

ROLES AND USES OF WATER IN SUSTAINABLE FOOD SYSTEMS: A CASE STUDY OF UNIVERSITY FARMS IN CALIFORNIA

RÔLES ET USAGES DE L'EAU DANS LES SYSTÈMES ALIMENTAIRES DURABLES : ÉTUDE DE CAS DES FERMES UNIVERSITAIRES EN CALIFORNIE

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ABSTRACT

This study investigates the role of water within sustainable food systems, by analyzing two university-based agroecological farms in California: the University of California Santa Cruz (UCSC) and the University of California Davis (UCD). Grounded in the broader context of food system transformation and the emergence of agroecology as both a scientific and a social movement, it addresses a key gap in the literature—the integration of water use and management into agroecological assessments. To address this gap, a mixed-methods design integrating qualitative and quantitative approaches was applied to these two case studies selected for their historical significance and institutional engagement with sustainability. This work first provides a descriptive overview of the selected food systems, highlighting their key structural and functional characteristics.

We then report the assessed level of agroecological integration within each system, based on the defined evaluation criteria. Finally, we examine patterns of water use in the studied agricultural contexts. Field observations, semi-structured interviews, and irrigation assessments enabled a comprehensive analysis of food system structures, agroecological practices, and water management across production, distribution, and consumption processes. With regards to the agroecological assessment of each farm, the results reveal that both farms operate localized, community-oriented food systems with a comparable degree agroecological advancement. At both sites, water use at the production level represents the dominant share of total water consumption when analyzing the whole food system. In these farms, water conservation is indirectly supported by agroecological practices such as mulching and crop selection.

There were many agroecological activities that did not explicitly targeting water preservation but nevertheless had positive secondary effects on water use. On the other hand, direct irrigation management remains underdeveloped. In conclusion, the studied university farms demonstrated strong potential as living laboratories for sustainable agriculture. With regards to irrigation, enhancing record-keeping and quantitative measurements as well as system upgrades will be essential next steps to improve water-use in this systems.

Keywords: Sustainable food systems; agroecological integration; agroecological practices; qualitative and quantitative approaches; Water use.

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RESUME

Cette étude examine le rôle joué par l'eau au sein des systèmes alimentaires durables, en analysant deux fermes agroécologiques universitaires en Californie : celles de l'Université de Californie à Santa Cruz (UCSC) et de l'Université de Californie à Davis (UCD). S'inscrivant dans le contexte plus large de la transformation des systèmes alimentaires et de l'émergence de l'agroécologie en tant que mouvement à la fois scientifique et social, elle comble une lacune majeure dans la littérature : l'intégration de l'usage et de la gestion de l'eau dans les évaluations agroécologiques. Afin d'aborder cet écart, une méthodologie mixte intégrant des approches qualitatives et quantitatives a été appliquée à ces deux études de cas, retenues pour leur importance historique et leur engagement institutionnel en faveur de la durabilité. Ce travail présente tout d'abord une vue d'ensemble descriptive des systèmes alimentaires retenus, en mettant en évidence leurs principales caractéristiques structurelles et fonctionnelles.

Nous rendons ensuite compte du niveau d'intégration agroécologique évalué au sein de chaque système, sur la base des critères d'évaluation définis. Enfin, nous examinons les tendances d'utilisation de l'eau dans les contextes agricoles étudiés. Des observations sur le terrain, des entretiens semi-structurés et des évaluations des systèmes d'irrigation ont permis une analyse approfondie des structures des systèmes alimentaires, des pratiques agroécologiques et de la gestion de l'eau tout au long des processus de production, de distribution et de consommation. Du point de vue de l'évaluation agroécologique de chaque exploitation, les résultats révèlent que les deux exploitations fonctionnent comme des systèmes alimentaires localisés et axés sur la communauté, présentant un niveau comparable d'avancement agroécologique. Sur les deux sites, l'utilisation de l'eau au niveau de la production représente la part prédominante de la consommation totale d'eau lorsque l'on analyse l'ensemble du système alimentaire. Dans ces fermes, la conservation de l'eau est indirectement favorisée par des pratiques agroécologiques telles que le paillage et la sélection des cultures.

De nombreuses activités agroécologiques, bien qu'elles ne visent pas explicitement la préservation de l'eau, ont néanmoins exercé des effets secondaires positifs sur l'utilisation de l'eau. En revanche, la gestion directe de l'irrigation reste peu développée. En conclusion, les fermes universitaires étudiées ont démontré un fort potentiel en tant que laboratoires vivants pour l'agriculture durable. En ce qui concerne l'irrigation, l'amélioration de la tenue des registres et des mesures quantitatives, ainsi que la modernisation des systèmes, constitueront les prochaines étapes essentielles pour optimiser l'utilisation de l'eau au sein de ces systèmes.

Mots-clés : Systèmes alimentaires durables; Intégration agroécologique; Pratiques agroécologiques; Approches qualitatives et quantitatives; Utilisation de l'eau.

INTRODUCTION

Over the past decades, there has been growing recognition that the global food system must undergo profound transformation as there is "a consensus that it is not delivering good nutrition for all and is causing environmental degradation and loss of biodiversity" (Wezel et al., 2020). In response, the concept of sustainable food systems has emerged as "a way to reduce these externalities" and to reconcile food security, environmental stewardship, and social equity. Central to these systems is agroecology, which provides both the scientific basis and practical framework for sustainability (Cleveland et al., 2014; Gliessman, 2016; Wezel et al., 2020). Yet, water remains a relatively underexplored dimension within agroecological research despite the fact that "90% of the water needed by an individual is embedded in their food consumption" (Antonelli et Greco, 2015, p. 18). Water is not only an essential resource for production as it contributes to 40% of global food production but it's also used in the processing of fresh vegetables (Leauthaud et al., 2025; Lehto et al., 2014, p. 246). This gap highlights the need for a deeper understanding of how sustainable food systems conceptualize, use, and preserve water, from production to consumption.

California provides a striking example of how agroecology supports sustainable food systems in a region where water scarcity is a critical challenge. In the late 1960s, California became a cradle of organic and sustainable farming movements, “not only as an agricultural method but as a cultural protest against the mechanized and chemical-intensive agribusiness model dominating the state”. In fact, the UC Santa Cruz Farm and the UC Davis Student Farm were among the first university-based initiatives to integrate ecological principles, social values, and practical training into agricultural education. As references for sustainable agriculture programs worldwide, they helped establish the foundations for ecologically resilient, equitable, and holistic food systems (Guthman, 2004; University of California, 2010).

The present study focuses on the role and management of water within sustainable food systems, with a particular emphasis on farms implementing agroecological practices in California. Firstly, the research provides a comprehensive characterization of each food system. Then, it assesses the level of agroecological transition achieved within these systems. Finally, the study focuses on water resources, examining their use, sustainable management, and irrigation practices in agroecological production.

METHODOLOGY

Overall approach

To understand each food system, its agroecological practices as well as its water use, two main types of data were collected: semi-structured interviews and direct observations. The interviews followed a pre-established set of questions but remained flexible and conversational to allow for in-depth exploration. This qualitative approach aimed to: (1) uncover the historical background of each case study, (2) identify all involved actors and their specific roles, and (3) quantify the volume of food and water circulating within the system. For each case study, a list of key stakeholders was compiled in advance.

In the end, 26 and 12 semi structured interviews were conducted, at UC Santa Cruz and UC Davis respectively. The interviewees consisted of both employed staff and students.

Study cases

The University of California Davis and Santa Cruz student farms stand out as strongly representative examples of university farms across the United States. Not only does their respective farm sizes align well with the average size across peer institutions but the way they produce food is also similar as nearly all the surveyed university farms are certified organic (or transitioning) and actively promote agroecological principles. Food distribution channels are also pretty similar, most of them including farm stands, community-supported agriculture (CSA), on-campus dining halls, and student food pantries. Finally, UC Davis and UC Santa Cruz strongly align with national trends in education, sustainability, food access, and research.

RESULTS & DISCUSSION

Overview of the selected food systems

Information collected for each food system was synthesized in the schematic diagram below, which illustrates their overall structure and organization, the roles of the various stakeholders, their interconnections and spatial relationships, as well as the flow and quantities of produce (Figure 1).

Both the UC Santa Cruz and UC Davis student farms illustrate how university-based agriculture can integrate food production, education, and community engagement. Yet, they differ in scale, strategies, and operational focus. Although both farms cultivate a similar area, the UC Davis farm produces roughly twice as much as UC Santa Cruz. This difference can largely be attributed to variations in crop planning and climate. The warmer conditions in Davis allow for extended production periods, enabling three cycles of annual crops and one cycle of cover crops per year, whereas UC Santa Cruz rarely practices

double cropping. Despite these differences in output, both farms function as living laboratories for agroecological research and experiential learning, hosting educational workshops and engaging students and children in sustainable agriculture. Notably, both farms participate in a shared research initiative called the “Student Collaborative Organic Plant Breeding Education” (SCOPE), promoted by the global UC system.

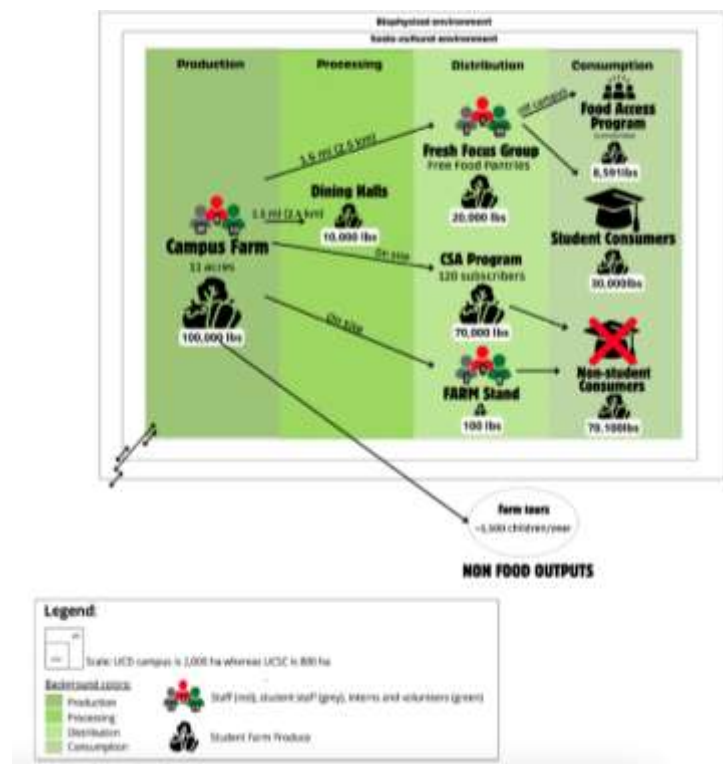


Figure 1: Schematic representation of studied food systems illustrated for the University of California Santa Cruz. The food system is represented inside certain biophysical and socio-cultural contexts. The system is divided into 4 stages: production, processing, distribution and consumption. Source: adapted from field data.

Processing of farm produce on campus also takes different forms at each university. At UC Santa Cruz, the Cowell Coffee Shop provides free healthy meals prepared by students from fresh farm produce, creating a unique, non-transactional space “that does not exist anywhere else.” In contrast, UC Davis lacks a comparable initiative, with the Fresh Focus team focusing primarily on processing surplus summer produce. Processing farm produce also remains a challenge for UC Davis Dining Services, which lacks sufficient labor to handle large volumes. Actually, it is precisely because “it was not practical” that UC Santa Cruz abandoned its partnership with Dining Services.

Distribution strategies further distinguish the two farms. UC Santa Cruz channels its produce through three distinct on-campus outlets, whereas UC Davis distributes fresh produce more widely across campus, with particular attention to minority communities. Both models are supported by the Basic Needs Program and therefore prioritize accessibility and cultural relevance over revenue generation. When it comes to direct revenue, Community Supported Agriculture (CSA) programs and farm stand sales play a key role. At UC Davis, a substantial portion of produce is sold through the CSA program, whereas UC Santa Cruz recently discontinued its CSA. Additionally, UC Davis operates a year-round farm stand while UC Santa Cruz limits farm stand sales to the summer months, reflecting its strategic focus on providing produce primarily during the academic year. These differences in production, processing, and distribution are reflected in consumption patterns. A larger share of students consumes farm produce at UC Santa Cruz, whereas at UC Davis the main consumers are CSA subscribers, typically university staff. In addition, while UC Santa Cruz focuses primarily on on-campus distribution, UC Davis stands out for also providing produce to local communities during the summer months.

Overall, both institutions demonstrate ways to balance production, research, and community impact within their unique biophysical and socio-cultural contexts. Nevertheless, both face ongoing challenges, particularly their reliance on external funding and limited labor capacity.

Assessed level of agroecological integration

With regards to the agroecological assessment of each farm, the results reveal that both farms operate localized, community-oriented food systems with a comparable degree agroecological advancement. UC Davis shows greater progress in governance and cultural initiatives, whereas UC Santa Cruz distinguishes itself through broader distribution networks and diversified soil management practices.

Let's do a detailed examination and comparison of the level of advancement of all measures implemented by both study cases, for each agroecological principle as defined in Wezel et al. (2020). Firstly, when considering both sites, the data show that the vast majority of agroecological actions are highly developed, while only 6.5% remain less advanced. These findings suggest that the studied systems have already reached relatively advanced stages in the pursuit of agroecological objectives. Actually, it is worth noting that the two sites share a considerable number of agroecological actions at a comparable level of advancement. In fact, 70% of all identified measures are common to both sites. A large proportion of the well-implemented measures relate to principles tackling the preservation of the environment, as stakeholders aim at reducing inputs by applying only "what we think is needed", improving soil health by "moving away from using the rolling cultivator" and "keeping the soil biologically active", preserving resources through efficient irrigation systems and fostering synergies with habitat beds and diverse cropping systems. Nevertheless, some logistical and organizational challenges remain. For instance, stakeholders report "a lot of leaks" in the irrigation system, and the frequent turnover of students disrupts continuity, as the departure of key team members at graduation often makes the following semester "chaotic". Socio-economic principles are also quite advanced, as "humanizing the food system" has become a priority, making healthy and culturally relevant food accessible while simultaneously promoting direct and sustainable food systems through numerous initiatives.

Patterns of water use

At both sites, water use at the production level represents the dominant share of total water consumption when analyzing the whole food system (91.7% at UC Santa Cruz and 96.8% at UC Davis). In these farms, water conservation is indirectly supported by agroecological practices such as mulching and crop selection. Indeed, there were many agroecological activities that did not explicitly targeting water preservation but nevertheless had positive secondary effects on water use. These measures actually accounted for 31% and 26% of total agroecological activities described at UC Davis and UC Santa Cruz respectively. On the other hand, direct irrigation management remains underdeveloped, despite its potential to significantly reduce consumption. In 2025, quantitative assessments revealed discrepancies between theoretical and practical irrigation use, with total water consumption in a specific location of the UC Santa Cruz farm nearly 2.5 times higher than the expected theoretical value using a preset irrigation strategy. This discrepancy could be due to inadequate valve manipulations, leaks and higher than expected flow rates.

In 2026, *in-situ* measurements throughout the growing season will allow us to further quantify the actual irrigation water use at the crop system scale and better identify the adaptive measures to be taken to improve irrigation management in the context of a highly diversified farm on the Central Coast of California. This will also highlight the main challenges of maintaining an irrigation system and proper schedule in a highly diversified context. In conclusion, the studied university farms demonstrated strong potential as living laboratories for sustainable agriculture. With regards to irrigation, enhancing record-keeping and quantitative measurements as well as system upgrades will be essential next steps to improve water-use in this systems.

CONCLUSION

This study explored the role of water within sustainable food systems, focusing on two university-based agroecological farms in California: UC Santa Cruz and UC Davis. Through a comparative analysis of their food system structures, agroecological transitions, and water management strategies, several key findings emerged. Both UCSC and UCD demonstrate that university farms can act as dynamic hubs linking education, research, and local food access. Despite comparable cultivated areas, UCD achieves roughly double UCSC's production, largely due to its warmer climate and extended growing season. UCSC, however, shows greater integration with on-campus food access initiatives. In contrast, UCD focuses more on community-oriented distribution through CSA programs and farm stands. These two complementary models illustrate how institutional settings can shape sustainable food system strategies. The agroecological assessment revealed that both university farms have advanced principles of "Economic Diversification" and "Social Values & Diets", while aspects like "Animal Health", "Fairness", and "Land and Resource Governance" remain underdeveloped. UCSC implements slightly more agroecological actions on average, yet both sites depend heavily on fluctuating student labor and project-based funding, which challenge long-term consistency.

Water use assessments highlighted significant inefficiencies and data limitations. Both farms rely heavily on irrigation but differ in management. UCSC's long-established irrigation framework enables more detailed tracking, whereas UCD's reliance on experiential knowledge limits documentation. Theoretical versus practical comparisons revealed substantial water losses mainly due to leaks and suboptimal sprinkler layouts. Overall, UCD achieved higher water-use efficiency compared with UCSC, demonstrating better conversion of water inputs into production. These findings stress that, even though both farms demonstrate awareness of water scarcity and have adopted agroecological practices that foster water conservation, direct improvements in irrigation management remain the most immediate and impactful strategy for reducing water consumption. Future research should aim to strengthen quantitative monitoring through systematic water metering, soil moisture tracking, and standardized agroecological impact indicators. Expanding cross-campus collaboration and integrating conventional farm comparisons would also deepen understanding of the transformative potential of agroecological university systems. Ultimately, this research underscores the promise of university farms as living laboratories for sustainable food production: spaces where ecological innovation, social equity, and practical experimentation intersect. However, realizing their full potential will require not only technical optimization but also long-term institutional commitment to funding, documentation, and systemic integration.

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