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Farming-as-a-service initiative in the making: Insights from emerging proto-practices in Sweden

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ABSTRACT

This paper focus on the emergence of farming-as-a-service initiatives that combines ideas about controlled environment agriculture with digital technologies to produce food in cities. These initiatives are founded upon the view that it can secure local food provision while reducing the environmental impacts of food systems. While there are promising value claims surrounding such initiatives, knowledge about their actual effects is limited. This paper begins to address this research gap by investigating the early uptake of such practices in user context. Exploratory case study research was conducted focusing on the emergence of farming-as-a-service initiatives in Sweden. Drawing on practice theory of innovation, it explores the implementation of digitally augmented and service-oriented farming practices in user contexts. The findings shows that its implementation follows a transformational alignment process where new practices detach or attach to existing flows of practices. While new practices of service-oriented farming are fluid and unstable in relation to established practices, they hold transformative potential. Thus, our study contributes with an in-depth understanding of the implementation of farming-as-a-service and highlight potential implication for further uptake of such practices.

Introduction

Food produced in digitally augmented and contained environments have become increasingly established in cities across the globe such as Stockholm, London and Singapore [1,2]. These urban farming practices use vertical and soilless growing systems such as hydroponics or aeroponics, which are collectively known as controlled environment agriculture [3]. The farm often takes the material form of modular entities that are located inside the built environment, e.g. basements, factories, restaurants and supermarkets. It uses artificial lighting and digital interventions (e.g. automation and robotics) for managing food production [4,5]. Given the controllable feature of such farming practices, they are promoted by policy makers, academics and funders for their potential to produce fresh food within cities all year round using fewer resources (e.g. land, water and chemicals) and with reduced food miles [4]. However, while urban farming practices are surrounded with promising value claims [6], knowledge about the actual effects of such practices on user context is underdeveloped.

Our study focuses on the work undertaken by firms who are involved in developing and implementing digitally augmented farming technologies. Currently there are several firms in Sweden and elsewhere which are developing modules for food production that are provided to the customer or consumer via a service. In such business arrangements, firms are leasing out digitally augmented in-store farming units, which are used by the customer, e.g. supermarket or restaurant, to produce food (e.g. leafy greens). While previous research has provided insights on such service-oriented farming initiatives (e.g. Martin and Bustamante [7]), there is paucity in research on the implementation of such practices in user contexts. As pointed out by Marvin, Yang [8], research is needed that considers the purpose and practices through which service-oriented farming are constituted as well as their socio-spatial consequences. This paper begins to address this research need by focusing on the actual and practical realities of implementing service-oriented farming initiatives on the ground. This matters because the implementation of service-oriented farming initiatives is situated in space and time, which suggests that problems and solutions arising during implementation are contextually defined [9]. Thus, by examining the early uptake of farming-as-a-service initiatives, this paper aim is to contribute with in-depth insights on their implementation in user contexts. Our study is guided by the following research questions:

1) What are the emerging practices of farming-as-a-service initiatives?

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2) How are these farming-as-a-service practices developing in relation to the context in which they are implemented?

Longitudinal case study methods were adopted to investigate a specific service-oriented farming initiative in Sweden. The initiative is a maturing start-up firm established in 2019. Its stated business proposition is to offer digitalised and automated growing solutions for production of leafy greens and herbs. The firm has implemented a number of farming-as-a-service (FaaS) initiatives in supermarkets and restaurants across Sweden. This paper is structured as follows. First, it introduces the analytical perspective and methods for analysing the implementation of service-oriented farming practices. To analyze how FaaS initiative is implemented on the ground, we use a practice theory perspective on innovation [10,11]. This perspective views innovation as the emergence of new practices that are constituted from a combination of recognizable elements: material, competence and meaning. Second, the results from case study research is presented with in-depth details on the implementation of service-oriented farming initiatives, which provides insights on its transformative potential and opportunities to act and shape innovation processes. Third, the findings are summarised, and conclusions drawn.

Analytical perspective

To advance uptake of service-oriented farming practice in cities, research has focused on the development and management of such initiatives. For example, there are several studies founded in production economics generating insights on greater productivity of indoor vertical farms compared to conventional farms [12]. There are also studies making claims that service-oriented farming can help mitigate social, environmental and economic challenges such as food security, reduced resource use (e.g. water, chemicals) as well as enabling shorter supply chains [13], (please see Oh and Lu [14] for a review). Much research on service-oriented farming follows the somewhat positivistic epistemology of environmental and resource management to generate insights on such developments. These studies offer credible and valid contributions to knowledge about resource flows and productivity associated with vertical farming. From a business studies perspective, service-oriented farming systems represents a business proposition that offers growing solutions for producing leafy greens and herbs [6]. This notion of turning product (e.g. leafy greens) into service (e.g. growing solution) resembles the idea of service-oriented business models, also called product-service-system (PSS). In general, PSS refers to an approach where firms are selling a service, function or a result instead of a product [15]. Indeed, research has provided valuable insights on the implementation of FaaS initiatives conceptualised as novel PSS business models [7]. However, such studies reduces knowledge about service-oriented farming into discrete variables such as business models and fails to account for the complex environments in which such farming practices develop.

The PSS perspective on innovation identifies that innovation constitutes not only new technologies or new products, but novel configurations of products, services and systems [15,9]. Seen this way, the product innovation refers to new configurations of material artefacts. For example, the product innovation of service-oriented farming initiatives is not necessarily the food it produces, but the material elements that enables food production. Service-oriented farming initiatives often takes the material form of modular entities, e.g. a plant factory, which can supposedly be located anywhere, e.g. in a space shuttle, on remote locations with extreme weather conditions, or in a supermarket. The service dimension of such innovations refers to the way the material artefact is being used and appropriated in both intermediate and final markets. For example, a 'smart farming unit' are being implemented in buildings such as supermarket or restaurant for producing leafy greens. For the supermarket, such approaches in PSS terms comprise a user- or result oriented service. In such business arrangements, the ownership of the product (e.g. a plant factory) is retained by the service provider, and the customer (e.g. supermarket) purchases the use of the product over a given period of time, e.g. renting or leasing; or the outcome of service provision, e.g. leafy greens. The system innovation refers to the socio-material infrastructures that enables as well as constrain the implementation of product-as-a-service innovations. For example, digitally augmented and contained farming practices are reliant upon relations with extant material infrastructures, e.g. digital-, energy- water systems as well as industry-, regulatory-, and consumer practices.

Many studies that adopt a PSS perspective on innovation often frames their analysis on business models to arrive at a higher level of abstraction, see for example Martin and Bustamante [7]. This offers a rich account on the emergence of new business models for service-oriented farming. Indeed, such studies may usefully inform developments of common PSS definitions and classification frameworks to inform PSS design processes and market developments. However, as pointed out by Cook [9], abstract accounts say very little about the implementation of such initiatives in socio-material context. Thus, while developments of FaaS includes novel configuration of product- service- and system innovation, analytical perspective is also needed to examine how such novel configurations emerges on the ground.

The analytical approach to investigate the implementation of service-oriented farming initiatives is therefore informed by constructivist perspective in social sciences. Rather than seeking to produce 'blueprint' abstraction of farming-as-a-service, our working assumption is that such initiatives are complex and contingent [12]. This analytical departure matter since digitally augmented farming practices in cities are in its infancy and abstract images does not reveal opportunities and challenges for its implementation in socio spatial contexts. Following the work of Mylan [16], we identify practice theory to inform the analysis on the implementation of service-oriented farming in user context.

Practice theory is relevant for its capacity to capture on-the-ground mundane routines or doings [16]. Innovation happens as new practices emerge, existing practices persist and practices no longer warranted disappears [11]. Practice theory builds on a rich body of literature, that identifies the procedures of actions as a practice that involves a commonly shared and routinized way of performing something, such as farming [17,11,18]. This implies that human behavior and technologies are recursively intertwined through the routines enacted by the practitioners. While there is no such thing as one unified theory of practices, theories of practices are increasingly applied in empirical studies of innovation [19]. For instance, Shove and Walker [20] use practice theory to examine innovation in everyday practices of households, e.g. showering, which in aggregate give rise to significant environmental impacts. Studies on innovation in everyday practices provides important insights on dominant structures that enables resource intensive practices (e.g. showering) to persist, and helps identifying socio-material elements that hold the most potential for change. As such, practice theory is suitable for the purpose of studying on the ground processes of socio-technical change, where change can take place in existing practices, from the emergence of new practices as well as the disappearance of practices no longer warranted [21,22].

We adopt practice theory perspective in this study to examine the implementation of service-oriented farming in cities. While such initiatives are surrounded by promising value claims of producing food in urban settings, the development and uptake of such farming practices are at an early stage where their configurations are emergent. FaaS initiatives are not yet established as collective routine in cities, which suggests that service-oriented farming practices are fluid and unstable compared with more established farming practices.

For our empirical investigation, we use the analytical framework developed by Shove, Watson, Pantzar [18], which defines practices as a process of making relations between three interlinked elements: material, competence and meaning:

- The material element refers to the 'objects' that enable practitioners to perform a practice, such as technology, tangible products and infrastructure. For example, the material element in service-oriented farming initiative includes, but is not limited to, the modular entity and material infrastructure that supports it.
- Competence refers to the skills and know-how of practitioners. Skills and know-how are mobilised by practitioners during routine behaviours and involves various decisions made by practitioners. For example, service-oriented farming initiatives is reliant upon skills developed by the service provider and user.
- Meaning refers to symbols, norms and collective conventions that govern action. For example, producing leafy greens in supermarkets rather than from the farm may challenge conventional practices of producing and purchasing food.

Building on this relational ontology, we conceptualize farming-as-a-service as emerging proto-practices where relations between elements of practices are fluid and unstable. Building on the work of Mylan [16], this analytical perspective suggests that new practices does not only require relations to be made between elements required to perform farming-as-a-service. Proto-practices also develops in contexts where other practices already exists. This means that the emergence of proto-practices are not only determined by the strength of the linkages between the elements within specific practices, but are also enabled and constrained by relations with other related practices. Since proto-practices are implemented in contexts where other related practices already exists, we adopt the concept of attachment and detachment from Callon, Méadel [23] to analyze the dynamics between proto-practices and established practices. Seen this way, the implementation of farming-as-a-service is conceived as a transformational alignment process through which proto-practices co-evolves in relation to existing practices, which is illustrated in Fig. 1.

This analytical framework is deployed in this study to create insights on practices of farming-as-a-service initiative as well as the dynamic relations between proto-practices of FaaS and more established practices. Methods for data collection and analysis is presented next.

Material and methods

Since there are few empirical investigations of farming-as-a-service initiatives in general, and in Sweden in particular, exploratory qualitative research was conducted. Our investigation on the implementation of farming-as-a-service initiative followed case study research methods [24]. This approach is useful to investigate contemporary phenomenon (e.g. farming-as-a-service) in depth and within actual contexts. It focused on a single case study on an urban agricultural initiative in Sweden. Consistent with the abovementioned case study, data were collected from multiple sources using multiple methods [25] such as document analysis, semi-structured interviews and site visits. Semi-structured interviews were conducted with key informants, notably people working for the firm and people using their service. Seven interviews were conducted with actors working for the firm as well as users of the service working in supermarkets at different geographical locations (see Table 1 for a detailed the description of the respondents and characteristics). An interview guide was developed and used for the interviews (see Appendix for detailed questions). Topics, which formed the basis for the guide, where framed around the following themes:

What are the emerging practices of farming-as-a-service initiatives?

How are these farming-as-a-service practices developing in relation to the context in which they are implemented?

Informed consent was obtained from all subjects involved in the study. Data was also collected via workshops and site visits to the firm's experimental cultivation below ground in Stockholm city centre. This was combined with two visits to supermarkets, one in Gothenburg and another nearby Stockholm, which were using the cultivation service on-site.

The qualitative data were analysed using a flexible analytical template approach [26]. Given the exploratory nature of this study, a flexible analytical template was developed using a funnel approach to facilitate analysis [27,28]. Here, the funnel approach refers to an analytical process, which becomes more focused as the research proceeds and the analytical template becomes more fixed. Consistent with this approach, exploratory research on farming-as-a-services were conducted simultaneously with literature review on innovation and urban developments. Data collection and analysis began with an initial set of questions and analytical themes. This led to refined questions and themes, which were informed by literature and in relation to the data collected. As such, data was collected and reviewed in light of literature in an iterative process. The approach called for continual re-interpretation and reflection. This means that we began our research by investigating service-oriented farming conceptualised as novel configuration of product, service and system innovation. However, as our analysis proceeded we adopted practice theory as analytical lens for investigating implementation of service-oriented farming in user

Table 1
Description of the respondents, interviews and site visits focusing on roles and local contexts.

Respondent	Professional role in relation to FaaS
Technical manager	Conducting experimental cultivation of FaaS in test bed and user settings (digital interview)
Plant scientist	Conducting experimental cultivation of FaaS in test bed and user settings (face-to-face interview combined with site visit)
Innovation manager	Conducting experimental cultivation in test bed and user settings (face-to-face interview combined with two site visits to test bed) (follow-up digital interview)
Internship student	Conducting experimental cultivation in test bed and user settings (face-to-face interview)
Store manager	Managing a supermarket in Gothenburg where FaaS is implemented (digital interview)
Cultivation responsible	Cultivating FaaS products at supermarket in Gothenburg (face-to-face interview combined with site visit)

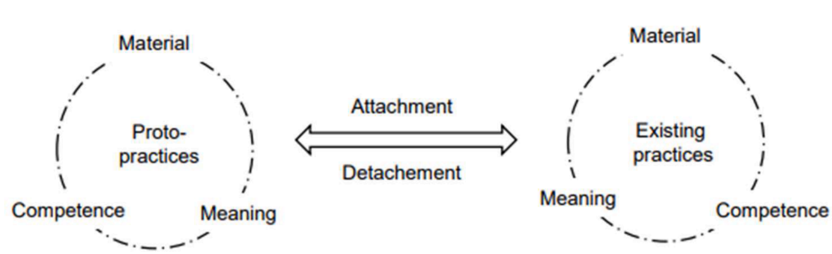

Fig. 1. Analytical framework to examine the implementation of proto-practices in relation to existing practices.

contexts. The conceptualisation of FaaS is described in Fig. 2.

For the remainder of this paper, practice theory is applied as analytical lens to examine how farming-as-a-service initiatives are implemented in user contexts, where the unit of analysis is practices.

Results

In this section, the empirical data from the case study are analysed in light of the research questions. First, we describe the technical equipment and analyze emerging proto-practices of farming-as-a-service, which includes prototyping farming-as-a-service in experimental settings and translating the prototype to user setting (e.g. supermarket). Second, we analyze emerging proto-practices of farming-as-a-service in relation to more established practices in the context in which prototypes are being implemented. An overarching summary of key events in the company's narrative is presented in chronological order in Table 2.

As illustrated in Table 2, the FaaS initiative that forms that basis for this case study builds on ideas developed in 2008 until 2018, which were refined in 2019 under the current firm. This firm developed a farming-as-a-service prototype in an experimental setting, which was subsequently transferred and implemented into user contexts such as supermarkets. Digitally augmented farming units (grow boxes) enables small scale farming practices that are distributed across users. This is different from more traditional horticulture, which is using arable land or greenhouses to produce vegetables. Traditional horticultural practices are replaced by small scale farming units that are located at the user.

Farming-as-a-service unit

Farming-as-a-service consist of varies technologies assembled together into a unit. The technical components of the digitally augmented farming unit includes the cloud system that assist information and the business arrangement. This is described in the following section.

The in-store farming unit is equipped with artificial lighting and digitalised technologies for climate control, sensing and monitoring of the food production. This creates a controlled environment through digital monitoring and steering equipment. This means it is possible not only to control, but also to automate, conditional variables for growing crops indoors, where up to a hundred parameters relevant for growing conditions are managed. This includes alarm systems, monitoring and sensors, combined with an intra-cloud service, which is used by the firms' technical service personnel. Since the farming unit is integrated with the building infrastructure this means the electricity used in the farming unit is circulated and reused to heat up the host building. Carbon dioxide exchange from the office environment is also reused in the farming unit and the firm has developed this technology. According to the firm's own experience, there were no systems available to buy that worked so they built and developed their own system based on best available technology for hydroponic cultivation. The farming units comes in different sizes and form the basis of the FaaS arrangements between the company and the user, e.g. supermarket or restaurant. The firm is also supplying all input goods e.g. seeds, nutrition, substrate, technical expertise, service, maintenance etcetera.

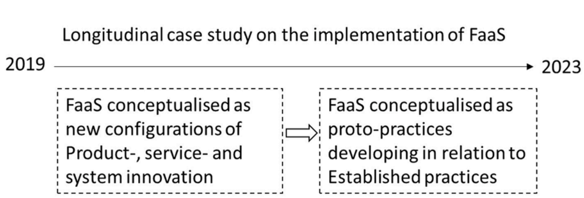

Fig. 2. Description of how the conceptualisation of FaaS changed over time as the longitudinal case study progressed.

Table 2
Overarching summary of key events.

Time	Location	Events/turning points
2008–2018	Stockholm/ test bed	The firm established a test bed in central Stockholm and searched for investors to develop cultivation. This initiative went bankrupt, and reorganised into a new business initiative.
2019	Test bed	The firm developed the prototype of an in-store farming unit and presented their FaaS solution at food events in Sweden.
2020	Supermarket	The firm implemented and tested an in-store farming unit in the user context of one supermarket in Gothenburg and another in Linköping.
2022	Market expansion	The firm implemented FaaS initiatives in five locations across Sweden as well as in Germany
2022	Redeveloping Test bed	The test bed is redeveloped into a mirroring system of the in-store farming units.
2023	Market expansion Test bed	Further market expansion to supermarkets and restaurants in southern- and mid-Sweden. Currently at seven different locations Investments in new AI equipment camera and experimentation with innovative technologies as well as new crops, e.g. radishes, strawberries, flowers etc.

The technology is combined with a cloud system that assist information management about variable growing conditions; and growing service, which include recipe, maintenance and supplies. This guides the users at the supermarket while the firm is responsible for monitoring the technology from a distance e.g. to secure nutritional values, humidity, temperature and plant growth. The software platform has two different functions, for control and monitoring. This second part becomes the interface to the customers called the synergy customer cloud.

This technological development opens up for new digitally augmented farming practices, where the farmer operates multiple farms from a control room setting. It also creates new supply chain relations between the supplier and retail, as well as retailing practices. The implementation of farming-as-a-service is unpacked in subsequent sections.

Practices of prototyping farming-as-a-service

Since FaaS is a novel practice, we investigated practices of prototyping ideas of turning food production into a service. The initiative took material form in the basement of a multistore building in central Stockholm. Antecedent events prior to the initiative can be traced back to another urban food firm established in 2008. The business proposition promoted then built on the idea of producing plants and vegetables on top of building infrastructures, such as 'green infrastructure'. One of the founders of the initiative described this as follows:

> "The idea was that they would build large skyscrapers that would supply megacities like Hong Kong, Beijing and Singapore with locally produced food. And the basis was really that… the arable land will not be enough to support people."

While the prior initiative did not succeed with their business plans and went bankrupt, their test bed including people with competence created a new urban food business. Ideas to produce food in cities shifted from a focus on "green infrastructure" located on top of buildings to producing food in controlled and digitally augmented environments. This idea gained financial support from national innovation schemes such as Vinnova, the Knowledge Foundation funds and FORMAS, which support innovations that accord with strategic national priorities. The idea to produce food in controlled and digitally augmented environments corresponded with an increasing demand for sustainable, healthy and local food supply.

A prototype of the in-store farming unit was developed in the test bed located in central Stockholm (see Fig. 3 for a description of the test bed). In this setting, material elements of prototyping, FaaS includes the basement and the technical kit for hydroponic food production such as systems for lighting, heating, humidity, air filtration and watering. Digitalised technologies were applied such as sensors for monitoring food production. The test bed setting also offered the opportunity to integrate hydroponic food system with the building ventilation system for recirculating air between the offices and the food production. Competences needed for prototyping this FaaS initiative includes, but are not limited to, plant scientist with knowledge and expertise to design and operate hydroponic food production. One respondent from the firm describes this competence:

> “The grower doesn’t really work with technology development at all, but he works with recipes. Developing a recipe from seed to harvest. Which in part involves figuring out which seeds to use.”

Engineering competence is also needed to integrate the in-store farming unit with building infrastructure. This technological prototype of an in-store farming unit was founded upon the view that it is a valid and appropriate ways to produce food in cities. Here, meanings associated with prototyping FaaS include for instance ideas about ‘hyperlocal’ food produced close to final markets, fresh and healthy food without pesticides and herbicides and sustainable use of resource inputs such as water.

The prototype was promoted at various food industry events across Sweden, which resulted in a commercial relationship between the firm and a supermarket located in Gothenburg. The store manager had a particular interest in trying new marketing concepts. Therefore, he was identified as an ideal partner for implementing the farming-as-a-service initiative in a user context.

Implementing farming-as-a-service in user context

The firm has implemented several FaaS units in supermarkets across Sweden, e.g. Linköping, Gothenburg, Stockholm and Scania. Indeed, supermarkets are a different socio-material context compared to the experimental setting where the prototype was created. Thus, the implementation of the FaaS prototype involved a process of translating and redeveloping the prototype from the experimental setting into a supermarket. In the user context, FaaS are based on contractual relations between the firm and the supermarket. This means that the firm install the in-store farming unit in the supermarket as a result oriented service. The owner of the supermarket has access to the production outputs (e.g. leafy greens), but the ownership and control over the in-store farming unit is retained by the firm. One of the firm’s initial FaaS units was implemented at a supermarket in Gothenburg in 2020. Since then, totally seven in-store farming units are currently installed by supermarkets and restaurants across Sweden, Figs. 4 and 5 shows the FaaS unit in different settings. The FaaS unit is placed nearby the department for fruit and vegetables in the supermarket and the service it provides is explained as follows by one respondent from the firm:

> “The "farming-as-a-service" that we offer is a concept, where the store builds the box […] Then we put a cultivation facility in there. We do the research and make sure it works. Then they can grow for a monthly fee. We own the equipment and they own their shop. Clear demarcation there. We are responsible for all training and all inputs. And also help in sales and demonstration.”

Turning to the practice theory perspective, the implementation of farming-as-a-service constitutes multiple proto-practices. These includes, but are not limited to, practices of sensing and monitoring food production undertaken by the firm as well as practices of producing, harvesting and selling food items undertaken by staff in the supermarket.

The implementation of the FaaS initiative into the supermarket requires considerable spatial rearrangement of the shop floor to accommodate for food production inside the building. The spatial arrangement in a supermarket is typically organised around compartments and shelves for the food assortment offered by the store. Installing an in-store farming unit means that spatial arrangements are needed for both producing leafy greens and for putting these on the shelf. Consequently, FaaS entails new practices that develops in relation to the building infrastructure. In supermarkets, leafy greens are typically placed at the entrance to create a fresh vibe for customers. Thus, the symbolic meaning of fresh leafy greens coincides with the implementation of the in-store farming unit in the retail store.

The initial idea was to position the in-store farming unit in the supermarket so that retail customers could harvest leafy greens or herbs by themselves. This idea built on value claims that customers are demanding fresh leafy greens that are locally produced. However, fear of contamination and associated health and safety guidelines identified a need to produce leafy greens in a closed space sealed off with lock where only trained staff could enter. The in-store farming unit was equipped with windows so that consumers could see the farm, but they were restricted from interacting with the farm. Furthermore, the retail manager also learned from the pandemic (2019–2020) that consumers prefer to buy leafy greens in plastic bags. This led to the adoption of packaging solution, which was added to the in-store farming unit. This insight

Fig. 3. A cultivation trial at the test bed in central Stockholm in early 2022 (to the left) and the newly developed mirroring facility of the same test bed in May 2023 (to the right).

Fig. 4. FaaS in-store farm in different supermarket settings in Stockholm (to the left) and in Gothenburg (to the right).

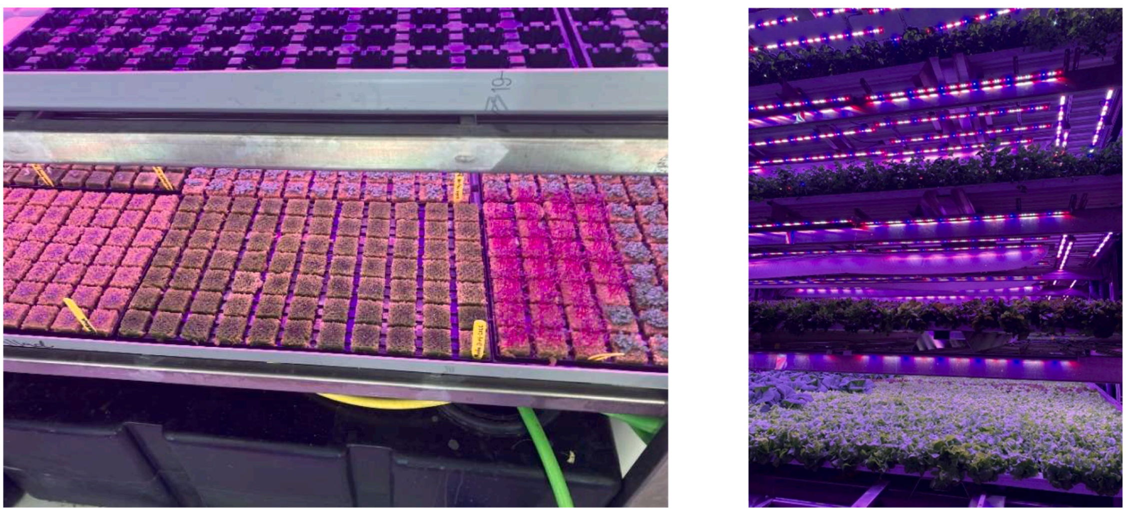

Fig. 5. The test bed at in central Stockholm (to the left) and the inside of an in-store farm in a supermarket setting in Stockholm (to the right).

shows proto-practices of farming-as-a-service co-develops in relation to more established practices in the user context, e.g. running a supermarket. Based on these empirical insights, we identify that farming-as-a-service initiatives were translated, redeveloped and adapted in relation to the user context.

Emerging proto-practices of farming-as-a-service in the user context entails practices of producing, harvesting and selling food items. This means that the implementation of the in-store farming unit into the supermarket engaged members of staff enrolled in practices of harvesting the production outputs and packaging. This is described as follows by a respondent from the supermarket:

> "It is clear that we will go in and become our own supplier and then we will get service and a machine that we operate and ensure ourselves. Moreover, for us, if you think about being a brilliant employer, we offer work in a store and suddenly you work in an urban garden. It was not quite what the staff saw from the start. "

As illustrated by this quote, the in-store farming unit can be cast as a positive experience for staff to engage with. This idea builds on particular meaning of farming practices such as working in an urban garden. However, given the closed and controlled nature of in-store farming unit equipped with artificial lighting, little is actually known about its consequences of working in such environments for human workers. Since the in-store, farming unit is owned and controlled by the firm providing the service, they engage in practices of sensing and monitoring food production. To assist such practices, the company are redeveloping the test bed into a mirroring system, which is deployed to learn how to operate farming-as-a-service. Specifically, with in-store farming units installed in supermarkets, the firm focus on the creation of recipes for growing food items inside the farming unit. The commercial relationship between the service provider and the retailer is illustrated by this quote:

> "We have people at the firm that we call customer success and they work closely together with customers so they ask the customers - what do you want and what do you need? And then they check with me - what do we have or they call me a couple of weeks before and they say what if we do black kale – can we do black kale? So if you give me 8 weeks I can give you a recipe."

This quote illustrates that the retailer can access recipes for the in-store farming unit. Here recipes refer to different type of varieties that can be produced by this service. The mirroring system is also used by the firm to learn how to respond to issues arising in the user context. Practices of sensing and monitoring farming-as-a-services also include a control room that is deployed to overlook production cycles. Since the firm is operating the service at a distance, on-duty engineers are enrolled to fix problems as necessary.

The empirical data on the implementation of farming-as-a-service into user context such as supermarket shows that relations between elements of such proto-practices are made in the context in which they are performed. Specifically, materials, meanings and competences are joined up in practices of FaaS. Table 3 illustrates some of elements that forms part of such practices.

The in-depth narrative of emerging practices of FaaS illustrates that relations between elements of such practices are fluid and unstable. This

Table 3
Description of how the elements are connected to certain practices.

Practices of FaaS	Material	Competence	Meaning
Producing food	In-store farming unit; sensing and monitoring equipment; control-room with mirroring system	Plant scientists to develop recipes; engineering competences for improvements and maintenance managing data	Result-oriented business model; local produce; resource efficiency; creating recipes
Promoting and selling food	In-store farming unit; packaging; shelf	Harvesting leafy greens, packaging and placing these on shelf	Demand for fresh and local produce; reliable supply of leafy greens; health and safety

suggests that such practices are moulded in relation to the context in which they are implemented. Thus, we now turn to the analysis of how FaaS develop in relation to more established and perhaps stable practices.

How proto-practices of farming-as-a-service develop in relation to context

Our analysis on the implementation of farming-as-a-service illustrated above shows that such practice both attach and detach from more established and stable practices. Notably, FaaS builds on a service-oriented business proposition where results rather than products form the basis for supplier-retail relations between the farmer and the supermarket. The commercial value proposition offered by the service provider is that it enables the store to produce fresh leafy greens that are locally produced in the store and sold directly to end-consumers. The firm operates the farm from a distance using sensing and monitoring equipment and the staff in the supermarket is enrolled to operate the in-store farming unit.

This shows that FaaS detach from more established business practices; rather than sourcing leafy greens from value-chain relations with farmers and distribution agencies, the supermarket source these via a service. As such, FaaS builds on a different meaning of farming that posits farming as a practice in rural areas that are distributed via intermediaries to the supermarket. Producing food in cities, using FaaS detach from such normative assumptions about farming. Rather than placing orders to suppliers, the retail managers establish contractual arrangement with a service provider and pays in advance for accessing the in-store farming unit rather than paying per unit sold.

This service-oriented logic of farming is surrounded by value claims regarding such as the varieties it can produce, the premium quality of the produce and its superior environmental performances. For example, the service provider states it can offer 70 different types of plants, and are constantly developing new recipes, which opens up to new market opportunities for the firm and the retailer, e.g. exotic varieties produced locally in the supermarket. These value claims attach to established practices and discourses of good food, e.g. fresh and local produce with good environmental performance. As such, products produced by the in-store farming unit is classified as premium products. However, since they are not produced on arable land they are restricted from using premium-product labels e.g. organic to communicate its sustainability credentials. Thus, it detaches at the same time from established standards associated with premium food. Here, our case study shows that new symbolic meanings of ‘premium products’ are developing in relation to controlled environment agriculture such as ‘beyond organic’ or ‘hyperlocal’. For instance, the farming-as-a-service initiative was promoted as ‘hyperlocal’ production where retail customers could harvest the leafy greens. This marketing practice was challenged by customers’ cultural preferences to purchase leafy greens in plastic bags rather than harvesting salad in the store. This shows that the implementation of farming-as-a-service both attach but also detach from established marketing practices found in retailer-supplier relations.

Discussion

This paper investigates the early uptake of farming-as-a-service to contribute with in-depth insights on their implementation in user contexts. Following the PSS perspective on innovation, FaaS constitutes a novel initiative in food and farming sectors where a digitally augmented in-store farming unit forms the basis for producing leafy greens in supermarkets. According to this perspective, innovation constitutes not only new technology (e.g. intelligent sensors, lights and monitoring equipment’s), but novel configurations of products, services and systems. While research on FaaS has provided insights on abstract accounts of such novel configurations (e.g. Martin and Bustamante [7]), there are few studies that considers how such initiatives are implemented in user contexts. This paper begins to address this gap in knowledge by focusing our attention to emerging practices of FaaS. Case study research were deployed and guided by the following research questions: what are the emerging practices of farming-as-a-service initiatives and how are these developing in relation to the context in which they are implemented?

Proto-practices of service-oriented farming

The case study identifies emerging practices to include prototyping farming-as-a-service in experimental settings, and practices of producing and promoting leafy greens via such services in supermarkets. Practices of prototyping FaaS involved a process of translating and redeveloping the prototype (i.e. the in-store farming-unit) from the experimental setting into a supermarket. Linkages between elements of proto-practices are made in experimental setting, which are subsequently redeveloped in user contexts. For example, ideas of shoppers harvesting leafy greens directly from the in-store farming unit informed developments in the experimental setting. However, such ideas were challenged by established health and safety guidelines as well as consumer expectations of buying leafy greens from supermarkets. Consequently, the in-store farming unit became a no-go zone for shoppers, and products were package in plastic wrappings, which is in accordance with how leafy greens are promoted and sold in supermarkets.

The analysis shows that proto-practices are fluid and unstable as such practices travel from the experimental setting and are reconstructed in user context. Similar to the work of Mylan (2015) this insight identifies that innovation, in this case the development and implementation of farming-as-a-service, is a transformational alignment process in which proto-practices co-evolves with more established practices. Here, linkages between elements of proto-practices have both tight and loose couplings, making such practices fluid and unstable in relation to more established practices. Thus, how product innovation, in this case the in-store farming unit, is appropriated and appreciated in user context has consequences for its implementation and subsequent diffusion.

Understanding the implementation of service-oriented farming

In analysing, the implementation of FaaS in user contexts we examined proto-practices in relation to user settings to account for how service-oriented farming is appropriated and used in intermediate and final market where carriers of practices also include retail staff and shoppers. Here we observed how elements of proto-practices were translated, redeveloped and adapted in relation to more established practices in the market setting. Since links between elements of proto-practice are unstable, they attach to, as well as detach from, more established practices found in the user context. Our analysis shows that meanings associated with service-oriented farming practices were challenged by more established ideas about promoting leafy greens in supermarket settings. For example, ideas about promoting products redeveloped where hyperlocal was identified as premium attribute for service-oriented farming rather than organic, which is an established label for premium products. FaaS also detach from more established ideas about supplier-retailer relations, since the farm is located inside the store. Importantly, practices of operating FaaS are fundamentally performed by a distant farmer, which requires more autonomous farming practices.

By investigating innovation conceptualised as proto-practices that develop in relation with established practices we can begin to reveal the transformative potential of such emerging practices. Indeed, FaaS is a marginal endeavor in the food and farming sector with few numbers of firms operating such services. Nevertheless, our analysis point at linkages being made between elements of service-oriented farming practices, which can be cast as emerging niche practices. These include material elements, e.g. digitally augmented in-store farming units, and competences, e.g. operating an in-store farming unit and meanings such as that controlled environment agriculture is an appropriate way to produce leafy greens.

Conclusions

In conclusion, service-oriented farming forms part of emerging digitally augmented farming practices where linkages between the elements of such practices are being formed by the carriers of such practices. Meanings associated with such proto-practices are very different from more established forms of horticulture since farming is undertaken at a distance and in closed and controlled environments. As such, different sets of competences are needed to manage data about plants rather than the plants themselves. Here, the design and development of in-store farming units builds on the idea that the ecological materiality of the sun, water and soil becomes less critical for food production. As noted by Lockhart and Marvin [29], in-store farming units represents efforts to simplify complex ecologies through technical means. Consequently, rather than building capacity to know ecological materiality, the capacity to capture, circulate, analyze and act on a set of digital data is of particular importance for operating service-oriented farming. Furthermore, the emergence of more autonomous forms of service-oriented farming initiative equipped with artificial intelligence means that it can potentially rescale farming practices where volume is created through multiple and distributed units. In contrast to farms on arable land, emerging proto practices of service-oriented farming emphasises small-scale units that are implemented closer to final consumers, e.g. supermarkets, restaurants or households. In such instances, service-oriented farming initiatives opens up opportunity for more distributed food production where the production is managed to some extent by centralised control-room. As service-oriented farming initiatives develop into more established practices, questions of ‘control’ in Controlled Environment Farming must be scrutinised. Given the value claims surrounding by the early developments of service-oriented farming initiatives, it is therefore important to reveal the contestations and instabilities that may limit efforts to control food production through technical means as well as its transformative potential on market developments. For the development and uptake of digitally augmented and service-oriented farming practices, more research is needed on multiple contexts of applications to learn more about how such practices are appropriated and appreciated in user contexts. Our paper contributes with an analytical perspective to pursue such studies.

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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Appendix: Questions for interviews

1. Welcome

We record (consent ok)

The interview is planned to take 45 min (maximum one hour)

2. The interview and the project

- Short summary: In the project, we investigate farming-as-a-service in a Swedish context.

3. Presentation round

Short presentation of us from Swedish University of Agricultural Sciences

Brief introduction of you

4. Purpose of today’s interview

Capture factors that may be of relevance to the project’s issue.

Understand how your company works and how research can contribute in the best way.

Next step: Publish the results in scientific articles.

5. Farming-as-a-service

Can you describe the company and your production with a focus on the development over the past year?

How do you carry out cultivation with the concept of farming-as-a-service?

What opportunities do you see with your cultivation system when you establish yourself in other environments with the user?

What challenges do you see with your cultivation system when you establish yourself in other environments with the user?

How do you see the possibility of scaling up your business?

Can you tell us more about your logistics chain?

How do you view the relationship with grocery stores or restaurants that use your service? Do you have any contracts?

What is the reason why you established yourself in a store instead of establishing a distribution company?

6. Market development

How do you see the market for your type of business?

How do you think it will develop?

7. Technology development and experiments

Can you describe how you work with the test bed?

How is technology used to enable farming-as-a-service? How is artificial intelligence used?

How do you choose to develop/adopt new techniques?

Are there suitable resellers of the technology you need?

How do you see the people working in the system versus the opportunity with increased development of automation?

8. Knowledge development

How do you train your staff at the company?

Can you tell us more about how you work with customer success to train the staff who use the service in stores or restaurants?

9. Profits with the production system

What benefits do your customers see with your production systems?

How do the authorities view your production systems?

Profits linked to sustainability?

What new research is needed?

10. Thank you for your time!

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