Exploring Aquaponics Systems as part of Food Planning and Environmental Management Strategy, Policy and Sustainable Placemaking: Examining Chinese and UK Food Growing Project Case Studies

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Abstract

This study aims to analyse several factors concerning the role of aquaponics in contributing to food availability in urban, suburban, and rural areas from the perspective of food planning and environmental management strategy and planning policies. When considering the usage of non-arable land in cities and communities to access locally grown fresh food, the hypothesis of this research is that the combination of aquaponics with community gardens and green roofs could be a sustainable approach to local sourced food and, therefore, benefit urban food system. The research applied a case study approach to conduct five semi-structured interviews with aquaponics practitioners in the UK and China. Aiming to explore the potential contribution of aquaponics to the urban environment and food systems as part of food planning strategy and policy and an approach to sustainable planning and placemaking. The results of the study show that the differences in policy and culture between the two countries have led to some similarities and differences in the outcomes of the cases. The development of aquaponics can bring benefits to cities in terms of education, water conservation and place-making in both UK and China. Despite aquaponics offers many benefits to cities, the lack of specific policy support, site availability and high entry cost have limited the development of aquaponics in cities in both UK and China. There are many more examples of aquaponics in China, some of which are in or near cities. Participants from China demonstrated that they utilized the grants and subsidies more effectively.

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CHAPTER 1. INTRODUCTION

This study aims to analyse several factors concerning the role of aquaponics in contributing to food availability in an urban, suburban and rural areas from the perspective of food planning and environmental management strategy and planning policies in the UK and China. The purpose of choosing the case studies in these two countries was to identify how aquaponics is practised in the context of varying cultures and policies between China and the UK.

Aquaponics is a farming method which combines aquaculture and hydroponics to produce plants and fish (Bernstein, 2011). In an aquaponics system, chemical fertilisers are not required, fish waste is converted to nutrients by microorganisms, which are absorbed by plants, resulting in clean and purified water returned to the fish tank (Bernstein, 2011). According to Sayara et al. (2016), aquaponic systems use up to 80% less water than traditional soil-based growing method. Based on the characteristics of aquaponics systems and the availability for cities to distribute agricultural products, urban aquaponics may have a positive impact on sustainable food production to locally sourced food and, therefore, benefit the sustainability of cities (Goddek, Joyce, Kotzen, & Burnell, 2019). Based on the focused literature review this research attempt to discover the relevant positive and negative aspects of aquaponics and urban agriculture within urban food and planning systems.

This comparative research was conducted by using qualitative methods. Qualitative methods are an inquiry that employs unique methodological traditions and analyses a social issue or human theme through qualitative inquiry (Srivastava & Thomson, 2009). Fieldwork consists of case studies, semi-structured interviews, and site observations undertaken on both a virtual and physical basis in order to acquire findings for the study.

Rationale

The global population is increasingly urbanized and is expected to reach 9.8 billion by 2050 (United Nations, 2018). Over 55 percent of people in the world live in urban areas (United Nations, 2018). The additional urban land for agriculture is limited and competitive with the growing construction (Goldstein et al., 2017). When considering the usage of non-arable land in cities and communities to access locally grown fresh food, the hypothesis of the combination of aquaponics with community gardens and green roofs could be one of the sustainable approaches to achieve it. The rationale of this study focuses on the existing research that suggests the integration of aquaponics systems within green roofs and community gardens, which however are limited (Thomaier et al., 2015; Khandaker and Kotzen, 2018). As a result, there is a deficiency in research regarding the role aquaponics could play in contributing to food systems, which should be an integral component of food planning strategies and policies, as well as a sustainable approach to planning and place-making. Therefore, conducting this study proves valuable in contributing toward bridging the existing research gap.

Research questions

The research questions outlined serve a vital role in this thesis, as they are instrumental in examining the significance and practicality of urban aquaponics in the context of urban food system.

Question 1. How could urban aquaponics contribute to urban food systems and what are the difficulties that it may encounter?
Question 2. Is it feasible to develop aquaponics as a part of green roofs and community gardens in an urban setting as a contribution to sustainable urban food systems?
Question 3. Could the planning system be more responsive to consider aquaponics as part of sustainable food system?

Aims

This research aims to explore the potential contribution of aquaponics to the urban environment and food systems as part of food planning strategy and policy and an approach to sustainable planning and placemaking. Additionally, the research aims to understand whether aquaponics can be included within green roof design and community gardens.

Objectives

There are five objectives of this research. The first is to explore aquaponics' knowledge, focusing on design, place setting, and advantages and disadvantages compared with conventional agriculture through literature review. The second is to explore the planning system in relation to the urban sustainable food system and urban agriculture in terms of policy through literature review. The third is to carry out fieldwork through five chosen case studies based on criteria related to the research aim. The fourth is analysing the findings from the case studies. The last objective to report findings, write and submit the final thesis. All the objectives are comprehensively addressed and clearly explained at the beginning of each chapter, ensuring coherence with the content presented in each respective chapter.

CHAPTER 2. THEORETICAL FRAMEWORK

Chapter 2 begins with an overview of a brief history of sustainable development and the impacts of climate change and growing population on the environment and cities. This has brought to light the problem of pollution and inadequate use of urban agricultural land.

Next, this chapter reviews the current literature on urban food and the planning system in the UK and China, an avenue of which is national policies. The major policies and strategies of urban food and planning system concerning food have been identified to provide background information in relation to policies and specific evidence at national and more local levels for the further discussion. The current urban food and planning strategies have also been identified and discussed to highlight the interaction between each other.

This is followed by an overview of urban agriculture worldwide, the UK and China with an explanation of the definition, benefits and challenges of the development of urban agriculture in cities.

Moreover, the interaction between planning system and urban agriculture has been discussed. The issues, difficulties and improvement of the development of urban agriculture have been explained. The thesis covers the reviews of the benefits that the urban agriculture possesses and how it contributes to the urban environment and local communities, in result to facilitate the planning systems to achieve their goals regarding environmental missions.

Finally, this chapter will end with a reviewing the existing aquaponics form in cities with a focus on making such as spaces, community gardens, living walls, rooftops and discussing aquaponics as an alternative farming method within urban agriculture to provide a conceptual framework for further analysis in this thesis.

2.1. Environmental issues and sustainable development

In the past 30 years, a continuing United Nation (UN) conference has identified elevated the environmental issue levels (Luterbacher and Sprinz, 2001). During the 1972 conference held in Stockholm, environmental issues were primarily considered as local problems (Luterbacher and Sprinz, 2001). These environmental issues were seen to arise domestically and had corresponding effects on their surroundings (Luterbacher and Sprinz, 2001). Following the Brundtland commission report acquired from United Nations Conference on Environment and Development (UNCED) in 1987, the concept of sustainable development was formally adopted in 1992 and has been kept since in subsequent conferences held at Rio de Janeiro (WCED, 1987; Meadowcroft, 2000). Sustainable development has been defined as *"the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs"* (WCED, 1987). According to Xavier *et al*. (2019), Agenda 21 action plan indicated the significance of domestic implementation and action to mitigate environmental and social issues globally.

Climate change is highly understood as one of the most pertinent examples of global environmental issues (Luterbacher and Sprinz, 2001; IPCC, 2018). The Intergovernmental Panel on Climate Change (IPCC) has delved deeply into the causes and effects concerning climate change since 1988 (Luterbacher and Sprinz, 2001). Subsequently, identifying in their reports that climate change has been caused by human activities (Luterbacher and Sprinz, 2001; IPCC, 2018). There are several global issues identified that are required to be mitigated. For instance, the reduction of biodiversity, the imbalance in the nitrogen and phosphorus cycles, the ocean acidification and mass land alterations (Luterbacher and Sprinz, 2001; IPCC, 2018). Several of these issues are reflected in cities, which have specific concerns regarding soil degradation, loss of biodiversity habitats and degradation of land in relation to the most productive areas of the city (Rawlins *et al*., 2015; Goddek *et al*., 2019).

Globally, 68% of the population will live in urban areas by 2050 and there will be approximately 70 million people moving into cities every year between now and the latter part of the 21st century (United Nations, 2018). When faced with this growing urban population, one of the challenges for urbanites is how to meet environmental requirements for community-based food with minimal usage of non-renewable energy, urban farmland, and minimal production of pollution (Nicholls *et al*., 2020). Given the prominence of food on the political agenda, it is not surprising that urban agriculture has gained worldwide attention for its role in supplying local food (Mbiba and Van Veenhuizen, 2001; Diehl *et al*., 2020;).

2.2. Urban planning strategies in terms of food within sustainable cities

2.2.1. The UK

To maintain global warming levels below 1.5 degrees Celsius between 2030 and 2052 as suggested by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2018), the UK's government policies have provided key drivers for encouraging sustainable food planning strategy and making to address environmental issues in both national and regional level (DEFRA, 2022). However, scholars argued that The Agriculture Bill 2019-21, intended to reform farming and food supply, is currently being discussed in parliament but is deemed insufficient in its current form to address the issues at hand (Shanks *et al*., 2020).

As a result of the development of cities, ecological footprints are created, which may pose a significant threat to the habitats of many species (Rees and Wackernagel, 1996). The demand to feed the community corresponds accordingly with the ever-increasing number of people encountered by major cities worldwide (Nicholls *et al*., 2020). According to DEFRA, The UK food system has just undergone its biggest stress test since the Second World War. In the past two years COVID-19 caused a high death rate and economic losses, including the mass furlough of people, with severe food insecurity and hunger (DEFRA, 2020, p.6). Furthermore, Brexit and Russia's invasion of Ukraine has resulted in sharp increases in food prices in UK (DEFRA, 2022). Therefore, urban farming is vital to the local community as it plays a significant role in sustaining the cities in the future. Parham (2021, p. 6) stated that "*conceptualisation of edible landscapes as a pathway for reconnecting urban people with food processes while enhancing biodiversity and ecosystem services*".

As the UK's food strategy has been reformed since leaving European Union, the future of agricultural governance is being debated. Some see this as both a threat and an opportunity (Mattioni *et al*., 2022). Because of global conflicts and the general decline of the UK's global influence, the potential vulnerability of the UK supply chain is increased (Lang, 2020). To reduce supply chain instability requires increased domestic production as a way to enhance food safety and reduce the environmental footprint of food items. Food production should be provided in natural and designed landscapes in well-designed places (NPPF, 2019 p. 27). A study conducted by Pretty *et al*. (2005) indicates that urban agriculture can reduce food miles which may result in lowering the overall generated embodied energy and corresponding carbon dioxide discharge.

Following the UK's exit from the EU, national policies render an overview of the rules and regulations for agricultural policy with a major priority of achieving Net Zero target (DEFRA, 2020; Cammies *et al*., 2021) to address environmental, health and economic problems. Among these, Table 1 presents those that are most relevant to the purpose of this study, which are listed below (Table 1). Arguably several of these issues have been highlighted in detail in the recently published UK’s policy paper of Government Food Strategy (GOV. UK, 2022). The strategy aims to promote the availability of healthy, affordable, and safe food for all citizens of the United Kingdom. The focus is on restoring and enhancing our natural environment as well as increasing the resilience and sustainability of food production and supply. Two of the main objectives of the Government Food Strategy are to provide choices and access to high-quality products that support healthier and home-grown diets for people through a sustainable, nature-friendly, affordable food system, and to provide sustainable sources of protein (GOV. UK, 2022).

For instance, the Birmingham Food System Strategy is an eight-year plan aimed at creating a sustainable and healthy food system in the city. It has been developed through a three-year collaboration with partners and citizens to ensure it supports all stakeholders. The strategy takes a whole system approach, considering various aspects such as food sourcing, education, waste, and the impact on different entities involved. It provides strategic direction for the development of an Action Plan, which will be a collaborative effort and not the responsibility of a single organization (Birmingham City Council, 2022). A positive example of the best sustainable food practices in cities conducted by Mattioni *et al*. (2022), shows that Birmingham (UK) is considered as one of the best sustainable food practices due to its Emergency Food Response (in response to the pandemic) and ensuing new Emergency Food Plan Food Conversation. A series of activities have been designed to listen to "Seldom Heard Voices", as part of its "Healthier Food City Forum", which will contribute to the development of urban food strategy (Mattioni *et al*. 2022).

Table 2.1. The information of national policies that support a more environmentally sustainable approach to urban agriculture (Compiled from GOV. UK, 2018; DEFRA, 2020; DEFRA, 2021; NPPF, 2021; DEFRA, 2022).

Key documents policy sets	**The most relevant aspects identified based on the key documents for this study**
National Planning Policy Framework (NPPF, 2021)	The relevant sections are listed below: • NPPF6 - Building a strong, competitive economy • NPPF9 - Promoting sustainable transport • NPPF11-Making effective use of land • NPPF12-Achieving well-designed places • NPPF13-Protecting Green Belt land • NPPF14-Meeting the challenge of climate change, flooding and coastal change • NPPF15-Conserving and enhancing the natural environment
Government food strategy (DEFRA, 2022)	• Committed to reducing agricultural greenhouse gas emissions and mitigating climate change To ensure: • high environmental and animal welfare standards • government's carbon budgets • environmental targets • the net zero strategy
An Agricultural Transition Plan 2021 to 2024 (DEFRA, 2020)	To achieve: • a renewed agricultural sector, producing healthy food for consumption at home and abroad, where farms can be profitable and economically sustainable without subsidy • farming and the countryside contributing significantly to environmental goals including addressing climate change To: • Link with wider Defra and government policies of The 25 Year Environment Plan and Net Zero and climate change adaptation
Guidance for Environmental Land Management schemes: overview (DEFRA, 2021)	Sustainable Farming Incentive aims to: • encourage actions that improve soil health • recognise how moorland provides benefits to the public (public goods) • improve animal health and welfare by helping farmers with the costs of veterinary advice for livestock Farmers will be paid to provide public goods, such as, improved water quality, biodiversity, climate change mitigation and animal health and welfare.
A Green Future: Our 25 Year Plan to Improve the Environment (GOV. UK, 2018)	• Paying for environmental and animal welfare outcomes • Improving farm prosperity • Direct Payments, including lump sums • Regulation of legal requirements

The National Planning Policy Framework was published by the Government to provide a balanced approach for England concerning the economic, social, and environmental aspects of development (NPPF, 2021). Consequently, local plans and neighbourhood plans must incorporate the policies within The National Planning Policy Framework, and it is a 'material consideration' when deciding on planning applications (NPPF, 2021). As a result of the planning system in England, the ecosystem elements are largely ignored, and are heavily influenced by transportation, economic, and demographic factors (Rawlins *et al*., 2015).

According to current proposals for planning reform, the planning process should incorporate provisions to protect and enhance the environment (Local Government Association, 2022).

England's planning system has recently undergone changes that may affect how land and ecosystem services are managed. Sustainable development must ensure environmental protection, enhancement, and economic growth, while protecting and enhancing the natural and historic environment (NPPF, 2021). Through the development of local neighbourhood plans, the National Planning Policy Framework aims to achieve this by transitioning from national spatial planning to community engagement and partnership (NPPF, 2021). As part of these plans, neighbourhood priorities will be established to address climate change and protect urban natural and historic resources (Rawlins *et al*., 2015). As centres for the development of mitigation and adaptation strategies, cities may provide a potential platform for the widespread adoption of these strategies (Grimm *et al*., 2008).

The Green Belt is a planning policy to prevent urban sprawl by keeping the land permanently open. It is defined and maintained by the local authorities in their jurisdictional area (Barton & Rankl, 2022). The local planning authorities (LPAs) are expected to establish the Green Belt boundaries within Local Plan (Barton & Rankl, 2022). The estimated size of the Green Belt in the UK is 16,382km^2 or 6,324 square miles as recorded at the end of March 2022, and 66% of each of the Green Belt land is used for agriculture (Barton & Rankl, 2022). Agriculture and forestry purposes are the one of the exceptions for construction of new buildings on Green Belt land, which is listed in the National Planning Framework (NPPF) chapter 13 (NPPF, 2021). According to NPPF (2021), the purposes of Green Belt are:

- "To check the unrestricted sprawl of large built-up areas
- To prevent neighbouring towns merging into one another
- To assist in safeguarding the countryside from encroachment
- To preserve the setting and special character of historical towns
- To assist in urban regeneration, by encouraging the recycling of derelict and other urban land"(NPPF, 2021).

Agriculture is a type of land use in cities, and the viability of urban agriculture is highly affected by planning systems (La Rosa *et al*., 2014). In accordance with planning permission posted on the GOV.UK website, all agricultural activities involving building something new, modifying or changing a building may require planning permission (GOV.UK, n.d.). Notably, it shows that local planning has a significant impact on land access for agricultural development in cities. According to Hardman *et al*. (2022), one of the obstacles to the development of urban agriculture is land access, which also encompasses the soil quality. Similarly, a survey conducted by Carey and Hochberg (2019) identified that the second biggest issue that stops urban agriculture to be promoted is land access. Moreover, biodiversity in the UK was recently assessed in a report prepared by the National Biodiversity Network (NBN, 2021), which demonstrates that the UK retains only half of its natural biodiversity, ranking lowest among the G7 countries. As soil communities change and biodiversity is lost, ecosystem multifunctionality and sustainability may be threatened (Wagg *et al*., 2014; Koopmans *et al*., 2017; Cusworth *et al*., 2022).

Literature on the subject highlighted integrating agriculture into urban planning and city development in many cities around the world has remained low (Mbiba and Van Veenhuizen, 2001). This result is also coherent with the statement from Parham (2020) that in some urban masterplans there is a lack of specific planning for food on the urban fringe. For example, orchards, market gardens, community gardens and dairies, or even further out, arable farming are not considered in the masterplans (Parham, 2020). Similarly, Rawlins *et al*. (2015) emphasized the planning system in England pays insufficient attention to ecological elements. DCLG (2011), cited in Rawlins *et al*. (2015) stated that the new proposals for planning reform to protect and enhance the natural environment, which might have the potential to have a synergistic effect on the development of urban agriculture.

The development and promotion of urban agriculture bring more benefits to cities (La Rosa *et al*., 2014). However, there is still competition between agriculture and construction in the use of land (Goddek *et al*., 2019). Recently a British local farm in Cambridgeshire was forced to move away because drainage works for the construction of a new town reduced the supply of water to the farm (Wicked Leeks, 2022).

2.2.2. China

The Asia and the Pacific Sustainable Development Goal (SDG) Progress Report 2019 evaluates the region's progress towards the 17 SDGs and emphasizes the need for accelerated action to achieve them by 2030. It serves as a call to action, revealing that Asia and the Pacific are not on track to achieve any of the 17 SDGs by 2030 based on their current trajectory (United

Nations & Economic and Social Commission for Asia and the Pacific, 2019). As a result of the COVID-19 pandemic, the number of people experiencing food insecurity is expected to rise from 135 million in January 2020 to 265 million by the end of 2020 (FAO, IFAD, UNICEF, WFP and WHO, 2020). China shares the same problem with the rest of the world: food self-sufficiency is declining, arable land is decreasing, and urban development is encroaching on a large percentage of farmland. By 2025, China could have a food deficit of 130 million tons (FAO, 2019).

People in China are concerned that the country's arable land is decreasing every year, making it impossible to feed China's 1.4 billion people (Yu *et al*., 2022). Scientific projections predict that China's population will reach 1.5-1.6 billion by 2040 or 2050 (He and Fang, 2017). The government's work report shows that China's arable land fell from 1.951 billion mu (130.07 million hectares) in 1996 to 1.827 billion mu (121.8 million hectares) in 2006 (Mu is an officially standardised unit of area measurement in China, 100 mu is equal to 6.67 hectares), a reduction of 124 million mu (8.27 million hectares) in ten years (Ministry of Natural Resources of the People’s Republic of China, 2007). In the Outline of the Eleventh Five-Year Plan for National Economic and Social Development Plan adopted at the Fourth Session of the Tenth National People's Congress of China in 2006, it was proposed that 1.8 billion mu (120 million hectares) of arable land is a legally binding target and a red line that cannot be crossed (Ministry of Natural Resources of the People’s Republic of China, 2007). China currently has a population of around 1.4 billion, and with 1.8 billion mu (120 million hectares) as the bottom line, the average arable land per capita is more than 1.2 mu (0.08 hectare) (National Food and Strategic Reserves Ministration, 2022). Studies have shown that 370 kg of grain per capita is a clear threshold and reaching this level would be able to meet the current food consumption needs (Ministry of Natural Resources of the People’s Republic of China, 2007). Therefore 1.8 billion mu is the lower limit of China's arable land holdings at this stage (Ministry of Natural Resources of the People’s Republic of China, 2007).

Land ownership in China is governed by a socialist public ownership system, which includes national or collective ownership of peasants under Article 2 of the Law of Land Administration of the People's Republic of China (Wang, 2016). To clarify, there are two types of land ownership in China; one is owned by the government, and the other is owned by peasant collectives (Wang, 2016). Additionally, according to law, the state may requisition peasant collectives' land in order to serve the public interest, and in accordance with the standard in law, proper compensation should be paid to the owners and users in a lump sum (Wang, 2016). Other than the two landowners mentioned above, other individuals cannot possess the land, but may only obtain the right to use it through certain methods such as purchase (Wang, 2016). Therefore, it is necessary to obtain land rights from the state or peasant collectives in China prior to utilizing the land formal (Wang, 2016). Likewise, this rule applies to urban aquaponics in this study, cultivation of land by residents without a right to use it, this is classified as informal agricultural activities and may even be considered illegal (Wang, 2016).

It has been warned by the FAO that the 12 mega-cities will have difficulty feeding themselves in the future (Wang, 2016). As a result of urbanization, food needs are increasingly centralized in densely populated areas, and the rural hinterlands are responsible for providing food for these densely populated areas (Wang, 2016). It should be noted, however, that the rapid expansion of urban built-up areas has reduced the availability of rural hinterlands for the basic food supply (Wang, 2016). It was predicted by Lester Russel Brown in 1994 that China's rapid industrialization would overwhelm the export capacity of the United States and other countries, causing food prices to rise worldwide (Wang, 2016). A further consequence of this rapid urbanization was the separation of agriculture and cities in China (Wang, 2016). Due to the distance between agricultural production and markets, food prices rose, energy shortages occurred, and food risks increased (Wang, 2016).

The challenge of food security includes both the quantity and quality of food. In spite of having 7% of the world's arable land, China uses 35% of the global total amount of chemical fertilizers and pesticides (Jin & Fang, 2018). Overuse of chemical products has resulted in a decrease in food quality, such as chemical residues. According to a survey conducted among 328 urban residents in Beijing on food safety, only 20% believe the vegetables they purchased were safe, illustrating consumers' trepidation regarding food safety issues (Zhang, 2013 cited in Wang, 2016). In light of all of these food security concerns, it would be prudent to reduce the amount of energy used in the production, transportation, and processing of food (Wang, 2016).

At present, the urban environmental construction in China is heavily influenced by the "City Beautiful Movement", which is overly concerned with visual and formal beauty (Wang, 2016). As a result of the proliferation of ostentatious "image" and "administrative achievement" projects, there are numerous large urban squares that lack actual function (Wang, 2016). For example, big lawns that look good but aren't accessible to the public, or large flower baskets that consume considerable water but wither quickly (Wang, 2016).

Landscape design in China is biased towards formal beauty, resulting in many urban problems and preventing the country from achieving sustainability (Wang, 2016). The program costs a lot, but serves only a "make-up" function, and it is considered a burden on urban development by Yu and Ji (Yu and Ji, 2000 cited in Wang, 2016). Additionally, although city beautification involves considerable investment in terms of construction and maintenance, it has limited ecological and social benefits, which may undermine the city's ability to develop sustainably (Wang, 2016).

Early studies of Chinese food systems were based on agronomy, ecology, and sociology, primarily from the perspective of ecological economics to examine the energy flow of agricultural ecosystems, logistic development and its impact on economic and social development, and supervision and regulation of social policies and regulations (Yang *et al*., 2020). As compared to other professions, urban agriculture has entered the field of architecture and planning earlier in China (Yang *et al*., 2020). However, the content relating directly to the food system has been delayed. Despite the evolution of food systems research from city-food relationships to integrating food into urban planning and design, food system still has a relatively low profile with urban systems in terms of support and recognition. A sustainable urban lifestyle also required food issues to be considered as part of an urban agriculture-oriented productive community food system (Yang *et al*., 2020).

2.3. Urban agriculture (UA) and horticulture worldwide, UK and China

To provide better clarity in distinguishing urban agriculture, it is crucial to introduce the concepts of agriculture and horticulture. Urban agriculture refers to the practice of producing food within cities (Ackerman *et al*., 2014; Van Veenhuizen and Danso, 2007). Agriculture is the systematic cultivation of plants and the rearing of animals for the purpose of producing food, fibber, medicinal plants, and various other products essential for sustaining and improving human life (National Academies Press, 2019). Horticulture is a specialized branch of agriculture that encompasses the scientific, artistic, and practical aspects of growing and cultivating fruits, vegetables, flowers, and ornamental plants, serving both aesthetic and consumption purposes (Winchester, 2022). Urban agriculture focuses exclusively on urban environments with the goals of enhancing food security and promoting sustainability within cities. In contrast, agriculture has a wider scope and can be practiced in both rural and urban settings, addressing diverse agricultural products and commercial demands. Horticulture, as a distinct branch of agriculture, is dedicated to cultivating fruits, vegetables, and ornamental plants, serving both aesthetic and consumption purposes.

Urban agriculture practice includes crop cultivation, animal husbandry, and diverse farming methods, incorporating both conventional and innovative approaches (Mougeot, 2005; Roggema, 2016). In the Global North, Urban agriculture is largely concerned with the production of fruit and vegetable crops (Orsini *et al*., 2013; Edmondson *et al*., 2020), and can be achieved in many ways. For example, community gardens, rooftop growing, allotments, controlled environment horticulture, and domestic gardens (Sam and Hui, 2011; Opitz *et al*., 2016; Edmondson *et al*., 2020). By utilizing local resources which include land, water, labour, and organic waste, urban agriculture produces food for local residents (Sam and Hui, 2011). It reshapes physical locations while involving a "normative spatial vision" that contributes to the construction of notions of space overuse (Purcell, 2001, p. 182).

The sustainability of each type of urban agriculture is generally characterized as follows:

- Community gardens foster social connections, contribute to local food production, and repurpose underutilized land (Fletcher and Collins, 2020).
- Rooftop farming utilizes unused urban spaces, reduces the need for transportation, and employs efficient irrigation and resource management systems (Sam and Hui, 2011).
- Allotments promote urban sustainability by fostering local food production, biodiversity, community engagement, and green space preservation (Fletcher and Collins, 2020).
- Controlled environment horticulture optimizes resource use, reduces water and pesticide usage, and enables year-round production in a controlled setting (Gómez *et al*., 2019).
- Domestic gardens provide opportunities for local food production, enhance biodiversity, and contribute to urban green spaces (Gaston *et al*., 2005).

In recent years, urban agriculture has been popularised in discussions pertaining to sustainable cities due to its extensive benefits including the reduction of the urban heat island effect. Moreover, these benefits also provide habitat networks within cities, protecting agricultural knowledge among urban populations, and increasing human health and well-being (Ackerman *et al*., 2014). Urban agriculture is therefore considered a powerful tool to address those associated with the Sustainable Development Goals (SDGs) 2: zero hunger, 3: good health and wellbeing, and 11: sustainable cities and communities (United Nations, 2015; Fletcher and Collins, 2020). Additionally, in the UK, increasing the sustainability, productivity and resilience of the agriculture, fishing, food and drink sectors are the key outcomes highlighted in the corporate report of the Department for Environment, Food and Rural Affairs Outcome Delivery Plan: 2021 to 2022 (Gov.UK, 2021).

Urban agriculture benefits the local ecological system, communities, and the economy, and also benefits the local people by contributing to their food security, community building, and education, and increasing social health (Dimitri *et al*., 2016). By transforming reproducible spaces into unique places, Urban agriculture, as a collective socio-cultural process, can contribute to place-making (Koopmans *et al*., 2017). Several scholars agree that urban farming could contribute to the future supply of high-quality produce for urban populations while also reducing food miles by growing fresh food locally (Sam & Hui, 2011; Santos, dos, 2016; Goddek et al., 2019). However, there are many challenges associated with urban agriculture, including the need for land, soil, and water and the lack of space for large-scale urban farms (Goldstein *et al*., 2017). Recent studies on urbanization and food security have pointed out that agricultural use and urbanization may compete for land in China, estimating a 5.3% loss in cropland and 8.7% decrease in crop output by 2030 (Wang *et al*., 2021).

Community gardens and allotment are a widespread form of Urban agriculture, offering agricultural opportunities to those without access to land (Fletcher and Collins, 2020). A plot is a piece of land, available for rent, that is primarily intended for growing fruit and vegetables on an allotment site, which may host many small gardens (Fletcher and Collins, 2020). In many medium-high density cities around the world, allotments are the only sort of agriculture that represents a large land area devoted to Urban agriculture besides intensive and greenbelt farming (Fletcher and Collins, 2020). Community gardens and allotment gardening share many characteristics (Fletcher and Collins, 2020). However, in the United Kingdom, community gardens provide free access for everyone and don't have a waiting list. In contrast, most allotments are owned by the local authority, managed by an allotment association, and cultivated by individuals or families. (GOV.WALES, 2021). Carey and Hochberg (2019) conducted a classification of urban agriculture in the UK, specifically focusing on land-based commercial, social enterprise, or community-led trade initiatives. The classification, as presented in Table 2.2 below, excludes allotments due to the specific research focus of Carey and Hochberg, although allotments are considered a part of urban food growing. Therefore, the table 2.2 has been modified by the author based on Carey and Hochberg (2019).

Table 2.2. The UK's land-based urban agriculture has been modified by the author based on Carey and Hochberg, (2019).

Land-based	**Description**	**Examples**
Allotment	A piece of land that is divided into sections and leased to individuals or families for the purpose of gardening.	Folly Lane Allotment Site in St Albans Beechwood in Allotments London
Urban brownfield and green spaces	Small-scale horticultural sites. Managed by social enterprises or individual growers marketing produce at farmers markets or directly via box schemes or independent retailers. Usually limited to veg or salad production.	Edible Futures in Bristol Growing Communities micro-sites in London
Urban farm	A city farm that is producing food and plants for sale (usually alongside other educational and community focussed activities)	Meanwood City Farm in Leeds, Heeley City Farm in Sheffield
'Community' Farm established to supply specific urban outlets	Located in or very close to the city. Usually specifically set up to deliver on strong local, environmental, and social values with consumer membership (in some cases) education and direct marketing focussed on the city. Scope for wide range of production and marketing links with rural farms within the city region.	The Community Farm Bristol Wortley Hall Walled Garden CSA farms
Producer and/or marketing co-operatives or business networks	Network of co-operating growers or retail/grower partnerships focussed on using city market to deliver on strong environmental and social values. Scale through co-operation enabling access to wider market opportunities (e.g. procurement).	Manchester Veg People Tamar Grow Local Growing communities
Small and medium-scale rural farms in the city region	Farms with predominantly but not exclusively local supply chains using marketing channels such as box schemes, farmers markets, farm shops, for some or all of their produce. Typically, but not necessarily member of a city region focussed producer and/or marketing network.	Plowright Organic, Somerset

Carey and Hochberg (2019), as shown in Table 2.2, have identified a variety of urban agriculture categories in the United Kingdom. However, this study specifically focuses on urban brownfields and green spaces, as well as urban and community farms within those categories of urban agriculture. Due to the fact that these types of urban agriculture are based on community values and are intended to serve the local community, which is the primary focus of the research. Additionally, a similar list of categories of Chinese urban agriculture will be presented in the following section to provide a visual and comparative effect between the two countries.

Chinese urban agriculture was introduced and implemented by some large cities such as Beijing and Shanghai during the early 1990s (Lang & Miao, 2013). Urban agriculture geographically refers to both peri-urban and intra- urban agriculture in China (Luehr et al., 2020). However, scholars augured that long term research on Chinese urban agriculture could not be carried out due to insufficient fundings for scientific research, which also suggests a lack of interest in urban agriculture (Yan et al., 2022).

A study conducted by Luehr *et al*. (2020) examined three distinct forms of Chinese urban agriculture including small-scale intra-urban, capital-intensive intra-urban and peri-urban agrotourism, which is listed in the table 2 below. Researchers argue that these three types of agriculture to be profoundly significant in the Chinese context (Luehr et al., 2020). In small-scale intra-urban agriculture, residents mainly grow for their own consumption, while a few entrepreneurs sell their crops for profit (Luehr et al., 2020). The majority of capital-intensive, intra-urban agriculture organizations are privately owned and have close connections to researchers and industry (Luehr et al., 2020). Additionally, it appears that most agrotourism farms are privatized, and the labour is often sourced locally (Luehr et al., 2020). The municipal, provincial, and national levels of the state are involved in all forms of urban agriculture, often acting as policy enforcers in intra-urban areas and, alternatively, providing incentives to encourage production in peri-urban areas (Luehr et al., 2020). It has been argued by researchers that small-scale intra-urban agriculture is an underappreciated practice by local governments (Horowitz and Liu 2017 cited in Luehr et al., 2020). Conversely, China is heavily researching and developing capital-intensive intra-urban food production, including vertical farming technologies such as plant factories, hydroponics and aquaponics, as well as 3D-printed and artificially synthesized food (Hayashi 2016). It has also been widely recognized that peri-urban agrotourism farms have been largely pursued by governments, shaping the outskirts of cities and the way urban citizens access natural environments (Yang et al., 2010 cited in Luehr et al., 2020).

Table 2.3. Three forms of Chinese urban agriculture were examined by Luehr *et al*. (2020)

Urban agriculture	**Description**	**Governance**

Intra-urban small-scale	Small-scale intraurban agriculture is primarily conducted by local residents, along with a few entrepreneurs who cultivate crops for the market.	Unregulated; prohibited in some places
Intra-urban capital-intensive	The majority of capital-intensive, intra-urban agriculture organizations are privately owned and have strong links with researchers and industry.	State neither incentivizes nor prohibits
Peri-urban agrotourism	Agrotourism farms are generally privately owned, and local labour is typically employed	State provides incentives

The three distinct forms of Chinese urban agriculture were analysed by Luehr *et al*. (2020), which provides a general information of the features of each type. As explained above, Luehr *et al*. (2020) examined small-scale intra-urban, capital-intensive intra-urban and peri-urban agrotourism forms, implying that there is a possibility of other types of urban agriculture may exist that were not included in their analysis. The scope of this study does not exclude a range of scales and forms of initiation, including those initiated by individuals, entrepreneurs, and governments. Therefore, these three forms of Chinese urban agriculture are considered as reference of this study. As previously explained, in the UK, a large number of local authorities operate allotment gardens. However, this is not the common form of urban agriculture in China, which is primarily organized on an individual basis (Table 2.3). Consequently, this provides a framed view of the specific land use that this study examines in relation to aquaponics, which encompasses the entire scope of this research.

Community gardens include small wildlife gardens, fruit, and vegetable plots on housing estates, polytunnels, and large city-based community gardens (Firth *et al*., 2011). Larger gardens sometimes serve as community hubs, providing not simply a green space, but also educational and training opportunities for residents. Furthermore, community gardens may operate in a variety of ways (Firth *et al*., 2011). Usually, each community garden evolves to meet the needs of the local community. They might then attract a broad array of users across multiple age groups (Firth *et al*., 2011).

Community gardens bring people together, which improves individual and community confidence (Holland, 2004). Open spaces provide an opportunity for people to grow organic food, and healing centres for those with mental and physical disabilities, along with opportunities for recreation, fitness, therapy, and education (Holland, 2004). Throughout the history of the UK, community gardens have been an important source of fresh food for residents (Holland, 2004). During the Second World War, for example, allotments provided affordable fresh vegetables and fruit to inner-city areas (Holland, 2004).

Green roofs are becoming more popular as a method of urban farming and being utilized for a variety of productive and sustainable purposes (Sam & Hui., 2011). Green roof systems are living vegetation systems that are installed on roofs to support the growth of plants (FLL, 2008). In addition to improving city dwellers' quality of life, green roofs could also reduce air pollution in cities, improve stormwater management, enhance biodiversity, and mitigate the adverse impacts of urban heat island (Luckett, 2009). It has been demonstrated that green roofs offer a variety of benefits ranging from amenities to ecological benefits as well as technical advantages and financial benefits (Hui, 2006) There is a growing consensus that green roofs may have a positive impact on cities both in terms of visual, aesthetic, and climatic aspects (Weiler and Scholz-Barth, 2009).

The installation of a green roof can also serve as a source of produce and food for the local community. Green roofs can provide additional useful and meaningful functions when edible rooftop gardens or farming areas are established on buildings (ARGP, 2008; Canadian CED Network, 2007). Brown and Carter (2003) outline four main purposes for agricultural green roofs, which include food production, active recreation, re-using wastes and educational opportunities.

2.4. Aquaponics in cities

The aquaponics method is derived from an agricultural system that utilises fish excretions as a nutrient source for plant growth (Bernstein, 2011; Somerville *et al*., 2014; Goddek *et al*., 2019). In aquaponics system, the waste produced by fish is broken down by microorganisms into nutrients, which are then absorbed by plants, resulting in clean and purified water being returned directly to the fish tank (Bernstein, 2011). According to Sayara *et al*. (2016), aquaponic systems use up to 80% less water than traditional soil-based growing methods. Dallsgaard *et al*. (2013) highlighted that water can be reused 95–99% when recirculated in an aquaponic system. Therefore, it is argued that aquaponics systems serve as a sustainable farming approach for urban agriculture (Somerville *et al*., 2014). Unlike hydroponics, aquaponics can also produce fish, contributing to greater economic viability in urban areas with diverse dietary requirements (Bernstein, 2011; Somerville *et al*., 2014; König *et al*., 2016).
Aquaponics might act as an alternative growing method to maintain sustainable urban farming that may positively impact food production and the environment (Adler *et al*, 2000; Goddek *et al*., 2019). Rakocy *et al*. 2016 cited that when compared with conventional farming methods,

aquaponic systems can not only save a considerable amount of water but also reduce the local community's reliance on petrochemical fertilisers and artificial nutrients. However, the initial investment in aquaponic systems is substantial, along with moderate energy inputs and skilled management (Cammies *et al*., 2021). In addition to producing pure food, an aquaponic system can also serve a variety of purposes, such as aesthetics, education, hobby, or entertainment, and should be designed accordingly, with the components (fish tanks, biofilters, hydroponic units) meeting the various requirements (Junge *et al*., 2017).

Aquaponics can be considered as an integral part of a global solution to improve the rate of food production (Adler *et al*, 2000). In contemporary urban settings, producing more food in urban areas is considered as part of addressing food security and a worldwide food crisis (Konig *et al*., 2016). Researchers are arguing or positing that by adapting to new alternative growing technologies as well as innovative technologies such as vertical farming and living walls, aquaponics systems are becoming more effective and sustainable (Khandaker and Kotzen, 2018). Moreover, by being space-efficient, aquaponic systems can be better integrated vertically into urban environment (Forchino *et al*., 2018). Whereas Somerville *et al.* (2014) claim that in spite of being a sustainable way to produce fish and plants, the position aquaponics holds in the market is hindered by the regulations of the European Union. Marketing their products become difficult for the producers, due to these regulations (Kledal *et al.*, 2019).

Aquaponics gained more attention in the last century in places with fresh water and arid regions, such as Australia and the US Virgin Islands, due to the demand for food for the growing population (Li *et al*., 2018). Small-scale food production was focussed on in Australia. The University of Virgin Islands focussed on the commercial production levels in order to create an industry (Li *et al*., 2018). Home-based aquaponics, also known as backyard aquaponics, is a small-scale and self-sufficient system that produced products meant for local consumption (Li *et al.*, 2018). Small-scale aquaponics is ideally suitable to be installed in schools, prisons, hospitals, supermarkets, and shopping malls (Li *et al.*, 2018). According to Somerville *et al.* (2014), home-based aquaponics decreases the risk of obesity due to unhealthy diets by keeping the quantity and quality of protein consumption under control. On the other hand, factory-based aquaponics is a large-scale system that is meant for international trade (Li *et al*., 2018). In the factory-based version of aquaponics, both fresh water and seawater methods can be developed (Li *et al*., 2018). Aquaponics using seawater could be more beneficial economically in terms of seafood production (Waller *et al*., 2015).

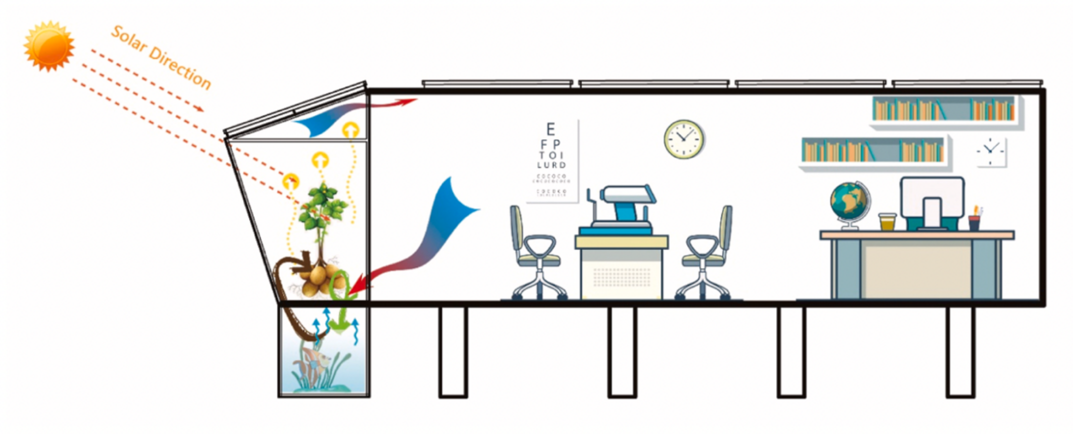
Another form of aquaponics is building-based aquaponics. According to Li *et al.* (2018), the idea of building-based aquaponics is based on the innovative form of urban green architecture, which combines food, architecture, production, and design to produce food on buildings in urban areas. It can be installed on the wall and rooftop of an existing building. This kind of aquaponics uses infrastructure on a medium scale basis (Li *et al.*, 2018). There could also be an increase in food production through building-based aquaponics, that uses new areas within buildings for cultivation (*Li et al.*, 2018). Li *et al.* (2018) mention that aquaponics has the potential to improve food production and also to support economic development in the future by means of efficient use of resources such as water, soil, fertilisers and pesticides.

A case study in Berlin has modelled an aquaponics scenario depending on the demand for fish in order to meet the required yield (Schrenk *et al.*, 2021). This was achieved through four different combinations of fish and plants by the use of catfish and tilapia and tomato and lettuce. The resulting combinations were catfish & tomato, catfish & lettuce, tilapia & tomato and tilapia & lettuce. The harvest ratios for these four combinations were 1:3.3, 1:10.2, 1:11.1 and 1:56.2 respectively (Schrenk *et al.*, 2021). The scenario was balanced to meet the demand of the city. This study has shown that the demand in the city could be met locally (Schrenk *et al.*, 2021). However, in order to make this possible, around 370 aquaponics units are required that would need an area of 224 hectares (Schrenk *et al.*, 2021).

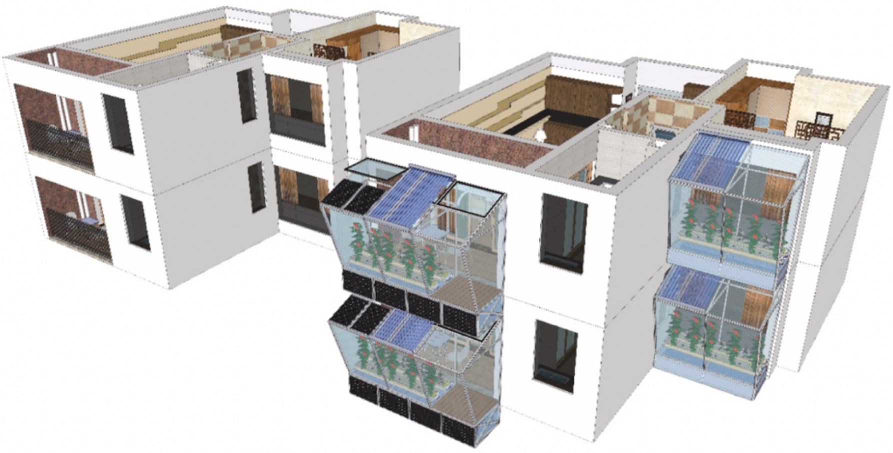
According to Zhang, Zhang and Li (2022), green walls have a great potential surface area that can be used for various purposes, including food production. Therefore, green walls have a very important role in contributing to the introduction of vegetation in urban areas without compromising on the street space. In the UK, aquaponics has been studied and applied by academic experts, landscape architects, urban designers and stockholders within cities to support the development of urban agriculture and serve communities (Khandaker and Kotzen, 2018; Konig *et al*., 2016). As an illustrative example, one of the landscape architects, Dr Benz Kotzen investigated aspects of combining living wall and vertical farming technologies in aquaponics. A study was conducted to grow plants vertically using less space (Khandaker and Kotzen, 2018). The living wall system was researched, and the main goal was focused more on the feasibility of applying different inert substrates in the living wall systems for vertical aquaponics (Khandaker and Kotzen, 2018). The outcome indicated that a pot framework showed better results concerning the management of the system when compared with substrates (Khandaker and Kotzen, 2018). Concerning substrates, horticultural grade coconut fibre, and horticultural grade mineral wool outperformed other substrates (Khandaker and Kotzen, 2018).

Practical experimentation has also been undertaken. In 2013, food producer GrowUp started a small vertical aquaponics farm inside an abandoned shipping container in central London for the sole purpose of making food more local and sustainable for the community (BBC, 2016). The farm is located on a rooftop in Hackney where salad and herbs were grown using aquaponics (BBC, 2016). In a further article, which was published on 17 April 2015 on the online website: The Fish Site, established that GrowUp received planning permission for a London warehouse to become the UK's first commercialised aquaponics farm creating a pioneering new model for sustainable, ethical food production in cities (Lucy, 2019).

Fig 2.2. below shows the model of a productive double skinned facade (PDSF) that was established with the combination of existing buildings and aquaponic systems. It may provide a stable environment for plants as well as people. A photosynthesis re-oxygenation aquaponics (PRO-AP) which is diagrammatically represented in Fig. 3 below has been built inside the PDSF.



(a) Conceptual diagram of productive double-skin facades (PDSF)



(b) Spatial integration mode of PASS and multistorytorey buildings

Fig 2.2. Model of PDSF. Source: Zhang *et al*. (2022).

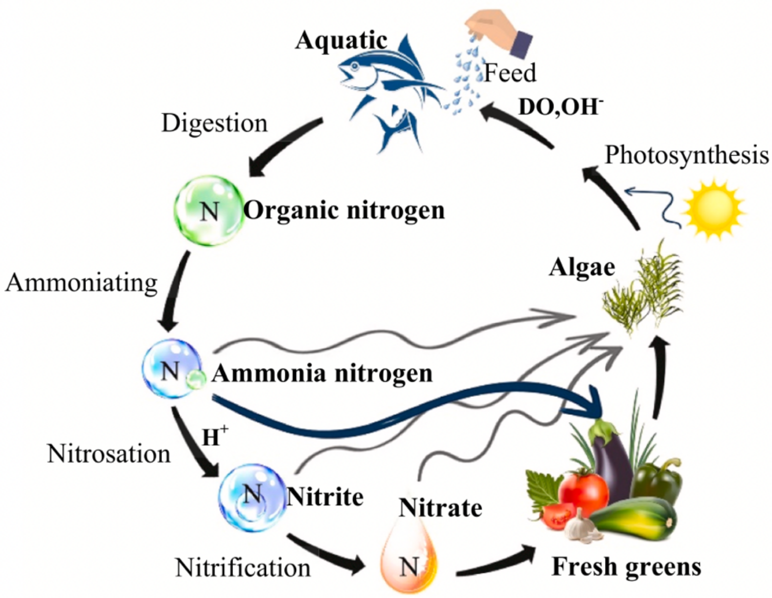


Fig 2.3. Diagram representing PRO-AP (Photosynthesis Re-oxygenation Aquaponics). Source: Zhang *et al*. (2022).

Models from a study conducted at a vertical farm of the Facilities and Environmental Laboratory of Northwest A&F University, Xi'an, Shanxi province, China are showcased below in figures 4 and 5. (Zhang *et al.*, 2022).

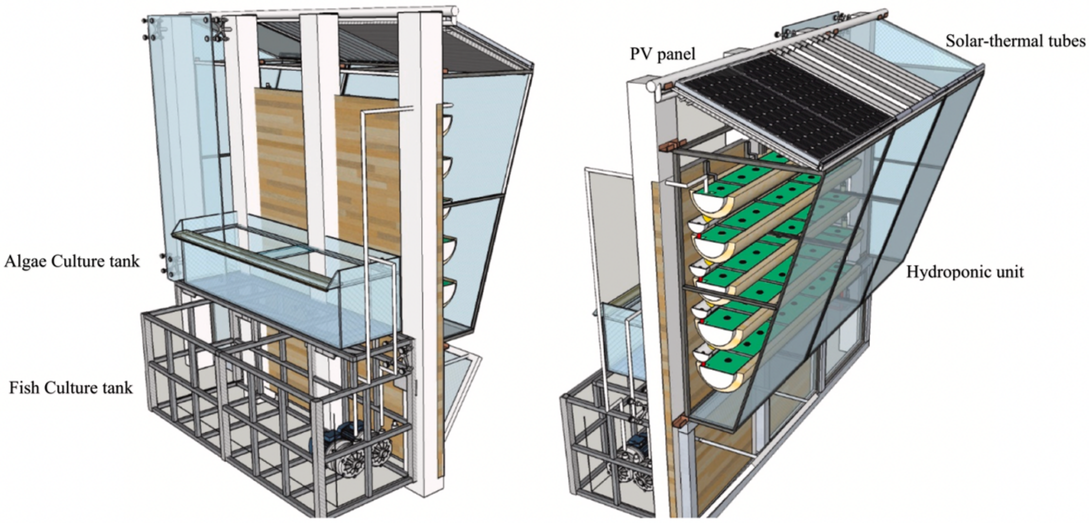


Fig 2.4. Diagrams of experimental systems. Source: Zhang *et al*. (2022).

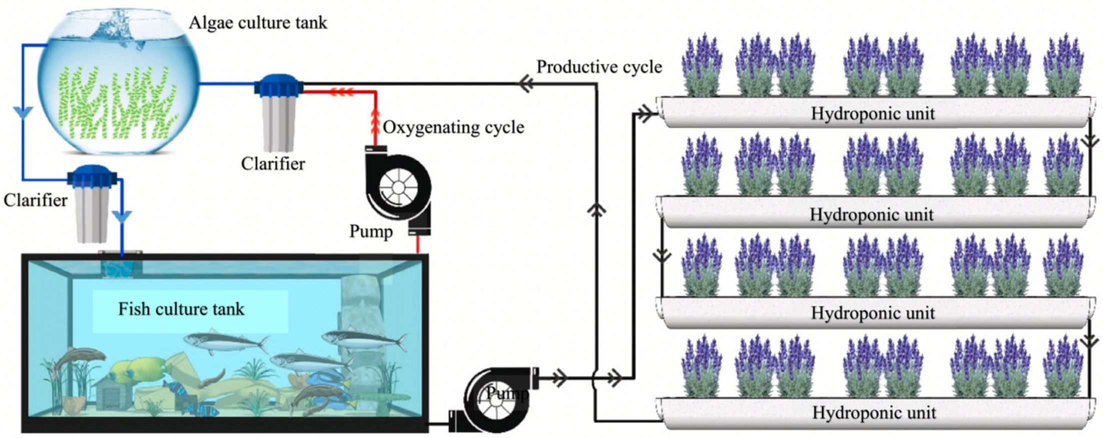


Fig 2.5.   Diagram of water circulation system. Source: Zhang *et al*. (2022).

In the experimented conducted in the above-mentioned site in China, an urban food production system was built. The necessary elements such as the fish, bacteria, algae, and vegetables were integrated organically (Zhang *et al*., 2022). It has been found that based on the effective process of photosynthesis of spirogyra, the PRO-AP model can supplement dissolved oxygen levels effectively. It has also been found that PRO-AP has many advantages in terms of stabilising water quality and reducing the costs of aeration (Zhang *et al*., 2022).

However, there is limited research supporting the development of aquaponic systems that are suitable for urban buildings (Zhang, Zhang and Li, 2022). According to König *et al*. (2016), aquaponics can address three pillars of sustainability, namely environmental, economic and social. The European Parliament mentioned that aquaponics can contribute to sustainably growing local food (Sanders, 2013 cited in Fruscella *et al.*, 2021). Despite of the sustainability of aquaponics, there has not been much research in the area. The research is in its infant stages which can be seen in the lack of publications in aquaponics as compared to aquaculture, green roofs, and hydroponics (Fruscella *et al*., 2021). Somerville *et al*. (2014) claim that despite being a sustainable way for the production of fish and plants, the position aquaponics holds in the market is hindered by the regulations of the European Union. Marketing their products become difficult for the producers, due to these regulations (Kledal *et al*., 2019).

2.4.1. Urban aquaponics in relation to planning

Aquaponics units do not require arable land, therefore, they can be located in areas of poor soil or in arid conditions or in urban areas (Cammies, Mytton and Crichton, 2021). Aquaponics has shown 72% lesser carbon emissions than hydroponics (Monsees *et al*., 2019). The government of the United Kingdom has acknowledged aquaponics as a system with high potential (Freeman, 2019 cited in Cammies *et al*., 2021). However, the government has also mentioned that the system needs a considerable amount of innovation in order to gain a commercial level (Black and Hughes, 2017 cited in Cammies *et al*., 2021). According to COST Action FA1305 (2018), there is no specific legislation governing aquaponic production of food.

Aquaculture in Europe is regulated by fisheries and aquaculture bodies, with a few exceptions under the EU Common Fisheries Policy for member states (Cammies *et al*., 2021). The location of the farm is highly responsible for the ease of obtaining planning permission in Europe. In the European Union member states, the planning, water abstraction and the building are governed at both national and local levels. Whereas in the United Kingdom, small polytunnels and small rural farms may not require planning permission (Joly *et al*., 2015 in Cammies *et al*., 2021). The prerequisites and permissions required for the development of aquaponics units are explained in Table 2.4 below with the help of one development management report as an example.

Table 2.4. Requirements and permits for aquaponics unit development in the UK

Development reports	**Important aspects of the development management report**
Horsham district council development management report	• Erection of polytunnel and storage building for agricultural aquaponics use. • Located in Calcot farm, Horsham road, Steyning. • Proposal part of farm diversification program to support the farming activity on the site. **Addressing the concerns raised by neighbouring representations:** i. no lighting is required internally or externally. ii. Electrical supply will run underground from the adjacent farm buildings to the storage building. No proposal to include backup generator. iii. Will include submersible pump within the fish tank which will not create any noise. iv. No cooling or heating systems. v. No wastage of water in the normal cycle. Disposal firm will be employed to empty tank if needed. vi. Company 'Hawkins', Cowfold will be employed for the disposal of dead fish. Minimal plant waste that would be composted on site.
Relevant government policies	**National Planning Policy Framework (2012)** NPPF1: Building a strong, competitive economy. NPPF4: Promoting sustainable transport. NPPF7: Requiring good design. NPPF11: Conserving and enhancing the natural environment.
Relevant farming roles for water	**Policy paper from Department for Environment Food & Rural Affairs (Defra, 2018)** The Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018 Farming rules for water –getting full value from fertilisers and soil
Relevant council policies	**Horsham District Planning Framework (HDPF 2015)** HDPF1: Strategic policy: sustainable development. HDPF2: Strategic policy: strategic development. HDPF10: Rural economic development. HDPF24: Strategic policy: environmental protection. HDPF25: Strategic policy: the natural environment and landscape character. HDPF26: Strategic policy: countryside protection. HDPF32: Strategic policy: the quality of new development. HDPF33: development principles. HDPF40: sustainable transport. HDPF41: parking.

The Table 2.4 above illustrates an example of aquaponics development in the UK that requires planning permission, based on information obtained from the development management report of Horsham District Council. The table includes the key aspects which are highly relevant to this study. The original report does not include information regarding the use of water, which is an essential aspect of aquaponics practice. To address this gap, the report has been modified by the author and included the relevant information that the operator should adhere to, which is provided in the table below.

The Centre for Environment Fisheries and Aquaculture Science (CEFAS), together with the Department for Environment Food and Rural Affairs (DEFRA) releases a guidance for the development of aquaculture systems in the UK. Table 2.5 below provides with key information and an overview of the latest guidance produced.

Table 2.5. Latest guidance produced by the Centre for Environment Fisheries and Aquaculture Science (CEFAS) and approved by the Department for Environment Food and Rural Affairs (DEFRA) for the Freshwater Aquaponics Farm.

Freshwater aquaponics farm-consent required	
Planning permission	Probably not required for small polytunnels and small-scale units
Water abstraction and discharge licences	May not be required for small scale units using tap water that recycle waste or use sewers for discharge.
Authorisation to run an aquaculture production business	Complete authorisation may be required only for large units. Smaller aquaponics units may only require a registration.
Authorisation to import livestock	This authorisation is required in case of the seed stock being sourced from anywhere outside of England, Wales or Scotland.
Permitting farming of alien species	Fully enclosed aquaponics does not require permitting and can be authorised by the Fish Health Inspectorate.
Approval to manufacture medicated feed	This is currently not applicable to the aquaponics sector. It is however required if veterinary medicines are to be mixed to feed the farmer's own fish.
Transporter authorisation	There are two types of transporter authorisation. Type 1: transporter authorisation for journeys greater than 65 kilometres and up to 8 hours. Type 2: transporter authorisation for journeys over 8 hours.
On farm welfare	The European Council Directive 98/58/EC dictates the welfare of fish on farms, and this is covered by the Animal Welfare Act 2006 and The Aquatic Animal Health (England and Wales) Regulations 2009. Welfare at slaughter is defined in the European

	Council Regulation No. 1099/2009 and this is currently being followed in England and Wales by The Welfare of Animals (Slaughter and Killing) Regulations 1995.
Disposal of mortalities	Disposal of fish mortalities under Council Regulation EC 1069/2009 on animal by products. Fish died from diseases are defined as category II and must be disposed in accordance with Article 13 of EC 1069/2009.

The tables 2.4 and 2.5 above record the planning, permissions and guidelines that are to be followed by aquaponics units to provide an idea of the process that goes into the setting up of aquaponics units. Since aquaponics has already been discussed earlier is type of farming that had land uses, setting them up may require planning permissions.

CHAPTER 3. METHODOLOGY AND METHODS

3.1. Methodological framework

The methods present in this research will achieve a comparative study by using case study and other methods. Case studies are a standard method of primary data collection and analysis (Yin, 2013, 1993; Stark and Torrance, 2005; Stake, 1994). To compare with experimental or quasi-experimental research, case study research is more flexible and viable alternatively in certain situations (Tellis, 1997). Case study research enables a scientific investigation of a real-life phenomenon and a delving more deeply into its environmental context (Ridder, 2017). Yin (1989a) suggested that fieldwork and data collection can be applied in an exploratory case study before identifying research questions. Yin (1989a) further explained that exploratory research needs to have a clear purpose or criteria by which it will be judged to be successful or not. Multiple case study research in different regions can deliver a competitive analysis (Vaughan, 1992). For instance, to analyse the possibilities and reasons for the limitations based on the various regimes' perspectives, contexts, and legislations. There are six sources of evidence in case studies that identified as follows: documents, archival records, interviews, direct observation, participant-observation, and physical artefacts (Yin, 1994; Stake, 1995).

3.2. Methods

A case-study method of this research is employed through five chosen fieldwork sites in the UK and China. The purpose of choosing the case studies in these two countries was to identify how aquaponics is practised in the context of varying cultures and policies between China and the UK. Sites were selected based on criteria of well-developed projects, and the location of urban, suburban and semi-rural contexts. This research is interested in that from which the possibility of urban aquaponics combined with green roofs and community gardens in both countries. In addition, to analyse the differences in implementation and compliance of urban agriculture within urban planning between two countries in.

For fieldwork, data were collected by semi-structured interviews virtually. Semi-structured interviews with practitioners and experts in aquaponics field were used to discover the knowledge and experiences of the interviewees, exploring the things that could not be directly observed and experienced by interviewers (Patton, 1990). Furthermore, questions for the interview were developed to support the research aim of exploring the potential contribution of aquaponics to the urban environment and food systems. The contents of questioning cover aspects that include participants' motivations, difficulties for doing aquaponics, and location and support from the government. The voice recordings of interviews were conducted under permission. Finally, desk-based and site observation were conducted to collect the primary date.

3.2.1. Literature review

As the knowledge foundation of this study, peer-review and grey literature have been reviewed related to the following aspects: (1) the relevant environmental issues and sustainable development; (2) urban planning strategies for food in the UK and China; (3) urban agriculture and horticulture globally, UK and China; (4) aquaponics status and its relation to planning within cities. All reading materials was primarily accessed online via Google scholar and the university's online library, governmental websites, and non-governmental websites. This literature review was conducted with the objective of gaining knowledge and understanding regarding the interaction between aquaponics and government policies and legislation in both the UK and China.

3.2.2. Selection of British and Chinese aquaponics sites (cases study)

Case study sites from UK and China were identified based on the criteria of well-developed aquaponics site and the locations of urban, peri-urban, rural hinterland. The information of each site includes the address, location, surrounding Landscape characteristics, size of the site, spatial categories, design and technology solution, type of fish, type of plants, type of farming, market, the latest updated date, scene display, official website, contact information, year of site establishment, supporting sectors for the project and annual turnover (Table 3.1 &3.2). The Chinese characters in the table represent the Chinese name and addresses of the sites, as some Chinese sites do not have English names, this will enable more accurate information to be provided. Some of the English names are translated directly from Chinese. The information marked with N/A in the table represents information that has not been identified due to an access restriction. Scene Display shows the available videos and images information about these sites that can be visualized without restrictions on access to foreign websites.

Table 3.1. British sites

British Sites / Criteria	1 EcoGro Farm	2 GrowUp	3 Bristol Fish Project	4 Alladale Wilderness Reserve-Aquaponic Garden	5 Farm Urban
Address	Coolings Lifestyle, Main Rd, Knockholt, Sevenoaks, Kent, England. Post code: TN14 7LJ	Green Lab, Corner of Keeton's Road and, Collett Rd, London SE16 4EE	Unit 1, Vale Ln, Bristol, City of Bristol BS3 5RU, UK	Ardgay, sutherland IV24 3BS	Farm Urban's Baltic basement, Liverpool, England.
Location	EcoGro Farm is situated at the Coolings garden centre, the Main Rd, Knockholt, Sevenoaks. Knockholt is a village and civil parish in the Sevenoaks District of Kent, England. It is located 5-mile (8 km) northwest of Sevenoaks and 5.7 mile (9.2 km) south of Orpington, adjacent to the Kent border with Greater London.	GrowUp operated "Unit 84" - a commercial-scale aquaponic urban farm. Based inside an industrial warehouse in Beckton, a suburban district in East London.	Bristol Fish Project is located in unit 1, Vale Ln which is about 3km away from Bristol city centre, London.	Aquaponic Garden at Alladale Wilderness Reserve, Ardgay, Scotland, it is located 2.5 km from Croick, Highland, Great Britain.	The farm is in the basement of the Liverpool Life Sciences UTC school on Parliament Street in Liverpool 8. The UTC is located in the Baltic Triangle, in the former Contemporary Urban Centre (CUC), Liverpool, England.
Surrounding Landscape characteristics	Plain	Plain	Plain	Highland	Plain
Size	N/A	762m^2	N/A	4000m^2	N/A
Spatial categories	Suburban	Suburban	Suburban	Rural area	Inner urban
Design and Technology solution	• Traditional polytunnels Commercial-scale Aquaponics system	N/A	N/A	Integrated Agri-Aquaculture system (IAAS)	N/A
Type of plants	N/A	basil, watercress, mustard and other green goodness.	Watercress	N/A	lettuce, basil, mint, parsley, chards and kale
Type of fishes	N/A	tilapia (cichlid fish)	Eels. European eels (*Anguilla anguilla*)	Trout	N/A
Type of farming	Aquaponics	Aquaponics	Aquaponics	Aquaponics	Aquaponics and hydroponics
Market	Consumers. Shops. Delivering boxes.	Consumers. Shops. Restaurants. Educational event.	Restaurants. Educational event.	Restaurants.	Education programmes to schools. Delivering boxes of Mighty Greens.
Official web	Instagram. https://www.instagram.com/ecogrofarm/TikTok. https://www.tiktok.com/@ecogrofarm?lang=en	https://www.growupfarms.co.uk/	https://bristolfish.org/about/	https://alladale.com/food/alladale-aquaponic-gardens/	https://www.greensforgood.co.uk/
The latest updated date	4 January 2022	09 March 2022	28 November 2018	N/A	17/12/2021
Scene Display	https://www.instagram.com/ecogrofarm/	http://www.growup.community/	N/A	https://bioaquafarm.co.uk/alladale-wilderness-reserve/	https://www.liverpoolecho.co.uk/news/liverpool-news/underground-farm-victorian-tunnel-beneath-17273804
Contacts	ecogrofarmorders@gmail.com	+447539350858	info@bristolfish.org	+44 (0) 1863 755 338 enquiries@alladale.com	info@farmurban.co.uk 0151 558 1348
Establishment	N/A	2013	2011	11/ 2018	2014
Supporting sectors for the project	N/A	N/A	Grant Funded by EMFF. Receiving funding from the European Marine Fisheries Fund.	N/A	kickstart from EU funding
Initiative	N/A	GrowUp	local community business	Alladale Wilderness Reserve	Farm Urban
Annual turnover	N/A	N/A	N/A	N/A	N/A

Table 3.2. Chinese sites

Chinese Sites / Criteria	1 Yu Geng Tian (渔耕田)	2 Xinxigang primary school-Sky Farm (信息港幼儿园天空农场)	3 The Aone Aquaponics Ecological Complex (Aone aquaponics 艾维农园)	4 De Qing Aquaponics 德清鱼菜共生
Address	Cai Shanzi, Group 2, Minjiang Village, Xinjin District, Chengdu city, China	118, Mingxing Road, Xiaoshan district, Hangzhou city, Zhejiang, China	Chikan Village, Yulindian Town, Muping District, Yantai City	De qing Bai yuan kang Digital aquaponics factory, Dongheng Village, Luoshe Town, Deqing County, Huzhou City, Zhejiang Province
Location	Yu Geng Tian is located in Minjiang village, the north of Xinjin county, where it is about 19 kilometers from the southwest of Chengdu city, Sichuan province, China.	The Sky Farm is situated on the rooftop of the Xinxigang primary school in Xiaoshan which is a municipal district of Hangzhou, Zhejiang Province, China.	Aone Aquaponics Ecological Complex is placed in Chikan Village, Yulindian Town, Muping District, Yantai City. It is about 27.35 km away from Yantai's city centre.	De Qing Aquaponics is placed in Dongheng Village, Luoshe Town, Deqing County, Huzhou City, Zhejiang Province. It is about 23.52 km away from Huzhou city centre.
Surrounding Landscape characteristics	Hill	Plain	Plain	Plain
Size	20000m^2	<300m^2	<12000m^2	4000m^2
Spatial categories	Peri-urban	Inner urban	Rural hinterland	Rural hinterland
Design and Technology solution	N/A	N/A	Integrated Agri-Aquaculture System (IAAS)	N/A
Type of plants	• Green onion, aubergine, bitter melon, perilla, mint, Chinese chives, tomatoes, squash, parsnips, Chinese Romaine (Cos Leaf Lettuce), lettuce, kale, celery, peppers, etc. • Strawberry, • Cactaceae, succulent plant	• Malus spectablilis, Nephrolepis exaltata	• Herbs: rosemary, lavender, thyme, sage, mint, rose geranium, etc. • Beetroot, dragon Fruit, Lysimachia christinae hance, etc. More than 500 species	• Cherry tomatoes, fruit cucumbers, lettuce, arugula, bok choy, chard, spinach, chicory, kimchi, iceberg lettuce, etc.
Type of fish	Gymnocypris przewalskii, carp, misgurnus anguillicaudatus,	Red carp	Carp, grass carp, crucian carp, silver carp, tilapia, sturgeon, koi	Scortum barcoo, Jaguar cichlid, Snakehead
Type of farming	Aquaponics	Aquaponics	Aquaponics	Aquaponics
Market	Site visit. Dinning in. Online Sales. Webcast explanation to deliver experience and investment. Derivative product (Mini-Aquatic Gardens). Technical Training academy.	Education.	Tour. Culture and Creativity Franchise. Dinning in.	Consumers. Shops. Restaurants. Research and development of biotech products.
The latest updated date	02 March 2022	N/A	17 February 2022	15 March 2022
Scene Display	https://www.douyin.com/video/6973139858399235339	https://mp.weixin.qq.com/s/6EenHpdOmARSTy_531BFjA	• https://www.douyin.com/video/6951371363550629154 • https://www.douyin.com/video/6958428659954863400 • https://weibo.com/aonefarm?sudaref=www.google.com • http://www.360doc.com/content/20/1107/11/72303081_944568192.shtml	Bilibili: https://space.bilibili.com/509324054 Webo: https://weibo.com/u/6403092659
Official web	https://www.yogotime.cn/	N/A	N/A	https://www.bilibili.com/video/BV1GS4y117rF?spm_id_from=333.999.0.0
Contacts	Mr. Chen 0086-19102691837	Mr. Zhao 0086-18663867783 WeChat: yz500a	0086-0535-4628216	Mr Gao WeChat: 17610173289
Establishment	2016	May 2021	2010	2018
Supporting sectors for the project	• Subsides from the agriculture sector • Tax free	N/A	N/A	N/A
Initiative	Yu Geng Tian	N/A	The Aone Aquaponics Ecological Complex	N/A
Annual turnover	N/A	N/A	N/A	N/A

3.2.3. Semi-structured interviews

In order to ensure adequate informed consent prior to the interview, an email or text message outlining the research project, aims, and contact details was sent to each participant. Contacts are made in accordance with the University of Hertfordshire's ethics policies regarding participants, researchers and third parties' dignity, rights, privacy, and health and safety. Following the Ethics Approval had been obtained (Appendix 1) participants for semi-structured interviews were recruited via email, WeChat, DouYin, TikTok, and Instagram depending on the participants' availability and convenience. The Ethic Approval documents can be found in the appendix section. In the case of participants who were willing to discuss the topics further, an interview was offered either immediately following the invitation or at their convenient time through a social media app of their choosing.

Semi-structured interviews were undertaken with the practitioners of aquaponics sites virtually for primary data collection. Interviews were recorded by the author when permission was granted. During April 2022, five semi-structured interviews were conducted with Chinese and British owners of aquaponics' sites regarding the status of aquaponics development based on predetermined questions. Four interviews with Chinese participants were carried out in Mandarin through WeChat voice calls on the 11th, 12th, 19th and 24th of April 2022. One site observation and a semi-structured interview with the owner of British aquaponics site were undertaken in English face to face in June 2022. Additionally, an extended interview was conducted in Mandarin with an ethnic Chinese working on an aquaponics project in Malaysia, who was recommended and introduced by one of the Chinese participants. Although this participant's farm was not selected for the study, his insights and experiences in the industry also provide value for this research.

Participants include Mr. W, the owner of EcoGro (British); Mr. X, the core founder of Aone Aquaponics (Chinese); Mr. C, the founder of Yu Geng Tian Aquaponics; Mr. Z, a project manager of Xiao Chuan Aquaponics and Mr. G, the core founder of De Qing Bai Yuan Kang digital aquaponics factory.

The questions that were asked during the interviews focus on the aspects, which include (1) the participants' motivations; (2) difficulties for doing aquaponics; (3) the exploration of the planning systems or government's support in relation to location; (4) subsides and renewable energy; and (5) the participants' views on the value of aquaponics within urban agriculture, which are listed below:

1. Why did you decide to set up the aquaponics business?
2. Are you aware of any planning systems or policies regarding renewable energy, subsidies, and the location of aquaponics businesses?
3. Have you encountered any problems with finding a suitable location? (Would you mind sharing your experiences?)
4. Is there any local council support, for aquaponics operators that you know of?
5. Do you think that aquaponics is important to urban agriculture or to sustainable cities?
6. Have you experienced any practical challenges?
7. Have you encountered any financial issues? (Would you mind to sharing them?)

Primary semi-structured interview with planning practitioners was also included in this research, it is important to note that limited resources constrained the availability of participants. Only one planning practitioner was able to participate in the interview remotely, while two other planners were casually questioned. The prepared questions are outlined below. However, it is worth mentioning that after the first question was posed, it became apparent that all three participants lacked knowledge about aquaponics. As a result, further questions regarding aquaponics were not asked during the interview.

1. What do you know about aquaponics?
2. Does your local plan identify aquaponics as a specific form of development?
3. Is your local authority broadly supportive of, or opposed to, aquaponics developments?
4. Have you received many (or any) planning applications for aquaponics development?
5. What are the specific issues that (you think will) occur in relation to aquaponics development, either in principle or as a consequence of planning applications?

Audio recordings were transcribed using Voice Memos and the Notability app, which enabled the transcription process as recordings to be slowed and paused as needed. Audio recordings were stored in an anonymous and password-protected file on the personal laptop and can only be accessed by the author to ensure the confidentiality. All audio recordings will be destroyed once the study has been completed in compliance with the Ethics Approval Guidelines.

Transcription of audio recordings from semi-structured interviews was conducted following interviews. The recordings were replayed and transcribed verbatim using the Dictate function of Microsoft Word into a new document. Whenever transcription errors occurred, corrections were applied manually according to the original recordings.

3.2.4. Analysis and interpretation of primary and secondary data

Analysing and interpreting the data collected is the next step. During this stage, the corrected textual material was coded separately according to the different research themes to help identify the key information regarding 'what kind of contributions of urban aquaponics can make to the urban food systems and what kind of difficulties that it may encounter?'. In the process of analysis and interpretation, the identified key information was further grouped and analysed to outline the similarities and differences regarding each topic between the two countries. The possibilities of combining aquaponics with green roofs and community gardens in an urban setting as a contribution to sustainable urban food systems, as well as whether the planning system will be more responsive in considering aquaponics as an integral component of a sustainable food system that were further analysed based on the identified primary and secondary data.

CHARPTER 4. FIELDWORK FINDINGS

The aim of this chapter is to provide the findings from case study research including desk-based research, the mappings of site locations, semi-structured interviews with participants involved in aquaponics, and site observations of the British aquaponics sites. The section begins with the presentation of a desk-based investigation of each case study consisting of maps and photos for each site. Moreover, the demonstration of the British site observation is also provided. The final section shows the findings from the semi-structured interviews with British and Chinese participants.

4.1. Findings from British and Chinese sites-maps and photos

The maps below show the general geographic distribution of British and Chinese sites (Fig 4.1, 4.2). The red icon are the labelled numbers of the sites in both maps, and the photographs in the circles are a presentation of real pictures of the interior or exterior environment of each site. The maps are used to locate the city in which the sites are placed in the country. Maps are created by author based on Laborieux, L. P. M. (2009). The sites' details include location, surrounding landscape characteristics and spatial categories that are explained in the following paragraph with the maps.

Figure 4.1 The geographic location and exterior environment of the British site, the map created by author based on Laborieux, L. P. M. (2009).
Source 1: Adapted from Laborieux, L. P. M. (2009).
Source 2: Taken by author in the British aquaponics site (2022).

Figure 4.2 The geographic location and exterior and interior environment of Site, the map created by author based on Ericmetro (2019)
Source 1: Adapted from Ericmetro (2019).
Source 2: Pictures of Sites two, three and five were provided by the practitioners of the site; Picture of Site four is from SOHU.com (2018)

2.1.1. Findings from Site One (British) on background information, maps and photographs

The figures of Google Earth map below show the location of Site one (British), which is indicated by the red circle icon, black arrow, and description label. The map contains the location of the site and scale. British Site one, EcoGro Farm operator's educational background is in biology. Having a great passion for aquaponics, he built a small aquaponics system in his garden in 2018. The success of the harvest encouraged him to start his own aquaponics business. EcoGro farm was established in 2020, which services the local people with weekly green boxes. This 150 square meter farm grows more than 10 kinds of vegetables, including watercress, spring onions, red and green cos lettuces, radish, rainbow chard, spinach, celery, cavalo nero, and coriander, and two kinds of herbs, basil and mint. his farm raises freshwater carp fish for plant growing.

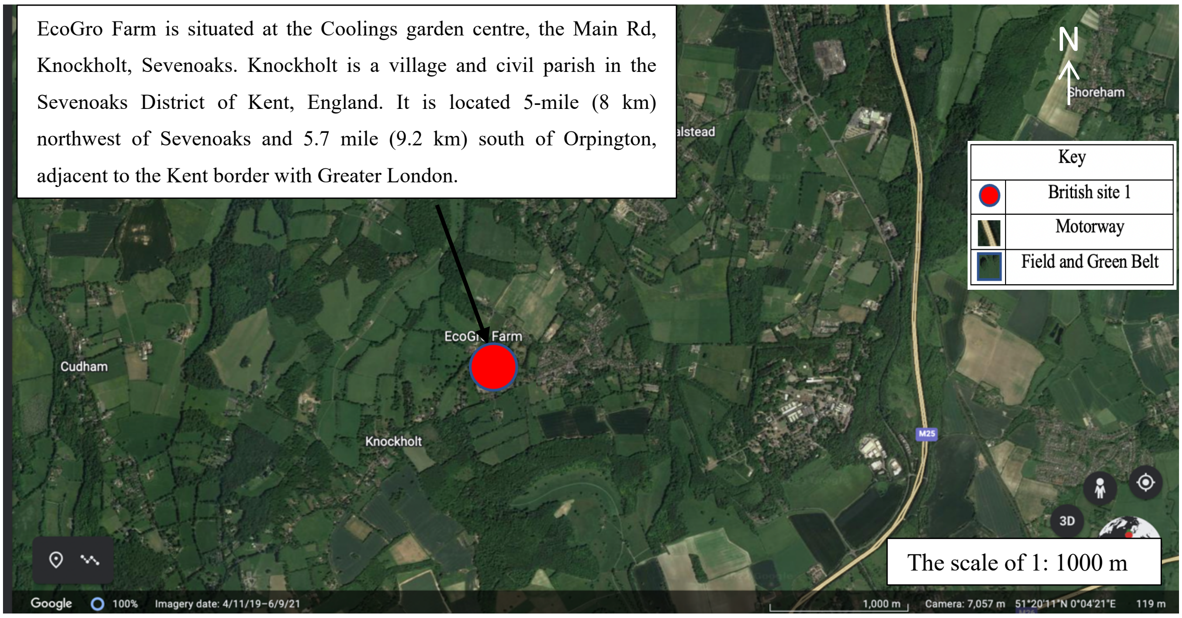


Figure 4.3 Aquaponics Site one (British) EcoGro Farm

Figure 4.4 Aquaponics Site one (British) EcoGro Farm

EcoGro Farm is located at the Coolings Garden Centre, on the Main Road, Knockholt, Sevenoaks. Knockholt is a village and civil parish in the Sevenoaks District of Kent, England. It lies adjacent to the Kent border with Greater London, about 5 miles northwest of Sevenoaks and 5.7 miles south of Orpington. Knockholt consists primarily of a ribbon development surrounded by green space within the Green Belt. Mixed arable farming is practised in the area. It is situated on a hilly, rural slope on the north slope of the North Downs, with views of London in the distance.

Figure 4.5 A set of pictures of the exterior and interior environment of Site one (British) EcoGro Farm

The images above show the site's external and internal environment, the environment in which the plants are grown, and how the practitioners manage and use the land space. The photographs were taken by the author when conducting the interview and site observation. The use of equipment and management practices on site also reflects the extent to which UK legislation is receptive to aquaponics enterprises. The technique of separating the plant bed from the fish tank is applied on this site. Unlike the Chinese sites, the fish in the UK site is only used as a source of nutrient fertiliser for the plants and are not used to generate profit. Therefore, the number of fish in the pond is only 16. A water recycling system is applied to help the water from the fish tank flow into the plant beds and to bring the water from the plant beds back to the fish tank. The participant described the discharge of the sewage from the site as being very minimal and almost non-existent. There is an EcoCooling system in the site, it is used to help reducing the indoor temperature during the hot weather. This system uses less energy and runs at less than 10% as compared to a refrigerated air conditioner, according to the farm owner.

2.1.2. Background information, maps and photos of Site two (Chinese)

The screenshots of each Google Earth map image have been used to illustrate the infographic for each site and to facilitate the identification of the distance between the site and the city. The red circle icon shows the site's specific location, which is pointed to by a black arrow and described in the text box. The yellow straight lines in Figures 4.6, 4.11 and 4.13 are used to measure the distance between the site and a nearby city or village.

Site two (Chinese), Yu Geng Tian was established in 2014. The founder used to be an IT manager. The farm covers an area of more than 20000 m^2, grows more than 50 kinds of vegetables throughout the year, and raises 8 kinds of freshwater fish. The founder also invested in constructing an aquaponics science space covering an area of more than 2,500 square feet and a Yu Geng Tian science museum. This farm currently generates an annual income of over £600,000.

Figure 4.6 Aquaponics Site two (Chinese) Yu Geng Tian

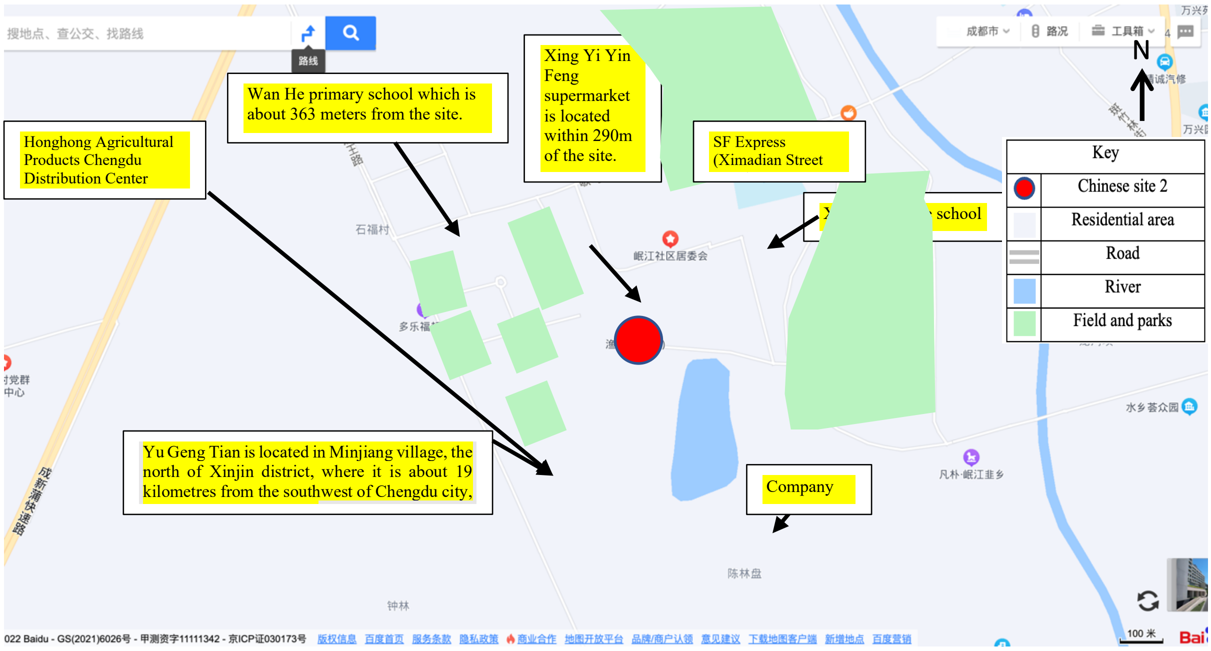


Figure 4.7 Aquaponics Site two (Chinese) Yu Geng Tian

Site two (Chinese), Yu Geng Tian is located in Minjiang village, north of Xinjin district, where it is about 19 kilometres from the southwest of Chengdu city, Sichuan province, China. This area could be categorised as peri-urban based on its vicinity because it is located in Xinjin district, which was a county and is officially established as Xinjing district on 30 June 2020 (Chengdu GOV, 2020). Furthermore, the site is surrounded by a supermarket, a primary and middle school, Honghong Agricultural Products Chengdu Distribution Centre, SF Express (Ximadian Street Store) and other companies within 280 to 380 metres of its vicinity. Finally, the population in Minjiang village is less than 20,000 (Chengdu GOV, 2020), which is one of the characteristics of peri-urban as classified by Loibl and Köstl (2008).

2.1.3. Background information, maps and photos of Site three (Chinese)

Site three (Chinese), Xinxigang primary school-Sky Farm was designed and managed by a project manager and editor Mr Zhao who is a project manager and editor in Xiao Chuan Aquaponics. He started working in the aquaponics area in 2014. The Xinxigang primary school-Sky Farm, is one of the projects he is primarily responsible for management. The company he works for focuses on creating landscape aquaponics scenarios and the combination of ecological farming in modern facilities. It is committed to building aquaponics and shrimp aquaponics technology as its core, also a collection of equipment development, technical training and design services.

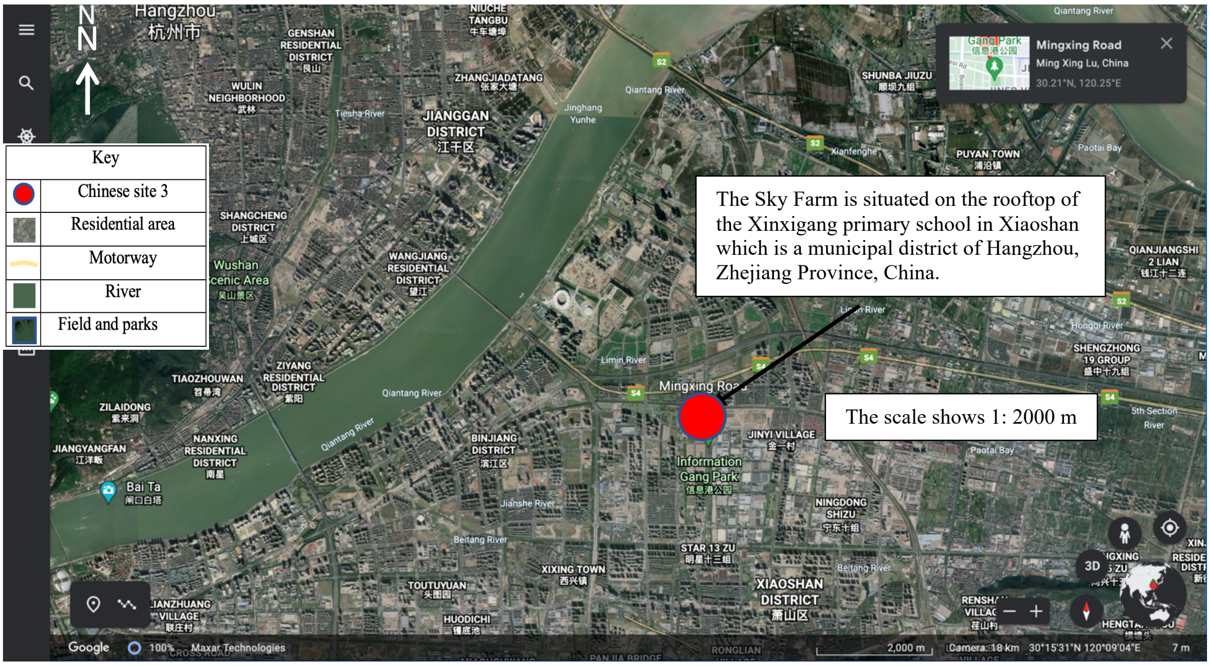


Figure 4.8 Aquaponics Site three (Chinese) Xinxigang primary school-Sky Farm

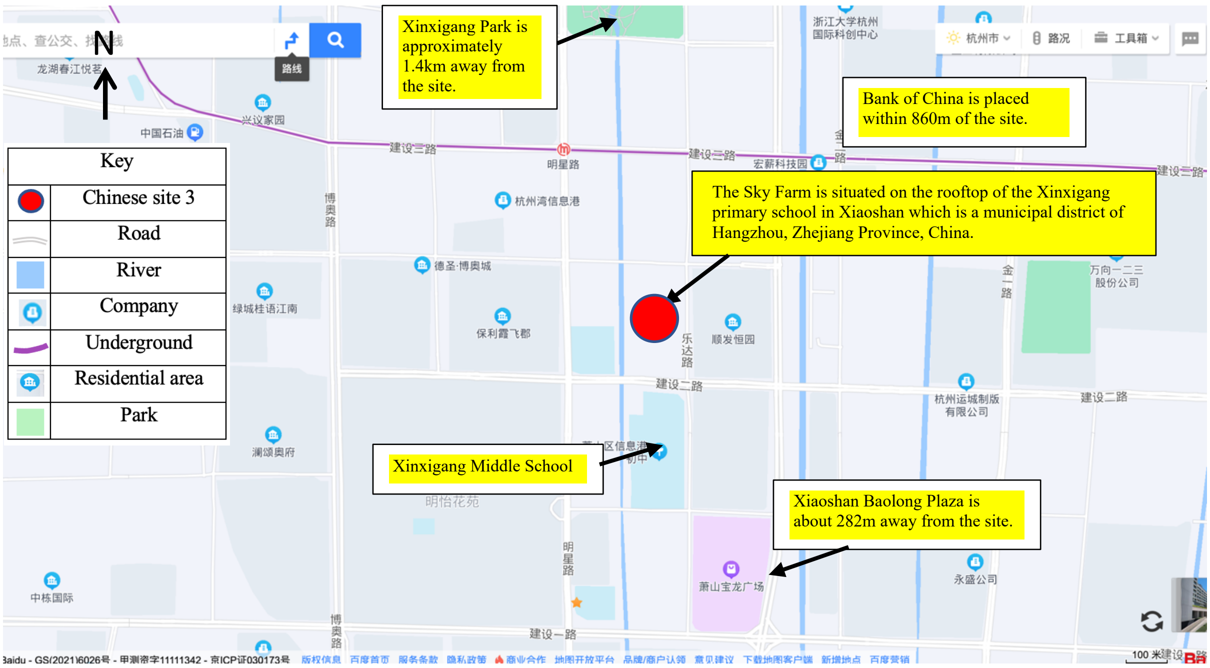


Figure 4.9 Aquaponics Site three (Chinese) Xinxigang primary school-Sky Farm

Figure 4.10 Aquaponics Site three (Chinese) Xinxigang primary school-Sky Farm

Site three (Chinese), Xinxigang primary school-Sky is situated on the rooftop of the Xinxigang primary school in Xiaoshan, a municipal district of Hangzhou, Zhejiang Province, China. The vicinity of the site includes a middle school, a plaza, a bank, a hotel, a park, a large number of companies and residential blocks within 1.5km. The spatial type in the site's surroundings shows a typical feature of inner urban.

2.1.4. Background information, maps and photos of Site four (Chinese)

Site four (Chinese), Aone Aquaponics Ecological Complex was founded in 2011. The official name is Aone Aquaponics Ecological Complex. It is the first interior aquaponics farm in China and is well-known in this field. The farm has independently owned 23 national patents, utility model patents and software copyrights that have been confirmed, disclosed and examined by the Chinese government. Recently, it has been officially promoted as a National-level High-tech New Technology Enterprise.

Figure 4.11 Aquaponics Site four (Chinese) Aone Aquaponics Ecological Complex

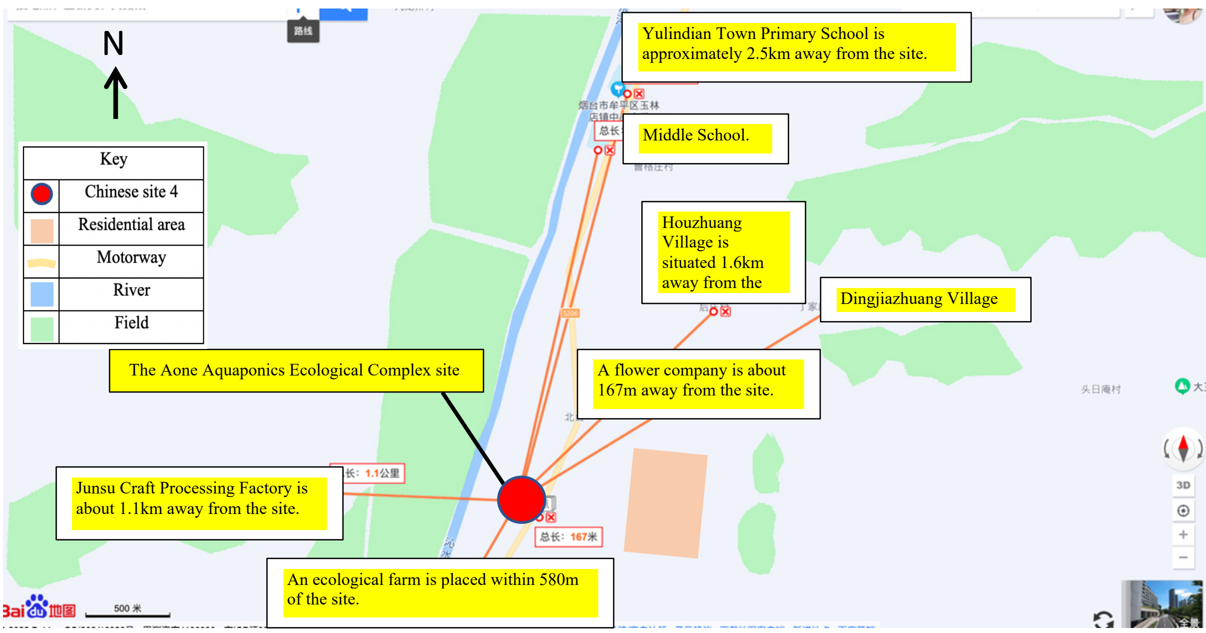


Figure 4.12 Aquaponics Site four (Chinese) Aone Aquaponics Ecological Complex

Site four (Chinese), Aone Aquaponics Ecological Complex is located in Chikan Village, Yulindian Town, Muping District, Yantai City. It is approximately 27.35 km away from Yantai's city centre. The primary and middle schools are distributed within 2.5 km of the northern part of the site. Three companies and Qinshui River are present around the site's vicinity. Based on the surroundings of the site, it is suggested to be categorised as a rural hinterland.

2.1.5. Background information, maps and photos of Site five (Chinese)

Site five (Chinese), Deqing Baiyuankang Ecological Agriculture was established in 2015. The core founder and his partners collaborated with the US company Pentair on an aquaponics project and founded Baiyuankang Ecological Agriculture Co. It is a modern high-tech agricultural enterprise that focuses on research and development, design and construction of intelligent aquaponics farming systems, intelligent circulating aquaculture systems, promotion of related technical services, production and sales of high-quality aquaponics vegetables and aquatic life products. One of their projects covers an area of 10,000 square metres, of which 4,000 square metres are for aquaculture and 6,000 square metres for vegetable cultivation. The project has an annual production of 300,000 kg of aquatic products and 1 million kg of vegetables, with approximately £9 million in annual sales revenue.

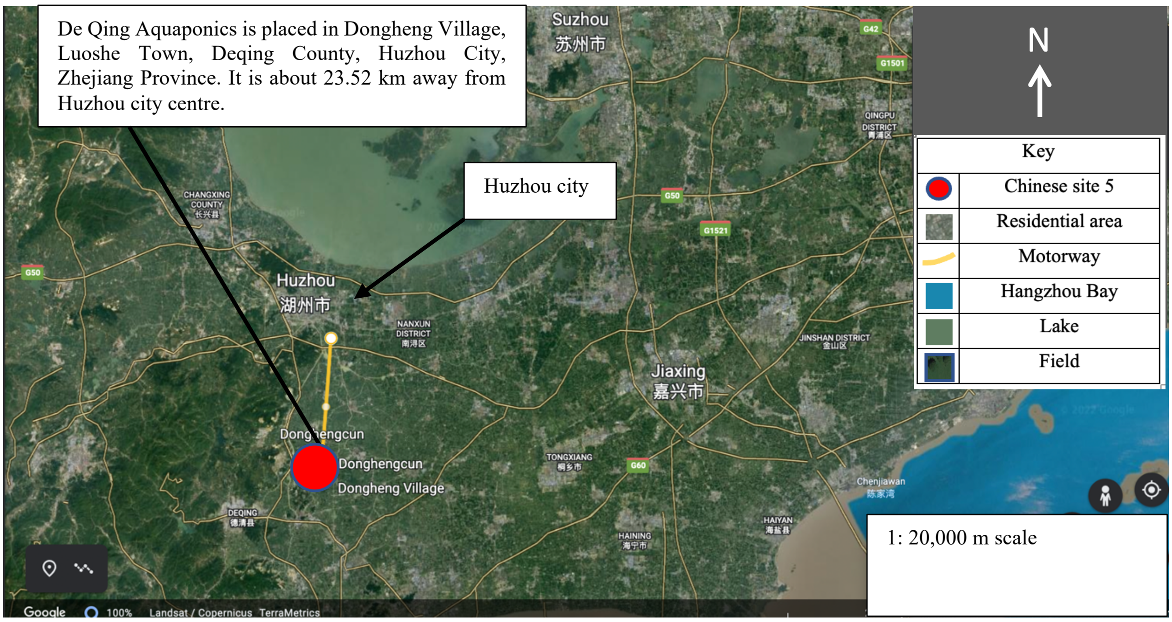


Figure 4.13 Aquaponics Site five (Chinese) Deqing Baiyuankang Ecological Agriculture

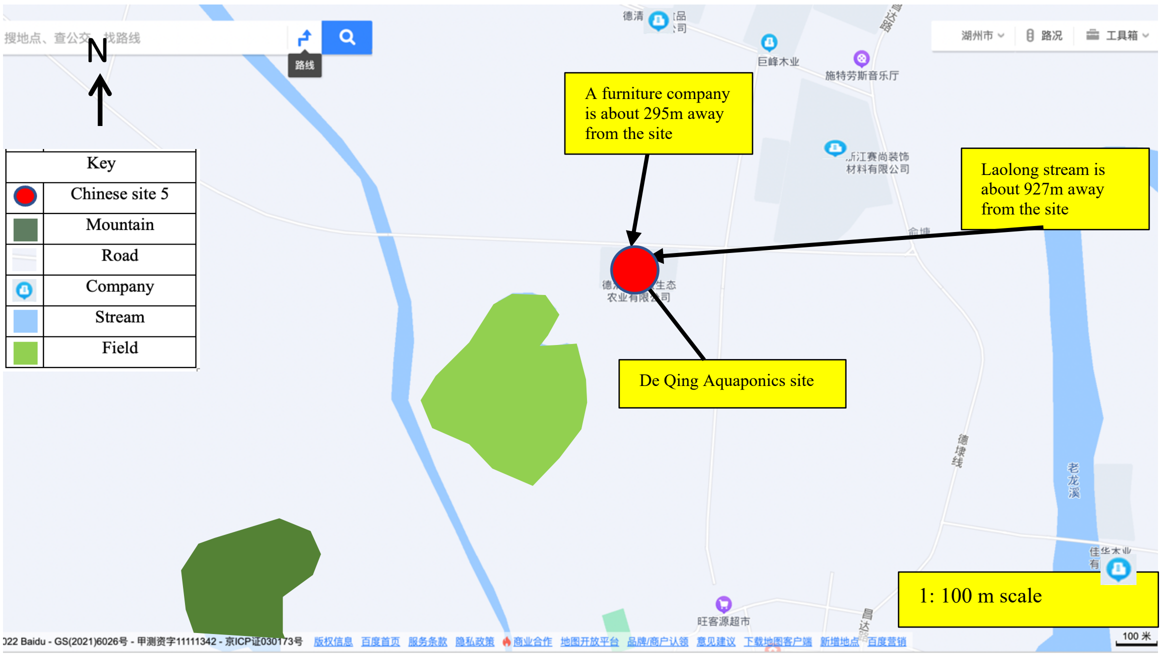


Figure 4.14 Aquaponics Site five (Chinese) Deqing Baiyuankang Ecological Agriculture

Site five (Chinese), De Qing Baiyuankang Ecological Agriculture Co is located 500m away north of Dongheng Village, Luoshe Town, Deqing County, Huzhou City, Zhejiang Province and is about 23.52 km away from Huzhou city centre. Dongheng village is located between hills and plains, with a total area of 6.21 square kilometres and 2,138 mu of arable land. There are companies, a concert hall and a stream within 500 metres of the site. The residential area as being 1000m to the south of the site was identified on the Baidu map. However, the scale of this map is limited to this distance.

4.2. Findings from British and Chinese aquaponics interviews

2.1.6. Questions 1. Why did you decide to set up the aquaponics business?

The first question, "*Why did you decide to set up the aquaponics business?*" was developed based on the reason of assisting in the exploration of the research aims and questions. It is important to understand why practitioners choose this profession in the first place. To find out the reasons behind it, and the factors that inspire them to want to invest time, effort, and money in aquaponics. Identifying the reasons may provide insights into the characteristics and advantages of aquaponics, therefore supporting further analysis of research into question one regarding how urban aquaponics could contribute to urban food systems.

The participant of Site one (British) has always been interested in doing different things or thinking in a slightly different view than most. So, aquaponics piqued his interest. As a concept growing food without soil but in water is madness and still amazes him today even after 4 years in the profession. He said, "*I have always been interested in the physical side of work e.g., building/creating and designing rather than accountancy, IT skills or maths so being able to produce a physical product rather than 'digital' one has always been more interesting for me.*" *"Then Aquaponics is a game-changing technology that can produce more food on less land with less resources. As the world and climate change around us, using less is more sustainable as we leave less impact on the world. We currently are our water usage by up to 90% and producing over well over 3kg of food for every 1kg of feed inputted."*

In contrast with Site one (British), the operator of Site two (Chinese) wanted to provide his two-year-old daughter who is allergic to IgE-mediated food, with organic and uncontaminated vegetables and fish. The second reason for him is that selling aquaponics products could increase his income if the price of the aquaponics products is slightly higher than that of the corresponding produce using conventional farming methods.

Similarly, the project manager of Site three (Chinese), Xinxigang primary school-Sky Farm shares the health requirement as the operator of Site two (Chinese). He wanted to work and live close to the natural environment. He said "*working and living on an aquaponics farm where I can be close to nature and eat fresh, unpolluted vegetables is also helpful for my body recovery"*

An agricultural background has led him to focus on more modern and ecological agriculture than traditional farming. He said, "*ecological farming is more in line with my values*." The last reason is that one of his acquaintances introduced him to work on Aone Aquaponics Farm.

As mentioned above, Aone Aquaponics Farm is the aquaponics Site four (Chinese). The owner shared three main reasons for his initiation. Firstly, his partners knew about aquaponics from a foreign website, and then his partners went to the United States to participate in training in aquaponics and thought this farming method was promising for the future. Secondly, the owner and his partner were both planning for retirement and wanted to do something exciting and meaningful after retirement. Lastly, he said, *"I wanted to do something that did not spend too much money and ideally would also generate some profit*."

The participant of aquaponics Site five (Chinese), Deqing Baiyuankang Ecological Agriculture majored in computer science at university. He learned about modern agriculture at an agricultural science and technology park in Xiaotangshan, Beijing, and has been concerned about it ever since. Later, while working in an investment company, he met his partner Mr Cao, an entrepreneur doing agronomy research at Cornell University in the US. Mr Cao was involved in an aquaponics project and invited to be a visiting professor at Nanjing Medical University in China to set up a state-key laboratory focusing on preventive medicine and oncology. During his research, he found that the incidence and number of cancers in China increased rapidly. Mr Cao then discovered that one of the primary sources of cancer is the food consumed. Food contamination, pesticide residues and other harmful substances enter the body through food. Mr Cao's view was to move away from passive treatment to a more advanced approach, which was to change the healthiness of the produce. A more rational approach to production would produce better quality products with less use of pesticides and chemical fertilisers. This is the starting point for the participant doing aquaponics. The participant and his partner's views on modern agriculture coincided, and they later founded the company together.

2.1.7. Question 2. Have you encountered any problems with finding a suitable location?

Potential site location issues are one of the key questions to ask in order to develop the thesis' aim. In response to this, participants were secondly asked "*Have you encountered any problems with finding a suitable location?*". This question helps me to understand how the choice of location affects the aquaponics enterprise, its importance and its constraints. How does the choice of location affect agricultural practices, how easy or difficult is it to choose a location and what are the constraints and where do they come from? It is hoped that the exploration of the questions will also provide insight into the management of land by local authorities. The research objectives and research questions 1, 2 and 3 of this study were designed to understand the current state of development of aquaponics in the city and whether the planning authorities are responding to its presence.

The participant of Site one (British) did find it difficult initially to find a location. However, he thinks that was down to the fact that they were a brand-new company and didn't have any background for potential people to believe in them until one did. He said, "*In terms of* *geography, you would defiantly be required to have a level site with strong weigh holding capabilities due to large amounts of water*."

The owner of Site two (Chinese) said

> "*The land I was looking for should meet two requirements: one is to comply with the land policy. The land use for aquaponics farms must not disobey Chinese national land management requirements of a 'Red Line' policy, which is that the total arable land in China shall be no less than 1.8 billion mu. The second is that it is close to the city and easily accessible. For example, the farm is a diversified business model that includes a range of activities for parent-child activities, agricultural tourism, and educational purpose. This relates to the distance between the location and the city. Therefore, it is inconvenient for city dwellers to come to visit if the farm location is too far away."*

In contrast, the project manager of Site three (Chinese) has worked for aquaponics companies. Therefore, he has not encountered the issue of finding a suitable location.

The founder of Site four (Chinese) has a more profound view of this issue because he has been in this field for a longer period of time. He said:

> *"The previous site I rented was demolished, and then the farm was forced to move out. I then moved to another site. I rented it wherever there was space and had to consider some economic reasons. Later, when it was implemented, I looked back and thought about it, and there were a lot of things I called regrets. For example, the distance from the city. It did not matter to us initially, but after establishing the farm, I hoped that some people from the city would come here to spend money, such as eating, picking, visiting, and relaxing. If the distance is far from the city, it may be more difficult for people to come. If the farm is close, it is within 20 km or 10 km, for people interested in or dependent on the farm for consumption, it is easy to drive over for them. Distance might restrict one's freedom in running a business."*

In addition to choosing a suitable location, he mentioned:

> "*There are also specific conditions to consider, such as temperature, light, wind and water, which can have varying degrees of influence. If the site is outdoors in the north of China in the middle of winter, the plants will freeze to death due to the low temperatures. If the plants freeze to death, they have no more capacity to absorb, and the whole system does not work. This is why it is essential to be in a polytunnel or*

greenhouse, and the type of polytunnel is crucial if it is going to be used. In northern areas, there is much snow in winter, so the slope of the polytunnel should be considered. If the wind is vital in the area, the polytunnel structure should be able to withstand the effects of the wind. There is also the question of whether the water level is high in the area where the site is located, which can also be a problem if the groundwater is very high".

According to participant of Site five (Chinese), this is often the case because practitioners are not experienced enough when starting farming, and they are not able to acquire the right site when they see them. He said:

"*This is especially the case with land transfers in China. There are several criteria to be established in order to find the right place. For example, transport and the human environment. Because the products produced through this model tend to be for the middle and high-end consumers, it needs to be as close as possible to places with high consumption levels. My first aquaponics site is a 40-minute drive from Nanjing. The second site is an hour's drive from Hangzhou. However, it may not be so easy to find land in places close to big cities. On a different note, agriculture is developing rapidly, and big cities are expanding. The available land or agricultural land has already been transferred out, so it is difficult to find. Secondly, the competition for land is very complicated, and it is not the case that if someone is willing to pay money, the government or the village committees will be willing to transfer it. The rent price has also to be considered, but it is negligible because it is a small percentage of the investment. The key issue is that some land is held by many farmers, some of whom are willing to rent it out and some of whom are not. So, it is challenging to deal with the local farmers and people."*

When he had experience in renting land, he communicated with the village committee, the village, the town and even the county leaders. He communicated with the top management, for example by asking the county, town or village leaders to inform the farmers and then rent the land in their name. The second method he used was to attract local governments to come to him through the popularity of his business since high-tech agriculture is very attractive to some local governments. He said:

"*At present, traditional agriculture is still the majority. Local governments are willing to upgrade their local agricultural models to improve their agricultural production methods. It is beneficial for the government and its personnel to improve the local area's*

> *visibility, efficiency, branding, and even exposure. So, they will also look for high-tech agricultural companies and invite them to invest. The local authorities will also provide a lot of support according to your needs. Some of the reasons why local authorities are particularly keen to bring high-tech agricultural companies to their area are to improve agricultural productivity, increase the value of local agriculture, and bring benefits to locals. Such as the use of labour and agricultural products."*

He has also mentioned that there is a very strict policy in China in that the red line of 1.8 billion mu of arable land cannot be broken up, which means finding a suitable site for his modern high-tech agricultural project can become even harder.

2.1.8. Question 3. Have you experienced any practical challenges?

The purpose of this open question is to explore the participants' experiences of difficulties they have encountered that might be able to contribute to the analysis of research question one, "*What are the barriers to urban aquaponics contributing to urban food systems*?".

In response to this, the participant of Site one (British) said

> *"Starting and cycling a system can be difficult. The process of turning pipes, tanks and grow bed from inanimate objects into a running system which provides the correct conditions for plants to flourish takes time and planning."*

Contrastingly, the owner of Site two (Chinese) encountered issues related to dead fish and financial difficulties. He said

> "*A lot of fish died due to inexperience at the beginning. The farm is currently facing a shortage of funds. Because establishing a larger-scale aquaponics farm is taking place. He is currently in the process of raising funds."*

Unlike the experiences of the two participants above, the project manager of Site three (Chinese) experienced a sudden power failure during the night that causes the fish to die from lack of oxygen. The polyester tunnel was blown open, and the insulation was blown away by the wind. Roads were closed, resulting in the fish feed not coming in. He said "*My experience over the years has made me aware of the concerns!"*Now he has three options that to be prepared when problems arise, he added. The current challenge for him is to develop a productive farming technique.

Optimistic about the challenge, the founder of Site four (Chinese) said "*There are challenges every day, but it would not be fun without them. It takes time for hands-on experimentation to understand, verify, and figure out how to solve problems*."

Similar to Site two, Site five (Chinese) also suffers from dead fish issues. The founder said

> "*My university degree was not in agriculture; I was still technically inexperienced in the early stages. The greenhouse had just been built and fish had to be transported from the provinces to be loaded into the system. The fish were already deprived of oxygen after a long period of shaking, friction and collision in the water container in the lorries, combined with the low temperature. The fish were put directly into the tanks without being treated because he was inexperienced. The temperature outside was around 5 degrees, but the water temperature in the tanks was already 15 to 18 degrees, and the fish died. A fish tank with a high-density culture contains 2,000 to 3,000 kg of fish in it. So, a significant loss occurred.*"

The second practical challenge that impressed him was selling the fish to a high-end shopping mall in Nanjing. The customers asked for live fish, so the fish were sold in a beautiful aquarium. The fish were healthy for the first one to four days, however, on the fifth-day red spots and decay started to appear on the fish. The fish were later transported back, which was highly costly.

2.1.9. Question 4. Is there any local council support for aquaponics operators that you know of?

Local governments are very important to the development of urban aquaponics. The UK is different from China in terms of policy and this question was set to explore whether the local government is supportive of aquaponics development in urban areas and whether the policies set by the government cover the industry. If so, in what ways are they supported? For example, through funding, land, or project support. By exploring this issue, it will also be possible to understand the differences in the corresponding policies in the two countries, which will provide evidence to support the analysis chapter of this study.

It is known through communication with the owner of Site one (British), there currently isn't any support from the local government.

In contrast, the Chinese government appears to be more supportive of agriculture. Site two (Chinese), the owner said

> "*Aquaponics is still niche agriculture, both in European countries and in China. So, there are no government subsidies for aquaponics in China. For example, I applied for some subsidies from the government, but they may not be related to aquaponics. I applied for subsidies for a technology demonstration, agricultural technology and research and development. It has very little to do with aquaponics. The government discontinued some subsidies, such as constructing a polytunnel greenhouse. In the past, some people would make a very high budget and apply for a government subsidy, which was half of the budget, but then not carry on with the project because they had received the subsidy. So, the government will not subsidise when the project is started. Applications will be able to get subsidies after their project has gone ahead and can make a profit through the market."*

The project manager of Site three (Chinese) is responsible for providing equipment, technical support, and management services to customers in the aquaponics company and does not know much about policy. However, he provided his opinion that aquaponics is too niche for the country to set an industry standard for aquaponics.

It appears that Site four (Chinese) has a similar answer to Site two (Chinese). The founder said

> *"There are no government subsidies for aquaponics. However, if the project is scientific or ecological, the government will subsidise a certain percentage. The first step is to set up a project. There are subsidies from the science and technology department, the science and technology bureau, the agriculture department, the agricultural bureau, and the development and National Development and Reform Commission (NDRC). This varies from time to time and from place to place. In the early days of my farm, the only subsidy was for the polytunnel. This was because the government was encouraging the building of polytunnels at that time. Applicants had to meet the standards the government required. At that time, my farm subsided from £7,000 to £8,000, and it took several years to get it. However, later on, the government found out that we were doing well, and I had bout 30 patents on my farm. So, the government started to subsidise. The polytunnel*

5 on my farm was subsidised for about £70,000. Later the government subsidised about £10,000. I was later advised to declare a national high-tech enterprise, which independent patent holders must support. In the end, my farm was passed. The farm has been a national high-tech enterprise all these years. The national high-tech enterprises also have specific preferential taxation in this regard."

Likewise, the participant of Site five (Chinese) shared a similar opinion that there were no specific subsidies for aquaponics in China. He said

> *"Government will subsidise half of the construction of a greenhouse, but it varies from 30%, 50% and 80%, depending on the local government's criteria. Subsidies associated with the establishment of projects are available. The government will assess whether the project is in line with local policies and the current direction of development of modern agriculture. If it does, the government will support half of the fund."*

2.1.10. Question 5. Are you aware of any planning systems or policies regarding renewable energy, subsidies, and the location of aquaponics businesses?

This question builds on the exploration of renewable energy, subsidies and agricultural land concessions as government support for agriculture is exploring if aquaponics enterprises are able to access this support. Through the literature review of this study, some aquaponics enterprises have applied renewable energy equipment to their farms. Moreover, this question contributes to the exploration of research questions two and three of this study.

The answer from the owner of Site one (British) to this question is that

> *"Aquaponics currently sits awkwardly between Horticulture and Aquaculture and therefore isn't that well known or currently supported through government schemes. To get help or funding you would need to look in these other two sectors rather than specifically for Aquaponics."*

The information provided by the participant of Site two (Chinese) is that

> *"There should be, but my farm doesn't need it because the climate in Chengdu is cloudy and rainy, and it's not cost-effective to use solar power."*

Similarly, the operator of Site four (Chinese) said

"*Aquaponics is still niche, and it is not enough to be classified as a separate category. So, it is difficult to make some regulations and policies for aquaponics. Renewable energy subsidies are supposed to be available, for example, for solar and photovoltaic. Nevertheless, I did not pay much attention.*"

Answers provided by the founder of Site five (Chinese) are that

"*There are subsidies. China is quite serious about agriculture, for example, there are agricultural loans, including reduced interest rates, and perhaps government departments also bear some of the interest. There is also no tax on agricultural products in our country. The government also gives incentives to those who apply for organic certification. There are also agricultural competitions organised by various departments such as the Communist Youth League and the Agricultural Bureau from time to time, with prizes awarded for winning projects*."

2.1.11. Question 6. Do you think that aquaponics is important to urban agriculture or to sustainable cities?

This question was set to gain practitioners' understanding of the role of aquaponics within urban agriculture and sustainable cities, and to contribute to the subsequent analysis of research questions 1, 2 and 3 of this study.

The participant of Site one (British) said

"*Not just aquaponics, but local food product is key to a good healthy diet that provides you with what you need to thrive and means you can know and trust where your food comes from.*"

According to the owner of Site two (Chinese), it is likely to have a positive impact. He said

"*Firstly, if the farm is in the city, it reduces carbon emissions. Secondly, aquaponics has no effluent discharge and does not affect the surrounding environment. If the farm is built on the roof of a shopping mall, it must be bustling on the weekend and attract more people to the farm, generating a profit and being educational. However, the city's cost* *is too high, and it is all commercial land, so the rent, electricity, and labour costs are much higher. It is not cost-effective to do it as a production*."

He added. Nevertheless, he accepts the idea of doing a short-term exhibition in the city, for example, building a small system to promote it in the city.

The project manager of Site three (Chinese) provided his opinions regarding this question.

"Aquaponics is crucial, but it is not the only one. There are many alternatives in agriculture. For example, urban farming can be done in a traditional way with soil or in a traditional way without soil. Such as growing strawberries in pipes for picking or using a wooden box with soil inside to grow vegetables. Aquaponics is kind of the icing on the cake in urban agriculture. Also, it is a unique concept or a special element. Besides, it provides not only fish but also vegetables. It can be combined with the landscape, production, entertainment, and visits. It is a feature of urban farming, and it is also in line with the direction of sustainable development or policy. Because it has zero wastewater discharge and no emissions, it will have even more functions if aquaponics production expands the industrial chain. For example, the aquaponics products include a wide range of fish and vegetables, which can be served in a hot pot after a visit; herbs can be grown and made into herbal sauces for gifts; herbs can be made into purees and essential oils for sale; a one-off entrance fee can be charged for the visit and the meal; technology can be sold, solutions and franchise fees can be charged; vegetables and fish can be sold locally. Fish is now easily transported, packaged, and oxygenated and then delivered by courier. In so many ways, aquaponics can offer things that other corresponding agriculture cannot, such as a good quality product with entertainment and landscaping. When aquaponics is considered as irreplaceable, it becomes important."

The following insight offered by the founder of Site four (Chinese). He said

"*Aquaponics is a broad concept that has different uses when broken down. There is the use of fish to produce vegetables and other plants, which has been developed very well in the USA. Secondly, it is a new model of farming which can be brought into the home. It is possible to grow one's vegetables, for example, on the balcony, as long as there are fish, using this system of microorganisms helping each other. Aquaponics can also be applied for landscape purposes. My farm has done some aquaponics landscapes. For example, planting flowers and grass to create a rainforest-like environment. Aone (the* *farm's name) values the fact that aquaponics has zero emissions. It is not like other agriculture where emissions, such as residues, cannot be absorbed and have to be cleaned up regularly. The aquaponics system does not need to be cleaned up regularly. The most prolonged water has not been changed for ten years in one of his projects. The water is still in there from ten years ago, but it has been absorbed and evaporated, so it has to be replenished in time.*

The founder of Site five (Chinese) believes that aquaponics is vital because aquaponics is also part of urban agriculture, which has a more significant social value than economic value. He said

"*The social value is the ability of urban agriculture to maintain a functioning city in the face of various risks and unforeseen factors, mainly in terms of self-sufficiency. For example, over 90 per cent of Singapore's agricultural products are imported, and the government wants to increase the production of urban agriculture to 30 per cent, but Singapore does not have the land to supply urban agriculture. The solution is to develop urban agriculture in underground cities, abandoned factories and on the roofs of buildings through technological means. What needs to be considered is the operating cost, the marginal cost at the end and the market acceptance."*

The second aspect he added is that urban farms can also be recreational agriculture in addition to preserving supplies.

"*For example, they can grow vegetables in the courtyard or balcony of a family. My company has also designed small-scale aquaponics systems for gardens, balconies, factories and school environments. The benefit of recreational farming is that it can be used for self-enjoyment as well as to solve the problem of buying vegetables and fish in crucial circumstances. Let's take the current situation as an example, lockdown in Shanghai makes it difficult for people to buy vegetables. Because of the lack of local supply, lorries transporting vegetables from other cities are not allowed in. Hangzhou shares the same problem as well, the vegetable market in Hangzhou supplies more than 50% of vegetables to the locals, but during the pandemic, the daily supply dropped from 5,000 to 6,000 tonnes to a few hundred tonnes. Although under this circumstance, Hangzhou could not be opened, which resulted in lorries not being able to enter and exit freely. The reason behind this is firstly, there would be many lorries from all over the country delivering vegetables, driven by the profit motive. Secondly, all lorries that can pass must have a special licence issued by the government, which is hard to acquire.*

Although if the licence is obtained, the risks involved would be very high. The lorries and drivers need to be quarantined locally or return to the local area for fourteen days, so instead of 30 deliveries a month, they are now transported twice a month, which leads to higher costs. Therefore, it is so important to develop urban agriculture."

2.1.12. Question 7. Have you encountered any financial issues?

Financial issues are related to operating costs and operating income. Financial issues are vital for practitioners in practice. It is one of the conditions that influence practitioners to get involved in this field. Participants' responses to this question may provide insight into what the barriers to the development of aquaponics are as outlined in the research question.

In response to this question, the owner of Site one (British) said

"Aquaponic systems are expensive to build and more expensive to run than traditional farms currently. However, as we scale running costs per unit should decrease."

According to the participant of Site two (Chinese)

"*The most challenging time was between 2014 and 2017. The workers could not be paid at the beginning, this was because the farm was still short of produce, and secondly, the vegetables could not be sold after harvesting. So, I started developing the internet to increase sales through online promotion. I use platforms such as WeChat, WeChat's Moment and Official Accounts to promote my products, and now I also have a live streaming marketing."*

Unlike Site one and Site two, the founder of Site five (Chinese) needs a significant amount of money for his second farm. He said

"*We are not the only ones with financial problems, but everyone in agriculture faces them. Because our founding team is relatively young. My partner is an expert and an academic, so he has limited capital. In the development process, there is a need to bring in technology, develop it and bring in people, and all this will require a lot of money. The total budget for his second site is over £3 million. It would have been impossible to invest this money on my own. So, it was a matter of finding like-minded investors to work with or raise funds with, and secondly, taking full advantage of policy support."*

CHARPTER 5. ANALYSIS

This section is consist of three parts which includes the following (1) extracting the key information acquired from participants responses according to each of interview questions, which helps to identify the keywords for further categorisation; (2) Categorising the keywords from each question responses to enable the similarity and differences between each aquaponics sites that are recognised; (3) To analyse the keyword categorised data from the interview responses and secondary data based on the research questions of this study, which includes the following: first, analysing the contribution of aquaponics to urban food systems in terms of water, placemaking and education from semi-structured interviews, and discusses participants' thoughts and opinions on the challenges of aquaponics; second, assessing the feasibility of developing aquaponics as a part of green roofs and community gardens in an urban setting as a contribution to sustainable urban food systems; and third, evaluating if planning system be more responsive to consider aquaponics as part of sustainable food system.

Table 5.1. An overview of key information extracted from interviewees' responses

Category	**Site**				
	1 (British)	2 (Chinese)	3 (Chinese)	4 (Chinese)	5 (Chinese)
Spatial categories	Suburban	Peri-urban	Inner-urban (Rooftop)	Rural hinterland	Rural hinterland
Market	Not selling fish. Selling plants. Shops. Delivery.	Selling fish and plants. Site tour. Dinning in. Online Sales. Webcast explanation to deliver experience and investment. Derivative product (Mini-Aquatic Gardens). Technical Training academy.	Education	Selling plants. Site tour. Cultural and Creative activity. Franchise. Aquaponics themed scene design and provide consultancy. Dinning in.	Selling fish and plants. Shops. Restaurants. Research and Development. Bioactive peptide extraction and R&D. Biological products.
Q 1. Why did you decide to set up the aquaponics business	Different. No soil. Interested in practical activity. Produce more food than traditional agriculture. Less land uses. Saving water.	Health. Profit. Food security.	Friend's influence. Health. Food security. Agricultural background.	Partner influence. Meaningful. Profit.	Health. Agricultural background. Partner influence. Food security
Q 2. Have you encountered any problems with finding a suitable location?	Could not get trust initially due to a brand-new company. A level site is required.	'Red Line' policy restriction. Distance from cities.	N/A	Forced to find a new site due to demolition. Distance from cities. Environmental condition.	Inexperience in negotiation. The complexity of land transfer. Distance from cities.

					Suitable land is not available. ‘Red Line’ policy restriction.
Q 3. Have you experienced any practical challenges?	Technical issues initially	Fish died.	Fish died. Infrastructure damaged by severe weather. Fish feed shortage.	No fun without challenges.	Fish sickness and died
Q 4. Is there any local council support for aquaponics operators that you know of?	Support is not available.	No specific support for aquaponics. Subsidies for technology demonstration, agricultural technology and research and development.	No specific support for aquaponics.	No specific support for aquaponics. Scientific or ecological projects can be subsidised. Subsidies for polytunnels and high-tech enterprises.	No specific support for aquaponics. Subsidies for the polytunnel, greenhouse and establishing a project
Q 5. Are you aware of any planning systems or policies regarding renewable energy, subsidies, and the location of aquaponics businesses?	Support is not available.	Renewable energy subsidies might be available	N/A	Renewable energy subsidies are available.	Agricultural loans. Tax-free for agricultural produces. Incentives for organic certification. Prizes to winners of agricultural competition.
Q 6. Do you think that aquaponics is important to urban agriculture or to sustainable cities?	Local food production is vital.	Reducing carbon emissions. No effluent discharges. Benefiting education. Suitable for rooftop of the shopping mall	It is crucial, but it is not the only one. It is versatile in the production of produce and application to various locations. No emission.	Producing locally sourced food, homegrown, landscape purpose, water conservation and no emission discharge that aquaponics possesses and deliver to cities.	Greater social value in maintaining cities being self-sufficient. Home grown. Suitable for rooftop of the building and underground. School and factory environment.
Q 7. Have you encountered any financial issues?	Highly entry cost.	Shortage of funds in expanding the farm.	N/A	N/A	Shortage of funds in expanding farm.

Table 5.2. Keyword categorisation from question one responses

	Keyword extracts from responses of Q 1. “Why did you decide to set up the aquaponics business?”										
Site	Different	No soil	Health	Profit	Food security	Interested in physical activity	Influenced by friends and partners	Meaningful	High yield	Agricultural background	Environmental concerns (e.g., less land use, saving water)
1(UK)	●	●				●			●		●
2(China)			●	●	●						
3(China)			●		●		●			●	
4(China)				●			●	●			○
5(China)			●				●			●	
○ This icon shows that the participant mentioned the above point in the subsequent conversation instead of directly responding to the question.											

Table 5.2 shows significant differences between British and Chinese participants regarding the reason for doing aquaponics business. As a result of the lack of soil, high yield, and lack of harmful effects on the environment, the British participant considered aquaponics to be unique. In contrast, the Chinese participants placed a greater emphasis on health, profit, and food security, and three of them were influenced by their friends and business partners.

Table 5.3. Keyword categorisation from question two responses

	Keyword extracts from responses of Q 2. "Have you encountered any problems with finding a suitable location?"								
Site	No credibility	'Redline' policy restriction	Distance from cities	Relocation	Environmental condition	The complexity of land transfer	Suitable land is not available	Inexperience in negotiation.	
1(UK)	●				●				
2(China)		●	●						
3(China)									
4(China)			●	●	●				
5(China)		●	●			●	●	●	

Table 5.3 indicates that the distance from cities is one of the most important factors, while the Redline policy is the second concerns for Chinese participants to find a suitable location for doing aquaponics. Conversely, the British site has encountered obstacles with regards to no credibility and environmental condition prior starting aquaponics business.

Table 5.4. Keyword categorisation from question three responses

	Keyword extracts from responses of Q 3. "Have you experienced any practical challenges?"				
Site	Technical issues initially	Fish illness/died	Maintenance/Repair	Fish feed shortage	No fun without challenges
1(UK)	●				
2(China)		●			
3(China)		●	●	●	
4(China)					●
5(China)		●			

Table 5.4 presents a clear difference between British and Chinese practitioners. While the British participant initially experienced technical challenges, the majority of Chinese participants encountered fish diseases, polytunnel maintenance and fish feed shortage.

Table 5.5. Keyword categorisation from question four responses

	Keyword extracts from responses of Q 4. "Is there any local council support for aquaponics operators that you know of?"				
Site	No specific support for aquaponics	Subsidies for high-tech enterprises	Subsidies for technology demonstration, agricultural technology and research and development	Subsidies for establishing scientific or ecological projects	Subsidies for polytunnels
1(UK)	●				
2(China)	●		●		
3(China)	●				
4(China)	●	●		●	●
5(China)	●			●	●

Table 5.5 illustrates that the British and Chinese participants unanimously share the same insights regarding the absence of local government support specifically for aquaponics. Nevertheless, the Chinese participants had other subsidies that they could apply from the government compared to the British participant.

Table 5.6. Keyword categorisation from question five responses

	Keyword extracts from responses of Q 5. "Are you aware of any planning systems or policies regarding renewable energy, subsidies, and the location of aquaponics businesses?"					
Site	Support is not available	Renewable energy subsidies might be available	Prizes to winners of agricultural competition.	Agricultural loans are available	Tax-free for agricultural produces.	Incentives for organic certification.
1(UK)	●	○				

2(China)		●				
3(China)	–	–	–	–	–	–
4(China)		●				
5(China)			●	●	●	●
○ This icon shows that the participant mentioned the above point in the subsequent site observation instead of directly responding to the question. – The icon shows that the participant has no knowledge regarding this topic.						

In Table 5.6, it can be seen that the Chinese entrepreneurs were more aware of their rights to receive government subsidies and supports than the British participants.

Table 5.7. Keyword categorisation from question six responses

	Keyword extracts from responses of Q 6. "Do you think that aquaponics is important to urban agriculture or to sustainable cities?"							
Site	Local food production is vital	It is environmentally friendly (e.g., no effluent discharges, water conservation, no/reducing (carbon)emission)	Benefiting education (includes site visit)	It is versatile in the production of produce	It is flexible on application to various locations (e.g., landscape purpose, rooftop and underground)	Producing locally sourced food	Greater social value in maintaining cities being self-sufficient.	Homegrown
1(UK)	●	○				●		
2(China)		●	●		●			
3(China)		●	●	●	●			
4(China)		●			●			●
5(China)		●	●		●		●	●
○ This icon shows that the participant mentioned the above point in the subsequent site observation instead of directly responding to the question.								

As shown in Table 5.7, all participants share the same understanding that aquaponics represents an environmentally friendly farming method in terms of no effluent discharges, water conservation, and no carbon emissions. The majority of Chinese participants believe aquaponics benefits education and can be applied to a variety of locations. In particular, the British practitioner pointed out that aquaponics can make the biggest contribution to urban agriculture by producing locally sourced food.

Table 5.8. Keyword categorisation from question seven responses

	Keyword extracts from responses of Q 7. "Have you encountered any financial issues?"	
Site	Highly entry cost	Shortage of funds in expanding farm
1(UK)	●	
2(China)		●
3(China)	–	–
4(China)	–	–
5(China)		●
– The icon shows that the participant did not provide their opinion regarding this topic.		

Table 5.8 demonstrates that for the British practitioner, the high entry cost is the main financial concern, while the Chinese practitioners face a shortage of funds for the expansion of the farm.

5.1. The contribution of aquaponics

5.1.1. Aquaponics contributes to the environment (water)

After participants confirmed, the interview questions focused on the initial reasons for initiation, the location, practical challenges, government subsidies, economics and the impact of aquaponics on urban agriculture or sustainable cities. Based on the conversations during the interviews and site observation. All participants made a positive statement regarding the impact of aquaponics on the environment (Table 5.7). Participants were asked do you think that aquaponics is important to urban agriculture or to sustainable cities, and four Chinese participants responded that aquaponics is an environmentally friendly farming method that involves no effluent discharge, saving water and has no or very low CO2 emissions. The owner of Site four mentioned *"Aone (the farm's name) values the fact that aquaponics has zero emissions. It is not like other agriculture where emissions, such as residues, cannot be absorbed and have to be cleaned up regularly. The aquaponics system does not need to be cleaned up regularly. The most prolonged water has not been changed for ten years in one of his projects. The water is still in there from ten years ago, but it has been absorbed and evaporated, so it has to be replenished in time."* (Analysis 2.1.11). The UK participants did not respond to the environmental aspects of this question in his feedback but mentioned during the site observation that aquaponics uses less water and discharges less effluent than hydroponics.

5.1.2. Aquaponics contributes to placemaking

Four (Chinese) of the five participants acknowledged the flexibility of the aquaponics system and its ability to integrate into many urban spaces (Table 5.7). For example, rooftops, basements, abandoned factories, offices and school. Two of them mentioned rooftop and one mentioned underground and abandoned factories. Two (Site three and four) participants considered aquaponics can be designed as landscape purpose. *"It can be combined with the landscape, production, entertainment, and site visit (Site three)."* "*Aquaponics can also be applied for landscape purposes. My farm has done some aquaponics landscapes. For example, planting flowers and grass to create a rainforest-like environment (Site four)."*

The participant believes that the contribution of aquaponics to urban agriculture and sustainable cities can also be reflected in the diversity of products available to meet the needs of a wider range of markets and people (Site three). He described aquaponics as a system that provides a wide range of fish and plants. This diversity in return can lead to a wider range of products that can meet the needs of more people and different markets. He said*, "the aquaponics products include a wide range of fish and vegetables, which can be served in a hot pot after a visit; herbs can be grown and made into herbal sauces for gifts; herbs can be made into purees and essential oils for sale; a one-off entrance fee can be charged for the visit and the meal; technology can be sold, solutions and franchise fees can be charged; vegetables and fish can be sold locally. Fish is now easily transported, packaged, and oxygenated and then delivered by courier."* One participant (Site five) believes that aquaponics is vital because aquaponics is also part of urban agriculture, which has a more significant social value than economic value. He further explained that urban agriculture could help to sustain cities in the face of various risks and unforeseen factors. He said "*The social value is the ability of urban agriculture to maintain a functioning city in the face of various risks and unforeseen factors, mainly in terms of self-sufficiency. For example, over 90 per cent of Singapore's agricultural products are imported, and the government wants to increase the production of urban agriculture to 30 per cent, but Singapore does not have the land to supply urban agriculture. The solution is to develop urban agriculture in underground cities, abandoned factories and on the roofs of buildings through technological means.*

5.1.3. Aquaponics contributes to education

Three participants (Chinese) acknowledged that aquaponics had a positive impact on education (Table 5.7). Site three (Chinese) is located on the rooftop of a primary school (Fig 4.2, 4.9 & 4.10). Prior to the formal interview with the project manager of Site three, he described that Site three was set up with the purpose of education. He believes that aquaponics system allows young children to learn about the origin and production of food, from the growth of fish to the culture of fish in China. The system is an excellent vehicle for science education due to the rich scientific principles and new technologies it possesses.

All of the participants in the data collected had experience of using their farms for educational activities. During the site observation, the owner of Site one (British) said that his farm receives site visits and science education activities. Site two was awarded a license by the Chengdu Municipal Bureau of Education in China as the Chengdu Youth Science Base. In general, these activities are organised by the schoolteachers who take the students to the farm for social and scientific purposes or by their parents who take their children to the farm for sightseeing. Both Site four and five are doing activities for sightseeing and science experience. Picture 5.1 shows the students' science experience activities at Site four, the picture is acquired from the official website of Site four.

Figure 5.1. Students attended science experience activities at Site four (Chinese). Source: weibo.com 艾维农园 (n.d.).

Aquaponics is a self-circulating, closed ecosystem that recycles water resources (Bernstein, 2011; Dallsgaard *et al*., 2013; Sayara *et al*., 2016). Pesticides and fertilisers are not required in this system, this results in zero pollution, and allows for three-dimensional cultivation and efficient land use, which is beneficial to environmental protection (Dallsgaard *et al*., 2013; Sayara *et al*., 2016). Science experience activities in aquaponics sites enable students to gain an understanding of environmental protection and water conservation, which illustrates the contribution that aquaponics can make to education in an urban environment.

5.2. The barriers to urban aquaponics contributing to urban food systems

5.2.1. Lack of support from the government

According to the results that acquired from the interviews, all participants provided similar responses in that there is no specific support from the local government for aquaponics (Table 5.5). Chinese aquaponics practitioners can apply for subsidies from the government in terms of (1) high-tech enterprises, technology demonstration, (2) agricultural technology and research and development, (3) establishing scientific or ecological projects, and (4) polytunnels.

In contrast, according to British aquaponics practitioner, he could not get access to any similar subsidies from the government compared to the Chinese practitioners (Table 5.5 & 5.6). The British practitioner mentioned that the government could support 40% of investing high tech equipment. For example, a robot that helps to pick and place plants. However, for a small-scale aquaponics operation does not require this large degree of advanced machinery, and the price of the equipment is expensive that the operator does not want to invest unless a large-scale aquaponics is implemented.

In the UK the government established a scheme titled the "Farming Transformation Fund Improving Farm Productivity grants" for the purchase of innovative farming equipment that increases productivity and improves the environment (Rural Payments Agency, 2022). Only projects estimated to cost over £87,500 can receive up to 40% of the grant for robotic horticulture and agricultural equipment (Rural Payments Agency, 2022). Accepted applicants can claim a grant from a minimum of £35,000 (40% of £87,500) up to a maximum of £500,000 (Rural Payments Agency, 2022). However, this scheme was only available between the 19th of January 2022 to the 16th of March 2022.

As explained above, the government grant is intended for large-scale farms rather than aquaponics farms operating on a small scale in the UK. Therefore, Site one (British) was not able to receive the government support for his aquaponics farm compared to his Chinese counterpart (Table 5.5 & 5.6). The Chinese aquaponics sites could obtain support from the government. Nevertheless, the subsides or grants are not specifically for aquaponics project both in the UK and China.

5.2.2. Finding a suitable location

Distance between city and farm is one of the main considerations for Chinese practitioners to find a suitable location (Table 5.3). A key consideration is that Chinese operators would like city dwellers to have easy access and travel to their farms for consumption. If the distance is too long, it may reduce people's interest in visiting a farm by travelling several hours on the road. Other obstacles of obtaining a suitable location for Chinese aquaponics operators include Redline policy restriction, environmental conditions, the complexity of land transfer, the unavailability of suitable land and inexperience in negotiation (Table 5.3). In contrast, the British operator did not have the similar distancing concern.

5.2.3. Fish disease control

Fish disease control is the most challenging practice for Chinese operators running an aquaponics farm at their early stage. Three Chinese operators have encountered fish illness (Table 5.4). Conversely, the owner of British site has not experienced the similar issue, as he mentioned during the site observation that he has obtained a degree in Aquaculture and Fisheries Management unlike the Chinese practitioners. This could be one of the reasons that the British operator was able to manage fish disease control. The second reason is that he does not wish to sell fish, but only produce plants (Table 5.1). Another cause of fish illness for Chinese operators appears to be having a large number of fish (200-1000 fish) in one tank, as opposed to the British operators, who have only 16 fish in a single tank. As a result, the quantity of fish in the Chinese sites differs significantly from that in the British sites because, unlike the fish can be sold in the Chinese sites, the fish in the British sites serves solely as a source of nutrition for the plants.

5.3. The feasibility of developing aquaponics as a part of green roofs and community gardens in an urban setting as a contribution to sustainable urban food systems

The primary data from this study shows the possibility of combining aquaponics with a rooftop (Fig 4.2, 4.9 & 4.10). In the case of Aquaponics Site three (Chinese) Xinxigang primary school-Sky Farm, which was built on the rooftop of the building in the centre of the city and was originally intended to provide science education for young children. In contrast, the primary data has shown none of existing operating aquaponics site is located on the rooftop of the building in the UK. According to Li *et al.* (2018) the idea of building-based aquaponics is based on the innovative form of urban green architecture, which combines food, architecture, production, and design to produce food on buildings in urban areas. It can be installed on the wall and rooftop of an existing building.

China is friendly to agriculture under its current Redline Policy, which helps to keep agricultural land from being occupied by development and construction (National Food and Strategic Reserves Ministration, 2022). As mentioned in the theoretical framework section 2.3 of this study, small-scale urban farming has not received much attention in China, while instead China is heavily researching and developing capital-intensive inner-city food production, including vertical farming techniques such as plant factories, hydroponics and aquaponics, as well as 3D printed and synthetic food products (Hayashi, 2016). So urban green roofs and community gardens have not received much attention from the relevant authorities.

5.4. Could planning system be more responsive to consider aquaponics as part of sustainable food system?

In this research five aquaponics farms as case studies were examined. The feature of aquaponics it possesses including (1) water conservation; (2) no chemical fertiliser and pesticides usage; (3) no effluent discharges (4) benefiting education; (5) producing local sourced food; (6) greater social value in maintaining cities being self-sufficient (7) homegrown (8) flexibility on application to various locations (e.g., landscape purpose, rooftop and underground); (9) reducing carbon emission by providing local food (Table 5.7).

Based on the information provided in the theoretical framework section, aquaponics can be described as a self-circulating, closed ecosystem that recycles water resources (Bernstein, 2011; Dallsgaard et al., 2013; Sayara et al., 2016). Dallsgaard et al. (2013) found that aquaponic systems can reuse 95–99% of water. The absence of pesticides and fertilisers leads to zero pollution (Dallsgaard et al., 2013). As a result, aquaponics is viewed as a sustainable urban agriculture approach (Somerville et al., 2014). In contrast to hydroponics, aquaponics can also produce fish, which increases economic viability in urban areas with diverse dietary requirements (Bernstein, 2011; Somerville et al., 2014; König et al., 2016).

Those features of aquaponics were explored from primary and secondary data that has been explained above, which provides evidence that aquaponics may serve as a sustainable approach to urban food system. The planning system should take a consideration to aquaponics as a potential sustainable farming method to contribute urban food system and consequently support national policies aiming to their environmentally sustainable goals.

CHARPTER 6. CONCLUSION

This research applied a case study approach to conduct semi-structured interviews with aquaponics practitioners in the UK and China. The differences in policy and culture between the two countries have led to some similarities and differences in the outcomes of the cases. The results of this study show that the development of aquaponics can bring benefits to cities in terms of education, water conservation and place-making in both UK and China. Despite aquaponics offering many benefits to cities, the lack of specific policy support, site availability and high entry cost have limited the development of aquaponics in cities in both UK and China.

Notably, aquaponics produce in Chinese sites appears to be more diverse than that in the British site, while the British practitioner has more environmental concerns than the Chinese participants. Compared to British practitioner, Chinese practitioners are able to maximise their profits through extended aquaponics produce (essential oil extraction, research and development of biotech products, selling fish and herb), franchise, dinning in, educational activities and online paid knowledge. Moreover, Chinese practitioners could obtain more sources of government support through subsides scheme, which include (1) high-tech enterprises, technology demonstration, (2) agricultural technology and research and development, (3) establishing scientific or ecological projects, and (4) polytunnels. Conversely, the UK's case shows that there are some government support grants for agriculture. However, due to the high application threshold (estimated project costs), small-scale aquaponics farms do not have the opportunity to receive the government support. Furthermore, there is a lack of product diversification and extended produce, which can lead to low profitability for the British practitioner and make it difficult to sustain the business.

Chinese case (Site three) shows the possibility of combining aquaponics with rooftops, and planning permission application was not required. Additionally, this site was built for educational purpose. In contrast, from both primary data and available secondary data have not proved that there is a British existing aquaponics site which is located on the rooftop of buildings. The aquaponics industry in China has many more examples, some of which can be found in or nearby cities. In the case of participants from China, it was evident that they utilized grants and subsidies more effectively (Table 5.5). The British sites were explored before selection, with two of them failing to respond to my initial contact (Table 3.1). British site 2 and 3 have already been closed (Table 3.1). The reason for closure remains unexplored as the operators were unavailable to contact and there is no public information available online for further investigation. Nevertheless, based on the results of this study, the reason for closure could be a lack of government support for small-scale aquaponic businesses, or a lack of diversification of produce in order to make substantial profits. This research suggests that the planning system should consider aquaponics as a potential sustainable farming method to contribute to urban food production and therefore support national policies aimed at reducing their environmental impact.

This research has led me to conclude that the British site does not provide fish for sale. In addition, during the case selection process, two other British sites were identified as candidates also did not sell fish and these two sites have already been closed. Comparatively, three out of four aquaponics sites in China involve the sale of fish. Therefore, I hypothesise that there are significant differences in fish-eating cultures and fisheries policies between the UK and China that might be behind this factor. Future research opportunities include a more in-depth exploration of these two aspects and a more comprehensive assessment of how aquaponics contributes to urban food systems within cities. Aquaponics demonstrates an innovative approach to food security and placemaking and maintains a functioning city in terms of food in the face of various risks and unforeseen factors such as Covid-19 pandemic. Therefore, it can be operated in the environment where future food requirements will be at great importance.

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Appendix 1. The Ethics Approval document (1&2)

Document 1

University of Hertfordshire UH

HEALTH, SCIENCE, ENGINEERING AND TECHNOLOGY ECDA

ETHICS APPROVAL NOTIFICATION

TO	Jiaye Bao
CC	Associate Professor Susan Parham/ Dr Avice Hall
FROM	Dr Simon Trainis, Health, Science, Engineering & Technology ECDA Chair
DATE	04/03/2022

Protocol number:	**LMS/PGR/UH/04898**
Title of study:	Exploring aquaponics systems as part of food planning and environmental management strategy, policy and sustainable placemaking: examining two Chinese and UK case studies

Your application for ethics approval has been accepted and approved with the following conditions by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

no additional workers named

General conditions of approval:

Ethics approval has been granted subject to the standard conditions below:

Permissions: Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

External communications: Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Invasive procedures: If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and copies of your completed consent paperwork to this ECDA once your study is complete.

Submission: Students must include this Approval Notification with their submission.

Validity:

This approval is valid:

From: 04/03/2022

To: 30/04/2022

Document 2

University of Hertfordshire UH

HEALTH, SCIENCE, ENGINEERING AND TECHNOLOGY ECDA

ETHICS APPROVAL NOTIFICATION

TO	Jiaye Bao
CC	Susan Parham
FROM	Dr Simon Trainis, Health, Science, Engineering & Technology ECDA Chair
DATE	31/05/2022

Protocol number: **aLMS/PGR/UH/04898(1)**

Title of study: Exploring aquaponics systems as part of food planning and environmental management strategy, policy and sustainable placemaking: examining Chinese and UK food growing project case studies

Your application to modify and extend the existing protocol as detailed below has been accepted and approved by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

no additional workers named

Modification: Detailed in EC2

General conditions of approval:

Ethics approval has been granted subject to the standard conditions below:

Original protocol: Any conditions relating to the original protocol approval remain and must be complied with.

Permissions: Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

External communications: Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Invasive procedures: If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and copies of your completed consent paperwork to this ECDA once your study is complete.

Submission: Students must include this Approval Notification with their submission.

Validity:

This approval is valid:

From: 31/05/2022

To: 31/10/2022

Please note:

Failure to comply with the conditions of approval will be considered a breach of protocol and may result in disciplinary action which could include academic penalties.
Additional documentation requested as a condition of this approval protocol may be submitted via your supervisor to the Ethics Clerks as it becomes available. All documentation relating to this study, including the information/documents noted in the conditions above, must be available for your supervisor at the time of submitting your work so that they are able to confirm that you have complied with this protocol.

Should you amend any aspect of your research or wish to apply for an extension to your study you will need your supervisor's approval (if you are a student) and must complete and submit a further EC2 request.
Approval applies specifically to the research study/methodology and timings as detailed in your Form EC1A or as detailed in the EC2 request. In cases where the amendments to the original study are deemed to be substantial, a new Form EC1A may need to be completed prior to the study being undertaken.

Failure to report adverse circumstance/s may be considered misconduct.
Should adverse circumstances arise during this study such as physical reaction/harm, mental/emotional harm, intrusion of privacy or breach of confidentiality this must be reported to the approving Committee immediately.