THE EFFECTS OF CLIMATE CHANGE ON APICULTURE INDUSTRY

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ABSTRACT

The study was conducted in the Central Province of Zambia during October to December 2016. The purpose of study was to find out the effects of climate change on honey production and income of the honey producers. The impact of climate change on honey production was measured by using the econometric model, i.e., $\mathbf{hp_i = \beta_i + \beta^1_{rdi} + \mu.}$ The overall significance of the model showed that the F- statistics was 0.6854, which was higher than 0.05. The study revealed that the honey production and income of the honey producers were decreased by 50 percent during the period of study, compared with the normal rainy season. The study also showed that the sources of loan and the amount of loan taken by the honey producers were smaller. The study concluded that the Government and the Non-Governmental Organizations should popularize the concept of community forestry; prohibition of forest burning and release of pollutants in to environment by the industries; use of modern technology in honey production & marketing and provision of loan by banks and micro finance institutions to the honey producing farmers against their quantity of honey production.

Keywords: Rain- days; Honey production; Income; Sources of loan.

INTRODUCTION

The global economic activity is picking up with a long awaited cyclical recovery in investment, manufacturing and trade. World growth is expected to rise from 3.1 percent in 2016 to 3.5 percent in 2017 and 3.6 percent in 2018 (IMF 2017). The past 20 years have seen enormous progress around the world in socio-economic indicators. The rapid diffusion of technology and greater access to capital and world markets have enabled economic growth rates that were previously unfathomable, and they have helped lift over 1 billion people out of poverty (World Bank 2017). Yet, climate change is a great challenge to both the developed and developing economies. At the conference of the Parties (COP 21) in Paris, 140 world bank client countries committed to implement their Nationally Determined Contributions (NDC) as part of an agreement to limit global warming to less than 2 ^{0}C by 2100 and make best efforts to limit warming to 1.5 ^{0}C. At the same time, public and private actors have reviewed their global commitments to increase investments and research and development, boost carbon pricing and end wasteful energy subsidies (World Bank 2016). The Intergovernmental Panel on Climate Change reported an approximate temperature increase ranging from 1.1 – 6.4 ^{0}C by the end of this century. Climate change affects global ecosystems. Climate change impacts on plant pollination. Africa is the most highly vulnerable to climate change, because of multiple shocks such as changes in both mean temperature and rain fall as well as their associated variability and the continent's low adaptive capacity (IPCC 2007).

Climate change influences honey bees at different levels. It will have a direct influence on their behavior and physiology. It alters the quality of the floral environment and changes colony harvesting capacity and development. Climate change is posing many challenges to developing nations. Among these are the effects of climate change on honey- bees' provisioning services including honey production. Honey bees are the major pollinators of about 73% of the world's cultivated crops. Climate change determines the activity of bees, characterized by elevated temperatures, could drastically impact their biology, behavior and distribution. Climate change affects every component of agricultural ecosystems, and impacts on bees at various levels, including their pollination efficiency (Rami Reddy, et.al. 2012). Table (1) shows the decline of honey bees population in the world due to climate change.

Table (1): Population Decline of Honeybees: World Scenario

Country	**Decline (%)**	**Duration**
Germany	57	Last 15 years
U.K	61	Last 10 years
U.S.A	>50	Last 20 years
Poland	>35	Last 15 years
India	>40	Last 25 years
Brazil	>53	Last 15 years
Netherlands	58-65	Last 25 years
China	>50	Last 20 years

Source: Rami Reddy, et.al (2012):

The Food and Agricultural Organization's statistical data indicated that in 2004 estimated world honey and bees wax production was 1.38 million metric tons (MT) and bees wax production 60.153 (MT). In comparison to these amounts, production in sub-Saharan Africa was 135,373 (MT) of honey and 14,165 (MT) of bees wax most of which came from a very few countries. Table (2) shows the quantity of honey and bee wax produced by selected African countries.

Table (2): Production of Honey and Bee wax (MT) in Selected African Countries

Country	**Honey Production (MT)**	**Bees Wax Production (MT)**
Angola	23,000	2,300
Burundi	240	45
Cameroon	3,000	287
Central African Republic	13,000	690
Chad	960	0
Ethiopia	39,000	4,300
Guinea	600	0
Guinea Bissan	65	100
Kenya	21,500	2,490
Medagaskar	3,930	390
Mali	300	60
Mozambique	390	65
Rwanda	30	21
Reunion	100	0

Senegal	550	77
Sierra Leone	500	110
Sudan	710	175
Tanzania	27,000	1830
Uganda	300	1,200
Zambia	200	2

Source: Adekola, et.al. (2006)

From the table (2) it is evident that Africa represents 9.8% of the world's production of honey and 23% of the world's bees wax production (Adekola, et.al 2006).

The Southern African region including Zambia has experienced negative impacts associated with climate change especially in the recent past decades where extreme events such as drought and floods and their severity have occurred more frequent than usual compared to past similar length of periods. Shongwe, et.al. (2009) observed not only a reduction in precipitation but also changes in the pattern of outset of rain where there is notable delay on the onset of rainy season and early cessation which had serious implications for systems including farming systems as well as crop or plant growing season. The table (3) shows the main features of Agro-Ecological Regions in Zambia.

Table (3): Main Features of Agro-Ecological Regions (AER) in Zambia

AER Number	**Average Annual Rainfall (mm)**	**Average Maximum Temperature**	**Average Minimum Temperature**	**Plant Growing Period (days)**
I	400 - 750	36 - 37	9 - 14	60 - 90
II a^1	750 - 1000	30 – 32.5	5 - 8	90 - 150
II a^2	750 - 1000	30 - 33	6 - 10	90 - 150
II b	750 - 150	30 - 32	5 - 8	90 - 150
III	1200 - 1500	30 - 33	8 - 10	140 - 200

Source: Thurlow, et.al. (2008)

Zambia has three Agriculture Ecological Regions which have been used as policy and adaptive management tool in agriculture, planning and investment. The impacts of climate change in the country's Agro Ecological Regions are evidenced through observed gradual increases in average temperature averaging 0.3 ^{0}C per decade and declining trend in amounts of rainfall. The rain fall pattern in Zambia is declining and the Southern Region (largely AER I and Western parts of AER II) receiving less rain and experiencing higher frequency of climate extreme events, drought and floods. An increased temperature and reducing precipitation along with the environmental factors contributed to increased evapo-transpiration, negatively affected growing season, led to lower crop yields (Phiri, et.al. 2013).

Objectives of Study

The specific objectives of this study are to:

1. Find out the effect of climate change on reduction in rain days and pollen production.
2. Know the effect of climate change on honey production.

3. Investigate the impact of climate change on the income of honey producers.
4. Establish the sources of loan and the amount of loan borrowed by the honey producers.

LITERATURE REVIEW

Musiliyu, et.al. (2015) considered deforestation as one of the contributing factors to global climate change. The forest provides excellent resources for bees and beekeeping and bees are a vital part of forest eco-systems. Bees are essential for sustaining environment because they pollinate flowering plants and conserves biological bio-diversity along with their products (honey, propolis, bee wax, royal jelly and bee venom) which are beneficial to man. Honey is produced when honey bees (Apis mellifera) suck nectar, sweet juice and pollens from different plant species available, composition of honey therefore varies according to the source of the nectar. Daniel, et.al. (2010) found that the Sustainable Development goal on environmental sustainability is unlikely to achieve due to deforestation in Zambia. The deforestation is well above the global and regional average and is closely linked to other key environmental problems such as land degradation, wild life depletion and loss of biodiversity and eco-system services. These problems constrain poor households' income opportunities through lowering agricultural productivity and access to different non-timber forest products. Climate variability is estimated to reduce agricultural growth by 1 percent per year. Loss of eco-system services and environmental degradation is largely unaccounted for in national accounts and statistics, which imply that real economic growth most likely is significantly lower than what the GDP growth rate indicates.

According to Phiri, et.al. (2013) climate change is due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The UN Secretary-General's High Level Panel on Global Sustainability (2012) defined climate change as a change in the state of the climate that can be identified by changes in the mean and /or the variability of its properties and that persists for an extended period, typically decades or longer. Whereas, the IPCC (2012) revealed that the green house gases (GHGs) in the atmosphere are responsible for climate change/global warming. According to the studies by NAPA (2007); Ngoma (2010) climate change influenced trends are observed and the trends include; changes in the start and cessation of the rainy seasons, increased or decreased average precipitation and increasing average and maximum temperatures. It was observed that the start of the rainy season changed tending towards late start and early ending resulting in shortened crop growing season.

CEEPA (2006); NAPA (2007); Thurlow, et.al. (2008); ZMD (2013) observed and predicted global trends in increasing average temperatures over time, including in Zambia. There was a steady rise in average maximum temperatures since the base line year 1950. According to Zambia meteorological department data (2013), the temperature rose by 0.33 ^{0}C per decade in the first three decades (1950-80) but from 1950-2010 the increase was approximately 0.6 ^{0}C per decade for the six decades under review and consistent with Neubert, et.al. (2011). Yamba, et.al (2009) studied at three different sites in three agricultural eco-regions in Zambia and observed increase in temperature at the rate of 0.34 ^{0}C, 0.26 ^{0}C and 0.48 ^{0}C per decade for Kapiri Mposhi, Mwansa Bombwe and Sesheke, respectively. The South-Western region of Zambia became drier and experienced a highly frequency of climate change events; droughts and floods that resulted

in shortened crop growing season and crop damages. (Neubert, et.al. 2011). Moonga (2011) revealed a decrease of mean seasonal rainfall distributions over Zambia for the periods 1940 to 1970 and 1971 to2005.

The study by Hegland, et.al. (2009) revealed that timing of both plant flowering and pollinator activity was strongly affected by temperature. Climate change altered the existing precipitation patterns. Some areas experienced decreased rainfall, leading to more extensive drought periods. Snow cover also was reduced with increased temperatures. This water stress decreased flower numbers and nectar production (Inonye 2008). Meriken, et.al. (2011) revealed that pollen quality changed along with climate conditions. There were negative effects of climate change on services provided by pollinating insects.

The study by Diana, et.al. (2012) revealed that both honey yields and areas suitable for honey production decreased under scenarios of climate change. The climate change had negative impacts on honey and honey bees. Roubik (2002) concluded that the pollination services provided by honey bees, both in natural and managed eco-systems, declined in response to multiple drivers of change, because pollination directly impacts the functioning of eco-systems and ultimately local and regional economies. Holmes (2002) and Jaussens, et.al. (2006) concerned about little attention paid to potential changes in the delivery of provisioning services such as honey and bee wax production. Saha (2003) and Shreshta (2006) stated that understanding these changes is important because beekeeping is promoted as a tool for rural development and conservation in developing nations in the tropics or regions there in.

Crane (1990) revealed that the environmental factors that impact the delivery of provisioning services by honeybees was climate change. According to Holmes (2002) at low latitudes, honey bees remain active throughout the year where as at high latitudes they pass through a period of complete inactivity. Likewise within the tropics, the activity of honey bees decreases with increasing elevation (Spivak (1992). Climate directly influences honeybee behavior given the strong dependency of bee foraging activity and flight on temperature, solar radiation and wind at a variety of time scales (Puspakadija 2007). Climate can indirectly influence honeybees through its effects on their resources base, including flowering plants pathogens and predators (Brandley, et.al. 1999). Raising atmospheric CO_2 levels impacts the agro-eco system in different ways. Firstly, it causes plant photosynthetic activity and water use efficiency (Drake 1997). Secondly, increase in CO_2 causes a reduction in nectar production in flowering species (Rusterholz 1998). According to Winston (1987) climate influences flower development and nectar and pollen production which are directly linked with colonies' foraging activity and development. Stockstad (2007) revealed that an excessive dry climate, which reduced pollen production and impoverished its nutritional quality, adversely affected bees of that habitat. A major effect of climate change on honeybees stems from changes in the distribution of the flower species (Thuiller, et.al. 2007).

The consequences of climate change are of recent realization and there is paucity of scientific literature on how climate change influences on agriculture, industry, health etc., The present study fills the gap in the existing literature on impact of climate change on apiculture industry in the Central Province of Zambia. This study not only investigated the impact of climate change on honey production but also on the income of the farmers involved in honey production.

METHODOLOGY

The study was based on multi-stage random sampling technique to collect the data. In the first stage the Central Province was selected out of ten (10) provinces in Zambia. In the second stage Kapiri Mposhi district was identified which consisted of six (6) Blocks, i.e., Mulungushi, Chipepo, Lukanga, Changonda, Nkole and Lounchu. In the third stage Mulungushi Block was selected which had six (6) Camps, namely, Luanshimba, Kakulu, Imansa, Kaunga, Lukanda and Kambosha. In the fourth stage Luanshimba Camp area was selected which had six (6) Zones – Luanshimba, Nchembwe, Mukabe, Ngololoeni, Njanji and Lyuba. In the fifth stage, Luanshimba Zone was selected which had 28 villages. In the sixth stage nine (9) villages – Njalamimba, Lukanga Kateneka, Kakulu Mabwe, Mukabe, Fumbelo, Makaiva, Njanji and Satulo- were selected. In the last stage, 68 honey producing households were selected . The primary data were collected in October and December 2016 for the immediate preceding agricultural season. The impact of climate change on honey production was measured by using the following econometric model.

$$\mathbf{hp_i = \beta_i + \beta_1 rd_i + \mu}$$

Where $hp_{i=}$ Honey Production during i_{th} season.

β = Constant

rd_i = Rain days reduced during i_{th} season

μ = Error term

Dependent Variable: HPI
Method: Least Squares
Date: 12/21/16 Time: 16:10
Sample: 1 68
Included observations: 68

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	31.63776	10.94889	2.889586	0.0052
RDI	0.134174	0.329762	0.406879	0.6854

R-squared	0.002502	Mean dependent var	35.94118
Adjusted R-squared	-0.012612	S.D. dependent var	23.19668
S.E. of regression	23.34250	Akaike info criterion	9.167399
Sum squared resid	35961.56	Schwarz criterion	9.232678
Log likelihood	-309.6916	Hannan-Quinn criter.	9.193265
F-statistic	0.165551	Durbin-Watson stat	1.937649
Prob(F-statistic)	0.685413		

The co-efficient of rd_i (i.e., the magnitude of impact of rain days reduced on honey production) is not significant because probability value is 0.6854 which is higher than 0.05. The R^2 is 0.0025 which is equal to 0.25 percent . It means only 0.25 percent of the variations in honey production are explained by rain days reduction. The overall significance of the model shows that the probability of F-statistics, which is used to test the overall significance of the model, is 0.6854 is greater than 0.05. This means that the model is not significant. Hence there is need to explore other factors affecting on honey production, i.e., topography, wind speed, colony management, land use etc., This confirms the study by Diana, et.al. (2012).

RESULTS

Climate Change Effect on Honey Production:

Table (4) shows climate change effect on honey production.

Table (4): Climate Change Effect on Honey Production

Before Climate Change (in Liters)	After Climate Change (in Liters)	Decrease (in Liters)	Percentage Decrease
72.75	35.94	36.80	50.59

Source: Primary data

Table (4) shows that before climate change the average honey production per household was 72.75 liters but due to climate change, i.e. reduction in rain days , the honey production per household was reduced to 35.94 liters, a reduction by 36.80 liters per household i.e. 50.59%.

Climate Change Effect on Income:

Table (5) shows the effect of climate change on income of honey producing households

Table (5): Climate Change Effect on Income of Honey Producing Households

Before Climate Change (in ZMW)	After Climate Change (in ZMW)	Decrease (in ZMW)	Percentage Decrease
2327.79	964.70	1363.05	58.55

Source: Primary data. Note: ZMW is Zambian Kwacha

Table (5) shows that before climate change the average income of household was ZMW 2327.79 but due to climate change the income of the household was reduced to ZMW 964.70. It was reduced by 58.55 percent, i.e., ZMW 1363.05. It can be observed that the honey production and the income was reduced by half due to climate change.

Sources of Borrowing and Amount Borrowed (in Kwacha)

Table (6) shows the sources of borrowing and amount borrowed by honey producers

Table (6): Sources of Borrowing and Amount Borrowed by Honey Producers

Source	No. of Honey Producers	Average Amount Borrowed
Bank	-	-
Micro Finance	01	1800
Co-operatives	12	967.50
Relatives	01	500.00
Friends	22	741.36
Total	36 (52.94%)	4008

Source: Primary data

Table (6) shows that out of 68 honey producers only 36 received loan from all the sources, which comes to 52.94 percent. The loan from banks is nil and the loan from micro finance institutions and the relatives is negligible. The main source of loan is from co-operatives and friends. The average amount of loan is 4008 Kwacha. The percentage of amount borrowed from micro finance, co-operatives and friends stood at 44.91 percent; 24.13 percent and 18.48 percent respectively.

DISCUSSION

The results of study showed that due to climate change rain days reduced, water shortage for crops and pollen production in plants reduced. This resulted in late sowing and short crop growing season. These results confirmed the outcome of studies by Winston (1987), Stockstand (2007), Rusterholz (1998), Roubik (2002), Hegland, et.al. (2009) and Musiliyu, et.al. (2015.
The study revealed that honey production was reduced by half comparing to the season in which rain days were normal. The average honey production was reduced from 72.75 liters during the normal season to 3594 liters, i.e., 50.59 percent decrease, during the climate change season. This result was in accordance with the outcome of many studies like, Diana (2012), NAPA (2007) and Ngoma (2010).

One more outcome of the study was that the climate change affected the income of honey producers due to reduction in honey production. The average income of honey producers was reduced from 2327.79 Kwacha during the normal season to 964.70 Kwacha, i.e., 58.55 percent decrease during the climate change season. These results confirm the outcome of the study by Daniel, et.al. (2010).

The study also revealed that only 52.94 percent of honey producing farmers received loan and the average loan amount was 839.44 Kwacha only. The percentages of loan received from banks, micro finance, co-operatives, relatives and friends stood at nil; 44.92; 24.13; 12.47 and 18.48 respectively.

CONCLUSIONS

The conclusions that emerge from the foregoing are:

- The existing trees and forest needs to be protected, besides planting of new trees.
- The concept of community forestry should be popularized. Both government and non-government organizations should take the initiatives.
- The industrialists should be educated to stop release of pollutants in to environment.
- Alternate energy sources like gas, solar etc., should be made available so that wood/forest burning for coal could be stopped.
- The beekeepers should be educated about the use of modern technology to increase honey production with less cost.
- Co-operative societies for production and marketing of honey and bee wax should be encouraged to get reasonable price and higher income to the honey producers.
- Since lack of finance was the main challenge of the honey producers in using the new methods of production, the banks and micro finance institutions could provide loan to the honey producing farmers against their quantity of honey production.

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