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Perspective

Solar energy development on farmland: Three prevalent perspectives of conflict, synergy and compromise in the United States

Zachary A. Goldberg

Department of Geography, Pennsylvania State University, 302 Walker Building, University Park, PA 16802, USA

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A B S T R A C T

As farmland has become a key place for grid-scale, ground-mounted solar energy development, there needs to be more analysis to explore what energy transitions mean for the future of agriculture. This article uses the food–energy–water (FEW) nexus framework to delineate three different perspectives of solar energy development on farmland. The first two perspectives fit into the FEW nexus language of "trade-offs" and "synergies" respectively, arguing that solar energy development either conflicts with agricultural land use and food security or, alternatively, that the two land uses can be co-located appropriately to create agrivoltaic systems. The third perspective is a compromise, arguing that solar energy - neither a complete trade-off to nor completely synergetic with continued agriculture - preserves farmland for future agricultural use. By analyzing these perspectives together, we further understand implications of solar energy development. While each of these perspectives is important, agrivoltaics has the greatest potential to play a positive role across both energy and agricultural transitions. Nonetheless, there are several key barriers to agrivoltaic development, including the need for sufficient access to water, local knowledge and appropriate agricultural resources, and sustained interest from solar energy developers. The development of agrivoltaics, and solar energy in general, should raise important political questions of land access and resource use.

1. Introduction

The transition to renewable energy is an unprecedented challenge that goes beyond a technical problem, requiring solutions from multiple societal perspectives to address the climate crisis [1–3]. These transitions are increasingly consequential for land use considerations [4–6,7] and, in particular, their impact on agricultural landscapes and rural communities [8–10]. Farmland is considered by developers to be ideally suited for utility- or grid-scale solar energy development [11]. While wind energy can more easily be deployed as "dual-use" with agricultural production, it is far more challenging to achieve this co-location for solar. Therefore, solar energy development problematizes the continuity of agricultural land use [12]. Moreover, this rural energy transition intersects with changing agricultural markets and practices [13,14]. At this intersection, solar energy development is increasingly becoming a factor in decision making over the uses of agricultural lands, often being considered just another "crop."

While there are ongoing attempts to develop grid-scale solar energy on sites previously developed for industrial uses, such as turning "brownfields" into "brightfields" [15], farmland will still likely be a primary target for solar expansion. The reasons for this are manyfold, and reflect why farmland has become the ideal site for any development that requires large footprints such as warehouses or housing subdivisions [16]. Similar to requirements for crop production, farmland provides the solar photovoltaics modules flat land with the necessary sunlight to produce electricity. In addition, farmland has already been cleared of "nuisances" from rocks to wetlands, forests, and endangered species, which would cause possible regulatory intervention from departments of natural resources and environmental protection. Further, farmland lacks the cumbersome infrastructure, hazards, or other design obstacles that may be present at industrial sites. For example, a landfill would have unstable soils and geological features that might deter development. For these reasons, farmland presents itself as a "blank slate" for developers of all sorts; however, this does not come without controversy particularly for solar energy, which is widely contested in rural spaces.

In this paper, I present and examine three perspectives of solar energy development on farmland that frame the compatibility of energy and agricultural systems differently. Articulating perspectives of resource systems allows us to not only better understand the debates and

E-mail address: zag5022@psu.edu.

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contestations of resource development, but also advocate for better policy and land use outcomes [9,17–19]. The first perspective is that solar energy competes or *conflicts* with agriculture by essentially replacing it with a non-agricultural use. Secondly, on the contrary, others argue that solar energy development can *synergize* or be co-located with agriculture through the concept of agrivoltaics, a type of dual-use of land that co-locates solar energy production and agricultural activities; however, there are many policy and infrastructure gaps that need to be resolved for successful implementation of this concept. The third perspective asserts that solar energy development can be a *compromise*. Advocates of this perspective argue that solar energy development can support farmland preservation by making payments to active farmers and through decommissioning plans that enable it to return to agricultural use once the solar energy infrastructure is removed.

In order to understand solar energy development, this paper grounds its analysis, especially the first two perspectives in the FEW (food-energy-water) nexus. The FEW nexus describes the socio-ecological interlinkages between resource sectors and the need for integrated research and policy agendas [20]. While integrated resource management and holistic approaches to environmental governance have long lineages in both theory and practice, the FEW nexus is a recent iteration that has emerged as a popular conceptual framework across many disciplines that works against siloed ways of thinking to create new ways of planning for resilient communities and regions [21–23]. For example, energy and agricultural policy have historically been separate domains for governance; localities have created climate plans aiming for carbon neutrality, while simultaneously passing policies that hinder renewable energy development [24]. This article could have elected to use more classic environmental discourses of degradation, conservation, and preservation [25]. However, the FEW nexus framing is commonly used in the context of solar energy and is productive in its particular use of the terms “trade-offs” and “synergies,” which can then be applied to land use decision making with different resource systems (see Moore-O’Leary et al.’s [26] similar use of language with the “land-energy-ecology nexus“framing). While the FEW nexus concept has been criticized for being too top-down and focused on the Global South, this article works to address this by incorporating more social perspectives and applying the framing to cases primarily in the Global North [27].

The construction of the perspectives in this article comes from research conducted on solar energy development on farmland in the mid-Atlantic US, and includes information from four relevant webinar series: Penn State Extension, American Farmland Trust’s Smart Solar Siting in New England Webinar Series, the American Solar Grazing Association’s (ASGA) Solar Grazing Monthly Webinars, and Cornell’s Planning with Agrivoltaics in Mind. Since this work was geographically grounded in the mid-Atlantic, it does not intend to offer a complete or holistic framework for all solar energy development on farmland. However, the framework outlined herein can be applicable throughout both the US and in different agrarian settings globally that are navigating the tensions of solar energy development, especially places with private land tenure regimes. After providing descriptions and applications of these three perspectives and example policies that have resulted from them, I will focus the discussion and conclusion on current challenges and future possibilities for agrivoltaics, which should be the focus for policy-making in the near term. While I argue that agrivoltaics is the most promising of the three perspectives, solar energy development will need to address issues of land access and tenure for farmers in order to fully synergize just and sustainable energy and food transitions [28].

2. The three prevailing perspectives of solar energy development on farmland

2.1. Trade-offs, competition, and land use conflicts

A common narrative among skeptics of rural solar energy development is that it displaces farmland and threatens food security [11,29–34]. Unlike rural opposition to wind energy development, which has often focused on visual and wildlife concerns in the US [35,36], many critics of solar energy development have emphasized conflicts with agricultural land use [37], including in the global context of rangelands for pastoralists in Morocco and India [38–40]. As noted in the introduction, it is important to reiterate that solar energy development’s focus on farmland is partially because this spares development of land that is important to biodiversity [41,42], as industrial farmland is already ecologically compromised [42,43]. Nonetheless, agricultural land preservation advocates posit that solar energy development should focus *also* on sparing farmland, particularly land that has been designated as “prime” [29,44–46] – a label often based on the soil classification and other characteristics for land considered most important for agriculture. These advocates advance the idea that grid-scale solar energy should be placed on already developed sites, such as parking lots, building structures, saline soils (or degraded farmland), brownfields, and reservoirs [47].

The competing land use perspective has had major influence on US state legislators and local zoning officials [48]. For example, Pennsylvania State Senator Gene Yaw stated that solar energy development is “basically putting a factory on top of the land” [49]. For these reasons, politicians from many states have frequently put farmland preservation goals at odds with solar energy development. In one example, Kathleen Hochul, Governor of New York, had to veto a bill that “prohibits development of build-ready sites on viable agricultural land” [50], while signing another bill that requires funding related to renewable energy to also be allocated to farmland protection programs [51]. However, there have been different types of “solar bans” on farmland throughout the country at different levels of government. For example, the Oregon Land Conservation and Development Commission restricts solar energy projects on the Class 1 and 2 soils [52], while Montgomery County in Maryland restricts community solar energy development in its agricultural zone, which comprises most of its developable land in the county [24]. In an analysis of seven different US states, Grout and Ifft [48] found that all seven imposed a tax penalty for developing large-scale solar energy on farmland, as this development was found to conflict with the goals of the state farmland agricultural preservation programs. The authors note a myriad of other ways that states deter solar energy development on farmland and incentivize alternative sites for development. At the local level, many zoning ordinances also define solar energy sites as “facilities” or “systems,” as opposed to the more colloquial term “farm,” to clarify their belief that solar energy is not a form of farming (see also Jefferson [53] or Owley and Morris [32]).

Siting of solar energy infrastructure at the very least problematizes previous agricultural land uses, especially mechanized crop cultivation, so there have been attempts to quantify trade-offs. In one German study, researchers found that solar energy development on farmland reduced crop yields by 40 % [54]. Given that electricity generation has higher financial returns than most agricultural commodities, the decision to maintain some farming operations - let alone sacrifice solar energy production through more spacing between solar panels to allow increased agricultural production - would require substantial policy or other social intervention.

2.2. Synergies, co-location, and agrivoltaics

As solar energy development has focused on farmland, the concept of agrivoltaics has transformed, in the last decade, from a nascent idea into a federally-funded research imperative [45,55–59]. While not necessarily located on farmland [60], agrivoltaics is the simultaneous use of land for solar energy production and agricultural activities, including crop production, grazing, or habitat for agriculturally beneficial insects (e.g., pollinators). The concept is rooted in older ideas of agroforestry, which integrates trees with crops or pasture that do not require full sun exposure; in the case of agrivoltaics, the solar arrays replace the trees as the "overstory" [56,61]. The earliest demonstrations of agrivoltaics were built in Germany and Japan in 2004, but others have since been built in Massachusetts in 2008, Italy in 2011, Malaysia in 2015, Egypt in 2016, and Chile in 2017 [62]. Beyond commercial demonstrations, researchers have observed workers at solar energy facilities cultivating plots of vegetables (Fig. 1). Agrivoltaics has even been nationally broadcasted during a long-form television commercial, titled "A Future Begins," that depicts a young, college-educated farmer who "saves" a family farm from being sold in part through solar sheep grazing (Fig. 2). An annual international conference devoted to agrivoltaics has been hosted in Piacenza, Italy (2021) and Daegu, Korea (2022). There has also been substantial grant-support extended from the US Department of Energy's Solar Energy Technologies Office and the Department of Agriculture's National Institute of Food and Agriculture. This type of funding has made research-related agrivoltaic systems in the US possible, and has supported the National Center for Appropriate Technology's Agrisolar Clearinghouse – an online database for agrivoltaic-related information.

While policies at the state level generally deter solar energy development on agricultural lands through tax penalties [48], there is some interest in incentivizing agrivoltaics in the US at the state and local level [63]. One prominent example is in Massachusetts, where the state offers incentives for agrivoltaic development through its Solar Massachusetts Renewable Target (SMART) program [64]. The SMART program provides an additional \$0.0600 kWh − 1 for qualified Agricultural Solar Tariff Generation Units, requiring solar arrays to be significantly modified to accommodate agricultural uses and placed on land officially recognized for agricultural use or as "prime" farmland [62]. Similarly, Hawaii is actively negotiating where and how solar energy development should take place [65]. Currently, Chapter 205 (Section 4.5a: 21) of Hawaii Revised Statutes require energy developers to acquire a special-use permit in order to develop on Class B or C agricultural lands and stipulates that they also make land "available for compatible agricultural activities at a lease rate that is at least fifty per cent below the fair market rent for comparable properties." However, it is too early to evaluate the efficacy of these policies in support agrivoltaics.

While crop cultivation underneath solar panels is generally limited to research and experimental projects in the US, agrivoltaics have been adopted for commercial use in the forms of (1) planting and maintaining habitat for pollinators and other beneficial insects and (2) grazing sheep at solar energy sites [66]. Certain solar energy development firms regularly incorporate vegetation plans to support habitat for beneficial insects and pollinators, providing an important ecosystem service [67,68]. States have supported this by developing programs that involve scorecards to assess whether a solar energy project could qualify for a pollinator-friendly designation [69]. There is also increasing interest from solar energy developers in vegetation management for sites that incorporates sheep grazing. This management strategy stems from the existing practice of targeted grazing, which involves contracting out vegetation services to a shepherd(ess) who is responsible for managing animals (i.e. sheep) to control for plant height, unwanted plants, and potential fire risks. In the case of solar energy sites, vegetation needs to be maintained so low that sheep are commonly moved onto a single site in the spring where they remain until the fall for more frequent grazing. Knowledge about grazing solar energy sites has become so specialized, such that the American Solar Grazing Association (ASGA) has become an active space for generating and sharing the know-how of solar grazing (i.e. animal behavior around panels, contracts with solar energy developers, and figuring out appropriate insurance). Nonetheless, the co-location and integration of different uses of land is inherently complicated and often requires planning from the earliest stages of development. Moreover, solar energy developers commonly promote agriculturally related benefits (i.e. "farmland preservation") without actually practicing agriculture or even incorporating ecologically-focused vegetation management.

2.3. Solar energy development as a land preservation tool

The third and final perspective posits that solar energy development preserves farmland by providing farmers with income that can support agricultural operations while also improving agricultural soils. This perspective, in a way, is a compromise that recognizes and responds to conflicts between solar energy development and farmland preservation goals, while also recognizing the critiques or limits to commercial implementation of agrivoltaics discussed throughout this paper. In other words, if agrivoltaics is not viable, then at least solar energy development is not fully compromising agricultural land. In fact, it may promote long-term synergies with agricultural benefits, especially in regions with already declining agricultural production. Rather than developing land for the "last crop" [70], which would be housing or a warehouse [71], proponents of solar energy development argue that installations may lead to improved farmland through regenerating soil health, since industrial agricultural production is paused during solar energy generation. In this way, solar energy is sometimes described as a 25- to 30-year "cover crop" [72,73]. A related idea is that lease payments to land owners from solar energy is just another way to "farm the sun" or "keep the family farm" [74–77]. These arguments are especially popular among solar energy developers in garnering acceptance in rural communities.

This perspective has been adopted by government institutions, solar

Fig. 1. A photo taken by Sujith Ravi of eggplant and pepper crops growing in between solar arrays in the Kutch district, in Gujarat, India.

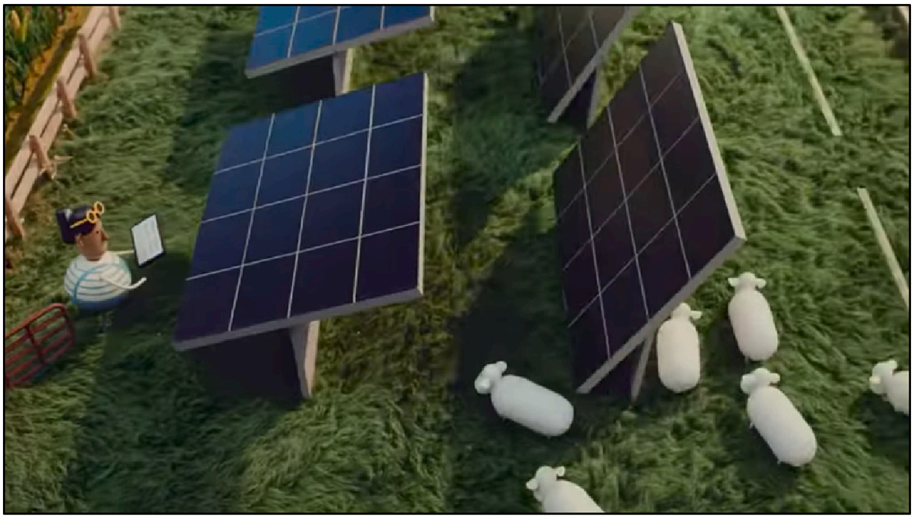

Fig. 2. A screenshot from "A Future Begins," a Chipotle commercial that includes a scene with a college-educated young farmer observing their solar grazing operation. (https://www.youtube.com/watch?v=HnwzRmqbWwE).

energy advocacy organizations, and farmland preservation organizations. For example, Rhode Island Department of Administration's Office of Energy Resources (OER) and Division of Statewide Planning (2019) have recommended that:

> Communities can support the economic viability of farms through allowing appropriate renewable energy development as a complementary use in a manner which keeps farms in agricultural production while preserving agricultural soils [78].

Another example of this is the American Land Trust's second "Smart Solar" principle:

> Safeguard the Ability for Land to Be Used for Agriculture: If solar energy is developed on farmland or ranchland, policies and practices should protect soil health, especially during construction and decommissioning, to ensure opportunities for farming in the future [79].

These examples of best practices are designed to ensure land can return to agricultural use (see also Byrne et al. [80]). As there is only a small but growing body of research on the impacts of solar energy development on farmland, it is unclear how development will ultimately affect soil health and future farm viability [26,81]. Moreover, even if this land could feasibly return to agricultural use after a solar lease, this does not consider the institutional, economic, and sociocultural interests that would seek to keep it for energy or other uses [82].

3. Toward more effective agrivoltaics policy

While I present these perspectives as distinct and distinguishable (Table 1), more often, statements associated with these perspectives are overlapping, muddled, or more nuanced. However, by delineating these three perspectives, we can better understand and interpret forms of solar energy policy, activism, and development. The first two perspectives have legacies in FEW nexus discourses [83], particularly in regard to land use debates. The competing land use perspective is a classic "trade-off" that relates to competing goals of food and energy security, while the agrivoltaics concept represents a possible technocratic fix that relies on the possibility of realized "synergies." It is important to note that the FEW nexus cannot adequately frame this debate entirely. The third perspective of farmland preservation suggests that the first two perspectives do not reflect the realities on the ground, and aims to appease advocates of farmland preservation by conveying that solar energy provides viable income for farmers while also potentially improving their land for future agricultural use. This third perspective highlights the limitations of the FEW nexus, which struggles to take into account "lived experienced realities" [84].

The FEW nexus analysis still maintains relevance in this discussion due to the importance of water resources in solar energy development. Solar energy panels can increase water resource efficiencies for crops [57,85] and animals through providing shade and shelter. In agrivoltaic operations, adequate water is necessary to ensure good crop growth and to provide drinking water for animals. In addition, solar energy development also highlights the FEW nexus critique of the separation of agriculture and energy in planning, governance, and research, although examples in the section above demonstrate some counter examples. While FEW nexus often focuses on idealized synergies often assuming agricultural and energy development are homogeneous and free from political economic influence, this discussion offers a more critical look with trade-offs or potential conflicts in mind, especially beyond the simplistic notion of risks to food security.

In farming communities that prioritize industrial commodity production, such as corn for ethanol production, it is not evident that there are any direct trade-offs to local food security that inherently accompany solar energy development on farmland [86,87]. Nonetheless, there are reasons to believe that there are significant trade-offs between solar energy development and certain farmland preservation goals, especially those that relate to cultural or aesthetic values (Ross, *Forthcoming*).

Table 1
Summary of the three prevailing perspectives of solar energy development on farmland.

	Perspective 1	Perspective 2	Perspective 3
Key words	Trade-offs, competition, and land use conflicts	Synergies, co-location, and agrivoltaics	Agriculture or farmland preservation
Example statements	Prioritize putting solar panels on roof tops or landfills; avoid placing solar on "prime" farmland; solar energy threatens our food security.	Solar energy can be co-located with agriculture; solar panels can provide a micro-climate for more efficient crop production; solar panels create ideal habitats for grazing sheep.	Solar energy provides farmers with income to maintain agricultural production; solar energy is a long-term cover crop that restores soil health.

While increased income from solar energy leases might be invested into agricultural activities, it is just as possible that income is used for household consumption rather than the farm economy or agricultural production [88]. Moreover, solar energy development alone does little to preserve agriculture beyond preventing certain plots of land from being developed into housing or more intense industrial uses, while it might make land even less accessible to farmers who are looking for land to lease [89,90]. Further transmission buildout could also encourage future rural industrial development at the expense of farmland. Even with the implementation of agrivoltaics, there can still be land use conflicts with previous agricultural and land use regimes [91]. Solar energy development as de facto farmland preservation is a tenuous argument at best due to many potential pitfalls and unknowns; therefore, it is important to maintain agricultural activities that promote the local economy and sustainable land use practices.

However, there are real barriers to widespread implementation of agrivoltaics, including the need for sufficient water resources, the presence of local agricultural knowledge and values, and the question of solar energy developer commitment [92]. First, in keeping with the FEW nexus, water resources are a key factor in agrivoltaics in several different ways. For water scarce regions, solar energy development supports agricultural practices by offering a microclimate with partial shading which allows for more effective irrigation [57,85]. In water rich regions, it is also critical to have sufficient on-farm water infrastructure (i.e. wells) for successful co-location of agriculture and energy production, especially in the case of solar grazing, as sheep require reliable, high-quality drinking water. However, the FEW nexus is an inadequate analytic to fully understand challenges, or "lived realities," of implementing agrivoltaics [84].

Second, the implementation of agrivoltaics requires local knowledge and perhaps local acceptance of certain agricultural practices that may be unfamiliar [10,46,93,94]. In the example of grazing solar energy sites, implementation requires both farmers with knowledge of grazing practices and sufficient sheep populations. While sheep agriculture was economically important in the US a century ago, today it accounts for only "1 percent of U.S. livestock industry receipts" [95]; therefore, the US government's support of sheep agriculture typically lags behind other countries' regulatory authorities, including in the approval of new antiparasitic drugs and treatments [96]. Local planners, agricultural extension specialists, and others might believe that agrivoltaics should look like farming that existed before solar energy development. For these reasons, critics point out that grazing solar energy sites might not be a true dual-use of land, because sheep grazing is not primarily for wool or meat production but just as a means to manage grass for energy production. Responding in part to these critiques, there is increasing agrivoltaic research that integrates more common agricultural practices in the US, such as hay, cattle, and horticultural production, so that agrivoltaics aligns more with existing, local agricultural practices.

Finally, developer interest and upfront incentive in agrivoltaics are critical for any implementation, as many developers are hesitant to take on any additional financial burdens, management complications, or other risks in solar energy development [92]. For successful implementation, solar energy developers need to invest early in site design. For grazing, sites require water infrastructure, vegetation plans, and coordination to ensure adequate animal populations. For crop cultivation or cattle, there are added challenges of increasing panel spacing and height to accommodate for larger animals and machinery, as raising panels requires considerably more material, labor, and equipment-related costs. As one grazier commented during an ASGA webinar, whereas "[there is] plenty of room on a wind farm for cattle," there are clear synergies between sheep and solar panels, while cows can be placed around wind turbines without any modification. For long-term success for agrivoltaics, more significant investment in infrastructure might be required to support new localized agricultural economies based on crops or animals that work well with solar infrastructure. For example, the size and grazing behavior of sheep allow them to be integrated relatively easily into a solar field, but for sheep to be more meaningfully a part of a local food and fiber economy, there needs to be investment into community and regionally scaled capacity for animal slaughter and shearing of wool. It is unclear how much long-term commitment solar energy developers have to make this agrivoltaic vision happen, although there might be substantial benefits in improving community relations that would potentially reduce future development costs [97].

Policy support is needed to manage these barriers to the further implementation of agrivoltaics [54]. While this paper highlights examples of policy, including both agricultural policies that inhibit solar energy and energy policies that promote co-location, the lack of regulatory or zoning coordination for agrivoltaics is a concerning gap [98]. In order to promote agrivoltaics, local governments can enact zoning, financial incentives, and legal resources to reduce costs for meaningful agrivoltaic development. In addition, farmland preservation programs can be modified to include agrivoltaics or dual-use in locally appropriate ways. At the federal and state levels, the US Department of Agriculture and state departments of agriculture can offer more clear guidance on the recognition of agrivoltaics so that farmers working at solar facilities can fully utilize their programs. If solar energy developers are unwilling to invest in the physical and social infrastructure required for agrivoltaics, there can be public or alternative-private investment into agrivoltaics. The Inflation Reduction Act can support agrivoltaics by allowing non-profit and public-owned developments to accrue previously granted tax benefits instead as a direct payment. Therefore, it is now more possible for solar energy to be developed for public and mission-driven purposes, rather for profit and financial reasons [99].

4. Conclusions and future directions for more just agrivoltaics

Solar energy development holds potential for community benefits to farmers and farmland, and the classification of these three perspectives helps identify potential pathways toward such transitions. Solar energy development is already having and likely to have increasing impact on rural agricultural communities. It could exacerbate ongoing trends related to rural industrialization, such as increasing land investment and rents, along with the importance of amenity services. This might even include limited and problematic forms of integration with agriculture, such as inclusion of plant habitat that attract beneficial insects during initial construction or using the solar site as spray field for confined animal feeding operations [100]. Ultimately, all three of these perspectives are incomplete. For land use conflicts, solar energy development does seem to compete with previous agricultural land uses; however, much of this production, especially dairy, has been already in decline in many places [101]. Solar energy is just one of many potential alternative land uses for farmland, and may be a preferable alternative to warehouses or housing [71]. In the case of the eastern US regions less proximate to urban centers, solar energy development is not necessarily replacing land particularly important for food security. Still, the perspective that solar energy development supports farmland preservation should be considered with caution, given the inability to accurately predict the ecological, social, and economic conditions decades into the future. It is entirely unknown what the political economic conditions will be in the many decades ahead during end of lease periods to make this claim. Moreover, investment in rural electricity transmission could lead to future industrial production, further threatening the rural agrarian landscape.

The agrivoltaics perspective is also incomplete, in part because there are a current lack of incentives to motivate solar energy developers to prioritize agrivoltaics. There likely will be more success for agrivoltaics in places that are severely impacted by land and water constraints [102,103]. For example, agrivoltaics seem highly applicable in places that are arid, highly constrained by land area, and also dependent on energy imports. While this scenario could be interpreted as a "win-win" solution in the FEW nexus framework, there is still a need to consider the lived realities of the local social and political context. For places that have more water and land resources, the possibility of agrivoltaics is more obviously dependent on social acceptance and policy support, as well as local knowledge of compatible agricultural practices. Organizations such as ASGA have helped build this type of specialized knowledge, particularly for sheep grazing to be meaningfully integrated with solar energy development.

Future discussion of this topic would benefit from the lenses of agroecology and food sovereignty, which have long prioritized social and political dimensions [104,105]. Policy to support the sustainable and just development of solar energy on agricultural land, particularly agrivoltaics, should work to ensure fairness in land use and ecological land stewardship. This will require commitments by the solar energy industry not to participate in harmful practices of land grabbing or, in the case of agrivoltaics, "green grabbing," which consolidates landholdings into larger corporate or investor-driven portfolios [91]. Renewable energy development, both wind and solar, already has a violent record of land dispossession around the world [39,40,106–113]. In addition, farming practiced underneath solar panels should be managed ecologically rather than industrially-intensive, striving to be decoupled from petroleum and energy-intensive industries which produce agrochemicals. Agrivoltaics also needs to strive toward increasing land access [114] and, more ambitiously, providing pathways to land tenure for farmers interested in local food production, especially those of marginalized identities. In this way, agrivoltaics can bring together two long separated sectors of agrifood and energy systems, and work toward a sustainable energy transition that supports a sustainable and just agrarian future.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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