

Uppsala University

Master Thesis

Empowering Smallholder Farmers to Achieve Food Sovereignty Through Soil-Less Agriculture

Authors

Abhijith Nag Balasubramanya

Fathimath Zainy Shaafiu

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Abstract

This study explores the question of how soil-less agriculture through hydroponics, aeroponics, and aquaponics can empower smallholder farmers to achieve food sovereignty as portrayed in documentaries. It addresses the power imbalance between large corporations and smallholder farmers in the traditional agriculture industry. Documentary research approach is used to understand the various applications and research aspects of soil-less agriculture from around the world. Real-life examples from different countries where these methods have been successfully implemented in the agriculture industry, ranging from large industrial settings to smallholder farmers in disadvantaged communities, are analyzed. Further, content analysis is done on these documents by constructing a matrix that combines the process of empowerment and the six pillars of food sovereignty to analyze the different forms of empowerment. The study also investigates how the use of soil-less agriculture can build capabilities through enhanced “well-being freedom” and “agency freedom” and empower smallholder farmers to achieve food sovereignty.

Keywords: *Food access, food sovereignty, food security, agriculture, alternative agriculture, soil-less agriculture, aeroponics, hydroponics, aquaponics, empowerment, power, smallholder farmers, vertical farming.*

CHAPTER 1

1 Introduction

The third agricultural revolution between 1950 and the late 1960s saw drastic changes in the way food was produced (Troughton, 1985). Technological advancements along with testing of chemical pesticides and fertilizers led to large scale farming practices around the world (Sharma and Singhvi, 2017). The excessive use of chemicals in agriculture degraded the soil and reduced the nutrient value of the food produced (Sharma and Singhvi, 2017). This further led to the desertification of what was once fertile land (Elbasiouny, 2018). Intense large-scale farming practices in the neo-capitalist world left behind a massive carbon footprint that contributed to global warming (Jiang et al., 2022).

Today, about 6% of the total carbon dioxide emission is caused by the agricultural industry (Han et al., 2018). It is estimated that one-third of the total food that is produced is wasted in the supply chain process from farmland to consumer (Boliko, 2019). Imports and exports of non-local food to markets around the world not only contribute to climate change but also lead to the decline in local food consumption in many places (Udmale et al., 2020).

The introduction of genetically modified seeds into agriculture by neo-capitalistic agrotech industries in many countries has given rise to issues related to food sovereignty with local smallholder farmers (Rock, 2018). These seeds are sold to farmers with the promise of generating higher yields without informing them about future consequences. The seeds are patented by these industries and hence the farmer must abide by the rules of the industry (Howard, 2015). The United States Supreme Court 1980 ruled that genetically modified seeds could be patented and that the buyer of these seeds must abide by the rules of these industries (Mascarenhas and Busch, 2006). This not only leads to the farmers losing their freedom to store the seeds from yield for future cultivation but also binds them economically to purchase the seeds each time from these industries (Howard, 2015). These issues lead to a difference in power structures between the smallholder farmer and the biotech industries that sell the seeds (James, Hendrickson and Howard, 2012).

Food sovereignty ensures farmers the right to produce food locally in an eco-friendly environment (Wittman, 2011). It provides them with the basic freedom to choose their method of cultivation that keeps them within the closed localized loop which not only provides economic incentives but also ensures ecological balance (Desmarais, 2008). Food sovereignty is an important

aspect to consider during food crises caused by climate change when mitigating famine-like situations not only for governmental organizations but also from an individual's perspective (Seiler, 2012). Food sovereignty could be seen as a form of social insurance that helps the local population recover during these situations and helps mitigate the negative impacts of climate change (Tilzey, 2020). Geographical limitations due to extreme temperatures in certain parts of the world may not favour traditional agricultural practices in the future. This calls for rapid change in the way food is produced throughout the world and an increase in the prominence of local food production systems.

The past three decades have seen substantial advancement in the scientific development of alternative agricultural practices (Stump, 2018). The late 90s and the early 2000s saw a revolution in the way plants can be grown. The National Aeronautic Space Academy (NASA) sponsored study in 1997 to test whether plants could grow in space aboard the Mir space station was the first known effort of growing plants aeroponically (Boen, 2007). This experiment not only showed the non-requirement of soil for cultivation but also recorded a higher growth rate of plants compared to the conventional cultivation practices with minimal use of water (Boen, 2007). Hydroponics agriculture on the other hand dates back to Babylonian times during the construction of the Hanging Gardens of Babylon (Panwar, 2020). A more advanced technological and scientific way of growing plants using only water and nutrients can be referenced back to the late 1930s and early 1940 when US troops cultivated fresh produce when stationed at the infertile Pacific Islands during the 2nd World War (Panwar, 2020). In the present day, many alternative agricultural practices such as container farming, closed-loop z-farming, aquaculture and other practices use hydroponic and aeroponic techniques in food cultivation.

This paper discusses how the concentration of power in the traditional agriculture industry has created an imbalance between smallholder farmers and large industrial farmers. This imbalance can be seen socially, economically, politically, physically and educationally which has hindered smallholder farmers from being food sovereign. Therefore, empowering these farmers to achieve food sovereignty is of great importance. This paper allows us to explore the new opportunities presented using soil-less agriculture as a tool to empower smallholder farmers to tackle food sovereignty issues. The main purpose of this paper is to connect the vital topics of food sovereignty and empowerment with soil-less agriculture, and to explore how smallholder farmers can empower themselves and potentially reclaim control over their food with the use of soil-less

agriculture.

Research Gap

Smallholder farmers face many risks in traditional farming practices that often affect their livelihood (Kuang et al., 2020). These risks could be due to unpredictable climate, land degradation, unfair price for their produce and lack of knowledge and technology (Laube, Schraven and Awo, 2011). These factors often cause power imbalance economically due to lack of market access, socio-politically due to lack of bargaining power and decision making, and educationally due to upgrading and diversification of the crops grown (Kuang et al., 2020). These issues pose a barrier to small-holder farmers in achieving food sovereignty. Therefore, it becomes important to explore new methods of agriculture that could help these farmers claim control over their food. Soil-less agriculture methods such as hydroponics, aeroponics and aquaponics could be some interesting avenues that could help smallholder farmers overcome the barriers imposed by conventional agriculture in achieving food sovereignty (Steenkamp et al., 2021). When discussing soil-less agriculture, the different levels of technology used in implementing soil-less agriculture also needs to be considered (Caputo, Rumble and Schaefer, 2018). This then raises the discussion of how alternative agricultural practices can empower smallholder farmers. There is limited literature directly linking soil-less agriculture to the process of empowerment and food sovereignty. Therefore, this paper tries to connect the concepts of soil-less agriculture with empowerment to enhance the capabilities of smallholder farmers to achieve food sovereignty.

Aim

This thesis aims to develop an understanding of how smallholder farmers can be empowered to achieve food sovereignty through soil-less agriculture using a documentary research approach. Various documents containing videos and reports about the implementation of soil-less agriculture from established organizations will be analyzed to understand how smallholder farmers can be empowered to achieve food sovereignty.

Research Question

How are the effects of soil-less agriculture on the empowerment of smallholder farmers to achieve food sovereignty portrayed in documentaries?

CHAPTER 2

In this chapter we will be exploring theories of empowerment, capabilities approach, different forms of empowerments, the concepts of food sovereignty and food security, ecocentrism and technocentrism in agriculture, and the role of aeroponics, aquaponics, and hydroponics in empowering smallholder farmers.

2.1 Theoretical Literature

2.1.1 Empowerment

The definition of empowerment is contested in research circles, with some referring to empowerment as a specific social science theory that is applicable in scenarios where there are varying power relations, while others use it as a noun and a verb often filling in for ‘enable’ or ‘allow’ in social science settings (Drydyk, 2013).

One of the first detailed conceptualizations of empowerment was by Batliwala in 1994 (Maiorano et al., 2021). It defines empowerment as being “a process, and the results of a process, of transforming the relations of power between individuals and social groups” (Maiorano et al., 2021). According to her, empowerment can be a process where power relations are shifted in three ways (Maiorano et al., 2021). They can be:

1. by challenging the ideologies that justify and sustain social inequalities
2. by changing existing patterns of access and control over economic, natural, and intellectual resources
3. by transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market

Challenging exploitative ideologies deals with the implicit biases and beliefs in society and can often be one of the hardest changes to make (Cornwall, 2007). Education is one of the strongest ways in which this can be challenged, as it informs people of alternate possibilities (Finnegan and Grummell, 2019).

Changing existing resource control and access has traditionally been a difficult avenue in the agriculture and food industry (Howard, 2021). There are many barriers to enter the traditional

agriculture industry - limited land and inhospitable climates being two of the most prominent ones (Howard, 2021). Even here, education can play an important role in changing the control of intellectual resources, and over a longer period, the control of other resources as well (Lybbert and Sumner, 2012).

2.1.2 Capabilities Approach

The Capabilities Approach - an influential framework that was introduced by Amartya Sen and developed further by Martha Nussbaum, may also be used (Enomoto, 2020) to discuss empowerment. The Capabilities Approach can be used to analyze an individual or a community's level of well-being (Enomoto, 2020). This is done by looking at various factors that contribute value to their lives (Enomoto, 2020). Capabilities are seen as central to the well-being of an individual or a community and as things that need to be satisfied to increase well-being, which is why the concept is often used in social work and policy making (Enomoto, 2020).

In his work, Amartya Sen writes about two aspects of freedom - 'well-being freedom' and 'agency freedom' (Enomoto, 2020). Well-being freedom is defined as having the freedom to live a life one values, and agency freedom is defined as having the agency and ability to pursue the goals one values (Enomoto, 2020). Empowerment, when defined as choice expansion, can then be said to be the same thing as agency freedom (Drydyk, 2013).

Empowerment can then be described as being a process in which individuals' capabilities are developed (Rowlands, 1995). The two concepts are often used together in reports, with some referring to the process of capability building as empowering, while others argue that how capability is built determines whether or not it is empowering (Couldry, 2019). According to Suarez-Balcazar et al. (2008), capability building can empower communities when it considers its stakeholders and ensures that their strengths and views are used in the process.

In the context of the agriculture industry, 'senses, imagination, and thought' which Nussbaum says allows people to sense, think and imagine using education (Holifield, Chakraborty, and Walker, 2018) is one of the most relevant capabilities which can help individuals such as

smallholder farmers reduce the power imbalance between themselves and large corporations in the attempt to achieve food sovereignty. The ability for people to grow their food would also mean that the capabilities of bodily health and control over one's environment are strengthened (Schlosberg, D, 2012).

2.1.3 Different Forms of Empowerment

Empowerment can be broadly classified into ten important categories based on an individual's capability to function freely in society.

Individual Empowerment

Individual empowerment or personal empowerment can be defined as an act of being in control of one's own life by taking decisions that convert intention into action without the interference of external agency (Hennink et al., 2012). This does not mean that an individual must do things solely by themselves but must have the freedom of taking decisions and being accountable for their actions (King Duvall, 1999).

Economic Empowerment

Economic empowerment is the capacity of an individual to make financial decisions and act upon it that provides control over their financial resources (Eggers del Campo and Steinert, 2020). It is a freedom that is necessary for each individual to earn, spend and grow their financial resources without any obstacles (Hawkins and Kim, 2011).

Social Empowerment

Social empowerment can be defined on both an individual and collective level (Herrmann, 2005). On an individual level, social empowerment is the freedom to make personal choices that provides access to internal and external resources that allows an individual to control the environment they live in (Banerjee and Jackson, 2016). On a collective level, social empowerment allows people to gain access to social resources that provides a sense of identity, community and well-being that helps them thrive in society (Antonella Delle Fave, Bassi and Massimini, 2011).

Political Empowerment

Political empowerment can be expressed as the right or freedom of an individual or a

community to represent themselves in decision-making process and to voice their needs and concerns in the formulation of policies that directly or indirectly affects the society (Hennink et al., 2012).

Community Empowerment

Community empowerment is defined as enabling a group of individuals with common interests or identities to gain control over the factors that shape their lives (Israel et al., 1994). Community empowerment also enables the group to voice their decisions to bring about a social or political change that benefits everyone that belongs to the community (Coy et al., 2021).

Educational Empowerment

Educational empowerment can be defined as the capability of an individual to access and gain knowledge through education (Monkman, 2011). Building knowledge and skills in people through education bridges the power imbalance in society by providing equal opportunity to each individual to grow socially and economically (Monkman, 2011).

Organizational Empowerment

Organizational empowerment refers to the ability of an organization to enable each individual within an organization to gain equal access to all resources and voice their decisions to achieve a collective goal effectively (Morse and Allensworth, 2015).

Cultural Empowerment

Cultural empowerment can be defined as enabling individuals of diverse culture and ethnicities to have equal access to opportunities by allowing them to uphold their cultural values (Beaman, 2016). This allows people from marginalized communities to represent their cultural beliefs and principles and to share the knowledge to others (Molina-Fernández et al., 2017).

Physical Empowerment

Physical empowerment refers to the freedom to access good nutrition and healthcare for the well-being of an individual (Mayoh and Jones, 2014). This can be achieved by improving the physical activities of individuals and by enabling access to clean water and culturally appropriate diets (Mayoh and Jones, 2014).

Psychological Empowerment

Psychological empowerment refers to the mental well-being of an individual to actively function in society (Christens and Lin, 2014). The four important factors of psychological empowerment are meaning, competence, self-determination and impact (Ergeneli, Arı and Metin, 2007). These factors are essential for an individual to build internal motivation that enables them to make cognitive decisions in their everyday activities (Ergeneli, Arı and Metin, 2007).

2.1.4 Power Imbalance in Traditional Agriculture

Howard (2021) through his research on traditional food systems reveals how large corporations dominate and control the traditional agriculture system. He criticizes these large oligopolistic firms for having a large negative impact on the food system and its stakeholders (Howard, 2021). Various examples are cited, from Walmart to Coca-Cola, for exploiting workers with low wages, price setting, pollution, and other negative impacts (Howard, 2021). The ability to do this and still profit lies in the fact that they exert a large degree of control over these systems (Clapp, 2021). As many people rely on these corporations, for employment and food, they are rarely boycotted or penalized for their activities (Clapp, 2021).

Howard (2021) discusses the advent of small organic farms and community-supported agriculture initiatives and discusses how they offer a small number of people an alternative, but how they are unable to compete effectively with large-scale industrial agriculture due to the vast difference in scale. One reason for this is that organic food is still considered relatively expensive in most developing nations (Charlton, 2016). This makes it inaccessible, as well as less appealing, to a large section of the population (Bhatta and Doppler, 2011).

Focusing more specifically on farms, Howard (2021) raises concerns about the asymmetry in power and information between industrial agriculture and smallholder farmers. For one, agriculture is increasingly industrialized today (Raven and Wagner, 2021). Machines now do a large percentage of the work that previously used to be done by people (Raven and Wagner, 2021). This creates a power imbalance in the traditional agriculture system as smallholder farmers can only afford to cultivate in smaller areas due to financial and technological barriers (Ravis and Notkin, 2020). The efficiency of the machines also means that small farms must do a lot more labor compared to big industrial farmers (Ravis and Notkin, 2020).

The power imbalance and information asymmetry continue to increase with the extensive use of genetically modified seeds and crops. Large corporations can produce crops that yield more, taste better, and are more resilient to external conditions (Howard, 2015). From a food security perspective, it could be argued that this is positive news (Ruane and Sonnino, 2011). More food can feed more people (Ruane and Sonnino, 2011). However, the genetically modified seeds are usually created by these large corporations who can afford to spend extensively on research and development (Lianos and Ivanov, 2016). The seeds are then patented by them which further tighten their hold on the market and the power imbalance between smallholder farmers and large corporation increases (Lianos and Ivanov, 2016).

Using these seeds can result in legal repercussions as the seeds are patented by these industries (Howard, 2015) after the United States Supreme Court 1980 ruled that genetically modified seeds can be patented, requiring the buyers to abide by the rules of these industries (Mascarenhas and Busch, 2006). The farmers are therefore unable to store the seeds from yield for future cultivation and are instead forced to purchase the seeds each time from these industries (Howard, 2015).

The practice of land grabbing is another way in which large-scale industrial agriculture corporations gain more power, thereby increasing the power imbalance between them and smallholder farmers (De Schutter, 2011). This results in smallholder farmers having to compete with large-scale industrial farmers who can pay large sums to acquire land from local landowners and capture the regional market with economies of scale (Mann, 2018).

These factors result in a dangerous increasing reliance on large corporations despite their negative impacts on people and the planet (Rickson, Saffigna and Sanders, 2009). These practices create an implicit hierarchy where the large corporations are on top, and the smallholder farmers are at the bottom (Rickson, Saffigna and Sanders, 2009). For example, Howard (2021) cites multiple cases of collusion between large corporations to increase the prices of food items. This is reprehensible in a world where millions go hungry daily (Beuchelt and Virchow, 2012).

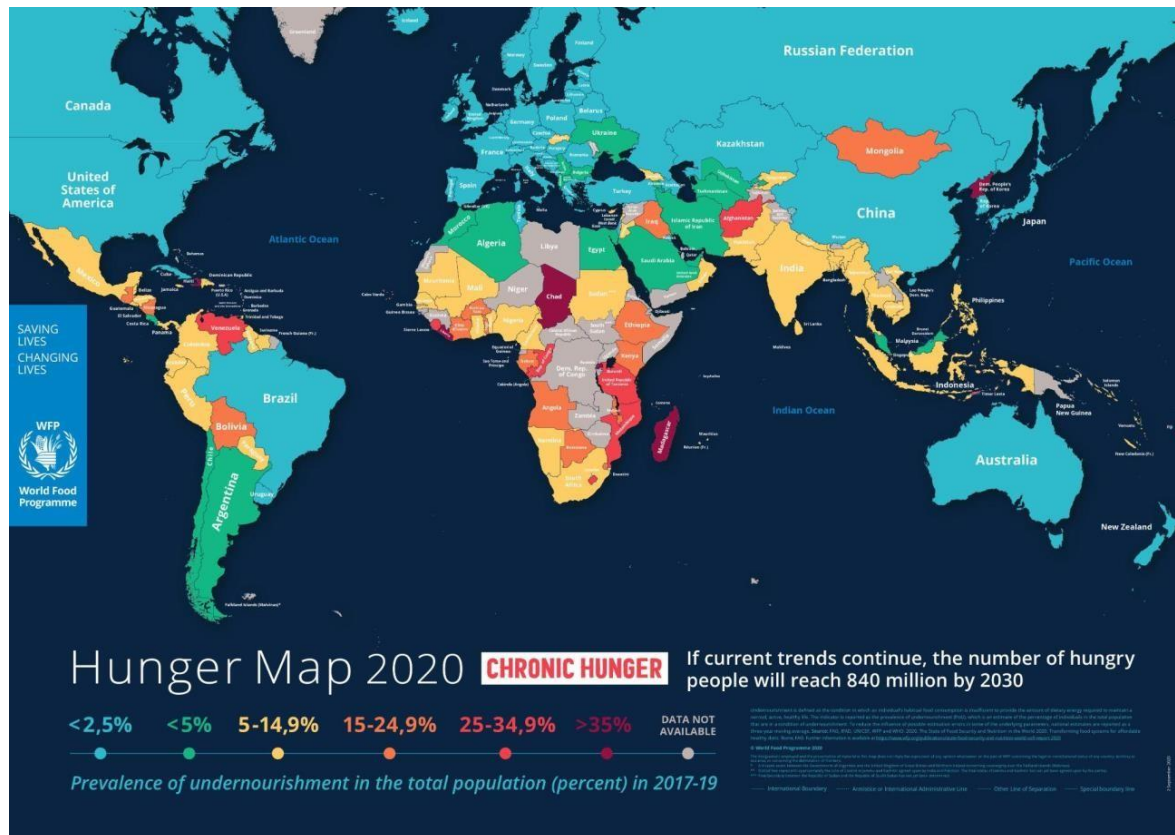


Fig.1 World Hunger Map 2020 by the World Food Programme

The United Nations Food Price Index hit an all-time high in February 2022. This was largely due to the war in Ukraine, as imports from Russia and Ukraine - often called “the breadbasket of Europe” were halted (Bilgic et al., 2022). This raises concerns about the possibility of widening food insecurity and chronic hunger around the world, threatening the survival of millions of people around the world who live below the poverty line (Charlton, 2016). This vulnerability to external shocks and market fluctuations makes it incredibly important to find local solutions to food throughout the year and to become food sovereign (Rotz and Fraser, 2015).

Therefore, it can be clearly seen that a big power imbalance exists between the smallholder farmers and the large-scale industrial farmers in the traditional agriculture system (Warning and Key, 2002). Empowerment of these smallholder farmers is an essential step to minimize the power imbalance to help build their capabilities and provide these farmers with opportunities to sustain themselves in the future (Grabs and Carodenuto, 2021). As discussed in the previous section, empowerment can be of various forms and the combination of the different forms of empowerment could help smallholder farmers achieve food sovereignty.

2.2 Literature Review

2.2.1 Food Sovereignty

Food sovereignty is defined as “the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems” (La Via Campesina, 2003). In other words, food sovereignty can be expressed as the ability of producers and people to cultivate, access, and consume food locally and naturally. Food sovereignty prioritizes producers, distributors, and consumers in a local food system over the demands of external markets and large-scale corporations to achieve social, economic, and environmental sustainability (Dekeyser, Korsten, and Fioramonti, 2018). It also promotes fair and transparent trade that assures just income to all the people involved in the local supply chain (Dekeyser, Korsten, and Fioramonti, 2018). It provides freedom for producers and consumers to choose the method of cultivation and the right to control their diet and nutrition (La Via Campesina, 2003). Food sovereignty enables people to engage in forming diverse new social relations to curb the inequalities that exist between genders, socioeconomic classes, and racial groups (La Via Campesina, 2003). The international food sovereignty movement supported by La Via Campesina, a worldwide network of small-scale farmers, has identified six principles or pillars of food sovereignty.

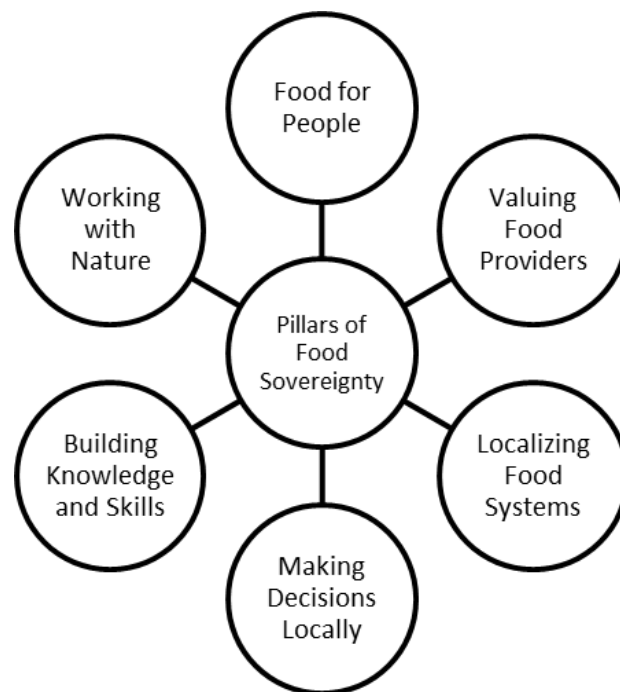


Fig.2 Pillars of Food Sovereignty

2.2.1.1 Food for People

Food for people is the first principle of food sovereignty which addresses the access to healthy and culturally appropriate food as a basic human right. Food, according to this principle, is not just viewed as a commodity for profit but as a necessity for the survival of people (Patel, 2009). It demands developing policies that encourage diversified food production within every region throughout the country (Jacobi, 2016). Food must be produced and distributed both locally and sustainably to match the required diet of the people who consume it (Edelman, 2014). Affordability of food is another important aspect of this principle as sustainably grown organic food is considered to be quite expensive in developing nations (Charlton, 2016). Food inflation is a serious threat to the survival of millions of people around the world who are living below the poverty line (Charlton, 2016). Food sovereignty considers accessibility and affordability of food to be a basic right for every human (Charlton, 2016).

2.2.1.2 Valuing Food Providers

The second principle or pillar of food sovereignty addresses smallholder farmers and other food providers as these people are often victims of violence, marginalization, and racism by neo-capitalist large-scale farming corporations and governments (Bernstein, 2014). Farmers and agricultural field workers are often exploited by higher authorities of power by stripping them of their land for mining or industrial agriculture (Bernstein, 2014). They are often made to sign contracts that confine them to long-term labour (McMichael, 2012). Food sovereignty promotes fairness in trade and assures just income to all the people involved in the local supply chain (Wittman, 2011). It gives priority to the smallholder farmers by empowering them with equal power over their produce and thereby balancing the power dynamics that exist (Wittman, 2011). This allows the producer the right to choose an agriculture practice that is socio-economically and environmentally sustainable (Wittman, 2011). Food sovereignty also ensures these smallholder food producers a right to a healthy work-life balance (Wittman, 2011).

2.2.1.3 Localizing Food Systems

The third principle of food sovereignty addresses localizing the food systems. It states that food must be considered a source of nutrition for a community rather than a commodity for trade (Hospes, 2013). The local and regional requirements are given the highest priority over the demands of the global market (Seiler, 2012). Localizing food systems have many benefits to the food producer and the community that consumes this food. Firstly, it provides the producers with the right to grow culturally appropriate food that caters to the needs of the local diet along with their preferred agricultural method (Wittman, 2011). Secondly, localizing food systems allow the entire supply chain to operate locally and thereby aids money circulation in the local economy (Wittman, 2011). Finally, it reduces the carbon footprint of the food produced as the entire supply chain revolves around the local market (Wittman, 2011).

2.2.1.4 Making Decisions Locally

The fourth principle of food sovereignty addresses local decision-making. It allows local and regional control over the resources such as land, water, plants, livestock, and other natural resources that belong to the locality (Wittman, 2011). These resources play an integral role in the local ecosystem and must be used and shared within the local community to keep it within a closed-loop (Wittman, 2011). Privatization of these resources through intellectual property rights for capitalistic profits would not only go against the principles of food sovereignty but also disrupt the functioning of the local ecosystem (Wittman, 2011). Therefore, any decision that must be made within the food or resource supply chain must be taken locally.

2.2.1.5 Building Knowledge and Skills

The fifth principle of food sovereignty addresses the importance of building knowledge and skills. Advancement in genetic technology and engineering have given rise to the emergence of newer plant species that are alien to the land (Lapegna and Perelmutter, 2020). These plants can contaminate the local ecosystem and hinder the traditional local food practices (Lapegna and

Perelmuter, 2020). Encouraging local food producers to build agricultural knowledge through scientific research and to share their skills with younger generations is of great importance (Jansen, 2014). The changing landscape and climate have left many traditional farmers with land that is not suitable for cultivation anymore (McMichael, 2014). These farmers lack the knowledge of alternative agricultural methods that have been tried and tested scientifically (Akram-Lodhi, 2015). Bridging the knowledge gap can help these smallholder farmers understand the need for a change in their farming methods that can prepare them for the future.

2.2.1.6 Working with Nature

The sixth and final principle of food sovereignty addresses the importance of ecocentrism. The food that is produced locally must take into consideration the protective use of natural resources to avoid its depletion (McMichael, 2014). It promotes natural ways of food production and distribution to reduce the harmful impact on the environment by reducing greenhouse gas emissions, avoiding monocrop cultures that affect the soil, and other industrial methods that can lead to health hazards to both people and the environment (McMichael, 2014).

2.2.2 Relationship between Empowerment and the Six Pillars of Food Sovereignty

From the previous sections, it can be seen that an interrelationship exists between the different forms of empowerment and the six pillars of food sovereignty. Some principles are directly related to some form of empowerment while others concentrate on combining more than one form of empowerment. The table below will show how the six pillars of food sovereignty are related to the different forms of empowerment.

Pillars of Food Sovereignty	Forms of Empowerment
Food for People	1) Individual Empowerment 2) Economic Empowerment 3) Cultural Empowerment 4) Physical Empowerment

Valuing Food Providers	1) Economic Empowerment 2) Physical Empowerment
Localizing Food Systems	1) Community Empowerment 2) Economic Empowerment 3) Political Empowerment 4) Organizational Empowerment
Making Decisions Locally	1) Social Empowerment 2) Political Empowerment 3) Community Empowerment
Building Knowledge and Skills	1) Educational Empowerment 2) Psychological Empowerment
Working with Nature	1) Economic Empowerment 2) Social Empowerment 3) Cultural Empowerment

Table 1: Relationship between Empowerment and the Six Pillars of Food Sovereignty

2.2.3 Food Security

Food security is a major part of food sovereignty and is defined as the ability of an individual to have access to sufficient nutritious food at any given time both physically and economically that meets their dietary needs (Pinstrup-Andersen, 2009). Food security is of concern both on a local scale and a global scale. Climate change and deteriorating topsoil across the world due to extensive agriculture practices have led to changing landscapes that may not be suitable for agriculture in the future (Gupta, 2019). Locally, some smallholder farmers may not be able to produce due to various environmental and technological factors (Cotula et al., 2011). One such important factor is the industrial production and sales of genetically modified agricultural seeds (Rock, 2018). In the past, smallholder farmers used to save their seeds after harvest for the coming years. The introduction of genetically modified seeds into the market by biotechnological industries has taken the freedom away from farmers of saving the seeds in the name of patents and intellectual property rights (Rock, 2018). These practices are not only a threat to the farmers financially but also affect the quality of the produce and the fertility of the land which leads to food insecurities (Rock, 2018).

2.2.4 Failure of Traditional Agriculture System to Achieve Food Sovereignty

It can be seen from the examples in the previous section how the traditional agriculture system has failed to empower smallholder farmers as a large power imbalance exists between them and the large industrial agricultural corporations. The imbalance is seen due to uneven distribution of resources between the two groups (Chamberlain and Anseeuw, 2018). Smallholder farmers, as the name suggests, have small pieces of land for cultivation with minimal output (Zerssa et al., 2021). They are more vulnerable to environmental changes as their economic situation completely depends on the harvest they get from their land (Jamshidi et al., 2019). Unforeseen weather conditions and climate change are their biggest external challenges (Jamshidi et al., 2019). Fertility of the soil is another major issue as these farmers are prone to using excessive chemical fertilizers that deteriorate the topsoil and make their land unsuitable for cultivation (Bekunda et al., 2005). Large industrial agriculture corporations on the other hand are economically strong enough to withstand any losses and due to their access to wider domestic and international markets, they have a stronger voice in society to take political decisions that may affect the society as a whole (Altieri, 1998). These reasons restrict smallholder farmers from attaining food sovereignty through traditional agriculture methods (Burnett and Murphy, 2014). Therefore, it becomes vital that alternative agricultural systems must be explored to understand whether these systems can help bridge the power imbalance that exists in order to achieve food sovereignty (EI-Kazzaz, 2017).

2.2.5 Soil-less agriculture – Z – Farming

Z-farming (Zero acreage farming) is the method of growing vegetation in unused spaces vertically in a closed-loop system (López et al., 2019). This type of farming practice can be usually found in big cities or in smaller areas where there is not enough space to grow vegetation conventionally. Hydroponics, aeroponics, and aquaponics are some of the soil-less agriculture systems within the z-farming method that grows food vertically on stands or towers without the use of soil (Khan et al., 2020). These systems of farming include a circular nutrient cycle where the plant absorbs the nutrients in the flowing water and purified water is sent back to the system. It is estimated that 94 -98% of the water that is used within these systems can be reused, hence making these systems the most sustainable method of farming (Lakhiar et al., 2018).

2.2.5.1 Hydroponics Agriculture

Hydroponics agriculture was first used during the Babylonian times around 600BC during the construction of the Hanging Gardens of Babylon (Panwar, 2020). It was also recorded by many explorers during 1100 AD the use of hydroponics by Aztec Indians and the Chinese Empires in constructing floating gardens (Panwar, 2020). The term hydroponics was first used in 1937 by Dr. William Frederick Gericke who authored the book Soil-less Gardening in 1940 (Panwar, 2020). Hydroponics is a system of soil-free agriculture that grows plants using nutrient-rich water (Panwar, 2020). The plants are supported on a growing medium like rock wool or sponge in growing cones or directly in incubator cells with clay pellets where the roots are suspended in the water under it (Food and Agriculture Organization, 2021). The water that is used in hydroponics agriculture can be both stagnant and flowing (Food and Agriculture Organization, 2021).



Fig.3 Hydroponics System

Working of Hydroponics System

Hydroponics agriculture involves various methods and techniques in the closed-loop system of plant cultivation. It uses 90% less water compared to conventional agriculture systems (Food and Agriculture Organization, 2021). The hydroponics system of cultivation consists of the following steps in the food production process.

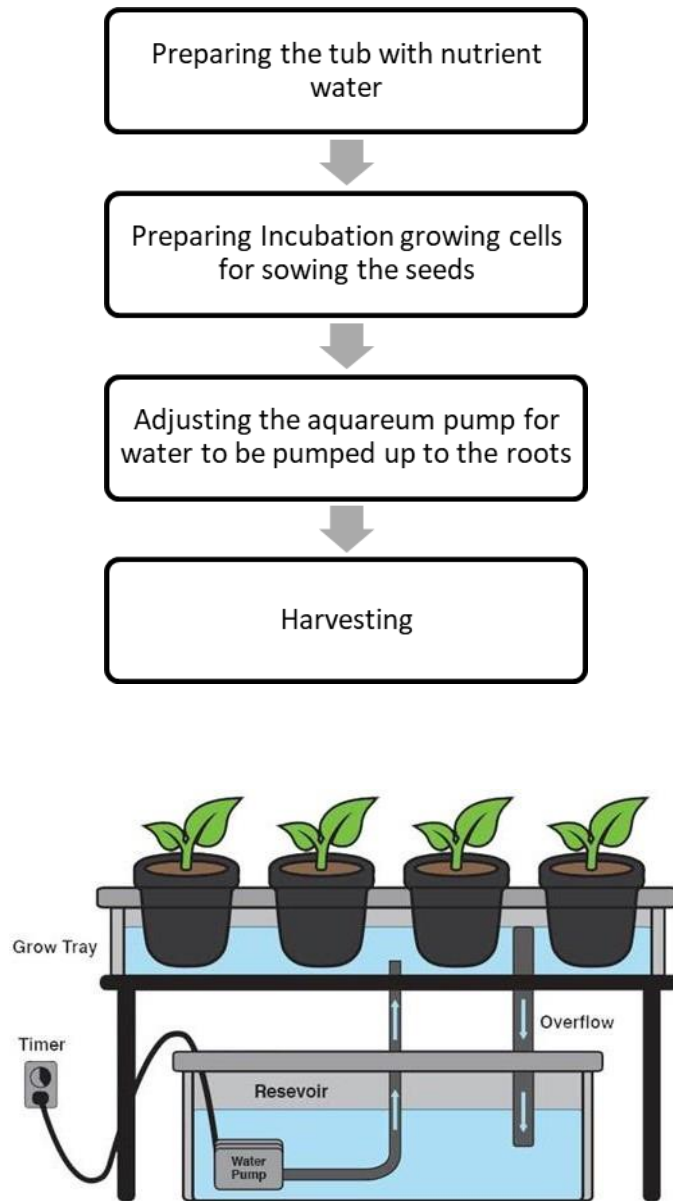


Fig.4 Working of Hydroponics System

2.2.5.2 Aeroponics Agriculture

Aeroponics agriculture was first used by a Dutch biologist, Frits Warmolt Went, in the year 1953, almost 30 years before the first aeroponically grown crop was sold commercially in a supermarket (Horti Daily, 2020). This term was patented by Richard Stoner in 1983 who later

founded many companies to research advanced aeroponics technology (Horti Daily, 2020). Aeroponics is a method of agriculture that is soil-free and uses minimal water for cultivating crops (Boen, 2007). In this method, the roots of the plants are suspended in the air where they absorb the nutrients from the dense mist of water vapor or from water droplets that hit the roots (Boen, 2007). Usually, aeroponics methods use hydroponics methods for sowing the seeds and germination. The grafting of already grown plants along with their roots directly into the aeroponics system also produces crop yield at a much faster rate (Kassaw and Frugoli, 2012).



Fig.5 Aeroponics Tower Garden

Working of Aeroponics System

The aeroponics method of cultivation involves various methods and techniques in its closed-loop system. Due to the cyclic nature of the system, water which is the most essential ingredient in food production can be conserved. About 94 – 98% of the water can be reused while the remaining 2 - 6% of the water is used by the plant or lost through evaporation or transpiration (Lakhia et al., 2018). The aeroponics system of agriculture consists of the following steps in its food production process.

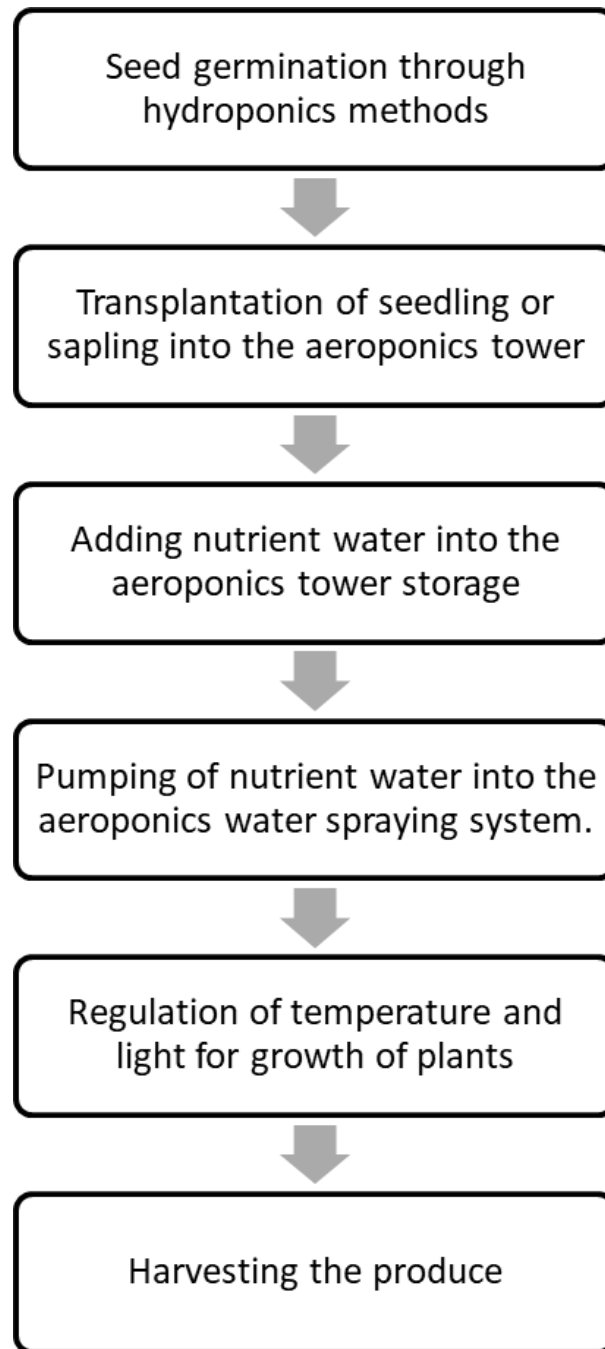




Fig.6 Working of Aeroponics Tower Systems

2.2.5.3 Aquaponics Agriculture

The aquaponics system of agriculture can be traced back to 1100 AD when it was practised by the Aztec Indians who cultivated plants on rafts on lakes filled with fish (Campbells, 2020). It gained traction in the 1970s by the works of Dr. Mark McMurtry in the field of soil-less agriculture (Campbells, 2020). Aquaponics is a method of agriculture that combines aquaculture (cultivation of fish) along with soil-less agriculture in producing two types of cultivation simultaneously (Stündl, 2019). It is a closed-loop system where the nutrient-rich water from the fish tank is used for hydroponic cultivation and the clean water from the hydroponics is circulated back into the fish tank, thereby cultivating both fish and vegetables simultaneously (Stündl, 2019).



Fig.7 Aquaponics System

Working of Aquaponics System

The aquaponics method of cultivation involves both techniques of aquaculture, to produce nutrient water and hydroponics for cultivation in its closed-loop system (Stündl, 2019). Due to the cyclic nature of the system, nutrient water which is the most essential ingredient in food production can be conserved (Stündl, 2019). The aquaponics system of agriculture consists of the following steps in its food production process.

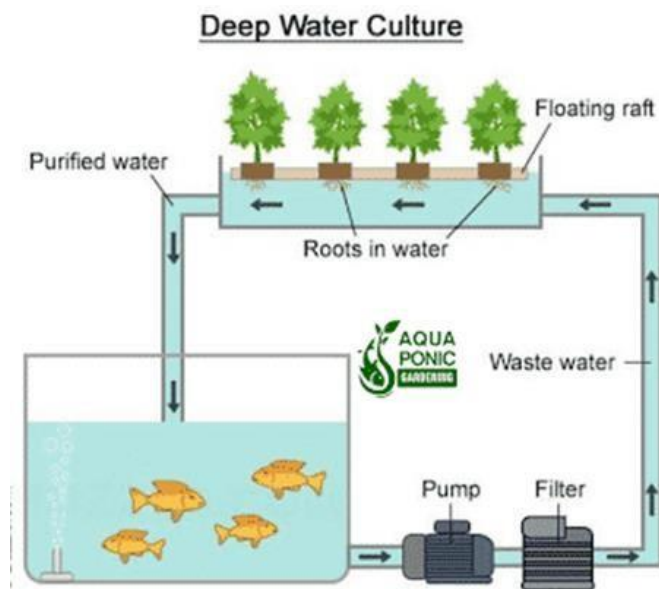
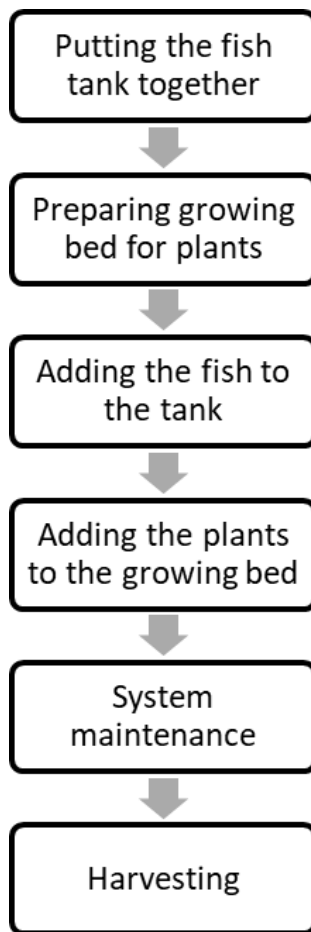


Fig.8 Working of Aquaponics System

2.2.6 Ecocentrism vs Technocentrism

Soil-less agriculture methods can be considered either ecocentric or technocentric based on how it is implemented. Ecocentrism is a nature-based philosophy where the rest of nature is considered equally valuable to human beings (Maclean, Brown, and Macmillan, 2018). Technocentrism is a tendency to focus on technology-based solutions and on its ability to control the environment (Chandler and Munday, 2016). According to ecocentrism, behavioral changes are required to solve environmental problems (O’Riordan, 1999). On the other hand, technocentrism considers technology to be the solution (O’Riordan, 1999). Ecocentrism, therefore, attempts to tackle the problem at its root – curbing human activity, such as overconsumption and the degradation of nature, that can affect the planet negatively (O’Riordan, 1999). Technocentrism attempts to manipulate nature and adapt to the current conditions using technology (O’Riordan, 1999).

2.2.7 Soil-less Agriculture – Empowering Smallholder Farmers

Alternative agricultural methods such as hydroponics, aeroponics, and aquaponics are not only used in big factories to grow food on a large scale but can also be used by smallholder farmers to grow crops sustainably on a small scale (Sharma et al., 2018). One of the biggest advantages of these agricultural methods is the amount of space required as most of these methods involve a vertical food production system that requires very little space to set up (Sharma et al., 2018). These methods of vertical farming have been experimented with under small spaces such as shipping containers, backyard greenhouses, underground shelters, and rooftop terraces (Mamta D. Sardare, 2013). Shipping container farms have been successfully implemented in many places across the United States and Canada by smallholder farmers and are expected to revolutionize the local food production system in the upcoming decades (Grow Pod Solutions, 2021). Backyard greenhouse farming using hydroponics and aeroponics methods of agriculture has provided a platform for individuals to grow food throughout the year with minimum investment to achieve food sovereignty (Ayambire et al., 2019). The Growing Underground farm in the main street of Clapham London is a very good example of how abandoned World War 2 bomb shelter bunkers could be used to grow vegetation and could be used for commercial purposes too (Peters, 2020).

Non-arid places such as Dubai and the northern arctic regions which face extremes of temperature have set up large-scale greenhouses to grow vegetation using aeroponics methods to achieve food sovereignty (Armanda, Guinée, and Tukker, 2019). Governmental initiatives such as the National Horticultural Board (NHB) in India are educating and encouraging smallholder farmers and individuals to start aeroponics and hydroponics greenhouses by providing subsidies of up to 33% on the initial investment (Krishi Jagran, 2022).

Critics of soil-less agriculture argue that removing soil from the agriculture system is unnatural and that it could affect biodiversity negatively. It could be argued that biodiversity and a healthy environment are vital to the empowerment of people in a healthy environment (Secretariat of the Convention on Biological Diversity, 2019). Soil-less agriculture may also be considered a technocentric solution as many of the systems rely on highly controlled environments to work properly. This reliance on technology may make these methods inaccessible to lower-income smallholder farmers who cannot afford to make the transition to soil-less agriculture.

CHAPTER 3

3 Research Methodology

This chapter details the methods we have used in research to study the use of soil-less agriculture and how it can empower smallholder farmers to achieve food sovereignty. We outline the process by which we have selected the data and how we attempt to analyze it. The methods have been explained in detail to make them easily replicable by future researchers.

3.1 Research Strategy and Design

In this thesis, the focus is on analyzing and understanding how smallholder farmers can be empowered through soil-less agriculture methods to achieve food sovereignty. The research intends to understand the role of hydroponics, aeroponics, and aquaponics in empowering smallholder farmers to achieve food sovereignty. This research also helps in understanding the ongoing research behind soil-less agriculture in many countries and how they could change the way crops are grown in the future. The role of soil-less agriculture methods and how these methods are empowering smallholder farmers can be understood by documentary research methods. Data about research and innovation of soil-less agriculture methods have been collected and analyzed through content analysis of documentaries on “High Tech Farms of the Future” by Deutsche Welle (DW). The data relating to the application of these soilless agriculture methods to empower smallholder farmers in various countries can be collected and analyzed through content analysis of various documents from the Food and Agriculture Organization (FAO) of the United Nations. The data that is collected through content analysis is further examined to understand the application of soil-less agriculture methods in empowering smallholder farmers to achieve food sovereignty.

This research consists of a qualitative design where secondary data is studied and analyzed to determine the importance of soil-less agriculture methods by understanding the theoretical framework of food sovereignty through empowerment theories. This provides us with an understanding of the significance of empowerment in achieving food sovereignty in the agricultural industry.

First, a documentary research design is formed, and significant documents, reports, and video documentaries are selected. Then, the data from the documentary research is collected and analyzed through content analysis. Content analysis is done of documentaries and reports to understand how soil-less agriculture is being researched and implemented in urban and rural settings. This provides us data regarding how farmers and individuals can be empowered through soil-less agriculture. This helps in understanding the content of the documents from both the research and application perspective.

3.2 Documentary Research

Documentary evidence is often used by researchers (Bryman, 2003). It is a form of secondary data and is often available in a larger quantity than other data (Bryman, 2003). Documentary evidence can involve quantitative data and qualitative data (Bryman, 2003). In this paper, the focus will be on qualitative data regarding the topic of interest. The sources of data used here will be varied and in different mediums to offer a more holistic view of the subject. These include a documentary by a news channel, videos uploaded by an organization on YouTube, and other written reports and articles.

This method is suitable for the required research for multiple reasons:

1. The use of documentary research allows us to observe and analyze the phenomena we study without actively interacting with the subjects. This, therefore, helps in reducing interviewer bias.
2. As our topic is not constrained to a certain geographical location, this method allows us to obtain data regarding projects around the world. This would otherwise have been very difficult given barriers such as access and language.
3. This method allows us to obtain data from varying points in time. We can obtain data from different sources in a limited time period and observe how projects have fared over time since we are using secondary documentary evidence.

For all the reasons explained above (Bryman, 2003), documentary research has been deemed an appropriate research method for this paper.

3.3 Data Selection

For the documentary analysis, relevant YouTube videos and an article that discussed soil-less agriculture and its use in communities have been chosen as the sample documents. In choosing our documents, cases from around the world have been obtained to gain a more holistic understanding of the role soil-less agriculture plays in empowering smallholder farmers around the world.

When selecting the material, the decision was made to select mainly videos for our research. Videos offer a large amount of information as it combines audio and visuals (Walker and Boyer, 2018). The subjects in the video can relay information through the words they say, the way they say them, as well as through their body language (Walker and Boyer, 2018). The surroundings in the video can also provide valuable information (Walker and Boyer, 2018). This makes videos a strong source of secondary data.

The videos were found using YouTube, which is currently the largest video-sharing website on the Internet (Waters and Jones, 2011). To find the videos, we used different combinations of some of the keywords we have chosen for our thesis - hydroponics, aeroponics, aquaponics, empowerment, and food sovereignty. We then watched all the videos we found most relevant to our topic and decided on the sources below as we felt that they represented the topics of empowerment, food sovereignty, and soil-less agriculture best. We also chose videos that were uploaded by organizations, instead of by individuals to increase the reliability of the videos. By choosing videos produced by organizations, we were also able to hear stories from more people than just an individual.

Title	Uploaded by	Media Type	Link	Date	Country	Type of Soil-less Agriculture
When Food Becomes Scarce - High Tech Farms of the Future	Deutsche Welle	YouTube documentary	https://www.youtube.com/watch?v=KIEOuKD9KX8	November 28th, 2020	Germany, Japan, Netherlands, Spain, Singapore	Aeroponics, Aquaponics, Hydroponics
H2Grow - An Introduction by Nina Schroder	WFP Innovation Accelerator	YouTube video	https://www.youtube.com/watch?v=iHDtTtXFGJM&t=3s	September 29th, 2017	Algeria	Hydroponics
H2Grow Model Hydroponics School Garden WFP Zambia	World Food Programme	YouTube video	https://www.youtube.com/watch?v=UYmBXUNG5eQ&t=14s	December 23rd, 2021	Zambia	Hydroponics
Seeds of Hope: Hydroponics tech in Zambia boosts school meals	World Food Programme	Web article	https://www.wfp.org/stories/african-school-feeding-day-hydroponics-school-meals-zambia-nutrition	February 26th, 2021	Zambia	Hydroponics

Table 2: Selected Video Data Table

3.4 Ethical Considerations

The research was designed in a precautionary way to avoid a breach of any kind of moral ethics. The documents used in the documentary research were carefully selected to address the subject of the research question from reliable sources. The research was approached with no preconceived notion about the subject of soil-less agriculture or its social implications such as food sovereignty or food security although one of the authors worked closely with aeroponics agriculture. The structure and flow of the research were constructed carefully by starting broadly and narrowing down into more specific areas later on to maximize readability. The data that was collected and analyzed from secondary sources were presented with a scientific critical perspective.

3.5 Content Analysis

Content Analysis is a method where the specific content of media is studied. This method can be seen as objective analysis of the words used in a document (Schreier, 2014). This method can be used with a written document, a video, an audio file, or other sources (Schreier, 2014).

Content Analysis can be classified into qualitative and quantitative content. It can be done in two ways - semantic and relational (Schreier, 2014). The semantic content analysis focuses on the themes covered in a document, whereas relational content analysis explores the relationship between these different themes (Schreier, 2014).

In quantitative content analysis, a document is referred to, and then the frequency of certain keywords is tested to see how often they occur (Coffey, 2014). It can be deduced that the more often certain words are used, the more important the narrator believes these words to be. Comparing the most frequently occurring words with the keywords mentioned by the writer in the keywords section or the title can give you an idea of how relevant the document is. If a document mentions sustainability as a keyword but this does not appear anywhere in the document, it is reasonable to question the paper's reliability and relevance. Therefore, one of the main ways in which we will condense the essence of a document is by referring to the most frequently used words. This allows the reader to immediately grasp the most important concepts of the documents.

However, the complete process of conducting content analysis consists of four steps (Bengtsson, 2016) as follows:

1. Decontextualization
2. Recontextualization
3. Categorization
4. Compilation

We first attempt to draw out the most important points in the document. These are usually more universal themes such as empowerment and food sovereignty in most of our chosen material. We then recontextualize it and see how each situation is unique. Here we look at more case-specific factors like the community's background and its initiatives.

The researcher can also use manifest analysis - where words are analyzed on the surface, or latent analysis - where deeper meaning is sought (Schreier, 2014). In our work, we have analyzed our chosen material in both ways.

3.6 Matrix - Categorization of Secondary Data

A matrix is used to facilitate the categorization section of the content analysis in this paper. The pillars of food sovereignty lie on one axis, and how empowerment can be achieved lies on the other. In this matrix, the methods of empowerment used are from Batliwala's work. This is done to demonstrate how these two often coincide, especially when discussing the use of soil-less agriculture. The factors that help achieve food sovereignty often deal with empowerment.

The matrix used here has the six pillars of food sovereignty labelled in the rows and the three methods of empowerment labelled in the columns. Short phrases or sentences have been input into the boxes where these coincide. The list will not be exhaustive and will instead focus on the most engaging points and these will then be explained in further detail.

Principles of Food Sovereignty	Empowerment Process Through Shifting Power Relations		
	Challenging the ideologies that justify and sustain social inequalities	Changing existing patterns of access and control over economic, natural, and intellectual Resources	Transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market
Food for People			
Valuing Food Providers			

Localizing Food Systems			
Making Decisions Locally			
Building Knowledge and Skills			
Working with Nature			

3.7 Frequency Testing

One of the methods used in analyzing the content is frequency testing. This can help us identify the most frequently used words in the documents we attempt to analyze, and therefore find what the document emphasizes the most. When choosing the most frequently occurring words, there is the potential for polysemy where a word may occur multiple times but carry different meanings (Tarasheva, 2011). Therefore, we have ensured that we only count words as repetitions if they carry the same meaning and not simply based on spelling. We have also not analyzed filler words as they do not carry any meaning and therefore do not provide any useful information about the content.

Another obstacle that arises when conducting frequency testing is the difficulty of connecting all related lexical variations of a word (Tarasheva, 2011). For example, the words ‘do’, ‘does’, ‘did’, ‘doing’, and ‘done’ all mean the same thing as the variation simply lies in the tense it is used. However, as these are not the same word, they may not appear when using certain automated frequency testing methods. This makes it challenging as using manual methods is not always feasible due to time constraints.

3.8 Trustworthiness

Qualitative research, as is done in this paper, cannot be evaluated using the same criteria as quantitative research, namely reliability, and validity (Bryman, 2012). It is valued instead by the

criteria of trustworthiness, consisting of four main factors which are:

1. Credibility
2. Transferability
3. Dependability
4. Confirmability

(Bryman, 2012)

The credibility criterion refers to whether the research has presented a true representation of the subject studied (Shenton, 2004). In consideration of this, a wide range of reputable sources have been studied to gain an understanding of the subject of the research. The secondary data that was collected through documentaries, documents, and reports were presented in the same tone as in the original documents during content analysis (Elo et al., 2014). The same data is further critically analyzed through scientific means (Elo et al., 2014).

To satisfy the transferability criterion and ensure that the work can be transferred into other contexts within reason, we have provided details of the context of this study (Shenton, 2004). This allows readers of the study to determine whether the results of the research can be transferred to another context based on similarities between them (Shenton, 2004). Suggestions have also been included under ‘future research’ to demonstrate how the research methods used here may be adapted to work in different contexts.

The dependability criterion ensures that the data is stable over time and whether the findings remain true (Bryman, 2012). Periodical peer reviews as suggested by Bryman (2012) were done throughout the creation of this paper to help achieve this.

Finally, the confirmability criterion strives to evaluate whether the paper is influenced by biases or opinions of the authors which may skew the results (Bryman, 2012). The research conducted was neutral about the results as it did not involve any presumptions that would affect the results of the research (Daszykowski, Walczak, and Massart, 2001). Any form of possible research bias was clearly stated in the section on Ethical Considerations (Suri, 2008). The use of peer reviews and feedback from a neutral audience also reduces the possibility of bias.

CHAPTER 4

4 Research Findings

This section discusses the selected data sources and conducts data analyses on them based on the literature covered in the previous sections. The research findings presented here are the basis to answer our research question – *How are the effects of soil-less agriculture on the empowerment of smallholder farmers to achieve food sovereignty portrayed in documentaries?*

4.1 Content Analysis

4.1.1 Deutsche Welle documentary on “High Tech Farms of the Future”

The Deutsche Welle documentary on “High Tech Farms of the Future” addresses the topics of food sovereignty, food scarcity, and soil-less agriculture. This documentary was published on the 28th of November 2020 and is available on the company’s website and YouTube. This documentary was specifically chosen as it covered all aspects of the research question and looked into soil-less agriculture practices and research from different parts of the world. This documentary helps provide a holistic view of the importance of soil-less agriculture in empowering smallholder farmers. In this analysis, the content of the entire documentary will be summarized and will be followed by a frequency analysis of commonly repeated words to understand the tone of the documentary. The complete transcription of the documentary can be found in the appendix section for further reference.

In this documentary, we see various examples of how soil-less agriculture has been researched and implemented in different parts of the world through different agencies such as research universities, large corporations, small-scale restaurants and disadvantaged communities. The documentaries also provide various perspectives from different actors on whether soil-less agriculture could be a potential solution for the future of agriculture. The actors include university research professors such as Toyoki Kozai from University of Chiba in Japan and Ernst van den Ende from Wageningen University in the Netherlands who through their extensive research over the years discuss the benefits of soil-less agriculture and how it could empower smallholder farmers with the decreasing cost of technology. They also believe that the future of agriculture could be a hybrid of traditional and soil-less agriculture to reduce the impact on the environment. The industrial actors such as Shinji Inada, the founder of Spread and Nicolas Leschke, the founder of ECF farm systems in Berlin point out that investing in soil-less agriculture is risk-free as one would be able to recover

the investment within a short duration of time and would be the best bet to move towards sustainable agriculture. Individual actors such as Akira Iijima and Shota Takao who transitioned from traditional agricultural practices to soil-less agriculture showed how practices of aquaponics and hydroponics helped them achieve better yield with almost no losses. Gropius Bau, a small restaurant in Berlin demonstrated how using hydroponics within their restaurant premises helped them gain access to fresh produce to serve their customers nutritious food. The documentary also provided the views of traditional smallholder farmers such as the Brandenburg farmer from Berlin and Almeria farmers in Spain who were devastated with traditional agriculture due to irregular rainfall and droughts but were also skeptical about soil-less agriculture as they believed that soil-less agriculture felt artificial as it did not include the richness of biodiversity that is usually seen around traditional agriculture. The documentary closes with several questions asking if we have another alternative option or if traditional agricultural methods be able to supply the food that the world requires without the use of fertilizers and pesticides. Further, Dr Ernst van den Ende from the Netherlands asks if one must produce sub-optimal yields using traditional methods and destroy nature or whether one optimize the growth using soil-less agriculture to save the environment.

In this documentary, a frequency testing content analysis shows that ‘plant’ and ‘farmer’ are the most frequently used words followed by ‘produce’, ‘grow’, and ‘greenhouses.’ It is interesting to note how these words have transitioned throughout the documentary. For instance, the word ‘plant’ initially was surrounded by words such as survival, not enough, and sterile which represented weakness. But as the documentary transitioned the word ‘plant’ was surrounded by words such as develop, nutrition, fresh, etc. representing strength. Similarly, the word ‘farmer’ was initially surrounded by words such as small, damage, lack, suffer problem, etc which represented a negative tone to the sentence and later transitioned into words such as soul, ethos, withstood, and inventive giving a positive tone to the sentence. The repeated changing of tone from negative to positive describes the flow of thoughts in the documentary.

4.1.2 United Nations Food and Agriculture Organization Videos

Some of the videos analyzed in this section have been produced and uploaded by the United Nations Food and Agriculture Organization. This makes it important for us to first get some background on this organization.

The United Nations Food and Agriculture Organization (UN FAO) describes itself as a specialized agency of the United Nations, leading international efforts to defeat hunger (Food and Agriculture Organization of the United Nations, 2022). The non-profit organization aims to achieve food security for everyone and to ensure that high-quality food is made accessible to them to allow them to lead active, healthy lives (Food and Agriculture Organization of the United Nations, 2022). Established in 1945, they now have 195 members, and they operate in 130 countries around the world (Food and Agriculture Organization of the United Nations, 2022).

H2Grow is an initiative by the UN FAO's World Food Programme to use hydroponics to grow food as a way to fight food insecurity around the world (Food and Agriculture Organization of the United Nations, 2022). Like many other non-profit organizations, the United Nations and its subsidiaries upload videos to their YouTube channel that are meant to educate and inform the public about their activities (Waters and Jones, 2011). The videos uploaded by this organization in conjunction with this initiative have been used as they discuss different real-life cases where the use of hydroponics has been empowering people around the world and improving their access to food. These videos are also unique and useful as a source of data because, unlike many other organizational documents, these videos feature participants and beneficiaries of their programs instead of internal stakeholders (Waters and Jones, 2011).

4.1.2.1 H2Grow - An Introduction by Nina Schroder



Fig. 2. Word Cloud for Nina's Video

This video discusses how a model school garden introduces the use of hydroponics to the community and how it benefits the students, the community, and the general public. It aims to dispel myths that hydroponics is expensive and discusses how it is easily adaptable. It also discusses how hydroponics allows students to practice what they learn and gain something beneficial out of it. This video highlights the affordability of hydroponics and value of education in empowering people to use them.

The video is narrated by a local hydroponics consultant called John Serwanga who explains the project, the public's hesitance to adopt the practice due to perceived costs and skill bases, and the benefits of the project to the community. While the video is produced and uploaded by WFP, the narrator openly speaks about the community's doubts as well. The narrator seems genuinely invested in the project and offers adaptations to the project design to improve affordability for locals - suggesting the use of bamboo instead of PVC pipes.

4.1.3 Seeds of Hope

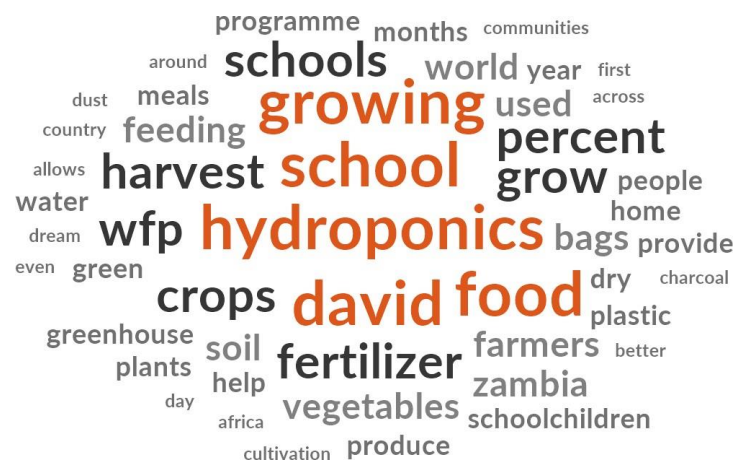


Fig. 2. Word Cloud for the Seeds of Hope Article

This article by Smeulders (2021) serves as a journalistic focus on how soil-less agriculture is being used in Zambia through the H2Grow initiative by the World Food Programme to supplement school meals and empower local communities. School greenhouses produce food hydroponically which can be used for school meals, and the surplus is used to generate income. Training in the use of hydroponics is also provided to students, parents, and teachers. This is valuable as the country faces various food security issues due to extreme weather.

The use of hydroponics in school greenhouses is discussed in general throughout the article, but there is a specific focus on a young boy called David who uses the knowledge he gained from school to grow food hydroponically at home, and who hopes to grow up to become a hydroponics consultant (Smeulders, 2021). While some hydroponics equipment can be expensive, the article gives examples of innovative adaptations used by David to achieve the same effect with low cost or leftover material such as recycled bottles and plastic sheets (Smeulders, 2021).

Interestingly, this article brings in the hydroponics consultant from the WFP Zambia video as well, as it mentions how the consultant provides consultation to David and his mother over the phone to help improve their yield (Smeulders, 2021). This close ongoing relationship and consultation are vital as this guidance allows smallholder farmers to attempt innovative new ideas with high potential, with more certainty.

4.2 Matrix Formulation – Principles of Food Sovereignty vs Empowerment Process Through Shifting Power Relations

	Challenging the ideologies that justify and sustain social inequalities	Changing existing pattern of access and control over economic, natural, and intellectual resources.	Transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market
Food for People	<ol style="list-style-type: none"> 1) Locally producing food that people want to consume with large-scale aquaponics (Schoneberg Farmer Berlin (DW). 2) Refugees grow animal fodder and improve the conditions of their livestock, giving them access to more affordable animal products (H2Grow Nina Schroder) 3) Affordable substitutes are used in hydroponics (H2Grow Zambia) 	<ol style="list-style-type: none"> 1) Finding different alternatives to grow rice in Japan as it is the staple food of the country (Shota Takao – Sake Brewery (DW)) 2) Hydroponics training upskills refugees and gives them better access to their food and improves opportunities for economic growth (H2Grow Nina Schroder) 3) Costs of hydroponics are reduced by using local resources increasing access to smallholder farmers to replicate the model (H2Grow Nina Schroder) 	<ol style="list-style-type: none"> 1) Growing rice on rooftops compared to large farms in promoting local food production (Shota Takao – Sake Brewery - DW). 2) Refugees growing their food are made less dependent on the market and state (H2Grow – Nina Schroder). 3) Hydroponics is used in the free which can reduce the risk of crop loss due to environmental conditions (Seeds of Hope).
Valuing Food Providers	<ol style="list-style-type: none"> 1) No losses, less energy for transport, and most sustainable agriculture (Toyoki Kozai - DW). 	<ol style="list-style-type: none"> 1) Achieving 100 times more harvest than traditional farming (Toyoki Kozai - DW). 2) Producing more food with fewer resources (Ernst van den Ende - DW) 	<ol style="list-style-type: none"> 1) From large farmlands to smaller spaces with high productivity (Toyoki Kozai - DW). 2) Sustainable water consumption. (Brandenberg Farmer - DW)

	Challenging the ideologies that justify and sustain social inequalities	Changing existing pattern of access and control over economic, natural, and intellectual resources.	Transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market
Localizing Food Systems	<ol style="list-style-type: none"> 1) Producing Local food in the middle of the cities, Sakirice wine (Toyoki Koza and Saki Farmer - DW). 2) Growing their food makes them less vulnerable to price and supply fluctuations (H2Grow–Nina Schroder). 	<ol style="list-style-type: none"> 1) Sharing the technologies with poor countries to promote local food production (Shinji Inada -DW). 2) The project relies on the strengths of the community and upskills them by teaching them how to grow food hydroponically with the desert's natural resources. They gain more access to local food sources by learning to produce them (H2Grow – Nina Schroder). 3) Self-generated solar power is used for the hydroponics system instead of unstable grid electricity. Recycled materials are used (H2Grow-Zambia). 4) Self-generated solar power is used for the hydroponics system instead of unstable grid electricity. Recycled materials are used (H2Grow – Seeds of Hope) 	<ol style="list-style-type: none"> 1) Short distances to supermarkets and restaurants avoid food wastage (Spread Factory - DW). 2) The hydroponic fodder increased milk production in livestock, making the community less reliant on external food aid for nutrition (H2Grow – Nina Schroder)

	Challenging the ideologies that justify and sustain social inequalities	Changing existing pattern of access and control over economic, natural, and intellectual resources.	Transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market
Making Decisions Locally	<ol style="list-style-type: none"> 1) Moving from smallholder rice farmer to aquaponic cultivation (Akira Iijima - DW). 2) The idea for the hydroponically grown fodder came from a local refugee to improve food access in the desert (H2Grow – Nina Schroder). 3) Food production gives locals more control over their food choices and their 	<ol style="list-style-type: none"> 1) Producing the required amount of food for local supermarket chain in Berlin (Shonenberg Farmer - DW). 2) The project relies on the strengths of the community and upskills them by teaching them how to grow food hydroponically with the desert's natural resources (H2Grow – Nina Schroder). 	<ol style="list-style-type: none"> 1) Producing required herbs and vegetation at the place of consumption to reduce carbon footprint due to transportation (Gropius Bau Restaurant - DW). 2) The hydroponic fodder increased milk production in livestock, making the community less reliant on external food aid for nutrition (H2Grow – Nina Schroder).
Building and Knowledge and Skills	<ol style="list-style-type: none"> 1) Growing plants without soil through less water and artificial light indoors (Ernst van den Ende - DW). 	<ol style="list-style-type: none"> 1) Use of agricultural fields with new technology and skills to optimize the growth through soil-less agriculture without harming the environment. (Ernst van den Ende - DW). 2) Local families learn new hydroponics methods and can use them to grow their food, improving diets and opportunities for economic growth (H2Grow – Nina Schroder). 3) Students apply their studies in hydroponics and training is provided to the community (H2Grow – Zambia) 	<ol style="list-style-type: none"> 1) Changing Technology, Introduction of LED, Reduced Costs (Prof Toyoki Kozai - DW). 2) The training reduces information asymmetry in the food system (H2Grow – Nina Schroder).

	Challenging the ideologies that justify and sustain social inequalities	Changing existing pattern of access and control over economic, natural, and intellectual resources.	Transforming institutional structures that reinforce and sustain existing power inequalities, such as the family, state, and the market
Working with Nature	<ol style="list-style-type: none"> 1) Impossible grain cultivation without irrigation due to climate change (Brandenberg Farmer - DW). 2) Unforeseen droughts and storms impact 30 million people in south Saharan Africa due to climate Change (DW). 3) Hydroponics allows food production despite the desert's infertile conditions and can reduce food insecurity and malnutrition (H2Grow – Nina Schroder) 	<ol style="list-style-type: none"> 1) Working outside of nature to save nature is a paradoxical situation (Ernst van den Ende and Brandenberg Farmer - DW). 2) The project uses the sun for solar power in the desert. It works around water scarcity and infertile soil by growing food without soil in a less water-intensive manner (H2Grow – Nina Schroder). 3) Hydroponics food production uses 90% less water than traditional agriculture which is important in drought-prone Zambia (H2Grow – Seeds of Hope). 	<ol style="list-style-type: none"> 1) Transforming megacity architecture towards environmentally friendly projects. Creating eco-centric cities that complement nature. Green Architecture (Christoph Ingenhoven -DW).

Table 3: Principles of Food Sovereignty vs Empowerment Process Through Shifting Power Relations

4.3 Matrix Discussion

In this section, the matrix is analyzed by understanding the connections between food sovereignty and empowerment found in the documentaries through the various types of empowerments as discussed in the literature review. Further the capability approach will be used to discuss how smallholder farmers can be empowered through well-being freedom and agency freedom. This will be done step by step, by detailing the connection between the different pillars of food sovereignty with the Empowerment process as defined by Batliwala.

Food for People – Empowerment Process

The large-scale aquaponics entrepreneurs from Schoenberg, Berlin explained how growing crops that are in demand along with breeding local freshwater fish, such as the Capital City Perch, for the local market has helped them grow sustainably over a local supermarket chain. This provided access for people to consume locally grown traditional food compared to food imported from far distances hence making both the farmer and the consumer individually and traditionally empowered.

The young smallholder farmer Shota Takao from Japan showed how rice, the staple food of Japan, could be grown in small spaces such as rooftops in the middle of the city. This innovative method allowed people in the city to access freshly grown staple food with a smaller carbon footprint due to short-distance transportation and hence empowering them both economically and culturally.

The H2Grow project trained several Sahrawi refugees and taught them the new technique of hydroponics which was more efficient compared to regular agricultural methods. The initiative helped the community with access to nutritious fodder for their livestock, and as a result, the refugees were able to have access to 250% more milk, and the mortality rate of the animals fell. The availability of rich nutritious milk physically empowered these individuals. This project also improved access to intellectual resources in the form of vocationally trained individuals and improved the availability of naturally grown food in the food-scarce desert. This further reduced food costs and the opportunity to sell the food for economic gain. This initiative brought in both economic and community empowerment through educational empowerment.

John from Zambia showed how growing food using new technologies like hydroponics does not have to be expensive. He gave examples of substitutes such as bamboo instead of PVC pipes that could be used to reduce cost. The Home-Grown School Meals program in Zambia, which provides meals to students is connected to many smallholder farmers who supply the required food to schools (Self Help Africa, 2019). This is beneficial as it provides students with healthy food, while also providing local farmers with a source of income (Self Help Africa, 2019). The new hydroponics model garden provided a way to grow food year-round indoors, which made them less susceptible to climate conditions and droughts. The gardens could grow some of the food required for these school mealson-site which could provide healthy food to students regularly (World Food Programme, 2020). This enhanced the affordability and accessibility of food to the local communities and thereby empowering them physically and economically as individuals and as a community.

Valuing Food Providers – Empowerment Process

The Brandenburg farmer emphasized the requirement of expensive irrigation systems for conventional farming which he believes add to the economic burden of conventional agriculture. Professor Toyoki Kozai from the University of Chiba, Japan through his 30 years of research said that soil-less agriculture is the most sustainable agriculture with no losses and requires less energy and resources throughout its supply chain. This could reduce the overall production cost for smallholder farmers. He also stated that soil-less vertical agriculture can yield 100 times more compared to conventional agriculture due to a controlled environment and believes that transitioning from large farmlands to smaller production places that consume less water and resources is an essential step towards achieving sustainability. Similarly, Ernst van den Ende, a researcher from the University of Wageningen said that soil-less agriculture consumes fewer resources compared to conventional agriculture and hence can make smallholder farmers both physically and economically empowered.

Localizing Food Systems – Empowerment Process

Professor Toyoki Kozai believes that localizing food production is essential as it reduces the complexity involved in the supply chain. Similarly, Shota Takao, a Japanese entrepreneur, challenged all odds and grew rice on rooftops in the middle of Tokyo to produce Sake wine, which is close to his market, reducing his supply chain costs. Shinji Inada, the founder of Spread, wants to share his knowledge and experience with poorer countries to promote local food production as he wants to empower local smallholder farmers. He also stated that shorter distances to supermarkets and restaurants from crop production lead to less wastage of food that can be beneficial to the farmer. This not only empowers the smallholder farmer economically but also allows these large organizations to be a role model in empowering smallholder farmers by sharing their knowledge and skills.

The H2Grow initiative gave power to the disadvantaged communities and their families in Algeria and Zambia and allowed them the resources to produce food to make them less dependent on the market and the state. This project used the strengths of the community members to build their capabilities by teaching them new methods of growing food. It also made use of solar power that was generated locally using local material. This was useful as Zambia's access to electricity is limited and there exist vast inequalities in the access to it. The rural population has very low levels of access to electricity at only 14% in 2020 while the urban population's access is at 85% (The World Bank, n.d.). Local materials such as bamboo were used instead of PVC pipes and recycled tires were used to grow plants in the model greenhouse. This program also eased the access of Sahrawi refugees to freshly grown fodder for their livestock and allowed them to control the resources used in producing it. It also allowed the community to produce nutritionally dense milk and meat from their livestock. They, therefore, became more self-reliant, and less dependent on external food aid provided to them. This further empowers both the individuals and the community members both socially and politically.

Making Decisions Locally – Empowerment Process

Akira Iijima, a smallholder farmer in Japan understood the risks involved in conventional

rice cultivation and transitioned into aquaponics agriculture to produce locally consumed vegetables. This transition helped him avert financial risks and empowered him financially. The entrepreneurs of the large-scale aquaponics farm in Berlin only grow vegetables and breed fish that meets the local demand. This has enabled them to minimize wastage and maximize profits.

For the H2Grow initiative in Algeria, the idea for using hydroponics originated from one of the Sahrawi refugees and the success of the program showed the value that individuals can bring to their communities by creating local solutions to the challenges they face. The Sahrawi refugee used her engineering and agrarian background and suggested the idea to produce fodder for the animals through Innovation Lab which was later implemented. The external food aid that the refugees usually received was high in starchy and sugary food as they tend to focus on the calorie count instead of nutritional adequacy (Grijalva-Eternod et al., 2012). However, when this diet was followed long-term as with the Sahrawi refugees, it could pose health risks to the community making them simultaneously undernourished and at risk for obesity and other co-morbidities (Grijalva-Eternod et al., 2012). The production of food using hydroponics can increase the agency of members of the community over their foodsystems and allow them to make dietary choices that are best suited to their needs. The initiative, through its local decision making, empowered these communities both socially and physically through improving their well-being and politically empowered them by allowing them to take decisions that were necessary for the survival of their community.

The restaurant at Gropius Bau in Berlin said that producing the required food at the place of consumption reduces the overall carbon footprint. It also provided its customers with freshly produced herbs and greens. This made the restaurant less dependent on external suppliers and less vulnerable to changing food prices. This allowed the restaurant to be economically empowered and their consumers to be physically empowered through rich nutrition in their food.

Building Knowledge – Empowerment Process

Researcher Ernst van den Ende from Wageningen University through his research showed that plants that are grown without soil, even with less water and artificial light, produce more yield compared to conventional agriculture. He believed that agriculture in the future must be done using

existing agricultural fields with new technology and skills to optimize plant growth through soil-less agriculture without harming the environment. Professor Toyoki Kozai stated that the invention and availability of low-cost LED lights had transformed the field of soil-less agriculture by reducing energy consumption and increasing the yield of the plants. This change in mindset will empower smallholder farmers psychologically to transition towards a new system of agriculture.

The H2Grow initiative showed how local families benefit from the knowledge gained through the project which allowed them to start farming at the refugee camp to become smallholder farmers who grow their food. The produce from these initiatives could improve the diet of the community. The Zambian school taught its students how to grow food using hydroponics and encouraged them to apply the subjects such as Mathematics, Chemistry, Physics, and Biology that they learned in school when working on the model garden. John, the hydroponics consultant in Zambia passed on his knowledge to the community so that they could replicate the system in their households and produce their food. One success story of this is in the case of David and his mother who started to grow different varieties of food at home. The UNFAO initiatives helped reduce the information asymmetry which is usually prevalent in traditional agriculture by teaching local communities about new systems of farming. The locals who now know how to operate the system can further pass this knowledge onto others, improving the community's capabilities to empower themselves against exploitative market systems. These initiatives helped build stronger self-sustaining communities through educational empowerment.

Working with Nature – Empowerment Process

The Secretary-General of German Agro Action stated that unforeseen droughts and storms would impact 30 million people in South Saharan Africa due to climate change. The desert's infertile soil and water scarcity could make it hard to grow food in the Sahara, making the communities that live their food insecure and at a higher risk of malnutrition. Hydroponics helped improve their access to nutritious food which empowered them physically, and as a result, helped reduce the economic inequalities.

The smallholder Brandenburg farmer believes that soil-less agriculture is artificial and does not include the biodiversity that surrounds it. He also stated that it is impossible to cultivate the land

without expensive irrigation systems. However, researcher Ernst van den Ende believes that soil-less agriculture, though seems like working outside of nature, is one of the possible solutions to protect the environment. Therefore, a change in cultivation method toward soil-less agriculture is an important step for empowering smallholder farmers in the future.

The Algerian and the Zambian H2Grow projects generated electricity using solar power which made use of the region's natural sunlight. This was used to run the hydroponics system which allows the community to grow food without soil. This system used less water which is valuable in the water-scarce region. Here we see the community use the existing natural resources like the sun, but also work around the lack of them like the scarce water. Hydroponic greenhouses can improve the level of food sovereignty in Zambia and make them less vulnerable to climate shocks, as well as less dependent on external food aid (World Food Programme, 2020). The Zambian greenhouse hydroponics not only provided economic stability to the community but also empowered them socially and culturally by making use of the natural resources available to them.

Christoph Ingenhoven an architect in Dusseldorf Germany envisions the future of megacities with eco-centric architecture that complements nature. He believes that the increased movement of the population towards big cities would increase the demand for food production. Infrastructure that allows urban farming could generate more green jobs and can be a possible solution for a sustainable future. Urban farming in the future could provide opportunities to smallholder farmers bridge the asymmetry between urban and rural livelihood and thereby empowering them both socially and economically.

4.4 Achieving Food Sovereignty by Enhancing Capabilities

The many real-life examples of smallholder farmers using soil-less agriculture has shown ways in which the alternative methods of agriculture can empower them to achieve food sovereignty. Food was grown in hostile environments, and improved yield allowed people to utilize their land more productively to meet their needs.

By analyzing the findings through Sen's capabilities approach, it was established that the smallholder farmers improved their agency freedom and well-being freedom by strengthening their capabilities of bodily health through better nourishment as seen in the case of the Sahrawi refugees

in Algeria. The Sahrawi community valued their livestock deeply as their culture and livelihoods are closely tied to their animals. However, the community lacked a proper food supply for them as they relied heavily on external food aid which did not provide animal feed. This resulted in the animals being undernourished and limited the benefits to the refugees from herding them. This made it difficult for the communities to continue their way of life and therefore they came up with the plan to grow livestock feed hydroponically. They managed to use the fresh livestock feed to rear healthier livestock which in turn provided the community with fresh, nutritious milk. The community which was previously disempowered and lacked the agency to decide their own diets found a way to take control over their food using soil-less agriculture.

Empowerment through strengthened capabilities with soil-less agriculture programs was also apparent in the model greenhouse in Zambia. Communities were taught how to use the new techniques of hydroponics and were thus given the ability to use their ‘senses, imagination, and thought’ to improve their lives and livelihoods. This was seen in the case of David and his mother who learned hydroponics and started eating healthier and also selling their crop for profit. They were able to use these methods to earn an income with which they could meet their non-food needs better to increase their well-being freedom.

The use of soil-less agriculture also offered smallholder farmers increased agency as they were offered new opportunities and the potential to become less reliant on external food suppliers for subsistence. This even offered certain participants the ability to sell some of their crop which allowed them to influence their own work lives. The use of soil-less agriculture methods also meant that the smallholder farmers like David and his mother learned innovative new skills and found ways to improve their farming methods.

Contrasted with the large corporations who used highly technocratic and expensive methods, the smallholder farmers used more sustainable methods of soil-less agriculture with the use of recycled materials and renewable energy. This shows that the smallholder farmers, when empowered to grow their own food, choose very simple but effective methods of food production. Producing their own food also empowered them in many ways. Learning the new techniques gave them educational empowerment, and the implementation of these practices aided them towards food sovereignty and economically empowered them. The ability to choose what they grew and how

they did it empowered the community and ensured cultural empowerment where the communities could choose diets that were specific to their needs and traditions and, hence increased their overall well-being.

CHAPTER 5

5.1 Conclusion

This research article has tried to answer the question: *How are the effects of soil-less agriculture on the empowerment of smallholder farmers to achieve food sovereignty portrayed in documentaries?* This was done by conducting documentary research through a deductive approach. Documentary research was conducted on various documents like videos and reports from established organizations. A content analysis was done to analyze the secondary data collected through these documents and frequency analysis was conducted to look for patterns of repetitions in the documents. Further, a two-dimensional matrix containing the six principles of food sovereignty and the three methods of empowerment was constructed to understand the interconnectedness of the topics in the use of soil-less agriculture. The matrix was further analyzed based on the different types of empowerments. Finally, the important role that soil-less agriculture plays in enhancing the capabilities of smallholder farmers through agency freedom and well-being freedom to achieve food sovereignty were discussed. The findings from the documentary research showed how the use of soil-less agriculture empowered smallholder farming communities and individuals economically, culturally, physically, socio-politically, and educationally.

Economically, the smallholder farmers in the documentaries who used soil-less agriculture were empowered by increasing their crop yield and limiting their resource consumption compared to their counterparts who used traditional agriculture methods. Smallholder farmers such as Akira Iijima and Shota Takao from the DW documentary showed how transitioning to soil-less agriculture methods using aquaponics and hydroponics respectively helped them improve their economic condition. Moving from large agricultural field to smaller confinements with controlled environments helped them achieve higher yields using less resources. Similarly, the H2Grow initiative in Zambia showed how David and his mother used the knowledge of soil-less agriculture to not only improve their nutritional diet but also sell the additional crops that were grown to make a profit.

Soil-less agriculture also helped communities be culturally empowered. The H2Grow initiative in Algeria showed how the Sahrawi refugees used hydroponics to their advantage to grow fodder for their livestock which was a big part of their culture. This not only improved their nutritional diet but also allowed them to uphold their traditional values. Similarly, the large-scale aquaponics farm in Berlin concentrated to grow only a certain variety of salad and breed Central

City Perch fish to cater to the local diet. This allowed them to not only profit locally but also to uphold the traditional values of the region. The Gropius Bau restaurant in Berlin also produced culturally appropriate food within their facilities to provide nutritious food to their customers.

The food grown using the soil-less agriculture methods also empowered smallholder farmers physically by providing them with the means for adequate nutrition. The Sahrawi refugees who relied on low-nutrition food aid managed to feed their livestock and obtain more milk from them for their community. This made them less reliant on external aid to satisfy their nutritional need and thus empowering them physically. Similarly, the Zambian school as seen in the H2Grow video also grew food in their model greenhouse using hydroponics agriculture. This food was used to prepare nutritious school meals for the students which physically empowered these children.

Soil-less agriculture empowered smallholder farmers socio-politically by localizing their food systems that allowed them to take decisions locally. These smallholder farmers and individuals made use of the resources that were available locally to exert a higher level of control over their own lives and the community that they lived in. The Sahrawi refugee camp started the hydroponic greenhouse with the help of a local refugees who used who used her education background to creatively construct the hydroponics systems used in the greenhouse. This greenhouse was operated by the local refugee families and therefore all decisions were taken communally. This reduced their reliance on external food aid which empowered them both socially and politically.

The new techniques of soil-less agriculture that were taught to smallholder farmers in the UNFAO H2Grow initiative in Zambia also empowered them educationally as they learned and practiced new methods of farming. John Serwanga from the Zambian school discussed how the model greenhouse helped students put the skills they learned in the classroom to use practically. The school also taught other members of the community how to grow food using soil-less agriculture and the hydroponics consultant also provided continuous consultation. The example of how David and his mother made use of this new method to grow food hydroponically illustrates how soil-less agriculture could educationally empower smallholder farmers and communities. Similarly, the knowledge of using renewal energy for the maintenance and running of the hydroponics system used by the Sahrawi refugees helped them optimize the resources used and empowered them educationally.

Soil-less agriculture also reduces barriers to entering the agricultural industry by reducing the amount of land and resources required for food cultivation. The controlled environments, higher predictability, and higher quantity of crop yields reduce the risk of losses posed to farmers due to environmental factors. The ability to better access and control food production empowers smallholder farmers to improve their nutritional diets and economic conditions.

It is observed that the use of soil-less agriculture has still not become a commonplace practice. Instead, it is concentrated in a few innovative areas of society. This is more commonly seen in high-tech companies, or disadvantaged communities through welfare programs. Only a few smallholder farmers such as Akira Iijima and Shota Takao from the documentary have transitioned towards soil-less agriculture. The UNFAO-led initiatives also show low-tech approaches to growing food using soil-less agriculture. This is not surprising as the use of hydroponics first started during Babylonian times in the absence of modern technology.

However, as stated by the Brandenburg farmer from Berlin in the documentary, changing the mindset of conventional smallholder farmers to adopt soil-less agriculture would pose a big challenge as conventional agriculture practices have been followed for generations and have a strong impact on their emotional and traditional values. The shift toward soil-less agriculture may cause cognitive dissonance to some farmers who have a strong endowment towards soil, land, and biodiversity. Akira Iijima, a smallholder Japanese farmer is a perfect example who demonstrates how this may be overcome as he uses soil-less agriculture, including biodiversity in the system, by using fish in aquaponics. This further raises the question of whether biodiversity in agriculture necessarily has to be centered around soil or if it can exist outside of it. Biodiversity and soil health could instead flourish if undisturbed by intensive agricultural practices. Transitioning into organic agriculture could be another solution in the long run, but it can be expensive (Charlton, 2016), and due to global warming and changing landscapes the process may be quite challenging.

These examples demonstrate how soil-less agriculture methods which are less reliant on technology and are more eco-centric can use solar power, water, and fish in food production. In these cases, the use of soil-less agriculture has seemingly contributed a lot to the lives of smallholder farmers and thereby enhancing both agency and well-being freedom. Surprisingly, the use of soil-

less agriculture is not more common, especially when the benefits of soil-less agriculture have been documented extensively in different research articles.

When it comes to individuals, this may be due to the current food system where many have gotten used to the convenience of supermarkets and lack the time to invest in growing their food. As for smallholder farmers, this may be due to a perceived lack of skills and capital required to change their current growing methods to adopt soil-less agriculture methods. This was evident in the example of the Zambian school, where many students were able to help and work on the hydroponics system. Yet, many people who were new to it felt that it was too intimidating. Due to the new techniques involved in soil-less agriculture, the lack of industry specific education and skills can act as a barrier to entry. Improving access to such information could help aid the transition of smallholder farmers towards soil-less agriculture.

Therefore, while soil-less agriculture offers ways in which certain issues of traditional agriculture can be mitigated, there need to be many other changes made in conjunction with this to properly overhaul the current flawed system. Soil-less agriculture is also certainly not the only way in which food sovereignty and empowerment can be achieved, however, it does offer promising new avenues that deserve more research in the future.

5.2 Limitations and Further Research

Policies and legal constraints were not considered in this paper due to the scope of the research question. However, this is an area that could be researched further as policies and laws can very strongly affect the food systems in certain countries. This can vary with countries having different socio-political systems. The economic aspects of transitioning to soil-less agriculture have also not been discussed due to variations in costs of implementation in different regions. Our paper has also used a select number of documentaries as the source material for research and therefore the results are representative of the limited number of resources used.

The difference in yield of soil-less agriculture between highly controlled environment and the low-tech environment is not discussed. Understanding the difference in yield using different systems can provide clarity on what extent smallholder farmers can be empowered to achieved food

sovereignty. As smallholder farmers both buy and sell food, it is hard to determine how food price fluctuations will affect them (Thompson, 2015). As such, in this paper, the price of food is not discussed to empower the smallholder farmers. Methods of ensuring a higher yield more predictably and safely have been emphasized instead.

Therefore, further research could be conducted on how soil-less agriculture could empower smallholder farmers by analyzing policies and how they affect food prices. One such research could be on the provision of organic labels to food produced through soil-less agriculture. These policies and regulations vary in different countries as some countries consider soil in which food is grown as organic while other countries consider the process and method in determining the organic nature of the food produced.

Further research could also be conducted on soil-less agriculture in specific locations or the production of a specific variety of crops. This could allow for an in-depth exploration of the impacts of the cultural, economic, and environmental factors on the implementation of soil-less agriculture. The matrix that has been used in our research can also be amended to use different theories of empowerment such as the Capability Approach. The portrayal of soil-less agriculture and its role on empowerment of smallholder farmers can also be studied using different source material, such as interviews or policy documents, in the future.

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Appendix

Transcript of DW Documentary – High Tech Farms of the Future

Unknown Speaker 00:01

Is this what the future of agriculture looks like? Vegetables and lettuces stacked on several floors artificially lit, fully automated farming, protected from drought frost, and storm. This isn't a futuristic vision. In Japan, this is already the reality.

Unknown Speaker 00:23

In this system, we can produce food under optimal conditions with high nutritional content and good taste all year round. That's the big difference between working in the field.

Unknown Speaker 00:39

working the fields in Brandenburg, these thick dust clouds are due to the drought. Without massive artificial irrigation, there would be no harvest are these fields facing an imminent collapse?

Unknown Speaker 00:56

As the conditions are currently, I would have to recommend my children look for a different professional job.

Unknown Speaker 01:02

the devastating drought here. heavy flooding elsewhere. Food production is in danger and catastrophic famines wreak havoc. Throughout the world, researchers are searching for solutions.

Unknown Speaker 01:28

A typical harvest in Japan the workers wear protective suits that are hygienic ly prepared. The environment is clinical. These lettuce heads are cultivated without soil and free of pesticides. In this room, the temperature always remains the same.

Unknown Speaker 01:52

I find it pretty good that I can always work indoors regardless of the weather. It's better than in the rice fields.

Unknown Speaker 02:01

Vertical farming is the name of this method from Japan as seen here at the company spread in Kyoto. The Roots thrive in a liquid nutrient solution without topsoil, but with the same natural ingredients such as sodium and potassium. lamps with a similar colour temperature to sunlight are used. solar collectors and the building's green facade indicate that progress is that home here at the University of Chiba in Japan and this futuristic-looking greenhouse experiments with vertical vegetable cultivation are being conducted. Professor to Yoky Kozai invented this method

in the 1970s. Back then he initially had problems finding the right light and had high electricity costs. The breakthrough came with LED technology.

Unknown Speaker 02:50

Originally, I wanted to help the small farmers who own small land parcels. Vertical farming enables one to achieve 100 times more annual harvest in a single area than conventional farming. So it's worth investing in such vegetable factories. These facilities can be set up anywhere. It's an important step towards sustainable agriculture. There are no losses during the harvest, and we use less energy for transport, productivity and profitability can be increased even further with the latest technology.

Unknown Speaker 03:25

This method is mainly used for vegetables and salads. As far as staple foods go, such as cereals or potatoes, more research is still needed.

Unknown Speaker 03:41

In Japan after the Fukushima catastrophe, there was a lot of interest in these new greenhouses because it is possible to produce all year round regardless of external influences. Thanks to our methods, the farmers have a stable production without damage from insects or worms. And of course, the system is sustainable. You can run these vegetable factories in the middle of the city and produce local food as needed.

Unknown Speaker 04:14

The contrast to agriculture in the fields once again the farmers lack water, a lot of water, and the weather is much too hot. temperatures of up to 40 degrees Celsius can dry up the soil to two meters deep.

Unknown Speaker 04:35

Large parts of Germany are affected by drought in the summer. The result can be the total loss of the harvest was high financial losses. Hans Heinrich Cohen hardens and Brandenburg is one of the farmers who suffer he grows potatoes and corn. His farm is located in an area with light dry soil without the help of expensive irrigation systems, nothing would grow on his farm. The water already needs to be pumped from deep underground and climate experts predict that even more extreme dry periods are expected to heat and Borden uncooked

Unknown Speaker 05:18

if you look at the ground here, no moisture's no plant can survive the floods with the game. That's why there's not much on this. Yeah, too miserable potatoes. Yeah, are a few more, which might have been okay, if they had enough water. Like last year, we are having a very dry year again, it's only rained half the amount that we normally would have had at this time of the year, or the soil is so dry from last year that even the little rain we've had over the last few days is not enough for the plants. And since we are near

Unknown Speaker 05:55

how can the farmer's problems be solved? How can we ensure that the food supply in the future is safe for hunting in University in the Netherlands is looking into these questions. At the renowned Agricultural University scientists are working on using new ideas and methods to finally defeat hunger in the 21st century. They are working on the assumption that in just 30 years, twice as much food will have to be produced as today. But the conditions for this have become worse. In order not to exacerbate the climate crisis, the area available for food cultivation should not increase. New methods are therefore needed to produce food in the future. Adds funding and is the head of the plant science department. He understands how grave the situation is.

Unknown Speaker 06:45

So if we change nothing, and we keep on consuming the way we are doing, and if we don't optimize the way we produce our food, then for the next 40 years, we will need to produce as much food as we did over the last 8000 years. And I think that gives a good impression. How big the challenge is to feed the world in 2050.

Unknown Speaker 07:13

With its huge greenhouses, The Netherlands is the second-largest food exporter in the world, and they take care of their resources. Vegetable Growers here need much less water to grow tomatoes than elsewhere, thanks to new irrigation techniques.

Unknown Speaker 07:32

Our research is focusing on producing more food but at the same time doing it with fewer inputs. So we need to produce more nutritious food, more safe food. And this challenge more with less and better is the overarching theme of our research programs.

Unknown Speaker 07:53

This is how daily life looks in the Spanish region of eimeria. Under this sea of plastic tarpaulins lies Europe's largest vegetable garden, artificially irrigated, and grown for export. Millions of tons of tomatoes, peppers, cucumbers, and other varieties are shipped from here, mostly to Germany. But intensive cultivation has its price. pesticides and fertilizers contribute to the fact that hardly anything grows here outside the greenhouses. And the Spanish vegetable farmers are running out of water, the whole area is drying up.

Unknown Speaker 08:39

The situation in Africa is even more extreme, especially south of the Sahara. The reason is an increase in weather catastrophes. It's almost impossible for the poor and hungry to lift themselves out of their misery without external help, says the Secretary-General of German agro action.

Unknown Speaker 09:00

Swati since 2014, the number of hungry people has continued to rise. And currently, 821 million people suffer English, we can see quite clearly that about 30 million people have been affected as a direct result of the climate change this claim hundreds are personally and very acutely affected by this because the storms currently hitting these countries were previously completely unknown. And this is just such a sign of the destructive force that a changing climate can trigger and how the people in the countries where we work are quite defenceless, and at the mercy of the elements and

Unknown Speaker 09:43

catastrophes, drought, and floods destroy not only the living spaces of inhabitants but also valuable agricultural land.

Unknown Speaker 09:58

Although Brandenburg farmer GreenHeart can solve his drug problems with technical help supported by the EU. He nevertheless is pessimistic about his future

Unknown Speaker 10:10

he says irrigation is the only way we can still grow things here you try to unblock grain cultivation is not feasible anymore. And we are no longer competitive worldwide here but the potatoes that we irrigate are sold here in the region, where we still have a market that we can sell to redeem to Congo via union.

Unknown Speaker 10:29

Back in Japan, the company spread and Kyoto headquarters for the new world of agriculture. Spread is currently the world's largest farm for vertical production. An employee of the company is on her way to work. Her clothes are more similar to what people wear in an operating theatre than on an outdoor farm. Here, hygiene regulations are very strict. All precautions are used to prevent germs from the outside from entering the production, as the food should be clean and unspoiled. In this closed sterile environment, the plants grow without the use of pesticides and fertilizers. A good 50,000 heads of lettuce leave the factory every day. This haul is only used for packaging. Others are used for growing various vegetables, including mushrooms and exotic herbs. The selection is large, none of the produce is washed as there are germs in the water that may cause the vegetables to spoil. Another advantage of this type of indoor farming is that the plants thrive on several floors above each other and need very little valuable floor space. The cultivation in some of the halls is already fully automatic. Shinji Inada founded the factory 15 years ago, you go to the misogyny

Unknown Speaker 11:52

back then climate change or the explosion of the world's population was not a big issue. So was there a market for factory grown vegetables anymore, but now we make a good profit. I don't think that factories will replace conventional farming completely. But I think that our way of farming will play a central role 20 or 30 years from now. We want to share the technology with

poor countries so that they can produce their food Oh, go into your status.

Unknown Speaker 12:23

Thanks to the short distances to supermarkets and restaurants. No goods are spoiled during transport, unlike in conventional supply chains. On the other hand, conventional agriculture in Japan is also in a deep crisis. farmers use pesticides as a necessary tool in rice cultivation. Rice, which is sacred to many Japanese is heavily subsidized in Japan. The market is largely protected by high customs duties. Price imports are considered an attack on cultural heritage. But the areas under cultivation are dwindling. The average size of a Japanese farm is just 1.8 hectares, which makes it difficult for farmers to make ends meet. That is why there are hardly any young people farming with the average age of a farmer being 66 years old. Cooperatives are formed in many places to be able to farm more effectively. But the increase in natural disasters is also causing them problems.

Unknown Speaker 13:32

To avoid being held hostage by these changes, the farmer Akira Iijima was inventive. I grew up with this is my aquaponic system he proudly explains. And a small greenhouse he is trying out a new form of agriculture aquaponic here for sure bred in large tanks. Akira Iijima has 250 sturgeons in his facility the fish excrement is pumped out and used as fertilizer for various vegetables. The water purified by the plants is then returned to the fish tanks. From rice farmers to modern aquaponic farmers. Almost all vegetables thrive here all year round and are independent of climate change. The greenhouse has even withstood an earthquake. The neighbouring farmers have already suffered this year. It rained too much and their plants did not get enough sun.

Unknown Speaker 14:41

Akira Iijima, however, can still carry his harvest to the market and dreams of an even bigger plant such as this one in the Schonenberg district in Berlin on the grounds of an old industrial complex greenhouses for vegetable growing in the middle of the city. groups of visitors from all over the world come here to learn about the goings-on inside. This is also an aquaponics farm, but on a grand scale, the current product, capital city basil, is ground with the excrement of fish bread in these tanks. The fish that is marketed in Berlin is of course called capital city perch.

Unknown Speaker 15:31

We have one dog we want to produce where people consume so we don't have long supply chains or long cold storage times and we have a much better co2 balance. I think our fish the capital city perch is the freshest fish you can buy here in Berlin.

Unknown Speaker 15:47

The principle is as old as the hills. The water that is polluted by the fish is extracted and used as manure for the plants. It has been used this way for centuries in China and by the Mayans of

Central America. The plants grow faster on shelves or in raised beds in these rooms than in a natural environment. The young entrepreneurs produced 9500 Basil pods per week for a supermarket chain, so it won't take long before the cost of the 1.4 million euro construction is recovered.

Unknown Speaker 16:22

7.8 billion people currently live on our planet. In a mere 30 years, it will be 11 billion. More and more people are leaving the rural areas. And according to United Nations study, two-thirds of the world's population will be living in cities in 2050. So more of these farms will have to be built, especially in Asia. They're their megacities already extend over huge areas without any agriculture, more plants and more greenery are needed in the cities. Urban planners face a new challenge. The inhabitants of megacities not only have to be supplied with living space, water, and energy, but they also need room for growing food.

Unknown Speaker 17:14

The district of architect Kustoff Ng and Holden and his staff are planning huge residential and office complexes and almost all the world's megacities, and they need to make them attractive to live in. Their homes interested me to be by hits

Unknown Speaker 17:29

we have to deal with overheated cities. Cities are significantly warmer and hotter than the surrounding areas, which we're dealing with cities that are not only dense, so to speak, but also sealed. So not often, there is little contact between the environment and the earth with correspondingly negative consequences due to the influx of people and overcrowding by the physical home. But it is no longer possible to ignore this problem. So the idea of revegetation and green architecture will play a major role in the future tour from

Unknown Speaker 18:05

this residential and office complex in Singapore as high as the Berlin Television Tower is an example of the district of architects' work. 20,000 people live and work here, a small town in a single building complex. In the middle of it is if green heart 350 different plant species helped to provide better air and a better climate.

Unknown Speaker 18:30

This nifty loss option is certainly not the solution for normal rural Central European areas. But it is the solution for high-density locations. Of course, if you plan to create a green area, you can also use it to produce food. So you have to have that effect you have the shading effect, and the fact that the food is produced here, so you have the benefit of oxygen production. An additional advantage is that if the produce is grown here, you also save co2 due to shorter transport routes that support

Unknown Speaker 19:04

vehicle angers property and green areas and not just for recreation. agricultural producers growing food and high rise buildings are on roofs next to huge office towers.

Unknown Speaker 19:17

I wouldn't dismiss it although it does of course seem bizarre because I think that from a central European perspective, it's difficult to imagine the density and intensity as well as the difficulties many of these cities will face in the next 50 years. What comes next is to achieve this with a quality that enables the people to live healthy lives there on a permanent basis for

Unknown Speaker 19:42

what sounds like a futuristic dream is already a reality in Asia. But also in Europe, more and more people are moving to the cities and the transport supply chains for food are getting longer. In the centre of Tokyo, the Ginza of the main shopping street of the metropolis, home to the large Japanese corporations and long-established institutions. A rice field in the middle of it is on the roof of a high-rise building. A saqi brewery grows the raw material for its rice wine here. In Japan psyche is not just an alcoholic beverage. It is an indispensable part of the country's culture, just like rice, which is why saqi and rice belong right in the heart of Tokyo for this brewery. It is also an experimental field for new varieties, the roof of a high-rise building as an agricultural alternative. Pretty cool now

Unknown Speaker 20:47

but in the beginning, they didn't take us seriously. No rice would grow here. It's much too bright here at night. And on the roof, it's much too hot. But our experiments have been good. And we're harvesting more and more. The rice grows well here. I think it's right that in Japan they were looking for different ways to grow rice and vegetables. It's a challenge. And after all, rice is part of our tradition. Let's dive right in.

Unknown Speaker 21:16

Each season, the brewery produces 50 bottles of Sakhi from its small rice field on the roof

Unknown Speaker 21:28

the historic building copious bow in the centre of Berlin right next to the museum's entrance hall is a restaurant. The illuminated glass cabinets are not just part of the decor. Inside grow herbs and salads. An Israeli startup based in Berlin has placed these plant cabinets in various restaurants in the city, as well as in the stores of a supermarket chain. They function similarly to the plant factories in Japan and ensure that the produce is fresh on the table. There are 50 mini-greenhouses in Berlin alone, and about 200 are already distributed throughout Europe. Two square meters of space in the planned cabinet corresponds to 250 square meters of regular

farmland, and less food is wasted in the kitchen. Because you only harvest what is necessary for the dishes that guests have ordered.

Unknown Speaker 22:29

We are harvesting from our farms two or three times a week. We don't have to wash it because it doesn't have any dirt. It has just water and roots. So it's perfect for the cook and also for the guests. This is, for example, it's crystal lettuce. First of all, it's lettuce, which is very hard to get in the market. So you can see that it's super crispy. And the fact that you just you're harvesting it and putting it straight into the plate, makes a huge difference. But the other thing, and I think this is the most important one is that we have access to flavours and to plants that you cannot get anywhere. For example, this one is, is Monster. And it's something that you cannot get in the market that is really like mustard. It's like it's sharp and spicy.

Unknown Speaker 23:24

Admittedly, this kind of special preparation is more for the enjoyment of a metropolitan minority. Presently, these greenhouses are not yet planned for mass production in Germany. At least lettuce here doesn't travel far to be put on the table. Factory plants are grown under artificial sunlight without Earth and with little water. An important step for the nutrition of the future and a challenge for conventional agriculture.

Unknown Speaker 23:54

We will work with nature. If you look around here, marks are singing like insects are flying around. But that isn't the case in these facilities. I believe that this is not what you want in the future. It's not nature. It's just an artificial product that comes to life. I just can't imagine it has nothing to do with my ethos as a farmer. For me, farming is having an area of land here where something is growing that I can take care of my defence artificial farming goes against the philosophy of what I want to represent with my soul as a farmer.

Unknown Speaker 24:28

But do we have another choice? Classical agriculture alone will not be able to supply the growing world population without the help from the laboratory for much longer. With plants that develop in a controlled way without the use of fertilizers and pesticides, and with less water.

Unknown Speaker 24:45

Assuming there will be a world population of 10 or 11 billion people we can't yet imagine how big the cities will become and at the moment it's almost considered progress. If you can successfully cope with overcrowding at all. It is an essential part of 21st Century technology that we achieve this because if we don't our survival on the planet may not happen.

Unknown Speaker 25:06

What do you want do you want to produce in such a way that you have sub-optimal yields, and you use, you need to use a bigger surface. And that means that you have to destroy nature, or you want to have your optimal yields per square meter. So my opinion is that we use our agriculture fields in such a way that we optimize the growth in order to save the environment.

Unknown Speaker 25:36

Our research is still just starting. However, in the coming decades, cities throughout the world will need to host vertical agriculture was safe, clean, and sustainable produce if we are to prevent food from becoming scarce.

Transcript of H2Grow - An Introduction by Nina Schroder

Nina Schroeder - Project Manager at WFP Innovation Accelerator

Hi, I'm Nina, I work at the innovation accelerator. I am going to tell you today how we grow food in the desert. So in the Algerian Sahara Desert, the Sahrawi refugees have been living there for about 40 years in camps. For them, animals play a very important role in their culture, but also in their diet. But as they themselves are completely dependent on external food aid, they very rarely have the means actually, to feed their animals. So very often, they actually end up eating garbage, leading to the very poor nutritional value of the meat and milk they produce. So one of the Sahrawi refugees with an agrarian and engineering background had the idea, why don't we use hydroponics to grow animal fodder here in the desert? Hydroponics is a growing technique, we don't need fertile soil. So actually, we thought, 'Why not? Let's try it out.' We brought in a high-tech solar-powered hydroponics container that can grow barley fodder in only seven days, from seed to harvest. We need solar power, actually to manage the water circulation pump that ensures that all the layers get sufficient water supply. We had local farmer families running this unit, to get to know the technique, and then to create a local replica to make this sustainable, because we thought only if it uses local expertise and locally available material, we can ensure that the families would build one of these things themselves to feed their animals. So we could bring down the cost to only 10%. And then we thought, 'Alright, we have this local replica. Now, what is the impact?' We looked at the animals that participate in the first trial, and we could see an increase in the milk production of the goats that were now fed with animal fodder by 250%. Also, we could see a decrease in the mortality rate. And we're now looking into the increase of the impact actually on the meat and milk quality. So what are the next steps? We currently have 20 of these local units implemented in the camp already ensuring that more than 500 people are benefiting from this next step is now

actually to look and what other regions or countries could this model be attractive to? Because we have many countries with water scarcity problems, and where livestock plays an important role in the livelihoods.

Transcribed by <https://otter.ai>

Transcript of H2Grow Model Hydroponics School Garden | WFP Zambia

John Serwanga - Hydroponics Consultant:

We are at Woodlands B Primary School. The project you're seeing here, we call a model school garden with solar as a source of power. We are piloting different hydroponic systems in this garden. The systems we are trying out here, are the low-cost hydroponics systems, which can easily be adopted at a household level without the limitation of income. The technologies we're using here, are using simple techniques. Whenever someone comes to the garden, there are one or two systems. One can easily say "I can do this." Many people when they come here, they're like, "We can't afford this." It looks like something out of people's incomes and knowledge. So the model school garden is trying to address those critical questions of affordability. As you're seeing here, the techniques we are doing here, are simplified hydroponic systems. We are planting using bamboo. We did it in PVC pipes, but again, we are trying to do it in bamboo trees to show people whether you don't have money to buy the PVC pipes, you can do it in bamboo trees. So, the message out here is hydroponics is adaptable and you can do it. To the learners. It has given them a chance to put what they learn into practice. Here, there is mathematics. Here, there is physics, and any application of any subject you have ever thought of. Chemistry is being applied here. So for learners, it's time for them to apply what they're studying in classes. So that's why the model school is so important for learners, the community, and the general public.

Transcribed by <https://otter.ai>