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Embracing bee-keeping technology to enhance smart farming: evidence from Lira city, mid-north Uganda

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Abstract: **This paper debates the means in which the idea of smart farming can be enhanced using beekeeping technologies in the sub-region of mid-north Uganda, as confidence in the budding of smart farming to bolster sustainable development provides way. Inside the familiar writings, there is abundant discussion of the pressure between realizing economic development as well as ensuring that there is sustainable growth, however, this discussion has seldom been stretched to bee-keeping in a less-developing country. More serious versions have occasionally been embraced in an all-encompassing outlook. A case study of one bee-keeping farm is selected to explore the prospect of smart farming through bee-keeping. It is apparent that this fluctuates significantly consistent with the level of technology adopted. No matter by what method smart farming is assembled, nevertheless, the degree to which its pathways offer it with some amount of reliance is determined by a comprehensive array of elements comprising availability of resources, readiness of the farmer, level of supports offered to the farmer, and ability to adopt the preferred technology. It is thus established that enhancing smart farming through bee-keeping technologies can be principally stimulating for farmers in the study area though the socioeconomic anxieties lie with obtaining initial investment capitals.**

Keywords: **Bee-keeping, honey, beeswax, propolis, pollen.**

1. INTRODUCTION

Apiculture is another word for beekeeping. It is the management of bees in beehives in order to produce honey, beeswax, pollen and propolis. According to Dogan, Adanacioglu, Saner and Tankma (2020), beekeeping is a branch of production that can be carried out with other agricultural activities in rural areas, and it is also one of the most important agricultural activities because of the importance of bee products in the human diet, their use in the pharmaceutical, traditional medicine usage in treatment and the role of bees in improving product quality in crop production. The practice of beekeeping also referred to as apiculture dates back many years and According to Tew (2016), there is evidence of people collecting honey from wild bees as far back as 15,000 years ago. Beekeeping involves introducing artificial hives where bees are domesticated for purposes of producing honey and other bee products ready for extraction (Zacepins, 2015).

According to FAO (2018), data on the number of bee colonies, china is in the first place with 9 million 148 thousand colonies, followed by Turkey in the second place with 8 million 133 thousand colonies. In terms of honey production globally, china is in the first place with 502 thousand tons, Turkey with 114 thousand tons, United States with 73 thousand tons and Russia with 69 thousand tons among others. Today 56 million beehives exist in the world ad 1.2 million tons is produced from these hives. ¼ of produced honey is subjected to trade and 90 percent of the exports come from nearly 20 honey producing countries (FAO, 2005). World honey production per bee hive is around 20 kilogrammes and this amount is 33 in China, 40 in Argentina, 27 in Mexico, 64 in Canada, 55 in Australia, 40 in Hungary, and approximately 16 kilogrammes in turkey. African production represents only 9.8 percent of the world production of honey

and 23.5 percent of beeswax. Exports of honey form sub-Saharan Africa countries some of which was intra-African trade in 2004 were 184 metric tonnes, export of beeswax were 721 metric tonnes. These amounts of exports and imports are minimal in the world trade figures which.

In Africa, honey production had an early history which dates back to 5000 years in ancient Egypt and Abyssinia (the former name of Ethiopia). The fertile ground for Bee production in Africa is the various ecological and climatic conditions, diverse flora and various honey bee colonies (Adjare, 1990). Honey is produced in different ways in Africa; by hunting, traditional (migratory, forest and backyard) and improved (movable-frame and movable top-bar) methods of beekeeping (Wilson, 2006). Much of African honey in production is gathered rather than farmed where hunters search for nests of truly wild bees in holes, in trees or burrows in the ground. This is mostly done in communal areas where wild colonies of bees live in hollow trees and caves are found, (Wilson, 2006). This type of honey harvesting (hunting) is commonly practiced in many African countries like South Africa, Zimbabwe, Morocco, Libya, Ethiopia and Tanzania (HBRC 1997).

In a number of places, traditional hives are hung on trees in the forest by beekeepers because bee colonies live within forest where they forage nectar and pollen from a very wide range of floral species (Janet et al. 2018). Thus, forest beekeeping in Africa has distinguishable features from other systems, such as large-scale bee farming or back-yard beekeeping because it is practiced in extensive systems and needs low-input, (Bees for Development, 2017). However, improved hive honey production is practiced to some extent in Africa. In this production system, different types of hives are used such as Kenya top-bar hive, Tanzania top-bar hive and Mud-block hives, but, most African countries are not yet in the position to use movable-frame hives. Four East African countries (Kenya, Uganda, Tanzania, and Rwanda) were licensed to export honey to the Europe (The European Commission, 2016). This has not been possible because their domestic demand exceeds available supplies of honey for example Ethiopia exploits 10.5% of 500,000 tones expected (Malede, Sahlu & Gitye, 2015), Kenya 14.6% of the 100,000 tones (Mwakalalukwa, 2016), Tanzania 13.8% of the 19.000 tones (Tutuba, Msamula & Tundui, 2019) and Uganda only 1% of the 500,000 tones expected production potentials (Kajobe, Agea, Kugonza, Alioni % Otim, 2009). According to UBOS and MAAIF report (2009), 60% of the households with beehives come from northern Uganda.

Beekeeping is an old and richest agricultural practice first documented to be common among the Teso, Batwa, West Nile and Kigezi regions of the country (Crane, 1999). Primarily dominated by honey hunting practices (collecting honey from the wild) and later transitioning into traditional beekeeping that is to say; hanging of hives made from local materials such as logs on trees, (Crane, 1999). In Uganda, promotion of modern beekeeping practices started in the early 1980's. During this time until now, beekeeping has been promoted as a diversified alternative livelihood to the rural households. This has enabled registration of Uganda as one of the seven African countries (Cameroon, Ghana, Tanzania, Zambia, Rwanda, Uganda and Ethiopia) licensed to export honey and beeswax from Africa to the European Union (The European Commission, 2016). The main products traded in Uganda are honey and beeswax (Amulen et al., 2017). In relation to local honey trade, 80% of the honey produced is sold through informal marketing channels. A census report by UBOS and MAAIF (2009) estimates about 10.5% of beehives in Uganda are top-bar hives with an average yield of 12 kilogrammes of honey per beehive per year, way below the beehive expected potential of potential of 26 Kilogrammes of honey per beehive per year. Meaning harvested yields are much below estimated beehive potential of 60 kilogrammes of honey per beehive per year (Kilimo Trust, 2012).

According to KILIMO (2018), honey production is steadily growing with an estimated annual production of 24,000 tons. This is produced by about 1,200,000 active beekeepers and over 700,000 colonized beehives countrywide. However, this production is still less than 1% of the country's honey production potential of 500,000 tons per year. Natural honey is the major bee product imported into Uganda (65% per annum). The United Arab Emirates and Tanzania are the major suppliers of natural honey to Uganda, accounting for 83% of the honey imports followed by Kenya (8%). On the other hand, Rwanda (49%) and South Sudan (26%) are the largest export markets for natural honey from Uganda. Kampala is the major hub where all the honey from the five watersheds and from other countries is traded. There is some considerable cross border trade involving both informal imports and exports. E.g., Imports from DRC to Nebbi and Arua in the West Nile region. However, only 2.7% of the total households in Uganda have been reported to own beehives, with an estimated annual production of 2,600 tonnes (MAAIF/UBOS, 2010). The Northern region of Uganda has the highest production while the Central sub-region has the least production (MAAIF/UBOS, 2010). The colonization of hives is highest in Eastern (72.1%) and lowest in Karamoja Subregion (60%) (MAAIF/UBOS, 2010).

Though beekeeping is spreading and the conditions are favourable almost countrywide, it remains dominant in Western Uganda (Kabarole, Kisoro, Mbarara, Ntungamo, Kabale, Bushenyi, Rukungiri, Kabarole) and West Nile (Arua, Moyo, Adjumani, Nebbi and Yumbe). West Nile has become a centre of focus following the establishment of an ultra-modern factory in 2003 by Bee Natural Products for processing bee products. Other regions have recently picked interest and as a result, production is famous in the districts of Kitgum, Kotido and Lira in northern Uganda and the districts of Luwero, Nakasongola, Mukono, and Kayunga in Central Uganda that have become top suppliers for the urban and peri-urban markets in and around Kampala (MAIIF, 2005). Trained Apiary Farmers (TAF) Assured Mixed Enterprises started as a small-scale farm in 2008, with a primary intention of increasing the honey production, fruits production and mixed farming as a business. TAF Assured Mixed Enterprises is registered with the Uganda Registration Service Bureau (URSB) as a Limited liability Company. The farm is seated on twelve acres of land. Notwithstanding the existing beekeeping potentials in Uganda today, the opportunity remains unexploited by most people partly due to insufficient documentation on its profitability, performance and specific contribution to human health served as motivation to the researcher.

The scope of this study was limited to four key aspects, namely; bee products, technologies used, value addition on bee products, and medicinal values of bee products. Regarding the bee products, several products are got from beekeeping. This include both primary and secondary products (Honey, Beeswax, Propolis, Venom, Royal jelly, Queens, Bees and Larva) but the study will be restricted to the first four products produced by TAF. With the technology used, this will cover the technology used in both harvesting/collecting and processing of the primary products of bees as being practiced by TAF. Concerning, value addition on bee products, a good number of primary bee products don't fetch much money either because of their quality or mystical reputation and characteristics but when value is added to produce secondary products before taking it to the markets, then their value and quality is enhanced. This aspect will focus on the secondary products like candle among others. And for, medicinal values of bee products, this study will focus on the medicinal values offered by different bee products which includes; honey, propolis, beeswax and venom according to TAF.

2. METHODOLOGY

This section will cover the methods used for collecting the data from the field, challenges encountered and the solutions used to bridge the gap. (a) Interviews; the researchers had an engagement with the managing director of TAF, the interview was guided by short-structured questions formulated before the visits on specific areas of interest. However, the researcher encountered a challenge of limited time from the side of the director. This didn't affect the findings because the researcher complimented the interview with others tetchiness like the documentary review. (b) Observation and discussions; the researchers were taken through different sites of the farm which was an opportunity which was used to complement the gaps created during the interview session. This was interrupted because no sooner had the researcher started the tour than it rained and some places like the processing plant was out of bound by non-staffs due to the threat of COVID-19. However, this didn't affect the outcome because the researcher was able to make the best use of the company profile accessed from the company profile. And (c) Documentary review; this was another procedure used by the researchers in obtaining the data that is required for this study. The manager presented the records of the firm which contained all the data the researcher needed.

3. THE OUTCOMES

This section will cover the field outcomes, the results or the actual findings on the four aspects above according to TAF while relating t with corroborating it with that of other scholars elsewhere.

Bee products

Several products are got from beekeeping. This include both primary and secondary products (Honey, Beeswax, Propolis, Venom, Royal jelly, Queens, Bees and Larva) but this study will be restricted to the first four products produced by TAF.

Honey - According to TAF, Honey is the natural sweet substance produced by honeybees from the nectar of the blossoms or the secretion of living parts of plants or execration of plant sucking insects on the living parts of plants, which honey bees collect, transform and combine with specific substance of their own, store and leave in the honey comb to ripen and mature. Labe, (2017) on the other hand referred to hones as a juicy and sweet substance produced by bees from nectar or secretion of flowers. It has a content of 80-85 % carbohydrates, 15-17 % water, 0.3 % proteins, 0.2 % ashes, and minor quantities of amino-acids and vitamins. Honey is used in some industries such as food, pharmaceutical, cosmetic and

brewery industries as their raw materials for the production of their commodities, for example, drugs, body creams, lip balm, confectionaries etc. Honey is also used as a sweetener in food, alternative to sugar. It is used as medicine for various ailments, burns and wound dressing and general stomach problems.

Beeswax **-** Beeswax is produced by worker bees from wax glands on their abdomen, it is used by bees to build combs in the bee hives. Due to its nature, beeswax can used industrially to make candles, light glues and shoe polish among others.

Propolis **-** According to both TAF and Labe (2017) is a primary product harvested form the bee hive and it is a mixture of various amounts of beeswax and resins collected by the honeybee from plants, particularly from flowers and leaf buds. To produce propolis bees add to the different material collected from plants some salivary secretions, wax and pollen for the final elaboration of the product. Propolis may be green, yellowish, dark grey, brown, red, black and others colours.

Venom **-** Bee venom according to TAF is one of the primary products of bees produced by bees ready to attack the enemy and it can be used in pharmaceuticals industries as input for other medicinal products. The production bee venom is climax during the first two weeks of the adult worker's life and reaches a maximum when the worker bee starts to get involved in hive defence and foraging. This reduces as the worker bee gets older. Production of venom by queen bee is highest on emergence, probably because it must be prepared for immediate challenge with other queens. It is further advanced by Singh and Verma (2017) as a product of honey, and is also called as Apitoxin. It is a bitter and colourless liquid which contains significant beneficial elements for health, for example, protein, amines and enzymes among others.

Technologies used

This will cover the technology used in both harvesting/collecting and processing of the primary products of bees.

Honey harvesting **-** According to TAAF, the equipment needed for harvesting honey includes; a clean plastic container, bee smoker, hive knife, hive opener, and a brash and the things used during processing are; honey extractor which consists of rotating handle used for extracting available hone after uncapping it, honey press used for further processing of honey after collection, airtight container for keeping the honey, sieving cloth/filter used for removing the primary impurities from the collected fresh honey, settling tank used for storing the honey for a period of 5-7 days and lastly packing materials before its branded for the market.

This was also observed according to Singh and Verma (2017) on the technology involved in harvesting and processing of honey, Filter Press is used for removing the primary impurities from the collected fresh honey. Extracted amount of honey is passed through a filter, which allows the pure honey to pass through and impurities are collected in the filter. Storage/Settling Tank is used for storing the honey. When some impurities of beeswaxes also entered in it, then all beeswaxes are separated because honey has the tendency to settle down. Pre-heating Tank is used for heating the honey for a certain period of time. Processing Tank is used for further processing of honey after collection. Maintaining of natural flavour and taste of honey is very difficult after extraction. Therefore, to get good market price, processing takes place by applying collected honey into a processing tank. Cooling Tank is used for decreasing the temperature which rises during pre-heating and collecting the pure form of honey. Packing and Labelling Machine: Different types of packaging machines are used for packing the processed honey into different sizes of packages with proper sealing. After packaging, appropriate labels is put on the packages for providing information regarding brand and other useful information. Though the technology used by both seem the same but slight variations was observed especially where Pre-heating Tank is used for heating the honey for a certain period of time.

Beeswax extraction **-** According to TAF, beeswax is extracted from the beehive using an ordinary manual knife, beeswax is then processed by melting using hot water and then sheaved to make it clean. This is related to the method used by (Singh and Verma, 2017) where combs are melted either with the help of passing warm water on beeswax or using solar wax melted, which can also be used for wax processing. Yadeta (2014), al so observed that wax ca be separated in solar wax melters, by boiling water and special processes. Though the procedure used seem to be the same but the researcher was able to observe a slight deference in the equipment used for extracting beeswax from the hives, (Singh & Verma, 2017) used electric uncapping knife as opposed to the local manual Kinfe used by TAF.

Propolis dissolution **-** After extraction, Propolis is put to dissolve in ethanol for three to four weeks as a way of processing to extract Propolis Stinchar and Propolis syrup.

Venom collection - According to Ali (2012), early collection methods of bee venom required surgical removal of the venom gland or squeezing each individual bee until a droplet could be collected from the tip of the sting and sometimes, adult bees may be used to sting the patient directly instead of collecting bee venom. There has been continuous improvement in the method of bee venom collector and this has been further echoed by Bogdanove (2017). According to TAAF, the technology used for collecting bee venom is called venom extracted. It's an electric powered machine with a glass put at the entrance of beehives for 20 minutes. This has been further observed by De-Graff et al (2020), bee venom can be collected by a venom collector either internally by putting the device inside the hive or externally by putting the device at the entrance of the bee hive. The machine consists of four parts (batter, electronic impulse generation, electric stimulator-surface that consist of stretched uninsulated wire and a glass slide on which the bee venom is secreted. This confirms that there have been serious advancements in the methods of bee venom collection and this could be attributed to its great importance especially in the medical field.

Value addition on bee products

Value addition takes two approaches that include; Innovation (improving the existing processes, procedures, products or creating new products altogether), Coordination which is focusing on arrangements among farmers who produce and market farm produce (it could be horizontal which means consolidation among farmers from the same level or vertical). Both TAF and Wilson (2016) is in agreement that many of the primary beekeeping products do not have a market until they are added to more commonly used, value added products. Even the value of the primary products may increase if good use is made of them in other products, thereby increasing the profitability of many beekeeping operations. This could either be because of their quality or mystical reputation and characteristics.

Value-addition to Honey - Much as there is very high demand for pure honey which is in a liquid form globally, but this product according to TAF has very low market value when its sold crude or raw for example a kilogram of honey cost between 8000-10000 Ugandan shillings only. According to Killimo Trust (2018), farm gate price in UGX/ Kilogrammes ranging between 5,000-7,000 for comb honey; and 8,000 - 20,000 for processed. This could be a justification that TAF had to add value to their honey to produce products like Honey wine. This done by boiling honey mixed with water and yeast which would be ready for consumption after 24 hours. This is also in relation to the value addition on honey according to (Krell & Nations, 1996a). Much as both the two sources made mention honey wine as one of the value-added products of honey, but Krell and Nations, (1996a), have added more value to produce honey meads, honey jelly, honey spreads and honey syrup among others that it's an opportunity for TAF to venture in to.

Value-addition to Beeswax - According to TAF, a lot of value is added to beeswax inform of candle, shoe polish (by boiling there is need to melt, mix with clear oil and powder), jelly and lotion (melt wax, add clear oil and perfume and the same procedure for jelly). This is not an isolated case as it's also observed from (Brandley, 2015), where it was echoed that, beekeepers should be aware about value and importance of beeswaxes because it is used for increasing the durability of leather, water proofing, preparing threads and candle process, furniture polishing, and shoe polishing among others. The researcher is able to make conclusion from the observation above that there are still greater opportunities to be exploited by TAF as far as beeswax and value addition is concerned.

Value-addition to Propolis - According to TAF Propolis is one of the primary products produced by honey bee and it has some therapeutic and antibiotic usage. After extraction, the researcher was able to observe that raw Propolis is dissolved in ethanol for three to four weeks to produce Propolis Stinchar and Propolis liquid. It is used to prepare cough syrups, toothpastes, skin soaps and skin oils.

Value-addition to venom - According to TAF value is added to bee venom after extraction by sieving, mixing venom powder with honey, then keep it for one month to produce venom syrup which is an immune booster, antibiotic and a pain reliever among others. Bee venom is a product of honey, and is also called as Apitoxin. It contains significant beneficial elements for health, for example, protein, amines and enzymes among others (Singh & Deepak Verma, 2017). Bee venom is commonly used by different pharmaceutical companies due to its medicinal and immunogenic properties for preparation of medicine for different diseases, for example, nerve pain (neuralgia), multiple sclerosis (MS), muscles problems and rheumatoid arthritis; and strengthening of immune system (Ramachandra, Subash, Joshi & Balachandra, 2012).

Medicinal values of bee products

The products of beekeeping are no longer just honey and wax but now include pollen, Propolis, royal jelly and bee venom. Consequently, colony management differs according to the product required. Since many therapeutic properties have been suggested for each of these products, there is the need to scrutinize, standardize and above all protect their purity. This study analyses the medicinal values of the above different products independently as seen here below:

Vales of Honey

Honey has a good number of values, namely:

a) *Diabetes Mellitus* - Both TAF and Ediriweera and Premarathna (2012) appear to agree on the use of honey in medications for diabetes. This according to TAAF, could be the reason for escalating demand for honey which has supposed their potentials. It is observed that the practice of using honey to cure diabetes has been a common practice in places like Ayurveda since ancient times. Other benefits of honey to diabetic patients are in two ways. Firstly; honey being three times sweeter than sugar, one may need a much smaller quantity of honey as a sweetener and honey contains lesser calories than sugar. The other is, by providing vitamins B_2, B_4, B_5, B_6, B_{11} and vitamin C, and minerals like calcium, iron, zinc, potassium, phosphorous, magnesium, selenium, chromium and manganese. The nutritional values of honey could be altered by feeding the bees with selective food. The researcher was able to observe that there is a similarity between the medicinal values of honey according to both sources.

b) *Honey for treatment and protection against heart diseases* - According to TAF, regular use of honey on bread instead of jam and blue band reduces the cholesterol in the arteries and saves the patient from heart attack while for those who have already had an attack, the process relieves them from loss of breath and strengthens the heart-beat.

c) *Antibacterial activity* - The researcher was able to confirm the speculation of TAAT that the high demand of honey could be related to its use as antibacterial by many. This was based on the study done by Abeshu and Geleta, (2016), the study cited that honey has been proven to have antimicrobial activity where it inhibits a broad spectrum of bacterial species.

d) *Honey used in wound healing* - According Kurek-górecka, Górecki, Szepecka-stojko, Balwierz and Stojko (2020), it is recommended that much as honey has the potential to stimulate healing and antimicrobial properties, honey should be evenly applied on the dressing pad rather than directly onto the wound to allow the diffusion of honey into the wound. Honey also inhibits the growth of bacteria and fungi by reducing their development on the skin surface. The researcher is able to make conclusion basin the increasing demand of honey as cited by TAF to be due to its ability observed above.

Medicinal Value of Bee Wax

Much as TAT also, produce jelly and lotion as their value-added products from beeswax, there is no evidence supporting that it is medical benefits to human skin. Emulsifier where they use it for the treatment of different skin complications in human beings. However, (Bogdanov, 2009) observed that both jelly and lotion produced from beeswax have medicinal values.

Medicinal Value of Propolis

Propolis, commonly known as bee putty, is a resinous, sticky substance produced by bees formed after mixing the secretions of insects with resin collected from plants. According to TAF, Propolis supply is both in raw form as Stinchar and in liquid form. This will depend on the demand of the customer because while other customers prefer Propolis stancher (raw Propolis), others want the liquid form. It is taken in oral form following medical prescription. Propolis has a wide range of medicinal benefits ranging from treatment for stomach ulcers, liver and kidney swelling, cuts, wounds and burns, toothaches, scabies and fungal skin infections among others. TAF appears to be in agreement with many scholars on the medicinal values of Propolis as observed by the researcher in the following ways.

According to Labe (2017), Propolis produced by honey bee has some therapeutic and antibiotic usage. It is used to prepare cough syrups, toothpastes, lotions, skin soaps and skin oils (Krell & Nations, 1996b)**.** In medicine uses of Propolis include treatment of the cardiovascular and blood systems (anaemia), respiratory apparatus (for various infections), dental care, dermatology (tissue regeneration, ulcers, excimer, wound healing particularly burn wounds, mycosis, mucous membrane infections and lesions), cancer treatment, immunes system support and improvement in digestive tracks (ulcers and infections), liver protection and support and many others.

It has been observed by Habryka, Kruczek and Drygas (2016) that the pharmacological properties of Propolis allow to make local anaesthetic, pressure regulation, strengthen secretion of bile, detoxification of the liver. Propolis is used in the prophylaxis and treatment of influenza, colds. Propolis is applied in the treatment of inflammation of the mouth and gums, protects the body from lead poisoning, arsenic. Propolis is used not only internally but also externally in the skin diseases, frostbite, bedsores, as well as chemical burns, thermal and radiation. Basing on the above, it is clear that Propolis contributes greatly to the medical field as far as healing is concerned.

Medicinal Value of Bee Venom

According to TAF, bee venom is produced in two forms as powder and as syrup and the known medicinal usage here is antibiotics and an immune booster. This is so far the most expensive product. There is an agreement between the medicinal use of bee venom as cited by TAF and other scholars as observed by the researcher; Therapeutic application of bee venom include their use in the management of bursitis, tendonitis, dissolving scar tissue, in the management of post-herpetic neuralgia, Lyme disease, rheumatoid arthritis, osteoarthritis, multiple sclerosis, and more, (Ram et al., 2014), also cited that bee venom hormone therapy causes unfavourable side effects such as the reduction in the activity of these vital hormone glands, while the bee venom constantly activates the activity of hormonal systems (Bogdanov, 2015), Researchers claimed that bee venom has therapeutic effects against many skin diseases like eczema, dermatitis, recurring boil, cicatrices**,** baldness, acne and other diseases (Kim et al., 2015). Bee venom has also been used in humans to treat neurological diseases with neuro inflammatory aspects, such as multiple sclerosis and Parkinson's disease (Kim & Jeon, 2014).

4. CONCLUSION

Beekeeping is an agricultural sector that had been practiced mostly on a small-scale and yet it has a lot of demand globally. Several government agencies and civil society organizations have taken it up in their policy frame works which has led to its rapid growth. Bees' products if handled properly can be of great importance medically, economically, organically and also leads to environmental sustainability. Since beekeeping don't need much space and capital to start, it's a good recommendation to the farmers since it can also be carried out alongside other agricultural activities.

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