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Sustainable Agriculture

ACHIEVING AGRICULTURAL SUSTAINABILITY WHILE GUARANTEEING FOOD SECURITY

In spite of a huge advancement in technology and un-precedent use of chemicals, recent surveys reveal that at present, around 900 million people are hunger-stricken due to various resource scarcities in the agricultural sector and therefore, the Food and Agricultural Organization of the United Nations (FAO) reported that there is need to increase the agriculture production by at least 60%, if we want to fulfill the needs of about 9 billion population in 2050. Up to now, to enhance the production of crops, farmers have mainly relied on use of chemical fertilizers and pesticides. It was and is believed that to feed the ever-increasing human population it is imperative to use chemicals in agriculture so as to enhance the yields and protect the crops against pests and pathogens. Moreover, introduction of transgenic crops through genetic modification were also implemented during the same period when chemicals were being unwisely introduced in the fields i.e. during the era of green revolution (1950s and 1960s), which undoubtedly increased the production rate but at the cost of losing sustainability of environment in form of genetic erosion of indigenous varieties of crops and loss of fertile land. Excessive use of chemicals in agro-sector has also led to deleterious environmental problems like pollution of soil, air and water, soil salinity, development of pest resistance, loss of fertility of soil, and now is posing serious threats to food security, biodiversity and human health escalating the rate of greenhouse gases (GHG) causing global warming and climate change.

To preclude these problems, it has become an indispensable need to administer such methods of farming which are ecologically compatible, holistic and are organic in nature. Sustainable approaches in agricultural sector are of utmost importance to improve the food security and nutrition problem around the globe. Agricultural sustainability can be achieved by utilization and implementation of techniques of farming which would increase production of crops to meet demands of growing population while at the same time it would conserve and protect environment and its natural sources. While the food production at global level has been satisfactory in the last 50 years, recent approaches in context to agricultural development have not been impressive in achieving food security and in ensuring sustainability of environment. Therefore farming practices need to upgrade towards the use of biological agents in order to maintain the sustainability of agriculture and hence the environment.

The Sustainable Development Goals Report (2018) by United Nations states that in order to achieve sustainability, uplifting of economic growth is necessary and is directly linked to achieve food security, improve nutrition and sustainable agriculture. To achieve the goals of food security and sustainability in agricultural sector, emphasis has to be made on the use of traditional biological methods amalgamating them with the recent innovations in biotechnology and bio-engineering. At present we know that biological alternatives are the only ways to save us from disaster in agriculture and lead to food security via sustainability. Sustainable agriculture techniques involving latest biotechnological tools and classic methods have to be the key focus of the environmental sustainability.

Prof. Ranjith Dissanayake
Chairman
Green Building Council of Sri Lanka

Editorial

TRANSITIONING TO A SUSTAINABLE AGRICULTURE

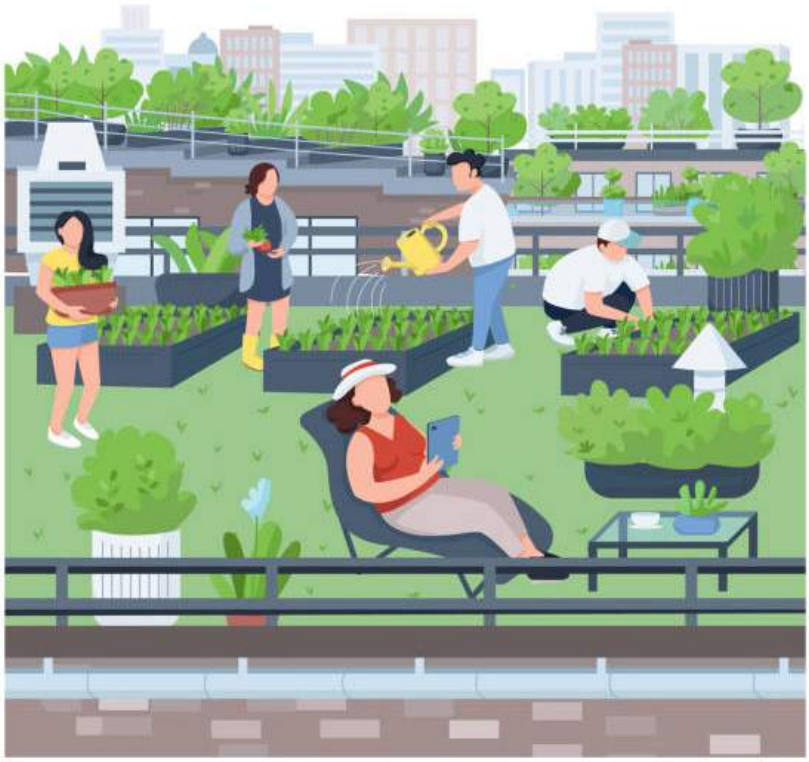
In the face of rapidly advancing climate change, biodiversity loss, and water scarcity, it is clear that global agriculture must swiftly and decisively shift toward sustainability. This system, with its reliance on monoculture, mechanization, chemical pesticides and fertilizers, biotechnology, and government subsidies, has made food abundant and affordable. However, the ecological and social price have been disastrous by causing erosion, depleted and contaminated soil and water resources, loss of biodiversity, deforestation, labor abuses, and the decline of the family farms.

Impacts of climate change such as droughts, floods and heat waves are hitting the farmers hardly making a threat to both farmers' businesses and our food supply. The predominant industrial agriculture model has left farms even more vulnerable to climate impacts. But policies and tools that support farmers in adopting science-based sustainable practices can make agriculture more resilient and adaptable, ensuring that farmers and our food supply can withstand climate challenges. Sustainable agriculture works with nature, using practices such as integrated crop/livestock management to increase biodiversity and keep the farm ecosystem healthy. This greatly reduces the need for chemical inputs, leaving the farm more viable and productive for the long haul.

However, critics of sustainable agriculture claim, among other things, that its methods result in lower crop yields and higher land use. They add that a wholesale commitment to its practices will mean inevitable food shortages for a world population expected to exceed 8 billion by the year 2030. With increased efficiency of sustainably farmed lands, advocates hold that sustainably farmed lands may be as productive as conventionally farmed ones.

Darshani Madumali,
Editor, The Green Guardian

Home gardening for sustainable urban agriculture as an all-rounder smart strategy



At present, urban and peri-urban home gardens getting fragmented and altered due to the growing demand of increasing and agglomeration of the population. As a result, environment equilibrium in the urban and peri-urban areas have been changed. This situation creates many harmful impacts on the economic, social, cultural and environmental spears of nations. However, home gardens are recognized as a key component of the human-manage landscape which can help to mitigate most of the climate-related problems and is one of the best solutions to the emerging socio-economic and climate-induced risks. The Covid-19 pandemic has created 48 to 59 million people to become or remain poor in 2021 in South Asia. Sri Lanka is no exception. The nutrition status of people in response to poverty has been significantly affected. Before the pandemic poverty rate showed a decreasing trend, however, the malnutrition rates certainly not followed the pace of poverty reduction. Though food is widely available across Sri Lanka, access to nutritious food is limited due to various socio-economic constraints. MCCAL (the lowest cost diet that only meets the average energy requirement) analysis carried out by the HARTI for the year 2014 mentioned, certain nutrients appeared to be more difficult to obtain than others including iron and calcium. As a result, Sri Lanka experiences a high prevalence of anaemia among children and pregnant women. Colombo district has reported a higher number of anaemia patients. The Western Province recorded the highest MCNUT (the lowest cost diet that meets the average energy and the recommended nutrient requirements). The MCNUT and MCCAL in the Western Province increased by 14 per cent and 41 per cent in the Yala harvesting season compare to the Maha planting season. In Maha planting season 22 per cent of the households could not access a nutritious diet. This increased to 28 per cent in the Yala harvesting season. This indicates the inability of households to access sufficient nutritious food could be a key contributing factor to malnutrition in the country. Though, the availability of rice has increased over years but remains insufficient to meet the per capita requirement of the country. The food consumption pattern has shifted from staple food to processed foods. On the other hand, food commodity prices have increased over the last five years period and this has also resulted in reduced access to nutritious food. The most suitable crucial centre to minimize the risk of low nutrition and certify urban food security is the sustainable urban home garden. 66.1 per cent of domestic residents in the Colombo district are not engaged in home gardening. Overall, promoting home gardens has a direct link with sustainable development goals (SDG). Around eleven sustainable development goals can be fulfilled through the proper enhancement of urban home gardens.

Three key focused areas could be addressed in promoting home gardens. One of the outcomes was producing fresh food in proximity to the source city. Hence, less energy is used for transport, cooling, storage and packing and in turn, reduces the food miles and lead to a decrease in the number of emissions into the atmosphere. This can reduce the vulnerability of the urban/peri-urban poor and enhance their coping capacity to respond to emerging threats of climate change as well. Promoting home gardens has the potential to enable productive reuse of organic wastes which can reduce methane emissions from landfills and reduce energy use in the production of fertilizers. Increased use of organic fertilizer would also reduce the environmental problems associated with improper disposal of solid waste. Reusing wastewater in the urban areas and rainwater harvesting for the enhancement of micro-irrigation facilities would free the great demand for freshwater for higher-value uses, thereon, the emissions from wastewater treatment also are reduced.

Home gardens are managed in a proper way to reduce environmental pressure. Individual home gardens share common traits while practising within bio-cultural eco-zones and form a corridor between urban and peri-urban is a specific habitat, especially for pollinator species and several other environmentally important species. These open green spaces are multifunctional lands, so, act as 'productive and therapeutic parks' or achieve recreational and cultural land use and they work on reducing the heat island impact as well by providing shade and enhancing evapotranspiration along with capturing CO2 and dust particles.

Urban home gardening is one of the strategic plans to ensure food security. Therefore, urban home gardens can play a vital role not in providing enhanced food supply but also, in increasing the diversity of food to some extent. Their potential for food security, income and urban-peri-urban middle-income employment have widely been reported by the Food and Agriculture Organization, in Bangladesh, Sri Lanka, India, Indonesia as well as beyond Asia. The benefits of home gardens regarding the wet zone provide one of the broader outcomes, reducing the vulnerability of the urban poor and enhancing their coping capacity through reducing the incidence and impact of extreme weather events on the urban poor, enhancing access to nutritious food and diversifying food sources and thereby reducing the impacts of disturbances in food supply from rural areas or imports and increase in food prices and diversifying income opportunities; creation of green employment, a safety net in times of economic crisis along with enhancing community building acting as a source of innovation and learning.

In conclusion, the design of a 'green mosaic' plan, in which the preservation of all complementary forms of productive green land use in the home garden is therefore necessary. In this context urban home garden as an all-rounder smart strategy to enhance urban agriculture is a win-win approach.

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M.D.K.L. Gunathilaka
Doctoral Researcher
University of Colombo

Current and future trends in organic farming towards a circular economy

The municipal solid waste generated in megacities raises up every day due to the population growth and urbanization in the world. After the production of food at croplands and other places, a portion of this food will be left away during the transportation and consumption as OFMSW (Garcia-Garcia et al., 2017) and the other portion will be converted into animal and human feces. Currently, a major portion of this organic waste is landfilled without getting any use. Switching from this linear approach in waste management practices into the circular economy (Paes et al., 2019); is beneficial for nutrient recovery in sustainable agriculture as well as for the food industry as shown in Figure 1. Therefore, developing organic fertilizers which is suitable for different types of crops is essential for building up self-sustaining communities in the future.

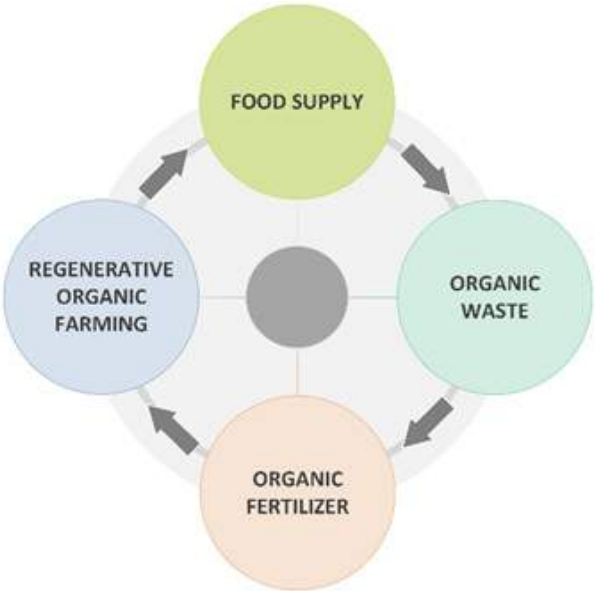

Figure 1: Circular system for nutrient recovery from organic matter

During the past few decades, chemical fertilizers had been extensively used for agricultural crop cultivation in Sri Lanka and all around the world. Because of the uncontrolled usage of these chemical fertilizers, severe socio-economic and environmental problems occurred on various occasions (NING et al., 2017).

At the same time, municipal solid waste is becoming a rising problem in the world due to improper waste management practices such as open dumping (Sharholy et al., 2008). To solve these two issues together, the physicochemical quality, suitability, and econometric demand of organic fertilizer for various crops should be evaluated separately to use as substitutions for the chemical fertilizers.

Resource recovery technologies such as composting and anaerobic digestion are well-established technologies in the world to convert organic waste into organic fertilizer (Samarasiri et al., 2021). Anaerobic digestion can be also used as an energy recovery technology, simultaneously (Samarasiri et al., 2017). However, these technologies are not widely practiced due to the technological knowledge gap in large-scale implementation. From the practical point of view, socio-economic and environmental feasibility studies should be considered before the implementation of these types of projects. However, it is a proven fact that these two technologies are far better than conventional waste management technologies such as open dumping and incineration. Therefore, it is essential to focus on these technologies more to build up this circular system for food security.

Regenerative organic farming is a novel area that not only focuses on applying organic fertilizers (Heckman, 2006); but also focuses on minimizing soil disturbance, maximizing plant and microbial biodiversity, incorporating year-round cover crops to sustain a living root, and incorporating grazing livestock. Sri Lankan traditional agricultural system is quite a role model for this regenerative organic farming and resource recovery. Therefore, it is our responsibility to find novel solutions by research and development, as well as practical implementation to fulfill the demands of present and future generations.

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B.K.T. Samarasiri
Department of Chemical Engineering, Lakehead University, Canada

Organic farming is a type of agriculture that use environmentally friendly pesticides and biological fertilizers produced primarily from animal and plant wastes, as well as nitrogen-fixing cover crops. Modern organic farming was created in response to the environmental damage caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture, and it provides a number of environmental advantages. Organic farming is a process that entails growing plants and raising animals in a natural environment. To preserve soil fertility and ecological balance while reducing pollution and waste, this approach employs organic resources while avoiding synthetic compounds. To put it another way, organic farming is a type of farming that entails growing and caring for crops without the use of synthetic fertilizers and pesticides. There are also no genetically modified creatures allowed. Crop rotation, green manure, organic waste, biological pest control, mineral and rock additives are all examples of ecologically balanced agriculture practices. Pesticides and fertilizers are used in organic farming if they are considered natural, and petrochemical fertilizers and pesticides are avoided.

There are numerous reasons for organic farming; the world's population is rapidly increasing, and feeding the world is becoming increasingly challenging. Food for all is in desperate need of sustainable cultivation and production. As dividends decline and returns become unsustainable, the Green Revolution and its chemical-based technology are losing favor. Other negative externalities generated by the usage of fossil fuel-based chemicals include pollution and climate change.

Protecting soil quality with organic material and encouraging biological activity, indirect provision of crop nutrients with soil microorganisms, nitrogen fixation in soils with legumes, weed and pest control using crop rotation, biological diversity, natural predators, organic manures, and appropriate chemical, thermal, and biological intervention, livestock rearing, taking care of housing, nutrition, and health, and rearing pigs are all examples of key features of organic farming.

The principle of health, the concept of fairness, the principle of ecological balance, and the principle of care are the four principles of organic farming. Organic agriculture must contribute to the health and well-being of soil, plants, animals, humans, and the environment, according to the principle of health. It is the preservation of one's mental, bodily, ecological, and social health. For example, it protects individuals from pollution and provides chemical-free, nutritious food. Fairness is visible in ensuring equity and justice of the shared planet among people and all living beings, according to the principle of fairness. Organic farming improves people's lives and helps to alleviate poverty. Natural resources must be used wisely and kept safe for future generations. Organic farming must be based on live ecological systems, according to the ecological balance concept. Organic farming methods must be compatible with natural ecological balances and cycles. Organic agriculture should be performed in a thoughtful and responsible manner to benefit current and future generations as well as the environment, according to the principle of care.

Organically farmed foods and agricultural products provide a lot of advantages. Organic foods are more nutrient-dense. Organic food is more richer in nutrients than conventionally grown food that has been grown for a longer period of time. The mineral and vitamin composition of a food item determines its nutritional value. Organic farming improves soil nutrients, which are then passed on to plants and animals. Chemicals are not present in organic foods. This is because, unlike their commercial competitors, organic farmers do not employ chemicals at any stage of the food-growing process.

Natural farming practices are used by organic farmers to ensure that humans and the environment are not harmed. These foods help to prevent diseases such as cancer and diabetes. Poisonous chemicals, insecticides, and weedicides are not used in organic farming. According to studies, a considerable portion of the population exposed to hazardous compounds employed in conventional agriculture has developed ailments such as cancer. Because organic farming avoids harmful pollutants, the number of illnesses and disorders caused by them is reduced. Any product that wants to be classified as organic food has to go through a series of quality inspections and have the manufacturing process thoroughly reviewed. In international marketplaces, the same norm applies. Consumers will benefit greatly from this because they will be able to obtain genuine organic foods.

Quacks who aim to profit from the organic food label by delivering commercially made goods are weeded out by these quality tests and inquiries. Organic goods are thought to be more expensive than conventional ones. They are actually less expensive because they do not require the use of costly herbicides, insecticides, or weedicides. In fact, organic foods can be purchased directly from the source at very inexpensive prices. The taste of food also influences its quality. Organic food is frequently superior to other foods in terms of taste. Organically cultivated fruits and vegetables have more sugar, which gives them a richer flavor.

Brix analysis can be used to determine the quality of fruits and vegetables. Chemicals used on commercial farms seep into the soil and contaminate it, as well as surrounding water supplies. This phenomena has an impact on plant life, animals, and humans. Because organic farming avoids the use of these harsh chemicals, the environment is safeguarded. Organic plants have a cellular structure that is more metabolically and structurally sound than conventional crops. This allows organic food to be stored for longer periods of time. Organic farming is chosen because it combats pests and weeds without using hazardous chemicals, has fewer input costs for agriculture, and maintains ecological balance while fostering biological diversity and environmental protection.

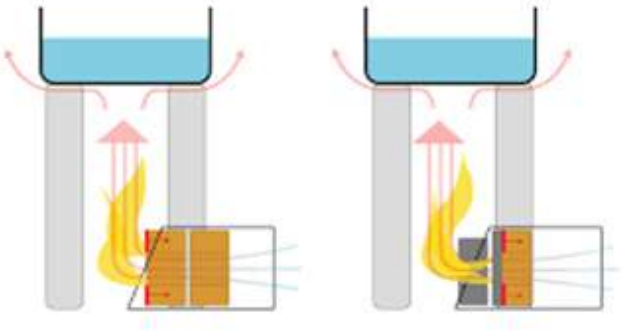
P.S.S.Pathirana
The student of Natural Resources department,
Sabaragamuwa University of Sri Lanka

BIO MASS BRIQUETTES FOR ENERGY CRISIS

In most Sri Lankan rural communities especially in mid country and the plantation community, forest resources are the predominant fuel source. The trees are felled, allowed to dry and the different parts of the dried plants are used as firewood. Another way that people use to generate heat and light is by converting wood to charcoal. Other plants, apart from trees, are also used as fuel sources. **The problem of felling trees for the purpose of using it as fuel** source is that it impacts adversely on the environment. One way of limiting the deforestation and protecting the environment is by using briquettes.

The common forms of briquettes are the coal and the biomass briquettes. Biomass briquettes originate from mostly agricultural residues which also includes the charcoal briquettes. By converting the agricultural residues to briquettes, a gamut of advantages is derivable. These include: Briquettes provide an easier way of getting energy supply for cooking and ironing of clothes as the briquettes can be transported easily than the agricultural residues. Briquettes provide cleaner emission than wood and other dried plants usually used for obtaining rural energy supply.

Biomass Briquettes



Fuel briquetting burning stove

Water weeds can affect negatively to the environment by impeding water flow and increase flooding and erosion, reducing water quality, creating health hazards, displacing natural vegetation and destroy aquatic life, preventing recreational activities, reducing fish habitat, blocking channels and irrigation equipment, preventing stock access to water. This water weeds can be processed into Biomass briquettes for cooking purposes. The briquetting of the water weeds were done using a manually operated briquetting machine. The cylindrical mould which serves as the compression chamber in the machine also serves as a burner unit for the produced biomass briquette, when it is detached from the main assembly. Although the use of the water weeds briquette took a longer time for cooking purpose when compared with the kerosene stove, an improved cooking time can be obtained when the water weeds briquette is aided with some saw dust. The water weeds biomass can serve as an alternative energy source.

Dumping of saw dust creates various environmental impacts especially in urban area. Commercial and industrial wastes, construction and demolition activities, pallets and packaging; and utilities are the main sources of urban wood wastes and finally, such materials take up a large amount of space in landfill sites and create the need for new waste disposal sites.

This water weeds and saw dust mixture can be processed into Biomass briquettes for cooking purposes. The briquetting of the water weeds were done using a manually operated briquetting machine. The cylindrical mould which serves as the compression chamber in the machine also serves as a burner unit for the produced biomass briquette, when it is detached from the main assembly.

The raw material for making briquettes are sourced from materials that would have been chunked, and as such it converts waste to energy ,Briquettes can be used in stoves and boilers Briquetting increases strength, density, heat emitted per volume of the biomass.

Eng. Anusha Lanai Ediriweera

BEYOND FOOD: URBAN AGRICULTURE TO COMBAT URBAN HEAT ISLAND EFFECT

Rapid urbanization in developing countries has been accompanied by an increase in urban poverty and food insecurity. According to estimates from the Food and Agriculture Organization, this phenomenon will worsen, with global food demand increasing by 70% by 2050 to feed the world's population. Although it is not a cure-all, urban agriculture has the potential to provide millions of people with a certain level of food security. As a result, urban agriculture, defined as the production of crop and livestock goods primarily in response to daily consumer demand within a city's boundaries, employing intensive production methods that use and re-use natural resources and urban waste, is gaining popularity as a means of addressing urban food security issues (Zezza, A. and Tasciotti, L, 2010). While the world is rapidly urbanizing and the concept of sustainable cities is becoming more relevant, Sri Lanka, in particular, is also witnessing the beginning of urban agriculture, with several initiatives in urban and peri-urban areas, which has evolved from an informal activity into a more commercial one.

Given that cities currently house 54% of the world's population, urban agriculture is an excellent means of achieving the Sustainable Development Goals (SDGs). Innovative methods of urban agriculture promote improved access to healthy food and better nutrition habits, improve the quality of urban environments, thus improving the quality of life of its inhabitants, and reduce the carbon footprint through shorter supply chains and more efficient use of resources and spaces. In addition to these myriad environmental, social, and economic benefits, urban agricultural interventions have been shown to provide climatic benefits as a heat mitigation strategy at the neighborhood scale.

In its most basic form, an Urban Heat Island (UHI) is an urban area that is significantly warmer than the surrounding rural areas (American Meteorological Society, 2000). This rise in local ambient temperatures in cities is caused by changes in urban morphology such as impervious areas, building height to street width ratios, construction materials, and most importantly, anthropogenic heat flux. The UHI effect is exacerbated in areas where climate change raises mean and peak temperatures, causing discomfort and higher levels of energy consumption for cooling, with additional air pollution and related health issues as side effects (Shahmohamadi et al., 2011; Taha et al., 1988).

Furthermore, as most cities house large populations of low-income people who frequently lack access to air conditioning or adequate healthcare facilities, urban centers are especially vulnerable to the threats of extreme heat events and heat waves – the next likely global disaster after Covid 19. As the world's urban population exceeds 54% of the total population and continues to grow, the number of vulnerable people will continue to increase as well (US Department of Economic and Social Affairs, 2014). Given the significance of these effects on human well-being, there is a growing awareness of the phenomenon of urban heat islands, with an emphasis on developing local strategies to tackle its impact. Several climatological studies have discovered that urban agricultural interventions can significantly lower the urban heat island effect and the need for energy-intensive air-conditioning and ventilation during the growing season. Urban agriculture increases the vegetation cover in and around cities, altering the surface parameters and providing a cooling mechanism through increased evapotranspiration.

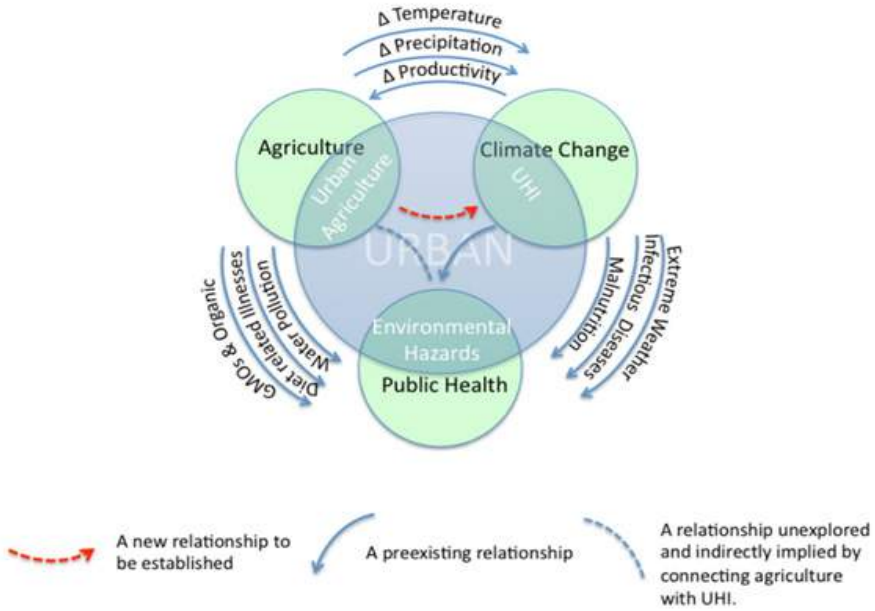


Figure 1: Conceptual Diagram - Relationships between urban agriculture, UHI, and public health in the urban sphere (Dana M. Habeeb, 2017).

According to research, agriculture implemented at the city scale reduces high nighttime temperatures in urban heat islands, which is a significant public health finding since nighttime temperatures are a better metric for capturing negative health effects from extreme heat than daytime temperatures (Dana M. Habeeb, 2017). An increase in agricultural land cover of 40,000m2 per 1km2 has been shown to reduce nighttime UHI temperatures by approximately 0.65°F at the neighborhood level (Dana M. Habeeb, 2017). As a nighttime cooling mechanism, agricultural lands outperform forested cover by a statistically greater margin. While urban agriculture continues to contribute to local temperature cooling, the magnitude of cooling decreases by up to 75% during extreme heat conditions (Dana M. Habeeb, 2017). In order to see nocturnal temperature decreases during heat waves, cities should ensure adequate agricultural vegetation cover in neighborhoods. In addition, when considered as a vegetative UHI mitigation strategy, urban agricultural interventions should be integrated with other climate adaptation strategies and considered for inclusion in local heat response plans for the maximum benefit. The effectiveness of vegetative strategies in UHIs is also influenced by urban morphology.

In conclusion, from a policy standpoint, urban agriculture would make cities more resilient, if envisioned as green infrastructure. Green Infrastructure is an integrative system that functions holistically and systematically in the urban environment by being optimally planned for in advance and in conjunction with other infrastructure systems. Similarly, urban agriculture should be an integrated system that allows other ecosystems to coexist with agriculture in order to maximize ecosystem benefits such as mitigating the urban heat island effect.

Asiri Lakshan Panditha
B.Arch (Hons.)University of Moratuwa

A TECHNO-ECONOMIC PATHWAY FOR SUSTAINABILITY IN THE AGRICULTURE SECTOR

Agriculture is a critical economic sector of Sri Lanka, employing 33.7% of the country's population and contributing to 8% of the GDP. Nearly 42% of Sri Lanka's land is devoted to agriculture [1]. Yet, agriculture's share in the SL economy has shown a declining trend, and Sri Lanka's 'Overarching Agricultural Policy' states that low returns/incomes on the land, labour and capital employed is a feature of the agriculture sector. The fact that only 7-8% of the GDP is earned through agricultural production even with such a high fraction of population is employed in this sector is a clear testimony to that effect [2].

Issues affecting the agricultural sector

Several challenges and shortcomings have been identified in the Sri Lankan agriculture sector. Food and Agriculture Organization of the United Nations (FAO) states that the Sri Lankan agriculture sector is currently suffering due to the following challenges among many others:

1. Subsistence farming and mostly part-time farming
2. Poor soil fertility management
3. Predominantly rain-fed agriculture and variability in rain (e.g. extended droughts, frequent floods) with climate change
4. High cost of production, low profitability, and hence low crop productivity
5. High post-harvest losses
6. Low level of mechanisation and technology adoption
7. Low levels of R&D
8. Low adoption of ICTs
9. High transaction cost
10. Lack of market-oriented production
11. Limited agro-based industries
12. Low level of value addition to primary products

The country has not adopted modern technologies and mechanised farming effectively, and instead relies on traditional agricultural methods [3]. The labour force available for agriculture is declining, and the labour productivity is also low [3]. Lack of relevant statistics and transparent information is also a striking feature in this sector. High quality data collection is not carried out, and there is no coordination between the relevant agencies [1]. Irrigation and water management face constant challenges due to competing needs created by sectors such as hydropower generation. Moreover, the issues affecting agricultural supply chains have become increasingly evident with the pandemic situation. Difficulties in matching supply with demand, excessive waste, and improper waste disposal are all a result of ineffective supply chains.

The environmental footprint of the agricultural sector is also high, due to impacts related to extensive use of water and fertiliser, and poor land utilisation. This is especially apparent when it comes to livestock-based agriculture. Emissions, a reflection of the energy consumption per kilogram of product, increases significantly when it comes to animal-based food items compared to crop-based food items. The water consumption intensity per kilogram is also much higher for animal-based food products compared to crop-based products. The water and emissions intensity of some common food products are listed below [4][5].

TABLE 1: EMISSIONS AND WATER INTENSITY OF DIFFERENT PRODUCTS

Food item	Water consumption (L/kg)	GHG emissions (kgCO2 eq/kg)
Beef	15,415	99.48
Pork	5,988	12.31
Chicken	4,325	9.87
Cheese	3,178	23.88
Rice	2,497	4.45
Bananas	790	0.86
Potatoes	287	0.46
Tomatoes	214	2.09

Technology integration

It is clear that technology has a major role to play in enhancing the performance of the agricultural sector from an economic perspective as well as in reducing its environmental and social impacts. Exploration and revival of traditional technological knowledge, adopting modern technology and adapting modern technologies for the local context are important to increase the yield and improve productivity in agriculture and related sectors. For example, studying traditional food processing technologies could reduce food waste, use of sensing and communication technology could lead to better crop management, and the development of greenhouses will lead to increase in the yield. The land use issue of agriculture, which especially plagues urban areas with high population density and farmland shortages, has been addressed in some countries via means such as vertical farming, with controlled environments and hydroponics being used for crop growth [6].

As elaborated in the Sri Lanka overarching agriculture policy, these multi-sectoral efforts will in turn reduce the utilisation of arable land and meet the requirement for reforestation that will ensure the preservation of the watershed area and thereby establish long-term sustainability of the nation [2]. At the same time, technology adoption and resulting increase of yield will reduce the labour requirement for agriculture and address the issue of the current sector-wide labour shortage. Most of all, the initiatives for increasing yield, reduction of waste, providing value for the end user, and ensuring sustainability will increase the contribution of the agriculture sector to the national GDP. For true economic sustainability, business models need to be investigated and developed to ensure that the expenditure on integrating modern technology is adequately recouped through the increase in production and reduced labour costs.

Life cycle thinking, circular economy, and further research

Life cycle thinking and circular economy principles can enhance the economic and environmental sustainability of this sector. By adopting life cycle thinking, the impacts associated with resource extraction, technology and material production, operations, and waste disposal activities related to the agricultural sector can be holistically assessed. Some initiatives that are expected to enhance sustainability can be counterproductive if not carefully managed. One such example comes from vertical farming, which is known to reduce water and land use, but usually with a very high energy intensity. This issue can be overcome by integrating renewable energy, for instance solar PV and battery storage, with this technology [6].

Circular economy principles can be used to ensure sustainability in agriculture using agricultural waste and residue as inputs for value generation. For example, crop residue and other wastes can be used in biomass energy generation, and a streamlined process for collection, transportation, and post-processing for energy generation needs to be established in order to create a sustainable model for waste-to-energy generation. Recycled agricultural waste can further be used as a resource for applications such as biodegradable packaging and household utensil development

Further research and development are critically needed in this domain within SL to fulfill the needs of this sector to ensure sustainability as well as nutrition and food security of the country's population. Development of new farming and irrigation technologies, low impact and organic fertilisers, post harvest technologies, inclusive supply chain models that benefit all stakeholders, certification processes, and transparent data sharing mechanisms are some initiatives that can support this sector. Impact assessment and mitigation efforts are also needed to cut down the water and emissions footprint of this sector to accomplish the status of zero hunger in a sustainable manner.

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Dr. Hirushie Karunathilake
Senior Lecturer
BSc Eng Hons (SL), PhD (Canada), AMIMechE, AMIESL
Department of Mechanical Engineering, University of Moratuwa

Dr. Himan Punchihewa
Senior Lecturer
BSc Eng Hons (SL), MSc (HK), PhD (UK), CEng, MIMechE, AMIESL
Department of Mechanical Engineering, University of Moratuwa

Study on the feasibility of rural and urban populations engaging in home gardening during the post-COVID period

Introduction

Home gardens hold a special place in Sri Lankan culture, as well as cultures all over the world. Sri Lanka, a tropical Indian Ocean island, has a climate that allows for crop cultivation all year. In Sri Lanka, home gardens account for 13% of the total land area. In today's world, the home garden serves as an additional source of nutritious food for the household. The home garden has a distinct role as a source of fresh produce, a place for families to gather, a cultural space to maintain one's roots, and an ecological role in the larger landscapes that these gardens are a part of.

In fact, COVID-19 is a serious illness with a high mortality rate. In any case, it is worthwhile to investigate how this unexpected and unwelcome phenomenon led to the development of home gardening in the context of the Sri Lankan COVID-19 facet. With the arrival of the second wave of COVID-19 in Sri Lanka and the country's closure, an increasing number of people turned to home gardening. Furthermore, the majority of low-income families were severely impacted by the situation, and the loss of their primary source of income caused them significant stress. Even middle- and upper-class people struggled to afford food due to barriers in the production and distribution processes. In the event of a pandemic, rushing to purchase food supplies raises concerns about safety. That is the importance of home gardening as a means of ensuring and enhancing family bonds, contributing to mental health, health safety, and overall well-being while creating green and healthy natural space. It is critical to highlight the initiatives taken by the Sri Lankan government in this regard. Recognizing the importance of home gardening for household food security, the government launched a program called Saubagya (meaning "prosperity") to promote a million home gardens through the Department of Agriculture.

Objectives

The main objective of this study is to assess the feasibility of urban and non-urban populations engaging in organic home gardening during the post-COVID period. Furthermore, it offers insights into how to shape urban, suburban, and rural areas in order to achieve Sustainable Development Goal 2 – Zero Hunger, as well as Sustainable Development Goal 11 – Sustainable Cities and Communities.

Materials and Methods

The objective of the study was to learn more about home gardening in Sri Lanka after the COVID era. As a result, the study's data collection used an online questionnaire survey with a convenience sample approach to reach the household respondents.

When looking at recent studies of similar investigations, such study methods appear to be deemed appropriate. An extensive review of home gardening literature was used to create the questionnaire. There were two sections to the questionnaire. The first section consisted of filtering questions to ensure that only Home Ganders answered. The remaining three sections focused on respondents' background information and household propensity to engage in post-COVID period home gardening and benefits, challenges, and suggestions to improve home gardening.

Results and Discussion

Of those sampled, 58.1% lived in rural areas, 35.5% in semi-urban areas and 2.65% in urban areas. There were between 3 and 8 members in almost every household as a whole. 57.1% of those families said they turned to home gardening before the corona epidemic. The remaining 42.9% turned to home gardening after the corona epidemic. 85% of them said they had a traditional rural home garden, and 2.47% of urban people said they had an urban home garden. A small percentage of 1.37% said they have a planned home garden. 89% of them use their garden, 8% their backyard, and 2.7% their concrete roof for home gardening. Most of them said that they use only about half a perch of land for home gardening.

Most said they spend between Rs. 250 and Rs. 500 a month on home gardening. But 60.13% said it costs them between 250 and 300 rupees a day to buy vegetables, fruits, and herbs. Furthermore, 12.9% said they spend more than Rs. 1000 per day on vegetables, fruits, and herbs. 53.6% said they use organic fertilizer for home gardening. But 46.4% said they use a mixture of chemical fertilizers and organic fertilizers. Here, 96.3% said that they would be used as fertilizer for the kitchen waste. But most of them said that, due to a lack of proper awareness, the kitchen waste would not be processed under a specific method but would be added directly to the cultivation. Many people say that they choose the crop that has the least problems controlling weeds, diseases, and pests in their garden. However, because home gardening does not use chemical pesticides, insect damage appears to be a threat. Protected net houses and traditional kem remedies would be effective in such cases. And also, plastic bottles, polythene bags, and gutters have been used to grow plants, as shown in Figure 1, directing waste management towards reuse. 55.6% said that gardening contributes 100% to their family's food security. 11% said it would not help in any way, and 48% said that about half of home gardens help with food security.

22.2% of home gardeners claim to make money by selling their excess produce. According to them, the amount varies between Rs. 1500 and Rs. 5000. The main problems they face in gardening are pest control, lack of knowledge, difficulty in controlling diseases, fertilizer preparation, and lack of land, water scarcity, and fungal infections. In addition, they said that it was not possible to procure essential fertilizers in recent times.

Figure 1 Use plastic bottles, polythene bags, and gutters have been used to grow plants.

Conclusion

According to this study, rural people began home gardening before the pandemic, but urban and suburban people began home gardening only after the Corona epidemic, according to this study. The study recommends that providing the necessary knowledge and guidance for home gardening by a public or private institution will be a valuable factor in the country's daily food security.

J.M.S.S. Jayawardhana
Department of Environmental Management,
Faculty of Social Sciences and Humanities,
Rajarata University of Sri Lanka,

The Island nation Sri Lanka which is rich in natural minerals is famously known as, “pearl in the ocean”. Surrounded by the sea and centered with, paddy, tea and coconut plantations all over the island. Staple food of Sri Lanka being rice, the island was flown with paddy fields.

Sri Lanka used to be a major exporter of paddy to support the world food demand. During that time, natural minerals and organic fertilizer were fed into paddy fields, which blossomed into a healthy yield of crop. Later with the industrial revolution, to satisfy the demand and supply for food crops. Chemically induced minerals, chemical fertilizer, pesticides were introduced to farmers. Forgetting the roots of traditional organic cultivation, chemical fertilizer usage has outgrown a massive pest in farmer’s mind. Leading to believe a fallacy that higher the chemical fertilizer used better the yield output be.

True, Chemical fertilizer induced into a crop as per the recommended standard usage, could stimulate the plant to bear more yield. But, utilizing chemical fertilizer more than the standard recommended by the Agriculture Department, is unhealthy for crops and toxic for living beings. The unaware farmer longs for more and more chemical fertilizer, with the hopes of gaining more and more yield output. Hence, is reluctant to satisfy only with the standard fertilizer presented, as a subsidy by the government to them. This has created a mania in the unaware, uneducated, stubborn and in the innocent farmers mind, which we call the chemical mania.

Chemical mania has pushed farmers to buy chemical fertilizer at any cost. Even after, receiving the standard quantity of chemical fertilizer as a subsidy. Drawing money from savings, appealing for loans from banks, pleading borrowings from neighbors, leasing property and jewelry for cash. All modes of obtaining cash go into buying additional chemical fertilizer from private bodies. All efforts rely on the hopes of being able to pay back after, the expected bloom of massive yield quantities from this cultivating season. The growing hopes thrash when the expectation hits with reality of limited yield output. Yield obtained after the season seems not enough to cover the cash liability bills.

This growing pain and burden of settling the costs has now grown as anxiety, leading to stress and depression. Finally leading to think that the only way out is by taking his/her own life. Further, the over used chemicals have being settled in the soils of the fields. The excess has been absorbed by plants and is deposited in the plant and crop. Some of the excesses have been mixed into water bodies resulting in eutrophication. Animals and humans depending on these water bodies, plant and crops for survival have resulted in poisoning. Causing long term health hazards or even death.

To mark and end to this chemical mania, in 2020 a research study was conducted in Sri Lanka. Gathering information from past research material, from interviews with agriculture and health experts and, from farmers and also by through a controlled experiment. Where one acre was controlled, and the other acre was non-controlled. The chemical mania falls fallacy, of higher the chemical fertilizer the better the yield was proven false (H0). It was statistically proved and from hands on results validated. That, using chemical fertilizer as per the standard only and not more could and, will ripe higher yield output (H1). Hence, concluded that chemical fertilizer is a useful component if used in right quantity as per the recommended standard.

Further for a Sustainable Long Term Run, which is still under experimental research. But proven with previous facts that, there is potential for gradually decreasing chemical fertilizer quantity we could achieve zero chemical fertilizer usage. Thereby ultimately reaching the point of only organic fertilizer in paddy crops, and further providing potential for hydroponics farming could lead for a better tomorrow.

Ms. Supéshala Colombathanthri
SLIIT Business School | SLIIT

Prof.Nagalingam Nagendrakumar
SLIIT Business School | SLIIT


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