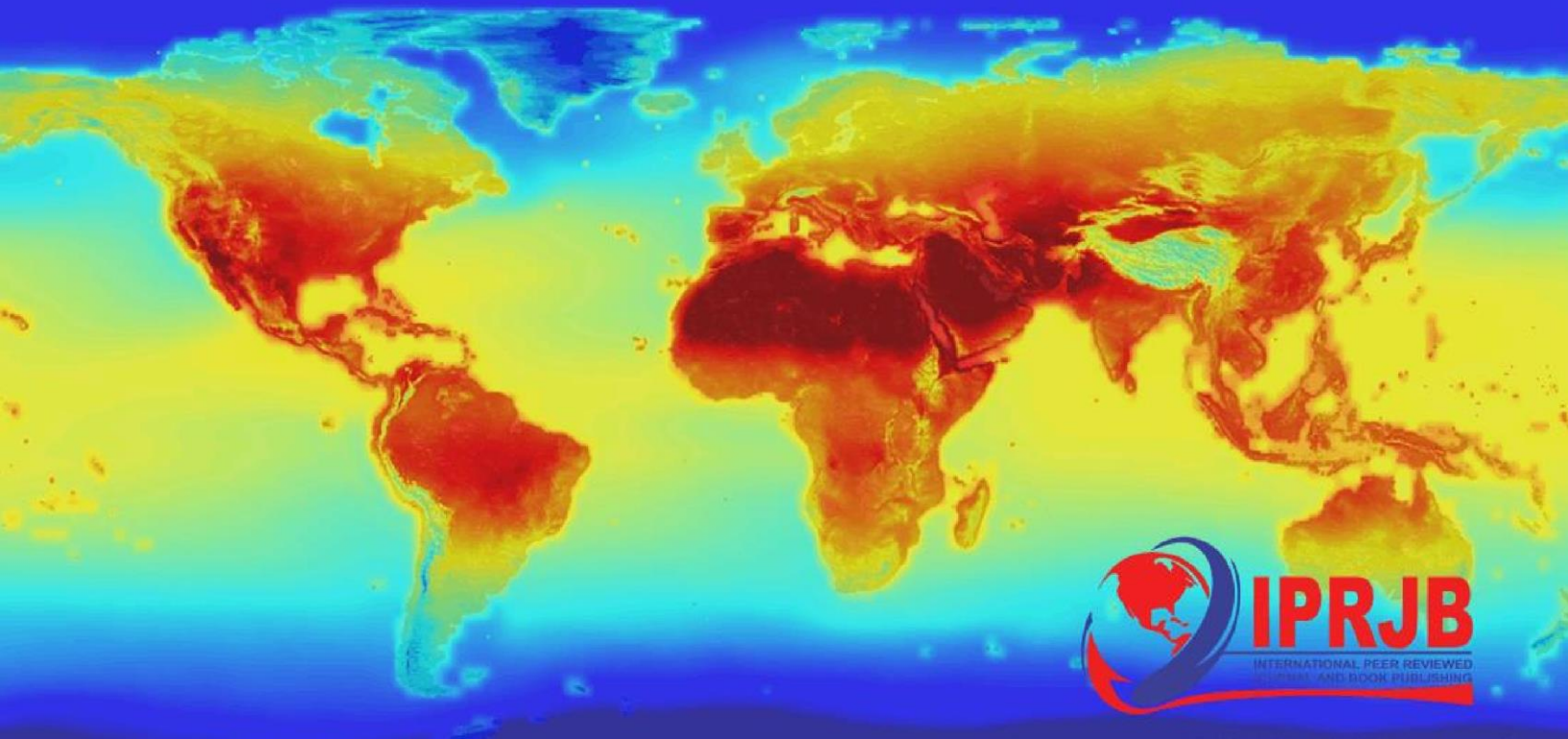
International Journal of

Climatic Studies

(IJCS)



IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

International Journal of Climatic Studies
ISSN: 2710-1061 (Online)
Vol.1,Issue No.5, pp. 65-73, 2017
www.iprjb.org

Effect of Climate Change on Bee Farming. A Critical Review of Literature

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ABSTRACT

Purpose: Climate warming affects the phenology, local abundance and large-scale distribution of bees. Despite this, there is still limited knowledge of how climate affect plant-pollinator mutualisms and how changed availability of mutualistic partners influences the persistence of interacting species. This article reviews the evidence of climate warming effects on bee farming and discuss how their interactions may be affected by change in climate. Bees provide the majority of biotic pollination and are at risk from a multitude of factors; changes in land use, intensive agricultural practices, mono-cropping (growing a single crop year after year on the same land), and the use of pesticides have all contributed to large-scale losses, fragmentation and degradation of bee habitat. The general objective of the study was to establish the effect of effect of climate change on bee farming.

Methodology: The paper used a desk study review methodology where relevant empirical literature was reviewed to identify main themes and to extract knowledge gaps.

Findings: The study found out Climate change is causing temperature shifts which are leaving bees unable to pollinate in time. Bees are severely vulnerable to extreme weather and climate change has caused flowers to emerge and bloom earlier. Changing temperatures have also reduced the size of their wild range by approximately five miles.

Recommendations: The study recommends that the local community needs to be enlightened on the need to form self-help group. These will provide them a platform to access more incentives and be able to share more information in relation to honey yield and to put more emphasis on providing food and water to bees during dry season

Keywords:*, climate change, beekeeping*

INTRODUCTION 1.1 Background of the Study

Bees provide the majority of biotic pollination and are at risk from a multitude of factors; changes in land use, intensive agricultural practices, monocropping (growing a single crop year after year on the same land), and the use of pesticides have all contributed to large-scale losses, fragmentation and degradation of bee habitats. Pests and diseases are also a threat to bee colonies, some of which have occurred as a result of transporting bees long distances. Furthermore, higher temperatures, shifting seasons and extreme weather events are also causing problems for bees (Smith et al., 2014).

Three out of four crops across the globe, which produce fruits or seeds for human consumption, depend on pollinators. As one of the most important pollinators in the world, bees are crucial for food production, human livelihoods and biodiversity. Unfortunately, bees and other pollinators are declining in abundance in many parts of the world with recent figures suggesting by as much as 30 per cent per year. If this trend continues, the cost of our fruit and vegetables could significantly increase, nutritious crops will be substituted increasingly by staple crops like rice, corn, and potatoes, resulting in an imbalanced diet, and the quantity of food in the world that relies on pollination by insects would diminish (IPCC, 2014).

Climate change and variability is a global issue of concern and its impacts vary spatially, geographically and temporally. Some areas experience an increase in rainfall whereas others document a decrease (Smith et al., 2014). The global terrestrial temperature has increased by 0.8°C in the past century and 0.6°C in the past three decades because of anthropogenic activities (Hansen et al., 2006). Climate change is encroaching slow but steady with an increase of temperatures of 0.5°C per decade (Hulme et al., 2001). This change has had impacts on people's livelihoods thereby affecting development, economic stability, biodiversity and ecosystems (Thornton et al., 2011).

The impact of climate change and variability is manifested both in developing and developed countries (Simms, 2005). Africa as a continent with limited natural resources is susceptible to impacts of climate variability and change leading to poverty escalation, increase in food price, high inequality, food insecurity, increase in energy price, an impediment to development and high incidences of disasters (Boko et al., 2007; IPCC, 2007). In East Africa, climate variability and change effects are evidenced by increased sea level (IPCC, 2001), rise in water in lakes and change in seasonal migration of wildlife (Thirgood et al., 2004), rainfall uncertainty (Simms, 2005) and other associated effects.

Apiculture is an important element of agriculture as it plays a major role in rural selfemployment, economic development and source of food (human nutrition). The key product of beekeeping is honey and wax and is a source of income to many farmers. Honey is used for several purposes such as food, medicine, cultural ceremonies and for religious purposes (Yirga and Teferi, 2010). Seventy three percent of the world crop pollinators are bees. These have an economic significance of €156 billion per year (Gallai et al., 2009). Honey production has grown globally. However, there has been a reduction in the production after the European Union banned the Chinese honey (Dong and Jensen, 2004), where they depend on organic honey from Kenya (Baylis et al., 2010).

The abundance of flora differs depending on landscape composition and complexity (Tscharntke et al., 2012; Shackelford et al., 2013). This differs depending on environmental condition, soil and other physical characteristics that influence species richness, density and population performance (Riedinger et al., 2014) since climate variability affects the ecological process that affects the spatial and temporal population and species composition (Stenseth et al., 2003). Plants are more sensitive to the growing season since they have different stages of growth that depends on environmental condition. Therefore, climate anomalies affect the growth at different season, for example, variation in temperature induces difference in floral and anthesis development (Hegland et al., 2009) and variation in evapotranspiration determines vegetation cover (Keane et al., 2002). This will affect structure and composition of species density in relation to the soil and water content (Gao et al., 2014). Plants produce nectar and pollen grain and during pollination, the bees are able to collect pollen grain that is essential for honey production (Kirsten et al., 2015). Bee keeping has been practiced for many years with only about a quarter of honey produced in arid and semi- arid (Carroll, 2006). In Africa particularly in Kenya, bee keeping is among the top important income generating activities. It is a source of livelihood to many households. The Government of Kenya currently has embarked on how to increase honey production. The decline in honey production has led to indigenous communities to engage in charcoal burning and other socio-economic activities. According to the development plan of 2014-2015, the major problems facing honey producing Counties include environmental degradation due to mostly deforestation, desertification, pollutions and climate change. Climate change and variability have led to the increased intensity and rate of recurrence of extreme weather conditions, floods, landslides and drought in the area (GoK, 2014). This paper examines the effect of climate change on bee farming

1.2 Statement of the Problem

Bees are extremely susceptible to certain mites and gut parasites, and these parasites have been steadily increasing due to warming weather conditions. Higher temperatures and more frequent heat waves as a result of climate change, are likely to exacerbate these problems in the future, which could cause Colony Collapse and wipe out entire hives.

Variation in temperature and rainfall has led to habitat loss, fragmentation and unfavourable condition for the organism to perform their duties. Honey production is the basic natural resource livelihood support systems that complement other livelihoods. Current trends in climate warming coupled with the increase in human populations are placing new stresses on the production ability of the fragile ecosystem to sustain bee farming households. There is need to establish the nexus between climate change on bee farming.

1.3 Objectives of the Study

The general objective of the effect of climate change on bee farming. A critical review of literature.

1.4 Justification and Significance of the Study

Globally, dry area covers about 41% of the entire land. Since climate variability is both a threat and an opportunity, these dry areas are more vulnerable to climatic threat than opportunities. Climate prediction shows that some parts of the world will become hotter and others drier. This

will alter societal performance, poverty escalation, hunger, and environmental degradation. Apiculture is a source of livelihood for majority of community and depends on favorable weather condition. Although people have diversified their livelihood in order to cope with unfavorable weather condition, it has been observed that the weather related impacts are manifested in all sectors. The shortage of water, high temperature, and increase net radiation affects plant phenology and pest infestation that affects honey production.. The findings of the study provided useful information that will help in the management of Arid and Semi- Arid Lands resources and improving the livelihoods of the people through increased honey production. This study enlighten issues being faced by the honey dependent local people because of climate variability.

LITERATURE REVIEW

2.0 Literature Review

The article reviews effect of climate change on bee farming. The literature review looked at the bee farming in the world generally .

2.1 Beekeeping and its contribution to the society

Organisms are adapted to different types of environments because of the differences in climatic conditions. Different countries has various types of wild honeybees (Adjare, 1990) with three sub species of Apis mellifera that have slightly similar morphology (Crewe et al., 1994). Beekeeping has been a traditional activity among many societies. Furthermore, beekeeping does not require an extensive and intensive labour and capital to start as it requires little input but it has a higher output and it is easy to harvest, process, and transport (FAO, 2012). Thus, every individual in the society can practice it. The ASALs communities use honey for traditional ceremonies for the purpose of strengthening social ties and other social activities such as marriage, reconciliation, birth and circumcision ceremony (FAO, 2009). Furthermore, bees are important pollinators in the world and indicators for terrestrial environmental change (Klein et al., 2006).

2.2 Overview of Climate variability

Climate variability is associated with extreme weather condition that affects farmers' output. The impacts varies with the magnitude from and one area to another (Davis and Ali, 2014). Kushnir, and Wallace (1989) and (Trenberth et al., 1998) predicted that regions would experience different weather condition in the late 1990s. Some areas will be drier, whereas other areas will experience warmer and others cooler weather conditions thus unpredictable weather with increasing temperature and change in the onset of rainfall altering the growth of fauna and flora (Roncoli et al., 2010). Therefore, the erratic nature of weather patterns results in reduction in agricultural production thus affecting the socio economic activities of many farmers (Cassman, 8 1999) impacting on livelihood of people who live in marginal areas because of fragile ecosystems (Maracchi, 2005; IPCC, 2007). These effects vary spatially depending on geographical location and socio-economic status of individuals and groups (McMichael, 2013; IPCC, 2014). According to IPCC (2014), some physical system or ecosystems are at risk of temporal or permanent damage.

The effects are manifested more among the farmers who depend on rain-fed agriculture especially in ASALs leading to food insecurity (FAO, 2012; IPCC, 2014), especially in sub-Saharan Africa

2.3 Climate variability and forage for bees

The abundance of flora differs depending on landscape composition and complexity (Tscharntke et al., 2012; Shackelford et al., 2013). These differences are function of environmental condition, soil and other physical characteristics that influence species richness, density and population performance (Riedinger et al., 2014). Climate variability affects the ecological process that affects the spatial and temporal population and species composition (Stenseth et al., 2003). Plants are more sensitive to the growing season since they have different stages of growth that depends on environmental condition. Therefore, climate anomalies affect the growth at different seasons. For example, variation in temperature induces difference in floral and anthesis development (Hegland et al., 2009) while variation in evapotranspiration determines vegetation cover (Keane et al., 2002).

This affect structure and composition of species density in relation to the soil and water content (Gao et al., 2014). Plants are adapted to different ecological condition based on climatic factor, soil type, moisture, pH and fertility (Robinson and Page 1989). Plants produce nectar and pollen grain and during pollination, the bees are able to collect pollen grain that is essential for honey production (Kirsten et al., 2015). This pollen grain heightens colony growth and increases long life or continued existence, brood production, colony survival, gland development, resistance against disease, increase individual life span, increase immunity and the growth weight of the bee (Paterson, 2006; Lee et al., 2015). Pollen grains contain large protein content and a higher protein content compensates for higher energy and nutrients used by bees (Eischen and Graham, 2008). The flow of nectar and protein decrease the broody adult ratio. The higher the pollen and nectar flow the more the adult that forage for food and water and hence growth of the colony hence bees prefer areas with abundance of flora (Gikungu, 2006). Although plants and animals live in a mutual relationship, climate change and variability have interfered with this relationship since climate variability poses a threat to pollination (Hegland et al., 2009; Schweiger et al., 2010). For instance, trees flower at different point in a season because temperature influences flowering, pollination, and anthesis. Plants will flower depending on the temperature of the season and the change in the temperature and rainfall alters flowering of the plants (Hegland et al., 2009; Luo, 2011). Depending on environmental condition and the position of the beehive, sometimes pollination will tend to decrease with distance from the beehive (Ricketts et al., 2008). Species diversity, richness/and abundance vary with landscape composition and complexity. This has an impact on the population of bees that tends to be abundant depending in areas with widespread of the flora (Grundel et al., 2010; Tscharntke et al., 2012). Honey composition also varies geographically depending on plant species except for Phytochemicals composition that depend on climatic conditions (Gemechis, 2012). Therefore, different bees are adapted to different condition in a given geographical area or environment (Ruttner, 1975). The raw materials for honey production are extracted from the interlinked environmental service. For instance, nectar is converted into honey and pollen into protein and lipids, which are source of food for the bee colony (Crailsheim, 1992). **2.4 Empirical Review**

Akala (2018) conducted a study on the relationship between rainfall variability on honey production among the pastoral communities.The study found out that beekeeping is among the livelihood diversification strategies likely affected by climate variability. Moreover the variation in temperature and rainfall influence forage phenology impacting on honey production in arid and semi-arid lands (ASALs).. Rainfall variability was exhibited in the study area and in some circumstances drought was experienced annually. On average, 19 plant species were recorded that the bees prefer in the study area. Rainfall variability was found to have significant positive correlation (r=0.423;p=0.001) on the effect on plant phenology thus altering flowering periods of many of the forage plants, changing the foraging behaviour of bees resulting to decrease in honey production. The findings of this study indicated that variation in rainfall has had an adverse effect on honey production and therefore there is need to incorporate land management strategies that will improve honey production in ASALs for sustainable livelihoods among pastoral communities in the context of climate variability.

Renaud Hecklé (2018) conducted a study on the factors affecting beekeeping adoption in Baringo County, Kenya with a focus on three smallholder farming communities. Semi-structured interviews were conducted with 90 informants in these communities, including 41 new beekeepers, 21 non-adopters, 13 group leaders, 10 village elders and 5 teenagers. In addition, 28 key stakeholders at national and local levels were approached. The findings show that in high traditional beekeeping areas apprenticeship pathway is predominant, while in low traditional beekeeping areas most of the beekeepers follow the traineeship pathway. The main factors affecting the decision of smallholder farmers to take up beekeeping were access to information, land and beehives, availability of alternative income generating activities, perceptions of beekeeping outcomes and performance, access to market, feelings towards bees, and cultural norms. The importance of these factors varies according to interviewee demographics (gender, age and level of education) and location. The findings suggested that to increase the uptake of beekeeping the following should be considered: (a) increasing awareness and knowledge in all locations but particularly in the low traditional beekeeping areas; (b) improving access to improved harvesting tools (e.g. smokers and protective clothing) and to movable comb or frame hives, especially for young people and women; and (c) supporting local social network

Ndyomugyenyi (2015) conducted a study was to assess honey production value chain with a view of improving household incomes in Lira sub-county, Lira district, Uganda. A total of 60 respondents were used for the study in four different parishes of the sub county. Data were collected using structured questions, observations, and interviews. Secondary sources of data were also reviewed. Most respondents who kept bees were males, were between 26-30 years and had little formal education. Local beehive usage was higher than modern beehives. The number of colonized beehives was more than that of either un-colonized or absconded beehives. Local beehives were more colonized than improved beehives. The majority of respondents used fire during harvesting honey, did not process their honey and used plastic bottles and Jericans as packaging materials. Most respondents indicated that honey bees depended on natural forage sources for honey production, although some planted forages or supplemented forages with sugar

syrup, maize and cassava flour. The main water sources for bees were swamps and morning dew. Honey was mainly sold to vendors in trading centres, while the least quantity of honey was sold to supermarkets. Apiculture contributed more income to households compared to other livestock species. The investment in apiculture per hectare was also higher than other livestock species. Lack of knowledge and skills and poor harvesting techniques were the major limitations to honey production. The study found out that beekeeping industry in Uganda calls for committed men and women who are business minded to work with all the stakeholders along the value chain to bring commercialization of beekeeping and marketing of honey and by-products to a reality.

2.5 Research gaps

Geographical gap is a knowledge gap that considers, the untapped potential or missing/limited research literature, in the geographical area that has not yet been explored or is under-explored.For instance Ndyomugyenyi (2015) conducted a study was to assess honey production value chain with a view of improving household incomes in Lira sub-county, Lira district. The study found out that beekeeping industry in Uganda calls for committed men and women who are business minded to work with all the stakeholders along the value chain to bring commercialization of beekeeping and marketing of honey and by-products to a reality.The study presented a geographical gap as it was done in Uganda while our current study will focus on effect climate change on bee farming

Methodological gap is the gap that is presented as a result in limitations in the methods and techniques used in the research (explains the situation as it is, avoids bias, positivism, etc.). Akala (2018) conducted a study on the relationship between rainfall variability on honey production among the pastoral communities . Rainfall variability was exhibited in the study area and in some circumstances drought was experienced annually. On average, 19 plant species were recorded that the bees prefer in the study area. Rainfall variability was found to have significant positive correlation ($r=0.423;p=0.001$) on the effect on plant phenology thus altering flowering periods of many of the forage plants, changing the foraging behaviour of bees resulting to decrease in honey production.The study presented a methodological gap as it involved correlation design while our study will adopt a desktop literature review method (desk study). Which involves an in-depth review of studies related to effect climate change on bee farming .

METHODOLOGY

The study adopted a desktop literature review method (desk study). This involved an in-depth review of studies related review of studies related to effect climate change on bee farming. Three sorting stages were implemented on the subject under study in order to determine the viability of the subject for research. This is the first stage that comprised the initial identification of all articles that were based on review of studies related to effect climate change on bee farming from various data bases. The search was done generally by searching the articles in the Article title, abstract, keywords. A second search involved fully available publications on the subject of on adaptation

practices to climate change and its impact on agricultural production. The third step involved the selection of fully accessible publications.

Reduction of the literature to only fully accessible publications yielded specificity and allowed the researcher to focus on the articles that related to review of studies related to effect climate change on bee farming which was split into top key words. After an in-depth search into the top key words (adaptation, climate change, agricultural production), the researcher arrived at 3 articles that were suitable for analysis. The 3 articles were findings from Akala (2018) conducted a study on the relationship between rainfall variability on honey production among the pastoral communities. The study found out that beekeeping is among the livelihood diversification strategies likely affected by climate variability. Ndyomugyenyi (2015) who conducted a study was to assess honey production value chain with a view of improving household incomes.

The study found out that beekeeping industry in Uganda calls for committed men and women who are business minded to work with all the stakeholders along the value chain to bring commercialization of beekeeping and marketing of honey and by-products to a reality and Renaud Hecklé (2018) conducted a study on the factors affecting beekeeping adoption in Baringo County, Kenya with a focus on three smallholder farming communities. The findings from the study indicated that the main factors affecting the decision of smallholder farmers to take up beekeeping were access to information, land and beehives, availability of alternative income generating activities, perceptions of beekeeping outcomes and performance, access to market, feelings towards bees, and cultural norms. The drawing and interpretation of research findings and sense which is not a quantitative impact evaluation, was important in this context, which implies that qualitative and thematic analysis was most suitable in this study

SUMMARY, CONCLUSION AND POLICY IMPLICATION FOR FURTHER STUDY

4.1 Summary

The study found out Climate change is causing temperature shifts which are leaving bees unable to pollinate in time. Bees are severely vulnerable to extreme weather and climate change has caused flowers to emerge and bloom earlier. Because bees are unable to adapt to the changing climate, they are unable to pollinate flowers and, thus, do not obtain nectar for their hives to use during the harsh winter months. Changing temperatures have also reduced the size of their wild range by approximately five miles . Beekeeping was found to be a suitable farming activity and had the potential to enhance environmental conservation as well as improve household income, nutrition and health, hence leading to poverty alleviation.

4.2 Conclusion

Widespread mortality of honey bee worldwide aptly demonstrates the fragility of this species, whose survival relies on an increasingly hostile environment. The reasons given to explain this phenomenon include pesticide use, new diseases, stress and a combination of these factors. As a result, climate change will shift the balance between the honey bee, its plant environment and its diseases. The honey bee has shown a great capacity to colonies widely diverse environments and

its genetic variability should enable it to adapt to such climate change. However, the fear is that climate-induced stress will in future compound the various factors already endangering the species in certain regions of the world. If humans modify the honey bee's environment, they also have a duty to take conservation measures to prevent the loss of this rich genetic diversity of bees. To understand the factors favouring the extinction of honey bees, it will be necessary to conduct fundamental research aimed at ascertaining the causes of mortality, as well as the effect of humaninduced environmental change. Environmental impact studies in the field, as well as the use of modern genomics methods made possible by the recent sequencing of the bee genome, are expected to play a prominent role in discovering the vital stress factors for these species

4.2 Recommendations

There is need to disseminate weather information to the local community and educate them on the need to plan for the changing season Rehabilitation of ASALs by planting flora that have long flower duration, alternate seasonally, preferred by bees and are drought resistance .Moreover the local community needs to be enlightened on the need to form self-help group. These will provide them a platform to access more incentives and be able to share more information in relation to honey yield and to put more emphasis on providing food and water to bees during dry season. Lastly there is need for regular inspection of the beehive to enable management of the beehive hence reducing the incidences of pest infestation. Since the incidences of pest infestation are increasing, the beekeepers need to seek for extension services

REFERENCES

Adjare, S. O. (1990). *Beekeeping in Africa* (No. 68/6). FAO.

Aizen, M. A., Garibaldi, L. A., Cunningham, S. A., & Klein, A. M. (2009). How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Annals of botany*, *103*(9), 15791588.

Aizen, M. A., Garibaldi, L. A., Cunningham, S. A., & Klein, A. M. (2009). How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Annals of botany*, *103*(9), 15791588.

Akala, H., Makindi, S. M., & Esilaba, M. (2018). Effects of Climate Variability on Foraging Behaviour of Bees: A Case Study of Marigat and Ratat locations in Baringo County, Kenya.

Al-Ghamdi, A. A., Nuru, A., Khanbash, M. S., & Smith, D. R. (2013). Geographical distribution and population variation of Apis mellifera jemenitica Ruttner. *Journal of Apicultural Research*, *52*(3), 124-133.

Brodschneider, R., & Crailsheim, K. (2010). Nutrition and health in honey bees. *Apidologie*, *41*(3), 278-294.

Dakos, V., Beninca, E., van Nes, E. H., Philippart, C. J., Scheffer, M., & Huisman, J. (2009). Interannual variability in species composition explained as seasonally entrained chaos. *Proceedings of the Royal Society B: Biological Sciences*, *276*(1669), 2871-2880.

Di, H. J., Cameron, K. C., Podolyan, A., & Robinson, A. (2014). Effect of soil moisture status and a nitrification inhibitor, dicyandiamide, on ammonia oxidizer and denitrifier growth and nitrous oxide emissions in a grassland soil. *Soil Biology and Biochemistry*, *73*, 59-68.

Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., ... & Klein, A. M. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *science*, *339*(6127), 1608-1611.

Gebrekirstos, A. (2015). *Honey and beeswax value chains analysis: The case of Adwa and Ahferom Districts, Central Tigray, Ethiopia* (Doctoral dissertation, Mekelle University).

Hecklé, R., Smith, P., Macdiarmid, J. I., Campbell, E., & Abbott, P. (2018). Beekeeping adoption: A case study of three smallholder farming communities in Baringo County, Kenya.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L., & Totland, Ø. (2009). How does climate warming affect plant-pollinator interactions?. *Ecology letters*, *12*(2), 184-195.

Huang, Z. (2012). Pollen nutrition affects honey bee stress resistance. *Terrestrial Arthropod Reviews*, *5*(2), 175-189.

Karanja, R. H., Njoroge, G. N., Gikungu, M. W., & Newton, L. E. (2010). Bee interactions with wild flora around organic and conventional coffee farms in Kiambu district, central Kenya. *Journal of Pollination Ecology*, *2*(2), 7-12.

Keane, R. M., & Crawley, M. J. (2002). Exotic plant invasions and the enemy release hypothesis. *Trends in ecology & evolution*, *17*(4), 164-170.

Ndyomugyenyi, E., Odel, I., & Okeng, B. (2008). Assessing honey production value chain in Lira Subcounty, Lira district, Northern Uganda. *Livestock Research for Rural Development*, *20*(5), 7-90.

Ruttner, F. (2013). *Biogeography and taxonomy of honeybees*. Springer Science & Business Media.

Sande, S. O., Crewe, R. M., Raina, S. K., Nicolson, S. W., & Gordon, I. (2009). Proximity to a forest leads to higher honey yield: Another reason to conserve. *Biological conservation*, *142*(11), 2703-2709.