BEYOND SOLAR FARMS: A CASE STUDY OF THE MOTIVATIONS, CHALLENGES, AND BENEFITS ASSOCIATED WITH DEVELOPING AGRIVOLTAICS AT JACK'S SOLAR GARDEN

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As members of the Master's Committee, we certify that we have read the thesis prepared by Tyler Swanson titled *Beyond Solar Farms: A Case Study of The Motivations, Challenges, and Benefits Associated with Developing Agrivoltaics at Jack's Solar Garden* and recommend that it be accepted as fulfilling the dissertation requirement for the Master's Degree.

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Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copies of the thesis to the Graduate College.

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Abstract

Solar energy is an integral part of an energy transition in the United States from a portfolio comprised primarily of fossil fuels to one led by renewable sources. However, growing social opposition to the development of solar energy facilities threatens to significantly delay, if not derail, an energy transition to renewable sources. Agrivoltaics, the co-production of agriculture and solar energy on the same plot of land, is an increasingly proposed solution for social opposition to solar energy. Despite the rapidly increasing development of agrivoltaic projects in the United States, there is a dearth of applied social science research into the motivations, challenges, and benefits associated with crop-based agrivoltaic systems. Drawing on rural geographic traditions of studying the changing uses and values of the rural landscape, this thesis addresses this key gap in social science agrivoltaics literature by using a case study of Jack's Solar Garden, a crop-based agrivoltaic site in Colorado. Utilizing a mixed-methods approach including interviews, content analysis, and media analysis, this case study yields valuable insights into the range of motivations, challenges, and benefits associated with implementing and operating crop-based agrivoltaic systems. This research reveals how the development of an agrivoltaic system resulted in meaningful compromise between a farmer wanting to install solar energy, and a local government seeking to preserve agriculture. Further, the development and operation of Jack's Solar Garden highlights the importance of stakeholder collaboration and the wide range of on-farm and community benefits that may accrue from agrivoltaic systems. The thesis concludes with recommendations for further research.

List of Acronyms

- **CALC**: Colorado Agrivoltaic Learning Center
- **CSA**: Community-Supported Agriculture
- **CSU**: Colorado State University
- **JSG**: Jack's Solar Garden
- **MW**: Megawatt
- **NREL**: National Renewable Energy Laboratory
- **PPP**: Public-private partnership
- **RES**: Renewable Energy Standard
- **SCF**: Sprout City Farms
- **UA**: University of Arizona
- **US**: United States

1. Introduction

Solar energy is an integral part of an energy transition in the United States from a portfolio comprised primarily of fossil fuels to one led by renewable sources. Almost three dozen US states have enacted policies encouraging or mandating the development of renewable energy sources (DSIRE, 2023), with solar energy expected to play a key role in achieving these targets (US Department of Energy [DOE], 2021). However, increasing social opposition from communities threatens to limit deployment of the technology and hinder the achievement of a clean energy supply. Local communities are increasingly opposed to the development of solar energy, with 116 US counties having banned or restricted solar energy development as of 2023 (Weise et al., 2024). A primary reason for local opposition to solar energy development is the impact of this new energy infrastructure on local landscapes (Stedman & Nilson, 2021). Recognizing the impact of solar energy development on place attachments, many scholars recommend that future solar development proposals align with local landscape values (Condon, 2022; Crawford et al., 2023). An increasingly prominent solution to align solar energy development with local landscape values is agrivoltaics, the dual-use of land for solar energy and agricultural production (Dinesh & Pearce, 2016; Barron-Gafford et al., 2019).

Agrivoltaics is often presented as a 'win-win' for farmers and solar developers. Farmers benefit from agrivoltaic systems through increased crop yields (Barron-Gafford et al., 2019), a diversified revenue stream (Cuppari et al., 2024), and preserving agricultural lands (Pascaris et al., 2020). For solar developers, agrivoltaics may improve public acceptance of proposed solar energy projects (Pascaris et al., 2022), increasing the likelihood of successful project development. Recognizing the potential of this novel co-utilization practice, policymakers have enacted programs supporting agrivoltaics at all levels of government (Pascaris & Jackson, 2023; Karhoff et al., 2024). In the US, over 580 agrivoltaic sites featuring pollinator habitat, crop production, livestock grazing, and greenhouse production are in operation at the time of writing (InSPIRE, nd). However, the development of these different agrivoltaic production styles is unbalanced. Crop-based agrivoltaic systems are generally recognized as more difficult to develop than pollinator or grazing systems because of added costs associated with design features such as raised panels. (Agir et al., 2023; Pascaris et al., 2020, 2023). Thus, pollinator habitat (417 sites on ~23,773 acres) and livestock grazing (218 sites ~9,057 acres) dominate the US agrivoltaics landscape, while crop-based agrivoltaic systems remain rare (35 sites on ~359 acres)[1] (InSPIRE, nd).

To date, social science research on agrivoltaic development in the US has largely focused on stakeholder perceptions of potential project scenarios (e.g. Pascaris et al., 2022; Cuppari et al., 2024) and the identification of perceived opportunities and barriers to development (e.g. Pascaris et al., 2020, 2023; Swanson et al., 2025). While applied studies of motivations and challenges associated with developing an agrivoltaics project are uncommon (Macknick et al., 2022). This

[1] The total number of agrivoltaic sites in the United States exceeds 584 because some host multiple agrivoltaic practices.

study addresses the literature gap in applied social science research on agrivoltaic systems in the US using Jack's Solar Garden (JSG) in Colorado as an illustrative case. A five-acre, 1.2-Megawatt (MW) crop-based agrivoltaic system, JSG is notable for three reasons. First, the development of the project was led by a farmer rather than an energy company, providing a key example of how agrivoltaics can benefit small-scale agricultural producers. Second, JSG was developed in the absence of an agrivoltaics-specific policy incentive, making it unique among crop-based agrivoltaic projects in the US which are generally developed with research funding or state incentives. Third, JSG has become a prominent community gathering space hosting community supported agriculture (CSA), tours, and farm-to-table events, showcasing how agrivoltaics can facilitate the development of multifunctional rural landscapes. Altogether, the gap in the literature and the novelty of JSG yields the question examined in this research. *What are the motivations, challenges, and community benefits of implementing and operating a crop-based agrivoltaic system?*

Following the rural geographic tradition of studying the transformation of agricultural practices and the emergence of alternative uses for the rural landscape (Gregory et al., 2009 p. 659), this case study yields several key findings that advance our understanding of the motivations, challenges, and community benefits associated with developing crop-based agrivoltaic systems. First, JSG highlights the potential for agrivoltaics to act as a policy compromise between solar energy and agricultural zoning. Second, the case emphasizes the role of public-private partnerships (PPP) in overcoming challenges to project development and operation. Third, JSG showcases the range of local benefits that can arise from a community-centered crop-based agrivoltaic project and identifies best practices for the development of similar projects.

2. Literature Review

2.1. Agrivoltaics in a changing rural landscape

For most of the 20th century, rural landscapes were dominated by productivist ideals prioritizing industrial-scale agricultural production (Marden et al., 1993; Woods, 2011). This trend has continued in recent decades, with US agricultural production value concentrating on larger farms (MacDonald et al., 2018) and placing pressure on small and medium-sized farms facing ongoing challenges of farmland fragmentation and loss (Hoppe et al., 2010; McDonald et al., 2018; Hunter et al., 2022). Concurrently, a growing prevalence of consumptive ideals emphasizes the enjoyment of land for its recreational and enjoyment values (Marden et al., 1993 p.11; Walker & Fortmann, 2003; Woods, 2011), presenting an alternative perspective on the value of the rural landscape. The coexistence of conflicting productivist and consumptivist land use ideals led to the recognition of "multifunctional" agricultural spaces enabling the broader social and environmental benefits that these landscapes can provide (Woods, 2011 p.81).

As modern forms of industrialized agriculture increase in prevalence and continue to pressure small and medium sized farms, emphasizing the multifunctional benefits of these farms provides an opportunity to preserve their operations. Agriculture is inherently a multifunctional activity, providing a range of social and environmental benefits in addition to agricultural production such as local identity and biodiversity (Woods, 2011 p. 80). Smaller operations can seek to achieve economic sustainability by emphasizing the value of these multifunctional characteristics their farms provide (Woods, 2011 p. 82). Increasingly, farms may cultivate a diverse array of crops while also operating recreation and tourism businesses, creating new opportunities for residents to interact with the rural landscape (Barbieri & Mahoney, 2009). However, on-farm adoption of renewable energy is increasingly viewed as a viable financial diversification scheme for operators, as governments continue to offer subsidies for the development of new renewable energy systems (Sutherland et al., 2015). On-farm adoption of solar energy is a particularly attractive prospect for farmers due to the potential for energy production to create an additional source of income (Morris & Bown, 2020) described as a 25-30 year "cover crop" that can return to agricultural production at the end of a lease (Goldberg, 2023 p.3). Unlike diversification activities such as diverse crop production and tourism operations which can increase access to the rural landscape, solar energy relates more closely to the large-scale agriculture practices that have traditionally defined the landscape (O'Sullivan et al., 2020). In recent years, the development of renewable energy in rural spaces has become so significant that some scholars suggest it comprises a new era of rural restructuring that re-emphasizes productivist landscape ideals in the context of industrial-scale energy production (Nilson & Stedman, 2023).

Agrivoltaics changes the nature of rural landscape change brought about by solar energy development, deriving dual use of the land for both agriculture and energy production (Dinesh & Pearce, 2016). Presently, only landowning farmers benefit from solar energy diversification, as they can earn payments for the lease of their land to a solar developer (Spangler et al., 2024). Tenant farmers are then placed into competition with solar developers for land and may lose access to land they previously farmed as they cannot offer the high lease prices that solar developers do (Gamper-Rabindran & Ash, 2024). The dual-use nature of agrivoltaic systems fosters support from farmers, who view the practice as a favorable alternative to single-use solar projects given their ability to avoid displacing agricultural production and potential to generate market advantages (Pascaris et al., 2020; Cuppari et al., 2024). Beyond benefits to farmers, agrivoltaics may also improve the social acceptance of solar energy development in rural communities, making the practice attractive to solar developers and residents (Pascaris et al., 2022; Rand et al., 2024). However, the dual-use potential of agrivoltaics does not imply that the practice is inherently a multifunctional land use in the sense outlined by Woods (2011).

Agrivoltaics combines two individually complex systems, solar energy and agricultural production, into a single land use, requiring that the unique actors associated with each of these systems communicate to develop an agrivoltaic project (Moore et al., 2022; Pascaris et al., 2023). Thus, the realization of these potential benefits of agrivoltaic systems is largely dependent on the entity driving adoption of a given project. Farmers tend to lack agency in the siting process for solar energy projects, which may complicate the development of agrivoltaic systems (Guarino &

Swanson, 2022). Examples of agrivoltaic development in France (Carrause & de Sartre, 2023) and China (Hu, 2023, 2024) suggest that the promotion of agrivoltaics by state governments and energy companies may result in a prioritization of energy over agricultural production. Agrivoltaic systems prioritizing energy may result in a transition away from traditional crop production (Nakata & Ogata, 2023), the dispossession of smallholder farmers (Hu, 2023, 2024), and the development of social opposition to agrivoltaic projects (Stedman & Nilson, 2021; Carrause & de Sartre, 2023). Thus, if an agrivoltaic project is to realize benefits, it is necessary to align the practice with the local landscape (Carrause & de Sartre, 2023; Hu, 2023, 2024).

2.2. Agrivoltaics in the context of local food systems

Local food systems are “rooted in particular places, aim to be economically viable for farmers and consumers, use ecologically sound production and distribution practices, and enhance social equity and democracy for all members of the community” (Feenstra, 1997 p.28). Ideal local food systems address both urban and rural concerns (Feenstra, 1997), while fostering socio-economic relationships and facilitating rural development that emphasize small farms and businesses (Abate, 2008). Literature examining the relationship between agrivoltaics and local food systems is largely underexplored with the notable exception of Moore and Lobell (2024), who found that members of indigenous American communities view agrivoltaics as an opportunity to strengthen their food systems. While currently underexplored, research examining the interaction between agrivoltaics and local food systems may reveal synergies that can help overcome challenges in both systems. The relationship between agrivoltaics and local food systems is particularly relevant in the case of crop-based agrivoltaic systems, which feature diverse ownership structures that expand the potential beneficiaries of agrivoltaics.

Crop-based agrivoltaics has the potential to synergize with local food systems through environmental stewardship and local economic development. Local food production may encourage farmers to adopt more environmentally friendly food production systems (Abate, 2008; Enthoven & Van den Broeck., 2021). Likewise, crop-based agrivoltaic systems are shown to support regenerative agricultural systems (Nakata & Ogata, 2023) and improve carbon uptake in crops while reducing irrigation needs (Barron-Gafford et al., 2019). Additionally, local food systems may yield economic benefits to communities by retaining local money and revitalizing rural areas (Enthoven & Ven den Broeck, 2021). Similarly, agrivoltaic systems are presented as having potential to create employment opportunities in rural communities (Chopdar et al., 2024) and encourage the development of local industries supporting agrivoltaic enterprises (Kochendoerfer & Thonney, 2021). Beyond synergies, crop-based agrivoltaics present an opportunity to overcome challenges with the operation of local food systems.

Crop-based agrivoltaic systems are particularly suited to addressing two primary challenges associated with local food systems: land access and seasonality. The loss of agricultural land in metropolitan areas due to population growth creates a challenge for farmers seeking to produce in local food systems (Abate, 2008). This challenge is exacerbated by the increasing age of the farming population, as a lack of available land and high land costs present significant barriers for young farmers seeking to enter the industry (Dennis, 2015). Local food systems engage with several alternative models to improve land access for farmers such as community land trusts, cooperative land ownership, and farmland trust organizations (Wittman et al., 2017). These models generally rely on assistance from non-profit organizations or close cooperation between a number of farmers to secure land (Wittman et al., 2017). Agrivoltaics presents a unique opportunity for alternative farmland access. Not only can agrivoltaic systems potentially reduce the conversion of farmland and undeveloped land to solar energy facilities (Brunswick & Marzilier, 2022), collaborations between solar developers and farmers may expand land access opportunities by providing opportunities to bring farmers onto existing or proposed solar projects that would not otherwise be in agricultural production (Kochendoerfer et al., 2019; Pascaris et al., 2020; Hazzard, 2024). In addition to land access, local food systems encounter challenges relating to providing a year-round crop supply due to seasonal variation (Abate, 2008). Agrivoltaic systems may provide a solution to this challenge as well, with research demonstrating that agrivoltaic systems can increase crop productivity (Barron-Gafford et al., 2019) and extend growing seasons (Sturchio et al., 2024). However, agrivoltaic systems are not without their own challenges to development.

Two challenges hinder the development of crop-based agrivoltaic systems: cost and regulatory silence. The US lacks a formal definition of agrivoltaics at the federal level, contributing to confusion regarding the development of agrivoltaic systems (Karhoff et al., 2024). Currently, only a handful of states have crafted policy relating to agrivoltaics (Pascaris & Jackson, 2023) resulting in uncertainty regarding project development (Pascaris et al., 2023). At the local level, policy restricting solar energy development on farmland presents an additional significant barrier to agrivoltaic development (Guarino & Swanson, 2022, 2023; Jackson et al., 2024). Additionally, agrivoltaic systems necessitate additional costs that farmers and solar developers may not have the resources or willingness to cover (Pascaris et al., 2020, 2023). Crop-based agrivoltaics tend to necessitate raising solar panels (Dinesh & Pearce, 2016), which increases costs to a point that may become prohibitive at the utility scale (Pascaris et al., 2023). Overcoming these challenges is necessary to develop a willingness to adopt agrivoltaics among farmers (Pascaris et al., 2020) and solar developers (Pascaris et al., 2023).

3. Background and Approach

3.1. Study background

JSG is located on a 24-acre third-generation family farm at the rural fringe of the City of Longmont, in Boulder County, Colorado (Figure 1). Historically, the farm produced hay, though by the mid 2010's hay production was no longer financially viable on the small acreage of the farm (Hammon, 2022). Constructed in 2020, JSG is a five-acre, 1.2 MW community solar garden owned entirely by the farm and features several partnerships with different organizations. While the project primarily hosts crop-based agrivoltaics, pollinator-friendly plantings border the site and a few sheep graze under the panels (Jack's Solar Garden, n.d.). Four key stakeholders were involved in the development and now, maintenance of JSG: (1) the farm manager, (2) a team of researchers, (3) a local agricultural nonprofit, and (4) an educational nonprofit. Byron Kominek[2] manages the family's farm and made the initial decision to develop the solar energy project that would become JSG. A team of researchers from the National Renewable Energy Laboratory (NREL), Colorado State University (CSU), and University of Arizona (UA)[3] helped design the solar array to support agrivoltaic production and conduct research on pollinator habitat, livestock grazing, and crop-based agrivoltaics respectively (Agrisolar Clearinghouse, 2022). Today, Sprout City Farms (SCF), a local urban agriculture nonprofit, manages agricultural production at the site, operates a CSA supplied by its production, and donates crops throughout the community. Finally, the Colorado Agrivoltaic Learning Center (CALC), a nonprofit dedicated to the development of educational and policy materials relating to agrivoltaics, hosts tours and organizes other events at the site (Agrisolar Clearinghouse, 2022). While other crop-based agrivoltaic systems feature farmer ownership, research, community energy production, and land access opportunities, JSG is the only agrivoltaic system in the US to incorporate all these different characteristics into a single project (InSPIRE, n.d.).

[2] The author received written consent from Byron Kominek to include his name in this paper.
[3] The author is currently a member of the University of Arizona team conducting crop-based research at Jack's Solar Garden, though he played no role in the development of Jack's Solar Garden and has not assisted in the experiments taking place on-site.

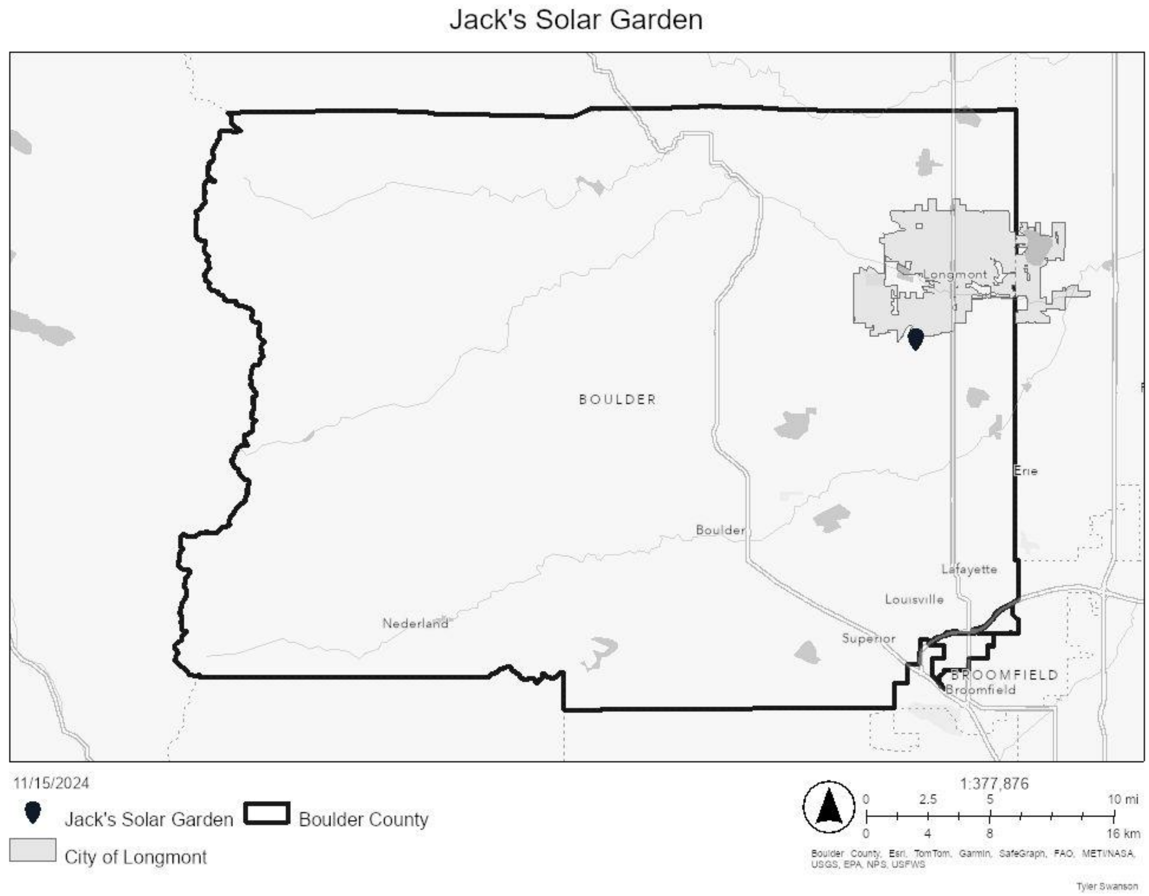

Figure 1: A map of JSG in relation to the nearby City of Longmont and Boulder County, Colorado.

3.2. Methodology

To better understand the motivations, challenges, and community benefits associated with implementing and operating a crop-based agrivoltaic system, this paper utilizes a case study approach. In rural geographic traditions, the case study is recognized as a valuable approach for understanding the social aspects of development processes (Marsden et al., 1993 p. 165). In this paper, the case study specifically follows an instrumental approach (Baxter & Jack, 2008). Rather than seeking to better understand the context in which JSG was developed or focusing on its unique attributes, the instrumental case study provides insight into a specific issue or helps to refine a theory (Stake, 1995, p.3). In this case, the instrumental approach is utilized to provide insight into the broader research question of understanding the motivations, challenges, and community benefits of implementing and operating crop-based agrivoltaic systems. The instrumental case study approach has been employed in current literature to examine topics such as technological innovation adoption (Ilott et al., 2013), and policy development (Lynch et al., 2017).

In gathering the data for analysis, this case study utilizes semi-structured in-depth interviews, document analysis, and media analysis to generate findings. Using multiple qualitative methods within a single study enhances the research, as they can yield insights that would not be discerned with a single method (Palakshappa & Gordon, 2006), and which complement the insights gathered from other methods (Darbyshire et al., 2005)

This study features interviews conducted between June and September 2024. Interviews lasted between 20-60 minutes and were conducted in-person and virtually using Zoom online meeting software. Twenty interviews were conducted across four stakeholder types: (1) agriculture stakeholders working for JSG and Sprout City Farms (n=6); (2) outreach and education stakeholders working for the Colorado Agrivoltaic Learning Center and Colorado State University Extension (n=6); (3) policy stakeholders working in the Colorado General Assembly (n=2), and (4) researchers associated with CSU, NREL, and UA (n=6) (Appendix A).

Interviewees were asked about their responsibilities at JSG, the benefits and challenges of working at the site, their interactions with other stakeholders, and other questions related to their specific role (Appendix B). To guard against bias, the author spoke with several members of each stakeholder group and reflexively analyzed interview data to ensure accurate representation of stakeholder opinions and the facts related to the development of JSG. Interviews were recorded with the consent of the interviewee and followed a semi-structured approach to allow the interviewees to provide in-depth reflections on their experiences and explore unique points they brought up (Adams, 2015). Once completed, interviews were transcribed using rev AI transcription software and reviewed to ensure accuracy. To maintain the anonymity of the interviewees, and due to the nature of stakeholders performing a variety of tasks that may overlap with various stakeholder types, stakeholders are assigned an ID (ex: SH10) which is used to reference quotes and information rather than a particular role such as ‘farmer’ or ‘researcher’. Appendix A includes a list of interviewees and interview questions.

The document analysis was informed by stakeholder interviews, consisting of relevant policy documents identified by stakeholders. Documents included in the analysis consist of state legislation, local policy, and planning documents. References to policy documents in the text use a randomly assigned ID (ex: PD4). Appendix C lists the seven policy documents gathered for this study. Finally, the media analysis was used to verify and expand upon information provided through interviews. Gathered media consisted of podcast interviews, local and national news articles, and opinion editorials. This analysis includes 19 pieces of media which are listed in Appendix D. References to media analyzed in the text are denoted by a randomly assigned ID (ex: MA5).

The interviews, policy documents, and media collected for this study were exported to NVivo 14 qualitative analysis software. The data was analyzed using the thematic analysis framework established by Braun & Clark (2006) and Clark & Braun (2017). Data analysis utilized an inductive approach, allowing the data to guide the findings and develop emergent themes rather than impose a pre-developed framework on the dataset. First, the author read through all the gathered data to identify common themes and topics of interest. The documents were then reviewed a second time, creating codes that organized the themes and topics identified in the initial read through. Codes were reflexively analyzed to reduce overlap and ensure accuracy with the data and were then organized into broad themes used to present the findings. Appendix E includes the codebook, definitions, and coding samples.

4. Results

The findings are presented in the form of a chronological narrative, with the emergent themes identified through the thematic analysis utilized to identify and describe key events in the development of JSG. Starting with the initial motivation to develop a solar energy facility, the following subsections discuss the decision to develop an agrivoltaic project, the reasoning behind incorporating various stakeholder groups in the development and operation of JSG, the use of agrivoltaics to help finance JSG, challenges of navigating diverse stakeholder interests, and the benefits that JSG has brought to the broader community. Altogether, the case study provides valuable findings on the motivations for adopting agrivoltaics on the farm, the various challenges of successfully developing and operating an agrivoltaic system, and the myriad community benefits that may arise from successful operation. Figure 2 displays a timeline summarizing key events in JSG's development discussed in this section.

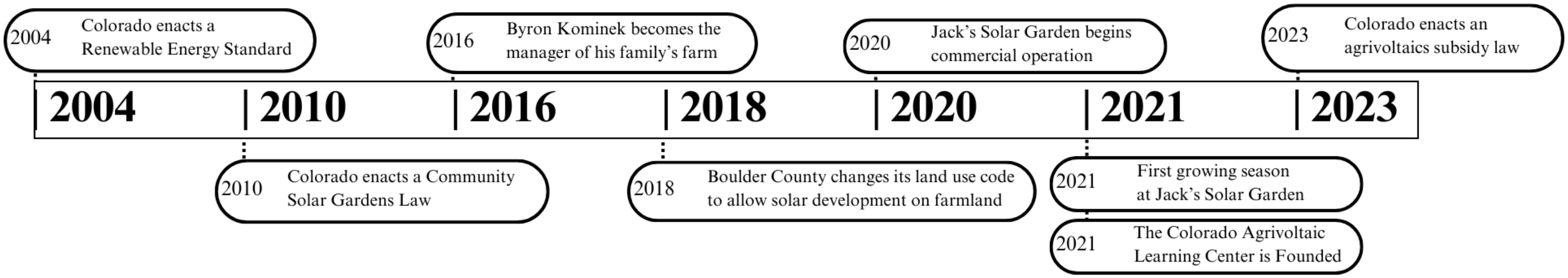

Figure 2: Key events that contributed to the development of JSG, as well as notable outcomes of the operation of the project.

4.1. Protecting the family farm: Motivations for development

When Byron Kominek (the farm manager) became the farm manager of his family's 24-acre farm in 2016, he quickly realized that hay production, the primary agricultural practice on the farm for nearly 50 years, was no longer financially viable (MA2; MA5; MA9; MA13; MA15; MA18). Keeping the farm in the family would require diversification into a new practice that would at least cover the farm's cost of operation. (MA15; MA18). After a conversation with a friend, the farm manager learned that his farmland had qualities suitable for solar energy production, namely the land's flatness and the farm's location near existing transmission infrastructure (MA18). Solar energy quickly emerged as the preferred means of financial diversification on the farm for several reasons. The farm's historical production of hay and livestock contributed to a lack of experience with other forms of agriculture and created a high level of uncertainty and risk regarding whether implementing a new agricultural practice would generate suitable returns (SH1, SH3). In addition, neighboring farms had already diversified into various agricultural practices such as equestrian farming and forestry, compounding the challenge of inexperience with competition for other producers in the local community (MA18). In contrast to common forms of agricultural diversification, solar energy was viewed to be a low risk, as selling energy to the grid would create a stable revenue stream for the farm that would last for the multi-decade lifespan of the solar array. (MA8). As a result, the idea of developing JSG emerged, with the name paying tribute to the farm manager's grandfather, who initially purchased the farm (MA13; MA18).

4.2. The first challenge: Agrivoltaics as a solution to local policy barriers

The decision to diversify the family farm's income using solar energy benefitted from a supportive state policy environment. The Colorado General Assembly enacted a renewable energy standard (RES) in 2004, setting a goal for the state to generate 30% of its energy from renewable sources by 2020 (PD6). The Colorado RES helped to create a market for renewable energy in the state. In 2010, Colorado further expanded its efforts to support renewable energy development when the general assembly passed a law requiring energy utilities operating in Colorado to purchase energy from community solar gardens, defined as solar energy facilities with a maximum capacity of two megawatts (MW) with at least 10 residents or businesses located in the same county who subscribe to receive the energy produced by the array (PD2). Thus, the Colorado RES created a general demand for renewable energy, and the law establishing community solar created a demand for small-scale solar energy in the state.

However, despite the supportive policy for solar energy cultivated by the General Assembly, local land use policy presented a critical barrier to development. At the time solar energy was established as the preferred means of diversification for the family farm, Boulder County, home to the farm, did not allow solar energy development over 100 kilowatts (kW) on any lands designated as Agricultural Lands of Significance in the Boulder County Comprehensive Plan (PD4). Agricultural Lands of Significance include agricultural land of local, statewide, and national significance, which considers soil quality and agricultural production (PD4). Preserving agricultural land was a key priority of Boulder County; on the other hand, so was the development of renewable energy. In addition to protecting agricultural land, Boulder County aimed to meet 50% of its energy needs with renewable energy by 2030 and 100% by 2050 (PD4). However, the county found that it would need more than the initially planned rooftop solar to meet its renewable energy goals and needed to explore additional avenues for generation (PD4; SH1; SH3).

The initial conceptualization of JSG only featured pollinator habitat under the panels, with the vegetation management strategy helping to provide beneficial land use and secure support for the site's development (SH1; SH3). However, in June 2018 the Boulder County Planning Commission rebuffed the plans to develop a solar array on farmland despite the plans to create pollinator habitat under the panels, citing the county's protections for agricultural land use as a reason solar energy could not occur (SH3; MA2; MA18). At this time, the farm manager connected with researchers NREL and UA, and the idea of using agrivoltaics as a compromise between Boulder County and the farm first arose. As a researcher explained:

> "So, I think when [the farm manager] first went to talk to some of the policy people, they told him that's not possible. And before, I had had all the legal pushback in Arizona in terms of knowing what that was. I said, 'Well, why don't you tell them that you're still doing agriculture, but you're adding the solar?'" (SH3).

The initial connection between the farm manager and the researchers soon became a formal collaboration. The farm manager agreed to allow the researchers to study agrivoltaics under the solar array and designed the array to accommodate the researchers' interests (SH3; SH12). In response, the researchers would secure grant funding to conduct their studies on the farm and accompany the farm manager to Boulder County government meetings where they would act as a source of information on agrivoltaics and discuss the research they planned to conduct (SH3, SH12; SH18).

> "My role was showing our actual results, summarizing some of the European stuff, showing how it can look different… but the fact that [the farm manager] was going a little bit more and saying, 'well, I'll try these different [panel] heights to see [if] people need to put the extra investment in' And [the farm manager] was already going higher to allow us to have the six-foot [panel height] option. [The County] saw buy-in. (SH3)

The collaboration between the farm manager and the researchers to use an agrivoltaic site design, as well as the Boulder County Planning Commission's conflicting goals of preserving farmland and transitioning to renewable energy established in their climate action plan, contributed to the successful revision of the Boulder County land use code (SH1, SH3, PD4). In November 2018, the Boulder County Board of Commissioners adopted an amendment to its land use code allowing for the development of ground-mounted solar energy systems on significant agricultural lands conditional on the provision of satisfactory installation, site, and management plans detailing the installation method of the array, the disturbed area, and the practices used to minimize disturbance while maintaining or improving soil quality (PD4). Thus, in the case of JSG, incorporating agrivoltaics into the design of the proposed solar site resulted in the project overcoming existing policy barriers preventing the construction of solar arrays on farmland and contributed to a revision of the local land use code.

4.3. Accumulating expertise: Recruiting stakeholders for successful operation

The farm manager initially connected with NREL researchers through a friend, and the organization agreed to help design the solar array for Jack's Solar Garden as part of the lab's ongoing agrivoltaics research (SH12; SH17; SH18). Fortunately, NREL had partnered with universities across the US to study agrivoltaics before engaging in developing JSG (MA3; MA18), giving the organization a wealth of experience to draw upon. The proposed solar array's size and design supported both NREL's and the researcher's objectives and thus created a desire to establish the project as a "shining star for research" (SH12). As a result, NREL played the role of convener, recruiting researchers who specialized in different research areas. Researchers from NREL would study pollinator habitat (SH12; SH17; SH17), while researchers from UA and CSU studied crop production and pasture grasses under the solar array (SH2; SH3; SH6; SH7; SH12). As a result of the research collaboration, the solar array was designed to raise half of the panels six feet above the ground and half of the panels eight feet above the ground (SH3; SH12), and each of the research teams received a portion of the land under the array to conduct their research (SH6). Findings from the research conducted at JSG have contributed to several advancements in knowledge regarding the physical and social aspects of agrivoltaics since the site was constructed (SH7; SH12; SH17).

In addition to conducting research, the farm manager and researchers wanted to include a farmer on the site to demonstrate the feasibility of crop production in an agrivoltaic system (SH3; SH12; MA18). Since the farm manager did not have experience growing the fruit and vegetable crops produced under the solar array, and researching the crops would be highly labor-intensive given their multi-acre scale, the farm manager and researchers decided to add the local nonprofit organization SCF to the project (SH1; SH3; SH12; SH18; MA18). SCF specializes in farming underutilized land in the Denver Metropolitan area, and farming under a solar array presented a unique opportunity to advance their mission while also developing best practices for farmers operating in an agrivoltaic system (SH3; MA14).

> "the land under solar panels is typically underutilized [Jack's Solar Garden] s another space that we saw that we could bring a food producing oasis into…we have a big focus on education and farmer training… So I think it's a really good space for use to be able to come in and trailblaze" – MA14

Incorporating the nonprofit into JSG solved several challenges associated with the site. The organization had a wealth of experience with vegetable production, which was the primary object of study by the researchers. Not only did the presence of the nonprofit provide the labor necessary to conduct research at the multi-acre scale of the site, but it also solved the knowledge barrier that previously prevented the farm from diversifying into other forms of agriculture production (SH1).

Furthermore, the researchers at the site did not have a use for the crops after harvesting them. The surplus crops, combined with SCF's experience practicing local agriculture, allowed the organization to establish a CSA operation at JSG. In summary, not only did collaboration between stakeholder groups enable the construction of JSG by helping revise local land use policy, but the incorporation of stakeholders with different areas of expertise allowed for the project to generate multiple benefits for research and local food production.

4.4. Agrivoltaics as marketing

Shortly after the Boulder County Board of Commissioners updated its land use code, JSG won a bid for development through Xcel Energy's community solar program (MA18). The selection of JSG for the bid by Xcel was attributed to the unique services provided by the array resulting from the collaboration between the farm, the researchers, and SCF (MA18). The five-acre solar array occupied one of the farm's three pastures (MA15), with three acres of the array reserved for research and two reserved for SCF (MA18). In addition to the research and CSA operations taking place under the array, the farm manager collaborated with the Audubon Society of the Rockies to develop a pollinator habitat barrier along the perimeter of the solar array, precluding the need to raise a fence around the site (SH18; MA18).

The initial plan for JSG involved leasing the land to a solar developer for the construction and operation of the array, with the farm receiving payments from the developer. After reviewing several offers, it was determined that owning the system would provide greater financial returns for the farm (MA9). However, the five-acre, 1.2 MW solar garden would cost $2 million, presenting a crucial barrier to site development. While the researchers and SCF secured funding to conduct their work on the site, they did not have any funding to assist in site construction. Thus, marketing became critical to the successful development of JSG. Once again, the farm manager and researchers collaborated to pitch the project to potential community solar customers to secure enough subscriptions to fund construction (SH1; SH3). During these informational sessions for potential customers, the farm manager discussed the reasoning behind transitioning the farm into a community solar garden and the wide range of activities that would take place under the solar array; meanwhile, the researchers would explain the concept behind agrivoltaics and the nature of the research they would conduct on the site.

Over time, enough community solar customers subscribed to finance half of the project cost, and the other half was financed by a bank loan using the farm as collateral (MA15). Construction began in 2020, and the site reached commercial operation in November. Like the efforts to change local land use policy, the agrivoltaic design of JSG helped the project overcome challenges that may have been more difficult to solve were it a conventional community solar garden that only generated energy and did not include any dual-use practices. Specifically, the incorporation of agrivoltaics and its attendant multi-stakeholder collaboration helped the project secure a bid for construction from the energy utility, and the unique marketing of JSG as an agrivoltaic project helped in pitching sales of the project's energy to local customers. While a crop-based agrivoltaic design useful in securing the development of the project, the successful operation of JSG was not without risk.

4.5. Navigating diverse stakeholder interests

Once constructed, the successful operation of JSG required the coordination of a range of stakeholder groups, including the farm manager, the researchers, and SCF, who had diverse interests in the project (Table 1). As the solar array owner, the farm manager's primary concern is the successful maintenance of the solar panels. The energy provided by the panels comprises the main source of income for the farm, and the panels themselves represent a significant financial investment (SH1; SH6; MA13). While the research and crop production under the solar array benefits the site's operation, the farm's continued operation depends on the successful maintenance of the solar array. The main concern of the research groups, on the other hand, is achieving their established research goals by studying the performance of crops, pollinator habitat, and pasture grass under and around the solar arrays (SH1; SH2; SH3; SH12; SH18). The presence of the solar array is a crucial aspect of the research, but the funding supports research experiments rather than the panels. Finally, SCFs main concern is growing produce, though it is also responsible for assisting in the crop production research on site (SH1; SH3; SH8; SH12; SH18; SH19; MA14). SCF also benefits from the presence of the solar array, as its construction resulted in the nonprofit having an additional site for crop production. However, it depends on crop production and fulfillment of its responsibilities to the researchers to maintain its presence on the site. Figure 3 shows images of JSG in operation.

Stakeholder Group	Primary Interest in JSG
Farm Manager	• Overcoming policy hurdles • Successful maintenance of the solar array • Diversification of farm revenues
Researchers	• Achieving established research goals • Developing best practices for AV design • Communicating research findings
SCF	• Advancing the organization's mission • Growing agricultural produce • Assisting in crop production research

Table 1: A summary of the primary interests that the farm manager, researchers, and SCF hold in the operation of JSG.

Figure 3: Photos of JSG taken by the author during a visit to JSG in September 2023. Top left: tomato production between rows of solar panels. Top Right: sheep grazing in a small pen under a row of solar panels. Bottom left: a tractor used to move supplies around the farm. Bottom right: leafy greens growing in between rows of solar panels.

The diversity of stakeholder groups and their associated interests in JSG occasionally results in tension among the groups as each seeks to achieve its goals. During the first production season, construction delays resulted in a partial crop season (MA14) and prevented SCF from selling its produce at the local farmers market (SH18). After constructing the solar array, preparing the site for agricultural production necessitated additional steps, including developing an irrigation system and decompacting the soil (SH18). SCF, responsible for preparing agricultural production at the site, sought to plant a small variety of crops while planting cover crops on most of the site to prepare the soil for the following season. However, the researchers needed to begin collecting data and advocated planting various crops on the entire plot to achieve that goal. After communication between the two groups, a compromise in which SCF agreed to plant a smaller range of crops on a portion of the plot while preparing the rest of the plot for agricultural production the following season resolved the tension in stakeholder objectives (SH3; SH12; SH18).

Unlike securing approval from the county or financing the construction of the solar array, navigating the diversity of stakeholder interests in the operation of JSG is a recurring challenge. Table 2 summarizes each of the challenges encountered by different stakeholders in both the development and maintenance of JSG. A common lesson learned in successfully addressing this challenge is establishing clear and codified expectations and agreements that delineate responsibilities before site operation (SH1; SH12; SH18). Transparency and communication between groups are also crucial, as they ensure that all voices and interests involved in the operation and maintenance of JSG are heard and respected (SH1). As one researcher explains:

> “It’s life, it’s a farm, it’s a solar project. Things happen every single month that you’re not expecting. And those agreements help you address those things that always come up and again, give sort of clear expectations on what’s needed for everyone. So, I would say that’s a big lesson learned is making sure you’ve got these rock-solid partnerships and understandings, common understandings among all partners nailed down from the beginning” (SH12)

Challenge	Encountered By	Solution
Boulder County land use policy prohibited the development of solar energy on agricultural lands.	Farm Manager	The farm manager and researchers collaborated with the county government to revise the county land use policy to allow for solar development on agricultural land while protecting agricultural production.
The scale of the research required more labor than the research teams had available, and the farm manager wanted to continue agricultural production under the solar array.	Farm Manager and Researchers	The farm manager and researchers recruited SCF to assist with research tasks and manage agricultural production at JSG.
Developing the solar array required significant upfront capital and required subscriptions from local energy customers.	Farm Manager	The farm manager collaborated with the researchers to market JSG as a novel means to purchase renewable energy while supporting local agricultural production, helping to improve interest and gather subscriptions.
The various stakeholders involved in the development and maintenance of JSG had a diverse range of interests that occasionally came into conflict with one another.	Farm Manager, Researchers, and SCF	The stakeholders adhere to a policy of transparency and consistent communication between groups and have resolved to establish clear written expectations and agreements relating to various groups' responsibilities.

Table 2: A summary of the challenges encountered by stakeholders in the development and maintenance of JSG with explanations of the solution reached.

4.6. Community benefits of Jack's Solar Garden

The solar array that comprises the foundation of JSG is a key source of income for the farm, with a capacity to provide over $320,000 in annual revenues (MA8). However, the project has contributed to a range of economic and social benefits beyond the financial diversification of the farm that are summarized in Table 3. Benefits resulting from the unique stakeholder interactions present at JSG include: (1) the provision of renewable energy for the local community, (2) the cultivation of crops for the local food system resulting from collaborative research practices, and (3) the founding of a dedicated nonprofit organization developing educational, outreach, and policy materials for agrivoltaics.

First, energy generated by the solar array is part of the community solar garden program. The 1.2 MW solar array that comprises JSG, while providing a stream of income that ensures the financial sustainability of the farm (SH1; MA8), also generates enough energy to power three hundred homes in the community (MA2) in addition to donating free renewable energy bill credits to low-income households as part of Xcel energy's community solar program (MA18).

Second, in addition to assisting with research at JSG, SCF also operates a CSA on the farm following regenerative practices, sells produce at local farmers' markets, trains new farmers, and donates crops to the community. Once harvested, the researchers donate their crops to SCF, who sells those crops in addition to those grown on their own two acres of the farm through shares of the CSA or at farmer's markets where the quality of the crops has cultivated a following among market goers (SH8). The stand at the farmers' market uses suggested pricing, ensuring that the crops harvested at Jack's are available to all community members (MA14). In addition to selling produce, SCF distributes over half of the crops harvested at JSG to low-income households through no-cost shares, schools, and food pantries. Further, SCF contributes to developing community space on the farm, organizing workshops and volunteer days that allow community members to visit and help work on the farm (SH5, SH8). The solar array that comprises JSG provides a unique marketing opportunity and helps SCF extend the growing season on certain crops (SH8; SH18; MA14), but the most widely cited benefit of the array is the shade that creates a cool environment for the farm workers during the day (SH2; SH3; SH4; SH8; SH12; SH18; MA14).

Third, the CALC expands the range of educational, policy, and outreach work that JSG can perform. After a successful first crop harvest at JSG in 2021, several stakeholders collaborated to establish the CALC (SH1, SH3) with a mission of advancing education, policy, and adoption of agrivoltaics in Colorado (SH1; SH3; SH5; SH9; SH14). The CALC operates with funding from large organizations such as the Walton Family and Cielo Foundations, along with the support of individual donors and businesses. As part of its mission, CALC hosts public and school tours of JSG (SH5; SH9; SH14) and creates educational curriculums on agrivoltaics for Colorado schools (SH9; SH14). At the time of writing, the CALC interacted with over 8,200 students and public members through on-and-off site presentations, high school tours, and college outreach events (SH14). Policy research is another key aspect of the CALC mission, and the organization provided information to state policymakers in the development of Colorado Senate Bill 23-092, which provided grant funding for agrivoltaic projects in the state (SH10; SH14; PD7). When SB 23-092 passed the Colorado General Assembly, Colorado Governor Jared Polis signed the bill into law at JSG (MA19).

The CALC connects members of the energy and agriculture industries to disseminate information on agrivoltaics through workshops and webinars providing information on developing agrivoltaic systems (SH5; SH14; SH15). The CALC has recently begun an effort to connect landless farmers with solar developers as a novel means of facilitating land access to farmers through agrivoltaics (SH5; SH13; SH14; SH15), expanding the potential for agrivoltaics to resolve ongoing challenges of farmer land access and ownership relating to solar energy development. While this project is still in development, it may yield important results for the future use of agrivoltaics. All the efforts of the CALC, along with those of SCF and the researchers, are showcased at an annual farm-to-table event at JSG, where members of the community can visit the farm, learn about the work done by the different stakeholders on-site, and sample the produce grown on the farm. While there are likely a wide range of agronomic and environmental benefits resulting from the agricultural production taking place at JSG, the identification and communication of these benefits is left to the researchers on-site.

Economic and Social Benefits	Primary Beneficiaries
Additional income source resulting from the sale of solar energy	Farm
Energy generated by the solar array as part of the community solar garden program	Residents and businesses
Local food production resulting from the ongoing research on agrivoltaic systems	Researchers SCF, Residents
Improved working environment due to the shade provided by the solar panels.	Researchers, SCF
Development of educational, policy, and outreach materials following the creation of the CALC	Educational institutions, policymakers, and residents

Table 3: A summary of the economic and social benefits resulting from the operation of JSG and the primary beneficiaries of these benefits.

5. Discussion

JSG provides a unique case of agrivoltaic development that sheds light on motivations for implementation, challenges with successful development and operation, and the on and off-farm benefits that may accrue from an agrivoltaic system. Three aspects of the case study constitute particularly notable findings that are discussed further in this section. First, the case of JSG illustrates how agrivoltaics can play a significant role in facilitating compromise around land use policy. Second, stakeholder collaboration is integral to overcoming challenges in the development and maintenance of an agrivoltaic system, according to the case findings. Third, the case study research reveals how agrivoltaic systems can act as multifunctional spaces when developed with community interests in mind.

5.1. The value of agrivoltaics as a policy compromise

The decision to adopt solar energy and crop-based agrivoltaics in the case of JSG are best understood when viewed separately. Initially, JSG was conceived of as a pollinator-friendly community solar garden that would provide a diversified income stream necessary to preserve the family farm. Crop-based agrivoltaics were not included in the project's design until after the initial proposal was rejected by the county board, as mentioned by SH3 in Section 5.2. The use of crop-based agrivoltaics was intended as a means of compromising between the farm's desires to develop a solar array and the county's desires to preserve agricultural land. This suggests that the economic motivations for developing JSG were related to the value of solar energy, while the integration of crop-based agrivoltaics was motivated by a need to overcome policy barriers to solar energy development. This is not to say that agrivoltaics cannot yield economic benefits, but that the nature of agrivoltaic development in this case, adopting a production technique that the farm had no experience with and allowing a nonprofit to manage and market the crops, makes the ultimate profitability of agrivoltaics at JSG difficult to determine.

Although the development of JSG was initially motivated by a desire for solar energy income, it is evident that the project has benefited financially from incorporating crop-based agrivoltaics into its operation. The practice provided a unique marketing opportunity for the farm to secure subscribers for the community solar array, and it encouraged the development of agritourism activities that benefit the CALC. One may argue that the decision to allow SCF to manage the farmland under the array for free is an admission that crop-based agricultural production is not economically viable; however, this decision was attributed to the farm's lack of experience producing specialty crops included in the researcher's experiments rather than the profitability of crop production. This finding extends the current agrivoltaics scholarship which highlights the economic benefits of agrivoltaics. Increased farmer incomes are often regarded as a primary benefit of agrivoltaic systems (Pascaris et al., 2020; Cuppari et al., 2024), and the case of JSG further identifies how the economic benefits of an agrivoltaic system may materialize. While crop-based agrivoltaic systems may yield additional revenues from increased yield, the primary economic benefits of crop-based agrivoltaics in the case of JSG include improved marketing for the sale of solar energy and the opportunity for agritourism revenues.

Beyond the economic benefits of agrivoltaic systems, the case of JSG is particularly valuable for illustrating the use of agrivoltaics as a policy compromise, a novel finding not emphasized in current scholarship. Current agrivoltaics literature suggests that the lack of an established regulatory framework such as definitions, policy incentives, and zoning strategies presents key barriers to development (e.g., Guarino & Swanson, 2022; Pascaris et al., 2023; Karhoff et al., 2024). Indeed, local zoning policy prohibiting solar development on agriculturally significant land nearly derailed the project. However, the successful development of JSG suggests that agrivoltaics can arise without a specific state policy incentive by leveraging existing renewable energy incentives and may be a viable means of overcoming barriers in communities with zoning laws that restrict solar energy development.

Interviewees attributed the development of JSG to the existence of a community solar policy in Colorado (SH1; SH3), which was itself developed because of the state's RES enacted in 2004. These state policies did not explicitly incentivize agrivoltaics, but they did create a market for renewable energy generation in Colorado with a specific emphasis on small-scale solar energy projects. Thus, renewable energy policies, particularly community solar programs, may present sufficient circumstances to incentivize the implementation of agrivoltaics in the agricultural sector, which is known to be receptive to policy incentives (Sutherland et al., 2015). While state policies were helpful in creating a landscape receptive to agrivoltaic development, the role of local zoning policy in determining ultimate approval for solar projects suggests local policy may play a more important role in determining the success of agrivoltaics implementation (Jackson et al., 2024). The development of JSG in a county without a zoning definition for agrivoltaics provides insight into how agrivoltaic projects can navigate barriers of local regulatory silence (Guarino & Swanson, 2022; 2023) and the patchwork of solar zoning codes that exist across the United States (Jackson et al., 2024).

The success of JSG should not suggest that agrivoltaics is a panacea for local opposition to solar development. The impacts of solar arrays on local landscapes are a commonly noted reason for opposition to solar projects (Crawford et al., 2022; Bessette et al., 2024), and a growing body of literature suggests that many agrivoltaic projects are constructed absent considerations of compatibility with local landscape and identity (e.g. Carrausse & De Sartre, 2023; Hu, 2023; Nakata & Ogata, 2023). However, the unique design of JSG that raised panel heights, and the interest of the researchers in studying the outcomes of agrivoltaic production on the site, demonstrated to the county government that the project would earnestly continue to practice agriculture in addition to its solar energy production and ultimately led to the revision of the Boulder County land use policy. Further research is needed to better understand how different agrivoltaic production systems, such as pollinator habitat and livestock grazing, may become compatible with local landscapes and whether the leading interest behind the project, such as farmers, researchers, or solar developers, further impacts perceptions of acceptability.

5.2. The importance of stakeholder collaboration

Several years of continued operation at JSG demonstrate how crop-based agrivoltaics can be successful. However, collaboration between stakeholders was necessary to overcome challenges in the project's development phase and also to maintain the project's successful operation over time. Crucially, the success of JSG project may not have been possible without the public-private nature of the project featuring the collaboration of public research institutions, a private landowner, and a non-profit serving public interests. The initial development of JSG was grounded in private for-profit interests of generating a new income stream for the family farm. However, the successful development of the JSG would not have been possible without public interests in conducting research and producing crops at the site. Collaboration among these public and private interests was integral to overcoming three primary challenges: local zoning policy prohibiting solar energy development on land of agricultural significance, financing the construction of the solar array, and successfully operating the different aspects of JSG. Altogether, this case study yields two key insights into the nature of challenges associated with an agrivoltaic system: First, JSG highlights the benefit of PPPs in facilitating the development and operation of agrivoltaic systems. Second, the case exemplifies the various challenges that must be overcome to develop and operate an agrivoltaic system successfully.

Literature on agrivoltaic project development in the US highlights the importance of collaboration and partnerships among stakeholders for project zoning, community engagement, and understanding multiple priorities, each relevant to solving the three main challenges experienced at JSG (Macknick et al., 2022). However, this scholarship has not explicitly examined the practice through the lens of PPPs such as the one utilized at JSG. This is surprising given the significant role that profit-driven solar developers play in assisting the development of agrivoltaic projects that are ultimately intended for nonprofit interests such as research (InSPIRE, n.d.). The presence of SCF as a partner in JSG is illustrative of shared farming on privately owned land, a particular form of PPP common to local food systems (Dennis, 2015; Wittman et al., 2017). The partnership between private landowner and public farming interests is particularly notable example of how agrivoltaics may help overcome land access issues faced by farmers in local food systems (Abate, 2008). However, while this form of PPP is a valuable form of land access for farmers in local food systems, it is not without challenges. Shared farming on privately owned land presents questions surrounding the stability of land tenure, challenges related to on-farm decision making, and concerns regarding imbalanced power dynamics between the landowner and the farmer (Wittman et al., 2017). These questions are particularly relevant in the case of JSG, as the grant funding that allows for the research to take place will not last forever, and the various partners will need to determine the nature of agricultural production once the research concludes. Future research needs to examine the agreements made between different stakeholders involved in an agrivoltaic project to understand how questions of land tenure, decision making, and power are addressed.

In addition to highlighting the role of stakeholder collaboration in overcoming challenges to developing an agrivoltaic system, the case of JSG illustrates the types of challenges encountered in project development. Current literature finds that the primary challenges associated with the initial development of an agrivoltaic system include regulatory barriers and implementation costs (Adelhart & Berneiser, 2024; Cuppari et al., 2024; Wagner, 2024). This case study validates the presence of these challenges to development, but it also highlights an operational challenge in coordinating stakeholder interests. The challenges associated with an agrivoltaic system may be best categorized as initial challenges experienced only once, such as securing approval from local government authorities to develop the project or financing the project's construction. They may also include operational challenges requiring consistent attention to ensure the orderly operation of the agrivoltaic project, such as the need to coordinate the diverse interests of stakeholders associated with the agrivoltaics project. More research needs to be done to better understand the diversity of challenges associated with agrivoltaic systems, especially distinguishing initialversus operational ones. This may also further improve implementation outcomes by setting realistic expectations for project stakeholders.

5.3. Beyond solar farms: The community benefits of agrivoltaics

Finally, it is critical to acknowledge the community benefits generated by the operation of JSG. This case study is unique, as the variety of stakeholders involved with JSG yields a broader range of benefits than is typically observed with current agrivoltaic projects. However, the uniqueness of JSG is valuable for furthering the development of agrivoltaics, as the diffusion of this innovative technological practice is still in its early stages and benefits from research on the various aspects of project development (Pascaris et al., 2023). Some benefits provided by JSG—local energy and food production, pollinator habitat, and research production—are commonly expected benefits of community solar gardens, CSAs, and agrivoltaic projects. However, the co-production of community solar gardens and community supported agriculture is novel, and illustrates how solar energy may be incorporated into the landscape in a multifunctional rather than purely productivist manner.

The current scholarship discussing on-farm solar energy development suggests the benefits of advancing the renewable energy transition (Sutherland et al., 2015) and improving local tax revenues (Moore et al., 2022). Agrivoltaics scholarship expects similar outcomes, with the added benefits of increased local food production (Chopdar et al., 2024) and the development of supporting industries in local communities (Kochendoerfer & Thonney, 2021). The case of JSG suggests that the off-farm benefits of agrivoltaic systems may extend far beyond what the literature currently discusses. Other benefits provided by JSG result directly from the CALC, which itself is a unique outcome among agrivoltaic projects. The CALC's development of educational materials for Colorado schools, research materials informing policy development, and local events open to the community contribute to JSG transcending the common 'productivist' nature of agricultural and solar energy production and establishing the site as a multifunctional space emphasizing the benefits that agrivoltaics provides to the local community. The embedding of various community-centric benefits into the project's operation aligns with the recommendations of Clausen and Rudolph (2020) to improve the synergy between renewable energy and rural development.

In addition to the range of benefits JSG provides to the local community, it also provides insight into how agrivoltaic projects can help overcome land access challenges for farmers. Section 4.3 explains that SCF viewed solar facilities as an underutilized space for agriculture and sought to partner with JSG to determine strategies for practicing crop-based agrivoltaics. Land costs and availability and access to capital are critical barriers for farmers (Dennis, 2015) which agrivoltaic projects such as JSG may be able to overcome. JSG is an example of shared farming on privately owned land, a common type of land access highlighted by Wittman et al. (2017) however, it is a unique ownership structure for agrivoltaic projects, as the energy, infrastructure, and land are all owned by the farmer, but land access and the agricultural production is freely given to SCF. The CALC's project connecting landless farmers with solar developers is similar, though in this case a solar company, rather than a farmer, is the key owner of the land. These ownership structures warrant further research to determine the best practices for facilitating farmer land access through agrivoltaics.

JSG is a strong example of how designing solar facilities for crop-based agrivoltaic production can yield successful multifunctional landscapes As more crop-based agrivoltaic projects are developed, practitioners should keep in mind the features that have allowed JSG to be successful. Projects that do not incorporate design features such as raised panel heights and spacing may result in unsuccessful agrivoltaic production and amount to little more than greenwashing, giving the appearance of providing a benefit to the local community without yielding tangible benefits (de Freitas Netto et al., 2020). Further, the importance of identifying stakeholders to collaborate with prior to beginning development is crucial. While crop-based agrivoltaics was introduced at JSG to help overcome a policy barrier, the successful development of the project may not have been possible without the assistance of various government, research, and community institutions to help design and operate the system. Finally, the use of agrivoltaic systems to generate community benefits should not be ignored. While agrivoltaics undoubtedly helped to bring financial stability to JSG, the project has also become a significant place of community food, energy, and knowledge production. Crop-based agrivoltaic projects may be developed in the absence of these aforementioned features; however, JSG showcases how agrivoltaic projects can become more than spaces of food and energy production and enhance their multifunctional value by actively engaging with their host communities.

6. Conclusions

The development of JSG occurred in a unique context that aided in the enabled implementation of the project. Colorado's supportive policy landscape for renewable energy, featuring a renewable portfolio standard and a community solar law, created a landscape favorable for developing small-scale solar energy projects. A supportive network of researchers with funding available to conduct agrivoltaic research also proved critical to project development, as they provided the expertise necessary for project design in addition to acting as reliable sources of information in meetings on revising local land use policy and pitching JSG to potential community solar garden subscribers. Finally, a farmer motivated to overcome adoption barriers and access to the financial resources necessary to fund the construction of the solar array proved to be the most integral aspect of JSG's success. Not all existing or potential agrivoltaic projects may enjoy the benefits of a supportive policy environment, research expertise, and financial resources enjoyed by JSG however, this case provides insight into the motivations and challenges related to the development of an agrivoltaics project that may prove to be increasingly common as the adoption of agrivoltaics continues. Further, JSG case highlights the diverse range of community benefits arising from adopting agrivoltaics, a topic underexplored in literature.

First, decisions to adopt crop-based agrivoltaic systems may be motivated by something other than the potential for additional income. In this case, agrivoltaics presented a means to overcome local policy barriers and gather support for developing a solar project. Second, local land use policy, project cost, and stakeholder coordination significantly challenge solar energy development. These challenges related to the development of agrivoltaic systems may be categorized as initial, experienced only once, or operational, recurring consistently throughout the project's operations. Additionally, the presence of stakeholders with expertise in agriculture and energy production can further assist in overcoming both initial and operational challenges by providing valuable information and coordinating responsibilities. Third, crop-based agrivoltaic systems can combine common benefits such as local energy and food production. However, they can also create unique benefits such as educational materials and cultivating community gathering spaces.

The findings of this case study suggest three avenues for future research. First, research should assess the impact of grazing and pollinator habitat agrivoltaic projects on local government perceptions of developing solar energy on farmland. The findings of this work would further clarify the potential for agrivoltaics to resolve barriers to solar energy development and reduce land use tensions between agriculture and energy production. Second, research should assess the role of agrivoltaic researchers in fostering successful agrivoltaic projects through the creation of agricultural innovation systems. The researchers involved with JSG contributed to the project's success from its initial conceptualization to its current operation, extending their involvement beyond their own experiments. The involvement of other researchers in agrivoltaic projects will clarify how prevalent collaboration between farmers and researchers is in developing agrivoltaic systems and may contribute to developing best practices for collaboration. Third, the impact of unique ownership structures on agrivoltaic project outcomes warrants further study. JSG is unique in that a farmer owns the energy, infrastructure, and land, but a nonprofit enjoys the value of agricultural production. Identifying and defining additional ownership structures for agrivoltaic projects will help determine how these structures influence operational outcomes and may also contribute to establishing best practices for ownership.

Appendix A: Interviewee details

Interviewee ID	Stakeholder Category	Date of Interview
SH1	Agriculture	June 14, 2024
SH2	Research	June 19, 2024
SH3	Research	June 19, 2024
SH4	Agriculture	June 19, 2024
SH5	Education and Outreach	June 25, 2024
SH6	Research	June 25, 2024
SH7	Research	June 25, 2024
SH8	Agriculture	June 26, 2024
SH9	Education & Outreach	July 2, 2024
SH10	Policy	July 3, 2024
SH11	Agriculture	July 3, 2024
SH12	Research	July 5, 2024
SH13	Education & Outreach	July 9, 2024
SH14	Education & Outreach	July 10, 2024
SH15	Education & Outreach	July 12, 2024
SH16	Policy	July 24, 2024
SH17	Research	July 22, 2024
SH18	Agriculture	July 22, 2024
SH19	Agriculture	August 14, 2024
SH20	Education & Outreach	September 13, 2024

Appendix B: Interview Questions

Research Stakeholder Questions

1. How did you come to be involved in research at Jack's Solar Garden?
2. What are your responsibilities as a researcher?
3. What has been your experience working on a research project that is also located at a private farm?
4. What are some of the benefits and challenges of doing research at Jack's Solar Garden?
5. Do any of the agriculture stakeholders play a role in shaping the research agenda that you work with?
6. Do you share information with the agriculture stakeholders? To what extent?
7. What is your outlook on the future of research at Jack's Solar Garden?
8. What were your initial thoughts on the proposed design of Jack's Solar Garden?
9. What was your main interest in conducting research at Jack's Solar Garden?
10. How did you support the development of Jack's Solar Garden?
11. Can you tell me about the decision to bring a community supported agriculture operation into Jack's Solar Garden?
12. What opportunities has the operation of Jack's Solar Garden provided you and your research team?
13. What is your outlook for the future of Jack's Solar Garden? Do you think this is a model that can be replicated?
14. What was the nature of the agreement that allowed you to conduct research at Jack's Solar Garden?
15. How did you get funding to work at Jack's?
16. What are the benefits and challenges of conducting research in a public location?
17. What are the benefits and challenges of sharing the research site with the Community Supported Agriculture Organization?

Agriculture Stakeholder Questions

1. How did you come to be involved in Jack's Solar Garden?
2. What are your responsibilities at Jack's Solar Garden?
3. What was your initial impression of practicing agriculture at Jack's Solar Garden?
4. How has your impression of Jack's Solar Garden changed over time?
5. What are the benefits of working at Jack's Solar Garden?
6. What are the challenges of working at Jack's Solar Garden?
7. Have you noticed any additional interest from CSA members due to producing crops in an agrivoltaic system?
8. Do you think there is potential to increase the benefits of CSA work by developing AV sites? What are those benefits?
9. What have been some of your key lessons learned from practicing agriculture in an agrivoltaic system?

10. What are your interactions with the onsite researchers like?
11. What is it like interacting with tourists visiting Jack's Solar Garden?

Education and Outreach Stakeholder Questions

1. How did you first become involved with Jack's Solar Garden?
2. What motivated you to become involved in agrivoltaics?
3. What are your responsibilities?
4. To what extent do you feel that Jack's Solar Garden contributes to your education and outreach goals?
5. Has the presence of Jack's Solar Garden made it easier to achieve your education and outreach goals?
6. How does Jack's Solar Garden contribute to your personal responsibilities?
7. How do you interact with the local community in your education and outreach work?
8. How would you describe your interactions with tourists at Jack's Solar Garden?
9. To what extent do you communicate with other stakeholders involved in the operation of Jack's Solar Garden?
10. What impact do you think your work has on the local community?
11. What challenges do you face in your education and outreach work?

Policy Stakeholder Questions

1. How did you first learn about agrivoltaics?
2. What motivated you to promote agrivoltaics legislation?
3. Could you tell me a bit about the experience in crafting the legislation that would support agrivoltaics? Why do you think last year's legislation passed when previous efforts had failed?
4. How have you interacted with Jack's Solar Garden and its associated groups?
5. What were your thoughts about solar energy on farmland prior to learning about agrivoltaics?
6. Some journalists have claimed that the Jack's Solar Garden site and the legislation recently passed have made Colorado a leader in the US agrivoltaics space, is this a position that you think the state will maintain?
7. What challenges do you foresee Colorado farmers facing in the adoption of agrivoltaics?
    a. Do you think these challenges could, and should be overcome by policy?
8. What role do you think organizations such as Jack's Solar Garden will play in the development of agrivoltaics in Colorado?
9. Do you have any plans to alter the current grant program or present any other forms of legislation?

Appendix C: Document Analysis List

Document ID	Citation
PD1	*2023 Boulder County Colorado sustainability, climate action & resilience plan*. (2023). Boulder County Government. https://bouldercounty.gov/climate/sustainability-plan/#:~:text=Boulder%20County%20Sustainability%20Plan.%20The%202023%20Boulder%20County%20Sustainability%20Plan
PD2	An Act Concerning Measures to Encourage Additional Investment in Solar Energy Generation Facilieies, and, in Connection Therwith, Authorizing the Creation of Community Solar Gardens, 40-2–127 Colorado Revised Statutes (2010). https://leg.colorado.gov/sites/default/files/images/olls/2010a_sl_344.pdf#:~:text=CONCERNING%20MEASURES%20TO%20ENCOURAGE%20ADDITIONAL%20INVESTMENT%20IN%20SOLAR%20ENERGY%20GENERATION
PD3	*Docket DC-18-0002: Proposed Amendments to the Boulder County Land Use Code related to Solar Energy Systems*. (2018, July 23). Boulder County Board of Commissioners.
PD4	*Docket DC-18-0002: Amendments to the Boulder County Land Use Code for Solar-related Uses and Regulations*. (n.d.). Boulder County Board of Commissioners.
PD5	*Resolution 2019-118*. (2018, November 27). Boulder County Board of Commissioners.
PD6	Renewable Energy Standards - Qualifying Retail and Wholesale Utilities - Definitions - Net Metering - Legislative Declaration - Rules, 40-2–124 Colorado Revised Statutes (2004). https://advance.lexis.com/documentpage/?pdmfid=1000516&crid=143cf1ff-d7b4-4060-b5bc-e37b966165fb&config=014FJAAyNGJkY2Y4Zi1mNjgyLTRkN2YtYmE4OS03NTYzNzYzOTg0OGEKAFBvZENhdGFsb2d592qv2Kywlf8caKqYROP5&pddocfullpath=%2Fshared%2Fdocument%2Fstatutes-legislation%2Furn%3AcontentItem%3A62NH-97S3-CH1B-T0H7-00008-00&pdcontentcomponentid=234176&pdteaserkey=sr0&pditab=allpods&ecomp=6s65kkk&earg=sr0&prid=4f18b37c-b3eb-413f-9ecf-831da31e0780
PD7	Concerning Opportunities For Voluntary Emission Reductions In Agriculturem And, In Connection Therewith, Making An Appropriation, General Assembly of The State of Colorado, SB 23-092 (2023). https://leg.colorado.gov/sites/default/files/documents/2023A/bills/2023a_092_enr.pdf

Appendix D: Media Analysis List

Media ID	Citation
MA1	AgriSolar Clearinghouse. (2022, August 10). Case Study: Jack's Solar Garden. *AgriSolar Clearinghouse*. https://www.agrisolarclearinghouse.org/case-study-jacks-solar-garden/#:~:text=Covering%20over%20four%20acres%20of%20land%20on%20a%2024-acre%20farm,
MA2	Allen, G., & Hickman, T. (2023, January 22). Why the ground under Colorado solar panels is ripe for growing food. *The Colorado Sun*. https://coloradosun.com/2023/01/22/colorado-solar-agriculture-agrivoltaics-lawmakers/
MA3	Ahsoka Contributor Group. (2024, March 23). Solar Is Here To Stay—Let's Do It Right. *Forbes*. https://www.forbes.com/sites/ashoka/2024/03/21/solar-is-here-to-stay-lets-do-it-right/\
MA4	Frazier, C. (2023, July 15). Community members learn about farming alongside solar panels at Jack's Solar Garden. *Daily Camera*. https://www.dailycamera.com/2023/07/15/community-members-learn-about-farming-alongside-solar-panels-at-jacks-solar-garden/?fbclid=IwAR14PuNPQmt5Dr54M1zD2-inex2dw5pikqXAE_K7ZtWHgZpEN9z_4vy2vHU
MA5	Hammon, K. (2022, April 24). Local News | Jack's Solar Garden south of Longmont grows interest in "agrivoltaics." *University Wire; Carlsbad*. https://ezproxy.library.arizona.edu/login?url=https://www.proquest.com/wire-feeds/local-news-jack-s-solar-garden-south-longmont/docview/2653878904/se-2?accountid=8360
MA6	Kominek, B. (2024, January 12). Opinion: Colorado needs to double down on its commitment to land stewardship in solar arrays. *The Colorado Sun*. https://coloradosun.com/2024/01/12/opinion-colorado-agrivoltaics-investment-clean-energy/
MA7	Kominek, B. (2024, June 7). Guest opinion: Byron Kominek: With new bill, Colorado has a chance to lead on agrivoltaics [News]. *Boulder Daily Camera*. https://www.dailycamera.com/2024/06/07/guest-opinion-byron-kominek-with-new-bill-colorado-has-a-chance-to-lead-on-agrivoltaics/
MA8	Krumrey, Y. (2020, September). How Jack's Solar Garden Hopes To Transform Farming—For Good. *5280*. https://www.5280.com/how-jacks-solar-garden-hopes-to-transform-farming-for-good/

MA9	Krumrey, Y. (2020, September). How Jack's Solar Garden Hopes To Transform Farming—For Good. *5280*. https://www.5280.com/how-jacks-solar-garden-hopes-to-transform-farming-for-good/
MA10	Solar*Rewards Community. (n.d.). *XcelEnergy*. https://co.my.xcelenergy.com/s/renewable/solar-rewards-community
MA11	Governor Polis Announces Funding for Agrivoltaics Grants to Help Colorado's Agriculture Industry Benefit from Solar Technology. (2023, December 19). *Colorado Governor Jared Polis*. https://www.colorado.gov/governor/news/11216-governor-polis-announces-funding-agrivoltaics-grants-help-colorados-agriculture-industry#:~:text=DENVER%20%E2%80%94%20Today,%20at%20CSU-Spur%20Governor%20Polis%20and%20Colorado%20Department
MA12	Santos, B. (2023, February 20). Impact of single-axis agrivoltaics systems on non-irrigated grassland. *Pv Magazine*. https://www.pv-magazine.com/2023/02/20/effects-of-single-axis-agrivoltaics-systems-on-non-irrigated-grassland/#:~:text=Overall%2C%20the%20present%20design%20leads%20to%209%25%20less,the%20slightly%20lower%20crop%20production%2C%20according%20to%20Sturchio.
MA13	Henderson, C. (n.d.). *Climate Week En Review: April 15, 2022* (No. 10) [Broadcast]. https://republicen.org/blog/climate-week-en-review-april-15-2022
MA14	Peterson, S. (n.d.). *Growing Crops Among the Solar Panels in Colorado* (No. 1) [Broadcast]. https://www.agrisolarclearinghouse.org/the-agrisolar-serial-podcast-episode-1-digging-into-agrisolar-with-sprout-city-farms-at-jacks-solar-garden/
MA15	Siegler, K. (2021, November 14). This Colorado "solar garden" is literally a farm under solar panels [News]. *NPR*. https://www.npr.org/2021/11/14/1054942590/solar-energy-colorado-garden-farm-land
MA16	Stevens, harry. (2023, May 10). We need an area the size of Texas for wind an solar. Here's how to halve it. [News]. *The Washington Post*. https://www.washingtonpost.com/climate-environment/interactive/2023/renewable-energy-land-use-wind-solar/#:~:text=Business%20as%20usual%20would%20require%20266,410%20square%20miles%20%E2%80%94%20an
MA17	Wagner, J. (2024, May 22). Sprout City Farms farms with Jack's Solar Garden [News]. *Left Hand Valley Courier*.

	https://www.lhvc.com/story/2024/05/22/news/sprout-city-farms-farms-with-jacks-solar-garden/9200.html#:~:text=Liza%20McConnell%20growing%20lettuce%20at%20Sprout%20City%20Farms.%20For%20Liza garden/9200.html#:~:text=Liza%20McConnell%20growing%20lettuce%20at%20Sprout%20City%20Farms.%20For%20Liza.
MA18	*Colorado Renewable Energy Society (Director). (2019, September 11). Bringing Community Solar to Boulder County & Colorado | Jack's Solar Garden, Xcel Energy & NREL [Meeting Recording].* *https://www.youtube.com/watch?v=SG6_pxk3HHs*
MA19	*Stroud, K. (2023, May 24). Gov. Polis visits Jack's Solar Farm [News]. Left Hand Valley Courier. https://www.lhvc.com/story/2023/05/24/news/gov-polis-visits-jacks-solar-farm/8004.html#:~:text=On%20Thursday,%20May%2018,%20Governor%20Jared%20Polis%20signed%20climate%20legislation*

Appendix E: Codebook, Definitions, and Sample Codes

Code	Definition	Sample Code	Occurrences
Genesis	the initial circumstances, motivations, and connections that led to the development of Jack's Solar Garden.	"Yeah, the Colorado had the color, uh, community solar garden legislation go about back in 2010. And so the utilities had to figure out or come up with a plan to allow folks like me to own and operate a solar array, putting power back into the community"	82
Operation	Code that relates to the ongoing operation and maintenance of Jack's Solar Garden.	"so this is where that's a bigger topic overall, which is sort of, it's a question about business models. And I think that it also relates to other nearby, for-profit Farmers looked at it and said, I don't think I could necessarily make as much money, or it might be hard to make it financially viable for farming on its own"	46
Outcome	The findings, projects, and other initiatives that have resulted from Jack's Solar Garden.	"I think getting all partners that are involved on the same page with signed agreements and in a good space together before you start work, it's going to be really essential"	74
Outlook	The planned future projects or thoughts on the future operation of Jack's Solar Garden.	"Um, if you put the panels up high enough, you can have cows out there. I mean that, I think that's the holy grail for voltaics moving forward"	16
Landowner	Discussions relating to owning the land of Jack's Solar Garden.	"I feel like he kind of just seems like the typical Colorado farmer to me, just really busy, really focused on his projects. I feel like because his projects and our projects are very separate, it does seem like it would be hard to really coordinate stuff with him"	49

Nonprofit	Discussions relating to the nonprofit organizations working with Jack's Solar Garden.	"We as a nonprofit got started in the Denver metro area, farming underutilized urban land, so places like school schoolyards and public parks and things of that nature. And because there's a few reasons why Jack Solar Garden fits into our mission, and the first one is because the land under solar panels is typically also underutilized"	150
Policymaker	Discussions of how policymakers have interacted with Jack's Solar Garden.	"this is amazing. I appreciate what you're doing on seven acres, but I need to figure out how to do it on 120 acres and do it a thousand times over. So that's the challenge for us is trying to make this transition and learning again, and I don't know that there are still policy considerations that have to be taken into account, but there might be"	28
Researcher	Discussions of how researchers have interacted as stakeholders at Jack's Solar Garden.	"We've been wanting to do a period of analysis of how well it works. I said, we will write grants to the National Science Foundation. We wrote four different grants, and finally we did get one from the geography and spatial system, which it was comparing basically, if this stuff works in Arizona, could it work in Colorado if you just change those? It wasn't even the policy or the economics or anything like that. It was just the environmental aspects of working in a cooler, less dry environment. And so once we could show him that we could have the resources to do the science"	90
Agriculture	Code relating to agricultural labor, operations, and production at Jack's Solar Garden.	"2021 was our first season of production, but because of construction delays with the retention pond for the irrigation system and a host of other things with construction projects, we had a partial season. We finally	90

		got water and we're able to get planted in late June, early July in 2021. So we saw a partial season last year”	
Communication	Mentions of how stakeholders exchange information.	“But this year we really wanted to buckle down on our partnership with the research team at University of Arizona because running a research farm is really different than running a farm”	61
Economy	Discussions of financial topics related to agrivoltaics.	“to be able to sell our electricity at a premium and, and get people on with what we were doing. Uh, we incorporated a lot of different partnerships into making our site more interesting. Uh, not not just for myself, <laugh>, and for our researchers, but hopefully for the community at large”	54
Education	Mentions of the educational services provided by stakeholders at Jack’s Solar Garden.	“we created the Colorado Agrivoltaic Learning Center that provides tours to folks on a weekly basis, uh, throughout the growing season. And then if people want special tours, they can sign up for those”	55
Barrier	Discussions of technical, economic, social, or legal barriers to the initial operation of Jack’s Solar Garden or one if its programs. In contrast to the challenges, barriers prevent something from happening	“no one county looks just like the one next to it, and it's pretty tough to kind of understand what all these different requirements are. And so, and also a lot of them aren't super agrivoltaic, um, friendly in those lane. Not, not necessarily by intent, but just, uh, a lot of the time these policies or these local policies aren't, uh, ready to go. And so we're also making model land use code, which we're in the process of doing now”	9
Benefit	Opposite of a challenge, describes something that enabled a project to work	“The one thing that was amazing was the shade that I had throughout the day, but at first it was like, this just seems like it's making it more difficult for farmers, at least on the	26

	better than it otherwise would have.	six foot side versus the eight foot side. But throughout it, I saw I was able to plant, again, radishes in the middle of the summer”	
Challenge	Code that relates to technical, economic, social, or legal challenges that hinder the effective operation of JSG or a project at JSG. This is different from the barrier code as the challenge does not prevent something from occuring.	“Byron also acknowledges challenges, including getting companies and lawyers on board with bringing agriculture to solar sites and finding people who want to be in agribusiness”	52
Opportunity	Opposite of barrier, this code describes a circumstance enabling the development of Jack’s Solar Garden.	“Like it creates opportunities to grow certain things more of the year, but it also creates challenges because other things are not as productive or take a lot longer to grow”	4

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