Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

School Roof Top Farming as a Sustainable Food Security Measure in Malaysia: A Conceptual Framework

Sheela Jayabaln[1], Nadzriah Ahmad[1], Siti Hafsyah[1], Zinatul Ashiqin Zainol[2]

[1]Faculty of Law, Universiti Teknologi Mara, Malaysia.
[2]Faculty of Law, National University of Malaysia, Malaysia
Email: sheelaj.balan@gmail.com

Rooftop farming presents a sustainable and innovative approach in enhancing food security in Malaysia through promotion of urban agriculture, fostering community resilience, and reducing reliance on imported food. Utilizing empty rooftops in schools to implement green roofs for food production can be a solution to the many challenges faced by urban agriculture, such as unavailability of land, no proper sunlight or unsuitable soil apart from food insecurity. School roof tops should be utilized for urban farming where the produce can be used in school food aid programmes. However, effective implementation requires collaborative efforts from government ministries, private sectors, academia, and local communities to provide necessary support, infrastructure, and policies conducive to school rooftop farming initiatives. Through concerted action, school rooftop farming can contribute significantly in building a more resilient and food-secure future in Malaysia because children can be educated and nurtured on urban farming as a sustainable development measure. Other countries such as India, Hong Kong and Europe have successfully experimented with urban agriculture via roof top. Adopting a systematic literature review qualitative method, comparative analysis, this article conceptualizes that Malaysia should embark on 'roof top farming' as a self-sustainable measure to overcome food insecurity. It discourses the potential challenges such as limited access to resources, technical knowledge, and policy support, and proposes strategies to overcome these barriers benchmarking the best practices of other countries.

Keywords: Self Sustainable, Urban Farming, Rooftop, and Food Security.

1. Introduction

Millions of kids worldwide attend school without food. Consequently, hunger impairs their focus and capacity to study. Some children do not attend school because of poverty and their families depend on them to assist in farming, work or take care of the house while their parents at work. These children suffer from food insecurity. UNICEF reports that globally, 1 in 5

deaths among children under the age of 5 is attributed to severe wasting. In Yemen, the nutrition crisis affects nearly 2.2 million children. In Gaza, 1 in 6 children under age 2 are acutely malnourished and in Malaysia, 1 in 5 children under the age of five is too short for his or her age due to the lack of proper nutrition.

Furthermore, the Covid-19 pandemic raised many concerns not only in Malaysia but also world wide of the preparedeness of a country in dealing with concerns such as economic stability, mental health, education, political stability and food security among others. Food security was one of the major issues especially among urban dwellers where due to many people losing their jobs and with the declaration of MCO (movement control order), issues of sufficiency, accessability and affordability of food raised concerns of food insecurity. The COVID-19 pandemic affected the food production, food processing, transport and logistics and the final demand on a global scale [1]. To address and avert food insecurity specifically for self-sustainability in Malaysia, rooftop vegetable farming should be the new norm and the way forward especially for urban dwellers as a long term measure to sustain household food security and nutrition [2]. Walters and Midden [3] stated in their article that, the production of vegetables on rooftops should not be thought of as a replacement for large-scale vegetable production in rural areas, but rather as an enhancement to the urban food movement by providing another source of local food especially in food aid programmes. In Sweden, for example, vegetable farming on roof tops creates an opportunity to produce food all year round, even in the winter seasons during which traditional local farms cannot grow food [4]. School rooftop farming is proposed as an intervention measure to food insecurity in Malaysia among the urban dwellers especially for school food aid programmes. Nonetheless, policies should be in place to regulate roof top farming. Adapting a systematic literature review qualitative method, comparative analysis, this article conceptualizes that school roof top farming should be the new norm among the urban dwellers with the assistance of the Government with proper regulative measures to regulate this model of farming. Therefore, to discourse the conceptual framework on school roof top farming, the following factors are discussed and analysed; (i) Why urban farming, specifically school roof top farming should be cultivated in Malaysia as the new norm to overcome food insecurity? (ii) What are the factors taken into consideration in other countries that practices school roof top farming, and (iii) What are the matters that should be recommended if school roof top farming is cultivated in Malaysia?

2. URBAN FARMING VIA SCHOOL ROOFTOP AS THE NEW NORM IN MALAYSIA: WHY?

The Covid-19 pandemic is a wakeup call to the world that self-resiliency to food security is of paramount important so that no one suffers from food insecurity which is defined as the condition of not having access to sufficient food, or food of an adequate quality, to meet one's basic needs (Food and Agriculture Organization (FAO). Even though earth is the biggest of the terrestrial planets, and the fifth largest planet overall with a human population of 7.8 billion, food security is still an issue. According to Thomas Robert Malthus [5] in his book, 'Essay on the Principle of Population As It Affects The Future Improvement of Society', published in 1798 states that a perfect state could be attained if human restraints could be removed. Malthus' objection was that the pressure of increasing population on the food supply

would destroy perfection and there would be misery in the world. Malthus was severely criticised for his pessimistic views which led him to travel on the continent of Europe to gather data in support of his thesis. He incorporated his research in the second edition of his Essay published in 1803. The Malthusian theory explains the relationship between the growth in food supply and in population. It states that population increases faster than food supply and if unchecked leads to vice or misery. The Malthusian doctrine dichotomizes that, there is a natural sex instinct in human beings to increase at a fast rate. As a result, population increases in geometrical progression and if unchecked doubles itself every 25 years. Thus, human population in successive periods of 25 years will be 1, 2, 4, 8, 16, 32, 64, 128, and 256 (after 200 years). Whereas, the food supply increases in a slow arithmetical progression due to the operation of the law of diminishing returns based on the supposition that the supply of land is constant. Thus, the food supply in successive similar periods will be 1, 2, 3, 4, 5, 6, 7, 8, 9 (after 200 years). Since population increases in geometrical progression and the food supply in arithmetical progression, population tends to outrun food supply. Consequently, an imbalance is created which leads to over-population. The food supply in arithmetical progression is measured on the horizontal axis and the population in geometrical progression on the vertical axis. To control over-population resulting from the imbalance between population and food supply, Malthus suggested preventive checks and positive checks. The preventive checks are applied by a man to control the birth rate. They are foresight, late marriage, celibacy, moral restraint, etc. If people fail to check growth of population by the adoption of preventive checks, positive checks operate in the form of vice, misery, famine, war, disease, pestilence, floods and other natural calamities which tend to reduce population and thereby bring a balance with food supply. According to Malthus, preventive checks are always in operation in a civilized society, for positive checks are crude. Malthus appealed to his countrymen to adopt preventive checks in order to avoid vice or misery resulting from the positive checks.

Sen, however, argues that measures for self-sufficiency of food alone is not enough to address the threat of food security [6]. Sen in his research on world famines concluded that during famines the important issue is not availability of food but the distribution and the lack of purchasing power of the poor i.e., accessibility. This led him to propose entitlement or a kind of right of the hungry to have employment so that they can buy food. Sen found that while China had a big famine where millions of people starved to death, India after independence with its democratic institutions and free media avoided famines. Sen and Jean Dreze wrote a book: 'Hunger and Public Action', where they suggested that that the government and the state are responsible for taking effective steps including enacting laws to ensure food security for all [7]. They explained that public action should also take place from below by grass roots groups, civil society and citizens to put pressure on the government because laws by themselves are not enough to provide food for all. Sen stressed the need for a firm recognition of the right to food, and comprehensive legislation to guarantee everyone the right. Sen's entitlement theory led the Indian government to the enactment of the of Chhattisgarh, Food Security Act, 2012 which was enacted by the Chhattisgarh government, and in 2013 India passed the National Food Security Act 2013. The Indian courts have developed rich jurisprudence to hold the government accountable for failing to realise the right to food of the people on the basis of the law which is gaining recognition in other parts of the world such as South Africa [8]. Which is why regulative measures becoming imperative in regulating food

security specifically through law. But law and policies alone are not sufficient in averting food insecurity. Alternative mechanisms to avert food security such as urban farming which in the words of John Malthus would be a preventative measure and urban farming should also avert distribution and the lack of purchasing power of the poor, overcoming Sen's theory of inaccessibility. Either way regardless of Malthus concern of human population taking over supply of food or Sen's dichotomy on the right to food, people suffered from food insecurity during the COVID-19 pandemic.

Since late 2019, the COVID-19 pandemic has spread quickly and broadly across the world, posing significant risks to food security and nutrition. The unfolding crisis has had an impact on food systems and has put people's access to food in threat due to a number of reasons. This pandemic has resulted in reduced incomes and higher food costs, bringing food out of control for many people and risking attempts to achieve Sustainable Development Goal (SDG) 2: "Zero Hunger." The condition is complex and unpredictable, with a high level of unpredictability. The worst results, according to the World Health Organisation , are yet to come [9]. Most health analysts predict that this virus will continue to circulate for a least one or two more years [10]. Which means food security is of paramount concern that should be addressed at any cost. Preventative measures are imminent. The authors' presupposition being one of the preventive measures should be by urban farming such as roof top farming to avert food insecurity.

According to Hamzah [11] rooftop's utilization as green open space is not new in Malaysia. Green roof can be seen in commercial, public, institutional and even residential buildings such as condominiums but it is not a norm. Though, some schools in Malaysia do encourage urban farming but it is cultivated in small scales around the school compound. It is very rare to find a roof top farming in schools or terrace houses in Malaysia. However, with the current scenario of urban area problems such as the shortage of land, urban heat island, crime, inflation, water shortage, design spatial constraints, the current pandemic etc., rooftop greening seems to be a viable solution to address food insecurity. Though there are many studies conducted on the environmental aspect of green roofs and the mechanics of green roof farming, but not many in the purview of pandemic, food security and regulative measures i.e. law and policies, especially in Malaysia. Let alone as a proposed solution to supplement school food aid programmes.

Due to the emerging global wave of accelerated urbanisation, urban farming has taken on new meaning. Urban farming or agriculture has been most concisely defined by Wagstaff and Wortman [12] as "all forms of agricultural production (food and non-food products) occurring within or around cities." Urban agriculture encompasses a broad spectrum of production methods and business models. Production systems can be broadly categorized as;

1. Ground-based outdoor urban gardens and farms;
2. Hydroponic or aquaponic indoor production;
3. Rooftop gardens and farms;
4. Landscaping and nursery businesses;
5. Urban livestock.

Urban agriculture is stated to have commercial, social, and environmental advantages for communities [13]. Urban agriculture provides a host of environmental, fiscal, health, and educational benefits. At a macro stage, urban agriculture is stated to contribute to a more robust and healthy food system because it is fresher and local food production reduces the need for packaging, refrigeration, storage and transportation of food, decreasing energy usage and costs associated with the production of food. Furthermore, fresh fruits and vegetables also improves accessibility to food. What more if it is from the roof top of a building. The discourse of this article is roof top farming should be cultivated in the urban areas of Malaysia as sustainable measure to address food insecurity. Roof top farming is where food crops are grown in roof buildings especially where there is no adequate agricultural land. Since schools should have ample space on roof tops, the space can be utilized for growing vegetables. The common usage of the roof top of a building is basically to provide protection against rain, snow, sunlight, extremes of temperature, and wind. In most countries a roof protects primarily against weather conditions. The role of the roof is the same in Malaysia. In a study conducted by Hamzah. Z.,[14], a traditional terrace house intermediate unit's roof is usually pitched and constructed of rough clay or concrete tiles. The overlooked structural area under it is used to store mechanical objects such as water tanks, heaters, plumbing, and electrical wiring. Due to the sun, the area is inhabitable during the day, but it is a possible for insects or other predators to hideout at night. It is also stated to pose security hazards such as fire break out and break-ins through the roof tiles. The capacity of the main roof as a functional area for green space has yet to be embraced in Malaysia. Whereas the benefits of green farming other than a self-sustainable measure are many namely;

- Green roofs also provide other environmental benefits such as reducing the urban heat island effect, improving air and water quality as well as the biodiversity of the city[15];
- The implementation of green roofs on a large scale will reduce the surface temperature, thus lowering energy consumption required for cooling and lower the energy bill [16]. Similarly, in the case of cold climates, excess thermal insulation provided by green roofs keeps the building warm, thus lowering the need for thermal energy required to heat the building [17];
- Efficient purpose for space that is otherwise underused [18];
- Hamzah [19], citing, Miller (1986) and others such as Thompson (2002) show that the desire for contact with nature will only increase as people become more urban in their way of living;
- Kaplan & Kaplan [20], in their Attention Restoration Theory also suggested the great impact that landscape has on human. They studied the effects of nature on people's health and relationship and discovered that office workers with just a view of nature were healthier and happier at work. It proved that nature can lift up people's mood and improve ability to focus and really help to improve self-contentment and thus wellbeing. What more during the MCO period in Malaysia, it was reported that mental health of people suffered generally either due to loss of income, fear, staying indoors, limited interactions etc.

But most importantly, if roof top farming is fostered in Malaysia, it should be one of the sustainable measures to avert food insecurity. A simple dynamic presupposition is, if every

terrace house with the empty space on their roof tops and school roof tops were to transform their roof top to vegetable farm in Malaysia, at least for self-sustainability, the occupant of the house and schools would not only have sufficient vegetables and fruits for self-consumption but can supplement school food aid programmes with fresh organic food.

A. Roof Top Farming: Development In Other Countries

Other countries that are stated to cultivate urban farming to supplement local food supplies are, such as, Bologna (Italy), Chicago (USA), Cleveland (USA), Hong Kong (China), Montreal (Canada), New York (USA), Portland (USA), Seattle (USA), Shanghai (China), Taipei (Taiwan), Tokyo (Japan), Toronto (Canada), and Vancouver (Canada), [21]. In Bengaluru, India, Garden City Farmers Trust, a highly successful movement run by intellectuals in Bengaluru encourage citizens to take up organic terrace farming [21]. Roof top farming is highly encouraged in India [22]. Furthermore, the infrastructure of residential buildings in India allows for roof top farming. Many Senegalese women in Senega, have found a method of self-employment in a time of high unemployment, while others have been able to diversify or increase their incomes through roof top farming [23]. The roof garden projects have also increased food security, at a time when the price of fresh vegetables is high, and availability is low. Poor families are able to produce fresh vegetables for self-consumption. In Sweden the green roofs create an opportunity to produce food all year round, even during the winter seasons during where traditional local farms cannot grow food, thus improving the country's food security and contributing to sustainable urban development. Roof top farming is gaining momentum world over. It is seen as one of the preventive measures to avert food insecurity.

The benefit of roof top farming should be extended to schools specifically to supplement food aid programmes since school roof tops is a wasted space that should be utilized for growing vegetables and fruits to overcome food insecurity. Moreover, school children can be taught about urban farming and the significance of eating healthy. School roof top farming may have a significant impact on promoting healthy lives, raising knowledge on nutrition, and enhancing children's food preferences. Generally, school farming may improve parental participation, build relationships between students and staff, and boost children's sense of self-worth that is a way forward in achieving self-sustainable goals. Moreover, studies on farm-based education have demonstrated to strengthen kids' bonds with the natural world and cultivate optimistic perspectives on environmental concerns.

B. Regulative Measures

Generally, legislations supporting the development of agriculture in the urban environment, represented by laws, by-laws and ordinances, are necessary to cultivate roof top farming. Even more so if roof top farming is going to be cultivated in terrace houses in Malaysia because there are none. For example, specific policies are required for building construction and food production [24]. Practical recommendation by Lawlor [25], (could be bench marked in developing green roof policy programme in the Malaysia. The recommendations were as follows: Phase 1: Introductory and awareness. The importance of the green roof environments and its beneficial characteristics should be introduced to the public as a starting point. Also, some green rooftop workshop could take place, where the practitioners visit some existing green rooftop and learn about the current green environmental policies. Phase 2: Community

Engagement. At this point, a local leader of an existing rooftop might organise some meeting with a different variety of actors, such as community leaders, mayors, architects, urban planners, building owners etc., to outline the importance of implementation of a green environment in the sustainable city development. Some fundings and national programmes might be reached during the process at this stage. Phase 3: Action plan development and implementation. There might be a development of the rooftop advisory or working committee at this stage. Some green rooftop project might be launched for the demonstration purposes, and green roofs tours are planned for the review of various types and designs of green roof environments.

As far as acknowledging the significance of regulating roof top farming, Toronto became the first city in North America to require green roofs in 2009 [26]. The Green Roof Bylaw requires residential, commercial, and industrial buildings with gross floor area of more than 2,000 square meters (21,500 square feet) to dedicate a percentage of roof space roof top farming. Furthermore, the bylaw in Toronto also details the minimum design requirements. Likewise, policy framework and laws to regulate roof top farming should be developed to encourage roof top farming in Malaysia. However, in bench marking the policy framework of other, the best practices of other countries should be localized to suit the environment, infrastructure and legal framework of Malaysia.

C. The Way Forward

Rooftop farming generally, should be a viable option for urban agriculture. The benefits of school rooftop farming are multifaceted, spanning educational, environmental, health, economic, social, and sustainability domains. Economically, rooftop farms can help schools reduce food costs by supplementing school meal programs with home-grown produce. The gardens also serve as natural insulators, lowering heating and cooling expenses by maintaining more stable building temperatures. Furthermore, schools can potentially generate revenue by selling surplus produce to the local community, creating an additional funding stream that can be reinvested into educational programs or maintenance of the garden. It provides a dynamic, hands-on learning environment that enriches the educational experience. Students gain practical knowledge in various subjects such as biology, chemistry, physics, and environmental science through direct interaction with the growth cycles of plants. This real-world application enhances STEM (Science, Technology, Engineering, and Mathematics) education by making abstract concepts tangible. Additionally, rooftop farming fosters an understanding of sustainable agriculture, encouraging students to develop environmental stewardship and potentially sparking interest in careers related to agriculture, sustainability, and environmental sciences.

More so it is a sustainable measure to avert food insecurity especially in times of an emergency. Further studies are however needed to explore roof top farming in Malaysia specifically school roof top farming in the areas of infrastructure, acceptability of roof top farming, policies and law to regulate. Furthermore, integrating rooftop farming into the frameworks of Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) principles can amplify its impact, guiding schools towards a more sustainable and socially responsible future.

3. CONCLUSION

In conclusion, school rooftop farming offers a plethora of benefits that span from educational enrichment, environmental improvement, health and nutrition, economic savings, social cohesion, and sustainability. By integrating these practices into the frameworks of SDGs and ESG principles, schools can play a pivotal role in fostering a more sustainable, healthy, and educated society. Urban farming is an essential aspect of urban sustainability, directly dealing with issues of health, food security, climate change, and mitigation as well as social capital and civic engagement [27]. Food production provided by green roofs can help support and sustain food for urban communities, as well as provide a unique opportunity to effectively grow food in spaces that are typically unused such as the roof top buildings in Malaysia. The utilization of alternative agricultural production systems, such as green roof technologies, will increase in importance as human populations become more urbanized and urban consumers become more interested in local foods for their families. The way forward involves strategic implementation, community engagement, and alignment with broader sustainability goals, ensuring that the full potential of rooftop farming is realized for the benefit of current and future generations well-being. Although cultivation of food on roof tops is a key component to avert food insecurity but school green roof or roof top farming is not the total solution to provide food security to urban dwellers. It should be viewed more as a supplement to other sources of food production in urban areas and as a form of sustainable measure.

Acknowledgements

Authors acknowledge the Universiti Teknologi MARA for funding under the Geran Penyelidikan (600-RMC/SRP-UNNES/5/3 (002/2020).

Conflict of interest: The authors declare that there is no conflict of interest.

References

1. OECD, 2020. Food supply chains and COVID-19: impacts and policy lessons: OECD.
2. Galhena DH, Freed R, Maredia KM (2013) Home gardens: a promising approach to enhance household food security and wellbeing. AgricFood Secur 2:8. doi:10.1186/2048-7010-2-8
3. Walters, S.A., Stoelzle, Midden K., 2018. Sustainability of urban agriculture: vegetable production on green roofs. Agriculture 8, 168.
4. Sen, F., 2018. A study of the potential of commercial rooftop greenhouse urban agriculture in Stockholm, Uppsala: SLU.
5. MacRae, D. Gunn (2024, May 16). Thomas Malthus. Encyclopedia Britannica. https://www.britannica.com/money/Thomas-Malthus.
6. Dreze, Jean, and Amartya Sen. 1989. Hunger and Public Action. Oxford: Oxford University Press
7. Durojaye, E. and Chilemba, E.M. (May 2018), "Accountability and the right to food: A comparative study of India and South Africa" Food Security SA Working Paper Series No. 003. DST-NRF Centre of Excellence in Food Security, South Africa.
8. Khorsandi, P. 2020. WFP chief warns of 'hunger pandemic' as Global Food Crises Report launched. World Food Programme Insight, 22 April 2020. (also available at https://insight.wfp.org/wfp-chief-warns-of-hunger-pandemic-as-global-food-crises-reportlaunched-3ee3edb38e47).
9. Scudellari, M. 2020. How the pandemic might play out in 2021 and beyond. Nature. 584: 22-25

August 5. https://www.nature.com/articles/d41586-020-02278-5.
10. Hamzah Z, Salleh. E, Jaafar M.F.Z, Yusoff W.F.M, M.F Irfan Mohd Nor. (2016). Transforming terrace housing roof top in Kuala Lumpur- A study on its construct's & variables. Journal of Design & Built, VOL 9 (2016), ISSN: 1985-6881.
11. Wagstaff, R. K., & Wortman, S. E. (2013). Crop physiological response across the Chicago metropolitan region: Developing recommendations for urban and peri-urban farmers in the North Central US. Renewable Agriculture and Food Systems, 30(x), 1–7. https://doi.org/10.1017/S174217051300046X.
12. Mogk, J. E., Wiatkowski, S., & Weindorf, M. J. (2010). Promoting urban agriculture as an alternative land use for vacant properties in the city of detroit: Benefits, problems and proposals for regulatory framework for successful land use integration. Wayne Law Review, 56(4), 1521-1580.
13. Safayet, M., Arefin, M. F. & UddinHasan, M. M., 2017. Present practice and future prospect of rooftop farming in Dhaka city: A step towards urban sustainability. Journal of urban management, 6(2), pp. 56- 65.
14. Alhashimi, Lamees & Aljawi, Lujain & Gashgari, Raneem & Alamoudi, Abrar. (2018). The Effect of Rooftop Garden on Reducing the Internal Temperature of the Rooms in Buildings. 10.11159/icmie18.114.
15. Jaffal, Issa & Ouldboukhitine, Salah-Eddine & Belarbi, Rafik. (2012). A comprehensive study of the impact of green roofs on building energy performance. Renewable Energy. 43. 157-164. 10.1016/j.renene.2011.12.004.
16. Kaplan, R., Kaplan, S. (1989). The Experience of Nature. University Press, Cambridge.
17. Walters, S., & Stoelzle Midden, K. (2018). Sustainability of Urban Agriculture: Vegetable Production on Green Roofs. Agriculture, 8(11), 168. doi:10.3390/agriculture8110168.
18. Agarwal H. P., Sinha R. (2017): Urban Farming – A Sustainable Model for Indian Cities. In: International Journal on Emerging Technologies 8/1. Bilaspur.
19. Doshi, R.T., et al. City Farming – the Natural Alternative, Experiences in India. Urban Agriculture Magazine (10) August 2003: 18-19.
20. Wilson, Alex and May Rickel Pelletier. A Garden Overhead: The Benefits and Challenges of Green Roofs. Environmental Building News, Special Reprint 10(11) November 2001, revised May 2003: 1-10.
21. Orsini F, Dubbeling M, Zeeuw de H, Gianquinto G (2017) Rooftop Urban Agriculture. Springer, Switzerland.
22. Lawlor, G., Currie, B., Doshi, H. and Wieditz, I. (2006) Green Roofs: A Resource Manual for Municipal Policy Makers. CMHC, Canada.
23. Brown, J. D. (2016). Biophilic laws: Planning for cities with nature. Virginia Environmental Law Journal, 34(1), 52-121.
24. Hernandez, M. & Manu, R., 2018. Growing greener cities: Urban agriculture and the impact on SDG 11. [Online] Available at: https://sdg.iisd.org/commentary/generation-2030/growing-greener-cities-urban-agricultureand-the-impact-on-sdg-11/.