8-23-2024

CLIMATE CHANGE PERSPECTIVES IN CENTRAL NEW YORK- BARRIERS, ADAPTIVE STRATEGIES AND CHALLENGES AMONG SMALL-SCALE FARMERS.

Frank Sarfo
Syracuse University

ABSTRACT.

Climate change is a global phenomenon that is already impacting the United States and other region, although its effects differ across regions. While extensive research has focused on how climate change affects agriculture in the northeastern United States, there is a lack of studies specific to the Central New York area and the perspectives of small-scale farmers regarding the effects of climate change on their practices. This study addresses this knowledge gap by investigating the perspectives of farmers in the region on climate change through in-depth interviews with small-scale farmers in Central New York. The study also examines the challenges and impacts they face and explores the adaptive measures they are taking on their farms.

Findings from the study reveal diverse perspectives among Central New York farmers regarding the impacts of climate change. Furthermore, the adaptive strategies employed by farmers exhibit significant variability. While they are proactively adopting strategies to mitigate the impacts of climate change, they are confronted with numerous challenges in the process such as limited access to financial resources, labor, land, technical expertise, and information.

This study is a first step in understanding what Central New York farmers think about and how they deal with the risks of climate change. Also, it shows the importance of engaging with local farmers to understand where additional climate adaptation policy is needed.

CLIMATE CHANGE PERSPECTIVES IN CENTRAL NEW YORK- BARRIERS, ADAPTIVE STRATEGIES AND CHALLENGES AMONG SMALL-SCALE FARMERS.

by
Frank Sarfo

B.S., KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, 2015

Thesis

Submitted in partial fulfillment of the requirements for the degree of

Master of Science in Food Studies

Syracuse University

August 2024

ACKNOWLEDGEMENTS.

First, I would like to thank all the farmers who agreed to be interviewed for my research despite their busy schedules. This material is based on research supported by the Syracuse University Falk College Seed Grant - Jimenez-Soto Falk Seed 2022.

Special thanks go to Rick Welsh, my academic advisor, for his unwavering support throughout my journey at Syracuse University and am glad to be working with you in the next phase of my studies. Laura-Anne Minkoff Zern, I am deeply grateful for your support for helping me get here and the opportunity to work with you on your project. To my professors and committee members, Anne Bellows and Jean Kayira, thank you for your knowledge, encouragement, and invaluable questions and critiques. My heartfelt appreciation goes to my mentor, Estelí Jimenez-Soto, for the opportunity to work with you, your continuous guidance, and all the assist provided.

To the Food Studies faculty, especially Naomi Shanguhyia and Chef Mary Kiernan, and the staff, Vincenza, and Jane, as well as the Falk ITS (Information Technology Services) team (Steve, Bradford, and Jeff), thank you for the opportunity to work with you every summer.

I extend my heartfelt gratitude to Larry and Betty Dungan, who have become like parents to me. To Brad, my pastor, his family, and the Good News Church in Santa Rosa Beach, FL, I appreciate the enormous support, love, and investment you've poured into me. To Jervis and Maxwell, friends who have become like brothers, I say a big thank you, as well as to all the amazing people I have met here in Syracuse—Esi, Eric, Akosua, Moses, and the Mosquito Group.

Finally, to the Stutts family: Phillip, Annie, and Parker—I sincerely love you all for everything you do for me and for making me part of your family.

TABLE OF CONTENTS.

ABSTRACT……i

ACKNOWLEDGEMENTS. iv

CHAPTER I: INTRODUCTION. 1

I. INTRODUCTION 1

II. RESEARCH QUESTIONS. 5

CHAPTER II: LITERATURE REVIEW. 6

I. PERCEPTION OF FARMERS ON CLIMATE CHANGE. 6

II. FARMERS' ADAPTATION TO CLIMATE CHANGE AND STRATEGIES. 7

CHAPTER III: METHODOLOGY. 10

CHAPTER IV: RESULTS. 12

I. FARMERS PERCEPTION ON CLIMATE CHANGE. 12

II. CLIMATE CHANGE'S IMPACT ON FARMERS 13

III. ADAPTIVE STRATEGIES BY FARMERS 18

IV. BARRIERS / CHALLENGES TO ADAPTATION. 26

V. ACCESS TO INFORMATION AND KNOWLEDGE- SHARING. 35

CHAPTER V. DISCUSSION AND CONCLUSION. 38

CHAPTER VI. STUDY LIMITATION, IMPLICATION FOR FUTURE RESEARCH AND RECOMMENDATIONS 47

I. STUDY LIMITATIONS 47

II. IMPLICATION FOR FUTURE RESEARCH. 48

III. RECOMMENDATIONS. 49

REFERENCES 51

CURRICULUM VITAE 57

CHAPTER I: INTRODUCTION.

I. INTRODUCTION.

Climate change, food insecurity, and biodiversity loss have been recognized as the triple threats of humanity (Petersen-Rockney et al., 2021). Over two-thirds of the land in Central New York (CNY) consists of agriculture and forest, with more than 150,000 acres in farmland (Blaisdell, 2018; Onondaga County Planning Agency, 2022) contributing significantly to the diversity and resilience of the food system by supporting hundreds of livelihoods and the local economy. Research has suggested strongly that ongoing climate change affects negatively the ecology and function of ecosystems, as well as the goods and services derived from them (Masson-Delmotte et al., 2021; Weiskopf et al., 2020). Climate change as a global phenomenon is already affecting many areas of the United States (Weiskopf, et al., 2020), although the impacts are not uniform across regions. Climate change scenarios have also shown significant effects on climatic variability, particularly for urban areas, which are generally influenced by the Urban Heat Island Effect – an increase in temperature with regards to the surrounding landscape (Tumini, & Rubio-Bellido, 2016). Changes in temperature and humidity can also have cascading effects on many ecological functions, including pest control and soil health.

For the Northeast (Lane et al.,2018), studies show that many crops will have yield losses associated with higher temperature stress and increased rain intensity, resulting in higher pressure from weeds, insects, and diseases (Masson-Delmotte et al., 2021; Wolfe et al., 2008). According to the USDA (USDA, 2012), changing trends towards warmer temperatures in NY have pushed the Plant Hardiness Zone to a new category in several regions, including Central New York-5b

from 6a. (USDA, 2012; see https://planthardiness.ars.usda.gov/). Similarly, New York State's ClimAID report has concluded that New York's Climate change in the state is predicted to increase temperatures, which will harm crops. These changes could explain more pests and diseases, higher pest/weed survival during winter, and severe impacts during the growing season (Horton et al., 2014; Rosenzweig et al., 2011). This is critical for New York, where the agricultural industry contributes significantly to the state's economy.

Given these challenges, agroecological science (Petersen-Rockney et.al.2021) has stressed the importance of diversifying agroecosystems (including rotations, polycultures, living mulches and conservation of wild habitat), because it can support farmers' resilience to external shocks, while provisioning culturally appropriate foods, pollination, pest, and disease regulation (Gliessman,2004). Lin et al., (2011) further emphasize that the use of ecologically based methods in addressing climate change impacts particularly methods used in small-scale farms, use less energy from fossil fuels and sustain ecosystem services– the benefits that people derive from nature– that are critical for food production and human wellbeing, including food security. Hence to use these methods requires understanding the socio-ecological complexities of farming under environmental change, as well as strengthening local capacities, while valuing local agroecological knowledge, along with the rich cultural practices that promote agrobiodiversity.

In the context of northeastern United States, studies on how climate change affects agriculture has been extensive, yet few focuses on understanding farmers' perspectives on how climate change impacts their farming practices (Lane et al., 2018). It is projected that climate impact in the northeastern region will differ from the rest of the country (Tobin et al., 2015)- specifically, a greater increase in average annual precipitation. From a review study conducted by

Chartrchyan and colleagues in 2017 on agricultural stakeholders' views and decisions on climate change across the United States, only a handful of studies specifically focus on the northern region. Despite limited research available, it is observed that through climate science information, farmers are adapting their practices in response to climate change (Jemison et al., 2014; Kuehn, 2016; Schattman et al., 2016; Lane et al., 2018). However, it is important to note that simply presenting climate science information to farmers does not guarantee their adoption of these findings (Walthall, 2012; Prokopy et al., 2015). Understanding what motivates or hinders farmers in dealing with climate change is crucial. Therefore, several studies emphasize the need to make climate change information more relevant to local contexts so farmers can effectively apply it (Bartels et al., 2013; Mase and Prokopy, 2014; Brugger and Crimmins, 2015; Tobin et al., 2017). Additionally, evidence suggests that farmers' personal experiences with climate-related events significantly influence their risk perceptions, which, in turn, impacts the actions they take to adapt to climate change (Schattman et al.,2016).

Also, it has been observed that agriculture in the northeastern regions differs from other parts of the country in several ways, most notably the prevalence of numerous small-scale farms - the backbone of local food systems, providing essential staples such as grains, fresh fruits, and vegetables directly to local market to ensure food security for nearby communities and a rapidly growing population of novice farmers (Schattman et al.,2016; USDA-ERS, 2016). Millions of people, particularly in rural areas, depend on small-scale local farmers for their daily sustenance. They contribute significantly to the diversity and resilience of the food system, cultivating a wide array of crops that may be better suited to local climates and ecosystems than large-scale monocultures. The vulnerability of these communities is heightened when climate change disrupts

traditional growing seasons, leading to reduced yields and increased uncertainty about food availability.

While there have been extensive studies on how climate change affects agriculture in northeastern United States, few focus on Central New York and the understanding of small-scale farmers' perspectives on climate change effects on their farming practices (Lane et al., 2018). As a result, this study aims to bridge the knowledge gap by exploring how farmers in the region perceive and address climate change-related effects. Local research on climatic change is essential for the development of policies and programs that promote farmers' adoption of climate change adaptation strategies (Schattman et al.,2016).

This study uses a grounded theory approach (Glaser & Strauss, 1967) since little is known about how farmers adapt to and the barriers they face in adaptation within the Central New York region. The aim is to address these empirical and conceptual knowledge gaps. This research will be the beginning of building a theory regarding farmers' adaptation to climate change in Central New York and exploring local farmers' perspectives on climate change. The study will also investigate the impacts and challenges these farmers face and the adaptive measures they are implementing on their farms. Through a grounded theory approach, I will analyze the collected data which will offer local insights, deepen understanding, and offer practical guidance (Strauss and Corbin, 1998) needed to be taken to address the impacts of climate change on farmers within the region. Research has already shown that farmers' perceptions and interpretations of climate change are fundamental factors influencing their decisions to adapt (Arbuckle et al., 2013; Schattman et al., 2016; Mase et al., 2017; Lane et al., 2018).

II. RESEARCH QUESTIONS.

1. What are the perceptions of farmers on climate change?
2. What is the impact of climate change on farmers?
3. What adaptive strategies are farmers implementing?
4. What are the challenges/ barriers to implementing those strategies
5. How do farmers access information and share knowledge?

CHAPTER II: LITERATURE REVIEW.

To address my research questions, I first present relevant literature in chapter two, in two parts: perception of farmers on climate change, farmers' adaptation to climate change and strategies.

I. PERCEPTION OF FARMERS ON CLIMATE CHANGE.

Farmers' perceptions of climate change significantly influence how they adapt strategies to address its effects (Arbuckle et al., 2013; Schattman et al., 2016; Mase et al., 2017; Lane et al., 2018). Studies like the ones conducted by Safi et al., (2012) and Gramig et al., (2013), reveal that farmers' perceptions are dependent on their personal beliefs and geographic location and as such climate change information is relevant in local context that fits each community (Arbuckle et al.,2013; Lane et al.,2018).

In different places, farmers have divergent views on climate change and its causes. A study conducted by Prokopy et al., (2015) at six different study sites including California and the "Midwest" in the United States discovered that some farmers believe climate change is happening and that human activities are a contributing factor (Haden et al., 2012). On the other hand, research done by Gramig et al., (2013) in Indiana shows that most "79%" farmers believed climate change is a continual natural phenomenon driven by natural factors rather than human activities. Others even consider it a fabricated issue (Gramig et al.,2013). These varying perspectives and understandings among different farmers shows the need for specific plans to effectively address and discuss climate change.

However, beyond belief and geographic location, understanding the concept of vulnerability is important. Vulnerability comprises exposure - the type and intensity of climate impacts, sensitivity-how these impacts affect the system, and adaptive capacity-the system's ability to withstand climate stresses (Smith &Wandel 2006). Adger (2006) adds that vulnerability is influenced by both natural and social factors such as farmers' level of education, exposure to scientific information, and personal experiences with changing weather patterns (Gramig et al.,2013).

Additionally, Schattman and colleagues in 2016 in their research about how farmers in Vermont perceive climate change risks and the on-farm strategies they use, also proposed that climate change threats are of great importance to farmers. The decisions they make are heavily influenced by how they see these threats. This then further shows the importance of farmers' perception when it comes to climate change adaptation and strategies.

In essence, the perception of climate change among farmers is diverse and can be shaped by a combination of factors which makes it harder to develop adaptation strategies for farmers to climate change when there’s not even a consensus that it exists.

II. FARMERS’ ADAPTATION TO CLIMATE CHANGE AND STRATEGIES.

Farmers already possess rich knowledge about their farms and surrounding landscape. Yet, sustaining a skilled and ecologically knowledgeable workforce in agriculture is a key step in maintaining diversified agroecosystems, and increasing the adoption of diversified farming practices (Carlisle et al.,2019).

Adaptability as described in the IPCC 2007 and UNFCCC 2010 report pertains to the process of how farmers make adjustment either in natural or human systems in reaction to current or future threats by climate change. These adjustments serve to mitigate potential harm and capitalize on advantageous opportunities and are influenced by many factors. Adaptation practices vary depending on specific circumstances and can be either proactive or reactive responses to perceived threats. To better understand farmers' adaptation, it is necessary to determine the factors influencing farmers' adaptation to climate change and their desire to adapt, including the current social and ecological conditions and policy-related barriers (Schattman et al., 2016; Lane et al., 2019; Alfaro,2021). This examination should encompass socioeconomic variables and the presence of policy-related obstacles and opportunities that can drive the adoption of diversified management practices within farms in the Central New York (CNY) region. As such the local focus on adaptation practices including the Central New York (CNY) region is part of a broader context where the importance of promoting biodiversity extends beyond rural areas. As urbanization continues to grow, with an expected increase of 2.5 billion people in urban regions by 2050 (UNDESA, 2019), the interconnectedness of rural adaptation and urban development becomes increasingly significant

From an environmental perspective, urbanization leads to significant changes in ecological communities, alterations in microclimatic conditions, prolonged high temperatures, loss of biodiversity, and declining soil quality (Zlotnik ,2017; Egerer & Cohen,2020). In urban landscapes, habitat loss, fragmentation, and climate changes have profound effects on biodiversity and the provision of ecosystem services—these are the benefits that people derive from nature. From a societal standpoint, cities are particularly susceptible to heightened social inequality, the

marginalization of disadvantaged communities, decreased public health, limited food access, and food insecurity (Egerer & Cohen, 2020).

However, maintaining or adopting new diversified farming practices is strongly dependent on climate change risk perceptions, business pressures, profitability, market conditions, capital and labor availability, skills, and ability to participate in robust farmer and market networks (Lane et al., 2018; Carlisle et al., 2019; Socolar et al., 2021; DeLonge et al., 2016). For example, in a study examining the barriers and opportunities to adopt agroecological practices in the strawberry industry, Guthman and Jimenez-Soto found that system "lock-ins," such as limited access to land and high rent costs, are major factors hampering adoption in disease-dominated landscapes (Guthman & Jimenez-Soto ,2021). Further, in the US context, policies have tended to "deskill" the agricultural labor force (Carlisle et al., 2019), and sharp political and socioeconomic divisions contribute to social disparities that make access to critical resources almost impossible for new farmers (Carlisle et al., 2019). Hence it is important to know that the perception of climate change as a risk is a significant factor that comes before any actions taken for adaptation (Brugger et al., 2015; Schattman et al., 2016; Lane et al., 2019).

CHAPTER III: METHODOLOGY.

This research was carried out in the City of Syracuse, surrounding Onondaga, Oneida, Cayuga, and Cortland Counties. The CNY region corresponds to Plant Hardiness Zone 5b (PHZ: average annual extreme minimum temperature in a 30-year period). According to the USDA, most of CNY has already moved from 5a to zone 5b, indicating warmer winters and a study by the New York State Energy Research and Development Authority (Rosenzweig et al., 2010) identified these agricultural areas as the most likely to be impacted by climate change.

Understanding how Central New York farmers perceive climate change, adapt their practices, and the barriers they face in implementing strategies on their farms is crucial. From May 2023 to March 2024, I conducted eleven in-depth, semi-structured interviews with small-scale farmers along the region's rural and urban interface. These farmers were involved in diversified vegetable farming, with six practicing organic farming. The farmers I interviewed had extensive experience, ranging from five to over forty years.

Interviews were done in person, on Zoom and on the phone, but most were done on Zoom and phone as farmers suggested, due to their busy field schedules, the most appropriate way was over Zoom or the phone. Each interview lasted from 45 minutes to 90 minutes. Interviews helped me capture diverse perspectives and understand how farmers' perception of climate change affects their farming practices, why they make specific decisions, what obstacles they face in adapting their practices and how they have access to information.

To gather participants, I used a convenience sample obtained through social and professional networks of diversified vegetable farmers within a limited geographic region. In this

way, I can control some environmental factors common to the farms in the area. Since there are no other data sources available for this research, interviews are the best method to begin with.

I also employed purposeful sampling. This helped me identify and interview individuals who could provide in-depth information, utilizing a deliberate non-probability sampling method. As outlined by Patton (2002), this sampling approach is appropriate when targeting interviews with individuals possessing specialized knowledge relevant to the subjects of interest. The interview process was guided by the idea of saturation, which means I stopped doing more interviews when I was no longer getting new information.

Interviewing these experienced and diverse farmers enabled me to capture diverse perspectives and adaptation strategies based on the rich local knowledge of small-scale farmers in the region. Interviews were both video and audio recorded, transcribed using otter.ai software, and analyzed with Dedoose for emerging themes related to perceptions, impacts, adaptive strategies, and barriers. The consent of farmers was sought before the interview. All procedures were approved by the Syracuse University Institutional Review Board.

Interview guide.

1. How did you get into farming? How many years have you been into farming and what farming operations are you involved in?
2. What are the major crops you grow?
3. Do you own the land, or you rent? Have you had any issue with land tenure?
4. Is climate change something you concern about in your farming operations?
5. Have you been impacted by climate change on your farm. If yes
6. How is climate change affecting your farming operation and farming as a livelihood in this region.

7. What are some of the experiences on your farm and how has it affected your farming practices?
8. What are some of the adaptive strategies you have implemented to combat climate change issues on your farm. Which ones and why?
9. What are the challenges/ barriers you are facing in implementing those strategies.
10. How do farmers access information and share knowledge among themselves in relation to climate change? And how important is that for you as a farmer?

CHAPTER IV: RESULTS.

I. FARMERS PERCEPTION ON CLIMATE CHANGE.

When farmers were asked about their perception on climate change and their level of concern about this subject, all eleven farmers interviewed responded they are much concerned about it and feel the impacts on their farms. They all acknowledged that climate change is real and is a matter of great concern. Their collective agreement on this question was not only surface level but was rooted in their direct experiences over the years as farmers. Farmers expressed profound concerns about the effects of climate change on their livelihoods and the sustainability of their farming practices. As quoted by farmer 9:

> *Climate change is not something that is hidden and can't be seen. This issue is real, and its effects can be felt by me daily on my farm and I think every farmer that you talk to also feels the same way. It is a big problem that needs an urgent solution but unfortunately those who have the power to change things in this world don't see it that way. Always small farmers like me and others are most affected.*

Another farmer who has been farming for more than 30 years explained climate change is happening and over the years she has noticed and observed extreme changes. She explains it this way:

> *This climate change thing is real. When I was younger, we used to have a weather you can predict but nowadays, it's hard to know what to expect… The temperatures are higher and with my experienced as a farmer for most of my entire life, I can tell you that the seasons have shifted and is very hard to plan when you are a farmer. So, climate change is very real and is happening and we are in it…*
> *Farmer 4*

To these central New York farmers, farming itself is hard, which comes with so much struggle, combining that with the effects of climate change makes it even harder

> *I think farming is already difficult because nature dictates everything and you must be so attentive to so many different parts of nature, whether it's the plants, the soil, the air, the bugs, all of it. There's so many dynamics in farming, and vegetable farming in particular. Climate change just makes it so much harder. It's like this extra level of being on your toes and unpredictability that it really narrows what people can do. And so, I think just that extra unpredictability from climate change makes it harder to continue making decisions. So, we're just kind of always struggling with this. How complex can we be and stay sane and make a profit?*
> *Farmer 2.*

II. CLIMATE CHANGE'S IMPACT ON FARMERS

Results from the interview with farmers reveal that they are all facing the impact of climate change. Farmers expressed their concern about the drastic changes in weather patterns over the years, which is unpredictable. This was a major concern for all these farmers as it alters their growing season. Some of the concerns concerning the unpredictability of climate included the

rising temperatures and variations in precipitation. This has resulted in issues like severe droughts, extreme rainfall leading to flooding, and interruption in their crops' growing cycles.

> *Unpredictable weather conditions, something that is really affecting the farming issues over here? Yeah, I mean, things are unpredictable, and especially in our climate, it's nice to rely on winter because especially for vegetable production, the seasons, like clear delineation of seasons and predictability is really important...the temperature variations, and these really extreme swings and temperatures that we experience in a given week and then across the season, makes it really hard to plan what to plant and when, because often things are like, it gets warm, and now you have crops that aren't supposed to be ready for another month, and they're ready now. And I don't have a market for them. I don't have the ability to even sell them because it wasn't part of our sales plan or vice versa. Like things that are supposed to be ready, that it gets so hot and now it gets cold, and the plants are in shock, and they're like, I'm not going to grow now because as the weather, it was too difficult. So that's what we're facing just this week, it has been so warm and then it got so cold again that the plants aren't growing. So, they're just hanging out and now we're about two weeks behind in what should be ready.*
> *Farmer 2*

The unpredictability of the weather pattern affects the growing season by altering the planting and harvesting seasons. This, when not planned carefully, can result in the loss of your crops:

> *And some things we've had to change because pumpkins or things like that, which have like 120 days (about 4 months) growing times. We don't necessarily have 120 days (about 4 months), honestly, in our actual season. So, we do have to be selective with earlier harvest, things that we can do because, like I said, we'll get frost this week. And last year, our first frost in the fall was September 15. It's very short that we can have things out. And part of that is because of that really rapid shift that is happening, because the same thing happens in the fall. It's really, really hot. And then all of a sudden, everything we have out is dying from frost which impact our fall production pretty quickly. We end up having to do a really mass harvest, like second week of September just to make sure that we get as much product out off as we can before that potential frost happens and then if we get anything after that, we kind of consider it a bonus. But we have to, in our minds, be ready to be able to harvest all of our stuff in September*
> Farmer 1.

Additionally, when seasons change for farmers, it becomes a huge challenge for them to make decisions. For farmers, making the right decisions in terms of knowing the timing to plant, irrigate,

when to expect frost, harvest etc. is important for a successful growing season. Farmers have always relied on data from past seasons and their personal experiences over the years to make informed decisions on their farms. Still, with the weather patterns been unpredictable, it is now difficult to plan and make projections. As echoed by this farmer on the impacts on her farm:

> *One of the most difficult things about growing vegetables is timing everything. Right. You have to guess at the beginning of the season. When is the appropriate time to start all my seeds? When is the appropriate time to set up the irrigation? When is the appropriate time to plant? And traditionally, farmers have made those decisions based on data from past seasons. When the last frost will be, when the ground will thaw, what is typical for rainfall in certain times of year. So, we were not really taken by surprise by the fact that it's not been raining really very much in May. So, we weren't really prepared with a functional irrigation system in time. And so, we're really struggling to keep everything watered right now.*
> Farmer 8

> *The unpredictability of the weather like rainfall makes it difficult to really plan because where I live, and farm is different. Hence knowing when it is going to rain so you plan not to water your crops is important. Now planning and projections is very difficult.*
> Farmer 5

In addition to the concerns about climate unpredictability, farmers also faced harsh conditions of the weather which resulted in loss of their crops translating to loss of capital and investments.

Besides the impact of harsh climatic conditions and changes in season, increase in pest infestation was also a major concern that was observed from the interviews. Eight out of the eleven farmers interviewed discussed the increase in pest infestation on their farms due to changes in climatic conditions. As the traditional growing seasons change with rise in temperatures and rainfall patterns, pests that were once limited to specific regions or seasons may extend their geographic reach and become a year-round problem. Also, pests that prefer warmer climates can grow and cause more damage to crop.

> *There's a lot of new pests coming down over here and that's sort of like climate change. Things coming up because it's warming up and they haven't been before. So, we've been getting a lot of pests like the Allium leaf miner and the sweet midge, which is harming my farm...last year, I lost most of my broccoli and cabbage because of this pest. It is very worrying for me, and I don't know if I should even continue growing them or not.*
> Farmer 11

As these new pests have found themselves in the region, it is difficult for farmers to find solutions to the impacts they cause on their farms. Most farmers acknowledged that they had no idea about what those pests were which was causing them to lose their crops:

> *one of the bigger indications of just the climate shifting and rapidly warming up here is that we're having populations that are able to winter over that we wouldn't have normally had and then they're just going gangbusters and reproducing so quickly...And so pests in particular, we seem to just always be on the forefront of whatever new bad bug is in New York State. We didn't know what it was necessarily. But then when we find out, we're like, oh, look at that now we have allium leaf miner. We didn't know what that was, that was killing all of our onion plants.*
> Farmer 2

Throughout our interview, farmers frequently brought up how they lost their crops. This was in response to unpredictable weather conditions and pest infestations caused by climate change. For this farmer she has observed over the years that:

> *When you get an early fall flood, it means you must suddenly harvest everything very quickly, because if you leave it out in the field, you can't stop it after it's been flooded. And then a flood in the spring. If your farm floods after you've already planted things, that's a disaster, too. So, over the years the flood has become more extreme, and it caused a lot of crop losses.*
> Farmer 4

Another who is a diversified vegetable farmer for almost 10 years in the region also revealed that;

> *About our crops and these gap seasons because the weather variations have been so extreme that a lot of the crops can't handle it. So we lost our arugula crop. Like, we should have had spring arugula. Four days we had record breaking heat. Arugula cannot grow in that condition. And that's typically like the best weather ever for growing arugula. So I'm not going to grow arugula anymore. I'm done, I'm done. No more arugula., but it was 80 degrees in April for like four days, which is record breaking heat.*
> Farmer 2

Furthermore, another impact observed from the interview was how wildfire impacts farms and their operations.

> *A week or 2 with wildfires, wildfire smoke coming down from Canada, which is a climate change issue. And that was something new that we had to deal with. Like, figure out how to keep our workers protected. Some of our workers had, you know, health issues where they couldn't be out in that. So, we needed to send them home. And other workers just had to put on masks and work in unhealthy conditions because we had to get the food harvested for the CSA members that we promised.*
> Farmer 4

A farmer rightfully sums up the whole issue on how climate change is impacting their farming operations within the region. She says:

> *Your whole year could be messed up due to these changes like late frost or an early drought which will make you lose everything you have worked hard for.*
> Farmer 3

Despite most climate impacts as observed from this study showing negative effects on agriculture, there is a notable positive observation around New York, where warmer growing seasons benefit corn cultivation, as noted by two farmers.

> *When the weather is warm, we experience longer growing season. You know the warm temperatures can extend the growing season and this allows us to plant our corn earlier, especially in the spring and harvest later in the fall.*
> Farmer 9

> *The positive aspect of the change in weather(warm) is for grain farmers who can grow 120 days variety corn in NY, and this is good for grain in the region.*
> Farmer 6

> *You know that frost is a big issue for us farmers here but when the weather is warm, Is good for my corn because the risk of late spring or early fall frosts which normally causes damage or even kill our young corn you know is somehow reduced due to unexpected cold snaps. That is very good because at least I don't get to lose most of my crops…*
> Farmer 11.

III. ADAPTIVE STRATEGIES BY FARMERS

When farmers were asked if they are adapting to climate change and what are some of the adaptation strategies they have been using, all responded to adapting to climate change and the most common theme that was prevalent was adaptations to management practices. These included changes in the variety of crops. Farmers responded that the harsh climatic conditions impacted their crops, hence have adapted to varieties that can at least withstand some weather events.

Farmer 8 said: *"We had to start growing drought tolerant varieties that are more adapted to this our climate".* Another farmer who has not changed the specific crops she grows but has just changed the varieties said:

> *So that was like something that we did to adapt to the changes in weather. And then we haven't changed the specific crops that we're growing, but we changed the varieties in order to have them be more tolerant of those extremes, like their drought or an abundance of water.*
> Farmer 7

Farmer 1 further explained that:

> *Yeah, so we've adapted. The weather condition impacts our soil and crops which made us change in the seeds we use. As these new seeds work best over here. So, we've switched to them because it's just more of a proven seed for our climate up here. And we've had pretty good success with that compared to the old ones. We also have figured out how to do better. So, we have tried various varieties, even of certain things. For example, the peas that we initially started growing didn't like our soil, so we just switched to a different variety that seems to do better.*
> Farmer 1

Although farmers are adapting to new varieties, one farmer revealed that, *'the traditional varieties that we used to grow had a better taste but now the problem is the traditional taste of these crops*

has changed. They don't taste like the ones we used to have, and customers keep on telling me but there is nothing we can do"(Farmer 10).

Additionally, farmers expressed about having to stop growing certain crops on their farms due to the impacts of climate change which is unbearable for them. As such the best adaptative strategy for them is to stop growing such crops as said by this farmer ''*So, yes, there are some crops that we had to sacrifice"*(Farmer 4). This diversified vegetable farmer summed it up with frustration in her eyes:

> *We have decided not to grow brassicas anymore. We can't do brassicas in the spring because the flea beetle population is just unmanageable in an organic system, we do have to stop growing things because we have pests that we can't control.*
> Farmer 2

Others also pointed out that, although these new varieties can resist the harsh weather conditions, they incorporate agroecological practices to help them achieve more success with their crops. According to Farmer 2:

> *You know, we do have a very diversified farm, and we maintain, you know, a lot of diversity, not just in our crops, but in the other spaces around the farm. So, we do incorporate agroecological principles into the things that we do*.

The most common practices that farmers talked about were crop rotation, cover crops, adoption of perennials, mulching, intercropping and minimal / no tillage.

> *One thing we've done is over the past couple of years, we've started cover cropping more things over the winter to try to help fix some of the nutrients in the ground.*
> Farmer 1.

Farmers explained that mulching reduces water evaporation and helps retain soil moisture, especially during the drought season, and suppressing weed growth. Also, cover crops help protect

the soil from harsh conditions such as erosion and those who practice organic farming particularly stated it suppresses weed growth. For farmer 5:

> *I use cover crops a lot. Growing these cover crops can help suppress the weeds. On our farm, we don't use herbicides because we are purely organic and the cover crops are a huge help for us and I tell you, the cover crops are also good for improving the condition of our soil.*
> Farmer 5

Additionally, farmers responded that crop rotation helps to reduce pest and pathogen infestation impact on their crops.

> *''We do a lot of rotation on our crops to avoid these pests that we are fighting. One thing that is common and we have noticed is, some pests are very crop- specific and this enables them to thrive more and more when the same crops are planted repeatedly. So, what we have done is rotating these crops and this disrupts their life cycles. When the life cycle is disrupted, their numbers are reduced as time goes on, so these are some of the strategies we have been adapting to avoid pathogen pests and pathogen issues".*
> Farmer 3

According to farmer 2:

> *I normally rotate my carrots with lettuce and tomatoes. Is very good for the soil health and these pests and disease pressure on our farm. On our field, we planted carrots and carrots improves the soil aeration since it's a root vegetable it breaks up the soil. But when you continue to plant carrots on the same field every year, it leads to the increase of these diseases like the rust fly and other nematodes and so what we do is, we rotate the carrot field with lettuce the following year. Lettuce has a shallow root system than the carrots and so they are able to disrupt the life cycles of these pests that cause damage to the carrots, you know because when they come they do not find their preferred host…Lettuce grows quickly and cover the grounds and this is helpful for fighting weeds…Then the next year we use tomatoes on that same field. Tomatoes are different from carrot and lettuce and their nutrient requirements are different too. This helps to balance the nutrient profile of our soil…Well, I do think diversity is important in breaking the cycles of pests and pathogens that are specific to the previous crops.*
> farmer 2

Furthermore, the addition of organic matter to the soil improves its vegetative cover. With crop residues, it prevents soil exposure to harsh climatic conditions and keeps the soil moist and suitable

for the crops, especially during the drought season as revealed by these farmers. Farmer 1 responded,

"We leave crop residues to incorporate into the soil. Like we'll plant radishes in the fall, but we don't harvest them, and we let them just stay over the winter. In September, we will plant one of those barley type cover crop mixes and we'll put that on and let it grow which stays over the winter. This helps lock in the moisture with the clay so that when spring comes, we're not already dealing with dry, cracked ground".

Another farmer stated it plainly:

> *Yeah, I guess last year during those rainstorms we saw just how successful the intentional application of organic matter into the soil in maintaining vegetative cover and cover crops. Because we do have a tributary that goes to Onondaga Creek in our woods, and it never floods. So, the runoff from our farm was not flooding that creek. So, we were actually holding all of that water on site. So that just told me a lot. But then also on the flip side, when we had some of those drought years, those same areas where we had applied heavy wood chip as mulch. If you put your hand six inches into the soil, it was still moist. So even without four weeks of rain, the soil is moist so that is why we are just putting so much organic matter down whenever we can get our hands on it and it takes years to get to where we need to. But this system that I have of this wood chipping and every two years we flip it in is helpful in building soil matter and our crops are really happy. That is one of those strategies we have been using".*
> Farmer 2

With the addition of wood chippings into the soil, farmer 5 echoed that for their farm, "We *inoculate our wood chips with fungus, that is the beneficial fungus pathways to embrace, you know, mycelium into our soil community which is good for soil fertility".* Farmer 3 went ahead to explain that ''*Soil amendment practices such as addition of chicken and goat manure into the soil helps improve the soil nutrient. We have chickens on the farm as well. So, what we do in the fall is we let them go, we rotate them into the fields that are done producing and let them kind of go through the field. So, they're reintroducing nitrogen in their natural way."*

In essence, the application of organic matter into the soil, whether wood chipping, crop residues or organic manure improves soil fertility.

Similarly, in response to observed changes, farmers have already begun to plant crops earlier in the spring and harvest later in the fall. Essentially, these agroecological practices increase the overall resilience of farming systems. They help to make agriculture more climate-adaptive by improving soil health, water management, and biodiversity, which benefits farmers and the ecosystem in the long run.

Besides adapting to new varieties, changes in crops grown and agroecological practices, another strategy farmers have adapted to is the use of climate-controlled environments like greenhouses. According to the farmers, these greenhouses allow them to cultivate their crops throughout the year. As rightly explained by this farmer:

> *The ability to have a greenhouse on my farm is a great help to me down here. I'm able to grow crops at least throughout the year. This helps me to supply my customers with fresh produce, which I don't think, based on the extreme heat waves we have been experiencing over the years, would have been possible.*
> Farmer 9

In the same way, another farmer further revealed that, for her the use of greenhouse enables her to grow and harvest throughout the year, especially high value crops within the region which ensures a steady supply of fresh produce to her customers:

> *So, things like Okra that are really high value to a lot of our customers but don't grow well in the Northeast, not for very long. We have a short window, but if I grew them in a climate-controlled environment, I could get a longer crop out of them.*
> Farmer 2

For this farmer, the use of greenhouses is '' *beneficial for meeting market demands*'', as it allows him to cultivate crops and supply them to the region that would otherwise be unavailable during certain seasons.

Similarly, others talked about the importance of having greenhouses on their farms in context of pest and disease control. For this farmer, greenhouse ‘’*reduces exposure to pests and diseases and which minimizes the need for pesticides”(Farmer 9)*. This is because the nature of greenhouses reduces the need for constant application of pesticides, as pests and diseases are less likely to infiltrate the controlled space.

Subsequently, farmers revealed they are adapting to climate change by making significant investments in irrigation systems and infrastructures such as building of wells. One farmer emphasized the importance of these investments, stating: ‘’*Investing more in your irrigation systems is of great importance* due to the ongoing drought over here*”*(Farmer 10). Another farmer detailed the major changes they’ve implemented to ensure water availability on the farm:

> *Yeah, well, the most major change is that we've invested in infrastructure. Like, essentially, we've just built wells and have intensive drip irrigation systems with timers and sprinkler systems for ones that aren't on drip. So, for example, our carrots aren't on drip, but they get sprinklers. Building a well is about like $10,000, and we've built two wells so far on different sides.*
> Farmer 7

These strategies are crucial for maintaining the sustainability of their agricultural operations amidst changing weather patterns and prolonged droughts. Investing in these drip irrigation systems deliver water directly to the root of their crops and not only that but these methods significantly reduce water wastage compared to traditional irrigation practices, ensuring crops receive adequate moisture during dry period. Another farmer shared their experience explaining that:

> *The first couple of summers on the farm were actually really dry but we were fortunate to have two ponds on the property, allowing us to irrigate from our own water supply. We use the irrigation system to manage the inconsistencies in weather since hand-watering isn't practical. And then if it doesn't rain for a week, it's literally like trying to grow stuff in stone. The soil becomes very hard, making it difficult for crops to grow. Many vegetables really do not have deep roots so when there is drought, they will dry out and die within four or five days, so we have to run the irrigation system regularly which is helpful.*
> Farmer 1

Lastly, another fascinating strategy that farmers have adopted to combat the impacts of climate change is through collaborative strategies and community building. For local farmers, this strategy is critical to sustaining their livelihoods and ensuring food security in the region. As explained by this farmer, ‘’c*ollaborations with these organizations, research centers and even among ourselves help us to find solutions to our on-site problems” (*Farmer 9). These collaborations enable them to get access to funding which helps to purchase or assist in investment of structures or equipment to adapt to climate change as rightfully said by this farmer ‘’*We work with organizations like the Natural Resource Conservation Services and Soil and Water Conservation District in order to implement additional conservation programs and provide funding for those. (*Farmer 7).

Others are engaged in agricultural cooperatives and community-supported agriculture (CSA) initiatives which serve as effective ways to build economic resilience among themselves. For the farmers who are part of a cooperative, *it enables farmers to pool resources, share risks, and access markets collectively (Farmer 11).* This improves their bargaining power and reduces individual financial burdens as they can invest in shared equipment, labor, adding value to their produce and increasing profitability. One farmer stated:

> *Just like working together, we have developed a collective care strategy that all our farmers are able to assist one another. If one is watering his crops and another is free, one can request assistance from the other. Like, can you come help me out when you when I need this done because there can be like a late hard frost, there can be, like suddenly, an unexpected amount of Labor. Just like working together to like to make sure that Labor is met. This helps them share ideas”*
> (Farmer 5)

The CSA programs enable them to obtain direct access to the market for their crops as echoed by this farmer ‘’s*o we have during the peak season, we were pretty good at distributing most of our*

products. We have enough market for it because we have a CSA. So we have our farm stands, and we have CSA"(Farmer 2) but not only that according to this farmer, "the CSA *creates this strong connection or you know this strong bond between us the farmers and the locals*(consumer)(Farmer 3)" ''*which is good for our local economy because it gives us a stable market"* (Farmer 4).This reduces the dependence on external markets for food which contributes to local food resilience.

Additionally, some of the farmers have been taking creative approaches to subsidize/finance their diversified farming operations. For example, some farmers emphasized the use of high-value crops such as hemp as revealed by this farmer ''*So, like any of the vegetables that grow in upstate New York, we grow blueberries, we grow hemp for CBD oil". Others are also engaged in* on-farm programming such as classes, tourism, etc., as part of their way to adapt to changing conditions, high costs in offsetting crop yield loss, among others. To this farmer, "*we use those county and federal programs to compensate for the cost of doing those conservation practices" (*Farmer 7). This farmer summed up the importance of community building:

> *We build a very strong community, a very strong resistance community to be able to overcome these issues that are important. We're not gonna be able to address these issues alone, working together on how to address things is the way to go.*
> Farmer 10.

IV. BARRIERS / CHALLENGES TO ADAPTATION.

Farmers interviewed responded that the most common barrier to implementing their strategies is financial constraints (Cost). One farmer noted ‘’*adaptive strategies are extremely expensive and require capital”(*farmer 6). These strategies according to the farmers are necessary for significant investment in infrastructures, equipment, seeds, acquisition of organic materials and many more. For instance, one farmer explained:

> *Farming itself is costly and to implement any adaptive strategies it requires extra finances which makes it more of a burden. Irrigation systems, compost materials and greenhouse all involve a lot of money to do so*
> Farmer 8

Another farmer further elaborated on the high cost of adaptive equipment and infrastructures particularly greenhouses:

> *We're still running off essentially just still investing our own money. We definitely would benefit from having equipment and infrastructures such as more greenhouse space yeah, but again, that's costly. Greenhouses are extremely expensive to acquire.... for instance, you still have to come up with the $30,000 up front... and for farmers, they don't tend to have a lot of collateral other than the farm itself to put up. So that's definitely difficult.*
> Farmer 1

Additionally, another farmer highlighted the challenges posed by the lack of affordable equipment for better crop management. She said:

> *It's like some of our better-covered crop strategies require expensive equipment which we cannot afford now.” Also, we don't have our own dump truck, so we're too small to have large equipment like that. We don't have a big tractor. We must move wood chips and compost but rely on outside sources of transporting compost to our site because we don't generate enough for our own use. We could have done a better job if I had access and more ready access or if it was less expensive. So that's just a challenge getting organic matter to our site at a reasonable price.*
> Farmer 2

Moreover, some farmers expressed concern about the high cost of sustainable practices which makes it difficult to stay true to the mission, especially those into organic farming:

> *It's difficult in staying true to your farming practices (Organic farming). A lot of these adaptations would be much easier if we were using roundup ready seeds that were drought resistant and everything else Monsanto's made seeds that can uphold through all that stuff, but we're adamant that we don't want to do that. The organic side of things makes things a lot more difficult for us to try to stay true to that mission*
> Farmer 1

Sustainable farming practices, ''although *are very beneficial when you consider the long-term impact especially in this climate, but it is financially stressful if you don't have enough support"*(Farmer 9).

Since cost is the major barrier to adaptation, ''*it influences most of our decisions, you make decisions based on the money you have available"*(Farmer 3).

Besides cost, limited access to financial resources and funds from the state was also a barrier for farmers. Farmers have already mentioned that adaptive strategies require substantial initial investments that the majority of them cannot afford. For instance, irrigation systems such as drip irrigation, which use water more efficiently during droughts, require not only the purchase of specialized equipment but also installation and maintenance costs. Similarly, constructing greenhouses to protect crops from extreme weather conditions to aid in all year-round production demands significant capital, often costing tens of thousands of dollars. Access to financial resources, especially support from government and institutions, is important to aid farmers' access to financial resources. For example, farmers explained that ''*such support is limited to them'"* (Farmer 3*)*. ''*Subsidies, grants, and insurance schemes which are designed to help us farmers most*

importantly in the phase of climate change to adapt, often we cannot access them because of these bureaucracies"(Farmer 10). For this farmer *''because we are small scale, most often we don't qualify for most government subsidies which are directed towards the big Ag. folks" (Farmer 11).*

Another farmer also elaborated that:

> *often people kind of expect farmers to just be able to fix these things, but it's really hard when we don't have enough funds even to keep our farms going and to also deal with these other larger issues. I think that farmers already do a lot and most of the grants are set up for large scale farms. They don't have any way to help, smaller farms who are ecological. They're like, oh, you're already doing fine. You're small, you don't need anything, you know. So, you know things are not set up in terms of government assistance to help people who are oriented towards good ecological care to improve their systems.*
> Farmer 4

From the interviews conducted, only two farmers revealed they had one-time access to funds from the state and even it is complicated:

> *We actually applied for and got a grant for greenhouses through the National Resource Conservation System as part of the USDA. So we received a grant from them. But the way even that grant works is...we have to pay for it up front and then get reimbursed... for instance, you still have to come up with the $30,000 up front even though you know you'll get it back. You can't get it back until construction is completed. So even when you can use resources like AG, resources that are out there, it still is cost prohibitive in the beginning upfront, it still is hard and for farmers, they don't tend to have a lot of collateral other than the farm itself to put up. So that's definitely difficult.*
> Farmer 1

However, not only limited access to state or federal funds but also the acquisition of loans is a challenge for small-scale farmers, especially vegetable farmers. This is because, most of these farmers, lack the collateral required to secure loans as further elaborated by this farmer:

> *Getting these agricultural loans is not easy...It normally requires you to have your own land or other assets which is significant as a collateral, but you know, I don't own this land and so how can they give me loans... which many small farmers do not possess.*
> Farmer 11

Even when they quality for these loans because they own the land, ‘’*farming is very risky and you don't know what to expect when it comes to your crops, you're thinking the weather conditions are unpredictable and pests which you might lose your crops* ...’’ (Farmer 8). This makes lenders wary of providing credit.

Farmers further revealed that the financial barriers to adaptation not only affect their immediate ability to respond to climate change but also have long-term implications for agricultural sustainability. This is because, ‘’*when we are unable to invest in adaptive strategies, our crops will be affected, see our yields will be reduced which is going to affect our food security and you know already the issue of food insecurity here in Syracuse..."(Farmer 11)*, ‘’*our soils will be affect*’’(Farmer 5) *and there will be an increased vulnerability to extreme weather events which is bound to happened and is not good..."*(Farmer 9).

Thus, without access to sufficient financial resources and adequate government intervention, many farmers remain financially and climatically vulnerable.

In addition to cost and limited access to financial resources and government intervention, farmers revealed lack of access to labor as a barrier for them to adapt to climate change.

According to them, ‘’we *want to implement strategies for like soil health and resiliency, but it requires having more labor on the farm which currently we cannot afford"(*farmer 5). These farmers revealed that labor is expensive and most often it limits them from hiring additional labor because as small-scale farmers, they operate on thin margins which makes them vulnerable and with the cost of production often times higher it doesn't match their sales, especially the vegetable

farmers. Additionally, with the competitive labor market dynamics, it strongly impacts farm labor availability and cost. One farmer explained that:

> *Climate change impacts is not only affecting us farmers but other sectors as well and with developments all over here, you can see that, its absorbing a lot of the work force and so, there is this big competition which makes labor very costly and most people don't want to be in the agriculture work force especially the youth and now that micron is coming, how many youth wants to come and work on the farm? So is a problem, a huge one.*
> Farmer 9

Also, small-scale farms lack extensive machinery and most automated systems, farmers mostly rely on manual labor for planting, weeding in organic farms, harvesting, farm maintenance and with the limited resources at their disposal, ''*acquiring more workforce to help them becomes a challenge"* (Farmer 11). The lack of financial resources to invest in labor-intensive adaptation measures leaves them unable to respond effectively to climate change. As a result, some of them try to use volunteers and sometimes internships which is not sustainable:

> *This is an issue because labor is expensive and sometimes, we normally use volunteers from university students and internships, but it is not sustainable. Also, to get people to work on your farm becomes a big challenge.*
> Farmer 1

Further, adapting to new practices, building infrastructure and usage of new equipment is labor intensive which requires more work force and not only that but as echoed by farmers, ''*agricultural labor is highly seasona*l''(Farmer 11) and normally the peak seasons for them is during the planting and harvesting periods. As climate change continues to happen it disrupts and alters their season which causes major changes in their planting and harvesting times which makes it difficult to plan and as such "i*t's really hard to find people to work on a farm during such moments" (*Farmer 8) eventually leading to shortages in labor availability and demand. These dynamics between labor

shortages and changes in their season result in delayed planting or harvesting, adversely affecting their crop yields and farm income.

Similarly, farmers revealed that '*farming is already a stressful profession, like, it comes with more stress"* (Farmer 8) and is *''intense, you find yourself outside for longer periods whether in the cold or the hot weather which comes with a lot of health risk."*(Farmer 11). Climate change exacerbates health risks for farmworkers, including heat stress, respiratory issues among others from increased air pollutants. These health risks impact labor availability and productivity ''*which just makes it really hard to justify continuing farming or working on the farmer"* (Farmer 8). For instance, as revealed by this farmer during summer 2023:

> *''A week or 2 with wildfires coming down from Canada, which is a climate change issue. And that was something new that we had to deal with. Like, figure out how to keep our workers protected. Some of our workers had, you know, health issues where they couldn't be out in that. So, we needed to send them home. And other workers like they just had to put on masks and work in unhealthy conditions"*
> Farmer 4

As such prolonged exposure to unfavorable weather conditions such as extreme cold, high temperatures can cause heatstroke and other health complicated conditions among workers, thereby preventing people from venturing into agricultural worker force (farm labor).

Furthermore, farmers talked about the lack of access to affordable and quality land. Land is an important resource for farming and without access to it, farmers struggle to grow crops which impact their yields. As revealed by farmers when interviewed, land tenure issues are a major concern to adapt to climate change. Many farmers work on rented lands rather than owning it, and this creates uncertainty about their long-term access. From the interviews conducted, only six farmers own their farmland. Without access to land or owning farmland, farmers are not committed

to invest resources in long-term adaptive measures such, infrastructure improvements, soil conservation methods and many and as a result exposes their farms to the impacts of climate change. One of the farmers further explained:

> *Access to land is a huge one, and not only finding land, but finding land that is favorable like leasing or purchasing condition. I didn't have long term access to my land. It was just like a year-by-year verbal agreement and once I started understanding more of these strategies and utilizing like all the benefits that perennials provide and how resilient they are, I realize that it doesn't make sense for me without having long term access to land and to invest in growing. There is that issue that you know access to land and namely long-term access to land really prevents people from having these resilient strategies. I also see a lot of farmers move from one land to another. So, there's a lot of like moving around, which is a big endeavor as you can imagine.*
> Farmer 5.

Farmers also explained that without access to quality and affordable land, adapting to climate resilient practices is a challenge. Some elaborated that, *"you need land to implement strategies such as build greenhouse, and land has become expensive due to developmental projects"* (Farmer 10). Because of climate change, there is a lot of migration to urban areas and as a result there is an increase in urban expansion (Adger et al., 2020) and developmental projects which is resulting in the conversion of available agricultural land alongside the predatory practices by big companies on local farmers to access their lands especially the ones who rent their lands (Potteiger & Weissman, 2021). This has led to the increase in prices of land which eventually limits their financial capacity by draining them to invest in adaptive technologies and practices such as installing irrigation systems, purchasing drought-resistant seeds, greenhouses, building of wells among others as revealed by the farmers. This makes them struggled as noted by this farmer:

> *We don't have access to land especially now, I mean, this is just kind of a regional thing in Syracuse, but are you familiar with the development project that's happening in North Syracuse? So, like, just in the last year land has the value of land around Syracuse has, like, gone through the roof. Yeah. So, we are struggling and don't really know what we should do.*
> Farmer 8

Another explains further that:

> *I see most of our agricultural lands converted for development and sold to solar companies. These companies cause damage to the soil which cannot be recovered.... predatory practices by big companies and firms targeting struggling farmers promising them huge incentives/money is worrying.... The value of land has increased more than before ….*
> Farmer 1

Lack of access to affordable and quality land limits the ability of farmers to expand their operations or even implement practices such as crop rotation and fallowing, which are essential for maintaining soil health and resilience to climate variability.

Also, the lack of access to local technical expertise was raised as a barrier. Some farmers revealed that climate is happening, and they need local expertise to help them with solutions on their farm.

> *Farming is difficult to be sure if something you have learnt will work. Because if something doesn't work, it's hard to know why there's so many factors that influence the way that a plant grows that it's difficult to ever be fully certain that you know exactly what you're doing. And so that makes it kind of intimidating to try new things along that same line. Even if you say you go to a conference and you're educated about some new strategy for cover cropping or new strategy for soil for moisture retention, it's very unlikely that the person who's giving that presentation telling you about that strategy has the exact same conditions that you do on your farm. So you're like, well, gosh, that sounds like it's working great for you, but my soil is different, or I have different pest issues, or for whatever reason, something might not work, and just like, yeah, finding the time and people with the knowledge locally to try these things on your farm is really a challenge.*
> Farmer 8

Others expressed the lack of support from their local agricultural extension services. This farmer sums it all up:

> *My county doesn't have a lot of support for vegetables. Our local cooperative extension like there just isn't a lot of vegetable firms around here, so they're very much more oriented towards dairy and big farms. They're not as helpful to us vegetable farmers. My experience and the experience of other small-scale vegetable farmers. When we go there,*

they say to us you're too small. We don't consider you a farm, so we are not gonna help you, or they will say I will write it down, and then they will never call you back, so they do not help us with anything. They only will work with big farms
Farmer 4

Lastly, some of the farmers explained that lack of access to markets was a barrier, especially during the winter season. According to some of the farmers, climate change is causing more unpredictable and extreme weather patterns. This unpredictability can lead to crops maturing faster than expected. The shifts in weather conditions can also affect crop yields, making it hard to maintain a consistent supply of produce. This variability can result in periods where there is either too much or too little produce, disrupting the balance of supply and demand. This farmer sums up the whole situation:

So, we have during the peak season, we were pretty good at distributing most of our products. We have enough market for it. But it is because we have a CSA. So, we have our farm stands, and we have CSA, but then we got people who want to buy it from us. Our challenge is when we do not have during the winter months and these shoulder seasons where we have a very small-scale CSA, but it gets like to sometimes we do not have enough volume. Sometimes, like I said, the weather changes and all of a sudden, a thing that I was planning on to distribute in three weeks is ready now, but I don't have a market for it. So, the winter months and the shorter season months are very hard, either we do not have enough or often we have products that we cannot sell because most other places do not. There is not a lot of New York farms that are in production in the wintertime, so there is not really markets that are ready for them. So, you must create your own. But that means going it alone. That means you do not get support from other farms to do it. Sothat iss challenging
Farmer 2

V. ACCESS TO INFORMATION AND KNOWLEDGE- SHARING.

For farmers in Central New York in my study, accessing relevant information on climate change is crucial to adapting their practices. When farmers were asked about how they access information in relation to climate change's impacts on their farms, they revealed that, they get information through Cornell Cooperative Extension which provides farmers with up-to-date research, educational programs tailored to local agricultural conditions. These services often include workshops and seminars. Aside from the Cornell cooperative extension, most farmers talked about local organizations such as Northeast Organic Farming Association of New York (NOFA-NY) providing an avenue where they can access information. NOFA-NY host events and provides resources that help farmers understand and adapt to climate change. As one farmer stated, "*Through farmers organizations, like NOFA, we benefit from shared knowledge and resources. They hold winter and summer conferences that are incredibly helpful for addressing these farming challenges we are experiencing here*"(Farmer 1). By participating in these programs, *we stay informed about the latest developments in climate science and agricultural practices which are helpful for this region"* (Farmer 9*).* Another farmer further explained that sometimes conferences, workshops or seminars are far from farmers and most importantly during ‘’ the *summer which is a busy season for us where the program is happening, the closest place or farm is 100 miles away. If you are a farmer, you are not going to travel 100 miles to another place in the middle of growing season"*(Farmer 2). Because of this, farmers utilized online resources. For them in this digital age, online resources have become valuable to them. They access websites like the Cornell Climate Smart Farming program which offers tools and resources specifically designed for New York farmers. Others revealed*, ‘’we join online forums and social media groups where they get to share experiences, ask questions, and receive advice from peers and experts"* (Farmer 3) and ‘’*make use*

of local media outlets and subscribe to agricultural magazines, newsletters which feature articles on climate-related issues, success stories, and expert opinions''(Farmer 4) that are relevant to the farming community.

In addition to accessing information through online websites, informal networking with other local farmers was disclosed as a crucial way for information dissemination. As said by this farmer, ''t*here's informal sharing when we run into each other at the market or sometimes* at community events''(Farmer 2) and another explained that'' *we are a farming community. So, there are other local growers that we know that we kind of talk to informally. Just our community is an agriculture type community"* (Farmer 1). According to other farmers, relationship building is very important ''*I do get information about new practices, mostly from other farmers, like a lot of word of mouth. So having personal connections with other farmers, organic farmers in the area, has been important for me. And learning how to farm, but then also learning how to deal with new challenges that come up"*(Farmer 7). For some ''*if you have good relationships, you could just call them and text. So, I text other farms all the time as needed. But yes, that just takes effort to make sure you are going out of your way to build that relationship"*(Farmer 2).

Moreover, farmers revealed that Central New York has the presence of educational institutions and research centers that focus on agricultural and environmental sciences. For instance, the State University of New York College of Environmental Science and Forestry (SUNY-ESF) provides insights into climate trends and adaptation strategies relevant to the region, likewise Syracuse university. Farmers access valuable information through university publications, research reports, and collaborations with academic researchers. Additionally, another farmer disclosed they ''*linked up with the National Resource Conservation Service and the local*

Agriculture office. So, we have worked with them a couple of times on questions that we have had" (Farmer 1).

In summary, despite all the challenges faced by farmers because of climate change impact, "*local farmers build communities that are really supportive of each other, and this enables us to share and access information*"(Farmer 1) as shared by this farmer.

CHAPTER V. DISCUSSION AND CONCLUSION.

The results from this study clearly show the farmers I interviewed perceive climate change as real and they acknowledge it is a great concern and is negatively affecting their production and livelihood. Their collective agreement on the impact was not only on the surface but was rooted in their direct experiences over the years as farmers. As a result, they make decisions based on how they perceive the impact over the years on their farming system. This finding agrees with studies conducted by (Schattman et al.,2016) which show that farmers' personal experiences with climate-related events significantly influence their perceptions, which, in turn, impact the actions they take to adapt to climate change. The farmers interviewed for this study were more progressive towards their perspectives on climate and are engaged in diverse practices compared to the typical conservative farmer found in the United States.

Also, farmers perceive they are vulnerable to these impacts by climate change, whether drought, flood or adverse climatic conditions, their crops and livelihoods are vulnerable to losses. This further falls in line with findings by Schattman et al., 2016 which they proposed that climate change threats are of great importance to farmers. The decisions they make are heavily influenced by how they see these threats. This then further shows the importance of farmers' perception when it comes to climate change adaptation and strategies.

Findings from this study further revealed that climate change has a massive impact on these small-scale local farmers who produce most of the local food in the face of harsh climatic conditions and socio-economic barriers. These farmers provide produce and food to communities and their residents, who already experience high rates of food insecurity. By extension, if these farms are struggling, that does not bode well for the people who get produce from them. Against

all odds, they still navigate through this challenging circumstance to adapt strategies necessary for continuation of food production to feed the various local communities.

Additionally, as revealed in this study, the major impact of climate change on farmers is more of climatic conditions such as the unpredictability of the weather impacting growing and harvesting season. Concerns identified in this study pertaining to weather unpredictability were rising temperature and variations in precipitation, leading to severe drought and adverse rainfall resulting in flooding. However, pest infestation was identified as a major impact due to climate change variations causing these pests to extend their reach causing more damage to their crops. Interviewees explained about how both extreme weather patterns and the pest infestation cause more havoc to their cropping production leading to loss of crop yields which eventually translates to loss of capital. These findings are similar to the findings from the study conducted by Lane et al., (2018) where they identified extreme weather events alongside pest infestations due to climate change to be detrimental to farmers and their operations. Already farmers see farming as a difficult occupation from the interviews conducted, however the impact of climate change has been extremely stressful for local farmers in central New York as observed in this study.

Although the study reveals more negative impacts of climate change on farmers, one potential benefit was recognized regarding the warmer growing season which is longer for corn farmers within the region. This further shows decisions and adaptations to climate change impacts on crops might be region specific which might need to be considered. This finding aligns with research conducted by Lane et al., (2018) that other participants in their research recognized potential benefits and opportunities arising from changing climate most especially when it comes to the advantage of longer growing season.

As observed in this study, we found that farmers are taking adaptive strategies in the face of this impact on their farms. Farmers are also adapting by changing the crop variety they used to grow to the ones that can withstand the harsh weather conditions within the region and others too have stopped growing certain groups as it is unbearable for them to keep up with the effects of climate change on their farms. The findings further reveal that agroecological practices are the most effective strategies they have adopted. These agroecological practices are crucial to address these impacts. For farmers it is not just about growing crops; it is about farming in a more sustainable way that would not bring more effects on their farms. This helps in dealing with the effects of climate change and makes farming systems strong, providing support to farmers' resilience to external shocks while provisioning culturally appropriate food (Petersen-Rockney et al.,2021). Most farmers in this study are adopting crop rotation, cover crops, organic matter additions, intercropping, mulching, and minimize/ no tillage. (Tobin et al., 2015; Lane et al., 2018).

I further observed in this study that farmers are investing in climatic control environments such as greenhouses. As revealed by the interviewees, the use of climate control environments enables them to cultivate a wider variety of crops that might not naturally thrive in the region's unpredictable climate, and this helps expand their market reach to the people within the region. Similarly, greenhouses as found by the farmers, aid in the control of pests and diseases. Their ability to produce crops throughout the whole year with minimal disruption from pests and diseases leads to an increase in yield which enables them to supply the region both in and out-of- seasons. This translates ''to massive economic benefits'' for them which reduces the financial strain associated with off-seasons. This economic stability allows for reinvestment in farm infrastructure, adoption of new technologies to combat climate change, and overall improvement in farm operations.

In the same way farmers are making investments in irrigation systems and infrastructures such as building of wells. These strategies are important for the sustainability of their farming operations, preventing wastage of water and conserving water especially during drought seasons.

Despite the investment in greenhouses and irrigation systems, it was found that farmers have adopted collaborative strategies and community building to combat the impacts of climate change. They do this through collaborations with local research centers and organizations which provide support and funds to help them secure equipment and farming materials among others to adapt on their farms. In addition, they are engaged in agricultural cooperatives and community-support agriculture initiatives which serves as a model for sharing resources and accessing markets, especially during the winter seasons when there are few markets. This helps reduce the dependence on external markets for food supply during those seasons and build local food systems and the economic resilience needed to adapt. Likewise, they deploy creative approaches such as diversification into high-valued crops like hemp, perennials and other educative on-farm programs and tourism to subsidize the cost of farming operations. As noted by farmers in this study, collective strategies and community building are excellent approaches for fostering resilience, resource sharing, and knowledge exchange. This not only promotes efficiency but also cultivates a sense of shared responsibility among the community. Farmers are implementing adaptive strategies based on immediate, localized concerns which are similar to the findings by (Arbuckle et al.,2013; Haden et al., 2012).

In as much as farmers are adapting to climate change, they are faced with challenges or barriers that impede them from successfully implementing these strategies. Findings from this study reveal that the major barrier to farmers implementing adaptation strategies is financial constraints(cost). As revealed by farmers, adaptive strategies are extremely expensive and require

capital to do that. Acquiring climate control environment such as greenhouse, organic materials, irrigation systems, trucks for farming, new variety seeds, and many are expensive. This makes adapting and maintaining sustainable practices hard and cumbersome. Findings from this study is similar to the study conducted by Lane et.al (2018) where they found that, farmers inability to adapt to climate change such as the use of cover crops among others is based on financial constraints. Likewise, the same findings from a study conducted by Takahashi et al., (2016) on climate change perception of New York farmers revealed financial constraints as a major barrier to adapting to climate change.

Apart from financial constraints(cost), limited access to financial resources and funds from the state was observed as a barrier to adapting. Adaptive strategies are costly and without financial resources, it becomes extremely difficult. Farmers in this study already revealed that farming costs a lot, rent of land, equipment, materials among many and as such having access to financial resources, for instance support from government or state institutions funds, is a great way to help them adapt but as small-scale farmers it is difficult to access these funds because most often they do not qualify for most government subsidies which are directed towards those in large and industrial agriculture. From the study, only two farmers revealed they had a one-time fund from the government. Also, the acquisition of loans is a challenge for small-scale farmers, especially vegetable farmers. This is because most of these farmers lack the collateral required to secure loans, as most interviewees do not own the land. As revealed by the farmers, agricultural loans typically require land or other significant assets as collateral, which many small farmers do not possess. Even when they do, financial institutions view farming as a high-risk business due to the risk of crop failure as a result of unpredictable weather conditions, pest infestations which makes lenders wary of providing credit. This limited access to financial support prevents farmers from

purchasing necessary equipment, seeds, and other inputs essential for climate adaptation. The findings from this study are not surprising given that Guthman and Soto-Jimenez- (2021) study found that system "lock-ins," such as limited access to resources (land) and high rent costs are major factors hampering the adoption of agroecological practices.

Thus, without access to financial resources and government interventions and farmers become financially vulnerable and creates a vicious cycle where financial constraints lead to decreased productivity, further reducing farmers' ability to purchase the necessary equipment and other inputs essential for the implementation of these critical adaptive measures.

Additional findings from this study found that farmers in the region face the challenge of limited access to affordable and quality land. Land is an important resource for adaptation and without access to it, farmers are limited to implementing adaptive measures in their field. When farmers do not own their lands, they are not committed to investing in long-term adaptive measures like building climate adaptive infrastructures and soil conservation methods. Farmers further revealed that the limited access to land could be attributed to the conversion of available lands for development projects and predatory practices by corporations for the land of struggling small - scale farmers especially the ones who rent their lands. This has an impact on the local food production and overall food system.

Despite the importance of agriculture for the region's economy, farmland is increasingly being lost to commercial and residential development alongside pressure from the solar industry in recent years (Potteiger & Weissman, 2021). Good quality farmland is the first-choice site for solar development, and this agrees with the analysis by Katkar et al., (2021) which reveals that, solar development in New York suggested that 44% of projects were built on crops, pasture, or hay

land, and 58% of solar projects were built on excellent quality soil, defined as prime farmland or farmland of statewide significance.

In New York State 65% of farmers rent land from a mix of active and non-operating farmland owners, and the percentage of farmland that is rented varies by county (USDA,2017).Pressures from urban residential development, together with the “Solar for All" program by New York State, has significantly increased the demand for renewable energy, with a rapid expansion of solar companies, which require a significant amount of land to build solar farms, and this is a big challenge for the local food system and local farmers. On top of that, the prices of land over the years have increased tremendously, limiting the financial capacity of these farmers by placing a heavy burden on their ability to invest in irrigation systems, tolerant seeds, greenhouses among many.

Therefore, access to land is critical for farm operations, particularly for new beginnings and farmers of color who often cannot afford to purchase the land outright. For minorities and new farmers, the availability and accessibility of suitable farmland makes solar farming an important threat to equity, justice, and sustainability for the county. Loss of rented land can be devastating to a farm business, food security, and rural livelihoods (Katkar et al.,2021). This finding is similar to Guthman’s and –Jimenez- Soto's (2021) which reveals that system “lock-ins,” such as limited access to land and high rent cost are major factors hampering adoption of agroecological practices. Protecting farmland is essential to maintaining a viable agricultural economy, securing farming livelihoods, and ensuring an equitable and resilient food system (Katkar et al,2021).

The results from this study also indicated that lack of access to affordable labor was a challenge for farmers to adapt. Already farmers have revealed that farming is a labor intense occupation and without extensive machinery and automated systems, it becomes more tedious.

Likewise, implementing adaptive strategies such as new practices and technologies requires labor to do so. Thus, small-scale farmers do not have the resources to acquire machinery and install equipment's that would help them, they therefore tend to depend on manual labor. The cost of production is high and most often, as said by many farmers, does not match their sales. Besides, with the labor market's competitive nature, and the working conditions such as working both in hot and cold seasons over a prolonged period with health risks further makes it challenging in acquiring farm labor. The finding from this study is similar to the study conducted by Takahashi et.al (2016) where they also observed labor to be barrier to adaptation. Hence, some farmers from this study use internships and volunteers to help on their farm but that is not sustainable.

I also find farmers' ability to access information plays a crucial role in making decisions pertaining to climate change. They access through services like the Cornell Cooperative extension which provides up to date information and organizes educational programs to assist farmers in acquiring the knowledge they need to adapt. Similar local organizations such as Northeast Organic Farming Association of New York was another avenue farmers access information. They provide resources to help farmers understand and adapt. In addition to information from services and organizations, farmers make good use of online resources for accessing information. Additionally, central New York houses some of the best educational institutions and as such farmers take advantages of such opportunities in connecting with researchers from these institutions such as Syracuse university, State New York College of Environmental Science and Forestry. Farmers equip themselves with the information they gather from these institutions through their publications, research reports, conferences and even some collaboration with academic researchers on projects.

In this digital age, they access information through websites, online forums, and social media groups where they share experiences, ask questions, and receive advice from their peers and experts.

Despite all this, the most common way of accessing information was through informal networking and community building. Farmers build relationships and communities that they can rely on each other as well as for exchange of information and learning from each other.

In summary, from my study I find that farmers are aware of climate change, and they perceive its impacts on their farms. The major impact as perceived by farmers were climatic conditions and pest infestation which results in loss of crop yield.

Also, farmers are adapting through agroecological practices which is necessary for sustainability and resilience. They are also investing in infrastructures and equipment that can aid in harsh climatic conditions and collaborating and building community which is crucial to minimize the impact from climate change. In as much as they are adapting, they continue to face challenges. These are socio-economic barriers such as financial resources, access to land, labor, and lack of support from government. The findings clearly reveal how farmers perceive and interpret climate change as a fundamental factor influencing their decisions to adapt to its effects. They face the same issue on their farms, especially impacts by weather patterns and localized concerns encourages adaptation.

CHAPTER VI. STUDY LIMITATION, IMPLICATION FOR FUTURE RESEARCH AND RECOMMENDATIONS

I. STUDY LIMITATIONS.

My study included only eleven farmers, so a larger and more diverse sample could have offered broader perspectives. Nonetheless, the study provides significant insights into the challenges farmers face and potential solutions. Given the small sample size, the findings should be interpreted with caution. The aim was to provide detailed descriptions and specific insights from the participants (Creswell, 2013; Lane et al., 2018), rather than to generalize. These findings are exploratory and can serve as a basis for future research on the impacts, adaptive strategies, and challenges of climate change on farmers and farming systems in Central New York. For example, this farmer sample could have more progressive views on climate change and its causes and effects than the general population of U.S. farmers.

Qualitative research is particularly useful for exploring topics with limited existing knowledge. In this case, interviews were the best method available due to the lack of other data sources in the region. While in-depth in-person interviews and farm observations would have enhanced the study, time constraints for the farmers and the research timeline were limitations. Despite these challenges, the study provides valuable insights and a solid foundation for future research.

II. IMPLICATION FOR FUTURE RESEARCH.

My study addresses the knowledge gaps on how farmers perceive and adapt to climate change within the Central New York region. These gaps are both empirical and conceptual and are the initial steps towards the process of building a comprehensive theory of farmers' adaptation to climate change, which I plan to continue expanding in future research. Such theory should include identification and adoption of new technologies- which involves understanding how farmers discover, evaluate, and implement new technologies that can help mitigate the effects of climate change on their agricultural practices; seeking resources from the state- examining the ways in which farmers access and utilize resources, funding, and support from state programs designed to aid in climate change adaptation; sharing of knowledge with other farmers - examining the networks and methods through which farmers share information, strategies, and experiences related to climate change adaptation and finally experimentation with climate-related challenge- exploring how farmers engage in trial and error to develop effective responses to the warming climate and its various impacts on their farming operations.

By addressing these elements, my study not only fills existing knowledge gaps but also lays the groundwork for a robust theoretical framework that can guide future research and practical interventions. This comprehensive approach will help farmers better adapt to the evolving challenges posed by climate change, ensuring the sustainability and resilience of agriculture in the Central New York region.

III. RECOMMENDATIONS.

The findings from this study can be used as a starting point to develop a more comprehensive understanding of perceptions of and responses to climate change risks by Central New York farmers that would capture a broader range of experiences—research that is largely absent in the region. Farmers adapting to agroecological practices to address climate change crisis is important to build sustainable climate-resilient system that fights climate change. This is because small-scale farmers contribute significantly to the food production within the local food system and economy and help address food insecurity within the communities and as such there is the need to support these farmers socially, politically, and economically by promoting community engagement and understanding the farmers' perspectives can foster a sense of solidarity that strengthens the fabric of local agricultural practice.

Further, policymakers need to prioritize the preservation of farmland and enact measures that protect agricultural interests. Legislation should address the encroachment of development projects and create safeguards against predatory practices by corporations. Advocacy for land-use policies that prioritize sustainable agriculture over short-term gains is essential to ensure the longevity of local farming practices and educational and training programs are needed to empower farmers to implement these sustainable agroecological practices successfully.

Additionally, small-scale farmers require economic support and incentives to implement sustainable climate-resilient adaptive strategies. This includes access to credit and labor, subsidies for adopting eco-friendly practices, and fair pricing mechanisms that protect farmers from exploitation. Investing in the economic viability of local agriculture not only supports the

livelihoods of individual farmers but also contributes to the resilience of the entire local food system.

Also, the state needs to implement and promote programs that provide economic support to small-scale farmers seeking to acquire land, offering grants, subsidies, or low-interest loans to ease the financial burden. Developing and expanding greenhouse initiatives by providing financial support or subsidies for the construction of greenhouses, allowing farmers to extend their growing seasons and protect crops from extreme weather events, and enhance overall production efficiency should be prioritized.

Lastly, establishing networks or platforms that connect small-scale farmers with a skilled and reliable labor pool addresses the challenges associated with labor shortages during peak seasons.

REFERENCES

- Adger, W. N. (2006). Vulnerability. Global environmental change, 16(3), 268-281.
- Adger, W. N., Crépin, A. S., Folke, C., Ospina, D., Chapin, F. S., Segerson, K., ... & Wilen, J. (2020). Urbanization, migration, and adaptation to climate change. *One Earth*, *3*(4), 396-399.
- Arbuckle JG, Prokopy LS, Haigh T, Hobbs J, Knoot T, Knutson C, Loy A, Mase AS, McGuire J, Morton LW and Tyndall J (2013) Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. Climatic Change 117(4), 943–950
- Bartels W, Furman CA, Diehl DC, Royce FS, Dourte DR, Ortiz BV, Zierden DF, Irani TA, Fraisse CW and Jones JW (2013). Warming up to climate change: a participatory approach to engaging with agricultural stakeholders in the southeast US. Regional Environmental Change 13(S1),45-5
- Blaisdell, M. (2018). The Farming Fissure: A Study Exploring Agricultural Diversification in Onondaga County, New York (Doctoral dissertation, State University of New York College of Environmental Science and Forestry).
- Briana Alfaro (2021). Soul Fire Farm. How alive is my soil? A Soul Fire Farm Guide to In-Field Soil Health Measurement Protocols with strategies for building Soil health to call Carbon back to the land.
- Brugger J and Crimmins M (2015) Designing institutions to support local level climate change adaptation: insights from a case study of the U.S. Cooperative Extension System. Weather, Climate, and Society 7(1), 18–38
- Carlisle, L., De Wit, M. M., DeLonge, M. S., Calo, A., Getz, C., Ory, J., ... & Press, D. (2019). Securing the future of US agriculture: The case for investing in new entry sustainable farmers. Elem Sci Anth, 7, 17.
- Carlisle, L., Montenegro de Wit, M., DeLonge, M. S., Iles, A., Calo, A., Getz, C., ... & Press, D. (2019). Transitioning to sustainable agriculture requires growing and sustaining an ecologically skilled workforce. Frontiers in Sustainable Food Systems, 3, 96.

- Chatrchyan A, Erlebacher R, Chaopricha N, Chan J, Tobin D and Allred S (2017) United States agricultural stakeholder views and decisions on climate change. Wiley Interdisciplinary Reviews: Climate Change e467
- Creswell JW (2013) Qualitative Inquiry & Research Design: Choosing among Five Approaches. 3rd edn. Thousand Oaks, CA: Sage.
- DeLonge, M. S., Miles, A., & Carlisle, L. (2016). Investing in the transition to sustainable agriculture. Environmental Science & Policy, 55, 266-273.
- Egerer, M., & Cohen, H. (Eds.). (2020). Urban agroecology: interdisciplinary research and future directions (Vol. 23). CRC Press.
- Foden, W. B. & Young, B. E. IUCN SSC guidelines for assessing species' vulnerability to climate change. (IUCN Cambridge, England and Gland, Switzerland, 2016).
- Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: Strategies for qualitative research. Aldine de Gruyter.
- Gliessman, S. R. (2004). Agroecology and agroecosystems. Agroecosystems analysis, 43, 19-29.
- Gramig B, Barnard JB, Prokopy LS (2013) Farmer beliefs about climate change and carbon sequestration incentives. Climate Research. 56:157–167
- Guthman, J., & Jiménez-Soto, E. (2021). Socioeconomic challenges of California strawberry production and disease resistant cultivars. Frontiers in Sustainable Food Systems, 5, 764743.
- Haden VR, Niles MT, Lubell M, Perlman J, Jackson LE (2012) Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change? PLoS One 7(12): e52882. doi:10.1371/ journal. pone.0052882
- Intergovernmental Panel on Climate Change (IPCC). (2007). Fourth assessment report: Climate change (AR4) Chapter 8: Agriculture.
- Janowiak, M. K., Dostie, D. N., Wilson, M. A., Kucera, M. J., Skinner, R. H., Hatfield, J. L., ... & Swanston, C. W. (2016). Adaptation resources for agriculture: responding to climate variability and change in the midwest and northeast.
- Jemison JM Jr, Hall DM, Welcomer S and Haskell J (2014) How to communicate with farmers about climate change: farmers' perceptions and adaptations to increasingly

variable weather patterns in Maine (USA). Journal of Agriculture, Food Systems, and Community Development 4(4), 57–70.

- Katkar, Venktesh, Jeffrey Sward, Alex Worsely, and Max Zhang. 2021` "Strategic Land Use Analysis for Solar Energy Development in New York." Renewable Energy, no. 173;861–75. https://doi.org/10.1016/j.renene.2021.03.128
- Kuehn D, Chase L, Sharkey T and Powers S (2016) Perceptions of maple producers towards climate change. Northeastern States Research Cooperative: SUNY-ESF.
- Lane, D., Chatrchyan, A., Tobin, D., Thorn, K., Allred, S., & Radhakrishna, R. (2018). Climate change and agriculture in New York and Pennsylvania: risk perceptions, vulnerability, and adaptation among farmers. Renewable Agriculture and Food Systems, 33(3), 197-205.
- Lane, Murdock, Genskow, Betz, & Chatrchyan. (2019). Climate Change and Dairy in New York and Wisconsin: Risk Perceptions, Vulnerability, and Adaptation among Farmers and Advisors. Sustainability, 11(13), 3599. https://doi.org/10.3390/su11133599
- Lin, B. B., Chappell, M. J., Vandermeer, J., Smith, G., Quintero, E., Bezner-Kerr, R., ... & Perfecto, I. (2011). Effects of industrial agriculture on climate change and the mitigation potential of small-scale agro-ecological farms. CABI Reviews, (2011), 1-18.
- Mase A and Prokopy LS (2014) Unrealized potential: a review of perceptions and use of weather and climate information in agricultural decision making. Weather, Climate, and Society 6(1), 47–61.
- Mase AS, Gramig BM and Prokopy LS (2017) Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. Crop framers. Climate Risk Manage 15, 8–17.
- Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., ... & Zhou, B. (2021). Climate change 2021: the physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change, 2.
- Onondaga County Planning Agency. Onondaga Farmland Protection Plan. http://www.ongov.net/p lanning/farmland.html.
- Patton, Michael Quinn. 2002. Qualitative Evaluation and Research Methods. 3rd Edition. Thousand Oaks, CA: Sage Publications.

- Petersen-Rockney, M., Baur, P., Guzman, A., Bender, S. F., Calo, A., Castillo, F., ... & Bowles, T. (2021). Narrow and brittle or broad and nimble? Comparing adaptive capacity in simplifying and diversifying farming systems. Frontiers in Sustainable Food Systems, 5, 564900.
- Potteiger, M. & Weissman, E. 2021. Food Plan CNY 2021 https://agriculture.ongov.net/wp-content/uploads/2021/03/Food-Plan-CNY.pdf
- Prokopy LS, Arbuckle JG, Barnes AP, Haden VR, Hogan A, Niles M and Tyndall J (2015) Farmers and climate change: a cross-national comparison of beliefs and risk perceptions in high-income countries. Environmental Management 56(2), 492–504
- Rosenzweig, C., Solecki, W., DeGaetano, A., O'Grady, M., Hassol, S., & Grabhorn, P. (Eds.). (2011). Responding to climate change in New York State: The ClimAID integrated assessment for effective climate change adaptation (Synthesis report). New York State Energy Research and Development Authority (NYSERDA). http://www.nyserda.ny.gov
- Safi AS, Smith WJ Jr, Liu Z (2012). Rural Nevada and climate change: vulnerability, beliefs, and risk perception. Risk Anal. Jun;32(6):1041-59. doi: 10.1111/j.1539-6924.2012.01836.x. Epub 2012 May 14. PMID: 22583075.
- Schattman RE, Conner D and Méndez VE (2016) Farmer perceptions of climate change risk and associated on-farm management strategies in Vermont, northeastern United States. Elementa Science of Anthropocene 4, 4–131
- Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity, and vulnerability. Global environmental change, 16(3), 282-292.
- Socolar, Y., Goldstein, B. R., de Valpine, P., & Bowles, T. M. (2021). Biophysical and policy factors predict simplified crop rotations in the US Midwest. Environmental Research Letters, 16(5), 054045.
- Strauss, A. L., & Corbin, J. M. (1998). Basics of qualitative research: techniques and procedures for developing grounded theory (2nd ed.). Sage Publications.
- Takahashi, B., Burnham, M., Terracina-Hartman, C. et al. (2016) Climate Change Perceptions of NY State Farmers: The Role of Risk Perceptions and Adaptive Capacity. Environmental Management 58, 946–957 https://doi.org/10.1007/s00267-016-0742-y

- Tobin D, et al. 2015. Northeast and northern forests regional climate hub assessment of climate change vulnerability and adaptation and mitigation strategies. Durham, NH: USDA Northeast Climate Hub http://climatehubs.oce.usda.gov/sites/default/files/Northeast Regional Hub Vulnerability Assessment Final.pdf.
- Tobin D, Radhakrishna R, Chatrchyan A and Allred SB (2017) Addressing climate change impacts on agriculture and natural resources: barriers and priorities for land-grant universities in the northeastern United States. Weather, Climate and Society 9(3), 591–606.
- Tumini, I., & Rubio-Bellido, C. (2016). Measuring climate change impact on urban microclimate: A case study of concepción. Procedia engineering, 161, 2290-2296.
- U.S. Department of Agriculture, National Agricultural Statistics Service. (2017).https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_York/cp36067.pdf
- UNDESA. United Nations, Department of Economic and Social Affairs, Population Division (2019). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations. (2019)
- United Nations Framework Convention on Climate Change (UNFCCC). (2010). Ecosystem-based approaches to adaptation: Compilation of information. Note by the secretariat. Available at: https://unfccc.int/resource/docs/2011/sbsta/eng/inf08.pdf .Accessed 3 Nov 2023
- Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations. (2019).
- USDA. USDA Plant Hardiness Zone Map, 2012. Agricultural Research Service, U.S. Department of Agriculture.
- USDA-ERS. 2016. State fact sheets: United States Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/data-products/state-fact-sheets/state-data.aspx.
- vulnerability and adaptation among farmers. Renewable Agriculture and Food Systems 33, 197–205(2018).

- Walthall C, Hatfield J, Marshall E, Lengnick L, Backlund P, Adkins S, Ainsworth E, Booker F, Blumenthal D and Bunce J (2012) Climate change and agriculture: effects and adaptation. USDA Tech Bulletin 1935, 186.
- Weiskopf, S. R., Rubenstein, M. A., Crozier, L. G., Gaichas, S., Griffis, R., Halofsky, J. E., ... & Whyte, K. P. (2020). Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States. Science of the Total Environment, 733, 137782.
- Wolfe, D. W., Ziska, L., Petzoldt, C., Seaman, A., Chase, L., & Hayhoe, K. (2008). Projected change in climate thresholds in the Northeastern US: implications for crops, pests, livestock, and farmers. Mitigation and adaptation strategies for global change, 13, 555-575.
- Zlotnik, H. (2017). World urbanization: trends and prospects. In New forms of urbanization (pp. 43-64). Routledge.

CURRICULUM VITAE

EDUCATION

Syracuse University (Syracuse, New York), 2023 -2024
Program of Study: Master of Science (Food Studies)

Thesis**:** Climate change perspectives in Central New York- Barriers, Adaptative strategies and challenges among small-scale farmers

Università Degli Studi Di Padova - Padova, Italy, 2020
Program of Study: Master of Science (Sustainable Agriculture)
Thesis: Preliminary assessment of crop growth and soil organic carbon dynamics in conventional and organic farming: A case study in the north-eastern part of Italy.

Kwame Nkrumah University of Science and Technology – Kumasi, Ghana, 2015
Program of Study: Bachelor of Science Agriculture

Thesis: Retrospective data analysis on poultry disease in the Ashanti region, Ghana. Undergraduate thesis.

TEACHING EXPERIENCE

Graduate Teaching Assistant - Falk College, Syracuse University, 2023 – 2024
Courses: Agroecology – Spring 2023
Farm to Fork – Fall 2023
Urban Food Systems- Spring 2024

- Lead classes and support the delivery of courses.
- Provide assistance to both instructors and students by holding office hours, clarify concepts, and provide additional explanations related to various course outline.
- Set questions and grade students reading reflections, quizzes, exams, and final papers.
- Provided constructive feedback.
- Collaborate with the course instructor and other TAs to ensure a cohesive teaching approach.

RESEARCH EXPERIENCE

Graduate Research Assistant - Falk College, Syracuse University, January 2023 – August 2024
Climate change: impact, strategies in Central New York .
Facilitate research efforts of the principal investigator by:

- Conducting literature reviews to understand the current state of knowledge on climate change, including recent research findings, policy developments, and emerging trends.
- Collecting data by conducting in-depth interviews
- Processing and analyzing gathered data using statistical methods.
- Writing research reports, papers, and article summarizing research findings.
- Collaborating with other members of the research team, including the principal investigator, co-researchers.
- Facilitate research efforts of the principal investigator by conducting literature reviews, conducting interviews, collecting, and analyzing data, preparing research materials, and assisting in the preparation of research reports or manuscripts.

Labor: Food Policy Councils as a Vehicle to Address the Racial Wealth Gap in Food System Labor

- Conducting both qualitative & quantitative research by exploring methods including literature reviews, qualitative case studies, interviews, focus groups and quantitative surveys across the nation.
- Collaborating on qualitative, quantitative, and data and document analysis,
- Developing research reports tool kit and manuscript for publication
- Creating visual presentations and effectively communicating findings to research partners and diverse audiences.

Inequalities: Women and Cocoa - Unpacking Gender Disparities in Ghana's Cocoa Farming- 2023-2024.

Developed a project funded by Goekjian/Maxwell African Scholars Union Research Grant to investigate and address the underlying barriers that contribute to gender inequalities among female cocoa farmers in Ghana.

Student Research - DAFNAE Department, University of Padova - Agripolis campus Legnaro, Italy – 2019 to 2020

- Designing field experiments and research and documented all findings.
- Monitoring of field experiments and data collection with sensors on various experimental fields.
- Harvesting and preparation of crop biomass samples for analysis.
- Performing laboratory chemical analysis of soil samples.
- Using scientific models for simulations
- Gathering, arranging and correcting research data to create representative graphs and charts highlighting results for presentations.

WORK EXPERIENCE

Student Work Collaborator, Department of Animal Medicine, Production & Health - Legnaro, Italy – 2020 to 2021

- Collaborate with the department and workers in accordance with all applicable standards, policies and regulatory guidelines to promote a safe working environment.
- Report any abnormalities exhibited by the animals in the experimental farm.
- Supervised workers

Field Coordinator, Ministry of Food and Agriculture-National Service, Ghana – 2015 to 2017

- Help the team to develop innovative approaches to monitor and evaluate the performance, effectiveness/impacts of agricultural intervention programs in the municipality.
- Support agricultural and livelihood response programs.
- Organized training to develop the capacity of staff and partners to increase their competence in sustainable agricultural practices for food security & economic development.
- Assist farmers in the diagnosis of farm and farming-related problems and advice on solutions to such problems.
- Organizing workshops and farm trails for farmers and educating them on the newly improved practices for sustainable food production and a healthy environment.
- Plan and implement the distribution of resources to the various rural farming communities.
- Prepare reports and monitor the progress of response programs and resources allocated to the rural farming communities.
- Engaging various stakeholders involved in rural livelihood response programs.
- Performed site visits for potential and future field locations as part of expansion planning.

PUBLICATIONS AND CONFERENCE PRESENTATIONS

Sarfo, F., Welsh, R., Jimenez-Soto, E (Forthcoming 2024): Climate change perspectives in Central New York- Barriers, Adaptative strategies and challenges among small-scale farmers. *Renewable Agriculture and Food Systems.*

Minkoff-Zern, LA., Robinson, JA., Sarfo, F (forthcoming 2024): ''Food Policy Councils & Labor report''. *Journal of Agriculture, Food Systems, and Community Development.*

Sarfo, F (Forth coming 2025)'' Women and Cocoa: Unpacking Gender Disparities in Ghana's Cocoa Farming''

Minkoff-Zern, LA., Robinson, JA., Sarfo, F (2024): Food Policy Councils as a Vehicle to Address the Racial Wealth Gap in Food System Labor. *Lender Center for Social Justice Symposium: Interrogating the Racial Wealth Gap* March 28, 2024

Minkoff-Zern, LA., Robinson, JA., Sarfo, F (2024): Food Policy Councils and Frontline Food Workers: Opportunities and Challenges for Labor Advocacy. *Agriculture, Food & Human Values*

Society (AFHVS) and the Association for the Study of Food and Society (ASFS) conference.Presented June 7, 2024

Sarfo, F., Welsh, R., Jimenez-Soto, E (2024): Climate change perspectives in Central New York-Barriers, Adaptative strategies and challenges among small-scale farmers. *Agriculture, Food & Human Values Society (AFHVS) and the Association for the Study of Food and Society (ASFS) conference.* Presented June 8, 2024

RESEARCH AND ACADEMIC GRANTS

- Goekjian/Maxwell African Scholars Union Research Grant (2023-2024)
- Falk college Assistantship 2023
- Veneto Regional scholarship, Italy. (2018 - 2020)

GRANTS AND AWARDS HONORS

- Evan Weissman Scholarship, 2024
- Falk College Food Studies Research Award 2024
- Falk college Graduate Assistantship 2023- 2024
- Goekjian/ Maxwell African Scholars Union scholar (Moynihan Institute of Global Affairs) 2023
- Goekjian/Maxwell African Scholars Union Research Grant (2023)
- Veneto regional Scholar, 2018

RESEARCH INTERESTS.

- Equitable food systems
- Food systems labor dynamics
- Inequalities within food system
- Climate change
- Social justice
- Food insecurity.
- Agricultural sustainability
- Food Policy

RELEVANT SKILLS

- Research skills
- Grant writing
- Academic writing
- Geospatial analysis.eg GIS
- Extensive knowledge of SPSS, SAS, R statistical programs,
- Review of scientific papers
- Modelling e.g. Salus
- Attitude for teamwork and international cooperation