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Qualitative Analysis of Industrial Hemp Production, Markets, and Sustainability in North Carolina, United States

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Abstract: The North Carolina hemp industry has fallen short of its projected success despite its potential economic benefits and opportunities for farmers. The floral hemp sector specifically has been struggling due to excessive production and decreasing prices. The objective of the research was to examine the experiences and obstacles faced by early adopters and stakeholders of the hemp industry in NC. Through structured focus group discussions and interviews, data were collected and analyzed to gain insight into the industry's direction. The results revealed that many floral hemp farmers have abandoned the crop because of financial setbacks, leading to a reduced interest in cultivation compared to five years prior. The floral hemp industry's rapid growth and decline have tempered farmers' expectations of the crop's potential. The findings will provide a foundation for further research into NC's hemp production and economy, enabling the provision of necessary information and extension services for profitable hemp farming in the state.

1. Introduction

Industrial hemp (*Cannabis sativa* L.) was a valuable source of income for farmers in the United States (U.S.) during the 1900s until the government began regulating its cultivation in the mid-20th century due to its misuse as a substance of abuse [1]. As a result of the government's crackdown on industrial hemp and the emergence of alternative industrial fiber crops, hemp cultivation on a large scale experienced a sharp decline in the U.S. [1]. Over the last few decades, there has been a significant increase in the worldwide demand for hemp products, leading countries such as Canada, China, and various European nations to capitalize on this opportunity by cultivating, manufacturing, and exporting hemp products to the U.S. [2]. To revive industrial hemp production in the U.S. and leverage the rising demand for hemp products across the world, Congress enacted the 2014 Farm Bill. This legislation facilitated the legalization of industrial hemp cultivation and authorized states to establish pilot programs for hemp research and cultivation [2,3]. In response to the 2014 Farm Bill, North Carolina (NC) promptly created the NC Industrial Hemp Pilot Program in 2015 [3]. This led to farmers in NC beginning the cultivation of industrial hemp in 2017, following the approval of the federal Agricultural Act of 2014 and the NC Industrial Hemp Bill of 2015 [4].

Currently, North Carolina (NC) is among the leading states in the United States in terms of hemp production. NC ranks 8th in area planted and harvested in the open, 9th

in area planted under protection, 10th in total production of floral hemp in the open, and 22nd in the highest floral hemp price per pound received, when compared to other states [5]. While the cultivation of industrial hemp in NC began successfully in 2017, after the enactment of the federal Agricultural Act of 2014 and the NC Industrial Hemp Bill of 2015, the state's hemp industry has not progressed as anticipated [6]. Production, processing, and market development have presented significant challenges for the sector. Despite the promising prospects of hemp as a viable and lucrative alternative crop, many licensed hemp growers in NC have abandoned the industry because of significant financial losses [6]. More than 95% of NC's hemp farmers focus on growing floral hemp specifically for the purpose of extracting cannabidiol (CBD) oil [7,8]. In the 2018/19 growing season, NC's hemp industry was a significant contributor to the national supply of floral hemp and produced enough floral hemp to meet the demand of the entire U.S. market [6]. However, due to the excess floral biomass produced during that period and the limited consumer demand for CBD products, numerous hemp farmers incurred substantial financial losses [6]. Consequently, many of the farmers who grew floral hemp in 2018/19 have abandoned the industry [6]. Despite the fluctuations and repeated crashes in floral hemp prices, both private and public stakeholders in NC are optimistic about the future of the hemp industry, particularly for fiber and grain hemp. However, more scientific and consumer-based research is necessary to comprehend the reasons for the decrease in interest in hemp production and the lack of progress in the industry. Identifying the reasons behind this decline is critical for addressing the challenges and fostering the development of a sustainable and profitable hemp industry. This can be accomplished through research that offers insights into the economic feasibility of hemp farming, the obstacles to success, and opportunities for improvement.

The present study forms a component of a broader initiative funded by the United States Department of Agriculture (USDA), which seeks to explore the economics of hemp production and research and how they impact farmers in North Carolina. The main objective of this study is to gain insight into the latest developments, obstacles, economic factors, and experiences of early adopters and extension agents who have a vested interest in the hemp industry in NC. This will establish a comprehensive understanding and essential knowledge base that can support further research and the development of effective solutions for the sustainable and profitable cultivation of hemp in NC. Since the hemp industry in NC is still emerging, there are no quantitative measures or data available on economic indicators, market structures, and the sustainability of hemp value chains. Hence, the use of qualitative analysis in this study is suitable for exploring a deeper understanding of the issues affecting the industry. Qualitative analysis is often used to investigate complex phenomena and gain insights into the perspectives, experiences, and behaviors of individuals and groups in detail [9–13]. This method enables us to collect comprehensive and detailed data that can offer a more profound comprehension of how different stakeholders view the complex issues facing the hemp industry in NC and why they hold these views. To this end, we employ qualitative responses generated through structured focus group discussions and analyze the responses using thematic content and narrative analytic techniques.

2. A Brief Review of Thematic and Narrative Analysis

2.1. Thematic Content Analysis

Thematic content analysis is a qualitative research method that involves identifying, analyzing, and interpreting patterns or themes in a dataset of textual or visual data [14–20]. It involves several steps, including data collection, coding, categorization, and interpretation [14–20]. In the data collection phase, researchers collect a dataset of texts or images. In the coding phase, researchers systematically identify and label relevant concepts, themes, or patterns in the data. In the categorization phase, researchers group similar codes into broader themes, which are then analyzed and interpreted to identify patterns or relation-

ships in the data. Finally, in the interpretation phase, researchers draw conclusions and derive meaning from the themes identified in the data.

Braun and Clarke [14] provide a comprehensive overview of thematic analysis, including the different approaches to coding, categorization, and interpretation of data. They suggest that thematic analysis involves six stages: familiarizing oneself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing a report. Guest et al. [15] also provide an applied perspective on thematic analysis, highlighting its usefulness in different types of research, such as healthcare, education, and social science. They suggest that thematic analysis involves a process of open coding, axial coding, and selective coding, and emphasize the importance of rigor and transparency in the research process. Hsieh and Shannon [16] compare and contrast three different approaches to qualitative content analysis, including conventional content analysis, directed content analysis, and summative content analysis. They suggest that thematic analysis is most closely aligned with conventional content analysis, which involves identifying patterns and themes in the data through a process of coding and categorization.

Patton [17] also provides a detailed discussion of thematic analysis, including the role of the researcher in the process of analysis and interpretation. He emphasizes the importance of reflexivity and transparency in the research process, as well as the need for systematic and rigorous data analysis. Ryan and Bernard [18] discuss techniques for identifying themes in qualitative data, including the use of coding, memoing, and diagramming. They suggest that thematic analysis is particularly useful for generating theory from qualitative data and emphasize the importance of using a structured approach to data analysis. Saldaña [19] provides a practical guide to coding qualitative data, including the use of coding schemes, coding software, and memoing. He emphasizes the importance of staying close to the data, being systematic in the coding process, and using reflexivity and transparency to ensure the rigor of the research. Finally, Thomas [20] suggests a general inductive approach to analyzing qualitative evaluation data, which involves identifying patterns and themes in the data through a process of categorization and interpretation. He emphasizes the importance of flexibility in the research process, as well as the need for systematic and transparent data analysis. In conclusion, thematic content analysis is a useful method for understanding the meaning and context of textual or visual data. It allows researchers to identify patterns and relationships in the data that may not be apparent through other forms of analysis.

2.2. Narrative Analysis

Narrative analysis is a qualitative research method that involves analyzing stories or narratives in order to identify themes, patterns, and underlying meanings [21–25]. It is particularly useful in studies where stories and personal experiences are central to understanding human behavior and social phenomena. One of the key theorists in the field of narrative analysis is Jerome Bruner, who has argued that humans use narratives to make sense of the world and to construct their own identities [21]. According to Bruner [21], stories help us to organize our experiences and make them more meaningful. Another important contributor to the field of narrative analysis is Michael Bamberg, who developed a method known as positioning analysis [22]. This approach involves analyzing the ways in which people position themselves and others in their narratives, in order to gain insight into their social and cultural identities. Other researchers have used narrative analysis to explore a wide range of topics, from the experience of illness and disability [23] to the construction of gender identity [24]. One particularly influential study in this area was conducted by Labov and Waletzky [25], who analyzed personal narratives from working-class African American speakers in order to identify the features of a "narrative schema" that was specific to their culture. Overall, narrative analysis offers a powerful tool for exploring the ways in which stories and personal experiences shape our understanding

of the world and ourselves. By analyzing the narratives of people, researchers can gain insight into complex phenomena.

3. Materials and Methods

3.1. Selection of Participants for Focus Group Discussions

In October 2021, we obtained the Public Request Contact Report for the Industrial Hemp License from the North Carolina Department of Agriculture & Consumer Sciences (NCDA & CS), which contained the contact information for 717 licensed hemp farmers in the state. However, the report did not specify which farmers were actively growing hemp and which were not. In order to obtain a more targeted list of licensed farmers who are currently growing or previously grew hemp, we reached out to hemp extension specialists at North Carolina State University and North Carolina Agricultural and Technical State University, who provided us with a list of 25 farmers. To ensure a random selection, we then contacted these 25 farmers via email and invited them to participate in a focus group discussion.

Out of the 25 farmers who were contacted, 15 of them responded to our invitation, but only 10 of them participated in the focus group discussion, resulting in a participation rate of 66% (i.e., the number of farmers who participated (10) divided by the number of farmers who responded (15)). The 10 farmers who did participate were heavily involved in hemp-related activities and were able to provide us with detailed information during the focus group discussions. Unfortunately, we were unable to elicit responses or participation from farmers who have ceased cultivating hemp for the focus group discussion. In addition to the focus group discussions, we also conducted interviews with two extension specialists who oversee the hemp programs at North Carolina State University and North Carolina Agricultural and Technical State University. These specialists use practical field research to evaluate the feasibility of cultivating new and emerging crops, such as hemp, in North Carolina. All interviews and focus group discussions took place between 7 February 2022 and 15 March 2022, based on the availability of the participants.

3.2. Data Collection

The data collection process for this study involved using a structured focus group interview technique that was approved by an Institutional Review Board (IRB). A focus group is a method that involves conducting in-depth group interviews with participants who are purposively selected but not necessarily representative of a specific population and who are focused on a given topic [26]. Even though focus groups are not usually linked with testing hypotheses, they remain a significant data collection method and are particularly valuable for gathering comprehensive and detailed research information [24,27]. A moderator typically leads focus group discussions by guiding the conversation towards topics of interest and prompting the group to share their responses. These discussions can often result in multiple detailed conversations for each topic or question. To conduct our research, we carried out four informal virtual interview sessions utilizing the questions listed in Table 1. The duration of each interview ranged from one to two hours. All focus group discussions and interviews were recorded. While there is no exact number of focus groups required for a research topic, we utilized the concept of theoretical saturation until a clear pattern emerged [28]. Typically, most researchers consider three or four interviews to be sufficient for simple research purposes [29–31].

Table 1. Key Focus Group Discussion and Interview Questions.

Hemp Farmers	Hemp Extension Specialists
What are some factors that motivated you to start your hemp business?	Would you tell us what services you could provide to farmers who are considering hemp?
Briefly discuss how you got started in this hemp business?	What factors influence farmers to start or add hemp to their farm operation?
How were you able to secure finances to start your hemp business?	What are farmers' expectations about hemp?
What agencies, institutions, or programs have you been able to utilize to assist you in establishing your business?	What problems have hemp farmers faced?
What are some of the major obstacles you faced in starting your hemp business?	Would you tell us about their farm organization?
Do you have a market for your hemp products?	Would you tell us how farmers market their hemp products?
Please explain how you have been able to find and maintain a market for your hemp products.	Would you tell us about how they source for funds for their hemp enterprise?
What changes have you made since starting your hemp business to ensure its success?	What trainings do you have available from your institution for farmers?
What are some of your long-term plans for the hemp business?	Any other information about hemp that you would like to be discussed?
What do you believe are some key elements to your continued success and survival in the hemp industry?	
What type of educational, technical or financial assistance do you need to ensure the sustainability of your hemp business?	
What are some lessons learned you could share with others that may be interested in starting a hemp business?	
In your opinion, will you encourage anyone to go into hemp production?	

We interviewed farmers who were not previously part of any focus group and were specifically chosen based on their current cultivation of hemp and/or possession of a license. The group of farmers included both small- and large-scale farmers from various locations across North Carolina, including Anson County in the south-central region, Bertie County in the northeastern Coastal Plain region, Warren County in the northeastern Piedmont region, and Wilson County in the Coastal Plain region.

3.3. Data Analysis

First, we transcribed the interviewee verbal responses into data using Descript. Next, we performed an inter-and intra-comparison of interviewee responses to identify significant patterns in the data. In the third step, we utilized content analysis to identify and categorize the emerging themes into nine overarching constructs that could encompass all the lower-level constructs. After that, we created a thematic conceptual framework (depicted in Figure 1) to comprehend the patterns in North Carolina's hemp industry. Lastly, we applied narrative analysis to connect and integrate the interviewee responses into a cohesive narrative.
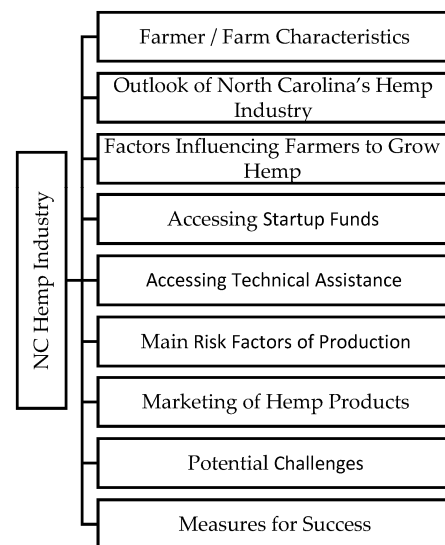
Figure 1. Thematic framework for interview responses.

4. Results and Discussion

The findings we obtained are specific to industrial hemp farmers located in NC. The results were generated through the systematic analysis of transcribed texts from audio-visual interview recordings.

### 4.1. Brief Characteristics of Participating Hemp Farmers and Farms

The farmers we interviewed were primarily individual growers who farm full-time and cultivate between 8 and 150 acres. While some only grew hemp, others grew various other crops alongside hemp. On average, those cultivating hemp managed at least 50 acres of land. Additionally, some farmers were part of a cooperative consisting of around 50 members who jointly cultivated between 1200 and 1500 acres on average. The focus groups were composed of both new farmers with ten years or less of farming experience and seasoned farmers with 11 years or more of farming experience.

4.2. Outlook of North Carolina's Hemp Industry

The NC Industrial Hemp Bill received approval on 31 October 2015 and began accepting applications for hemp licenses in 2017. Over the course of four years, from 2017 to 2021, the number of licensed hemp cultivators in NC surged by over 1100% (Figure 2).

At the beginning of the industry, farmers in NC were primarily focused on cultivating grain and fiber hemp due to their lack of knowledge about floral hemp and its uses. In addition, some farmers preferred to cultivate fiber hemp as they regarded it as an industrial crop, unlike floral hemp that can carry a stigma because of its association with marijuana. However, this changed rapidly with the emergence of the CBD market. The previous years of floral hemp production in other states, such as Colorado and Kentucky, demonstrated that there was money to be made in CBD. The high demand for CBD in 2017 motivated most farmers in North Carolina to grow floral hemp. As a result, many farmers switched to growing floral hemp. As per the insights provided by hemp extension experts, the demand for floral hemp, primarily used for CBD, does not necessitate a substantial production acreage. Prior to the collapse of the floral hemp industry, NC was producing a lot of floral hemp biomass, leading to an oversupply of the crop for which there was no market. This miscalculation of demand for CBD both domestically in NC and across the U.S. caused the collapse of the floral hemp industry. Consequently, several farmers in NC are no longer as enthusiastic about hemp production as they were during the floral hemp boom. The rise and fall of the floral hemp industry in the state have lowered farmers' expectations about the potential of hemp.
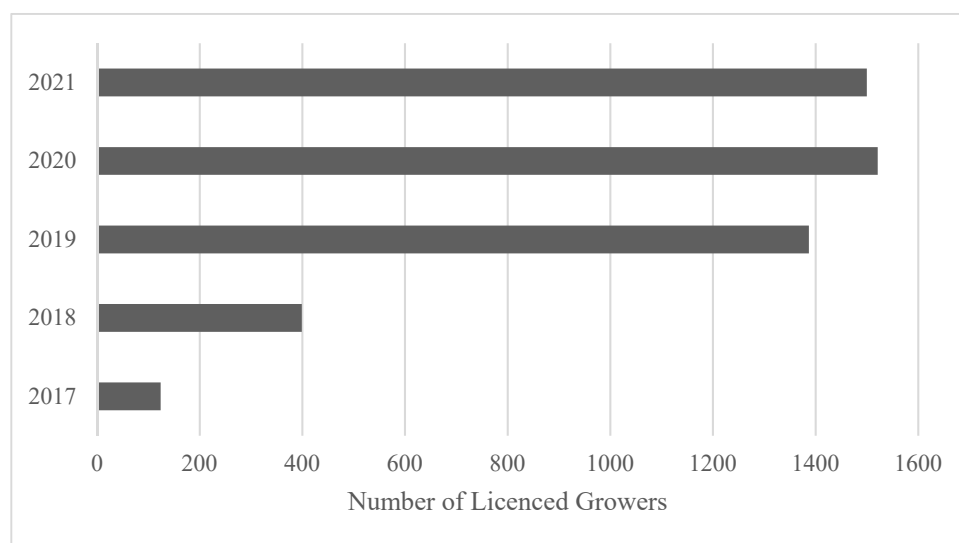
Figure 2. Licensed Hemp Growers in NC, 2017–2021, National Hemp Report, 2022. Note: The NC Department of Agriculture has indicated that not all licensed industrial hemp farmers are actively growing hemp. Some farmers have obtained the necessary license but are yet to commence growing the crop.

The current demand for floral hemp is not very high, resulting in a significant reduction in the number of acres under cultivation. Between 2019 and 2021, there has been a reduction of almost 20% in licensed acreage, compared to the massive increase of over 600% between 2017 and 2019 before the industry downturn (refer to Figure 3). Although the number of licensed hemp growers is on the rise, they are not licensing as many acres of land as in 2019. Furthermore, the number of acres that are planted is even lower than the licensed acres [3,32], as some farmers who obtained licenses to grow hemp have not yet started cultivating the crop, according to the NC Department of Agriculture. Our interviews with extension experts also revealed that new license holders are not necessarily growing hemp. Additionally, some previous growers have stopped cultivating hemp but still retain their license, while active growers have reduced the number of acres they cultivate.
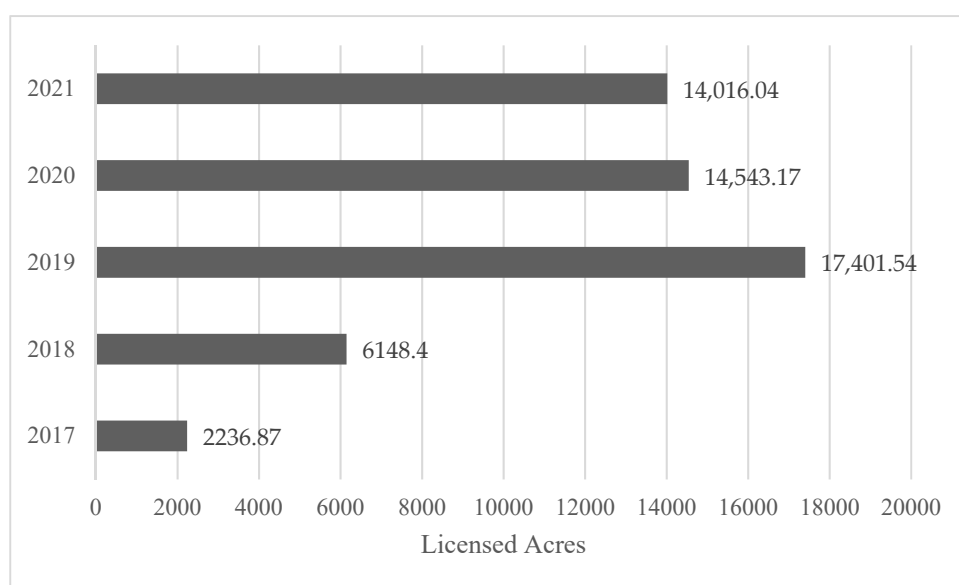

Figure 3. Licensed Hemp Acres in NC, 2017–2021. Source of data: NC Department of Agriculture. Note: NC does not have data on licensed acres beyond August 2021 since the U.S. Department of Agriculture has been handling licenses following the wrap-up of NC's pilot program.

The farmers who are still growing floral hemp are now vertically integrated and processing it into marketable products, such as creams, drops, smokeable hemp, CBD, and Delta-8 THC. Despite the setbacks experienced in the floral hemp industry, there is still some optimism and anticipation regarding fiber hemp ("...it's coming and, um, it just can't seem to happen fast enough."—Farmer Gary). Hemp experts consider fiber hemp a better match for the production system in NC. Although there is a demand for fiber hemp, there are agronomic challenges associated with its production, as well as processing difficulties and economic concerns related to ensuring that farmers can profitably grow it. According to the experts interviewed, the industrial promotion of fiber and grain hemp in NC was not as strong as it was for floral hemp. The state has not witnessed as many fiber hemp processors compared to floral hemp processors. Despite the lack of early industrial promotion for fiber hemp, extension specialists believe that a more measured approach to its growth in the state is preferable so as to avoid repeating the negative experiences of the floral hemp industry. Hemp experts suggest that farmers need to be more pragmatic about profitability and recognize the competition with China, Canada, and Europe, which have decades of production and processing experience that North Carolina lacks. China and Canada have planted 1.8 and 1.5 times more acres than the U.S., and their planted acreage is 76 and 65 times greater than that of North Carolina, respectively [5,32].

4.3. Factors Influencing Farmers to Grow Hemp

A decade prior to the 2014 farm bill, many farmers had already been anticipating hemp production. They had been encouraged by their peers who were growing hemp legally in other parts of the country. One farmer, for instance, had been advised by a friend to "do it" if he ever got the chance to work with industrial hemp. From the outset, farmers played a key role in lobbying the legislature to pass the NC Hemp Bill. They made their representatives aware of their support for any legislation related to hemp production, which ultimately helped to secure its passage ("*I knew at some point something was going to come up in the legislature to pass it here in North Carolina, I said, please support it. Hemp is a very good thing and we need to be, you know, we need to be growing this in North Carolina.*"—*Farmer Gary*). Figure 4 provides a summary of the factors that motivate North Carolina farmers to engage in hemp production.
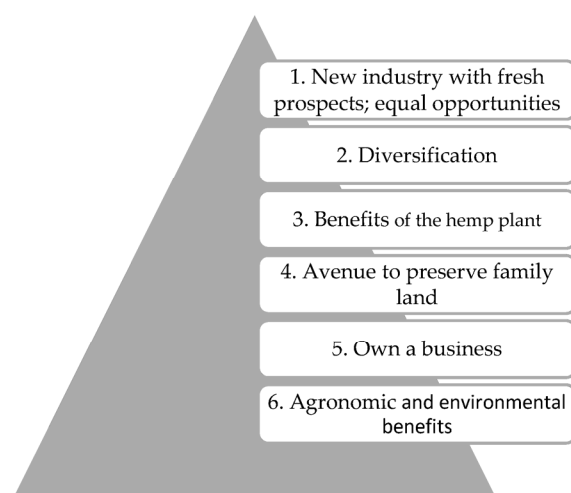
Figure 4. Factors influencing NC farmers to grow hemp.

The novelty of hemp as a new industry with fresh prospects was a major factor that enticed farmers. Every farmer was determined to remain relevant in this emerging industry to reap the rewards that typically accrue to large-scale farmers. According to extension experts interviewed, hemp is a high-value crop that can generate a significant income for farmers. Hemp is significantly more lucrative than other crops, such as kenaf, switchgrass, and sorghum, even when grown under similar conditions [33]. It is estimated that hemp

can generate around USD 2632 per hectare, whereas the revenues for kenaf, switchgrass, and sorghum are only USD 908, USD 803, and USD 1725 per hectare, respectively [33]. Despite recognizing the steep learning curve and anticipating the initial challenges, farmers believed that perseverance would yield significant benefits. Moreover, some farmers relish the novelty of growing hemp and hope that it could soon extend to marijuana. In the words of Farmer Larry, "*hemp provides a chance to legally produce and use a product that was once illegal, thereby reducing the associated criminal activities*".

Some farmers view hemp as a viable option to diversify their farming practices in order to increase income [34] and reduce risk [35]. During the early stages, many tobacco farmers saw floral hemp as a suitable alternative to diversify their tobacco farm because it could be integrated into the existing tobacco production system: "*It is almost like a one-to-one fit*", according to extension expert David. This allowed tobacco farmers to leverage farm resources, such as transplanters, labor, and drying barns, which they already had. Consequently, numerous tobacco farmers in NC ventured into floral hemp cultivation. However, many of these farmers are no longer growing hemp because they are the kind of growers who cultivated large acreages of floral hemp for extraction but did not find a market for their products. Another factor that attracted some farmers to the hemp plant is its potential uses. Farmers are fascinated by the fact that a single plant such as hemp can offer holistic medicinal [36–40], nutritional [41,42], cloth manufacturing [43–46], constructional [47–49], and environmental benefits [50]. Hemp has been shown to improve soil structure, water-holding capacity, and nutrient availability [51]. Hemp has the potential to sequester a greater amount of carbon in subsoil [52] and can also help mitigate deforestation [53]. Minority farmers who were interviewed view hemp as a chance to create a multi-generational business and preserve their land. Prior to hemp, some minority farmers reported that their land was unused, and hemp offered an opportunity to utilize family land that would otherwise be idle and taxed. One participant mentioned that they were selling CBD products produced by other companies, and they saw the legalization of hemp in NC as a chance to transition from selling CBD products made by other companies to producing and selling their line of CBD products.

4.4. Accessing Startup Funds

The challenge of accessing startup funds is a common issue for many farmers [54–56]. Our research revealed how farmers were able to overcome these startup costs. One farmer shared that after the NC hemp bill was passed in 2015, he collaborated with other farmers to request USD 200,000 in startup funds from the NC Commissioner of Agriculture. However, their efforts were unsuccessful as the commissioner wanted the industry to rely on private investment for funding. Despite this setback, most farmers found alternative ways to raise funds to get their hemp businesses started. Some farmers started small and used personal savings or family funds to minimize risk ("*I sold a portion of my land to get me started*"—Farmer Calvin). However, not all farmers took this cautious approach, as one farmer mentioned that many took out loans to begin farming hemp despite being advised not to plant more than they could afford to lose. Farmers who were unable to generate the necessary startup costs formed cooperatives and shared the expenses among themselves. By doing so, they were able to buy hemp seeds in bulk at a reduced price and spread their risk. The majority of farmers interviewed reported that they started by working with cooperatives. For instance, one farmer indicated that his cooperative was able to raise about USD 150,000 to start. Another farmer shared that he and three other friends grew 10 to 40 acres of hemp to mitigate their risks. In addition, other funding sources were mentioned, such as retirement funds, military disability payments, loans from the Paycheck Protection Program (P.P.P.), and Economic Injury Disaster loans. Figure 5 provides a summary of the funding sources that were discussed by the farmers.
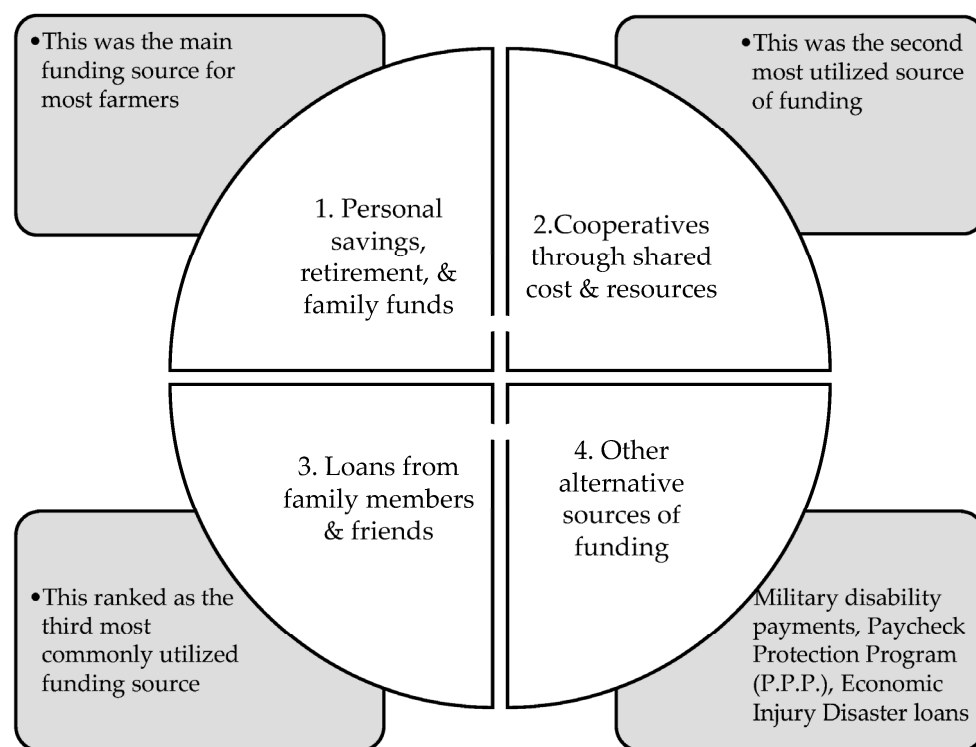
Figure 5. Sources of startup funds.

4.5. Accessing Technical Assistance

The farmers who were interviewed reported that North Carolina Agricultural & Technical State University (N.C.A.T), North Carolina State University (N.C.S.U), the Farm Service Agency (F.S.A.), and some seed companies have provided valuable assistance with research and technical information. As hemp is a new crop, initial research services were based on farmers' needs and challenges, such as fertilization and harvesting, and recommendations were provided based on research findings. However, one farmer mentioned that farmers were primarily responsible for gathering information during the early stages, as the universities were slow to begin research. Farmers started growing hemp before universities began researching and providing guidance. Nevertheless, ongoing research by N.C.A.T and N.C.S.U. has been instrumental in developing and experimenting with new hemp varieties, as most European varieties are unsuitable for North Carolina. According to hemp specialists, research on the science and agronomic practices of fiber hemp production should receive similar attention as tobacco did in North Carolina, with the aim of improving production while minimizing adverse environmental impacts.

In addition to conducting research, farmers are provided with extension services through county meetings. During winter county meetings, extension agents and specialists visit farmers to provide training and updates on the hemp industry, as well as share research trial results and recommendations. Field days are also organized by extension agents to showcase research results, demonstrate plots, and facilitate networking among farmers and specialists. Since hemp is a new crop, building connections throughout the production and supply chain is crucial. Farmers and stakeholders who participate in these events can develop new networks, and those involved in hemp processing and product development can connect with hemp farmers.

To enhance engagement with farmers and stakeholders, extension agents and NC hemp specialists leverage social media platforms, such as Facebook, Instagram, and Twitter. They also utilize extension web portals to post key dates for events such as field days, as well as share research updates and other relevant hemp news. Through the web portal, farmers can also communicate with agents and specialists. Additionally, specialists create and publish materials, such as free production guides and fact sheets, online.

4.6. Main Risk Factors of Production

According to the extension specialists interviewed, fiber hemp cultivation is associated with various risk factors, but obtaining the appropriate seeds is considered the biggest risk and the most expensive aspect of growing the crop. Inadequate seed quality can result in decreased yields, poor plant growth, and a higher incidence of pests and diseases [57,58]. According to the extension specialists, many of the varieties available in NC were developed for northern latitudes and tend to flower too early. Farmers indicated they have experimented with different varieties, such as the Polish strain that produced beautiful plants but only grew to knee height and flowered prematurely, instead of reaching the desired height of 10 to 15 feet. Chinese varieties are known to flower at the right time and produce a high biomass yield, but they pose challenges, such as poor seed quality, including low germination rates and a tendency to contain more than the legal limit of 0.3% THC. If the THC level exceeds this threshold, the crop must be destroyed, and insurance coverage will not apply according to extension experts interviewed. To mitigate risks associated with fiber hemp cultivation, extension specialists from N.C.A.T and N.C.S.U. conduct variety trials in multiple locations throughout North Carolina with varying soil types. These trials help determine if there are regional differences in how different fiber hemp seed varieties perform.

Floral hemp production has been found to require a significant amount of labor investment, making it a labor-intensive crop [59,60]. The labor-intensive nature of this crop is considered a primary risk factor in the production process [59]. The labor required for the production of floral hemp is significant due to the need for manual labor-intensive tasks, such as pruning and harvesting [59]. This is particularly true for hemp grown for cannabidiol (CBD) extraction, which requires a higher level of precision [60]. Similarly, the production of floral hemp in North Carolina demands substantial investment in labor. Based on interviews with extension experts, many growers of floral hemp in NC depend on H-2A (temporary guest worker) labor since they cultivate other labor-intensive crops, such as sweet potatoes and tobacco. Moreover, some farmers employ their family members for labor. To minimize labor risks, extension experts suggest that floral hemp producers should contemplate shifting towards a mechanized system for direct seeding, harvesting, and shredding of harvested materials for extraction.
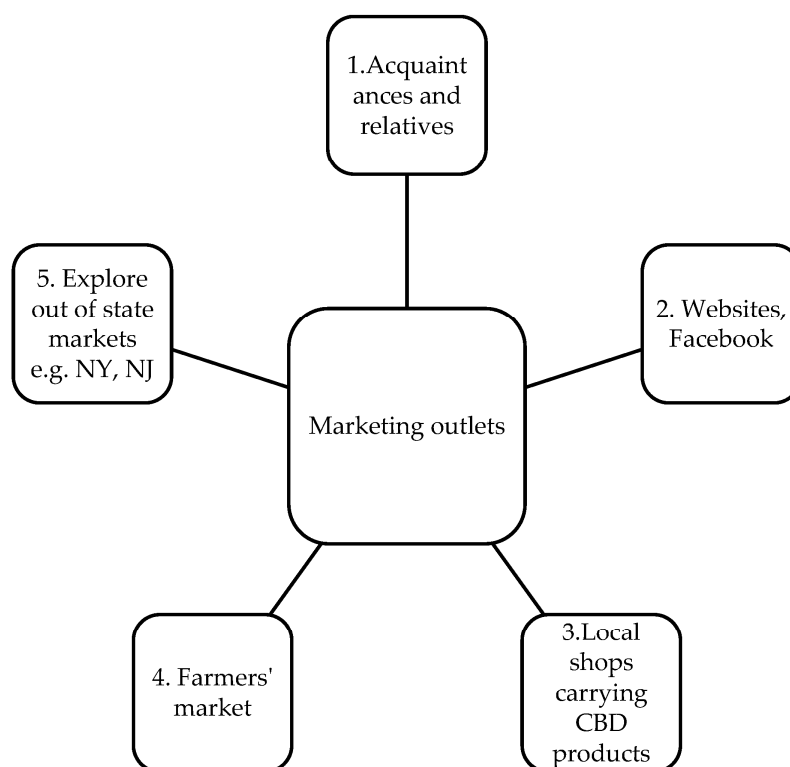
4.7. Marketing of Hemp Products

North Carolina has the potential to benefit greatly from the burgeoning hemp industry, as the demand for hemp-based products continues to rise globally. The growth of the fiber hemp sector in the U.S. is projected to increase steadily (as illustrated in Figure 6). Unlike floral hemp, which has limited CBD consumption, fiber hemp has virtually limitless potential as it can be transformed into a wide range of products, including textiles, compostable bioplastics, and construction materials. Additionally, growers are hopeful that the National Hemp Feed Coalition will approve hemp products as animal feed ingredients, which could spur the production of hemp grains in NC.

Although there is considerable interest in the potential uses of hemp, the market for these products may not be as extensive or profitable as originally anticipated. As the hemp market in NC is not fully matured, fiber hemp producers often secure contracts with companies, particularly those in the construction industry, who are willing to purchase their products. Only a small number of farmers have integrated vertically, meaning that they grow, process, and market hemp-based products, such as tinctures, skincare items, and beauty products, on their websites, Facebook, and other online platforms. Some farmers also approach local shops that stock CBD products to make sales, while others sell their products at nearby farmers' markets. The majority of farmers sell their products to acquaintances and relatives and provide free samples to them for feedback, which has helped some farmers to maintain and expand their customer base. According to one farmer, the hemp market in NC is currently not as substantial as it is in the Northern United States. Therefore, exploring and identifying hemp product markets in other states, such as New

York and New Jersey, has proven beneficial for his hemp business. A summary of the marketing outlets that were discussed by the farmers is presented in Figure 7.
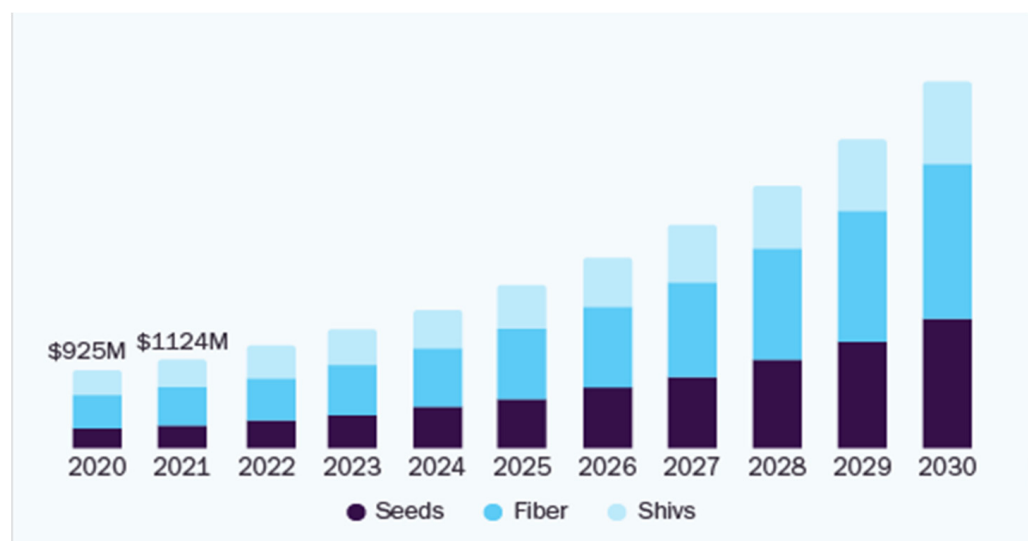
Figure 6. Size of U.S. Industrial Hemp Market by Product, 2020–2030 (USD Millions). Source: https://www.grandviewresearch.com/industry-analysis/industrial-hemp-market (accessed on 20 February 2023).

Figure 7. Marketing outlets for hemp products.

4.8. Potential Challenges

A synopsis of the potential challenges addressed by farmers and extension experts is presented in Figure 8. Furthermore, we offer a comprehensive analysis of the challenges below.

1.Marketing challenges	• Lack of markets for floral hemp products • Fiber growers unable to meet high fiber demand • Processors failing to uphold contractual obligations to farmers
2.Lack of knowledge about:	• Seed density • Processing techniques • Equipment selection.
3.Undercapitalization	• Inadequate funds to cover production cost • Lack of funds to establish processing infrastructure especially for grain and fiber hemp
4.Agronomic challenges	• Pests and and diseases; Soil born dieseases • Absence of suitable machinery from seed to sale • Obtaining the right clone from a reliable source
5.Institutional challenges	• Some banks do not acknowledge hemp as a legal business • The public has not fully accepted hemp as a legal product • Difficulty in obtaining crop insurance

Figure 8. Potential challenges facing the hemp industry in NC.

Finding markets to sell hemp products remains a major issue for many floral hemp farmers. While regulatory uncertainty may cause challenges in securing stable markets for hemp products, especially hemp for CBD [32], many farmers in NC were also overly ambitious and optimistic during the early stages of floral hemp production. This resulted in overproduction and a sharp decline in the price of floral hemp from USD 40 per pound to a mere USD 2 per pound, leading to substantial losses for many hemp farmers in NC who had grown hundreds of acres of floral hemp without any contract. Without a contract, growing hemp is a considerable risk.

Another marketing hurdle is the lack of infrastructure for processing hemp products. Many farmers do not have access to processing facilities, which can limit their ability to produce value-added products [61]. The main issue with North Carolina's fiber market is the high demand for large quantities of fiber by purchasing companies, which is beyond the current knowledge and infrastructure capabilities of hemp fiber growers. Farmers in NC are missing out on lucrative market contracts due to limited infrastructure and inability to meet the required demand for fiber hemp.

On the flip side, many farmers who were fortunate enough to secure contracts encountered difficulties with dishonest companies that reneged on their agreements to pay the farmers. Some processors failed to uphold their contractual obligations to the farmers. From a floral standpoint, numerous assurances made by buyers and processors could not be substantiated. Certain companies sold clones to farmers but then failed to follow through with their commitment to purchase the farmers' output. In 2018, for instance, some of the farmers who were interviewed entered into an agreement to cultivate fiber hemp for a particular company. They planted 600 acres of fiber hemp all over North Carolina. However, the company eventually went bankrupt and failed to fulfill its contractual obligations. Aside from the seeds provided by the company, the farmers lost everything else they invested in the project. In 2020, hemp farmers in Kentucky sued an Owensboro-based hemp company in a class-action lawsuit, alleging that the company failed to pay them hundreds of thousands of dollars for their contracts. The lawsuit claims that the company breached

the contract, committed fraud, and engaged in racketeering, among other allegations [62]. There are also instances of farmers failing to uphold contracts. In 2019, Big Bush Farms located in Marion County, Oregon filed a lawsuit against three local farms it contracted to grow crops under its state hemp production license. The lawsuit alleges that the farms did not provide the agreed-upon biomass [63]. Processors, in some cases, may have more bargaining power than farmers, which can lead to unequal contractual agreements. Some of the farmers interviewed shared instances where they were compelled to accept lower prices from contract buyers because purchasing evaluators cited issues with farmers' hemp biomass. This can make it difficult for farmers to negotiate favorable terms and can leave them vulnerable to processors failing to uphold their obligations.

Farmers are facing another major issue, which is a lack of knowledge about the hemp industry. Many of them have heard about the potential opportunities in hemp production and jumped on the bandwagon without fully comprehending the industry. According to one farmer, people were hyping up the potential profits of hemp without providing adequate education on how to achieve them (*"People were telling us how much money we could make but no one educated us on how to make it"—Farmer Moses*). Farmers are claiming that they lack sufficient knowledge about various aspects of hemp production, including seed density, processing techniques, and equipment selection. Lack of knowledge can result in decreased yields, increased costs, and lower profits [64]. Extension services play a crucial role in disseminating essential information to farmers. However, the main challenge they face is the fact that hemp is still a relatively new crop in North Carolina, and they may not have answers to all of the farmers' questions.

Insufficient funding hinders the level of support necessary for sustainable agriculture [65]. Farmers interviewed identified undercapitalization as a major hurdle, particularly when it comes to cultivating floral hemp, which is a costly crop to grow. The cost of production is a significant obstacle, as some farmers do not have adequate funds to cover these expenses and operate a successful hemp business. Although grain and fiber hemp offer greater potential for use than floral hemp, farmers have indicated that there is no processing infrastructure for these crops in North Carolina, particularly for grain. As a result, farmers have refrained from producing hemp for grain, and establishing processing infrastructure for grain and fiber hemp in NC has been challenging due to a lack of funding.

Hemp cultivation in NC faces agronomic challenges from pests and diseases, such as corn earworms that can damage floral hemp and pathogens that consume foliar, affecting maturing buds [66]. However, the scarcity of effective products labeled for combatting hemp pests and diseases further exacerbates these agronomic issues [67]. Furthermore, the absence of suitable machinery from seed to sale and the impact of multiple soil types on a single parcel of land affect production, variety, and equipment needs. Obtaining the right clone from a reliable source is another challenge, although the issue of genetic variability has been reduced by better breeding, according to extension experts. The 0.3% THC limit remains a persistent concern for CBD extraction, since THC and CBD are interdependent in production [68]. As CBD increases, so does THC, limiting farmers' ability to maximize CBD levels without surpassing the 0.3% THC threshold. As per the extension experts we interviewed, farmers need to harvest prematurely to avoid surpassing the THC limit, which results in a CBD yield of only 7% to 8%. However, with an enhanced comprehension of hemp biochemistry, it is possible to prevent the THC limit from being exceeded.

Some farmers reported that certain banks do not acknowledge hemp as a legitimate business, making it difficult for their hemp ventures to open bank accounts or carry out transactions. Additionally, convincing the public that hemp is a legal product has proven to be a challenge for many farmers. Some people are hesitant to associate themselves with any hemp product due to fear of legal repercussions. Another significant challenge that farmers face is obtaining crop insurance. Insuring a new crop such as hemp is particularly challenging because there are limited historical data on crop yields, growing costs, and market prices. As a result, insurance coverage for new crops, including hemp, is typically hard to come by initially. Although these challenges are significant, they are not insurmountable.

With appropriate strategies and support, it may be possible to facilitate the growth and long-term success of the industry in North Carolina.

4.9. Measures for Success

The prevailing mindset among farmers is one of continuous learning and adaptation to changes in the hemp industry. Farmers are constantly seeking to enhance their knowledge of hemp plant genetics, production techniques, and processing methods. They are particularly keen to learn about optimal planting density and farm technology, such as using a forage harvester to cut hemp into manageable lengths for baling. Some farmers are interested in cultivating their own clones for floral and fiber hemp, while others are considering exploring fiber hemp cultivation in the future.

Certain fiber hemp farmers have incorporated regenerative farming practices into their fiber hemp production to effectively compete with weeds. According to the farmers, they usually plant fiber hemp without chemical inputs or fertilizers before weed germination to save costs. Additionally, farmers have learned not to grow hemp without a contract, whether it is for CBD, fiber, or grain. The farmers stated that many CBD contracts never materialized, and as a result, they are now adopting a "show me the money first" approach before committing to growing hemp for any processor. Some farmers have also learned to add value to their floral biomass, especially when the market value of floral biomass dropped from USD 40 per pound to USD 2 per pound. Successful floral hemp farmers are mostly vertically integrated, handling all aspects of cultivation, processing, and product development. Unfortunately, North Carolina has not seen any successful fiber hemp producers due to several factors, including a lack of funds and quality genetics.

Several individual farmers have ceased cultivating independently and instead opted to collaborate as cooperatives in growing hemp. The cooperative buys large tracts of land and leases sections of it to its members for cultivation. This allows for shared use of equipment, as the farmers are in close proximity. Ultimately, most farmers aim to specialize in the hemp industry instead of spreading themselves too thin. They believe this strategy will allow them to command premium prices from buyers and generate immediate profits. Furthermore, the farmers seek the cooperation of buyers and processors in navigating the risks involved in producing the hemp crop, as farmers are a crucial component of the hemp industry. In summary, we inquired of the farmers whether they would recommend others to venture into hemp production. The following are some of the farmers' individual responses:

1. *"Yes, especially hemp fiber, because it can be used for so many things such as textile, packaging materials, building materials, and biofuels among other things."*
2. *"Yes, but you need to be committed and willing to learn."*
3. *"Yes, and I will let them know about the risks involved too."*
4. *"Yes, because it's an opportunity to flip an illegal industry into a legal industry."*
5. *"Yes, but it's going to take a team effort through shared assets due it the capital intensive nature of hemp cultivation."*
6. *"Yes, because it is an opportunity to create a business and a legacy to pass on from one generation to the other."*
7. *"No, not yet, because I wouldn't like to go through all the processing and even selling of the product. It's very challenging we do not yet know what the yields look like or what the processing and costs are going to be. There are too many unknowns."*

5. The Way Forward

The hemp industry in North Carolina is relatively new but promising due to increasing demand for hemp products globally. However, the state lacks the necessary infrastructure for efficient production and processing. Europe, Canada, and China all have established infrastructures, technical and management expertise, and established markets. As a result, the U.S. imports more processed hemp from Europe, Canada Europe, and China than raw hemp [32]. As demand for sustainable materials grows, there may be new opportunities for

hemp-based products. Hence, future work should focus on developing and strengthening the value chain of hemp products. While there is a possibility for fiber and grain hemp to be employed in the coming years, the market for CBD extracted from floral hemp encounters ongoing obstacles from a regulatory environment that is deemed precarious and as a result of actions implemented by the Food and Drug Administration (FDA). There are excellent regulatory standards in Europe and Canada [32] that we can gain knowledge and insights from.

There is also a need for collaborative research on the chemistry, agronomy, and economics of the hemp plant to support the growth and success of the hemp industry. The economic aspect of any product is crucial to its implementation in various industries. A study by Parvez et al. [69] on the potential of industrial hemp for bioenergy production in Canada revealed that conducting a techno-economic evaluation can provide investors with essential information, including identifying the most suitable applications for hemp to target and determining the viability of hemp processing technologies in the industry.

6. Conclusions

This article examined the experiences and obstacles faced by early adopters and stakeholders of the hemp industry in NC in order to gain insights that can support further research and the development of more efficient and effective solutions for the sustainable and profitable cultivation of hemp in North Carolina. To achieve this, we conducted focus group discussions with farmers and personal interviews with extension experts from NC State University and NC A&T State University. The data obtained were analyzed using thematic content and narrative analytic techniques. Our findings from this study indicate that:

- Many floral hemp farmers have abandoned the crop because of financial setbacks.
- The main factor that attracted farmers to hemp was its novelty as a new industry with promising prospects.
- Personal savings, retirement funds, and support from family were the primary sources of financing.
- The main risk associated with fiber hemp production was obtaining appropriate seeds, whereas labor requirements were the primary risk factor for growing floral hemp.
- The main target market for hemp products was acquaintances and relatives.
- The three major challenges faced by the hemp industry in NC were marketing, inadequate knowledge, and undercapitalization.
- Farmers considered continuous learning the foremost measure of success. Other key success factors included securing buyers with reliable contracts and financial resources to pay the farmers and identifying a significant market before commencing production.

Overall, the majority of hemp farmers we interviewed indicated that they would advise others to proceed with caution when considering entering the industry. However, based on their experiences with hemp, extension experts are warning that it would be preferable to take a step back and reach a point where interested parties have a thorough understanding of the markets and how to cultivate the hemp crop. It is worth noting that the study had some limitations, including a lack of gender diversity among focus group participants and reduced participation in the focus groups due to the use of virtual platforms during the COVID-19 pandemic.

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