

Building a Resilient Local Grain Chain:
Perspectives from Colorado's Farmers, Millers, and Artisan Bakers

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By

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ABSTRACT

The development of local food systems as an alternative food network has catalyzed positive change in communities through the addition of social, economic, and environmental value. Grains occupy a large part of the food system and our diets, yet they have largely been neglected in the local food systems movement. The local grain movement is now making a comeback, expanding across the United States, and many other countries. Efforts to rebuild a local grain economy has gained momentum in Colorado, but little is known about the structure and function of this network. Using a mixed-methods approach, this capstone project investigates the general structure of the local grain chain and the key people involved within it.

This study also explores Colorado's local grain chain as an alternative food network to identify qualities of resilience. As social-ecological systems, local food systems are resilient, and can quickly adapt and recover from disruptions. Local food systems are characterized by their short supply chains, strong linkages, and powerful ability to withstand disruptions. By positioning the grain chain as a social-ecological system, this research identifies characteristics of resilience within the local grain chain. This study found that Colorado's local grain chain has a network of strong relationships, local ownership, synergy between stakeholders, creative adaptability, ecological diversity, and the ability to rebound after a disturbance. This study hopes to contribute findings that are valuable to researchers and practitioners who are interested in applying a social-ecological resilience perspective to strengthen and add value to local grain chains.

BIOGRAPHICAL SKETCH

Mika Ulmet is a graduate student in the M.P.S Global Development Program at Cornell University. Her research interests lie in building resilient communities, integrating agroecology in food systems, and creating economic opportunities through value addition. Mika holds dual degrees in Biology and Environmental Science from the University of Denver, and a master's degree in Sustainability Planning and Management from the University of Colorado-Boulder. Fueled by her desire to protect the environment, Mika pursued experiences that allowed her to see the beauty of the natural world through many lenses. Her most impactful memories include growing up in four countries, restoring trails in the San Juan Mountains of Colorado, backpacking across the glaciers of Alaska to research ecological succession, monitoring water quality for The Nature Conservancy, and working with different non-profit organizations to improve access to nutritious foods in food insecure areas.

Prior to attending Cornell, Mika served as a Peace Corps Food Security Volunteer in the western region of Nepal. There she worked with women and children to promote sustainable farming practices and healthy nutrition interventions, leading projects in oyster mushroom cultivation, diversified vegetable production, cover cropping, and cooking demonstrations. She also taught health, nutrition and environmental education classes to students aged 12-16, and secured a USAID Small Projects Assistance grant for small-scale beekeeping.

Mika is currently living in upstate New York, working as a sourdough baker at Wide Awake Bakery. When she is not hiking in the woods, or playing with plants in the soil, she is in the kitchen baking bread with different grains. Mika aspires to create transformational change within the grain chain to support local communities and livelihoods.

DEDICATION

This capstone project is dedicated to the beautiful country of Nepal, where kindness and generosity returns full circle in the most unexpected ways.

To my village in Pyuthan— the birthplace of my love for grains. I will never forget walking into village for the very first time and seeing the sun's rays illuminate fields and fields of golden wheat.

To my host family, neighbors and friends in village, this project is dedicated to you, to thank you for opening my eyes to new beginnings and experiences, and teaching me the importance of living life to the fullest.

And lastly, to my wonderful, loving parents, Tom and Sayuri Ulmet, who have, from the very beginning taught me to always aim high and do good for others. Your unwavering patience, love, and faith in me has been a beacon of light along this unpaved, meandering journey I have chosen to take.

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PERSONAL MOTIVATION

The premise for this research originally came to light when I stumbled upon the existence of sourdough bread at the very beginning of the COVID-19 pandemic in 2020. Quarantining in isolation after being evacuated from the Peace Corps, I was in the middle of a book called *Cooked: A Natural History of Transformation* by Michael Pollan. I had just started the chapter on sourdough bread when my mother stopped by to drop off a loaf of homemade sourdough. When I took a bite of this naturally leavened bread, I was amazed. I couldn't believe that something baked without any commercial leavening could taste so good. The day after I left quarantine, I immediately dived into baking my first loaf of sourdough bread. Needless to say, I was hooked.

During the pandemic, the first challenge I encountered was finding a bag of flour at the local grocery store. Flour was scarce because of sudden pandemic demand. Despite being surrounded by fields of wheat in Colorado, it was near impossible to purchase a bag of flour from the supermarket. This sudden shortage made me question the effectiveness of our current grain supply chain, as it accentuated the flaws in which the conventional food system manufactures and distributes flour. Meanwhile, across the U.S, individuals and families turned to home baking during quarantine. This renewed interest in baking, coupled with the scarcity of flour prompted consumers to look for locally grown and milled grains. A new wave of support for a stronger network of farmers, processors, and food businesses looking to add value to the local grain chain emerged. All these factors combined led me to design a capstone project that investigated the relocalization of grains in local food systems and captured the perspectives and motivations of the people involved in producing, processing, and baking with alternative grains.

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CHAPTER 1 INTRODUCTION

1.1 Project Background

*“Like liquid gold the wheat-field lies,
A marvel of yellow and green,
That ripples and runs, that floats and flies,
With the subtle shadows, the change, the sheen
That plays in the golden hair of a girl.
A cloud flies there--
A ripple of amber—a flare
Of light follows after. A swirl
In the hollows like the twinkling feet
Of a fairy waltzer; the colors run
To the westward sun,
Through the deeps of the ripening wheat”*

(Hamlin Garland, Dakota Wheat Field)

Throughout history, humans have had a close relationship with grains. The first domestication of grains can be traced back to ten thousand years ago to the Fertile Crescent, an area known as the birthplace of agriculture, but more specifically, a region that encompasses modern Israel, Jordan, Syria, Egypt, southern Turkey, Iraq, and Iran (Fromartz, 2014). Emmer, einkorn, and barley are some of the earliest grains that have co-evolved with human civilizations. Grains such as amaranth, millet, quinoa, rye, sorghum, teff, and wheat are important nutrient and energy sources in diets, and have been found to contribute carbohydrates, proteins and vitamins that are essential in supporting healthy human functioning. Grains have also played a large role in shaping regional and global economies. The domestication and cultivation of wheat fueled the armies of ancient regimes and the creation of a global grain trade system (Myhrvold, 2017). From the Ancient World to this Age of Information, the production, distribution, and

consumption of grains has been integral to the development of societies, as well as in sustaining the diets and livelihoods of billions of people.

Across the U.S, in recent efforts to localize food systems, farmers, researchers, educators, activists, and consumers have partnered together to create a value chain centered around local vegetable and fruit production. Although this movement has widely popularized the consumption of locally grown food, it has neglected to include grains. In the U.S, grains like wheat and corn are cheaply produced, heavily subsidized, and sold as agricultural commodities on the global market. Regulations and policies that have favored a commodified agrifood system has made it difficult to relocalize grains, as the way in which they travel from the farm to the consumer depends heavily on a centralized grain economy. Standardized methods of cultivation and processing caused by the rise of industrial food production has allowed food corporations such as Cargill, ConAgra Foods, and Archer-Daniels-Midlan (ADM) to consolidate control over the food system. As a result of both horizontal and vertical integration along the supply chain, the number of locally operated small- and mid-sized farms, grain elevators, flour mills, and seed suppliers in the U.S has declined precipitously. Although efficient in its methods of mass production, our established conventional food system is rigid, and excludes small-scale, local farmers involved in diversified grain cultivation.

As a response to this commodified system, local and regional actors have begun to rebuild local and regional grain chains, bringing exciting new avenues for alternative, local, value-added markets. Farmers, millers, bakers, maltsters, chefs, and others whose lives are touched by grains, add social, environmental, and economic value to local food systems. Many

of these people do so by promoting sustainable agricultural systems, diverse market economies, and whole grain consumption within the local food system.

Led by farmers, millers, bakers, and passionate grain activists, in the past two decades education, marketing, and grassroots initiatives have increased the demand for local grains across the U.S. Integrating grains into local food systems is a step towards creating a sustainable future for our livelihoods and the planet. Grains are the forgotten piece in the local food puzzle, and they must be included for us to move forward in achieving socially responsible supply chains, robust local economies, resilient agricultural systems, and healthy, vibrant communities.

1.2 Project Design and Research Questions

The general structure of this capstone project and its research questions are presented below. The project begins with a literature review that provides the reader with a brief background on the history of wheat cultivation and its role in shaping civilizations. Next it describes alternative food networks, the local grain movement in the U.S, opportunities for value-addition, and resilience in social-ecological systems. Using information gained from the literature review, the following research questions were identified and applied to the context of Colorado's local grain chain:

- What is the general structure of the local grain chain in Colorado?
- How are people connected within the grain chain? What are the roles and relationships between these three key stakeholders (farmers, millers, and artisan bakers)? What are their motivations in supporting a local grain chain?
- In what ways have farmers, millers, and bakers co-created value in the grain chain?

- What are the characteristics of resilience within the local grain chain, what are its biggest challenges to becoming more resilient, and how do people hope to achieve a more resilient grain chain?

Next, this research details the methodology used in data collection. I used a mixed-methods approach to gather information that would allow for greater understanding of the social network and dynamics within the local grain chain. Stakeholders were identified based on referrals by the Colorado Grain Chain, a 501(c)5 membership organization composed of locally owned and operated businesses and consumers who support local grains. To further increase the pool of participants, I reached out to local farmers and bakers through Instagram, to ask for their participation in this survey. Informal observations and semi-structured interviews with six participants were conducted by phone and over Zoom. These interviews were then transcribed and coded using ATLAS.ti to determine correlations and differences in people's perspectives on these topics. The results section highlights the perspectives of these key stakeholders, relating it back to the themes discussed in the literature review. This is followed by an analysis of the structure and function of Colorado's local grain chain, and a discussion on its characteristics of resilience.

1.3 Assumptions

To begin, I would like to address a few assumptions that underlie this research. This project assumes that food systems are a type of a social-ecological system that has properties of resilience. A social-ecological system is defined as an integrated system where humans are part of nature and therefore cultural, political, social, economic, ecological, and technological components interact (Berkes & Folke, 1998). This project assumes that social-ecological food

systems are resilient and are inherently better than the conventional food system (Skog et al., 2018, Vroegindeweij & Hodbod., 2018). Improving resilience in communities, farming systems, and businesses has been discussed in research to combat global issues such as climate change and food insecurity. It is thought that resilient systems are persistent, adaptable, and diverse, and therefore able to recover from shocks (Walker et al., 2004). In contrast to this, systems with low resilience are more vulnerable to change, and more likely to collapse in the event of disruption. By positioning food systems as social-ecological systems we can learn to apply characteristics of resilience to strengthen alternative food systems like the local grain chain.

Second, the assumption that conventional agrifood systems threaten the overall health, well-being and sustainability of communities has led me to invite farmers and businesses who support the use of sustainable agricultural practices and principles of environmental stewardship to participate in this research. Regenerative farms are holistic, and are examples of resilient systems that maximize the use of ecological processes to adapt to changes in the system. Farmers who implement farming practices such as reduced tillage, cover cropping, and natural nitrogen fixation build a foundation for the future of their farm by investing in the long-term health of their soil. This can be difficult to accomplish in conventional monocultures, where fertilizers, pesticides, and intensive tillage tend to degrade the environment.

Another assumption in this study is that alternative food networks (AFNs) provide more value to communities than conventional food systems. AFNs are small networks of producers, processors and consumers that promote the development of sustainable food production and consumption (Edwards, 2016). This project assumes that local grain chains, as an alternative

food network, are an integral component in creating a more sustainable and equitable food system. The provision of various social, economic, and environmental benefits to communities through the local grain chain makes value addition within AFNs a worthwhile topic to investigate.

The final assumption is that the participants in this study whose livelihoods revolve around local grains (producers, processors, and consumers), have been benefited by the establishment of a local grain chain. Due to their involvement in the local grain chain, it is assumed that these stakeholders are motivated by similar social, environmental, cultural, and economic reasons to support the relocalization of grains. In addition, although this project solely focuses on the cultivation, processing, and consumption of wheat, it is important to note that the farmers, millers, and bakers are also involved in producing and using other value-added grains like millet, amaranth, rice, corn, and quinoa.

1.4 Research Contributions

Recent literature has investigated the relationship between grains and alternative food networks (Forrest, N., & Wiek, A, 2021); the definition of “local” in grain economies (Hills et al, 2013); the relocalization of wheat (Hills et al, 2013; Empey et al, 2020; Mann, 2016); value addition in the grain chain (Doty et al., 2012; Hergesheimer C., & Wittman, H., 2012; Stanco et al., 2020); and community building through bread (Halloran, A., 2020; Mars, 2015). While there has been extensive research on the breadbasket of the U.S, cereal grain production, resilience in local food systems, and alternative grain networks, I found that resilience in local grain chains is still an under-researched area. The 2007-2008 global food crisis and its impact on grain-

producing nations has shown just how necessary it is to investigate local grain chains as an alternative food network and to research their ability to withstand and overcome disturbances in the same way social-ecological systems do.

First, this project will investigate value addition within the local grain chain in Colorado from the perspectives of farmers, millers, and bakers. It will then seek to map out the structure and function of this network with a specific focus on the production, processing, and baking of wheat. Finally, through the application of a resilience index developed by Worstell & Green (2017), this research will determine characteristics of resilience within the local grain chain. Examining Colorado's local grain chain will uncover the interconnections within localized grain economies and short supply chains, as well as provide insight into the underlying values that play a role in transforming the way in which wheat is grown, processed, and consumed.

The results of this case study will be valuable to researchers and practitioners who are interested in applying a social-ecological resilience framework to understand the network and function of local grain chains. To adapt to future global disasters, there is greater need for further research to determine the characteristics of resilient, short value chains. The findings from this project may also provide valuable information for communities looking to establish or strengthen their network in preparation for unexpected disruptions.

1.5 Thesis Organization

Chapter 1 gives a general overview of the project (including the research questions, project design, assumptions, and research contributions) to provide background context for the following chapters.

Chapter 2 is a literature review that presents the reader with a brief insight into the history of wheat cultivation and its influence on modern wheat production in the U.S. This is followed by an overview of local food systems and how this relates to the local grain movement. This chapter will also provide details about organizations involved in increasing grain literacy, creating diverse market economies, and bridging the gap between producers and consumers. The chapter ends by talking about resilience in local food systems, the key principles behind using the Worstell & Green resilience index to assess resilience, and how this framework will be used in analyzing the data collected through this research.

Chapter 3 details the research methodology used to collect data for this project. It provides information about the interviews and surveys conducted, a description of the participant observations (e.g farm tours, bakery visits, marketing events), a description of the main themes presented in the interviews, and my chosen method of data analysis.

Chapter 4 presents the results of this study. It begins with a biographical overview of the participants in this study and their role in the local grain chain. This is followed by a description of the ways in which the involvement of these key stakeholders has added value to the grain chain, their motivations behind supporting a local grain chain, and the impact of COVID-19 on their businesses. The chapter also presents the views of the Colorado Grain Chain (a 501(c)5 membership organization), their vision for the future, as well as challenges and opportunities for building a resilient grain chain.

Chapter 5 presents the benefits and barriers of the local grain chain and relates this back to the literature that was discussed in Chapter 2. To highlight the network size and diversity of this value chain, I map out the general structure of the local grain economy by pinpointing the

key stakeholders who are involved in growing and sourcing local wheat. Finally, using a resilience index from Worstell & Green, I identify characteristics of resilience within the grain chain.

Chapter 6 summarizes the key findings of this project and provides recommendations on areas for future research. It concludes by suggesting ways to build stronger local and regional grain economies, creating a diverse market for local grain products, and increasing grain literacy.

CHAPTER 2 LOCAL GRAINS IN FOOD SYSTEMS

2.1 The Rise and Fall of Grains

For centuries, bread wheat (*Triticum aestivum*) has played an important role in the history of human civilization, shaping culture, traditions, religion, and rituals across the world. Archaeologists have traced the consumption of these grass seeds back to 100,000 B.C.E, by analyzing starch residues found on Middle Stone Age tools (Mercader, 2009). The practice of gathering and planting wild wheat berries over the course of thousands of years led to the advent of agriculture, which is thought to have first emerged 8,000 to 10,000 years ago in the Fertile Crescent, an area that encompasses Israel, Jordan, Syria, Egypt, southern Turkey, Iraq, and Iran. Nurtured by the hands of Neolithic farmers, the seeds of ancient grains were planted in the fertile soils along the Euphrates and Tigris Rivers (Fromartz, 2014).

Emmer, einkorn, and barley were among the first crops selected for cultivation based on certain traits that maximized the success of a plentiful harvest. Early farmers selected and re-planted wild wheat berries with advantageous characteristics, such as larger seed heads, threshability, or better adapted to the local climate. One such example of this selective breeding process was the hybridization between wild goat grass (*Aegilops tauschii*) and emmer, which led to the emergence of bread wheat that we consume today (Haider, 2013). Currently, bread wheat accounts for 90% to 95% of all wheat produced in the world.

As hunter-gatherers gave up their nomadic ways for more sedentary lifestyles tied to agriculture, this gave way to the establishment of social, economic, and political structures in agricultural societies. The domestication of wild wheat varieties and other grains led to an increase in agricultural production, bringing wealth, urbanization, and trade to ancient empires in the cradle of Mesopotamia (Montgomery, 2008). Although other ancient grains such as barley and millet were central to the diets of other cultures, wheat continued to gain importance culturally and economically as a tradable commodity. Qualities such as a long shelf life, easy transportability, and versatility made this grain grow in popularity (The Cooking Lab, 2017). In Egypt, bread held great cultural and religious significance, as it was deeply intertwined with the rituals, celebrations, and everyday life of the Egyptians. The highest quality loaves were frequently offered as gifts to both the living and the dead. Laborers were paid with leavened bread made from the simplest of ingredients, flour, yeast, water, and a touch of salt, while Pharaohs dined on more elaborate loaves flavored with spices or molded into the shape of animals or female figures. As such, wheat fueled the expansion of large civilizations across Egypt, Greece, and Rome.

The importance of wheat in bread as a food staple continued to spread across the world. Wheat became a commodity crop that was traded across East Asia and Europe through Old World trade routes and seaports. During the Middle Ages, peasants, laborers, lords, and kings in Britain commonly incorporated bread made from wheat into their daily meals. Bread, in all its forms, was considered both a luxury item and a staple food accessible to people regardless of their social class, wealth, or status. Wheat berries have been cooked into porridge, malted for beer, ground into flour, and boiled as pottage. Even during times of crop failure and famine,

when wheat became scarce and meals were limited, those who were impoverished relied on bread as a food source by modifying some of its ingredients. While the wealthy dined on bread made from pure wheat flour, peasants ate loaves that contained straw, clay or ground tree-bark, and the addition of other grains, with a minuscule amount of wheat. Wheat was an important food source that transcended the boundaries of social hierarchies throughout famine and times of abundance.

In the 19th century, advances in mechanized agriculture paved the way for a new agricultural philosophy in the United States that promoted intensive production at the farm level. Land in the U.S was cheap, plentiful, and forests were cleared across the country, revealing land rich with fertile soil. Farmers abandoned traditional farming techniques rooted in building soil health and fertility, such as crop rotations and the addition of manure, in exchange for less time intensive farming practices that were destructive to the soil. Montgomery, in his book, *Dirt: The Erosion of Civilizations*, mentions the exhaustion of land as “the curse of American agriculture”, and describes the correlation between shifting farming practices and the decline in crop yield: “By the advent of mechanized agriculture in the mid-nineteenth century, per-acre wheat yields in New York were just half of those from colonial days despite advances in farming methods” (2008, p. 130). Improvements in farming machinery helped reinforce this cycle of unsustainable, intensive farming. The development of new and improved farming equipment increased the production of wheat, which alleviated some of the challenges associated with feeding a growing population. However, like every wicked problem, little did people know that these advances in agriculture would lead to major environmental, social, and economic issues.

Industrialization, mechanization, and the specialization of agriculture massively impacted the livelihoods of wheat farmers across the U.S. The creation of farm policies implemented by the U.S government in the early 1930s caused a shift towards cheap food production through intensive agricultural practices. After World War I, larger and more industrialized farms were viewed favorably by the government for their scale of production and efficiency. Small farmers were incentivized through subsidies to purchase new farm machinery and fossil-fuel based inputs to maximize their crop yields. As a result of specialization and standardization of agriculture in the U.S, the way crops were grown, processed, and distributed shifted to favor energy-intensive, large-scale production. Smaller farms that could not compete against the larger farms were famously told by President Nixon's Secretary of Agriculture, Earl Butz, to "get big or get out." Farmers found themselves caught on the treadmill of production, forced to choose between investing in the latest farm equipment to achieve higher yields, or giving up their farming livelihoods. As a result, the agricultural landscape in the U.S today is a vastly different landscape compared to what it was fifty years ago.

The rapid increase in median farm size in the wheat belt went hand-in-hand with the dismantling of grain infrastructure and decline in wheat production. As small farms sank into more debt trying to keep up with agricultural production, larger farms consolidated their power by purchasing more land. The gap between small and large-scale farms widened, leading to the loss of small, family-owned farms. Compared to 6.8 million U.S farms in 1935, there are only 2.02 million farms today, and 44% of our agricultural production lies in the hands of 3% of farms (USDA, 2020). The agricultural system that the current U.S economy depends upon has not only caused the loss of small to mid-sized farms, but also furthered the collapse of

infrastructure, culture, and land degradation in rural communities. To this day, farming families struggle to make a living because of the socio-economic impacts caused by the industrialization of agriculture. Grains are the pillar of the livelihoods, diets, and economy of the American people. Yet, a majority of domestically grown grains are being exported to other countries. By tracing the cultivation of grains throughout history, we can see how influential the prioritization of crop productivity and profit were in the creation of our modern grain chain.

2.2 Alternative Food Networks and the Local Food Movement

Alternative food networks (AFNs) first emerged in Europe to connect food consumption and production to environmental and social justice initiatives. They arose in response to the problems created by the dominant industrial food system, which is dependent upon the use of fossil fuels, chemical pesticides and fertilizers, intensive tillage, and other environmentally destructive practices. AFNs are small networks of producers, processors and consumers that promote the development of sustainable food production and consumption (Edwards, 2016). They are locally embedded, have shorter supply chains, and are known to enhance livelihoods and build stronger linkages within communities. Examples of AFNs include retail venues such as farmers' markets; alternative methods of growing food including urban agriculture and vertical farming; and social initiatives like Community Supported Agriculture (CSA) programs and the local food movement. Those involved in AFNs share values such as environmental sustainability, social justice, and animal welfare within food systems (Edwards, 2016). In addition, they can be highly complex in structure, varying in number and diversity in their connections, are dynamic and ever-changing, and can capture economic and social value along the supply chain (Forrest, & Wiek, 2021).

The local food movement as an AFN has played a major part in educating consumers on where their food comes from and how their food is produced. According to the United States Department of Agriculture (USDA), local food is broadly defined as “a food product that is raised, produced, aggregated, stored, processed, and distributed in the locality or region in which the final product is marketed”. Although there is currently no universally accepted definition of local food, USDA guidelines refer to it as the production and distribution of products within a certain geographic area, such as within the state that the product originated, or less than 400 miles from where it was produced. Local food systems developed as an alternative to the industrial food system are known to catalyze change within communities because they provide public benefits to different sectors including economic development, food security, and environmental sustainability (Trivette, 2012).

Support for local food systems across the U.S has continued to grow, and its positive impacts are beginning to show. Education and marketing campaigns led by local food activists have shifted consumer mindsets and their purchasing decisions. Consumers are more aware about where and how their food is produced. They are also making food choices based on the origin of the food, supporting family farms, and their interest in artisanal foods (Martinez et al., 2010). A study by Kearney showed that grocery shoppers believed that local food helps local economies, provides better assortment of products, gives healthier alternatives, improves carbon footprint, and increases organic production (Kearney, 2013).

Local food systems that can foster strong partnerships and networks and are able to regenerate organizational capacity from within itself can be successful in achieving social transformation. They capture social capital by building personal networks and relationships within communities, organizations, and institutions. There has also been significant progress in the way major institutions and companies view local food production in the U.S. For example, the USDA initially trivialized the importance of local food but has now changed its stance (Worstell & Green, 2017). Furthermore, as part of its sustainability initiative, large corporations like Walmart have committed to incorporating local produce sourcing into their operations (Bloom & Hinrichs, 2017).

Although there has been transformative change within this system, the local food system has its many challenges, and farmers involved in selling their produce to local markets face a multitude of risks. These risks include price competition from multiple sellers, low sales volumes, and costs associated with direct marketing and on farm processing (Biermacher et al., 2007; LeRoux et al., 2009). The silver lining is that the market for local food continues to grow, and that end-consumers are more willing to pay money for local products (Hills et al., 2013; Kearney, 2013; Martinez et al., 2010). Determining the threshold of how much consumers are willing to pay for local food will give clarity on how to develop marketing strategies for creating a value-added market. The future of food is dependent upon strengthening local food systems by building stronger connections and integrating the values of end-consumers and users with local farmers who are involved in socially just, economically viable, and ecologically sound methods of food production.

2.3 The Local Grain Movement in the U.S

The local food movement has mostly focused on the relocalization of vegetables, fruits, and animal products in food systems. The inclusion of grains within the local food system is still in its infancy, which is largely due to the challenges it faces, such as a lack of small-scale processing equipment, lengthy shelf-life, location (it tends to be grown in areas of low population density), and its propensity to be used as unrecognizable ingredients in food products (Hills, et al., 2013). In recent years, efforts to localize grains across the U.S have ramped up, largely because there is more transparency throughout this supply chain in comparison to the commodity grain chain, and because the identity of the grain can be preserved through its entire lifespan. Consumer demand has also stimulated new market opportunities for higher value grains produced by local farmers and grain processors. There has, in particular, been a strong interest in specialty wheat varieties such as einkorn, emmer, and spelt, as well as other grains such as rye, oats, and barley (GrowNYC, 2021). Incorporating the use of specialized grains into food products like craft beers, bread, and pasta has been largely successful in adding value to local grain economies, and has been trending in popularity amongst chefs, bakers, maltsters, and other artisanal end-users.

Within the last two decades, a series of social initiatives triggered the re-emergence of the grain relocalization movement. In 2002, a group of millers, manufacturers, scientists, and chefs established the Whole Grains Council to promote the consumption of whole grains. This led to the creation of the Whole Grains Stamp, a packaging stamp that details how many grams of whole grain ingredients are in a serving of a product. This stamp has been recognized and utilized in more than 60 countries. Official members of the International Whole Grains Initiative,

the Whole Grains Council's network has expanded globally, and they continue to further this movement by assembling and disseminating scientific information, hosting conferences to raise consumer awareness about the nutritional benefits of whole grains, and supporting the development of public-private partnerships (Whole Grains Council, 2021).

Another development that catalyzed this movement occurred in 2007, when a grassroots group of concerned individuals interested in revitalizing their local grain economy founded the Maine Grain Alliance, a non-profit organization dedicated to rebuilding Maine's grain infrastructure. That year, Maine Grain Alliance launched their very first Kneading Conference, a national grain and baking conference that showcased the work of grain professionals in their communities (Maine Grain Alliance, 2021). The Alliance nurtured the development of collaborative partnerships that were instrumental in creating a market for local grains. Since then, they have awarded small farms and businesses with more than \$200,000 in technical assistance grants for equipment and infrastructure development.

The number of key actors involved in the relocalization of grains has substantially grown across the country. Millers, bakers, and chefs committed to using local flour have established partnerships with farmers to create a market for alternative grains. Bakers have begun to actively seek out local grains for their flavor and nutritional content to incorporate them into their baked goods. Farmers too, have championed this movement by transitioning from monocropping high-yield varieties to diversified cropping systems. Bob Quinn, an organic wheat farmer in Montana, believes that by adding value-added grains in his farming system he can bring back life to the

soil, rural livelihoods, and people's diets. In the following statement he articulates the deeper value that grains provide through their cultivation:

"This is the deeper promise behind the many small steps I've taken to add value to my business as a wheat farmer. When a few other processors and I started milling our grain whole, in the 1980s, we wanted to bring back the nutritional value that had been refined away for the past century. When I converted my farm to organic, {...} I wanted to bring back the life in my soil. And when I began rediscovering heirloom grains—the seeds our ancestors planted—I realized just how much taste and nutrition we'd sacrificed in the rush to breed high-yielding varieties" (Quinn and Carlisle, 2019).

In the Northeast, some of these changes have been brought about by new rules and regulations that require a certain percent usage of local grains. For example, in 2009, GrowNYC Greenmarket stimulated demand for local grains by implementing a rule that required bakers to use 15% locally grown and milled grain in their products if they were to continue selling their bread in New York City's Greenmarket. Their decision to implement a minimum percentage was a catalyst in the production of food-grade grains. Since then, the regional grain economy in the northeast has grown to support a large network of farmers, processors, and bakers. To further expand the cultivation and consumption of regionally grown grains, GrowNYC Greenmarket increased this minimum percentage to 25%. However, the average percentage of local grains in the end products is much higher at 39%. In 2020, a total of 32 bakeries involved in GrowNYC Greenmarket used 100-5000 lbs of local/regional flour, which has supported the production of wheat on 300 acres of farmland (Culinary Breeding Network, 2021).

The grain relocalization movement has also gained momentum in other regions in the U.S. For example, in the South, a coalition between artisan bakeries, local growers, and millers arose from a common shared interest to create a regional supply chain centered around sustainable farming systems and specialized grains. This initiative was led by Jennifer Lapidus, the founder of Carolina Ground and author of Southern Ground. In 2012, Lapidus received a USDA grant to build a mill that would serve its community. As presented in **Figure 1**, the number and distribution of independently owned mills across the United States remains low due to consolidated production and ownership concentration in the milling industry (The Whole Grains Council, 2021). Mills are a critical intermediary in the farm-to-institution and the farm-to-consumer supply chain, yet there are not enough small independent mills across the country to accommodate processing a higher supply of flour from local wheat farmers. Noticing this gap, Lapidus realized that a community mill was the missing intermediary that would connect farmers to bakers in the Carolinas region. In her book, Southern Ground, she states, “We envisioned a mill centered upon the idea that place matters; a community mill connecting farmer, miller, and baker, one that was environmentally and economically sustainable, decreasing food miles, and stabilizing prices” (2020, p. 9). Carolina Ground sources its grains from local farms and sells a selection of stone-ground pastry and whole wheat flour made from winter wheat to bakeries, restaurants, grocery stores, and institutions. They now serve dozens of bakeries across the South, including Alabama, Florida, Georgia, North and South Carolina, Tennessee, and Virginia, and frequently attend events such as the Asheville Bread Festival to share their knowledge and skills with the public.



Figure 1 Small scale growers, locally owned mills, advocates, and researchers involved in localizing grains, and their distribution across the U.S

(Source: Daily Grains, 2021)

A similar resurgence to strengthen local and regional grain chains is happening along the West Coast. In western Washington State, Stephen Jones founded The Bread Lab at Washington State University. The Bread Lab is a research lab dedicated to experimental wheat breeding, test baking with different flours, and creating decentralized, equitable food systems. Jones realized there was a great need for building a regional food system that included economically viable grain crops when he discovered that local farmers were losing money to the commodity export market despite growing grains as part of their crop rotations (Halloran, 2015). The Bread Lab since then has contributed to furthering the science of non-commodity wheat breeding and the development of alternative grains for diversity, flavor, and quality. The level of interest in the

use of local wheat amongst bakers in western Washington has been found to vary according to location and is dependent on a variety of factors such as consistency of flour quality, quality of flour, and reliable supply (Hills et al, 2013).

In California, the passing of the California Homemade Food Act in 2012 was instrumental in creating a space for artisan home bakers to become a part of the local grain movement. The California Homemade Food Act is a bill that permits the preparation and selling of certain foods within private-home kitchens. Cottage bakeries such as The Humble Bakehouse, The Beach Cottage Bakery, Mission Bakehouse and Alchemy Bread, to name a few, have centered their business model around nourishing their community— using locally grown and milled quality flour in their baked goods. Rose Lawrence, who started out as a cottage baker, is now the founder and owner of Red Bread in Los Angeles, California. Lawrence makes artisanal sourdough bread using locally grown whole grains, and has a strong partnership with Grist and Toll, a stone mill that sources alternative grains from farmers within their grain shed (Lawrence, 2017). Another cottage baker, Bonnie O'Hara of Alchemy Bread, also emphasizes the importance of using local grains, but credits the success of her bakery to her partnership with her community.

“How did a tiny cottage bakery with no storefront, no marketing and no listed address on the outskirts of a rough downtown neighborhood grow to draw a crowd? The answer is community. I started baking out of my tiny home oven and delivering my bread around nearby neighborhoods on my cargo bike 3 years ago. I started small by investing a lot of time in my community. I partnered with my friend who is a doula, to give my bread to postpartum moms after their new baby was born. Donated bread to preschools,

elementary schools, church dinners, and made meals for friends that were sick or injured.

Taught baking classes to kids through local culinary classes and 4H clubs” (Alchemy Bread, 2021).

Alchemy Bread is just one example of a business whose heart lies in its community.

Businesses that are centered around the community not only support the local food system but also play a major role in strengthening people’s connections to their food. Directly involving customers as the purchasers of the product, as well as the marketers and promoters of local grains invokes a sense of community and enthusiasm for supporting their local grain shed (Mars, 2015). Community supported bakeries and their customers are dependent on each other, and close relationships with growers and millers. Working together to promote the value of local food consumption may inspire a new wave of strong local food leaders who want to revitalize grains in local food systems.

Efforts to revitalize local grain economies are not without its difficulties. The development of local and regional grain initiatives tends to be hindered by supply chain challenges, including material (climate issues, pests), technical (quality and quantity issues, storage, and cleaning facilities), and relational (knowledge and skill sharing, marketing, and pricing schemes) issues (Hergesheimer & Wittman, 2013). Other challenges associated with relocalizing grains and their corresponding solutions to overcome them are highlighted in **Table 1**.

Table 1 Challenges associated with grain relocalization and ideas for solutions

Challenges	Solutions	Sources
Infrastructure: Barriers for farmers include high up-front equipment costs to perform necessary functions such as seed planting, harvesting, threshing, and cleaning. In terms of local processors, there are a limited number of processors who produce consistent identity-preserved flour because they are inhibited by their lack of access to machinery.	Invest in the redevelopment of local processing, storage and distributing infrastructure. This will build a foundation for a strong grain economy. The cost of production will decrease if there is more infrastructure to support local processing.	Hergesheimer & Wittman, 2012
Price: The price of commercially available local flour is expensive.	Establish a more equitable system where prices are determined by the growers, millers, and bakers rather than the global commodity market.	Hills et al., 2013
Quality: There are inconsistencies in the quality and availability of locally and regionally produced flour. Farmers may not have a consistent crop every year, local blends may not perform as expected, and flour may not always be available.	Strengthen relationships between supply chain intermediaries as it is less energy, money, and time intensive for businesses to source from one or two distributors rather than many small suppliers.	Hills et al., 2013
Value addition: Establishing a local grain chain may be difficult because of the existing structures of the conventional grain network. The current grain sector is highly consolidated, and profit is lost through processing intermediaries.	Foster local partnerships and direct contracts between farms and mills to establish a guaranteed outlet for farmers to make a profit. Alternatively, farmers can capture this added value by doing the milling and marketing of their flour themselves.	Baker, & Russell, 2017; Hills et al., 2013
Land access: Farmers are paying more to rent land due to increasing land prices and competitive bidding among buyers, making it difficult for small-scale farmers looking to expand production. This barrier is even higher for farmers of color.	Advance policies that reduce barriers associated with land access and inequities in land ownership. Providing security in land tenure will help protect the livelihoods of farmers.	National Young Farmers Coalition, 2020

Seed availability: There is a shortage in the available supply of clean, high-quality seeds in regions such as the Northeast. Consumer demand for heritage varieties has increased but prices for heritage seeds are high and often difficult to access.	Increase institutional support for nonprofits and seed saving foundations that preserve the identity of heritage varieties. Seed companies should also be encouraged to provide greater access to quality grain seed for small-scale farmers.	Blair & Dimitri, 2017; Hergesheimer & Wittman, 2012
Market competition: Low prices from the commodity market and economies of scale make it difficult for locally produced organic grains to stay competitive with larger operations.	Encourage businesses to incorporate a percentage of local flour into their food products to stimulate value added grain production. Another solution is to create regulations and policies that help establish new markets to stimulate consumer demand.	Blair & Dimitri, 2017; Halloran, 2015
Knowledge and skill-sharing: Growing, processing, and using grains is knowledge intensive and technical.	Develop strong social networks that funnel technical and experiential assistance from educational institutions, non-profit organizations, and extension programs to local growers, millers, businesses, and consumers.	Hergesheimer & Wittman, 2012
Consumer education: Wheat is considered a commodity crop and flour is viewed as a cheap, mass-produced product. Changing the way these grains are valued by consumers will progress the development of a diversified grain supply chain	Increase awareness about alternative local and organic grains. Marketing and education surrounding the quality, nutritional value, and identity of alternative grains needs to be increased. Transparency along the supply chain on who grows the grain as well as where and how the grain is grown will help end-point consumers make informed choices.	Hills et al, 2013; Hergesheimer & Wittman, 2012

The grain chain is a highly complex network that involves the participation of a diverse group of stakeholders. Nurturing the relationships forged between growers, processors, millers, end-users, researchers, advocates, and consumers is critical, as the people who are involved are hard-pressed to implement large-scale systemic change in the food supply chain on their own.

Non-profit organizations that have played a major role in building and maintaining these connections include The Artisan Grain Collaborative, Common Grain Alliance, Maine Grain Alliance, Northeast Grainshed Alliance. The Artisan Grain Collaborative, for example, has created a thriving grain shed that is centered around knowledge sharing, collaboration, environmental and economic stewardship, and access and equity (Artisan Grain Collaborative, 2021). As presented in **Figure 2** we can see the various nodes of connection and collaboration between a network of diverse stakeholders who are working to make local and regional grain chains possible.

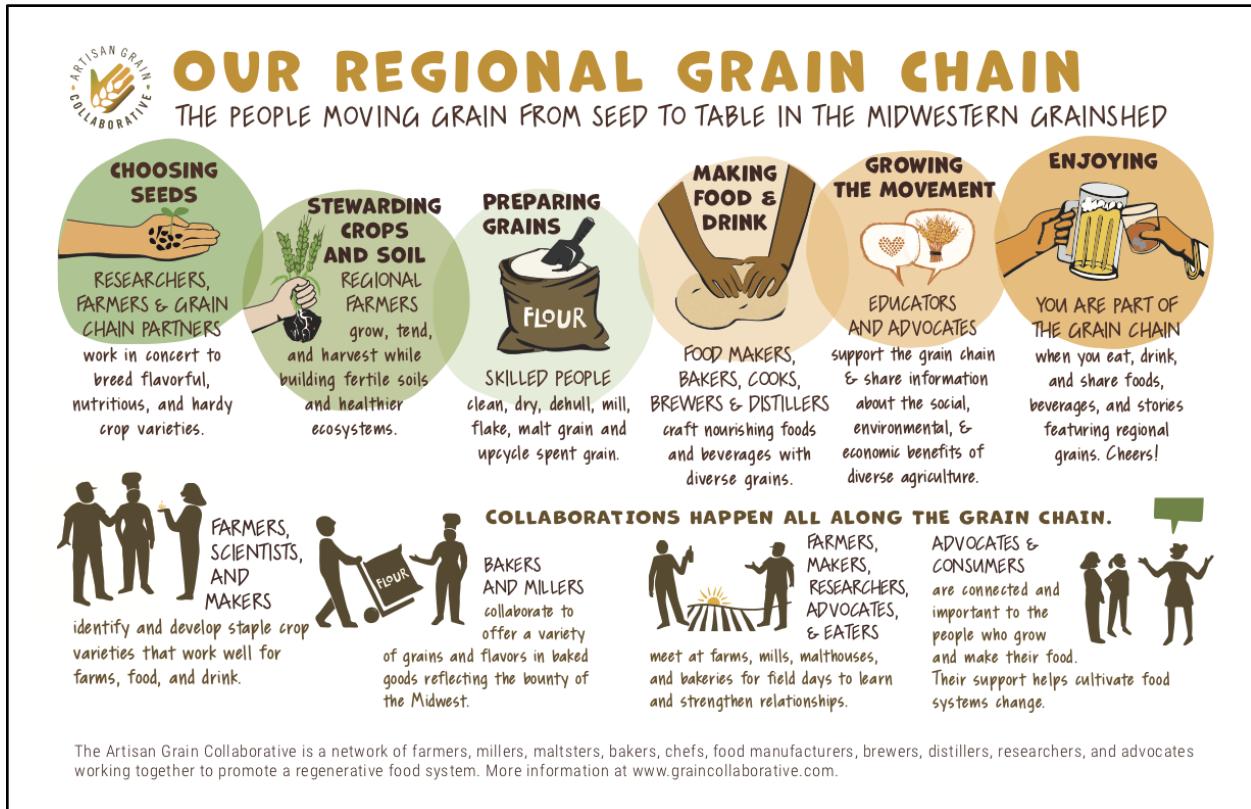


Figure 2 An illustration by the Artisan Grain Collaborative that showcases the diversity and intersections between different stakeholders as well as their roles within their grain chain

(Source: Artisan Grain Collaborative, 2021)

Although the grain relocalization movement is relatively young, it has made strides in delivering social, economic, and environmental value to every sector of the grain chain. Unlike commodity food systems that are driven by productivity and technological advancement, people involved in alternative food networks, such as the localization of grains, have been driven by different kinds of values and motivations centered around sustainability, and protecting the health of communities and the environment. This next section will discuss the different forms of value-addition within a local grain chain and their benefits to communities.

2.4 Value Addition in the Grain Chain

In the U.S, the majority of domestically grown grains are commodity crops that are exported and traded to other countries. The mass production of grains in the conventional food system and their distribution across lengthy supply chains has added significant costs on farmers, processors, end-users, and consumers. In contrast to this, research has found that investing in local and regional grain markets adds social, environmental, and economic value to food and farming systems, which supports the overall health, well-being, and sustainability of communities. Below are some examples of environmental, economic, and social outcomes that are characteristic of local and regional grain chains. The future of the grain movement lies in capturing and adding value along shorter food supply chains.

2.4.1 Environmental

Grains deliver many benefits to the environment when incorporated into regenerative and ecological farming systems. Regenerative farming systems are broadly described as alternative farming systems that produce a variety of outcomes that lead to increased environmental benefits

(e.g. sequestering carbon and improving soil health) or engage in processes (e.g. cover cropping and livestock integration) that achieve these outcomes (Newton et al., 2020). Some regenerative farmers grow a diversity of field grains including ancient grains like emmer, einkorn, spelt, and heirloom varieties such as Red Fife, Turkey Red, and Sonora. Growing a mix of grains preserves genetic diversity. Some varieties may even withhold traits that allow for greater resistance to drought or excessive rainfall. In addition to this, integrating different crops in farming systems has been found to increase land productivity, reduce chemical fertilizer and pesticide use, increase nitrogen efficiency, suppress weeds, and improve soil structure and function (Baker & Russell, 2017).

Small grains add environmental value to farming systems because they are important rotation crops used to reduce pest pressure and break disease cycles. Planting small grains with other crops such as buckwheat, millet, rye, corn, and nitrogen-fixing grain legumes is known as crop diversification. Crop diversification provides many socio-ecological benefits, such as contributing to yield stability and improving soil health, as well as reducing environmental risks associated with climate change (Bybee-Finley, 2018). Increasing plant diversity in this way can promote all four ecosystem (provisioning, regulating, cultural, and supporting) services in farming systems.

Increasing crop diversification in farming systems is also a climate and economic risk management strategy for farmers. This is because growing a wide variety of crops provides multiple uses that appeal to different markets. For example, wheat is a source of food, seed and straw, rye can be used for distilling, cover cropping and seed, and barley is useful as seed and for malting and animal feed. In upstate New York, Thor Oechsner from Oechsner Farms grows food-grade grains such as hard red spring wheat, hard red winter wheat, and soft white winter

wheat, which he sells to Farmer Ground Flour, a local mill he helped establish. He also cultivates other value-added crops such as soybeans for dairy feed, rye for flour, malting, and distilling, corn for cornmeal and malting, clover for hay and silage, and buckwheat for flour. These crops are an important part of his crop rotation plan, which play a role in suppressing weeds, building soil tilth, increasing soil organic matter, fixing nitrogen, and providing forage for bees (**Figure 3**). By promoting crop diversification, farmers can add value to their farming systems, which can lead to new market opportunities for businesses, restaurants, and institutions, and the provision of a wider variety of non-commodity, whole grain options for consumers.

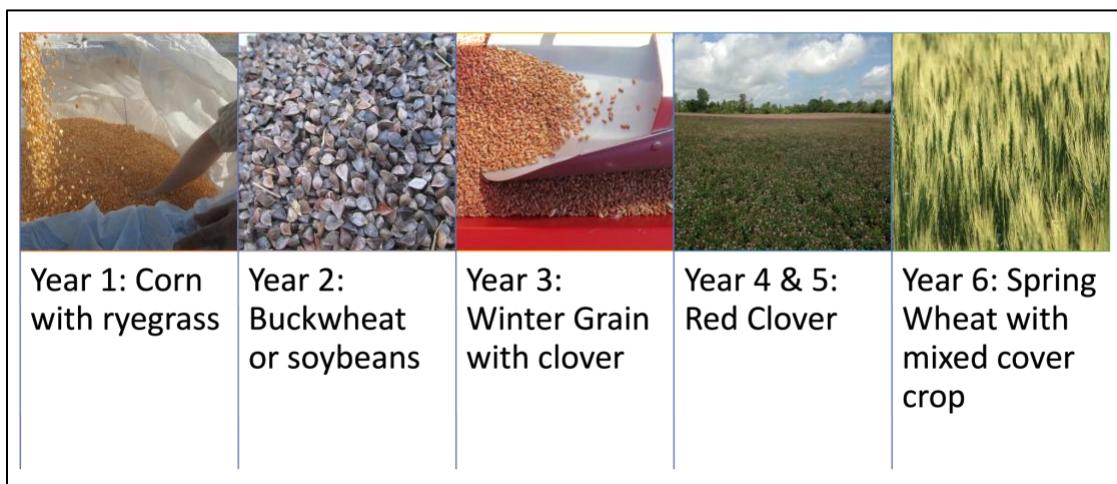


Figure 3 Thor Oeschner’s regenerative six-year crop rotation plan for his grain farm

2.4.2 Economic

The localization of grains has been financially profitable, bringing economic growth and job opportunities to both rural and urban communities. In recent years, farmers have been motivated to shift to organic grain production, especially diversified organic grain production, because the value-added markets for this are more profitable than conventional grain production (Peterson et al, 2012). For example, in Montana, Bob Quinn is a leader in reinvigorating his rural

community through his efforts to cultivate Khorosan, an ancient wheat variety, and the establishment of a multimillion-dollar grain company, Kamut International. In launching this business, Quinn created a pathway and provided a stable source of income for farmers in his community to switch to organic farming. His four other value-added enterprises: a mill that processes organic and heritage grains, an organic grain snack company, a wind farm, biofuel business, and his involvement in regenerative and diversified cropping systems has helped create a profitable regional grain economy (Quinn, 2019).

In the Northeast, investments in regional grains have led to the proliferation of new businesses, distilleries, breweries, and mills, which in turn have created jobs, promoted local food products, and created stronger links between regional farmers, processors, distributors, and end-makers (Blair, 2017). Profits generated by breweries that locally source their grains have been reinvested in local communities through the form of grants. In 2014 and 2015, Allagash Brewing Company and Quimby Family Foundation jointly awarded the Maine Grain Alliance \$20,000 to distribute to 30 small grain-based businesses in Maine (Maine Grain Alliance, 2021). Small assistance grants like these have helped small farms and businesses purchase the equipment and infrastructure they need to scale up their operations. They have also been used to support innovative food businesses and entrepreneurs who are dedicated to building up their local grain economy. Farmers, processors, and business owners are diverging from the commodified mainstream grain economy to develop alternative value supply chains that are place-based, to provide more market connectivity and economic growth opportunities within that region. This trend has spread across the U.S from the Finger Lakes region in New York (Baker,

2017), to the Midwest (Halloran, 2020) to the South (Lapidus, 2020), to western Washington state (Hills et al., 2013), and even to central Arizona (Forrest & Wiek, 2021).

Consumers have shown a burgeoning interest in purchasing and consuming whole grain products. This has opened a new realm for value-addition and economic opportunities to develop artisanal food products such as pasta, bread, beverages, and pastries made from alternative grains like heirloom wheat, barley, quinoa, millet, sorghum, and amaranth. The future for local grains is bright as food products marketed as "local" have been found to bring in higher prices than mass-produced conventional products (Skog, 2018). In addition to this, farmers and millers can take advantage of the new niche direct markets for heirloom and heritage wheat varieties that bakers and distillers have created in their pursuit for unique flavors (Ramanujan, 2017).

A 2019 Eat-Lancet report recommended that for the world to achieve healthy diets and global sustainable food systems, people must increase their consumption of plant-based foods, especially fruits and vegetables, whole grains, nuts, and seeds (Willlett et al., 2019). Evidence has shown that consumption of whole grains decreases the risk of cancer, type 2 diabetes, and cardiovascular diseases. They are also an important source of fiber, protein, lignans, phenols, and immune supporting vitamins and minerals (American Institute for Cancer Research, 2018). With these health benefits in mind, food products that provide additional nutritional value, such as aleurone flour, chips and tortillas made from barley, as well as coffee and tea substitutes from wheat and barley have been identified by the Agricultural Utilization Research Institute to have tremendous market potential (Doty et al., 2012). Given these reasons, it is likely that the market

for local grains will continue to grow, and open new doors for food products and recipes that promote the consumption of alternative grains.

2.4.3 Social

Local grain chains can add social value to communities by strengthening personal networks and relationships between people. When industrial large-scale grain production became centralized in the Midwest, this tore apart existing connections between grain farmers, processors, and consumers in rural communities. Since then, consumers have become even further removed from the way grains are cultivated. Standardizing the production of grains to create mass-produced commodity goods for baking and cooking has encouraged the loss of diversity and traceability of grains in our food system (Halloran, 2015).

In contrast to this, local grain chains have increased opportunities for consumers to directly become more connected to the people who produce their food. In an ethnographic multi-sited study of localized grain chains, Hergesheimer & Wittman traced the way grains travel from field to plate in British Columbia to investigate the impact of shorter food supply chains in food systems. They found that alternative grains chains generate social value by promoting the traceability of local food production, preserving the identity of local producers and consumers, redefining the range of local food production, and testing and strengthening the development of niche markets (Hergesheimer & Wittman, 2013).

Shorter alternative grain chains also offer the possibility of creating stronger social connections by building relationships and increasing trust between consumers and producers

(Forrest & Wiek, 2021; Stanco et al., 2020). Although the development of stronger ties is a promising benefit associated with shorter value chains, critiques of local food systems argue that there are no ways to measure the strength of these social connections (Trivette, 2011). However, opportunities that create deeper social networks (e.g grain-based community gatherings, field days, conferences, and hands-on educational workshops) can inspire and empower others to become involved in revitalizing their local grain economy. GrowNYC Greenmarket hosts special events like Grains Week where consumers can meet different growers, makers, chefs, artisans, and entrepreneurs, and learn about the use of local grains in their products. These types of events support all the stakeholders involved and create opportunities for more knowledge sharing within the network. Aside from increasing deeper connections, they also improve grain literacy, consumer awareness, as well as access and availability to local grain products.

2.5 Resilience in Alternative Food Networks

The world faces an unprecedented number of challenges and uncertainties. Climate change, environmental degradation, rapid urbanization, unsustainable population growth, malnutrition, rising global food prices, and the collapse of lengthy food supply chains are just some of the problems we face in the 21st century. To this, the Food and Agriculture Organization (FAO) stated, “responding to these challenges requires a systems-based approach that addresses the range and complexities in a holistic and sustainable manner” (FAO, 2021). To achieve social, environmental, and economic sustainability, research has looked towards resilience as a solution to these issues (Salvia & Quaranta, 2017; Walker et al., 2004; Zautra et al., 2009). The origin of resilience research derived from the field of ecology, and now it is referenced in a variety of fields, including development, urban planning, and engineering. Resilience is defined as “a

system's ability to respond to external disturbances while maintaining the same function, structure, identity, and feedback" (Holling, 1973). A resilient system has characteristics of persistence, adaptability, and transformation (Folke, 2016), and can withstand and overcome disturbance without being destroyed. In contrast to this, systems with low resilience are vulnerable and cannot adapt quickly in the event of a disruption, often unable to recover to their original state once they cross a certain threshold (Holling, 1973).

Food and farming systems are examples of incredibly complex social-ecological systems (SES) that are affected by changes triggered by unexpected disturbances. A social-ecological system, as defined by Berkes & Folke (1998), is known as "an integrated system in which humans are part of nature and therefore cultural, political, social, economic, ecological and technological components interact". A food system, for example, is an SES because both human and natural elements act as a coupled system (Foran et al., 2014). Farmers are connected to their natural environment and rely on provisioning and regulating ecosystem services to produce food for consumption. Food systems are not immune to changing conditions. An example of a gradual disturbance in a food system is longer and more frequent periods of drought that threatens the livelihoods of wheat farmers. Head et al. found that wheat growers in Australia developed different coping strategies tailored to their farm to adapt to the risk and uncertainty brought on by climate change (2011). As such, applying characteristics of resilience to strengthen the structure and function of food and farming systems could be a potential solution to adapt to and mitigate the effects of climate change.

Different frameworks have served as useful tools for scholars to measure and identify resilience in different SESs (Hodbod & Eakin, 2015; Resilience Alliance, 2010, Skog et al., 2018; Worstell & Green, 2017). In one study, Skog et al., used a framework that examined the four factors needed to create a resilient system to analyze Vermont's local food system (2018). These four components were identified as: willingness to live with change and uncertainty; social diversity for reorganization; using different kinds of knowledge; and creating capability for self-organization. Researchers found that it was difficult to measure and assess these resilience components, such as a system's capacity to live with change. However, they determined that resilience within the local food system was added because of certain adaptive governance rules that were implemented by the key actors in that food system. Another study by Hodbod & Eakin utilized a different SES framework to evaluate California's food system and identify its attributes of resilience (2015). According to this framework, resilient systems are characterized by high response and functional diversity. The framework they used is presented below (**Figure 4**), with the intention that any food system can be mapped onto this map according to the system's functional and response diversity.

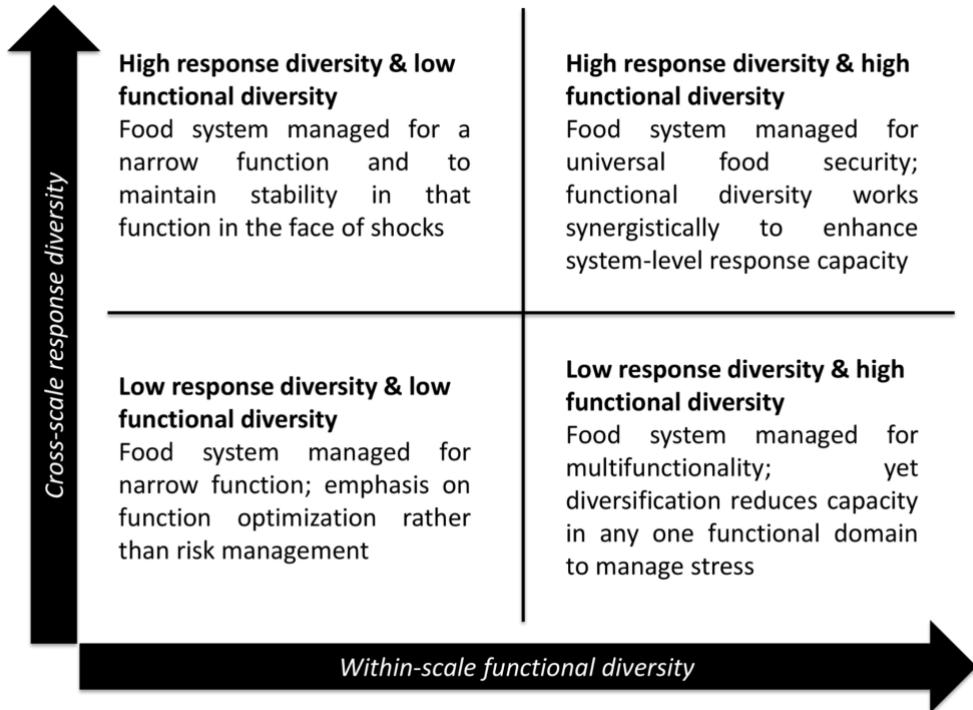


Figure 4 A framework used by Hodbod & Eakin (2015) to identify and assess resilience

Lastly, Worstell & Green developed a qualitative tool that allows people to identify characteristics of resilience in food systems and communities (2017). After examining six notable frameworks that analyzed resilient systems, they defined eight common qualities that are necessary for creating resilience in food systems. These eight qualities are: modular connectivity, locally self-organized, increasing physical infrastructure, responsive redundancy, complementary diversity, conservative innovation, ecologically self-regulated, and embracing disturbance for transformation. The intention of this framework was to provide a foundation for the development of a resilience index that would help decision makers improve resilience in food systems and communities.

As shown by the examples above, adopting certain frameworks to map out resilience is useful in facilitating the development of sustainable local and global food systems. Through analyzing the local grain chain as an SES, we can utilize this information to create a network that is more diverse and resilient. Skog et al. (2018) summarizes this by stating, “the goal is to create a resilient SES, which is able to reorganize itself and recover after disturbance, learn from that experience, and develop new structures and processes to adapt to changing conditions while still retaining its essential function”. To increase resilience in food systems, we need to first identify what its key attributes of resilience are and what areas are needed for improvement. Colorado faces many uncertainties, including the possibility of extreme weather due to climate change, volatile commodity markets, and rising costs across supply chains—all variables that could drastically impact the production, processing, and consumption of grain. Using the framework and criteria presented by Worstell & Green, the final section of this study will attempt to determine characteristics of resilience in Colorado’s local grain chain.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Case Study Background

For a long time, agriculture has been the front and center of Colorado's economy. Major food and beverage companies such as Coors (1873), Celestial Seasonings (1969), Horizon Organic (1991), Justin's (2004), and Bhakti (2007) have all found their origins in Colorado. Others have brought innovation and sustainability to the agricultural value chain. Since their inception, many more environmentally and socially mission-driven businesses focused on addressing the cross-cutting sustainability concerns associated with food production have emerged there. Graff et. al (2014) have found that the proximity of major agricultural production to a major urban corridor, the co-location of major research institutions, and Colorado's ability to build innovation capacity by attracting and retaining talent are the main drivers of this innovation cluster. Due to these reasons, Colorado is well positioned to support the growth of alternative food networks and value-added businesses seeking to rebuild the local grain economy.

Colorado is one of the many areas in the U.S where the relocalization of grains has gained traction. Most famously known as a valuable part of the winter wheat belt that extends across Kansas, Oklahoma, Texas, and Nebraska, it is a major wheat producing state in the US. Hard winter wheat, corn, millet, and sorghum are the major grains produced in this state. In 2020, corn led the way with a total production of 122,960,000 bushels, followed by winter wheat (41,040,000 BU), barley (41,040,000 BU), sorghum (5,100,000 BU), and millet (4,495,000 BU) (USDA, 2021). Interestingly, wheat is the state's only major food grain crop (Colorado Wheat,

2021), as corn is primarily grown for animal feed and ethanol, sorghum for forage, barley for malting, and millet for forage and bird seed. Roughly 80 percent of Colorado's wheat is exported internationally, and in 2020, it produced \$190,836,000 worth of wheat on 1,900,000 acres of land (USDA, 2021).

3.2 The Grain Chain: From Farm to Bakery

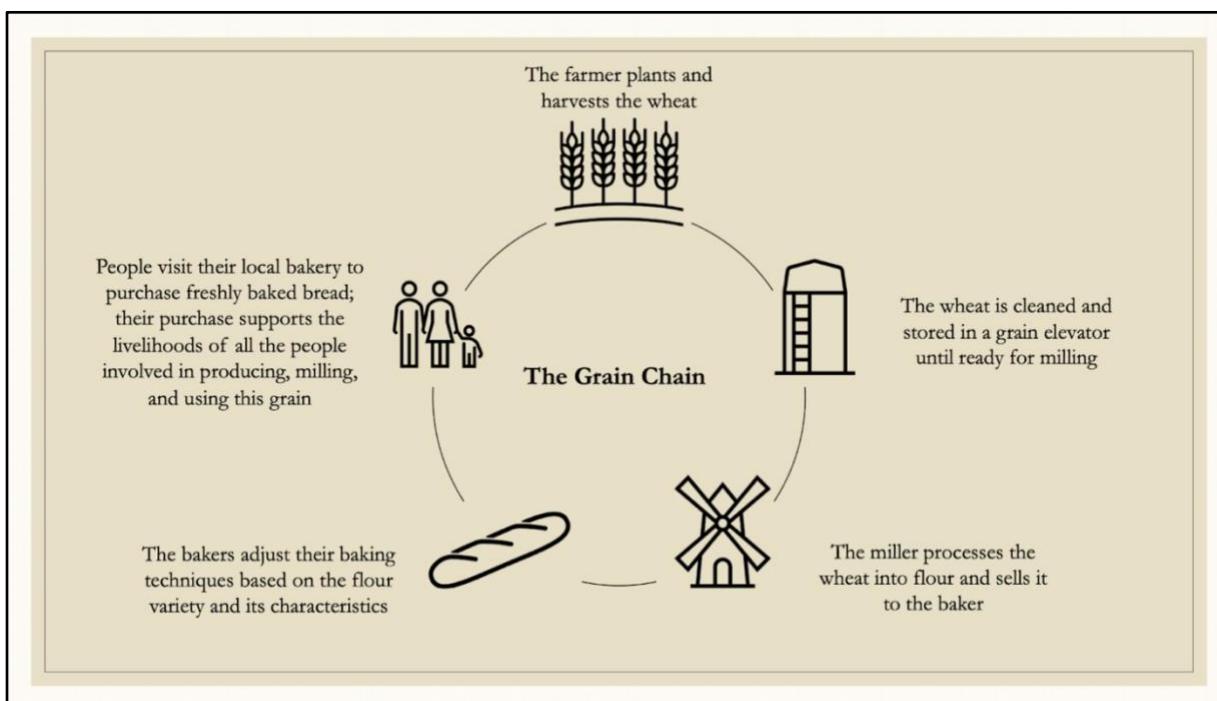


Figure 5 All stages of wheat throughout its lifespan: from farm to processor to mill to baker to consumer

(Source: Mika Ulmet, 2021)

- 1) The lifecycle of wheat begins with the farmer carefully selecting and planting seeds to grow in their fields (**Figure 5**). The varieties grown at the farm are determined according to market demand, farmer preference, and contracts with buyers. Forming mutually beneficial partnerships with local buyers and establishing equitable contracts allows

farmers to take risks like diversifying their cropping systems and growing different varieties of alternative grains. Having a guaranteed buyer provides extra assurance for farmers, reducing market risk, and allowing for direct involvement in a growing marketplace for high value grains.

- 2) After the grain is harvested, it is transported to a nearby grain elevator where it is cleaned, tested, sorted, and either stored on site or sold to flour mills. Growers may also have their own storage facilities and equipment to handle the grain. Some farmers may also have strong relationships with local millers, who understand the mechanism behind processing grains in a specific way to capture nutritional quality and flavor.
- 3) Millers play an important intermediary role between farmers and bakers because they know which types of grains and products are in demand and can inform farmers what the market is calling for. Farmers who sell directly to local mills can stay competitive in a commodity market because they capture some of the profits generated by growing high-value grains. Direct sourcing relationships between the farmer and the miller also facilitates transparency along the grain chain, including greater information sharing about the grain's quality and growing conditions.
- 4) Once the grain has been processed and milled, it ends up in the hands of the baker. Working with flour from single origin crops has its challenges; inconsistencies in the quality of flour (e.g., protein, moisture content, ash percentage, falling number) from year to year means that bakers must adjust their baking strategies to accommodate these

changes in flour type. By shifting hydration levels and fermentation times, bakers can work with different varieties of flour that have lower protein content and still produce quality bread. Bakers committed to working with local flour must be willing to work with what is available. Developing a seasonal menu or providing a selection of baked goods that incorporate grains grown on local farms that year are other ways in which bakers can extend their support for local farmers.

- 5) The final link in the cycle of grain is between the baker and the consumer. Bakers play an influential role in raising awareness about the benefits of consuming alternative grains, as they are in direct control of what their customers eat. The biggest barriers of artisanal bread consumption have been found to be associated with price point and flavor, as many people are accustomed to purchasing cheap, commercially yeasted, white bread produced in factories. Artisanal bread made with locally and sustainably grown flour has caught the attention of consumers who care about using their money to vote for causes that align with their personal values like mitigating climate change, supporting local economies, and nutritional health, which are all issues closely linked to wheat production.

As wheat is a major food grade crop grown in Colorado for human consumption, as well as an important part of society for cultural, environmental, social, economic, and nutritional reasons, I chose to look at the structure and function of Colorado's grain chain through the perspectives of stakeholders whose livelihoods revolve around this crop. Hergesheimer & Wittman (2012) defines the grain chain as, "the social networks involved in moving grain from fields to processors and consumers in both conventional and newly emerging, alternative small-

scale grain production initiatives”. The recent ancient and heirloom wheat renaissance in the U.S has also started to gain momentum in Colorado. It is a growing movement led by committed farmers, millers, bakers, brewers, artisan producers, and researchers who care about the ways in which alternative grains are produced, processed, and consumed. As Colorado stands on the precipice of a new frontier for value-addition in the grain chain, this study hopes to contribute to the general development and understanding of the structure, nodes and connections, and function of the grain chain.

3.3 Research Design

I used a mixed-methods approach that incorporated both quantitative and qualitative data to analyze the social network and dynamics within the local grain chain. Stakeholders who work with wheat from various stages in the grain chain (farmers, millers, bakers, and local grain advocates) were identified and interviewed about their involvement. All survey respondents, interviewees, and participants in this research are listed below in **Table 2**. Additionally, the following section describes the three forms of data collection (surveys, interviews, and field observations) in further detail.

Table 2 List of small grain producers, millers, bakers, who participated in this study, and their roles within Colorado’s local grain chain

Participant	Role in local grain chain	Research methodology	Colorado Grain Chain Member
Aspen Moon Farms	Farmer	Site visit	Yes
Blue Grouse Bread	Artisan baker	Survey, interview	Yes

Bristlecone Bakeshop	Artisan baker	Survey	No
Colorado Grain Chain	Organization	Interview, community events	Yes
Dry Storage Co	Baker and Miller	Survey	Yes
Grains from the Plains	Farmer	Survey, interview, site visit	Yes
Grateful Bread	Artisan baker	Survey	No
Freshly Milled	Miller	Survey, interview, site visit	Yes
Moon Raccoon Baking Co	Artisan baker	Survey	No
Moxie Bread Co	Artisan baker	Interview, site visit	Yes
Nightingale Bread	Artisan baker	Survey, interview, site visit	No
Pig and Plow	Artisan baker	Survey	Yes
Precision Pours	Artisan baker	Survey	No
Raleigh Street Bakery	Artisan baker	Survey	Yes
Tumbleweed Bread	Artisan baker	Survey	Yes

3.4 Survey

The first part of data collection involved creating and sending out a Qualtrics survey that asked each stakeholder (farmer, miller, and baker) questions that were tailored to their profession and their involvement in Colorado's local grain chain. I initially connected with local farmers and businesses that were members of the nonprofit, Colorado Grain Chain to ask if they would like to participate in this study. The Colorado Grain Chain (CGC), a 501(c)5 membership organization that connects locally owned and operated businesses and consumers to the local grain chain. They promote the cultivation and use of small grains and are dedicated to strengthening this network across Colorado by providing education opportunities, technical

assistance, and branding opportunities for businesses. CGC has a total of 72 members, 50 of whom are consumers, and 22 are local businesses. From this list of 22 businesses, there were a total of 14 farmers, millers, and bakers, who I identified as eligible (based on their profession) for participation. I purposely excluded other food-grade grain businesses because the scope of this project focuses solely on farmers, millers, and bakers. Furthermore, grocery store bakeries and large national commercial bakeries were not included because I decided to center this research on locally and independently owned businesses. Survey piloting was conducted, and feedback was provided by multiple consultants, including Florio Arguillas from the Cornell Center for Social Sciences, Stef Senders from Wide Awake Bakery, and Professor Katie Fiorella from the Department of Population Medicine and Diagnostic Sciences & Master of Public Health Program at Cornell University, and her lab members. On July 26th, 2021, the finalized survey was sent via email. Seven people (50%) responded. To further expand the sample size, I directly reached out to local farms, millers, as well as cottage and professional bakers through Instagram. Out of the 17 additional people I messaged, 5 (29%) responded and completed the survey. The total response rate was 38%.

Survey participants were notified of the project's objective, their involvement, risks/benefits, and their protection of privacy. They were then asked to sign a consent form prior to their participation (**Appendix 1**). The participants were also given the option to enter a \$15 raffle, which was awarded to six respondents who completed the survey. The survey included a total of 16 questions on a wide range of topics about business (e.g number of employees, annual revenue, number of years operating in Colorado), sourcing (e.g where they sell their wheat to or source their flour from), and partnerships with other people involved in the grain chain.

Participants were also asked their opinions on their definitions of local, the importance of and reasons for supporting the local grain chain. In other sections, respondents were asked specific elements regarding their business, such as the varieties of wheat grown, the type of products they sell, or how many local mills they source their flour from. A complete version of the final questionnaire can be found in **Appendix 2**.

3.5 Semi-structured Interviews

Semi-structured interviews were used to supplement any missing information, as well as to gain a deeper understanding of the perspectives of the stakeholders participating in the local grain chain. I noticed that certain questions from the survey did not completely capture the context, attitudes, or motivations of the respondents. Survey respondents were invited to opt-in for a follow-up interview to talk about their role and involvement in the local grain chain. All 12 (100%) of the respondents indicated interest in sharing their experiences with me. From these 12 respondents, I selected six people to interview. Interviewees were offered \$20 for their time and generosity in their participation. Interviews took place from July 23rd to August 18th, 2021, and were conducted both in-person and through Zoom. Interviews typically lasted anywhere between 30 minutes and one hour. The main purpose of this was to facilitate an open discussion, which was important because it allowed participants to tell their story and opinions in their own terms.

Some of the questions I brought up in the interview touched upon themes that would answer some of the overarching research questions of this study. For example, a key part of this study was designed to identify the motivations behind those involved in supporting the development of a local grain chain and why this is important to them. Questions asked in the

interview can be found in **Appendix 3**, which includes: *What is your connection to wheat and what motivated you to start your business in this area? As a farmer, what kinds of organic practices do you use to grow your wheat? What are your reasons for incorporating more heirloom varieties into your crop rotation? Can you describe your involvement in the grain chain? Do you have any examples of partnerships that were instrumental in your business?* In addition to interviewing farmers, millers, and bakers, I also interviewed representatives from CGC about their involvement in the local grain chain, their vision for the future, and what must be done to strengthen the grain chain. While I did not directly bring up questions about resilience to each farmer, miller, baker, or local grain advocate, I did ask about the impact of COVID-19 on their businesses and discovered how they adapted to the challenges they faced.

3.6 Field Visits and Experiential Learning

Over the course of July and August 2021, in addition to conducting these surveys and interviews, I participated in activities that would allow me to gain a better understanding of the structure and function of Colorado's local grain chain. Activities included managing CGC's Instagram platform for their biannual Grain Chain 4 Change Racial Justice bake sale, participating in a planning meeting in preparation for their summer and fall educational grain school events, and attending a brainstorming event about branding/marketing opportunities for local grains. These activities exposed me to the breadth of CGC's network, allowing for me to appreciate how diverse the connections are within it.

The following activities were also instrumental in broadening my understanding of Colorado's grain chain. I spent a full day baking at a local sourdough bakery in Colorado

Springs, learning from start to finish their process of making bread for their community. I chatted with co-founders Ted Steen and Claudia Bouvier of Pastificio Boulder, observed how they made their pasta, and visited their plots of blue durum wheat they are growing in partnership with Aspen Moon Farms. I sampled many kinds of locally grown whole grain products including Moxie Bread Co.'s naturally fermented pine nut and pumpkin seed Millabrod, Pastificio's heirloom and ancient wheat pasta, and Nightingale Bread's high hydration apricot and thyme sourdough. Grains from the Plains graciously invited me to their farm where they showed me their farm machinery and fields of heirloom wheat. Lastly, I partnered with Sprout City Farms to provide a bread share for their CSA members, in which I baked three varieties of sourdough bread each week over the course of five weeks, highlighting different varieties of locally grown heirloom flour and flavors. The main reason in doing this was due to my own desire of wanting to gain firsthand experience of what it means to be a part of the grain chain from a cottage baker's perspective and live through the successes and challenges they face.

3.7 Data Analysis: Transcription and Coding

After conducting the interviews, a digital transcription platform called Otter.ai was used to transcribe each one. Each interview was double-checked and corrected, as there were some minor errors that arose due to factors like sound interference in the audio recording. The average time it took to transcribe and edit each one was two to three hours but varied depending on the length of the interview. Once they were transcribed, they were coded on ATLAS.ti, and searched for similarities and differences among different categories. The use of this platform allowed for data points to be selected and rearranged, which was helpful in data identification, especially with identifying commonalities linked to a certain topic. ATLAS.ti allows the user to create

network maps, which visually represents data to show different relationships within categories. It is a useful tool that allows the user to conceptualize ideas and see the network and relationships within their data.

CHAPTER 4 RESULTS

4.1 Stakeholders and their Motivations for Supporting a Local Grain Chain

The grain chain is composed of a diversity of people from different backgrounds, interests, motivations, and values. Those involved in building a local grain economy share interests in promoting the cultivation and consumption of local grains. The following section will introduce the different stakeholders involved in the local grain chain in Colorado, their motivations behind those involved in supporting the development of a local grain chain and why this is important to their livelihoods.

4.1.1 Farmers



(Source: Mika Ulmet, 2021)

Diversifying and integrating regenerative farming practices within farming systems has become quite a popular concept among grain growers in Colorado. Aspen Moon Farms, Black Cat Organic Farm, Cure Farm, and Jones Farms Organics are examples of farms that rotate grains in diversified food production systems. Grains from the Plains is a fourth-generation family farm located along the Eastern plains of Colorado, in the town of Hugo. Laura and Kevin Poss, together with their seven children, lease roughly 1,000 acres of land to grow a variety of

specialty grains. Concerned with the negative effects of chemical fertilizers and pesticides on the health of the people and the environment, they switched from conventional farming to organic farming. Although they are not yet organically certified, they are actively utilizing organic farming practices to grow hay millet, peas, triticale, as well as heirloom wheat varieties like Turkey Red, White Sonora, and Scout 66.

Laura and Kevin sell their crops directly to home bakers, mushroom growers, livestock producers, restaurants, small bakeries, and occasionally to grain elevators. Laura also runs her own milling business, where she grinds the heirloom wheat berries harvested from their fields into fresh flour for her customers. They sell roughly 40 to 60 pounds of flour to their customers across the U.S, each week. Soon they hope to transition to no-till farming and continue to build up a diverse farming system composed of more than 20 different varieties.

Laura and Kevin both mentioned that developing a local grain economy is very important to them because they want to support and take care of their own people. One of the things that bring them great joy is to hear from customers who share their baking stories about the flour they grow and mill. Customers with gluten sensitivities have shared their stories about how wheat from Grains from the Plains has been transformational for them and have described how they have been able to eat their heirloom wheat without having any negative side effects. They take great pride in feeding and nourishing people with the grains they grow.

4.1.2 Millers

There are only a handful of independently owned and operated artisan mills in Colorado, but this number has grown in recent years. Moxie Feed and Seed, Dry Storage, Freshly Milled, and Mountain Mama Milling are four mills that are working to strengthen the local grain chain in Colorado, to restore what has been lost. One of the missing links within the local grain chain is the infrastructure to process grains. Without mills, grains cannot be converted into value-added products that end users can purchase. Michelle Moffat, a local farmer, and treasurer of the Colorado Grain Chain, decided to take on the challenge of milling high extraction whole grain flour, and do what large-scale mills cannot do—process niche, heirloom wheat berries into high-quality, flavorful flour that contains the endosperm, germ, and bran, all of which are required for maximum nutritional integrity.





(Source: Mika Ulmet, 2021)

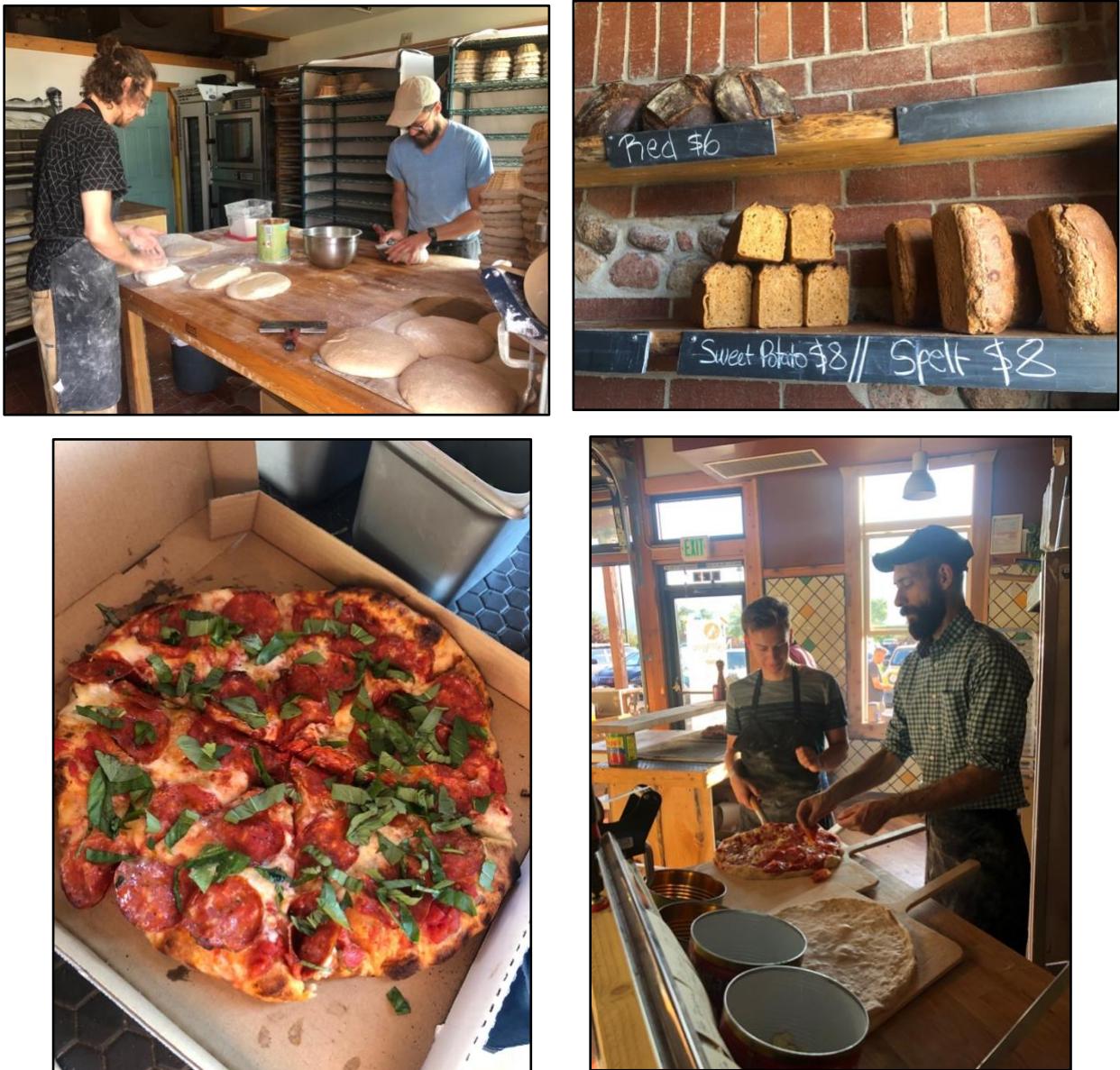
Michelle specializes in milling heirloom varieties grown by local farmers along the Front Range of Colorado. A portion of her grain are heirloom varieties she grows herself on her seven acres of land. These heirloom varieties are India Jamou, Ricor Roco, Red Fife, and Rouge De Bordeaux, which are all uniquely different in their characteristics, textures, flavors, and milling properties.

One of Michelle's motivations behind starting a mill comes from her keen interest in the environment. Connecting with Phil Taylor, a long-time friend and founder of Mad Agriculture, led to discussions about regenerative farming, carbon sequestration, and how grains can make a big difference in combating climate change. He encouraged her to start a mill because there were no processors in the area. Another reason why Michelle was interested in becoming a miller was

driven by her desire to help people eat more whole grains, for health and nutrition reasons. Michelle would like to continue to raise awareness about these benefits and hopes to someday partner with schools and cafeterias to encourage the consumption of whole grains.

In 2019, Michelle attended the Grain School at the University of Colorado, Colorado Springs to learn about farming and milling grains. Less than a year later, she opened her milling company, Freshly Milled, in Longmont, Colorado. Freshly Milled produces whole grain flours using a traditional stone mill. Soon after launching her business, she was impacted by the effects of the COVID-19 pandemic. This added an additional layer of challenges to an already difficult profession. Due to the pandemic, Freshly Milled had to close, and now the business and equipment are up for sale.

4.1.3 Bakers



(Source: Mika Ulmet, 2021)

Artisan bakeries are also a key component of local grain economies. Naturally leavened breads like sourdough have deep traditional and cultural significance in Europe, and bakeries that offer these breads can be easily found on every corner in many European cities. With

sourdough, bakers work with bacteria and yeast to bring life to flour, using the process of fermentation to make bread rise. The sourdough process is often described as both an art and science. In this, bakers must be precise, detail-oriented, and flexible as there are a multitude of variables that could influence the quality of the final product. Even the slightest change in temperature, humidity, the type of flour, its growing conditions or the health of the starter can affect the taste and texture of the final loaf.

Nightingale Bread is a small sourdough bakery located in Colorado Springs. This bakery is most known for its sourdough bread and yeasted baguettes, but it also offers a whole range of products including wood-fired pizzas, pastries, granola, cookies, and sandwiches. The owner of the bakery, David McInnis, converted an old elementary school classroom into the bakery in 2016. The atmosphere of Nightingale Bread instantly conveys the same feelings of warmth of a bakery in Europe. The space is oriented so that when people first walk in, the first thing they see is the mill. This was intentionally placed because every bake begins with grinding the grain into flour, which brings the attention of the consumer to the entire baking process. David wants only to make a normal, decent bread for his community, but his humble loaves are more than that. They are packed with nutrition and flavor, and are the epitome of authenticity, a prime example of what real bread should look and taste like.

Nightingale Bread is well connected to the regional grain chain because of its direct relationships with its suppliers and customers. David sources his ingredients from small-scale farmers as much as he can because he wants to use the bakery to support other organic farmers in the region. Most of the flour they purchase is from Central Colorado, from a farmer/miller

named Kris Gosar, the owner of Mountain Mama Milling. David also buys ancient grains from growers in South Dakota, and Kansas, as well as white flour from Central Milling in Utah. David sees his role as a baker as an important part of helping people grow and pursue their dreams. Through his bread, he hopes to see the local culture in his community transform into something that is more mature, resilient, durable, and beautiful.

Characteristics of Bakeries in Colorado

One of the goals of this study was to determine what kinds of general characteristics bakeries in Colorado have in common with each other. **Table 3 (Appendix 5)** presents the descriptive characteristics of the bakeries who participated in this study. All the participants who responded to this survey are bakery owners. Of the 9 respondents, 78 percent are small-scale bakeries, employing four or less full-time staff members. 56% have been in operation for one to five years. The bakery that has been in business for more than ten years has a staff of more than twenty employees. Every bakery indicated it sells more than one item, with 89% selling sourdough as their main product. Three bakeries (33%) had an average annual revenue of \$10,000 to \$49,000, four (44%) reported having a revenue between \$50,000 and \$499,999, and two (22%) made over \$500,000. Four out of nine bakeries make roughly 100 to 1000 loaves of bread per week and six (66%) use retail as their only sales strategy, either directly selling their bread at their storefront, farmers markets, pop-ups, farm stands and community supported bread share, or a combination of all. Bakeries that have wholesale accounts have relationships with restaurants, grocery stores and hotels. Eight out of nine bakeries reported sourcing their flour from within Colorado, and 22% percent indicated they mill their own flour in-house. The majority (67%) of surveyed bakeries purchase their flour from two mills.

Different Wheat Varieties Used by Bakers

Interestingly, bakers in Colorado use a total of 11 different ancient and heirloom wheat varieties in their products (**Table 4**). The most commonly used wheat varieties are Rouge de Bordeaux (hard red winter), spelt (soft winter), and Turkey Red (hard red winter). Rye is another popular grain that bakers include in their products. Rye provides numerous environmental and nutritional benefits, and are used as grain, forage crops, and cover crops. However, as it is not a type of wheat, this study does not go into further detail on its use.

Table 4 List of ancient wheat and heirloom varieties that Colorado bakeries use in their baked goods

Common Name	%	N	Scientific Name	Type	Class	Origin	Date of Release
Clark's Cream	4.3%	2	<i>Triticum aestivum</i> ssp. <i>aestivum</i>	Heirloom	Hard white winter wheat	USA-Kansas	1972
Einkorn	4.3%	2	<i>Triticum monococcum</i>	Ancient	Spring wheat	Fertile Crescent	10,000 years ago
Emmer	8.7%	4	<i>Triticum dicoccon</i>	Ancient	Spring/winter wheat	Fertile Crescent	N/A
Khorosan/Kamut™	6.5%	3	<i>Triticum turgidum</i> ssp. <i>Turanicum</i>	Ancient	Hard red spring wheat	Egypt	N/A
Red Fife	8.7%	4	<i>Triticum aestivum</i> ssp. <i>Aestivum</i>	Heirloom	Hard red spring wheat	Canada	1842
Rouge de Bordeaux	15.2%	7	<i>Triticum aestivum</i>	Heirloom	Hard red winter wheat	France	1800s
Scout 66	2.2%	1	<i>Triticum aestivum</i> ssp. <i>aestivum</i>	Heirloom	Hard red winter wheat	Nebraska	1967
Sonora	13.0%	6	<i>Triticum aestivum</i> ssp. <i>aestivum</i>	Heirloom	Soft white winter wheat	Mexico	1770
Spelt	15.2%	7	<i>Triticum aestivum</i> ssp. <i>spelta</i>	Ancient	Winter wheat	Fertile Crescent	8,000 years ago
Turkey Red	15.2%	7	<i>Triticum aestivum</i> ssp. <i>aestivum</i>	Heirloom	Hard red winter wheat	Russia	1873

Yecora rojo	4.3%	2	Triticum aestivum ssp. aestivum	Heirloom	Hard red spring wheat	California	1975
None of the above	2.2%	1					

Bakers' Definitions of "Local"

In the survey, bakers were asked to select their definition of local from the following options: along the Front Range of Colorado, within Colorado, within Colorado and its bordering states, and other (**Table 5**). 67 percent of respondents selected within Colorado as their primary definition of local. Other responses were based on distance. One bakery reported Southern Colorado and Northern New Mexico as local because they are geographically centered in that region. Another baker defined local as, “I make it, you’re local. You buy, it’s local.” This indicates that this person’s definition of local is based on the geographical location where the final product was purchased, and not necessarily where the ingredients come from. Results from this survey suggest that bakers’ definitions of local are subjective and dependent on a variety of factors.

Table 5 Bakers in Colorado and their definitions of “local”

Bakers' definitions of local	N	Percentage
Within Colorado	6	66.7%
Within Colorado and its bordering states (Utah, Arizona, New Mexico, Nebraska, Kansas, Oklahoma, and Wyoming)	1	11.1%
Other	2	22.2%

Bakers and their Perceived Importance of Supporting Local Grain and Flour

Varieties

Bakers were also asked their personal opinions on the importance of supporting a local grain economy, purchasing local flour, and baking with heirloom/ancient wheat varieties. Bakers

were asked to select one option on a scale of one (extremely important) to five (not at all important). The mean values and standard deviation are presented in **Table 6**. Supporting a local grain economy was perceived to be the most important (1.78), followed by locally grown flour (2.00). Baking with heirloom/ancient wheat varieties was the least important out of the three, which may be because bakers are interested in purchasing flour that they know is reliable and consistent and works well for them. Some bakers indicated they are not convinced that heirloom/ancient wheat varieties are worth the price that is often asked of them.

Table 6 Mean values and standard deviations in terms of perceived importance of local grain and baking with heirloom/ancient wheat flour

Importance	Mean	Standard deviation
Local grain economy	1.78	0.79
Locally grown flour	2.00	1.33
Baking with heirloom and ancient wheat varieties	2.33	1.33

*Mean scores are on a scale from one (extremely important) to five (not at all important)

4.1.4 Colorado Grain Chain

The Colorado Grain Chain (CGC) is a nonprofit organization composed of farmers, millers, bakers, brewers, distillers, maltsters, pasta-makers, chefs, and passionate people dedicated to the grain revival movement in Colorado. CGC was an idea that materialized into reality due to discussions held at the University of Colorado, Colorado Springs's (UCCS) Grain School. The Grain School was established by Nanna Meyer in 2016. Meyer is an associate professor of human physiology and nutrition at UCCS, and is the founding director of the Colorado Grain Chain. Upon realizing the absence of whole grains in Colorado's local food system, Meyer decided to address this issue by creating a space where experts passionate about relocalizing grains could gather to brainstorm and problem-solve. The Grain School is an online course that covers key areas in farming and processing, nutrition, culinary uses, community

building, and more. Over time, as a result of these discussions, a shared sentiment to create more of an organization to integrate all stakeholders along the grain chain materialized organically and led to the creation of CGC.

CGC offers a wide range of grain-related educational workshops, field events, roadshows and networking opportunities for their members and the public. In their bi-annual member newsletters they highlight the work that their members do, showcase different grains, and share recipes. One of the goals of the organization is to increase grain literacy among consumers. Over the past year, they hosted a series of online events through their Grain Home School, and have invited both grain experts from all professions, including Guy Frenkel of CEOR Bread, Jennifer Lapidus, Amy Halloran, Bob Quinn, Mona Esposito, and Apollonia Poilâne to share their expertise. One great aspect of CGC is their commitment to making education accessible to the public—these recordings have been preserved and are through YouTube for free.

CGC plans to attend more road shows within Colorado and the neighboring states. In September 2021, they attended the Pueblo Chili Fest to raise the profile of corn, leading demonstrations in both processing and culinary techniques. Another important aim of CGC is to raise awareness for the cultural heritage and landscape of grains in Colorado, connect with BIPOC populations, and advocate for the preservation of indigenous grains. In November 2021, they organized a two-day Grain School in the Field event which focused on restoring the food ways of corn. Participants attended hands-on workshops to learn how to nixtamalize corn, work with local artisans to make tortillas, and get direct professional culinary experience on commercial and home uses for this grain.

Additionally, CGC organizes a Racial Justice Bake Sale twice a year, where they enlist the help of bakeries, cottage bakers, home bakers, and “grain changers” to bake bread and raise money for Indigenous, BIPOC and anti-racist organizations transforming the food system. In 2020, they raised a total of \$10,288, which was donated to Frontline Farming, Black Lives Matter, and Child and Migrant Services in Colorado. Although still early in its development, CGC is a leader in the revitalization of local grains and continues to build new bridges and networks along the grain chain in new and exciting ways. The complete timeline of the various development stages of CGC is presented below (**Figure 6**).

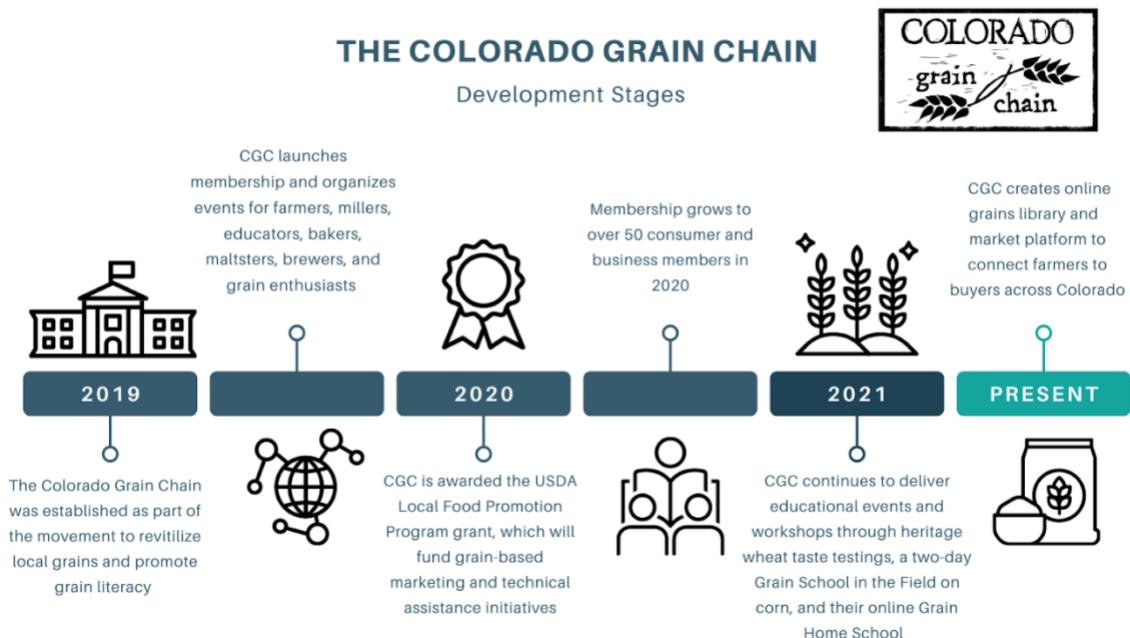


Figure 6 Colorado Grain Chain and a timeline of its key development stages

(Source: Mika Ulmet, 2021)

4.2 Network Size and Diversity of the Local Grain Chain

By mapping out the general structure of the local grain economy and pinpointing the key stakeholders involved in growing, sourcing, and using local wheat, we can identify areas of strengths and vulnerabilities within this network. **Figure 7** is an example of how stakeholders can be mapped out to display the wide range of people who are a part of the grain chain. The map categorized stakeholders into one of the following categories: farmer (blue), miller (green), baker (red), grain chain advocate (purple), and researcher (orange). Business members of the Colorado Grain Chain are represented as circles, while others are displayed as triangles. In actuality, this network is significantly more complicated and extensive than what is represented in this diagram. Stakeholders were found to wear many different hats, which added to the complexity of mapping these relationships out. For example, there are some farms that grind and sell their flour, mills that bake and produce bread, and bakeries that grow, mill, and bake with the grains they produced. Yet not one participant in the local grain chain was found to be self-sufficient; every person was connected to someone else in one way or another.

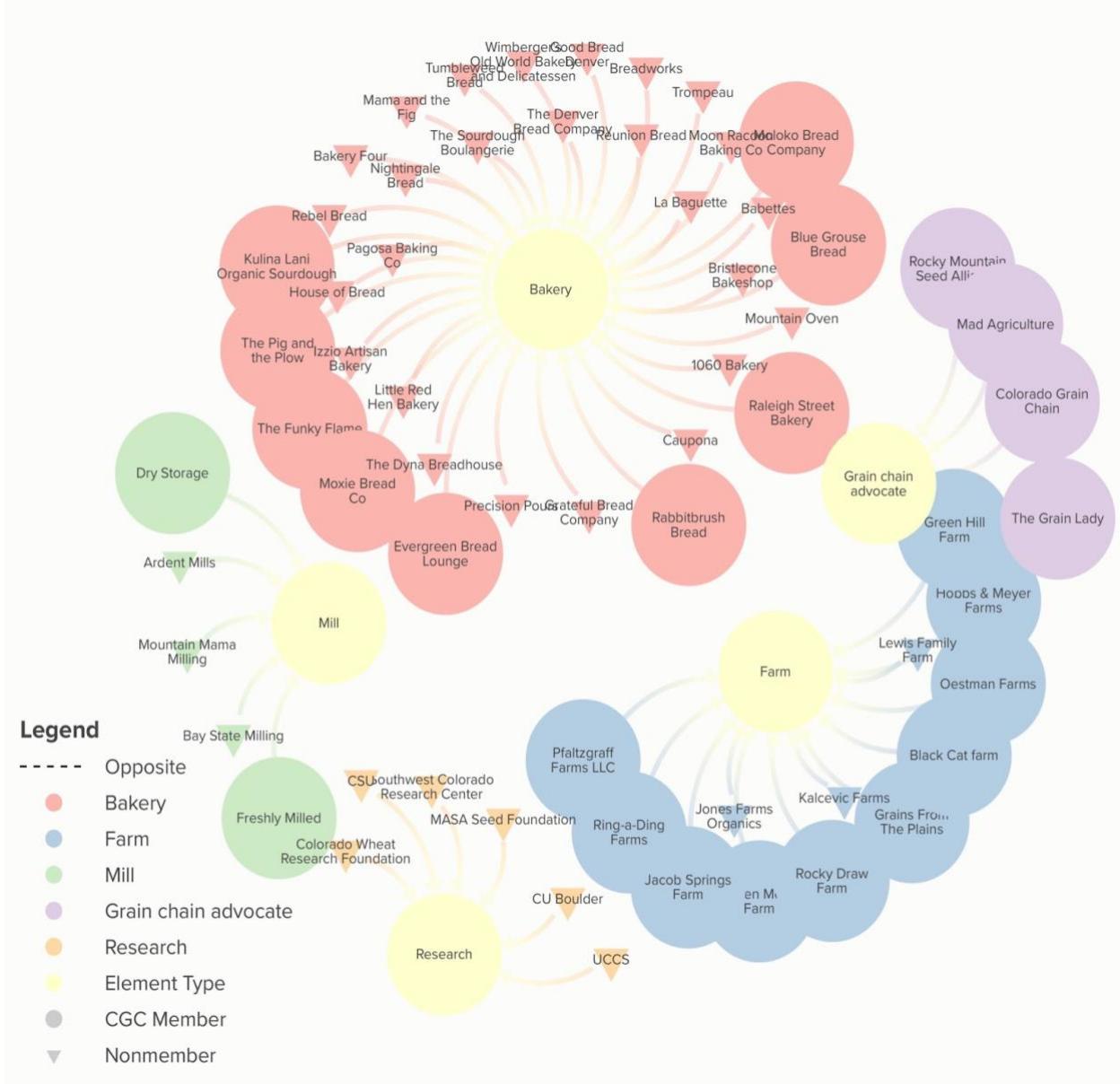


Figure 7 A stakeholder map that shows the various actors in Colorado involved in the production, processing, marketing, research, and advocacy of grains

(Source: Mika Ulmet, 2021)

Figure 8 is another example of a systems map that shows the interconnections between key stakeholders. This map highlights the proportion of bakeries that use a portion of locally sourced flour in their baked goods. As shown by the map, the number of bakeries has exceeded the number of small mills in the region. With the exception of Ardent Mills and Bay State Milling, there are only three locally owned mills: Dry Storage, Moxie Feed and Seed, and Mountain Mama Milling. It would be worthwhile to further explore the structure of this network, such as identifying the number of businesses, restaurants, and end-users that can be supported by a single mill.

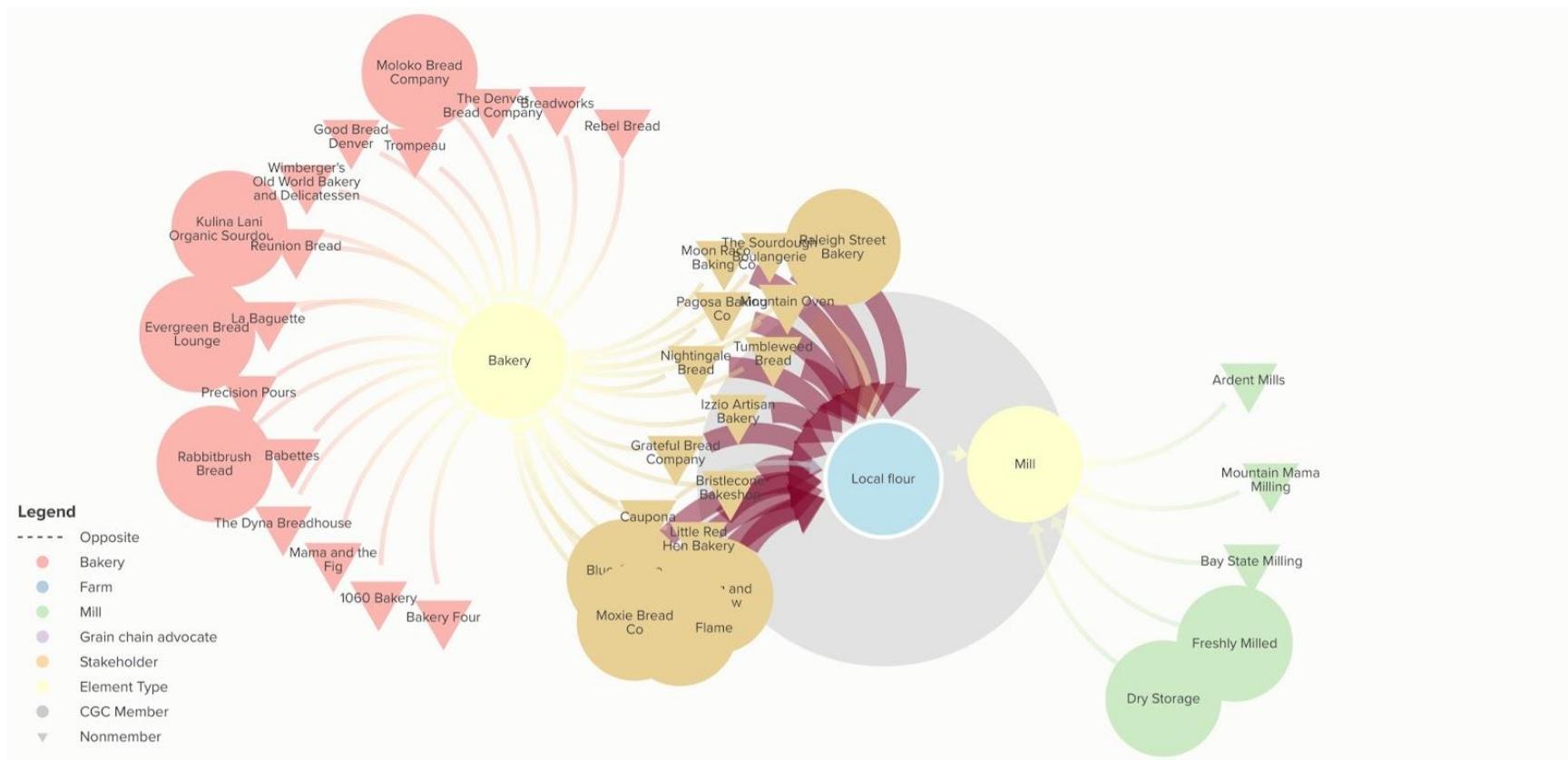


Figure 8 The proportion of bakeries in Colorado that source a portion of flour from local processors

*Note: Freshly Milled should instead be changed to Moxie Feed and Seed

(Source: Mika Ulmet, 2021)

4.3 Value Addition

This section outlines stakeholder perceptions on value addition, perceived benefits of supporting the development of a local grain economy, and how they deliver environmental, economic, and social value through their work. This study captures only a sliver of perspectives of those involved in revitalizing local grains and does not encompass the diversity of participants who are part of this movement. Results from the survey (**Table 7**) indicated that the top three benefits associated with the local grain chain are:

1. More traceability and transparency within the supply chain.
2. Stronger partnerships between producers, processors, and consumers.
3. A local grain chain is more resilient than the conventional supply chain.

Table 7 Perceived benefits associated with supporting a local grain chain from the perspective of Colorado farmers, millers, and bakers

Perceived benefits of supporting a local grain chain	N of responses	Percentage
More traceability and transparency within the supply chain	8	88.9%
Stronger partnerships between producers, processors, and consumers	8	88.9%
Reduced food miles	4	44.4%
Economic advantages created by a niche market	3	33.3%
Greater personal agency over the supply chain	3	33.3%
Higher quality of products	4	44.4%
A local grain chain is more resilient than the conventional supply chain	5	55.6%
Other	2	22.2%

*Participants were asked to select their top three choices

Interviews with stakeholders provided deeper insight behind their motivations for supporting a local grain chain. The primary reasons for their involvement were related to caring for the environment, supporting a local economy, and strengthening relationships within their community. This next section highlights key stakeholder perspectives on environmental, economic, and social value addition.

4.3.1 Environmental

Interviewees demonstrated that environmental values such as sustainable farming or combating climate change go hand-in-hand in supporting the development of a local grain chain. Some farmers involved in cultivating small grains have animals as part of their farm rotation, adding manure back to the soil, which improves both soil health and fertility. Other farmers use winter or spring wheat to break disease and pest cycles, or aid in weed suppression. One farmer mentioned the challenges of growing organic wheat on sandy soil, stating, “it's kind of hard to raise anything on there because we get a lot of wind out here. And the wind just blows our crops by” (farmer/miller). They expressed the need for more soil coverage to reduce soil erosion and land degradation. One baker was concerned about the environmental sustainability of growing certain crops, especially less drought-tolerant, more water-intensive varieties. They suggested encouraging farmers to grow grains for human consumption instead of animal feed as a solution.

“Because originally, there were a lot of people growing for Coors Brewery; they were growing barley for Coors, so a lot of people had grain processing equipment. And then when the price of barley dropped, people switched to growing alfalfa for animal feed.

With the water situation changing, I'm not sure how sustainable this is in this region. So, it's been a good time to approach people and ask if they are interested in growing grain for human consumption" (baker).

Where they source their grains from, and how these grains are grown matters to grain chain stakeholders. One baker, for example, described how he started his relationship with direct farmer grain, because of the way in which local farmers used biodynamic and regenerative farming practices to grow their heirloom wheat:

"I had worked with Turkey Red before, and he offered to get the sample. She's a 900-acre biodynamic rotational farm with maybe a third of the farm in wheat at any given time, so a fully closed-loop system. She has wild cattle and bison there. She's a crop certifier, organic crop inspector, and a biodynamic inspector. So that was our entrance into direct farmer sourcing" (baker).

Stakeholders further downstream of the grain chain have been highly supportive of regenerative agriculture practices that have positive environmental and social impacts such as the revitalization of soil health, enhancement of biodiversity, and restoration of degraded natural resources. Some have acknowledged the value of diversified farming systems in sustainable food production, expressing interest in promoting the farmers who implement these principles through their businesses.

“It's also better for the land not to have the same thing on it over and over again, {...} like, plant it with legumes or buckwheat. But anyway, more variety will be good. And to really look at things that are not just wheat is important. And I think the grain chain needs to focus on that as well. You can make bread with other things besides wheat” (farmer/miller).

Promoting small grain diversity can be a potential benefit for local grain sellers.

Consumer demand is a driver of alternative grain production, and farmers, millers, and bakers have noticed an uptick in their customers asking for single-origin flour and different varieties of wheat. One farmer mentioned customers asking for Red Fife, Sonora, and Einkorn, noting that there seems to be a demand for uncommon varieties, and that if they could sell Einkorn, they wouldn't have to work an off-farm job anymore because of the profits generated by its high marketing price.

4.3.2 Economic

For the most part, interviewees have indicated that supporting a local grain chain is important for several economic reasons, including revitalizing rural economies and keeping people employed in the community:

“I think just to be local and take care of your own. I mean, like how we discussed before that the manager from the grain elevator, he said most of our grain around here goes to Japan. I mean, that's wonderful. But I'd rather take care of my backyard, then people far away across the nation” (farmer/miller).

Small businesses are vital in keeping people employed in the community. Blue Grouse Bread is an example of a bakery that created a market opportunity for value-added grain growers to become profitable. Hannah and Ben Rossman founded their sourdough bakery with the goal to provide a consistent market for farmers to sell to. They provided an economic pathway for farmers to grow grains for human consumption. To gauge interest in grain production, they initiated conversations with local farmers at events in Norwood to see if anyone would be willing to grow grains for their bakery instead of animal feed and found growers interested in becoming suppliers. They partnered with growers who were willing to experiment with alternative varieties such as Turkey Red and Spelt, and other specialty grains. The whole grains they buy from their local farmers is ground into fresh flour by an eight-inch stone mill they at the bakery and immediately baked into bread. Over the past five years, they have slowly increased the percentage of whole grain wheat in their Country Bread from 20 to 35 percent. Today, one hundred percent of Blue Grouse Bread's whole grains are sourced from Colorado farmers.

Increased transparency within the supply chain is another economic advantage that local grain chains provide to the public. One interviewee expressed the value in consumers learning where their food comes from and how it is grown:

"I think it's important to know where your food comes from. And it's important for a number of reasons, you know, for community reasons, to help keep employment local. So you can see where your food is grown and what you think their practices are"
(farmer/miller).

Growers, processors, and end users can use this opportunity to share the stories of the people involved in the making of the final product, as co-creating value within the grain chain mutually benefits all parties involved, leading to stronger brand identity for local products. Take for example, the Colorado Proud logo, which is recognized as a symbol that promotes food and agricultural products made in Colorado. Single origin heirloom wheat earns more than commodity wheat in the market, which makes this crop profitable despite its lower yields. Bakers, pasta makers, maltsters and chefs can support farmers by creating a market for these crops. Low prices from the commodity market and economies of scale make it difficult for locally produced organic grains to stay competitive with larger operations. Farmers and millers require capital and new infrastructure to scale-up their operations if they want to keep up with the demand for locally grown grain. One participant describes this as a major challenge for them:

“I think our milling challenges are that we’re not big enough for a commercial mill and too big for a personal mill, even the Mock Mill 200 stone grain mill. But if we can be a commercial mill, we can ship flour to other states. We can have something bigger that processes better, that’s more meant for our size. And then we can also maybe sell flour to, you know, bakeries, restaurants” (farmer/miller).

The process of growing value-added grains is different from growing commodity wheat. Cultivating heritage varieties is knowledge-intensive, requiring prior decision making and planning, which in contrast to commodity wheat farming, can oftentimes be hands-off and uninvolved. Buyers who cut contracts with farmers take care of the harvesting, while farmers oversee the planting and growing, and have no control over where the grain goes:

"I looked out on his field, and there was wheat everywhere. And then finally, you know, I found some wheat, 'Is that your field?' He said, 'well, it's my field, but I just sort of like, contract grow'. I said, "well, what's the variety?", 'I don't know' {...} And he said, 'you know, they come and they plant it, and then they come and harvest it. And I only know it's being harvested because I look out and there are combines on the property'"
(baker/miller).

Through mechanization and standardization, the conventional grain chain simplified the cultivation and processing of commodity crops, but in doing so, it also removed individual agency over the supply chain. For example, after farmers harvest their grain, it is shipped off to a remote milling location where it is processed elsewhere and may not even be consumed where it was originally grown. Farmers also have no control over the price of commodity wheat despite how much work they have invested. Stakeholders involved in the local food movement in Colorado are now discussing ways to regain control, and find solutions to this problem:

"People are thinking, 'well, what are the components? And how do you build a local grain economy?' Well, you have to do it in a way that makes sure that where the grain is produced is also where it's processed, where it's stored, where it gets cleaned, where the seeds get cleaned, where they get dehulled, where it gets stored, where it gets milled, where it gets malted. All of these things we don't think about...local small-scale farmers are not used to doing" (grain chain advocate).

4.3.3 Social

Interviewees indicated different forms of social value addition that stem from supporting the local grain chain. For example, participants discussed the strength of their partnerships between producers, processors, and end-users, noting that their connections with people is the piece that adds value to the work they do.

“You just either develop or don’t develop a certain rapport with people and you just think, man, I want these people to succeed to grow. I really like Kris Gosar. He’s a really interesting guy. {...} And I always like when it comes to dropping off wheat. We just get talking. So I want him to succeed and anything towards that” (baker).

“The owner would just come down and that connection piece was pretty awesome because he’s busy as hell. I’m busy as hell. I ended up being here when he came to grind his wheat on a Friday before the Saturday market, and we drank a beer or two and hung out and caught up, you know, and yeah, I remember every time I see him driving away, I’d be like, ‘man, that’s why I do this’. Like, gosh, we’re doing so much great work together, you know, within the county and the community. But to spend time together, it’s really special” (baker/miller).

Many interviewees talked about the importance of being connected to the right people: people who can provide support, knowledge, resources, and assistance in times of trouble. As trust is built between parties, this leads to stronger relationships, and greater collaboration. One participant described how, in exchange for space to store grain, the farmer paid the participant in

seed. The participant received India Jamou from a farmer who was well-connected in the local grain chain and had experience growing trials of alternative wheat varieties (farmer/miller). This exchange led to more opportunities for collaboration and sharing of resources. Non-monetary transactions can happen in exchange for goods and services, and it is common to see these favors repaid in different ways.

“So we kind of had a collaboration going. And then he was able to use my seed cleaner. I had a seed cleaner on the farm to clean the seed. I've had a couple different groups use the seed cleaner, because the issue with grain is like it's capital intensive. {...} And so, as a community, if people can get different pieces, and people should be writing grants for this, then then I think it can work. But some equipment like the combine is harder to share” (farmer/miller).

Participant 5, for example, recognizes the value of connecting people along the grain chain to help businesses find their niche:

“I think we want more farmers to grow, to experiment with growing these grains. Because it's not a highly profitable prospect. They have to do it because they want to. They have to do it because they see that it has value. You know, obviously, we don't want anybody to lose money. But it's not like they're gonna get rich doing this. But I think it's really rewarding, it's rich in other ways. It's richly rewarding in terms of being able to do something like this for relocalizing grain and connecting more with artisans who are building up their businesses, because they want to work with local farmers. That they're

connecting to consumers who really value the idea that, ‘I can get grain milled by Michelle Moffatt. And she got the grain from Aspen Moon Farm.’ yeah, so that's exciting” (baker/miller).

Buyers further downstream of the grain chain can also play an important part in generating social value by supporting other actors further upstream. For example, when Blue Grouse Bread opened, they realized it was easy to find buyers because passionate chefs who care about the local food movement were waiting to source bread from an artisan bakery.

“They were all buying bread from Cisco, and a lot of our chefs really care about local food. So it was kind of easy to just slide in there. All the chefs we work with are super into the local food movement. We didn’t have to sell much of our story, we kind of were just like, this is what we have. It’s been pretty easy to just become part of that community”
(Blue Grouse Bread).

CHAPTER 5 DISCUSSION

A well-connected and diverse local grain chain is a vital component of healthy communities because it facilitates collaboration, which leads to strengthened partnerships between producers, processors, and consumers, and creates a stronger local culture for grains. As this network expands, the establishment of new businesses creates new jobs and keeps money circulating in the local economy. The local grain economy in Colorado is a complex ecosystem composed of both natural and man-made components, which support multiple social, environmental, and economic functions. This network of stakeholders is vast, and is made up of not just farmers, millers, bakers, and artisan makers, but also artists, activists, academics, politicians, teachers, and families. The stakeholders who participated in this study have all expressed that there is value in supporting the development of a local grain chain that is mutually beneficial to all.

5.1 Grain Chain Resilience and Vulnerabilities

In the face of climate change, global pandemics, and supply chain problems, it is evident that the livelihoods of the people who rely on the production, processing, making, and marketing of value-added grain products may be severely impacted by future disruptions. Therefore, there is value in exploring how to make local grain economies more resilient, because resilient systems have the ability to adapt and recover from changes in the system. Through the application of a framework developed by Worstell & Green, this next section aims to determine which characteristics of resilience are present within Colorado's local grain chain, and which areas are

weaknesses. **Table 8** provides a brief overview of qualities of resilience that have been identified within Colorado's local grain chain.

Table 8 The eight qualities of resilience identified by Worstell & Green (2017) and its application to Colorado's local grain chain

Eight qualities of resilience	Definition	Qualities of resilience identified in Colorado's grain chain
Modular connectivity	A resilient community is tightly connected to other communities	A diversity of strong partnerships exist between farmers, millers, bakers, researchers, and educators along the Front Range, San Luis Valley, and Western Slope regions of Colorado. These have been strengthened by the sharing of knowledge and educational resources. Educational events organized by CGC, UCCS's Grain School, Mad Agriculture, and Rocky Mountain Seed Alliance provides networking opportunities and the development of new relationships.
Local self-organization	The system is owned and managed by local farmers, processors, buyers, and marketers	Unlike the conventional grain chain, where production, processing, and distribution is controlled by a small number of large corporations, Colorado's local grain chain is well connected to different communities. Stakeholders along the grain chain have agency over decision-making processes, such as deciding which types of grain to grow, what products to sell, and which markets to sell to.
Infrastructure	Physical infrastructure including natural, built, and human capital is accumulated over time	Infrastructure for grain processing is in its infant stages. Demand for high-value, locally grown grains has exceeded the current supply of grains and bottlenecks in the processing sector limit farmers from scaling up grain production. Moreover, supply chain shortages from the pandemic have caused problems for some stakeholders, which limits their ability to purchase new equipment. Shortages in built capital (low availability and access to farm machinery, mills, and mixers), natural capital (harvest losses caused by drought, pests, and diseases), and human capital (layoffs and pandemic restrictions) are examples of challenges stakeholders must address.
Responsive redundancy	Resilient systems have	Stakeholders in the local grain chain have been engaged and supportive about transferring knowledge

	back-ups that replace skills, abilities and functions that are lost	to grain chain newcomers. However, outside disturbances can test a business's ability to replace essential skills, resources, and functions that are lost. One farm in Colorado showed high levels of redundancy during a period of transition. It was able to stay in operation and carry through with harvesting its grain despite the loss of human capital. Small businesses are especially vulnerable to stressors because they have less reserves. Other small businesses in CO have struggled to recover from the loss of financial capital caused by the impacts of the pandemic.
Complementary diversity	Wasted outputs are converted into valuable inputs from one system to another. Resilient systems are characterized by high complementarity between stakeholders.	At the farm level, nutrient cycling and waste management is facilitated through regenerative farming practices such as manure application, carbon sequestration, and cover cropping. At the mill level, there are several enterprises scattered across Colorado that have combined their farming and milling operations with different sales outlets, selling locally grown grains to restaurants, bakeries, grocery stores, and consumers. At the bakery level, bakers have collaborated to offer consumers products that complement each other. An example of this is the creation of a collaborative bread club between different bakeries (Rebel Bread, Moon Raccoon Baking Baking Co, Sugar Bakeshop, etc), during the pandemic that offered consumers a selection of baked goods.
Conservative innovation	A resilient system is open to new ideas and encourages innovation	Key actors in the local grain chain have demonstrated flexibility in the face of change. During the COVID-19 pandemic, one bakery in Colorado offered grocery store services to its customers. They took orders from its customers and sold staple food items such as milk, eggs, sugar, and flour when there were major grocery store shortages. Another bakery opened a brand-new retail location and a mill, to combat the flour scarcity caused by the pandemic.
Integration of natural ecological systems	Works with nature to maximize natural ecological processes	Many farms have minimized their farm inputs and shifted towards utilizing natural ecological processes to manage their land. Rotational grazing, building soil organic matter, permanent soil coverage, and intercropping are some of the ways in which farms have incorporated ecological principles into their farming systems. Mad Agriculture offers consultation

		services and support to farmers to help them transition to regenerative practices.
Periodic transformation	Has the ability to reorganize itself and recover after a disturbance	The local grain chain is in a state of growth and transformation. Involved stakeholders displayed high degrees of adaptability in response to the disruptions caused by the COVID-19 pandemic. Mills demonstrated flexibility by shifting from wholesale to online retail, the shortages caused by the collapse of the conventional grain chain stimulated demand for flour and bread, and bakeries were able to remain in business by modifying their methods of ordering and distribution.

In applying this framework, it is evident that Colorado's local grain chain exhibits certain characteristics of resilience. Stakeholders within the local grain chain are well connected and supported by other nodes in the network, which proved to be an asset to strengthening their ability to overcome adversity. The strengths of the local grain chain include high modular connectivity, local self-organization, complementary diversity, conservative innovation, integration of natural ecological systems, and demonstrated ability to rebound after a disturbance.

Infrastructure and responsive redundancy are two areas that need improvement. Investments in each of these areas can serve to only strengthen the overall system, as increases in certain assets can lead to gains in others. For example, the establishment of an online marketplace for local grains that connects farmers to buyers increases modular connectivity across the state. Farmers will be incentivized to transition to ecological farming practices if buyers express interest in paying the price premium for sustainably grown grains. Showcasing the stories of the people involved in making the value-added product on the online marketplace

would inform the consumer about these key linkages. Consumers who browse the marketplace would learn that their purchase not only supports the livelihoods of the people involved in making this item, but also delivers social, economic, and environmental value. This spiraling up of assets will generate value addition which will lead to increased diversity and resilience within the system.

An area of vulnerability within Colorado's grain chain is the scarcity of processors. Findings from this study showed that the greatest number of stakeholders occupy the roles of bakers, farmers, and millers, respectively. Bottlenecks in the system may be caused by a number of factors, one of them being the low number of mills within the state. This may cause problems for both farmers and bakers. For example, farmers looking to transition to heirloom and ancient wheat production may find it challenging to find intermediaries who can process their grains, because the number of worker-owned mills that can process and blend different varieties of grains are limited, which creates constraints on the growth of farmer-miller partnerships. This also limits the capacity of bakeries that are thinking of increasing the percentage of local whole grain flour in their products. Findings from this study have also shown that bakeries play an important role in contributing to the local economy by creating value added products made from alternative grains and directly selling these to consumers. There is a large variety of bakeries in Colorado including cottage, micro, bakery food trucks, retail, and wholesale bakeries. As the demand for artisanal bread made with local wheat has continued to grow, one of the greatest barriers is price-point, as well as low grain processing capacity. As such, bakeries have turned to other solutions to mitigate supply issues, such as purchasing their own mill to grind their flour or finding an out-of-state supplier.

It should be noted that one limitation of this study is that the breadth of connections and attributes of resilience within the local grain chain has not been thoroughly examined. Individual resilience, different forms of capital, the strengths and lengths of social relationships are examples of topics for future research. Stakeholders within the local grain chain are unique, and each person exhibits different characteristics of resilience. A healthy and functioning food system captures value along the entirety of the supply chain, and grain chains are an integral part of this. As a result, there is greater need for more research to be conducted on local grain chains and how they are well-positioned to become resilient social-ecological systems.

CHAPTER 6 CONCLUSION

The local grain chain in Colorado is an example of an alternative food network that has demonstrated resilience in the face of adversity. Through the application of a resilience framework developed by Worstell & Green, this study identified certain characteristics of resilience within Colorado's local grain chain. These characteristics include diversity of strong partnerships between stakeholders (high modular connectivity), agency over decision-making (local self-organization), synergy between stakeholders (complementary diversity), creative adaptability (conservative innovation), incorporation of ecosystem services into farming systems (integration of natural ecological systems) and lastly, strong ability to rebound after a disturbance (periodic transformation). Two areas, limited physical infrastructure and low responsive redundancy, were identified as weaknesses within the local grain chain.

The grain chain represents more than a transaction of goods or a flow of financial capital within a short supply chain. Rather, it is a network of complex, social relationships, a record of tradition, history and culture, a celebration of ecological diversity. It is comprised of countless invaluable social, economic, and environmental assets. Examples of value-added benefits generated through the grain chain include the exchange of goods and lending of services, the creation of local jobs in the immediate community, supporting sustainable farming systems, promoting the consumption of nutritious grains, and revitalizing rural economies, to name a few. This study found that stakeholders supporting a local grain chain generates many benefits: including revitalizing rural economies, keeping people employed in the community, more traceability and transparency within the supply chain, and the cultivation of stronger partnerships

between producers, processors, and consumers. Numerous connections within the grain chain have contributed to increased resilience in communities due to a positive “spiraling up” effect that led to the creation of more assets.

6.1 Recommendations

The local grain chain is still nascent in its stages of development and is in a period of growth and transformation. It is composed of a diverse network of small businesses, entrepreneurs, producers, processors, non-profit organizations, institutions, and consumers. For the grain chain to sustainably grow, there is greater need for cross collaboration between stakeholders, marketing of value-added products made from ecologically grown grains, grain education and awareness, supply chain development, and investments in infrastructure. There are numerous areas for further improvement within local grain economies. As such, the following section outlines a set of recommendations that producers, processors, consumers, and grain advocates can take to build a strong and resilient local grain chain:

- Find ways to capture and retain value generated within the local grain chain to support the needs of grain producers, processors, and buyers in the state of Colorado. By investing different forms of capital (financial, built, cultural, human, financial, political, natural, and social) into local economies, pathways that lead to co-creation and value addition can be developed at every stage along the grain chain. Connecting grain growers to new market opportunities, helping farmers secure equitable contracts with buyers who want to purchase alternative grains, partnering with CSA shares to distribute specialty grain-based food items and crops, and establishing a Colorado-wide unified label that

allows consumer to identify products made with locally grown grain are just a few ways that can facilitate the development of an interconnected network.

- Connect restaurants, schools, farmers' markets, food banks, grocery stores, and hospitals with local grain farmers to stimulate a demand for alternative grains. Consumer interest in whole and alternative grains has increased over the years. What is now needed is the development of policies that will incentivize the consumption of nutritious, whole grains at institutions like schools and hospitals. The local grain chain would benefit from the establishment of a program that models New York States' No Student Goes Hungry initiative. This initiative reimburses schools who purchase at least 30 percent of their school lunch ingredients from local farms. This policy could work as an incentive for local schools, hospitals, and major institutions to source a portion their whole grains from Colorado growers.
- Encourage growers to incorporate diversification into their farming systems. Given the numerous challenges farmers face in dealing with climate change, it would be beneficial to connect farmers with buyers who want to purchase high-value, nutrient-dense, less well-known ancient and heirloom grain varieties that are well-suited for Colorado's climate. Restoring lost grains, as well as alternative grains like quinoa, finger millet, fonio, amaranth, and adding them into crop rotations with nitrogen fixing grain legumes will deliver long-term social and environmental benefits to farming systems, increase agricultural biodiversity, and improve the availability of wholesome, heart-healthy grains.
- Expand education and grain literacy to the public through storytelling, marketing, workshops, conferences, and grain-based field events. There is a great need to increase

awareness about the benefits of whole grain consumption, to support the health and well-being of people.

To conclude this project, I would like to mention that the research presented in this study barely scratches the surface of understanding the functions of this complex, interconnected system. I found the exploration of the local grain chain, with all its challenges, to be an absolutely rewarding journey. There are many opportunities for further research and more yet to be done to appreciate and preserve the diversity of grain-centered cultures and communities across the world. As for the U.S, there is room to expand and strengthen the local grain movement, by incorporating grains into food and farming systems, connecting local grain chains to regional grain sheds; advocating for social justice and equity; building climate resilience into farms and communities; increasing access to nutritious whole grain products; and cultivating new and traditional foodways. Finally, the greatest takeaway from this project for me was discovering that there is tremendous value in building a local grain chain, because ultimately, it is all about cultivating relationships in communities, and supporting those whose livelihoods are touched by grains.

ANNOTATED BIBLIOGRAPHY

- 1) Baker, B., & Russell, J. (2017). Capturing a Value-Added Niche Market: Articulation of Local Organic Grain. *American Journal of Agricultural Economics*. 99. 10.1093/ajae/aaw100.**

This paper examines the interdependent connections in the organic grain chain in the Finger Lakes region of New York. It maps out the value chain with a focus on the partnerships between an organic farm, a milling enterprise and a community-support bakery. The findings from this report show how institutions and policies can help establish new markets to meet consumer demand in a small grains value chain. The establishment of strategic partnerships in the entire value chain can lead to the creation of new markets.

Themes: Strategies for local food system development, connection to local markets, type of grains milled, product list, seeding rates, operating costs.

- 2) Barnes, Jessica. (2016). Separating the Wheat from the Chaff: The Social Worlds of Wheat. *Environment and Society*. 7. 10.3167/ares.2016.070106.**

In this paper, the author looks at the multifaceted dimensions of human-wheat relationships to analyze the social world associated with this crop. The author compiles existing literature on wheat to analyze the social relationships built through the perspectives of wheat as a seed, plant, and grain.

Themes: Political and social implications of wheat production and consumption, tracing the flow of wheat through relationships, how wheat shapes the social world.

- 3) Blair, H. R., & Dimitri, C. (2017). Bridging Crop Diversity and Market Development in the Northeast Grain Renaissance. *Journal of Agriculture, Food Systems, and Community Development*, 7(4), 51–60. <https://doi.org/10.5304/jafscd.2017.074.015>**

Diverse crop rotations with grains will bring farmers multiple revenue streams, improve soil quality, reduce pest outbreaks, and benefit consumers through the provision of fresh and healthy products. Gives an overview of the historical context about grain production in the northeast. This study also provides reasons why and what steps need to be taken to create a market for value-added rotation crops in farming systems.

Themes: History of grain production in the northeast, current and developing grain markets, value added rotation crops in farming systems, key stakeholders, challenges with adopting alternative farming practices.

4) Dotty, N.C., et al. (2012). Value-added opportunities and alternative uses for wheat and barley. Auri Agricultural Research Institute.

The authors in this report outline ways to add value to wheat and barley cultivation through the creation of novel products. It explores value-added and alternative uses for wheat and barley such as the creation of whole grain products, biodegradable plastics, aleurone flour, and coffee and tea substitutes such as roasted wheat and barley beverages.

Themes: Emerging markets for wheat and barley products, end products, value addition, new or improved characteristics of wheat and barley, potential and probability of success.

**5) Dunne, J., Chambers, K., Giombolini, K., & Schlegel, S. (2011). What does 'local' mean in the grocery store? Multiplicity in food retailers' perspectives on sourcing and marketing local foods. Renewable Agriculture and Food Systems, 26(1), 46-59.
doi:10.1017/S1742170510000402**

This study examines the role of retailers in local food systems. The researchers interviewed retailers that market their food products as local and found that the definitions of local vary between retailers. Respondents selected supporting the economy as the main reason for carrying local foods. The researchers propose a place-based bioregion labeling system to standardize local foods.

Themes: The differences in the definition of "local", why local foods are carried, what products are considered local, how are they labeled.

**6) Empey, N., Wald, S., & Jiang, Z. (2020). Going Local: Developing Sustainable Small Grain Economies in Southeast Michigan. University of Michigan.
<https://deepblue.lib.umich.edu/handle/2027.42/155002>**

This research was a study led by graduate students from the University of Michigan. It investigates the feasibility of expanding local grain markets in Michigan. The students conducted interviews and provided a set of recommendations for practitioners based on their findings. They suggest that one solution to address the upfront costs and the lack of equipment farmers face is to create a cooperative of local grain producers who can pool their resources and share equipment and information.

Themes: Grain economy analysis, barriers to building a local grain economy, designing, and conducting a grain trial, perspectives of people involved in local grain economies

- 7) Forrest, N., & Wiek, A. (2021). Growing a sustainable local grain economy in Arizona: A multidimensional analytical case study of an alternative food network. Journal of Agriculture, Food Systems, and Community Development, 10(2), 507–528.**
<https://doi.org/10.5304/jafscd.2021.102.031>

The researchers in this study examined and analyzed Arizona's local grain economy by mapping out its size, network structure, composition, evolution, its impacts on the broader local economy, as well as its long-term sustainability. The main motivations for being a part of the grain chain include making personal connections, creating a culture and identity around heritage grains, reducing food miles, and contributing to the local economy.

Themes: The development stages of a local grain economy, motivations behind being a part of this economy, its functions, challenges, and visions for the future

- 8) Fromartz, S. (2015). In search of the perfect loaf: A home baker's odyssey. Penguin Random House LLC.**

This book covers everything about bread—from heritage grains and the formation of the breadbasket to the ways in which different cultures grow wheat and make bread. The author also dives into the historical roots of grain cultivation and connects this to current methods of wheat production and processing by interviewing key influencers and bakers who are championing the real bread movement in the US.

Themes: Grain production, history of wheat, nutritional benefits of whole grains, recipes, local bread, diversifying the grain chain

- 9) Graff, G., Berklund, A., & Rennels, K. (2014). The Emergence of an Innovation Cluster in the Agricultural Value Chain along Colorado's Front Range. Colorado State University.**

The Colorado Front Range has emerged as a center for agriculture and innovation. In this report, the authors explore the factors that favor the Colorado Front Range as a location for innovation in the agricultural value chain. Through a series of case studies, the authors of this report highlight the innovators in different sectors (e.g. soil fertility, bioenergy, local foods, water technology) along the Front Range. For example, this report outlines the successes of Limagrain, a seed and wheat breeding company that teamed up with O'Dell Brewing Company to develop an "Innovation Ale". They also provide a list of the major companies who are working together to increase opportunities for innovation.

Themes: Innovation, collaboration, network building, rural economic development, emergence, cultivating growth in the agricultural sector, public private partnerships

- 10) Halloran, A. (2015). The New Bread Basket: How the new crop of grain growers, plant breeders, Millers, Maltsters, bakers, brewers, and local food activists are redefining our Daily Loaf. Chelsea Green Publishing.**

Amy Halloran tells the story of wheat from the different perspectives of people involved in their local grain chain (e.g farmers, millers, bakers, maltsters, educational institutions, farmers markets). This book also provides important information on key projects and organizations working to increase grain literacy and transform the way wheat is produced across the country.

Themes: Small-scale grain production, diversified crop rotation systems, history of wheat, alternative grain networks, farmer extension, how to revive a local grain chain, market opportunities and innovative projects using different grains

- 11) Halloran, A. (2020). Neighbor Loaves Program Aims to Maintain Regional Grain Value Chains and Feed the Community. Journal of Agriculture, Food Systems, and Community Development, 9(3), 41–44. <https://doi.org/10.5304/jafscd.2020.093.031>**

This article provides a brief overview of the Neighbor Loaves Program and its impact on local and regional food systems in response to the 2020 COVID pandemic. The Neighbor Loaves Program, a program created by the Artisan Grain Collaborative, helped small businesses survive the pandemic. In this program, consumers were invited to purchase a loaf of bread at full price to donate to a local food pantry. Through this initiative, a demand for bread was created and production was stabilized. This article describes the involvement of different bakeries and consumers and their role in distributing bread to local food pantries.

Themes: Baking with local grains, strengthening a local and regional grain economy, community food security, food distribution, and supporting local businesses.

- 12) Head, L., Atchinson, J., Gates, A., & Muir, P. (2011). A Fine Grained Study of the Experience of Drought, Risk and Climate Change Among Australian Wheat Farming Households. Annals of the Association of American Geographers, 101:5, 1089-1108, DOI: 10.1080/00045608.2011.579533**

The article focuses on documenting and analyzing drought, risk and climate change in relation to wheat farming in Australia. They found that farmers have different coping strategies for managing risk. Most risk management occurs in-situ at the farm level, which includes increasing local control by increasing on-farm storage of harvesting grain, information gathering, and using different forms of technology to gather information.

Themes: Wheat farming and climate change, on-farm risk management, dealing with risk and uncertainty, patterns of vulnerability, documenting personal experiences of risk and drought over time

13) Hergesheimer C., & Wittman, H. (2012). Weaving Chains of Grain. Food, Culture & Society, 15:3, 375-393, DOI: 10.2752/175174412X13276629245803

Findings from this study in British Columbia show that alternative grain chains facilitate the traceability of local food production, preserve the identity of local producers and consumers, redefine the range of local food production and test and strengthen the development of niche markets. This is an examination of the links within a network that promote knowledge sharing and the participants' role and connections in the regional grain chain.

Themes: Social length and strength of the short food supply chain, local grain (a niche market), traceability, social networks, barriers to strengthening local grain initiatives.

**14) Hills, K. M., Goldberger, J. R., & Jones, S.S. (2013). Commercial Bakers' View on the Meaning of "Local" Wheat and Flour in Western Washington State. Journal of Agriculture, Food Systems, and Community Development, 3(4), 13–32.
<https://doi.org/10.5304/jafscd.2013.033.022>**

The authors of this study interviewed commercial bakers in western Washington State about the relocalization of grain production. Bakers were asked about their definition of "local", their perceptions about customer willingness to pay price premium for local wheat, and the barriers to the development of a local wheat system

Themes: Importance of wheat origin to customers, baker's definition of local, perceived barriers to locally produced wheat, challenges in developing a local wheat supply chain.

**15) Hills, K.M., Goldberger, J.R. & Jones, S.S. (2013). Commercial bakers and the relocalization of wheat in western Washington State. Agric Hum Values 30, 365–378.
<https://doi.org/10.1007/s10460-012-9403-9>**

Findings from this report show that 61% of bakers in western Washington State had an interest in purchasing local flour. They found that bakers were more likely to purchase regionally produced wheat flour if the quality and reliability of the flour supply was consistent.

Themes: Interest in purchasing local flour, characteristics of bakers that are interested in purchasing local flour, benefits and barriers to purchasing regionally produced flour

16) Hodbod, J., & Eakin, H. (2015). Adapting a social-ecological resilience framework for food systems. Journal of Environmental Studies and Sciences, 5. 10.1007/s13412-015-0280-6.

In this article, the authors argue that the current conventional food system is vulnerable to unanticipated change and shocks in the system. They apply a resilience framework to California's food systems. The framework assesses the response and functional diversity of food systems. It is primarily used to evaluate a food system and its resilience attributes. They conclude that a key attribute of a resilient system is diversity, as it helps increase the capacity of a system to cope with change. This framework is useful in the sense that it can be applied to any food system that has been affected by disturbance.

Themes: Maintaining resilience in food systems, the benefits of applying a resilience framework to evaluating food systems,

17) Lapidus, J. (2021). Southern ground: Reclaiming flavor through stone-milled flour. Ten Speed Press.

This book showcases the local flour movement in the South, and describes how transformation in the local food system was created. It is part cookbook, part narrative that describes how a regional grain chain was established from the community level. It highlights the stories and recipes of the bakeries in the South who bake their bread using flour from Carolina Ground. It describes the partnerships between many different actors including growers, millers, seed breeders, educational institutions and bakers. It is a cookbook that shares with the public the knowledge and wisdom that has been accumulated in the baking community in the South, and tells a story about where flour comes from.

Themes: value addition in the grain chain, sustainable food systems, regional milling, breeding for flavor, community partnerships, linking the farmer, the miller, and the baker.

18) Mann, E. (2016). Diverse forms of market engagement: Grounding food sovereignty in the experiences of Ontario's ecological grain farmers. UWSpace.

<http://hdl.handle.net/10012/10876>

This thesis provides insight into Ontario's grain chain, specifically with a focus on the localization of grains, food sovereignty, and creating diverse economies to support the work of ecological grain farmers. It dives into the challenges that farmers face and investigates the success they face in marketing their grains.

Themes: Ecological grain production and farming practices, motivations for their involvement, marketing ecological grain in Ontario, market opportunities and strategies

- 19) Mars, M. (2015). From Bread We Build Community: Entrepreneurial Leadership and the Co-creation of Local Food Businesses and Systems. Journal of Agriculture, Food Systems, and Community Development, 5(3), 63–77. <https://doi.org/10.5304/jafscd.2015.053.005>**

This study explores how entrepreneurial leadership can promote the co-creation of local food businesses and food systems. It is a case study that describes how a community supported baker business model can successfully involve customers in co-creating local food systems. Customers who support community supported bakers become more involved as marketers of bread, promoters of local grains and champions of the local food movement because the baker brings a greater sense of community through this interactive business model.

Themes: Creating a cohesive, vibrant, local food systems, community co-creation. How entrepreneurial leadership of local food entrepreneurs might contribute to the emergence and evolution of LFSs through directly involving consumers.

- 20) Peterson, H., & Barkley, A., Chacon-Cascante, A., & Kastens. (2012). The Motivation for Organic Grain Farming in the United States: Profits, Lifestyle, or the Environment?. Journal of Agricultural and Applied Economics. 44. 137-155. 10.1017/S1074070800000237.**

This study examines the motivations behind organic grain farming. Findings from this report show that organic grain farmers are motivated by profit as well as environmental stewardship and organic lifestyle goals. The two main reasons behind people's motivations for organic farming are self-interest and other-interest. Some organic grain farmers have adjusted their profit model to meet their social and environmental goals.

- 21) Prahalad, C. & Ramaswamy, Venkat. (2004). Co-Creation Experiences: The Next Practice in Value Creation. Journal of Interactive Marketing. 18. 5-14. 10.1002/dir.20015.**

This article introduces a new model of value creation. It describes how companies can create more value by providing personalized co-creation experiences for their customers. Value can be co-created by strengthening the interactions between the business and the consumer through increased dialog, access, transparency and a personalized understanding of risk-benefits. Co-creation is the joint creation of value, by both the company and the customer. This study found that consumers will be more willing to pay for a product or service they find value in.

Themes: Value creation through co-creation.

22) Salvia, R., & Quaranta, G. (2017). Place-Based Rural Development and Resilience: A Lesson from a Small Community. *Sustainability*, 9, 889. <https://doi.org/10.3390/su9060889>

This is a case study that identifies the factors that led to the development of community resilience in Caggiano, Italy. The authors found that increasing social capital and trust, using cascading processes to build upon initiatives, and bringing together disconnected sectors through a systematic approach can generate greater resilience.

Themes: The social, economic and environmental factors that lead to a resilient community.

23) Stanco, M., Nazzaro, C., Lerro, M., & Marotta, G. (2020). Sustainable Collective Innovation in the Agri-Food Value Chain: The Case of the “Aureo” Wheat Supply Chain. *Sustainability*, 12(14):5642. <https://doi.org/10.3390/su12145642>

Shifting to sustainable collective innovation processes can lead to the creation of a agri-food supply chain that is more environmentally and socially sustainable. This study showed that consumer driven preferences can further the development of a product obtained from local sustainable supply chains. This study asks the following questions: What are the factors determining a sustainable collective innovation process, and which tools can make a collective innovation process effective?, and highlights the success of a new sustainable Barilla pasta that was created through the sustainable collective innovation process.

Themes: New supply chain, innovative agri-food value chains, consumer-driven sustainable food products and new market creation, socially responsible companies, governance models, collective innovation, creating shared value

24) Skog, K.L., Eriksen, S.E., Brekken, C.A., & Charles, F. (2018). Building Resilience in Social-Ecological Food Systems in Vermont. *Sustainability*, 10. 10.3390/su10124813.

This paper investigates local food systems in Vermont and how they serve as a catalyst for creating resilience in other social-ecological systems. This study found that people connected to their local food system are invested because of their personal motivations, such as their place identity, environmental concerns, and sense of social responsibility. This study uses a framework that investigates the four factors necessary in creating a resilient socio-ecological system. Researchers use a case study approach and snowball sampling to interview participants in the local food and agricultural system in Vermont.

Themes: Adaptive resilience in local food systems, positive governance, place-specific identities, creating resilience in social-ecological systems.

25) Sullins, M. (2014). Zia Taqueria: Building a Local Supply Chain in Southwestern Colorado. *Journal of Food Distribution Research*, 45(3), 1-13. [10.22004/ag.econ.191005](https://doi.org/10.22004/ag.econ.191005)

Zia Taqueria is a restaurant located in Durango Colorado. This study looked at the ways in which Zia Taqueria created stronger links within the local food system. It found that the restaurant created new links within the local supply chain by purchasing and supporting local farmers, businesses, and community events. This case study is an example of how small businesses can help create a local supply chain.

Themes: How small businesses can create a supply chain for locally grown and processed foods, how local investments can provide positive outcomes and benefits to communities

**26) Trivette, S. A. (2012). Close to Home: The Drive for Local Food. *Journal of Agriculture, Food Systems, and Community Development*, 3(1), 161–180.
<https://doi.org/10.5304/jafscd.2012.031.008>**

The author of this paper identifies the benefits of a local food system as well as its shortcomings. This study finds that local food systems have the potential to provide public health benefits, promote stronger social ties, and resolve the problems of the conventional system, but requires structural and institutional change in the ways food is produced and distributed in order to do so.

Themes: Sustainable agriculture, food miles, local and organic production, economic vitality, social responsibility and justice, conventional vs alternative food systems

27) Vroegindeweij, R., & Jennifer Hodbod. (2018). Resilience of Agricultural Value Chains in Developing Country Contexts: A Framework and Assessment Approach. *Sustainability* 10, no. 4: 916. <https://doi.org/10.3390/su10040916>

This paper develops a new framework to assess resilience in the context of agricultural value chain in developing countries. Drawing upon the Resilience Alliance's assessment framework and different value chain analysis techniques, the authors outline a participatory systems approach to assess value chain resilience, which can be adapted by multiple value chain actors and their partners to assess resilience.

Themes: Understanding the value chain system by mapping out the structure of the value chain, describing the services and marketable products, the role that it plays in food security, and identifying ways to build resilience.

28) Worstell, J., & Green, J. (2017). Eight Qualities of Resilient Food Systems: Toward a

Sustainability/Resilience Index. Journal of Agriculture, Food Systems, and Community Development, 7(3), 23–41. <https://doi.org/10.5304/jafscd.2017.073.001>

The authors of this article determined a set of similar qualities of resilient food systems after analyzing six different resilience frameworks. They then developed a resilience index to help people improve resilience at the community and farm level.

Themes: SES resilience, resilience frameworks, identifying characteristics of resilience in systems, definition of ecological resilience, determining the common qualities of resilient locally self-organized food systems.

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APPENDIX 1

Survey and Interview Participant Consent Form

Welcome to this research study!

I am asking you to participate in a research project titled “**Building a Resilient Local Grain Chain: Perspectives from Colorado’s Farmers, Millers, and Bakers**”. This study is being led by **Mika Ulmet**, a graduate student in the Global Development Department at Cornell University. The Faculty Advisor for this study is Kathryn Fiorella, Assistant Professor in Department of Population Medicine and Diagnostic Sciences & Master of Public Health Program at Cornell University.

What the study is about

To better understand the local grain chain in Colorado, this research will examine the connections between key stakeholders (farmers, millers and artisan bakers); assess the ways in which the local grain chain has impacted livelihoods; and identify characteristics of resilience within this system. Your participation in this project will inform other communities and stakeholders on how to strengthen and increase resilience within local grain chains.

What I will ask you to do

If you agree to participate, I will ask you to take part in a 45 min to 1 hour interview, and you will be given \$20 for your time.

Risks and benefits

This study poses no risks from participating in this research. There are no direct benefits to participation beyond an opportunity to share your experiences and perspectives in this academic study.

The results from this research may help inform communities about the importance and value that key stakeholders provide to communities through their active engagement in the local grain chain. This information may benefit other people now or in the future.

Taking part in the interview

Your involvement in this study is voluntary, and you may refuse to participate before the interview begins, cease at any time, or skip any questions/procedures that may make you feel uncomfortable, with no penalties if you choose to withdraw. You have the right to withdraw at any point during the study.

Audio/video recording and photographs

Audio recordings and recordings taken from online video conferencing platforms will primarily be used to capture missed data that I, the Principal Investigator, fails to record. These data will be

used exclusively by the Principal Investigator throughout the duration of this study, and upon completion of the research, will be destroyed after five years. Additionally, any photographs taken will be used for the final research paper, as well as other purposes beyond this analysis including publications, presentations and promotional purposes. I ask for your permission to grant me the right to make, use and publish recordings in whole or in part in media forms now known (such as film, slides, and digital audio) or developed in the future. This includes the right to edit or duplicate any images/recordings. There will be limitations on reproduction, distribution, performance or display of the images/recordings. You will not have the right to inspect or approve the finished product or printed/published matter that uses the images/recordings or versions of the images/recording. Lastly, you will not receive any financial compensation for commercial and/or non-commercial (as appropriate) uses of the images/recordings.

Questions or concerns

The main researcher conducting this study is Mika Ulmet, a graduate student at Cornell University. Please ask any questions you have now. If you have questions later, you may contact Mika Ulmet at mu225@cornell.edu or at 720-301-6952. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at 607-255-5138 or access their website at <http://www.irb.cornell.edu>. You may also report your concerns or complaints anonymously through Ethicspoint online at www.hotline.cornell.edu or by calling toll free at 1-866-293-3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

By signing your name below, you acknowledge: Your participation in the study is voluntary. You are 18 years of age. You are aware that you may choose to terminate your participation at any time for any reason.

APPENDIX 2

Survey Questions sent to Local Grain Chain Stakeholders

Are you a farmer, miller, or artisan baker?

- Farmer
- Miller
- Artisan baker

Farmers

- What is the name of your farm?
- How many years have you been farming in the Colorado Front Range area for?
 - Less than 1 year
 - 1 to 5 years
 - 6 to 10 years
 - 11 to 20 years
 - More than 20 years
- How many full-time employees do you employ?
 - 4 or fewer
 - 5-10
 - 11 to 20
 - More than 20
- How many acres is your farm?
 - 0 to 50
 - 51 to 250
 - 251 to 1000
 - Over 1000

What is the average annual revenue of your business?

- \$10,000 to \$49,999
- \$50,000 to \$99,999
- \$100,000 to \$249,999
- \$250,000 to \$499,999
- More than \$500,000

What percent of your farmable land is dedicated to wheat production?

- Less than 25%
- 26% to 50
- 51% to 75%
- 76% to 100%

On average, how many bushels of wheat do you produce per acre?

- Less than 10
- 11 to 26
- 26 to 50
- More than 50

Who do you sell your wheat to?

- Colorado specialty mills
- Colorado commercial mills
- Out-of-state specialty mills
- Out-of-state commercial mills
- Other (please specify)

How many mills in Colorado do you sell your wheat to?

How many varieties of wheat do you grow on your farm?

- None
- 1 to 2
- 3 to 5
- More than 5

Which varieties of wheat do you grow? (Select all that apply)

- Ancient (e.g Einkorn, Emmer, Spelt)
- Heritage (e.g Turkey Red, Red Fife, Clark's Cream)
- Modern (e.g Gallagher, Warthog, Glenn)

Please select the different ancient and heritage varieties of wheat that you grow (Select all that apply)

- Clark's Cream
- Einkorn
- Emmer
- Khorasan/Kamut
- Red Fife
- Rouge de Bordeaux
- Sonora
- Spelt

- Turkey Red
- Other (please specify)
- None of the above

How important is growing heritage wheat to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

How do you define local?

- Within the Front Range of Colorado
- Within Colorado
- Within Colorado and its bordering states (Utah, Arizona, New Mexico, Nebraska, Kansas, Oklahoma, and Wyoming)
- Other (Please specify)

How important is supporting a local grain economy to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

What do you think are the potential benefits of supporting a local grain chain? (please select your top three choices)

- More traceability and transparency within the supply chain
- Stronger partnerships between producers, processors and consumers
- Reduced food miles
- Economic advantages created by a niche market
- Greater personal agency over the supply chain
- Higher quality of products
- A local grain chain is more resilient than an industrial grain chain
- None of the above
- Other (please specify)

Millers

1. What is the name of your mill?
2. How many years have you been operating your mill in the Colorado Front Range area for?
 - Less than 1 year
 - 1 to 5 years

- 6 to 10 years
 - 11 to 20 years
 - More than 20 years
3. How many full time employees do you employ?
- 4 or fewer
 - 5-10
 - 11 to 20
 - More than 20
4. What is the average annual revenue of your business?
- \$10,000 to \$49,999
 - \$50,000 to \$99,999
 - \$100,000 to \$249,999
 - \$250,000 to \$499,999
 - More than \$500,000
5. What types of mills do you operate?
- Stone ground
 - Roller mill
 - Both
6. What is your daily wheat processing capacity?
- Under 200 cwt
 - 200-399 cwt
 - 400-999 cwt
 - Over 1,000 cwt
7. How many tons of flour do you mill annually?
- Less than 25,000 tons
 - Between 25,000 and 50,000 tons
 - Between 50,000 and 100,000 tons
 - Over 100,000 tons
8. How many wheat farmers do you partner with?
9. How many of these wheat farmers are located in Colorado?
10. Which varieties of wheat do you grow? (Select all that apply)
- Ancient (e.g Einkorn, Emmer, Spelt)
 - Heritage (e.g Turkey Red, Red Fife, Clark's Cream)
 - Modern (e.g Gallagher, Warthog, Glenn)
11. Please select the different ancient and heritage varieties of wheat that you mill (Select all that apply)
- Clark's Cream

- Einkorn
 - Emmer
 - Khorasan/Kamut
 - Red Fife
 - Rouge de Bordeaux
 - Sonora
 - Spelt
 - Turkey Red
 - Other (please specify)
 - None of the above
12. How important is milling heritage and ancient wheat varieties to you?
- Extremely important
 - Very important
 - Moderately important
 - Slightly important
 - Not at all important
13. Who do you sell your flour to? (Select all that apply)
- Commercial bakers
 - Artisan bakers
 - Distributors
 - Commercial food service companies
 - Grocery retailers
 - Distilleries/breweries
 - Other (please specify)
14. What is your definition of local?
- Within the front range of Colorado
 - Within Colorado
 - Within Colorado and its bordering states (Utah, Arizona, New Mexico, Nebraska, Kansas, Oklahoma, and Wyoming)
 - Other
15. How important is supporting a local grain economy to you?
- Extremely important
 - Very important
 - Moderately important
 - Slightly important
16. What do you think are the potential benefits of supporting a local grain chain? (please select your top three choices)
- More traceability and transparency within the supply chain
 - Stronger partnerships between producers, processors and consumers
 - Reduced food miles
 - Economic advantages created by a niche market

- Greater personal agency over the supply chain
- Higher quality of products
- A local grain chain is more resilient than an industrial grain chain
- None of the above
- Other (please specify)

Artisan Bakers

1. What is the name of your bakery?
2. How long has your bakery been in operation for?
 - Less than 1 year
 - 1 to 5 years
 - 6 to 10 years
 - 11 to 20 years
 - More than 20 years
3. How many full time employees do you employ?
 - 4 or fewer
 - 5-10
 - 11 to 20
 - More than 20
4. What is the average annual revenue of your business?
 - \$10,000 to \$49,999
 - \$50,000 to \$99,999
 - \$100,000 to \$249,999
 - \$250,000 to \$499,999
 - More than \$500,000
5. What products do you make? (Select all that apply)
 - Sourdough bread
 - Commercially yeasted bread
 - Cakes/cupcakes
 - Cookies
 - Doughnuts
 - Granola
 - Pasta
 - Pastries
 - Other (Please specify)
6. How many loaves of bread do you bake per week?
 - Less than 100
 - 101 to 1000

- 1001 to 5000
 - 5001 to 10,000
 - Over 10,000
7. To whom do you sell your bread to? (Select all that apply)
- Retail (farms stands, CSA, etc. - Please specify)
 - Wholesale (other farms, regional market, restaurants, grocery stores, etc. Please Specify)
 - Other (Please Specify)
8. Where do you source your flour from? (Select all that apply)
- Within the Front Range of Colorado
 - Within Colorado
 - Within Colorado and its bordering states (Utah, Arizona, New Mexico, Nebraska, Kansas, Oklahoma, and Wyoming)
 - Other (Please specify)
9. How many mills do you source your flour from?
- 1
 - 2
 - 3
 - 4
 - More than 5
10. How many of these mills are based in Colorado?
11. Please select the different varieties of wheat that you bake with (Select all that apply)
- Clark's Cream
 - Einkorn
 - Emmer
 - Khorasan/Kamut
 - Red Fife
 - Rouge de Bordeaux
 - Sonora
 - Spelt
 - Turkey Red
 - Other (please specify)
 - None of the above
12. How important is baking with heritage and ancient wheat varieties to you?
- Extremely important
 - Very important
 - Moderately important
 - Slightly important
 - Not at all important

13. How important is baking with locally grown flour to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

14. What is your definition of local?

- Within the front range
- Within Colorado
- Within Colorado and its bordering states (Utah, Arizona, New Mexico, Nebraska, Kansas, Oklahoma, and Wyoming)
- Other

15. How important is supporting a local grain economy to you?

- Extremely important
- Very important
- Moderately important
- Slightly important

APPENDIX 3

Interview Questions

What is your connection to wheat and how did you become interested in your profession?

What motivated you to start your business?

How would you say your business is connected in the local grain chain?

How has being involved in the local grain chain affected your business?

How did COVID 19 impact your business? What challenges did you face?

How did you bounce back? What did you do to adapt to the changes brought on by the pandemic?

What do you think are some of the greatest areas of vulnerability in the local grain chain?

What do you think are some challenges that prevent the local grain chain from becoming stronger and more resilient?

What do you think needs to be done to make the local grain chain stronger?

How important would you say is supporting a local grain economy to you?

Why do you think it's important to support a local grain economy?

APPENDIX 4

IRB Approval



Cornell University
Office of
Research Integrity and Assurance

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Institutional Review Board for Human Participants

Notification: Activity Not Human Participant Research

To: Mika Ulmet

Protocol ID#: 2106010397

Protocol Title: Building a Resilient Local Grain Chain: Perspectives from Colorado's Farmers, Millers and Bakers

Date: July 15, 2021

Your request for IRB review of the project referenced above was reviewed by Cornell's Human Research Protection Program (HRPP). The project as described does not meet the definition of "human participant research" as defined by the Department of Health and Human Services Code of Federal Regulations 45CFR 46, for the following reasons:

- Research is focused on aspects of grain production, not on the personal opinions or attributes of individuals who will provide information for the study.

Therefore this project is not subject to review and oversight by Cornell's Human Research Protection Program (HRPP), and IRB approval is not required for the project activities to commence.

If you make any changes to the research activities that might change whether this involves human participants, please notify our office of those modifications before they are implemented. IRB review and approval is required before research activities have begun on a project that falls under Cornell University's HRPP.

Cc: Kathryn Fiorella

APPENDIX 5

Table 3 Characteristics of bakeries in Colorado

Bakery characteristics	N	Percentage
<u>Length of establishment</u>		
Less than 1 year	0	0.0%
1 to 5 years	5	55.6%
6 to 10 years	3	33.3%
More than 10 years	1	11.1%
<u>Number of full-time employees</u>		
4 or fewer	7	77.8%
5 to 10	1	11.1%
11 to 20	0	0.0%
More than 20	1	11.1%
<u>Average annual business revenue</u>		
Less than \$10,000	0	0.0%
\$10,000 to \$49,999	3	33.3%
\$50,000 to \$99,999	2	22.2%
\$100,000 to \$249,000	1	11.1%
\$250,000 \$499,999	1	11.1%
More than \$500,000	2	22.2%
<u>Number of loaves of bread baked per week</u>		
Less than 100	2	22.2%
101 to 1000	4	44.4%
1001 to 5000	2	22.2%
5001 to 10,000	1	11.1%
Over 10,000	0	0.0%
<u>Sales strategies</u>		
Retail	6	66.7%
Wholesale	1	11.1%
Both	2	22.2%

<u>Products made</u>		11.1%
Cakes/cupcakes	1	55.6%
Commercially yeasted bread	5	77.8%
Cookies	7	0.0%
Doughnuts	0	22.2%
Granola	2	0.0%
Pasta	0	66.7%
Pastries	6	88.9%
Sourdough bread	8	11.1%
Other	1	

<u>Source of flour*</u>		88.9%
From within Colorado	8	88.9%
From Colorado's neighboring states	8	22.2%
From other states in the US	2	0.0%
From outside of the US	0	22.2%
Milled in house	2	

*more than one answer was selected

<u>Number of mills where flour is sourced from</u>		
Zero	0	11.1%
One	2	55.6%
Two	6	22.2%
Three	1	11.1%

<u>Number of Colorado mills where flour is sourced from</u>		
Zero	1	11.1%
One	5	55.6%
Two	2	22.2%
Three	1	11.1%