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Impact of Climate Change on Bitter Honey in Chattogram Mangrove Forest Area: An Exploratory Study

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Abstract:

Bitter honey, a unique product of Bangladesh, is under serious threat of extinction, primarily due to climate change. This study explores the impact of climate change on the production, quality, and quantity of bitter honey using qualitative methods. This study employed a qualitative, non-probability data collection method to interview honey collectors and honey sellers. A total of 10 in-depth interviews identified several factors directly related to climate change. Bitter honey, produced in August from the pollen of Gewa, Neem, Bitter Gourd, Minjori, Boroi, and Koroi trees, has seen a sharp decline in production. Excessive rainfall, flash floods, reduced floral growth and resources, increased honeybee mortality, premature hive cutting, and Deforestation are the key factors in this decline. Particularly, excessive rainfall disrupts honey collection and damages hives, while high heat kills bees and larvae. In previous years, collectors could harvest up to 14 kg per hive, which has now fallen to 2-3 kg. Deforestation for the establishment of industrial zones in Mirsharai and Sitakundo has further threatened honey production by destroying floral resources and bee habitats. The study emphasizes the urgent need for a comprehensive policy to protect both the production of bitter honey and the ecosystem in the Chattogram mangrove. Awareness among the public, government, and all stakeholders is crucial to preventing climate change issues in this region. These issues not only affect honey production but also endanger the whole ecosystem.

Keywords: Bitter honey, Climate change, Mangrove forest, Honeybee, Deforestation.

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1. Introduction

Honey is commonly perceived as a sweet liquid used to enhance the flavor of food and as a natural remedy due to its antioxidant properties, which help combat various diseases in both humans and animals. Its sweet, sticky texture makes it versatile. However, it may come as a surprise that bitter honey also exists and is often valued even more highly for its medicinal properties. In certain regions around the world, bitter honey is produced, collected, and even sold at a premium, surpassing the price of regular sweet honey.

The bitter honey named ***Corbezzolo*** (strawberry tree in Italian) **honey**, produced in Sardinia, Italy, is renowned worldwide for its premium quality and is exported to various regions across the globe. A popular saying about Sardinia reflects its distinctiveness: 'Sardinia was a harsh island; everything on the island was unappealing, and even its abundant honey was bitter' (Ulloa et al., 2015). This unique type of honey can also be found in the Sierra de Monchique in Portugal, Indonesia, and several regions of Africa and Asia. The characteristic bitterness of this honey primarily derives from the pollen collected by bees from the flowers of the strawberry tree (Floris et al., 2021). This honey is highly valued for its extensive nutritional benefits and is regarded as the ultimate remedy on Sardinia Island (Rosa et al., 2011). It is rich in vitamins, minerals, and anti-inflammatory compounds. It has been cherished for generations on an island famous for the exceptionally long lives of its residents, many of whom live well past 100 years (Vallianou, 2014). Honey extracted from the strawberry tree flower also contains nutrients that help prevent colon cancer (Afrin et al., 2019).

This type of honey is also found in various regions across Asia and Africa. In the mangrove forests of Borneo, located in the Loksado area of South Kalimantan and on Bangka Belitung Island in Indonesia, there are specific areas where bitter honey is harvested. Local communities have been collecting this honey for generations. The bitter honey, derived from Sungkai flowers, is noted for its anti-diabetic and anti-inflammatory properties (Hamidah et al., 2019). Furthermore, according to Otmani et al. (2019), the bitter unifloral honey from the Mediterranean coast of Algeria exhibits more potent antioxidant properties than the sweet polyfloral honey from the same region.

Bitter honey is also produced in the southeastern mangrove forests of Bangladesh, particularly in the Mirsharai area of Chattogram. Local communities have been collecting this natural, bitter honey from the mangroves near the Bay of Bengal for generations. The honey here is primarily derived from the Gewa trees in the forest. A single comb can be harvested three times within one season, with some extending to four or five extractions. Typically, 20 to 30 kilograms of honey are harvested at a time, with potential yields reaching up to 40 kilograms. It is highly valued for its medicinal properties and is particularly popular among consumers with diabetes (Stefanis et al., 2023; Lazaridis et al., 2024).

The climate in the coastal areas of the Bay of Bengal has been severely impacted by climate change over the years. The production of bitter honey also decreased in quantity, and there is a risk that this bitter honey could become extinct in the near future (Awulachew, 2025; Gajardo-Rojas et al., 2022). However, this issue has received limited research attention and advocacy focus. Focusing on this risk can provide us with the insight we need into this issue, and possibilities for a way forward to save this unique and priceless delicacy unfold.

Figure 1: Study area (Village, Mangroves, and Coastline) – Google Earth.

2. Literature review

Research has identified bitter honey in Algeria, Indonesia, Italy, and Bangladesh (see Table 1) (Daniyan et al., 2024; Floris et al., 2021; Hamidah et al., 2019; Otmani et al., 2019; Olas, 2020). According to every piece of literature found on bitter honey, it explains that this honey is more nutritious than the sweet ones. However, climate change is negatively affecting the production, collection, and taste of this honey.

Table 1: Comparison of global studies on Bitter Honey

Study location	Threats	Key findings	Sources
Sardinia, Italy	Declining production linked to rising temperatures in Sardinia.	Strawberry-tree (*Corbezzolo*) bitter honey is renowned for its rich antioxidant and medicinal compounds.	(Floris et al., 2021)
Indonesia	Declining production is connected to excessive rainfall and extreme heat.	Bitter honey from *Sungkai* flower has anti-diabetic and anti-inflammatory properties.	(Hamidah et al., 2019)
Algeria (Mediterranean coast)	Declining production is connected to premature harvesting and extreme heat.	Unifloral bitter honey from the Algerian Mediterranean coast shows stronger antioxidant properties than local polyfloral honey.	(Otmani et al., 2019)
Mirsharai mangroves, Bangladesh	Declining production is connected to excessive rainfall, floods, heat, premature harvesting, and Deforestation.	Bitter honey in Mirsharai is produced from mangrove flowers, which are valued medicinally, but there have been recent sharp declines in quantity and quality.	(Chowdhury, 2025)

2.1. Threat of climate change

Current issues of climate change may put honeybees' lives at risk and lead to the extinction of some rare honey harvests. There are serious problems with honey production and collection that can be caused by climate change. Both the honey production and the lives of honeybees are in danger. The honey collectors in Bangladesh's Sundarban are very concerned about their next generation and whether they can continue this profession. The production of honey has been declining over the past few years, which concerns honey collectors (Chowdhury, 2025; Mahankuda & Tiwari, 2024).

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2.2. Impact of climate change on the lives of honeybees

Bees, particularly honeybees, are facing an existential threat. The effects of climate change have manifested globally, with rising temperatures serving as a key indicator. In the first half of this year, humanity experienced an unprecedented heatwave worldwide, signaling that 2024 is set to become the hottest year on record, surpassing previous temperature records (Sangomla, 2024).

Neumann and Straub (2023) highlighted threats posed by rising temperatures to honeybee populations. Extreme heat significantly shortens their lifespan, often leading to colony losses within honey hives. While particular bee species have shown adaptability to climate change, prolonged exposure to extreme conditions can diminish their resilience. Also, the growing impact of pests and the increasingly frequent seasonal shifts force bees to migrate to new regions in search of more favorable conditions (Quinlan et al., 2023). Increased temperature impacts the spring migration of honeybees. Moreover, hive damage, pest aggression, thermal stress, and increased resistance collectively contribute to shorter lifespans within bee colonies (Abou-Shaara, 2016; Landaverde et al., 2023; Lanoix, 2021).

Bees' diseases can be caused by mites, protozoa, bacteria, viruses, and other parasites. The flowers can save water, which can be used by bees (Mensah et al., 2016). But when the flowers can't save any water in extreme heat or in deserts, it is more likely to lead to the death of bees in those areas. Shortages of food in dry climates lead to poor nutritional quality in honeybees. In extreme conditions, when bees must adjust their behaviour, they lose some of their genetic diversity and enter into competition, leading to ecological imbalances. Overall, this impact leads to high honeybee mortality rates (Conte & Navajas, 2008).

2.3. Impact of climate change on the taste and existence of honey

Global honey production has been declining in recent years, primarily driven by climate change. Extreme heat and natural disasters are causing widespread agricultural failures and forest destruction, leading to reduced flower production and a lack of floral resources for bees, which impacts pollination rates (Neumann & Straub, 2023). Moreover, shifting land-use patterns and extreme cold weather are reducing soil productivity, further limiting floral growth. As a result, honeybees are forced to migrate to warmer regions, contributing to the overall decline in honey production (Lanoix, 2021; Quinlan et al., 2023).

In certain regions, heavy rainfall washes away flowers and their pollen, making them less attractive to honeybees. The absence or shortage of pollen forces bees to migrate in search of more abundant floral resources, ultimately leading to a decline in honey production in affected areas and increased honeybee mortality. Also, the quality of honey has diminished as some flower species have disappeared (Conte & Navajas, 2008).

The Sundarbans mangrove forest in Bangladesh has such rich resources for honey production. However, honey production and harvesting in the forest have been declining over the past few years (Roy and Hossain, 2015; Mukhopadhyay et al., 2018). Many people rely solely on honey harvesting as their livelihood, but extreme weather in Bangladesh has severely affected honeybee birth, growth, and honey production in this region. There is a growing risk that future generations may no longer be able to harvest honey from the Sundarbans. Many honey harvesters have already abandoned the profession and moved to the capital city in search of alternative sources of income (Chowdhury, 2025; Mahankuda & Tiwari, 2024).

2.4. A way forward

Honey production and harvesting play a crucial role in maintaining ecological balance by promoting pollination, which supports the reproduction of various plant species. This process is essential for environmental conservation, economic growth, food security, and addressing health and social issues. To sustain these benefits, it's crucial to preserve honey and prevent its decline. Key actions include planting trees, boosting floral productivity, and reducing carbon emissions. Moreover, combating climate change and global warming is vital to safeguard both the existence and quality of honey (Koech et al., 2023).

Bitter honey, a rare delicacy found in the mangrove forests of Mirsharai, Chattogram, Bangladesh, faces the risk of extinction, much like other honey varieties in Bangladesh. Intensive urbanization and industrialization in the region have led to

Deforestation and rising temperatures, threatening this unique and rare species of honey (Hossain et al., 2024). Therefore, it is crucial to explore and address the potential threats to preserve this rare and valuable resource.

2.5. Research gap and significance of this study

Extensive research has been conducted on several issues and prospects related to climate change. In Bangladesh, numerous studies examined climate challenges and proposed numerous mitigation strategies. However, research focusing on the threat of extinction and the declining quality of unique delicacies is limited. Although some studies have addressed these issues in their specific contexts, this area remains largely unexplored in Bangladesh. With the ongoing effects of climate change, the threat of extinction for many traditional delicacies continues to grow. One such delicacy is the bitter honey from the mangrove forests of Bangladesh, which is at risk of losing both its existence and quality due to various climate-related factors that urgently require attention. This study investigates the impact of climate change on bitter honey. By exploring this issue, this research aims to uncover the causes and consequences of climate change on bitter honey, with findings that can raise awareness among stakeholders and the public about the broader impacts of climate change on this unique delicacy.

The objective of this study is to assess the impact of climate change on the existence and flavor of "Bitter Honey." Specifically, the research seeks to explore whether there are any threats affecting the existence and taste of bitter honey in the mangrove forest of Mirsharai, Chattogram, to identify and understand how climate change influences the mangrove forest and bee populations, and to examine whether such changes directly affect the existence and flavor of this unique honey.

3. Method

This research follows a qualitative research approach to explore the existential threat and changing taste of bitter honey. The study area includes the mangrove forests in Mirsharai and Sitakundo in Chattogram District, which include *Moghadia* Mangrove Forest, *Saherkhali* Mangrove Forest, *Domkahli* Mangrove Forest, *and Bogachatar* Mangrove Forest (see figure 1). The population of this study comprises honey collectors who harvest honey from these mangroves and honey sellers in this region. There are only a few collectors and sellers of this unique delicacy in Bangladesh. Only seven individuals who collect bitter honey were found across the entire mangrove forest area, and only three (03) shops were found where they do research and sell the bitter honey (see Table 2 for sociodemographic information of respondents). A non-probability convenience sampling method was used to select the respondents. In-depth interviews were conducted with 10 respondents through a semi-structured interview guide, which included seven honey collectors and three honey sellers. Also, the researcher made observations during data collection to gain a comprehensive understanding of this issue. Once the researchers reached data saturation, the data were systematically coded using open and axial coding, and some categories emerged. All coding processes were conducted by the authors based on the recordings and the transcript. No software is used for this process. The coding framework for this study began with open coding using specific keywords from the transcript, followed by axial coding to develop categories. Subsequently, several sub-themes were identified, which ultimately resulted in the emergence of core themes. Finally, the findings were presented thematically. A small number of people from the local communities in the mangroves collect and sell this honey, but there are growing concerns about its potential extinction, as honey production has been declining over the years. This reduction, along with potential changes in honey's flavor, may be linked to climate change. To achieve a holistic outcome from this study, interviews with honey collectors and sellers provide valuable insights into the flavor changes and the existential threat to bitter honey, possibly tied to climate change.

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Table 2: Sociodemographic information of respondents

Sociodemographic Information	Frequency (n)	Percentage (%)
Involvement with Bitter Honey		
Collector	7	70%
Seller	3	30%
Gender		
Male	10	100%
Age		
25-34 Years	3	30%
35-44 Years	3	30%
45-54 Years	3	30%
55-65 Years	1	10%
Experience in collecting/selling Bitter Honey		
1-5 Years	5	50%
6-10 Years	1	10%
11-15 Years	3	30%
16-20 Years	1	10%
Village		
Domkhali, Mirsharai, Chattogram	2	20%
Bogachotor, Sitakundo, Chattogram	5	50%
Mirsharai Municipality, Mirsharai, Chattogram	2	20%
Chattogram City Corporation, Chattogram	1	10%
Total	**10**	**100%**

BRAC ethically approved this research, and all the respondents verbally consented to participate in this research. All these interviews were conducted in the *Domkahli* and *Bogachatar* Mangrove Forest area in September and October 2024. Each of these interviews has taken approximately 40 to 50 minutes to complete (see figure 2-7 for graphical details). All interviews were conducted in Bengali and recorded with the respondents' verbal consent. The interviews were then transcribed and translated by the authors.

Figure 2: Hive of Bitter Honey (Location: Bogachotor).

Figure 3: Into the Mangroves (Location: Domkhali).

Figure 4: The Minjiri Tree (Location: Domkhali).

Figure 5: Office of Forest Officer (Location: Domkhali).

Figure 6: The Construction of a New Road through Deforestation (Location: Bogachotor).

Figure 7: The Entrance Path of Village with Bitter Honey (Location: Bogachotor).

4. Findings and Analysis

The data for this study were collected through in-depth interviews with respondents using a semi-structured interview guide (see Appendix 1). Subsequently, the data were coded, categorized, and subjected to thematic analysis to obtain a comprehensive understanding of the status, future prospects, and threat of extinction of bitter honey, as well as the relationship between climate change and bitter honey.

4.1. Overview of bitter honey in Bangladesh

Bitter honey is a unique delicacy found exclusively in certain areas, including parts of Bangladesh, particularly mangrove forests. This honey is produced from the nectar of certain mangrove flowers, which contain a bitter essence but attract honeybees with their distinctive fragrances. This process results in the production of bitter honey. As a honey collector said:

> *"Since bees collect nectar from various flowers, the honey can sometimes taste bitter, while other honeys might be sour or a mix of sweet and sour. It is impossible to predict when these types of honey will be produced, as the flavor is determined by the specific flowers the bees visit. When bees gather nectar from Gewa and Neem flowers, for example, the honey becomes bitter." (Md. Islam, Honey Collector)*

This bitter honey contains no sugar or sucrose, which makes it particularly popular among individuals who are unable to consume sugar, such as those with diabetes or high blood pressure. As one honey collector noted:

> *"Bitter honey, in particular, has numerous nutritional benefits that many people are unaware of. Some individuals have difficulty consuming regular honey, but they can easily tolerate bitter honey without issues." (Md. Selim, Honey Seller)*

This honey can only be produced in mangrove forests, as the trees with flowers containing bitter nectar are found there. Also, the honeybee species that produces this honey, Apis dorsata, cannot be domesticated and is found only in forest environments. A honey seller further explained:

> *"The Apis dorsata bee produces this type of honey, but it cannot be domesticated, so this honey cannot be cultivated in artificial environments. It is only available in forests, particularly in saline and mangrove regions, where both the Apis dorsata bee and Gewa trees coexist." (Md. Shahin, Honey Seller)*

This observation demonstrates that *Apis dorsata* bees are non-selective pollinators, collecting nectar based on scent rather than flavor preference, which explains the variety of honey flavors produced from the same forest area.

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4.2. Place & time of getting bitter honey

The primary source of this honey is the Gewa tree, which grows in mangrove forests. The tree's flowers typically blossom in August, making this the key period for bitter honey production. As one seller remarked:

> *"The honey from the Gewa blossoms has a bitter taste—though not overly bitter, it is not sweet at all. This honey is typically harvested in August and is particularly beneficial for individuals with diabetes or those with dietary restrictions on sugar." (Md. Shahin, Honey Seller)*

Bitterness can also be present in other types of honey, as honeybees are unable to distinguish between different flowers. As a result, traces of bitter honey may be found in other varieties. As one seller explained:

> *"This honey is harvested from trees that thrive in saline areas, and its distinct bitterness comes from the flowers of the Gewa tree. Since bees collect nectar from a variety of flowers, traces of bitterness may also be found in other honeys." (Md. Shahin, Honey Seller)*

In Bangladesh, most flowers bloom during the spring season, which falls in the months of Chaitra and Baishakh (March, April, May). Consequently, honey production during this period is significantly higher compared to other months. As one collector noted:

> *"The months of Chaitra and Baishakh are the best time for honey collection, as new flowers bloom, and honey production is optimal in summer." (Md. Rezvi, Honey Collector)*

4.3. Cause of bitterness in bitter honey

In the mangroves of Mirsharai and Sitakundo, six different varieties of honey can be found. These varieties encompass sweet, bitter, sour, and hybrid combinations of these flavors. As one honey collector suggests:

> *"I have been collecting honey for about eight years. In our forest, we have six different types of honey. One is very sweet, another is slightly salty and sweet, one is bitter, another is bittersweet, there's a kind that comes from new flowers, then there's sour-sweet honey, and finally, there's purely sour honey." (Md. Akbor Hosen, Honey Collector)*

In summary, the types of honey found in the Mangrove at Mirsharai and Sitakundo are as follows in Table 3:

Table 3: Types of Honey found at Mangrove at Mirsharai and Sitakundo

Type	Taste
Type 1	Sweet
Type 2	A mix of slightly salty and sweet taste
Type 3	Bitter
Type 4	Bittersweet
Type 5	A mix of sour and sweet tastes
Type 6	Sour

Bitter honey derives its distinctively bitter taste from a variety of flowers, including those of the Gewa tree, bitter gourd, and Neem tree. As the harvester explains:

> *"Bitter honey comes from flowering plants like bitter gourd, Neem, and Gewa. The honey from the Gewa tree is particularly bitter, as its flowers have a pleasant smell but produce honey with a bitter taste. Bees are unable to distinguish the flavor, so they collect the nectar based on the scent, resulting in bitter honey." (Md. Nurul Haque, Honey Collector)*

The honey gradually transitions from sweet to bitter, then finally sour during the final period of the year. Initially, the honey is purely sweet, but over time, it acquires a bitter note, influenced by the blossoms of the *Jamgach, Barai, Koroi,* and *Minjiri* flowers, ultimately turning sour. As one collector posits:

> *"The first collection (in a season) yields sweet honey; the second tends to be bitter, or bittersweet; and by the final harvest, the honey has a slightly sour taste. The flavor entirely depends on the flowers in bloom. Towards the end of the season, flowers from trees like Jamgach, Barai, Koroi, and Minjiri contribute to the production of bitter honey." (Md. Mostofa, Honey Collector)*

4.4. Demand for bitter honey

The demand for bitter honey is comparatively lower than that of other types of honey. The most popular honey in Bangladesh comes from the blossoms of the Khalisha flowers in the Sundarbans. Despite offering superior nutritional value, bitter honey has not achieved the same level of popularity. As one seller said:

> *"The bitter honey available in Mirsarai is rarely stocked, as demand for it is comparatively lower, primarily purchased by individuals with diabetes. Honey from the Khalisha and mustard flowers remains in high demand." (Md. Shuvo, Honey Seller)*

The lack of demand is primarily due to insufficient marketing and promotion of bitter honey. Other varieties of honey have received so much attention that bitter honey has consistently lost its markets. As one seller explained:

> *"Many people are unaware of the benefits of this bitter honey, as it has not been widely promoted. In our shop, we offer honey at prices ranging from 600 to 2000 taka, depending on the floral source. The bitter honey from Gewa flowers is sold at 1000 taka per kilogram." (Md. Shahin, Honey Seller)*

4.5. Relation of bitter honey with climate change issues

Recent climate challenges, including excessive heatwaves, heavy rainfall, and flash floods, have severely impacted the production of honey (see figure 8). These calamities have significantly disrupted the resources in the mangrove ecosystem, and honey production is no exception. As one honey seller stated:

> *"This year, honey production has been affected by floods, and the quality of honey has not been as good. Honey thrives in warm conditions, especially when exposed to sunlight." (Md. Selim, Honey Seller)*

Extreme weather conditions adversely affect the lives of honeybees, floral resources, and beehives, which are the primary components necessary for honey production. As a honey collector stated:

> *"The heavy rains have been a significant factor in this decline, as the rain damages the honeycombs and prevents the bees from finding food, resulting in a reduction in honey production." (Md. Ziaur Rhaman, Honey Collector)*

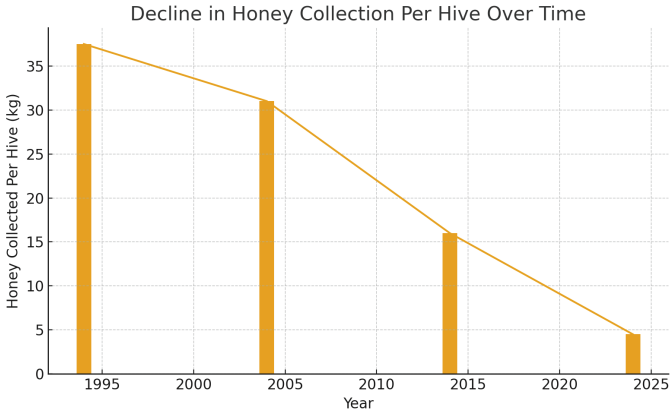

Figure 8: Decline in Honey Collection per Hive over Time (Source: Authors, through summarizing data from the respondents)

4.5.1. Impact on the lives of honeybees

Many collectors in the mangrove region harvest the hives before they are fully capped, and many do not use proper methods when cutting the hives. These practices, combined with excessive heat, result in the death of honeybees and larvae. As a honey collector expressed:

> *"The premature harvesting discourages bees from nesting in those areas again. Honey thrives in the summer, but extreme heat can cause many young bees to die, which in turn reduces honey production." (Md. Rezvi, Honey Collector)*

Using the proper method for cutting a hive and collecting honey is crucial to ensuring the honeybees feel safe and remain intact and alive. As a harvester stated:

> *"If the harvesting process is not done properly, many bee larvae die, which means there will be less honey in that hive the next time. If the hive is cut correctly, the larvae will survive. However, as the forest continues to shrink, the number of honey hives is also decreasing." (Md. Rezaul Karim Biplu, Honey Collector)*

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4.5.2. Lack of floral resources

Floral resources are the most crucial element in honey production. Flowers are the sole source of pollen from which honey can be made. But these floral resources in mangrove ecosystems are diminishing due to factors such as rainfall and flooding. As one honey seller asserts:

> *"Seasonal shifts have disrupted the blooming of plants, resulting in a decline in honey quality. While honey is typically better during the summer, excessive rainfall reduces both its production and flavor." (Md. Shuvo, Honey Seller)*

Deforestation has resulted in the extensive destruction of broad forest areas in the regions of Mirsharai and Sitakundo. This, in turn, has led to a significant reduction in floral resources in these areas. As one honey seller remarked:

> *"In Mirsarai, since the establishment of the industrial zone, many forests and gardens have been cleared, reducing the number of flowers available for bees. As a result, honey production has declined." (Md. Selim, Honey Seller)*

During periods of heavy rainfall, flowers are unable to grow properly, and pollen is washed away. Consequently, honeybees are not attracted to the flowers, which ultimately leads to a decline in both the quality and quantity of honey. As one disheartened honey collector expressed:

> *"There is no honey in winter, but honey production is best in summer, especially when the flowers from all the trees are in bloom. The weather also has a direct impact on honey production because honey is closely connected to flowers. If the weather is bad, the flowers won't bloom properly, which in turn affects both the quality and quantity of honey." (Md. Rezaul Karim Biplu, Honey Collector)*

Sunny weather is beneficial for the growth of flowers. Under such conditions, flowers are able to bloom properly, and with the appropriate warmth, the quality of the honey also improves. As one harvester explained:

> *"Sunny weather produces better flowers, and as a result, better honey. Honey thrives in the heat, as it is dependent on flowers, and the more sunshine, the better the quality of the honey." (Md. Nurul Haque, Honey Collector)*

4.5.3. Deforestation

Deforestation is one of the primary causes of the decline in both the quantity and quality of bitter honey. Just a few years ago, premium-quality honey was being produced in the mangroves of Mirsharai and Sitakundo. But in recent years, due to the creation of industrial zones, most forested areas have been cleared, resulting in a decline in the quality of bitter honey. This Deforestation has led to numerous issues in the region, many of which are directly connected to climate change. As one honey collector stated:

> *"A few years ago, the mangrove forest in this area produced excellent honey. However, with the ongoing Deforestation to make way for industrial zones, many trees have been cut down, and fewer flowers are blooming in those areas, resulting in a decrease in honey production." (Md. Rezvi, Honey Collector)*

The industrial zone is set to be further expanded into the forested area, resulting in increased Deforestation and leaving no forest remaining in that region. The activities for this expansion are already underway. As a consequence, the quantity and quality of honey will decline even further, and new climate-related issues will emerge. The weather will become more extreme, and, over time, the climate will inevitably change. As one honey collector affirmed:

> *"If the forest is destroyed, it will decrease further. Many forests are currently being cut down to make way for industrial zones, and many trees are being removed. The industrial zone will continue to expand, and it is expected to eventually reach our area as well. A road is being built right now, and in the next phase, it will be extended by another 5 kilometers. At that point, it will no longer be a forest." (Md. Rezaul Karim Biplu, Honey Collector)*

4.5.4. Excessive heat

A warm environment is beneficial for honey production. However, excessive heat can sometimes result in a decline in honey quality and even cause the death of honeybees. As one seller noted:

> *"Honey, in its pure form, does not spoil even if stored for years, and exposure to sunlight preserves its quality. However, due to both weather changes and adulteration, honey quality is on the decline." (Md. Shuvo, Honey Seller)*

However, in most cases, the morning heat is beneficial for honey production. From 9 am to the following two hours, honey yields are at their highest in warm weather. According to a harvester:

> *"Honey is at its best when it gets sunlight from 9 am onward; the heat during those next two hours is crucial for better quality honey. Afternoon heat, however, does not contribute to honey production." (Md. Akbor Hosen, Honey Collector)*

This suggests that while moderate morning heat benefits honey production, excessive afternoon temperatures damage hives and harm bee populations. There appears to be an optimal temperature range, with benefits below this threshold and harms above it.

4.5.5. Excess rainfall

Rainfall is one of the most impactful factors in climate change, contributing to reduced honey production. Rain not only washes honey away from the hive but also prevents honeybees from leaving it. During this period, honey production comes to a complete halt, and any honey that has been collected is washed away. As both a seller and a honey collector stated:

> *"Weather conditions also negatively impact honey production. For instance, rain prevents honey from being attached to the combs, leading to a reduced harvest. During rainy periods, bees tend to hide and are unable to gather nectar, resulting in honey being washed away." (Md. Selim, Honey Seller)*

> *"Even a single drop of water can cause the honey to flow out, leading to a reduction in the quantity of honey. Honey and water should never mix. Sometimes, if there are many bees, they shield the hive from water, but if the bees are absent, the honey is lost when rainwater enters the hive." (Md. Nurul Haque, Honey Collector)*

During heavy rainfall, honeybees are unable to leave the hive, forcing them to consume the honey stored within the hive in order to survive. This leads to a decrease in honey production as both the stored honey is consumed and new honey cannot be produced. As one honey harvester said:

> *"Rain significantly impacts honey production. When it rains heavily, bees cannot go out to gather nectar. If they cannot go out, they resort to consuming the stored honey within the hive." (Md. Islam, Honey Collector)*

Due to the rain, honey production has gradually decreased. Collectors now tend to harvest less honey than they did a few years ago. Rainfall can be somewhat destructive to honey collection, negatively impacting both yield and the process. According to a collector:

> *"I no longer collect as much honey as I used to; the quantity has decreased significantly. One of the main reasons for this is the rain. When there is heavy rainfall, bees do not return to their hives, resulting in less honey production." (Md. Rezaul Karim Biplu, Honey Collector)*

4.5.6. Flash floods and excessive flooding

Floods also have a detrimental effect on both honey production and quality. During floods, bees are unable to leave the hive, and in some cases, the flowers and hives themselves are destroyed, leading to a scarcity of food. Consequently, floods are not only harmful to people but also to honeybees, as well as to the production and quality of honey. As one seller expressed:

> *"Floods also damage the flowers, causing them to fall prematurely, which deprives bees of their food source, further reducing honey production." (Md. Selim, Honey Seller)*

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Floods not only destroy floral resources during the event itself, but also result in the permanent loss of many flowers. Consequently, even after the floodwaters recede, honeybees are unable to gather nectar due to the scarcity of flowers. As one harvester aptly posits:

> *"Rain and floods cause flowers to fall prematurely, and without flowers, no honey can be produced. Floods also destroy many bee nests, so both rain and flooding are detrimental to honey production." (Md. Rezvi, Honey Collector)*

4.5.7. Premature harvesting

The quality of bitter honey has significantly declined due to the practice of early honey harvesting. People often engage in this practice to achieve greater commercial gain. Premature harvesting not only reduces the quality of the honey but also makes it thinner in consistency. According to a seller:

> *"We source honey from sweet flowers in the Sundarbans and Mirsarai, but lately, the quality of honey has been declining due to various factors. Early harvesting, before the honeycombs are fully capped, reduces both the quality and quantity of honey. As commercial honey traders increasingly harvest prematurely, the honey is not as thick or as pure as it should be." (Md. Shahin, Honey Seller)*

The quality has declined so significantly that it now requires more honey than before to produce one kilogram. The decrease in density has reached such an extent that this is the case. As a seller affirms:

> *"The honey is now thinner than it used to be, requiring more volume to produce one kilogram. As a result, many sellers resort to adulteration to thicken the honey." (Md. Shuvo, Honey Seller)*

The size of a honeycomb does not necessarily indicate higher honey production. A large honeycomb can also yield less honey. Experienced collectors, with several years of expertise, are able to estimate the amount of honey in a hive, while novice collectors often struggle to predict accurately and may end up harvesting from the wrong honeycombs. As one collector noted:

> *"Not all honeycombs produce the same quantity of honey; some yield 1 kg, others 2 kg, and some even 10 kg. Many people cannot estimate the honey yield, but those of us with years of experience can accurately predict how much honey a hive will produce." (Md. Islam, Honey Collector)*

4.6. Threat of extinction of bitter honey

Both the quality and quantity of bitter honey have been steadily declining over time. Five years ago, a single beehive produced 12-14 kilograms of bitter honey, but this has now decreased to just 2-3 kilograms per hive. As a result, there is an existential threat to the future availability of bitter honey. As one collector stated:

> *"I have been collecting honey for around 4-5 years now. In the past, we used to harvest 10 to 12 kg of honey from small nests, but now, even though the nests are larger, we struggle to collect more than 2-3 kg of honey." (Md. Mostofa, Honey Collector)*

Bitter honey is only available for a brief period each year. However, even during that short window, its quantity has been steadily decreasing. Also, the honey itself has become thinner in consistency compared to previous years. As the collector expressed:

> *"This type of bitter honey is only available for a short period each year, and its availability has been steadily decreasing.....The taste naturally varies from season to season, yet the honey is becoming thinner, and the overall quantity is decreasing. If this trend continues, bitter honey may not be available in the near future." (Md. Ziaur Rhaman, Honey Collector)*

Deforestation has further complicated the threat of bitter honey's extinction. The forest in the study area has been destroyed at an alarming rate to make way for an extensive industrial zone, which also poses a significant threat to the existence of bitter honey and all other varieties of honey. As the honey collectors stated:

> *"However, I think that honey production*

will decline even further in the future. As the forests and gardens continue to disappear, there will only be small amounts of honey left in the countryside." *(Md. Islam, Honey Collector)*

"If the trees remain healthy, and if they are not cut down, and the weather improves, honey production will continue in the future. Since I started collecting honey, the taste of the honey has remained largely the same, but the quality has decreased significantly, and the quantity is almost nonexistent now." *(Md. Akbor Hosen, Honey Collector)*

4.7. A way forward

The honey from the Mirsharai and Sitakundo areas remains superior in quality compared to that of other regions. However, its quality has declined from previous levels. Increased promotion and greater awareness about bitter honey could help preserve this unique delicacy from the risk of extinction. According to a seller:

"Although the honey we now collect is somewhat inferior compared to earlier harvests, we believe that with increased promotion, the demand for bitter honey will grow as more people become aware of its unique health benefits." *(Md. Shahin, Honey Seller)*

Premature honey harvesting leads to the death of honeybees, a decline in honey quality, and negatively impacts its flavor. Therefore, harvesting fully capped hives using proper methods can help avoid these issues. As one collector stated:

"We avoid breaking the hive when there is less honey because we know that after 7-8 days, the honey will improve. Many people today complain that they cannot find good hives, but this is often because new collectors break the hive too early, before the honey has matured." *(Md. Nurul Haque, Honey Collector)*

Moreover, reversing the process of Deforestation can contribute to safeguarding this unique delicacy from extinction. However, climate issues have severely impacted the production, quality, and flavor of bitter honey. Therefore, raising awareness among all stakeholders is essential in preventing this extinction of bitter honey.

5. Discussion

This study identified several climate-related factors that threaten bitter honey production. Bitter honey is an exquisite and unique product of Bangladesh, found in only a few places globally. But this delicacy is under serious threat of extinction, largely due to climate change-related issues. This study explores the threats of bitter honey's extinction and examines the overall impact of climate change on its production, quality, and quantity. Using a qualitative approach, 10 in-depth interviews were conducted with honey collectors and sellers through a semi-structured interview guide. The study identified several significant impacts of climate change on bitter honey.

The study found that bitter honey is primarily produced in August, sourced from the pollen of *Gewa*, *Neem*, Bitter Gourd, *Minjiri*, and *Koroi* trees. These trees produce bitter pollen, which imparts the distinctive bitterness to the honey. This honey is produced in a short time frame, and its production has been declining over time. The main reasons for this decline include excessive rainfall, flash floods, lack of floral resources and growth, the death of honeybees, premature cutting of hives, and Deforestation. Excessive rainfall was identified as the most detrimental factor. During heavy rainfall and floods, honey is washed away from honeycombs, and honeybees are unable to leave the hive to collect nectar. Excessive heat also leads to the death of honeybees and their larvae. Without adequate floral resources and growth, there are no alternative sources for honey production. These floral resources are severely affected by excessive rainfall, floods, and heat. All factors, except premature harvesting, are directly linked to climate change. These factors were also found to negatively impact the honey lives and honey production in previous literature (Conte & Navajas, 2008; Sangomla, 2024; Lanoix, 2021).

In past years, honey collectors were able to harvest up to 14 kg of bitter honey from a single hive, but this has now decreased to just 2-3 kg per hive. In addition to the decrease in quantity, the quality of bitter honey has also declined. It now requires more honey to produce 1 kg of bitter honey, and its density and thickness have been compromised

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due to climate-driven factors. All honey collectors interviewed agreed that in the near future, the production, quality, and quantity of bitter honey will decline even further. So, the bitter honey is in serious threat of extinction in the near future.

Moreover, extensive Deforestation is underway to establish an industrial zone in Mirsharai, which has already led to the destruction of nearly half of the mangrove forest, with the remainder at risk. This Deforestation results in fewer floral resources and reduced honeybee habitats, and ultimately less honey production. It is crucial to raise awareness among the public, government, and all stakeholders to prevent the ongoing destruction of these forested areas for industrial development. This issue not only threatens honey production but also endangers the entire ecosystem. A comprehensive preventive policy is urgently needed to protect the unique bitter honey and the broader ecosystem of the mangrove forest area in Chattogram. The reviewed literature also addresses these issues, and several honey variants are similarly threatened with extinction worldwide (Neumann & Straub, 2023; Lanoix, 2021; Quinlan et al., 2023; Landaverde et al., 2023).

The limitations of this study include a small sample size, a lack of quantitative data, a lack of existing national and international literature on bitter honey, and no lab experiments. There are only ten (10) people found who actually have knowledge about bitter honey at the Chattogram mangrove forest. Additionally, no study has found single quantitative or experimental insights regarding bitter honey.

6. Conclusion & Recommendations

The production of bitter honey is currently facing severe threats due to recent extreme weather events, such as heavy rainfall and flash floods in the Chattogram area, which have severely impacted its production, quality, and taste. Compounding this issue, extensive Deforestation is taking place in the region, particularly in the mangrove areas of Mirsharai and Sitakundo, which are likely to be destroyed entirely if this continues. Over the years, both the production and quality of bitter honey have declined significantly. This year, the production has dropped to such an extent that honey harvesters and sellers are predicting heavy losses in the near future. Immediate attention is required to safeguard not only the honey but also the surrounding ecosystem.

This study has identified key recommendations to address these pressing issues, particularly in relation to climate change and the protection of bitter honey. The core recommendations are as follows:

- Establish protected zones within the mangrove forest that explicitly prohibit industrial development and designate enforcement mechanisms and penalties for illegal Deforestation. Partner with local communities as stewards of protected areas.
- Implement local and regional climate adaptation measures, including: (1) reforestation of degraded mangrove areas, (2) promotion of drought-resistant tree species that support honeybee forage, (3) wetland restoration to reduce flooding impacts, and (4) support for honey collector adaptation strategies, such as early warning systems and alternative income sources.
- Establish honey collector cooperatives or associations to: (1) regulate harvest timing to prevent premature harvesting, (2) establish shared sustainability guidelines, (3) provide collective marketing for bitter honey, and (4) create income stabilization mechanisms.
- Reconsider the proposal for an industrial zone in the mangrove forest area to avoid further exacerbation of climate-related problems.
- Raise awareness among all stakeholders, including local residents, project officials, government entities, and policymakers, to prevent the further decline of bitter honey production.
- Promote the uniqueness of bitter honey to encourage broader support for its preservation.

In addition, mitigating climate-related challenges should be a top priority. While addressing all the issues will be difficult, collaboration among all stakeholders, including government, local harvesting communities, and non-governmental organizations (NGOs), combined with a comprehensive policy, could be effective in protecting bitter honey from extinction. It is also worth noting that no published research or work on bitter honey has been conducted in Bangladesh to date. Such research could raise awareness and

drive policy-level changes. Exploring these issues further may uncover additional ideas and solutions.

In summary, protecting unique delicacies like bitter honey requires collective effort to build a more climate-resilient community, which will ultimately help resolve many climate-related issues.

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Appendix 1: Semi-structured Interview Guide Impact of Climate Change on Bitter Honey in Chattogram Mangrove Forest Area: An Exploratory Study

(For Honey Collectors and Sellers)

Name: **Phone Number:** **Address:** _____

1. How many years have you been engaged in collecting (or selling) this honey?
2. Why is the bitter honey of the *Mirsarai* region different from other types of honey? What is the level of demand for this honey?
3. Why does this honey taste bitter? Are you aware of any unique nutritional properties of this honey?
4. Has the production, collection, taste, or thickness of this honey altered in some way compared to before? If so, in your opinion, what are the reasons behind this alteration?
5. To what extent of rainfall and heat (and for how many days) does the quality and quantity of this bitter honey remain good?
6. In the past, when you went out in the morning to collect honey throughout the day, how much honey would you usually get? Due to changes in temperature or rainfall patterns/ intensity, are you now getting less or more honey compared to before? If less, what do you think are the reasons?
7. Do you think the seasons of heat and rainfall are occurring at the usual times now? Has the climate (long-term weather pattern) of this region changed over the past 15-20 years compared to before?
8. Over the past few years, what types of changes (increase or decrease) have you noticed in the production and collection of honey?
9. In your opinion, is there any possibility that the production of this honey may further decline or that it may disappear in the future?
10. Do you think the decline in production and collection of bitter honey is in any way related to climate (long-term weather) change? If yes, how are they related?
11. According to you, what could be the possible solutions or ways to overcome this situation? What would be your advice?
12. Do you think there is a possibility that this bitter honey might disappear in the future? If so, what reasons do you see behind it? Do you have any suggestions for maintaining the taste or quantity of the honey?
13. You may share any additional comments, advice, or information you would like to add.

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