Alexandria University
Alexandria Research Center for Adaptation to Climate Change
(ARCA)

Climate change and livestock

Vulnerability and adaptation

By
Yahya Zakaria Eid, *Ph.D.*
Faculty of Agriculture, Kafrelsheikh University
Egypt

ISSN 2314-8874

April 2014

ARCA Working Paper

Working Paper No. (2)

Climate change and livestock

Vulnerability and adaptation

By

Yahya Zakaria Eid, Ph.D.

Faculty of Agriculture, Kafrelsheikh University
Egypt
yahya.eid@agr.kfs.edu.eg

April 2014

Table of contents

Page

1. Introduction 3

2. Objective 4

3. Livestock classification 4

4. Climate change's impacts on livestock 5

4.1. Quantity and quality of feeds 5

4.2. Heat stress 6

4.3. Water 7

4.4. Livestock diseases and disease vectors 7

4.5. Biodiversity 8

4.6. Systems and livelihoods 9

5. Response to climate change impacts in livestock systems 10

6. Egyptian Context: A situation analysis 12

6.1. Pasture and Forage Resources 13

6.2. Opportunities for improvement of pasture and forage resources under climatic change 16

7. Livestock in Egypt 18

7.1 Animal production 18

7.2. Integration of livestock into farming systems 19

8. Livestock challenges and possible adaptation options under climate change 21

9. Conclusion 22

10. References 23

1. Introduction

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) (VijayaVenkataRaman et. al., 2012). Such change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land-use. Ever since the industrial revolution began about 250 years ago, manmade activities have added significant quantities of greenhouse gases (GHGs) to the atmosphere. According to the Third Assessment Report on climate change 2001 of the Intergovernmental Panel on climate change, the atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have grown by about 31%,151% and 17%, respectively, between 1750 and 2000 (IPCC 2007), such increase in the levels of GHGs, it is argued, have contributed to greater warming, which, in turn, can impact the world's climate, leading to change in climate. Indeed, scientists have observed that over the 20th century, the mean global surface temperature increased by 0.6 ◦C. However, the Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7000 years ago marking the beginning of the modern climate era – and of human civilization (VijayaVenkataRamanet. al., 2012). Most of these changes in the climate are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receive.

Nevertheless, the evidence for rapid climate change (IPCC Fourth Assessment Report) is compelling:

(1) Sea-level rise: Global sea level rose by about 17 cm (6.7 in.) in the last century. The rate in the last decade, moreover, is nearly double that of the last century;

(2) Global temperature rise: Most of observed global warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years;

(3) Warming oceans: The oceans have absorbed much of the increased heat, with the top 700 m of ocean surface showing warming of 0.302◦C Fahrenheit since 1969;

(4) Shrinking ice sheets: The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 150–250 km^3 (36–60 cubic miles) of ice per year between 2002 and 2006,while Antarctica lost about 152 km3 (36 cubic miles) of ice between 2002 and 2005 (IPCC 2007);

(5) Declining Arctic sea ice: Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades;

(6) Glacial retreat: Glaciers are retreating almost everywhere around the world – including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa; and

(7) Ocean acidification: Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30%. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year (IPCC 2007).

Livestock systems especially in developing countries are changing rapidly in response to a variety of drivers. Globally, human population is expected to increase to 9.2 billion by 2050. More than 1 billion of this increase will occur in Africa. Rapid urbanization is expected to continue in developing countries, and the global demand for livestock products will continue to increase significantly in the coming decades (Delgado et al., 1999). Given the complexity of livestock (and in most cases crop–livestock) systems in developing countries, a mix of technological, policy and institutional innovations will be required. On the technology side, improvements will be linked to a combination of feed and nutrition, genetics and breeding, health and environmental management options, with different combinations appropriate to different systems. At the same time, the climate is changing. Significant changes in physical and biological systems have already occurred on all continents and in most oceans, and most of these changes are in the direction expected with warming temperature (Rosenzweig et al., 2008).

2. Objective

The objective of this working paper is to review and shed light on some elements of the complex relationship between livestock and climate change with emphasis on developing countries in general and Egypt in particular.

3. Livestock classification

We use the systems classification of Sere and Steinfeld (1996), whose methods were built on the concept of the agro-ecological zone, which is relevant to climate change work perspective. There are two parts to the classification. The first is the agro-climatic part is based on the length of growing period (LGP), defined as the period in days during the year when the rain fed, available soil moisture supply is greater than half the potential evapotranspiration (PET). It includes the period required to evapotranspire up to 100 mm of available moisture stored in the soil profile. Excluded are any time intervals with daily mean temperatures of less than 5 °C. Three categories are defined: (1) Arid/semiarid, with a LGP of less than or equal to 180 days; (2) Humid/sub-humid, with a LGP greater than 180 days; (3) Tropical highlands/temperate. Temperate regions are defined as those with one month or more with monthly mean temperature, below 5 °C. Tropical highlands are defined as those areas with a daily mean temperature, during the growing period, of between 5 and 20 °C. The second part of the classification distinguishes between solely livestock systems and mixed farming systems. Solely livestock systems are those in which more than 90% of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and less than 10% of the total value of production comes from non-livestock farming activities. Mixed farming systems are, meanwhile, livestock systems in which more than 10% of the dry matter fed to animals comes from crop by-products, stubble or more than 10 percent of the total value of production comes from non-livestock farming activities.

The solely livestock systems are, in turn, split into two: (1) Grassland-based systems, in which more than 10% of the dry matter fed to animals is farm produced and in which annual average stocking rates are less than 10 temperate livestock units per hectare of agricultural land. (2) Landless livestock production systems, in which less than 10% of the dry matter fed to animals is produced on the farm and in which annual average stocking rates are above 10 temperate livestock units per hectare of agricultural land. The landless systems are further split into two categories: landless monogastric systems, in which the value of production of the pig/poultry enterprises is higher than that of the ruminant enterprises; and landless ruminant systems, in which the value of production of the ruminant enterprises is higher than that of the pig/poultry enterprises.

The mixed systems are further broken down into: (1) Rainfed mixed farming systems, in which more than 90% of the value of non-livestock farm production comes from rainfed land use; (2) Irrigated mixed farming systems, in which more than 10% of the value of non-livestock farm production comes from irrigated land use (The classification system of Sere and Steinfeld (1996) is tabulated in Table 1).

Table 1 Livestock systems according to the classification of Sere and Steinfeld (1996) and adapted from Thornton et al.(2009)

Generic	Specific	System
LG (livestock only)	LGA	Livestock only systems, arid–semiarid (LGP < 180 days)
	LGH	Livestock only systems, humid–subhumid (LGPP180 days)
	LGT	Livestock only systems, highland/temperate [a]
MR (mixed rainfed)	MRA	Mixed rain fed crop/livestock systems, arid–semiarid (LGP < 180 days)
	MRH	Mixed rain fed crop/livestock systems, humid–subhumid (LGPP180 days)
	MRT	Mixed rain fed crop/livestock systems, highland/temperate [a]
MI (mixed irrigated)	MIA	Mixed irrigated crop/livestock systems, arid–semiarid (LGP < 180 days)
	MIH	Mixed irrigated crop/livestock systems, humid–subhumid (LGPP180 days)
	MIT	Mixed irrigated crop/livestock systems, highland/temperate [a]
LL (landless)	LLM	Landless monogastric systems
	LLR	Landless ruminant systems

4. Climate change: impacts on livestock

Climate change can have a number of direct and indirect impacts on livestock, organized according toThornton et al. (2009), as follows:

- Quantity and quality of feds;
- Heat stress;
- Water;
- Livestock diseases and disease vectors;
- Biodiversity; and
- Systems and livelihood.

Each of these aspects will be discussed in details in the following subsections.

4.1. Quantity and quality of feeds

Climate change can be expected to have several impacts on feed crops and grazing systems, including the following (Hopkins and Del Prado, 2007): (1) Changes in herbage growth brought about by changes in atmospheric CO_2 concentrations and temperature; (2) Changes in the composition of pastures, such as changes in the ratio of grasses to legumes; (3) Changes in herbage quality, with changing concentrations of water-soluble carbohydrates and N at given dry matter (DM) yields; (4) Greater incidences of drought, which may offset any DM yield increases; and (5) Greater intensity of rainfall, which may increase N leaching in certain systems. The impacts of increased atmospheric CO_2 concentration on plant growth are well studied. It causes partial closure of stomata, which reduces water loss by transpiration and thus improves water-use efficiency (Rotter and van de Geijn, 1999). Dixon et al. (2003) conducting vulnerability analyses in eight African countries, concluded that average biomass generally increased for warm-season grasses and decreased for cool-season forbs and legumes as optimal grassland conditions shifted from lower to higher latitudes (although other studies indicate that higher temperatures will often favor forbs and legumes over grasses). It is likely to be smaller impacts on livestock yields per se, compared with grassland biomass, because of the ability of livestock to adjust consumption in response, although whether the area for livestock production can increase, is a very site-dependent question .The key point seems to be that climate impacts on plants depend significantly on the precipitation scenario considered. Changes in evaporation–precipitation ratios modify ecosystem function, particularly in marginal areas, in ways that are not fully understood (IPCC, 2007). The (IPCC, 2007) summarizes the impacts on grasslands for different temperature changes. Warming of 2 °C suggests positive impacts on pasture and livestock productivity in humid temperate regions. By contrast, negative impacts are predicted in arid and semiarid regions. Very few impact studies have been conducted for tropical grasslands and rangelands (the LGA, LGH and LGT systems). Some recent work is highlighting the need for a considerable expansion of effort in this area (Dixon et al. 2003). These factors are critical to ensure sustainable management of semiarid grazing systems. Therefore, it was argued that there is need for a new generation of dynamic grazing models that can provide land managers with the information needed to adapt to climate change (Dixon et al. 2003).

4.2. Heat stress

It seems that there are not enough work done on the direct impacts of climate change on heat stress in animals, particularly in the tropics and subtropics. Easterling and Apps (2005) stated that a lack of appropriate physiological models that relate climate to animal physiology rather limits the confidence that can be placed in predictions of impacts. It is clear, however, that warming will alter heat exchange between animal and environment, and feed intake (SCA, 1990), mortality, growth, reproduction, maintenance, and production are all, potentially affected. McDowell (1972) noted that significant changes in feed intake and numerous physiological processes do not occur in the range 5–25 °C. However, the thermal comfort zone is influenced by a range of factors, and is much higher in tropical breeds because of both better adaptation to heat and the lower food intake of most domestic cattle in smallholder systems. Clearly, hot and humid conditions can cause heat stress in livestock, which will induce behavioral and metabolic changes, including reduced feed intake and thus a decline in productivity. Rotter and van de Geijn (1999) suggest that impacts of heat stress may be relatively minor for the more intensive livestock production systems where some control can be exercised over the exposure of animals to climate (particularly the LLM and LLR systems). The wide geographic distribution of livestock production is some evidence for its adaptability to different climates. As these authors point out, livestock are a much better hedge than crops against extreme weather events such as heat and drought. Even so, whether the mean temperature increases of the coming decades are within the range that can be tolerated or not by existing distributions of different genotypes of cattle in the tropics, is essentially unknown. Similarly, the impacts of increased frequencies of extreme heat stress on existing livestock breeds are not known, nor do us know if there are critical thresholds in the relationship between heat stress and physiological impacts. Nevertheless, the tropics and subtropics contain a wealth of animal genetic resources that could be utilized in relation to heat-stress-related issues. There is considerable value in better understanding the match between livestock populations, breeds and genes with the physical, biological and economic landscape; this landscape livestock genomics approach should lead in the future to understanding the genetic basis of adaptation of the genotype to the environment (Sere et al., 2008). Over this longer term, ongoing genetic improvement through both natural and artificial selection should allow a certain degree of adaptation to gradual changes in climate to occur.

4.3. Water

Globally, freshwater resources are relatively scarce; amounting to only 2.5% of all water resources, and of this, about 70% is locked up in glaciers and permanent ice (MA, 2005). Estimates of the renewable global water supply are very imprecise, but lie between 33,500 and 47,000 cubic km per year, about one-third of which is accessible to humans, once its physical proximity to human population and year-to-year variability are taken into account (Postel et al., 1996). Groundwater also plays an important role in water supply – between 1.5 and 3 billion people depend on groundwater for drinking (MA, 2005). There is considerable uncertainty associated with estimating available groundwater resources and their recharge rates, and this makes assessments of water use particularly challenging. The agricultural sector is the largest user of fresh water resources, accounting for some 70% of water use. Irrigated areas have increased fivefold over the last century. Even so, the growth in water use by other sectors has been faster in recent decades than for agriculture. Global freshwater use is projected to expand 10% between2000 and2010, down from a decadal rate of 20% between 1960 and 2000, reflecting population growth, economic development, and changes in water-use efficiency (MA, 2005). Globally, each person consumes 30–300 l of water per day for domestic purposes, while it takes 3000 l per day to grow each person's food (Turner et al., 2004). Perhaps the key issue relating to water is its uneven distribution. The MA (2005) states that water scarcity is a globally significant and accelerating condition for 1–2 billion people worldwide, resulting in problems with food production, human health, and economic development. By 2025, 64% of the world's population will live in water-stressed basins, compared with 38% today (Rosegrant et al., 2002). The extent and nature of livestock's role in the global water use equation is the subject of considerable debate. Water use in the livestock sector includes not only the water used at farm level for drinking and the growing of feed crops, but also other servicing and product processing roles. Steinfeld et al. (2006a,b) provide quantitative estimates of direct and indirect water use in the livestock sector, and discuss livestock's role in water pollution. Some of this water intake comes from forage, and forage water content itself will depend on climate-related factors in well-understood ways: forage water content may vary from close to 0–80%, depending on species and weather conditions. In summary, while the response of livestock to known increases in temperature is predictable, in terms of increased demand for water, attempts to quantify the impacts of climate change on water resources in the land-based livestock systems in developing countries are fraught with uncertainty, particularly in situations where groundwater accounts for a substantial portion of the supply of water to livestock, which is the case in many grazing systems, for example. The coming decades will see increasing demand and competition for water in many places, and policies that can address allocation and efficiency issues will increasingly be needed.

4.4. Livestock diseases and disease vectors

The impacts of changes in ecosystems on infectious diseases depend on the ecosystems affected, the type of land-use change, disease specific transmission dynamics, and the susceptibility of the populations at risk (Patz et al., 2005a,b) – the changes wrought by climate change on infectious disease burdens may be extremely complex. Climate change will affect not only those diseases that have a high sensitivity to ecological change, but there is also significant health risk associated with flooding. The major direct and indirect health burdens caused by floods are widely acknowledged, but they are poorly characterized and often omitted from formal analyses of flood impacts (Few et al., 2004). There is quite a large literature on the prospective impacts of climate change on health and disease, but much of it is devoted to human health and vector-borne disease, unsurprisingly. The effects of climate change on livestock and non-vector-borne disease have received only limited attention. A more important effect may be on genetic resistance to disease. While animals often have evolved genetic resistance to diseases to which they are commonly exposed, they may be highly susceptible to “new” diseases. Climate change may bring about substantial shifts in disease distribution, and outbreaks of severe disease could occur in previously unexposed animal populations (possibly with the breakdown of endemic stability). Effects on vectors: there may be several impacts of climate change on the vectors of disease (midges, flies, ticks, mosquitoes and tsetse are all important vectors of livestock disease in the tropics). It notes that new studies are focusing on the spread of animal diseases and pests from low to mid-latitudes due to warming. Models project that bluetongue, which mostly affects sheep and occasionally goat and deer, will spread from the tropics to mid-latitudes (Anon, 2006). Most assessments do not explicitly consider the impacts on livestock health as a function of CO2 and climate combined. Whether CO_2 impacts are important or not in this regard, is essentially unknown. Perhaps more than other livestock-related impacts, climate change effects on livestock disease suffer intrinsic problems of predictability. Kovats et al. (2001) noted that there has been a tendency to oversimplify the mechanisms by which climate change may affect disease transmission. There are in general many factors operating, and considerably more work is needed on disease dynamics and how these may adapt to a changing climate. These things make impact assessment of livestock diseases in developing countries particularly challenging.

4.5. Biodiversity

Modern drivers of change are already having substantial impacts on biodiversity. The loss of genetic and cultural diversity in agriculture as a result of the forces of globalization, for example, is summarized by Ehrenfeld (2005). He notes the case of rice varieties in India – in 20 years' time, rice diversity will be reduced to 50 varieties, the top 10 of these accounting for more than 75% of the country's rice area – to be contrasted with the fact that probably something like 30,000 different indigenous varieties have been grown in India over the last 50 years. Similar scales of loss have been seen in varieties of domestic animals; of the nearly 4000 breeds of ass, water buffalo, cattle, goat, horse, pig and sheep recorded in the 20th century, some 16% had become extinct by 2000, and 12% of what was left was rare. The 2007 FAO report on animal genetic resources indicates that 20% of reported breeds are now classified as at risk, and that almost one breed per month is becoming extinct (CGRFA, 2007). There is considerable regional variation, however. In developed regions, 20–28% of mammalian species are classified as at risk, and these regions have highly specialized livestock industries, in which production is dominated by a small number of breeds. For developing regions, the proportion of mammalian species at risk is lower (7–10%), but 60–70% of mammals are classified as being of unknown risk status (CGRFA, 2007). Much of this genetic erosion is attributed to global livestock production practices and the increasing marginalization of traditional production systems and associated local breeds. The drivers of these changes in developing countries depend on the system (Sere et al., 2008). In the landless industrial systems (LLM, LLR), genetic resources are essentially the preserve of the private sector. In the mixed systems in developing countries (MR, MI), the pressures to intensify to meet demand are increasingly involving crossbreds with exotic breeds, while in the grazing systems (LG), high levels of diversity are often encountered and traits of disease-resistance and tolerance of harsh environments are widely present. However, livestock numbers are frequently declining in these systems, and small endemic populations are particularly at risk (Sere et al., 2008). As CGRFA (2007) notes, pastoralists and smallholders are the guardians of much of the world's livestock genetic resources. This poses particularly challenging problems for conservation, but there is a great deal that can and must be done, in the search for appropriate and effective schemes of biodiversity management, including the setting up and implementation of appropriate institutional and policy frameworks (Sere et al., 2008).

4.6. Systems and livelihoods

Most of the work done on agricultural impacts of climate change has focused on crops, and there is relatively very little literature on the impacts of climate change on farming systems, whether they contain livestock or not. There is a considerable literature from a development perspective on how farming systems may change in response to key drivers. For example, a general model of crop–livestock interactions and intensification first developed by Boserup (1965) and expanded by McIntire et al. (1992) describes system change as an endogenous process in response to increased population pressure. As the ratio of land to population decreases, farmers are induced to adopt technologies that raise returns to land at the expense of a higher input of labor, the direct causal factor being relative factor price changes. This generalized framework may be modified by many factors other than population growth. Environmental characteristics play a significant role in determining the nature and evolution of crop–livestock systems, as do factors such as economic opportunities, cultural preferences, climatic events, lack of capital to purchase animals, and labor bottlenecks at key periods of the year that may prevent farmers from adopting technologies such as draft power (Baltenweck et al.,2003). Livestock systems in developing counties are extremely dynamic. Various drivers of change can be identified: increasing populations and incomes are combining to drive considerable growth in demand for livestock products, and this is projected to continue well into the future (Delgado et al., 1999), although at diminishing rates (Steinfeld et al., 2006a,b). One implication of this is the intensification of land use in the production of livestock feed. A second feature of the growing demand for livestock products is the shift in location of livestock production: the rapid urbanization of (particularly monogastric) livestock production (the LLM systems), followed in time by ruralization again, primarily in response to environmental drivers. In addition to the factors associated with the "livestock revolution" (Delgado et al., 1999) and "livestock in geographic transition" (Steinfeld et al., 2006a,b), other drivers may have far-reaching impacts on the livestock sector in the coming decades: the green agriculture movement (organic food, fair trade, etc.)

In addition to the direct impacts of a changing climate on many aspects of livestock and livestock systems, there are various indirect impacts that can be expected to impinge on livestock keepers in developing countries. One of the most significant of these is the impact on human health. As with livestock diseases, the changes wrought by climate change on infectious disease burdens may be extremely complex. Patz et al. (2005a,b) list several diseases as high priority for their large global burden of disease and their high sensitivity to ecological change. For the tropics, these include malaria across most systems; schistosomiasisand lymphatic filariasis in cultivated and inland water systems in the tropics; dengue fever in tropical urban centres; leishmaniasis and Chagas disease in forest and dryland systems; meningitis in the Sahel; and cholera in coastal, freshwater and urban systems. Impacts of climate change on malaria distribution, for example, are likely to be largest in Africa and Asia (Van Lieshout et al., 2004), although climate change is not likely to affect malaria transmission in the least developed countries where the climate is already highly favorable for transmission. In addition, climate change will have further impacts on heat related mortality and morbidity and on the incidence of climate sensitive infectious diseases (Patz et al., 2005b), and these may be considerable. While climate change impacts may have few direct impacts on other important diseases such as HIV/AIDS, climate variability impacts on food production and nutrition can affect susceptibility to HIV/AIDS as well as to other diseases (Williams, 2004).

In conclusion, some of the major knowledge gaps concerning climate change impacts on livestock-based systems and livelihoods that may be of particular importance todeveloping countries are shown in Table 2.

Table 2: Some of the knowledge gaps of climate change impacts on livestock-based systems and livelihoods in the tropics and subtropics (Thornton et al.(2009)

Area	Gap
Feeds: quantity and quality	Rangelands (LG): primary productivity impacts, species distribution and change due to CO2 and other competitive factors, estimation of carrying capacities
	Mixed systems (MR, MI): localized impacts on primary productivity, harvest indexes and Stover production
Heat stress	What is the extent of the problem, in a development context?
Water	Surface and groundwater supply, and impacts on livestock (particularly LG systems)
	Effective ways to increase livestock water productivity
Diseases and disease vectors	How may the prevalence and intensity of key epizootic livestock diseases change in the future?
	How may climate change affect diseases as systems intensify (particularly MR, MI, LL systems)?
Biodiversity	'Ecological biodiversity': what will happen to numbers of species as systems change?
	Animal breed biodiversity: can the animal genetic resources that might be useful in the future be specified?
Livestock systems	Localized impacts on livelihoods
	How will systems evolve in future?
	Magnitude and effects of systems changes on ecosystems goods and services
Indirect impacts	How do human health impacts of climate change intertwine with livelihood systems and vulnerability?

5. Response to climate change impacts in livestock systems

If the target of stabilizing climate temperature increases to 2 °C above pre-industrial levels is to be met, this is likely to require stabilization of the CO_2 concentration below 450 ppm. This is certainly possible, and some see this as an economically attractive goal (Stern, 2006). Meeting this target will need to involve the implementation of stringent climate policies and very substantial cutting of greenhouse-gas emissions. Given that there are considerable lags in the earth system, climate change impacts are inevitable in the coming decades, even if all emissions were cut tomorrow. Particularly for vulnerable people, adaptation options will be needed if households are to cope with the changes brought about. Some of these options may be able to reduce the negative impacts of livestock on climate (mitigation) while at the same time increasing household food security, income, and/or system resilience (adaptation). In this section, we highlight some key researchable issues related to adaptation and mitigation associated with livestock systems in the tropics and subtropics.

The (IPCC, 2007) notes that a wide array of adaptation options is available, but more extensive adaptation than is currently occurring is needed to reduce vulnerability to future climate change. There are barriers, limits, and costs, but these are not fully understood, let alone quantified (IPCC, 2007). There is a great variety of possible adaptive responses available, including technological (such as more drought-tolerant crops), behavioral (such as changes in dietary choice), managerial (such as different farm management practices), and policy options (such as planning regulations and infrastructural development). Adaptation options to climate change has been summarized by Kurukulasuriya and Rosenthal (2003), who define a typology of adaptation options that includes the following: (1) Micro-level adaptation options, including farm production adjustments such as diversification and intensification of crop and livestock production; changing land use and irrigation; and altering the timing of operations. (2) Income-related responses that are potentially effective adaptation measures to climate change, such as crop, livestock and flood insurance schemes, credit schemes, and income diversification opportunities. (3) Institutional changes, including pricing policy adjustments such as the removal or putting in place of subsidies, the development of income stabilization options, agricultural policy including agricultural support and insurance programs; improvements in (particularly local) agricultural markets, and the promotion of inter-regional trade in agriculture. (4) Technological developments, such as the development and promotion of new crop varieties and livestock feeds, improvements in water and soil management, and improved animal health technology. This suggests the need for several activities, which are relevant to agricultural systems in general, not just those with livestock in them (Table 3): (1) The collation of toolboxes of adaptation options and, more importantly, the identification of the domains where these may be applicable or relevant, at broad scales through the use of spatial analysis, and at more localized scales through more participatory, community based approaches. (2) The need for generic and comprehensive impact assessment frameworks has been noted in successive IPCC Assessment Reports. Such frameworks will need to be able to address the costs and benefits of different adaptation options, and they need to be comprehensive and comparable with similar efforts in other sectors such as the disaster management sector. (3) Adaptation to climate change requires changes to or modifications to behavior. Research cannot effectively contribute to the improvement of adaptive capacity without a comprehensive understanding of the context in which decisions about adaptation are made, and the capacity of decision makers to change. Adaptation may be constrained by the institutional, social, economic and political environment in which people must operate. There is an urgent need to consider developing collaborative learning processes to support the adaptation of agricultural and food systems to better cope with the impacts of climate change.

Table 3: Some researchable issues in the areas of frameworks and tools, adaptation and mitigation, related to livestock systems in the tropics and subtropics (Thornton et al.(2009)

Area	Researchable issues
Methods andtools	❖ Comprehensive framework development and implementation, for impact assessment and trade-off analyses
	❖ Tools and databases for effective targeting
Adaptation	❖ Which options, and where are they applicable/viable (toolboxes)
	❖ Information supply and demand (‘‘Research into use”)
	❖ Under what conditions will specific livestock-related risk management options work?
Mitigation	❖ Assessment of biofuels: where and how can they contribute to poverty alleviation in livestock systems, and what are the key trade-offs in biofuels
	❖ versus feed versus conservation agriculture and soil fertility management?
	❖ Carbon sequestration: where and how can this contribute to poverty alleviation in livestock systems, and can the associated institutional issues be
	❖ addressed appropriately?

6. Egyptian Context: A situation analysis

As stated by El-Nahrawy (2011) and Yigini et al., 2013, Egypt has a total area of about one million square kilometers, of which only 3% is used for agricultural production. The population is increasing at an annual rate of 2.5% and reached more than 80 million by the year 2012. Food consists predominantly of cereals—wheat, maize, rice and sorghum—which provide 72% of the energy and protein supplies. The per capita consumption of animal products is very low, approximately 16 g/day. Mean annual per capita consumption is 9.7 kg of red meat, 48 kg of milk, 6 kg of white meat, 4.9 kg of fish and 4 kg of eggs. The annual growth rate of animal production has remained around 4%. The continuing economic boom and an economic policy that favors consumers have greatly increased the standard of living of the population, particularly in the food sector. Over recent years, the demand for meat has grown and imports of meat have increased. Milk and meat prices have increased substantially. The government has committed itself to a phased withdrawal from direct intervention in the market, the abolition of government control of the prices of most products, and a gradual reduction in the number of public sector employees.

6.1 Pasture and Forage Resources

Egypt has little effective rainfall, at most 200 mm unequally distributed and on limited areas; therefore, Egypt has poor rangeland, although vast areas of more than 10 million ha exist. According to FAO (2010) rangelands provide only 5% of animal feed in Egypt. Egypt depends largely on Egyptian clover (berseem) as the main forage crop and on crop residues and by-products. The cultivated area of berseem ranges from 1 050 000 to 1 260 000 ha annually in the Delta and Nile Valley. There is a competition between berseem and wheat, especially on old land, where the productivity is the highest for both crops. Although there is a wide gap between available and required feed, there is very rapid development in the animal wealth to meet the high demand for animal products. Recorded share from animal protein is about 17 g/day in 1997 and planned to be increased to 21g per capita by 2017 (FAO, 2003). The degradation of natural resources in Matrouh and Sinai governorates is part of an endemic cycle of poverty, lack of viable production alternatives and uncoordinated regional development. Although livestock production under prevailing climatic conditions is risky, livestock owners are able to avert the risk somewhat through:

- The purchase of barley and processed feed.
- By transporting their flocks to the Delta or Siwa oasis during years of severe drought.

Depending on the definition used, various sources put the area of rangelands in Egypt at somewhere between 4 and 10 million ha. Hegazi*et al*. (2005) indicate that the main areas of rangelands are distributed over the Northwest Coast (NWC) region, the Sinai Peninsula and the Halayeb-Shalayin region in the South East corner of Egypt bordering the Red Sea. In these regions livestock rising based on rangelands as a principal source of feed is traditionally the main occupation of the Bedouin inhabitants.

Main range types include:

Salt-Marsh: Characterized by a high density of salt tolerant shrubs. In general the amount of grazing obtained is small and generally restricted to the early autumn, due to the low palatability of the dominant shrubs which have a high salt content;

Rockland: Characterized by the dominance of the semi-shrub *Gymnocarpusdecander*, and found on rocky ridges and eroded slopes. Although plant density here is generally low, the palatability to small ruminants of most species is high. The vegetation is grazed mainly in the summer and autumn;

Sub-desert: Similar to Rockland in the presence of *Gymnocarpus*sp. but with a greater species diversity and productivity due to the more favorable soil conditions. This vegetation type is found mainly south of SidiBarrani and is grazed chiefly in winter and spring;

Coastal Plain: *Artemesiaherba-alba* is the dominant species. It occupies areas with relatively deep, medium-textured soils. The density of shrubs and herbs is high; **Eroded Coastal Plain**: Characterized by open stands of the low shrub *Haloxylonarticulatum*and occupying degraded sites in the northern plains. Species diversity is low as is the density of annuals. Provides some summer and autumn grazing;

Inland Dunes: This range type is on stabilized and semi-stabilized inland sand dunes, mainly in the SidiBarrani area. The characteristic species is the perennial forb *Plantagoalbicans*associated with numerous other shrubs and perennial forbs and grasses. The density of both perennial and annual species is high in stabilized areas. Grazing of this vegetation takes place mainly in spring and early summer;

Saline Uplands: Characterized by the salt-tolerant, semi-shrub *Suaedapruinosa*, with low species diversity and density. Grazing takes place mainly in early summer and in the autumn; and

Desert Range: The main range type in the southern area. The soils are often shallow or covered with a thin sheet of sand. The dominant species here is the desert shrub *Anabasis articulata*. Plant density is very low, with the exception of low areas receiving additional moisture from run-off. Camels graze this vegetation type year-round whilst sheep and goats may obtain some grazing here mainly in the winter.

Few data are available from actual stocking rate trials to estimate the carrying capacity of the range types.

The annual / feed production of the rangelands varies between nil in poor rainfall years to 74.13–98.84 feed unit (FU) with an average of 49.42 FU/ha/year. On the basis of the barley area in 1990 and an estimated production of 568.34 FU/ha of barley, the carrying capacity of the area extending from Ras El-Hekma to Salloum was estimated at about 93000 sheep units (SU)/ year while the actual number of small ruminants raised at the time was about 214000 SU, indicating that the rangelands can only support about 44% of the actual number of the small ruminants raised. This also indicates that at least 60% of feedstuff requirements came from outside resources. Any shortage in the supply of feeds from outside the region would have to be offset from rangelands because the grazing animal will be maintained on the rangelands causing more deterioration of rangelands and lower production of grazing herds.

A recent report estimated the consumable productivity of some plant communities in Bakbak project (south west of Sidi-Barrani) at between 49.42–74.13 kg/dry matter /ha/year. The average productivity of the whole area was estimated at 61.78 kg/ha/year. This area is a part of the natural poor degraded range type. Due to proximity to the mountains, the wadis in Halayeb basin have more floristically variable vegetation with higher frequency of palatable species than wadis in Shalateen basin. However, Shalateen rangelands are suffering more from heavy overgrazing due to excessive animal numbers, cutting and uprooting of trees and shrubs. Furthermore, herbaceous plant communities in the wadis of Shalateen basin are dominated by the unpalatable species of *Sasolabaryosma*and*Francoeriacrispa*. In the wadis of Halayeb basin there are more palatable species dominated by *Panicumturgidum*which is good forage grass. Similarly, WadiHedrerba in Halayeb basin has the richest grazing resources and the highest potential for conservation and improvement of the wadis. The most important forage species in WadiHederba are *Panicumturgidum*, *Aristidamutabilis*,*Artemisajudaica*and*Lyciumshawii*which could provide good useful grazing resources for small ruminants and camels during winter and summer.

In Egypt forages for livestock feed are mainly produced under irrigation. Irrigated forages contribute about 18% of the value of field crops and are grown on the average on about 1 260 000 ha annually (FAO, 2003). These include: multi-cut (long season) berseem (*Trifoliumalexandrinum*L.); single cut (short season) berseem; alfalfa (*Medicago sativa* L.) (Figure 16B); hybrid forage sorghum (*Sorghum sudanense X Sorghum bicolor*) and Sudan grass (*Sorghum sudanense*(Piper) Stapf.); pearl millet (*Pennisetumglaucum*L.); fodder maize (Darawa) *(Zea mays* L.); maize or corn silage; and minor forages such as cowpea (*Vignasinensis*L.), teosinte (*Euchlaneamexicana*Schrad.), Italian ryegrass (*Loliummultiflorum*), guar (*Cyamposistetragonoloba*), fodder beet (*Beta vulgaris* L.), chickling pea or rough pea (*Lathyrussativus*), elephant grass (*Pennisetumpurpureum*Schumach), Amshoot (*Echinochloastagninum*), sesbania (*Sesbaniasesban*L.), and triticale. Forage crops, mainly fresh berseem during winter and as hay during summer, represents about 60% of available local feed. Summer forage crops such as Darawa, millet, sorghum, cowpea, Sudan grass, corn silage represent about 5% of the available local feed. Alfalfa which provides feed all the year around represents about 5% of the available local feed.

Berseem occupies, meanwhile, about one million ha seasonally. Nevertheless, berseem has not received much attention compared to cereal crops; i.e. wheat, rice and corn (SADS, 2009).The remarkable increase in cereal productivity in the last two decades (from 8 million Mt in 1980 to more than 22 million Mt in 2009) is mainly due to developing high-yielding cultivars and making their certified seed available to growers. Unfortunately, this is not the case for berseem (SADS, 2009).

In this context, there is a set of limitations including for example:

1. The public sector plays almost no role in forage seed production.
2. Since forages are not final products and are not easy to determine (such as for cereals), then it is necessary to encourage farmers to use certified seeds which needs demonstrations to convince farmers about the differences between good seed and bad seed.
3. As long as the farmers are not aware of the important role of good and certified seed from improved cultivars of the forages, the demand for seed will be very limited; hence the role of the private sector would be very small.
4. Unfortunately, the important role of berseem in Egyptian agriculture is not clear for the policy makers.
5. Pollination mode for berseem is still unclear and considering berseem as a self-pollinated crop makes limitation for isolation from neighbouring fields.

Since there is limited natural grazing in Egypt, large ruminants mainly feed on crop residues. Buffaloes eating rice straw are a familiar sight. By-products are a part of the rations of dairy stock and fodders are often complementary to straws and stovers. Table 13 contains details of various crop residues, average amounts available annually and when they are available. The amounts of wheat, rice and corn straw and bagasse available are considerable.

As farm crop residues and wastes can cause environmental problems unless they are re-cycled, their use or conversion and use as unconventional or non-traditional feedstuffs can be doubly beneficial. Upgrading the nutritive value of residues could be an important means of clos-ing the feed gap. The amount of wheat straw produced annually in Egypt is about 7.3 million ton. The growing rate from using the same amount of feed could be doubled if the technology of treating the straw with urea could be transferred to and adopted by farmers. Similarly, converting corn and sorghum straws to silage at the right time would improve its nutritive value. The total amount of farm residues is estimated to be more than 25 million Mt. In addition, feed from various forms of waste totals some 3 million Mt and includes: animal by-products (poultry manure and offal, tannery waste) and plant by-products (potatoes, tomatoes, oranges, grapes, dates, brewers' waste, and kitchen waste).

Research results from various studies have shown that there were no big differences between traditional and non-traditional feedstuffs in terms of their nutritive value as measured by chemical analysis and amino acid contents and also between various non-traditional feeds, and also average body weight gain, feed consumption and conversion and feed efficiency. When non-traditional feedstuffs were fed to four-week-old chicks there were no significant differences between tomato seed meal and cottonseed meal in terms of animal performance (body weight gain and feed consumption) although there were feed efficiency differences. These results are very encouraging in terms of making use of agro-wastes.

It should be noted that recycling farm-residues and agro-wastes as feedstuffs comprises a wide range of economic as well as environmental benefits such as:

1) Minimizing the competition between humans and animals on grains and pulses.
2) Minimizing the pollution. Recycling farm residues of various crop straws as well as wastes of different vegetables and fruits to feedstuff will help to solve a growing pollution problem.
3) Cheap feedstuffs will be available to be used in formulating feed thus reducing the cost of producing meat and animal by-products. In addition, more cereals and pulses will be available for human consumption.
4) Creating a new industry.
5) Reducing imports of feedstuffs.

6.2 Opportunities for improvement of pasture and forage resources under climatic change

To improve pasture and forage resources in Egypt, a number of measures can be undertaken including:

- ### Rangeland rehabilitation

Traditionally, rangeland grazing was the basis of livestock production. During the last few decades these lands have been exposed to degradation caused by transformation into agricultural land (increased water and wind erosion), by overgrazing leading to further erosion and narrowing of the botanical composition. Increasing animal numbers have disturbed the balance between available forage and carrying capacity. Greater emphasis needs to be given to the establishment of viable management systems to alleviate the degradation of the pasture lands in the Northern Coast and Sinai as well as introducing medic-cereal rotations and developing and distributing fodder shrubs to control desertification.

- ### Possible ways to alleviate the degradation

Conservation and where possible improvement of existing grazing lands (coastal, low plateau and high plateau) could be achieved through:

- Developing a tree seedling nursery capacity in the villages, and planting, in cooperation with local land users, of improved fodder trees and shrubs.
- Enhancement of soil stabilization by the planting of windbreaks, using trees or shrubs with reasonable nutritive value.
- Identification, in cooperation with local user groups, of useful local forage species, initiation of seed collection and multiplication programs and, finally, over-seeding selected rangelands with seeds of good nutritive value local grass and legume species.

- Application of restricted grazing when it is possible.

- ## Establishment of improved pasture

As mentioned above many of the common rangeland species occur naturally in Egypt. Considerable research and development have been carried out on these in the past through the Matrouh Resource Management Project (MRMP) aimed at realizing sustainable resource management and alleviating poverty in its mandated area, extending over 320 km along the North West Coast of Egypt with 60 km in land on average.

- ## Integration of forages into farming systems

Integration of forages, especially Egyptian clover, into farming systems is considered very unique not only in terms of agronomic aspects of fodder production in the cropping sequence, but on the complete package of socio-economic and technical issues as well as the sustainability of the natural resources, especially soil fertility, and on marketing of both forages and animal products. Including berseem in the cropping system is a excellent choice for soil improvement and increasing soil fertility with its ability to add high levels of nitrogen (53–71 kg/ha) by symbiotic N2 fixation (Graves et al. 1996). It means that every year there would be more than 714000 ton of fixed nitrogen (Graves et al. 1996) added to Egyptian cultivated lands. Additionally, berseem has been for more than five thousand years considered indispensable in rotation with cereals, cotton and other crops due to its high N2-fixing ability. Without growing mainly berseem and other legumes, the high productivity of non-leguminous crops could not have been maintained. Also, using the crop residues for animal feed is common in the irrigated areas. As noted above, feed supply is a serious constraint on animal production in Egypt. Imported raw materials of feeds, which lead to a trade deficit, have been much used traditionally. Now there is renewed interest in all local feed resources. Large quantities of crop residues (more than 25 million ton) are available and frequently used by farmers.

- ## Tree fodder

Range vegetation is generally characterized by the dominance of perennial shrubs with some trees in the middle plateau and the southwest coastal ranges. Wadi beds in the north and middle parts of Sinai represent a valuable source of grazing for sheep and goats on account of the lush spring growth of the herbaceous vegetation. Rangeland vegetation is generally depleted from overgrazing and shrub uprooting for fuel wood. Overgrazing results mainly from the lack of alternative feed resources particularly during the long dry summer season. Efforts have been made to introduce fodder shrubs e.g. AtriplexnummulariaandAcacia salignain the sandy areas of the north coast to fix the dunes and provide supplementary grazing for animals.

- ## Utilization of saline water for crop/forage production

Establishing irrigated forages such as alfalfa (Medicago sativa L.), ryegrass (LoliumperenneL), pearl millet (PennisetumglaucumL.), cowpeas (VignasinensisL.), Egyptian clover (TrifoliumalexandrinumL.), Rhodes grass and fodder beet (Beta vulgaris L.) using poor quality underground water is considered one of the best ways of overcoming shortages in feed, especially in desert areas. Since most of the rangelands are degraded because of recurrent drought and overgrazing due to mismanagement, it is crucial to find sustainable sources of feed resources, especially forage crops.

7. Livestock in Egypt

Animal production in Egypt represents about 30% of total agricultural production. The majority of farms are family farms of less than one hectare, with mixed livestock and crop production.

7.1 Animal production

The average numbers of adult livestock per farm are 1.02 buffalo cows, 0.94 cows, 1.14 sheep and 1.06 goats. There has been a steady increase in numbers, particularly of cattle (from 3.53 to 5.00 million), buffaloes (3.38 to 4.00 million), goats (3.43 to 4.55 million) and sheep (4.47 to 5.50 million) over this period. Camels, however, have declined from 141 000 to 110 000 head. Scale of enterprise: Three production sub-systems can be identified. These include traditional extensive, semi-intensive and intensive sub-systems. The first one is characterized by low production inputs and outputs and holding of few animals. It is practiced for sheep, goats, cattle, and buffalo in the various agro-ecological zones. The intensive production sub-system is characterized by high inputs and outputs as well as very large livestock holdings. This sub-system operates on the production of exotic cattle and constitutes about 10% of the total animal production system. About 60% of white meat production comes from intensive units. The semi-intensive sub-system depends on improved local breeds and husbandry techniques. It is practiced for lamb and calf fattening. Small farmers who do not own agricultural lands or control agricultural holdings are the main source of animal production. Livestock form an important component of the agricultural sector, representing about 24.5% of the agricultural gross domestic product with value of around EGP [Egyptian pounds] 33.6 billion [USD6.1 billion] in 2007 (SADS, 2009). There is no surplus of animal production for export except some limited numbers of sheep and goats. The sector is depending mainly on the private sector, with the majority of animal breeders being smallholder farmers and the share of the government sector is less than 2% of the total animal numbers. The ruminant sector is well-integrated with cropland since Egypt has limited natural pastures. Animal production is highly dependent on cattle and buffaloes as milk-producing animals, as well as male animals and un-reproductive females are fattened for meat. The cattle population totaled 4.6 million head, while the buffalo population reached 4.0 million head in 2008. The cattle population is concentrated in both Middle Delta and Middle Egypt regions with percentages 22.4 % and 26.2%, respectively. While 32.2% of the buffalo population is in the Middle Delta region and 22.4% is in the Middle Egypt region. Nevertheless, 31% of the sheep population is concentrated in Upper Egypt, compared to 22.38% in Western Delta region. The goat population is concentrated in both Upper Egypt and Middle Egypt regions with percentages of 36 % and 23.5%, respectively.

Indigenous cattle represent about 60% of the all cattle, while mixed-breed cattle represent about 37% and imported cattle about 3%. It is worth mentioning that 65% of the cattle population in the

Western Delta region is mixed-breed, while in Middle Egypt the percentage of mixed-breed is 18.5% only.

Meat and milk productivity of both cattle and buffalo experienced significant increases during the period 1980–2007. Average cow milk production increased from around 675 kg/head/season in 1980 to around 1.3 ton/head/season in 2007, due to increased number of indigenous cows mixed with foreign cows. As to buffaloes, milk production increased from around 1.15 ton/head/season in 1980 to around 1.4 ton/head/season in 2007, as a result of increased mechanization of farm operations. With regard to meat production, average weight of the cow carcass increased from around 132 kg/head in 1980 to around 200 kg in 2007, due to establishing fattening farms as well as improving animal feeding practices. The average weight of the buffalo carcass increased from around 129 kg/head in 1980 to around 176 kg in 2007, as a result of expanding the first and second stages of the young male animals fattening project (SADS, 2009).

Poultry production is progressively increased during the last fifteen years since the products of poultry (meat and eggs) could sufficiently cover the local consumption. The poultry and egg sector in Egypt has been developed dramatically since the early 1990's, enhanced by economic reform and government policy. In 2001, poultry meat production, reached 646,600 metric ton, exceeded all other types of meat. In value terms, 26 percent of Egypt's total livestock products came from poultry meat and egg production. In fact, Egypt's livestock sector contributed 27 percent of total domestic agricultural production in 1999. It is noticed that, more than 90% of poultry production is found in the Nile Valley and Delta zone. On the other hand, poultry production activities are still not intensified and limited in the other agro-ecological zones. The total number of Egg farms in Egypt is about 14519 and produce around 628144000 eggs per year. Such amounts of egg production are enough to cover the local requirements. Most of egg production is produced in the Nile Valley and Delta zone while the Desert zones are poor in their egg production due to several factors mainly environmental. However, one of the major constraints that encounter the poultry industry in Egypt is infectious diseases, which is responsible for great economic losses. It consequently has devastating effects particularly on intensive production. Although vaccination programmers have reduced the incidence of diseases; vaccination program can not alone cope with infectious diseases adequately. Therefore, special attention has been made to the ability of poultry breeds to respond to pathogenic challenges.

7.2. Integration of livestock into farming systems

Livestock/crop production is an excellent example of an integrated production system where fodder crops and agricultural residues provide the feed for animals. The majority of small farmers (about 90% of farmers) practice this system. Animal manure makes the soil more productive than would be the case in their absence. More than 50 million m3 of animal manure are produced annually. An important part of the forage is grown on the farm whereas concentrates are purchased. Some hay and straw are often bought. Although green forage and silage form the greater part of the ration, hay and concentrates are also important.

The main characteristics of the animal production sector are:

- 17.3% of the cattle population and 6% of the buffalo population are owned by people who do not own agricultural land.
- 89% of the cattle population and about 75% of the buffalo population are in agricultural holdings of less than 2.1 ha.
- 93% of the cattle population and about 86% of the buffalo population are in herds of less than ten animals.
- 25% of the sheep and goat populations are owned by people who do not own agricultural land.
- 83% of the sheep population and about 87% of the goat population are in agricultural holdings of less than 2.1 ha.
- 51% of the sheep population and about 55% of the goat population are in herds of less than ten animals.

Integrating livestock into farming systems has a number of limitations including:

- Inadequate feeding is the major limiting factor for animal development which causes high mortality of young animals and low daily gain and reproduction performances well below the genetic potential. Inadequate feeding results from low pasture productivity especially in the rainfed areas and inadequate use of berseem due to lack of producer knowledge of nutritional value and feed requirements.
- Inadequate stock water in most range areas. Animals may have to travel long distances to water points, and some water is of poor quality.
- Inadequate herd management practices leading to uncontrolled reproduction with no castration of inferior males and low replacement of old females. These practices lead to little or no genetic improvement in the herd.
- Health management of the herd is still insufficient, despite the efforts being made by the Ministry of Agriculture.
- Resource degradation, including soil loss to water and wind erosion, loss of soil fertility, soil salinization, decrease of aquifers, and degradation of range due to overgrazing, and cultivation of marginal lands.
- Access to improved bulls and artificial insemination services is limited, especially for small farmers.
- Climate constraints, particularly the high frequency and severity of drought.

Moreover, from socioeconomic perspective, limited land, water and rapidly growing population require continuing intensification of production on a limited natural resource base. Intensification requires ensuring high yields, greater input efficiencies, reduced negative environmental effects, a greater knowledge base and efficient management. Moreover, changes in the socio-economic environment have been brought about by changes in urbanization and higher incomes and the need for more export earnings or substitution of imports. Socio-economic constraints to improving the pasture and forage resources and to animal production can be summarized as follows:

- Intrusion of other uses such as dry land farming, both traditional and mechanized onto rangelands.
- Insufficient technical packages, staffing and extension.
- Changes in production systems where more concentrates are being used while most of its raw materials (especially corn and soybean) are imported, put extra pressure on farm financial resources and stability and on ranges.
- Animal product prices to the producer not sufficient to encourage investments due to the competition with imported products.
- Since the majority of animal breeders are composed of small farmers and they rely on animal products for both food and living, most of the above constraints highly affect them economically as well as socially.

8. Livestock challenges and possible adaptation options under climate change

The main challenges on livestock production are the shortage of local feed resources, particularly in summer, limited water and cultivable land, and the poor quality of local breeds of livestock.

Research is needed on the following:

- Genetic and environmental factors influencing the performance of the Egyptian breeds, including low fertility, particularly in summer, and causes of calf loss.
- Production of progeny-tested bulls to improve buffalo and cow milk production, use of artificial insemination and introduction of exotic germplasm.
- Selection to increase milk production from native and imported breeds, establishment of an elite herd and conservation of native breeds
- Productivity in desert conditions, and use of artificial insemination and embryo transfer techniques
- On-farm studies to evaluate the performance and optimal flock structure of local and cross-bred in different regions, and systems model analysis of existing and proposed production systems in the desert and Delta regions
- Increase in forage production through selection and better management of berseem, improvement of alfalfa production in reclaimed land, and replacement of forage maize by new, multi-cut forage crops
- Increase in the production of white and yellow maize grains, which are the main energy source in animal feeds.

- Building the research and researcher capacity to be enable to face the challenges of climatic change on the long run.
- Increase the stakeholders and public awareness with the problems associated with climatic change to be able to understand and adapt the preventive and reactive measures.

Priority Issues to minimize the negative effect of climatic change on livestock in Egypt

- Increase animal productivity of.
- Decrease mortality and morbidity rates.
- Facilitate access to feed, water (from traditional and non-traditional) and veterinary services.
- Maximize wastage use.
- Organize small farmers for input services.
- Organize small producers for collective integrated marketing.
- Better access to improved production technology.
- Better access to rural finance and markets.

9. Conclusion

As Thornton et al.(2009) stated; There is still a great deal that is not well understood concerning the interactions of climate and increasing climate variability with other drivers of change in livestock systems and in broader development trends. Multiple and competing pressures are likely on tropical and subtropical livestock systems in the future, to produce food, to feed livestock, and to produce energy crops, for example. Livestock and livestock systems are substantial users of natural resources and globally they contribute significantly to global warming, while at the same time they make contributions of critical importance to the livelihoods of at least a billion poor people in rural households, almost all of whom are in developing countries. The gaps in treatment of livestock systems in developing countries as regards the provision of ecosystems goods and services and the maintenance of livelihoods, and how these may be affected in the future, represent an unacceptable situation. But if future scientific assessments are to do justice to the topic of livestock keepers in developing countries, then a great deal of urgent work is needed that addresses several broad issues, including firstly; much more clarity is needed concerning the benefits of livestock, the negative impacts they can have on greenhouse-gas emissions and the environment, and the effects of climate change on livestock systems. The regional and local variations in public goods and dis-benefits associated with livestock need to be understood, before technology and policy options for adaptation and mitigation can be targeted appropriately. Much of the agricultural impacts work done to date is continental or regional in scope, but such work constitutes a blunt instrument – much higher-resolution assessment will be needed if targeting is really to meet the needs of the most vulnerable people. Secondly, while a great deal is known about how livestock keepers cope with climate variability, much more information is needed concerning the nature and extent of the tradeoffs possible between different crop and livestock enterprises, and between on- and off-farm income sources, in different situations. For most livestock keepers in the developing world, the variability of the weather patterns they experience is projected to increase. Changing climate variability may have critical effects on food security; in addition to impacts on food availability, variability may strongly affect the stability of food supplies and vulnerable people's ability to access food at affordable prices. Key to both of these broad issues will be the further development and refinement of impact assessment frameworks that can evaluate potential and implemented adaptation and mitigation options at regional and local scales, their effects on livelihoods, and the trade-offs that arise between income, food security and environmental objectives.

10. References

- Anon, 2006. Bluetongue confirmed in France. News and reports.Veterinary Record 159, 331.
- Baltenweck, I., Staal, S.J., Ibrahim, M.N.M., Manyong, V., Williams, T.O., Jabbar, M., Holmann, F., Patil, B.R., Herrero, M., Thornton, P.K., de Wolff, T., 2003.SLP Project on Transregional Analysis of Crop–Livestock Systems. Level 1 Report: Broad dimensions of crop–livestock intensification and interaction across three continents. ILRI, Nairobi.
- Boserup, E., 1965. The Condition of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. Aldine Publishing Company, London, UK.
- CGRFA (Commission on Genetic Resources for Food and Agriculture), 2007.The State of the World's Animal Genetic Resources for Food and Agriculture. FAO, Rome, 523 pp.
- Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S., Courbois, C., 1999. Livestock to 2020: the next food revolution. Food, Agriculture and the Environment Discussion Paper 28.IFPRI/FAO/ILRI, Washington, DC, USA.
- Dixon, R.K., Smith, J., Guill, S., 2003. Life on the edge: vulnerability and adaptation of African ecosystems to global climate change. Mitigation and Adaptation Strategies for Global Change 8, 93–113.
- Easterling, W., Apps, M., 2005.Assessing the consequences of climate change for food and forest resources: a view from the IPCC. Climatic Change 70, 165–189.
- Ehrenfeld, D., 2005. The environmental limits to globalization. Conservation Biology 19 (2), 318–326.
- El-Nahrawy M.A, 2011. Country Pasture/Forage Resource Profile. (http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Egypt/Egypt.html)
- FAO. 2003. Strategy of Agricultural Development in Egypt Up To 2017. MOA.May 2003, Cairo, Egypt (In Arabic).
- FAO. 2010. Valuing Rangelands for the Ecosystem and Livelihood Services. Thirtieth FAO Regional Conference for the Near East. Khartoum, the Republic of the Sudan, 4–8 December 2010. Pub. NERC/10/ INF/6 December 2010.
- Few, R., Ahern, M., Matthies, F., Kovats, S., 2004. Floods, health and climate change: a strategic review. Tyndall Centre Working Paper 63.<http://www.tyndall.ac.uk/publications/working_papers/working_papers.shtml>.
- Hahn G L, 1999. Dynamic responses of cattle to thermal heat loads. Journal of Animal Science 77, 10-20.
- Hegazi, A.M., Afifi, M.Y., El Shorbagy, M.A., Elwan, A.A. & El-Demerdashe, S. (eds) 2005. Egyptian National Action Program to Combat Desertification.Arab Republic of Egypt, Ministry of Agriculture and Land Reclamation, UNCCD, Desert Research Centre, 128p.
- Hopkins, A., Del Prado, A., 2007. Implications of climate change for grassland in Europe: impacts, adaptations and mitigation options: a review. Grass and Forage Science 62, 118–126.
- IPCC (Intergovernmental Panel on Climate Change), 2007. Climate Change 2007: Impacts, Adaptation and

Vulnerability. Summary for policy makers.<http://www.ipcc.cg/SPM13apr07.pdf>.

- Kovats, R.S., Campbell-Lendrum, D.H., McMichael, A.J., Woodward, A., Cox, J. St H., 2001. Early effects of climate change: do they include changes in vector-borne disease? Philosophical Transactions of the Royal Society, London, Series B 356, 1058–1068.
- Kurukulasuriya, P., Rosenthal, S., 2003. Climate change and agriculture: a review of impacts and adaptations. Climate Change Series Paper No. 91, World Bank, Washington, DC.
- MA, 2005.The Millennium Ecosystem Assessment. ''Ecosystems and Human Wellbeing: Scenarios, vol. 2", Island Press, 2005. <http://www.maweb.org//en/products.global.scenarios.aspx>.
- McDowell, R.E., 1972. Improvement of Livestock Production in Warm Climates.Freeman, San Francisco, California. p. 711
- McIntire, J., Bourzat, D., Pingali, P., 1992. Crop–Livestock Interaction in Sub-Saharan Africa.The World Bank, Washington, DC.p. 246.
- Patz, J.A., Campbell-Lendrum, D., Holloway, T., Foley, J.A., 2005a.Impact of regional climate change on human health. Nature 438 (November), 310–317.
- Patz, J.A., Confalonieri, U.E.C., Amerasinghe, F.P., Chua, K.B., Daszak, P., Hyatt, A.D., Molyneux, D., Thomson, M., Yameogo, L., Lazaro, M.M., Vasconcelos, P., Rubio- Palis, Y., Campbell-Lendrum, D., Jaenisch, T., Mahamat, H., Mutero, C., Waltner- Toews, D., Whiteman, C., 2005b. Human health: ecosystem regulation of infectious diseases. In: Ecosystems and Human Well-Being. Current State and Trends, vol. 1.The Millennium Ecosystem Assessment. http://www.millenniumassessment.org.
- Postel, S.L., Daily, G.C., Ehrlich, P.R., 1996. Human appropriation of renewable fresh water. Science 271, 785–788.
- Rosegrant, M.W., Cai, X., Cline, S.A., 2002. Global Water Outlook to 2020, Averting an Impending Crisis. A 2020 Vision for Food, Agriculture, and the Environment Initiative. International Food Policy Research Institute/International Water Management Institute, Washington DC, USA/Colombo, Sri Lanka.
- Rosenzweig, C., Karoly, D., Vicarelli, M., Neofotis, P., Wu, Q., Casassa, G., Menzel, A., Root, T.L., Estrella, N., Seguin, B., Tryjanowski, P., Liu, C., Rawlins, S., Imeson, A., 2008. Attributing physical and biological impacts to anthropogenic climate change. Nature 453 (May). doi:10.1038/nature06937.
- Rotter, R., van de Geijn, S.C., 1999.Climate change effects on plant growth, crop yield and livestock. Climatic Change 43, 651–681.
- SADS - Sustainable Agricultural Development Strategy Towards 2030. 2009. Agricultural Research & Development Council. Arab Republic of Egypt, Ministry of Agriculture & Land Reclamation. Oct. 2009.
- SCA (Standing Committee on Agriculture), 1990.Feeding Standards for Australian Livestock: Ruminants. CSIRO Publications, East Melbourne, Australia.
- Sere, C., Steinfeld, S., 1996. World livestock production systems: current status, issues and trends. FAO Animal Production and Health Paper, 127.Food and Agriculture Organization, Rome.
- Sere, C., van der Zijpp, A., Persley, G., Rege, E., 2008.Dynamics of livestock production systems, drivers of change and prospects for animal genetic resources. Animal Genetic Resources Information (42), 3–27.
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C., 2006a. Livestock's Long Shadow: Environmental Issues and Options. FAO, Rome, Italy.
- Steinfeld, H., Wassenaar, T., Jutzi, S., 2006b. Livestock production systems in developing countries: status, drivers, trends. Rev. Sci. Tech. Off. Int. Epiz. 25 (2), 505–516.
- Stern, N., 2006. The Economics of Climate Change.Cambridge University Press, Cambridge, United Kingdom.
- Thornton PK, Van de Steeg J, Notenbaert A, Herrero M. 2009. The impacts of climate change on livestock

and livestock systems in developing countries: a review of what we know and what we need to know. Agricultural Systems;101(3):13–27.

- Turner, K., Georgiou, S., Clark, R., Brouwer, R., Burke, J., 2004.Economic valuation of water resources in agriculture. From the sectoral to a functional perspective of natural resource management. FAO Paper reports No. 27, Rome, Italy.
- US-EPA. 2005. U.S. Greenhouse Gas Inventory Reports: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004. US-EPA # 430-R-06002.US-EPA, Office of Atmospheric Programs (6207J). Washington, D.C. 20460.
- Van Lieshout, M., Kovats, R.S., Livermore, M.T.J., Martens, P., 2004. Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. Global Environmental Change 14, 87–99.
- VijayaVenkataRamana, S., S. Iniyanb, RankoGoicc., 2012. A review of climate change, mitigation and adaptation Renewable and Sustainable Energy Reviews 16 :878– 897
- Willliams, J., 2004. Sustainable development in Africa: is the climate right? IRI Technical Report IRI-TR/05/01.The International Research Institute for Climate Prediction, Palisades, New York.<http://iri.columbia.edu>.
- Yigini Y., P. Panagos, and L. Montanarella, (eds). 2013. Soil Resources of Mediterranean and Caucasus Countries

Please address comments and/or queries for information to:

Alexandria research center for Adaptation to climate change (ARCA)
P.O. Box 832
163, Horreya Avenue Chatby
Alexandria – Egypt
Fax: 002 03 4249290
Or
E-mail: info@arca-eg.org