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Innovation and Sustainability through Urban Agroforestry and Houseyard Garden

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ABSTRACT

Now-a-days urban ecosystems are experiencing many environmental, societal and economical challenges. The expansion of urban area leads to the deforestation, hazardous environment, poverty and insecurity of food and other natural resources. In the last few decades urban areas have experienced a tremendous change. Many innovative ways are also emerged out to remediate the negative impact of urbanization. House yard gardening and agroforestry practices in urban areas can alleviate the negative impact on earth ecosystem caused by rapid urbanization. Agroforestry can combat climate change, sustains economic, social and environmental benefits for the urban people and also important for carbon sequestration of urban area. Houseyard garden is an integrated system which comprises different things in its small area that produces a variety of foods and agricultural products. Upscalling agroforestry and houseyard gardening with a number of ecofriendly components like vegetables, spices, medicinal plants, mushrooms etc. ensured food security as well as livelihood of urban people. In some countries urban agroforestry and houseyard gardening offered environmental, social and economic benefits to human beings of urban areas. These practices also support the conservation of plants and allied organisms. The adoption of agroforestry and houseyard gardening policy by the people of urban areas can remove all these challenges resulted from rapid urbanization. Houseyard garden and agroforestry has risen to prominence as a land-use strategy to address global climate change and provide other environmental, economic and social benefits. Innovation and improvisation on such innovative approaches are of particular importance because any part of urban agriculture including urban agroforestry and urban houseyard gardening is adapted to specific urban challenges and opportunities.

Keywords: *Urban area, Ecosystem, Agroforestry, Houseyard garden, Innovation, Sustainable development etc.*

Introduction

In general context urbanization is regarded as one of the index of development. Urbanization can be simply defined as the process in which an area undergoes through temporal, spatial and sectoral changes in the demographic, economical, technological and environmental aspects of life in a given society (Narayan, 2014). In the developed world, urbanization amplify many global threats like resource shortage, climate change, unhygienic environment, congestion and poverty. Urban areas occupy only 4% of global land which is resided by almost 53.4% people (Anon, 2014; Endreny, 2018). Day by day the urban areas as well as urban population are increasing rapidly and impart a great pressure on ecological balance of the earth. Population growth and rapid urbanization goes hand in hand with hazardous environment, poverty and insecurity of resources like food, fuels etc.

Rapid expansion of urban area throws many challenges to the existence of earth ecosystem. The urbanization process brings indeed a wide range of unwanted consequences, which go from the reduction of fertile lands to deforestation, environmental pollution, improper drainage of the rainfall, and creation of peri-urban areas where socio-economic constraints are exalted and poverty is condensed (Baud 2000). In an increasingly urbanizing world, only innovation plays a critical role as a channel for safeguarding and promoting sustainable development.

Since few years innovation has been increasingly practiced by people of urban area to cope up with the situation. Among the innovative strategies for sustainable development of urban areas most common strategies are agroforestry and houseyard gardening. Urban agroforestry could serve as a progressive form of urban agriculture in which agricultural and horticultural crops are cultivated along with the tree. Houseyard garden or home garden is one of the time-tested local strategies of urban agriculture that are widely adopted and practiced in various circumstances by urban people. It provides food products from different types of crops (grains, root crops, vegetables, mushrooms, and fruits), animals (poultry, rabbits, goats, sheep, cattle, pigs, guinea pigs, fish, etc.) as well as non-food products (e.g. aromatic and medicinal herbs, ornamental plants, tree products). The chief purposes of houseyard gardening includes sustainable production, proper utilization of space and income generation, in addition to fulfill the environmental and ecological balance (Gariya *et al.,* 2016). Logistically, houseyard gardens and agroforestry provide easy day-to-day access to fresh vegetables and fruits, leading to enriched and balanced diets by supplementing various nutrients like proteins, vitamins, and minerals (Galhena *et al.,* 2013). In most of the urbanized parts of tropical and subtropical Eco zones, houseyard gardens are amalgamated with agroforestry. Innovative policy and sustainable use of the products of houseyard garden and urban agroforestry can improve environmental, social and economic development of urban areas directly or indirectly. Innovations can be technical, involving new, improved or adapted products or services, or they can be more social or organizational and institutional, entailing new practices, or improvements in the strategy of entrepreneurs, farmers or organizations.

Urban area and its Problem:

Urban areas are complex systems with social, ecological, economic, and technical components interacting dynamically in space and time (Pickett *et al.,* 2001; McPhearson *et al.,* 2016). Urbanization is a gradual process by which more and more people migrate from rural area or countryside to an urban area such as cities, towns, and that leads to expansion and growth of cities and towns. Impacts of urbanization are mostly negative. Presently most of the urban areas are facing many serious problems-

(i) Environmental condition in urban area is very poor. If it is not planned properly, especially in developing countries like India. Urbanization directly transforms the local biophysical environment and changes the conditions for organisms living there, generating new selection pressures and adaptations (Mengistu and Alemayehu, 2017). Concentrated energy use leads to greater air pollution with significant impact on human health. Automobile exhaust, large volumes of uncollected waste, improper drainage system, high level of noise and other pollution also damage the ecological balance of urbanized areas. Research has shown that urban areas are typically warmer than their rural counterparts and is strong enough to cause major physical and mental health problems for the people of urban area (Lemonsu *et al.,* 2015; Ward *et al.,* 2016).

(ii) Overcrowding is a great problem of urban area. Overcrowding occurs when too many people accommodate into a little space. Unplanned urban growth causes strained infrastructure, growth of slums, environmental degradation, traffic problems and high living cost. Uncontrollable growth of urbanization is dangerous for physical health, mental health and sanity of many citizens. High population density, unemployment, poverty, cultural differences, loneliness and accommodation problems are some factors of mental stress intensification (Kalhor and Mahdisoltani 2015).

(iii) Urban expansion inevitably covers some agricultural land while hike in land values and land markets around cities often motivate the owners to selling it for constructions or using it for non-agricultural uses. Globally, urban land cover is projected to increase by 1.2 million square

kilometer by 2030, nearly tripling the urban area in 2000; this could result in considerable loss of habitats in key biodiversity regions of world including protected areas (Seto *et al.,* 2012).

(iv) Rapid urbanization exerts a strain on existing resources such as food, water, fuels and other ingredients of daily life.

(v) Urbanization-induced habitat loss and fragmentation leads to reduced populations of native plants as well as wildlife and decreased connectivity between vegetation patches (Marzluff and Ewing 2001; Williams *et al.,* 2005; Parsons *et al.,* 2019).

(vi) Poorly planned urban regions are more prone to daily threats such as air and water pollution and inadequate waste management, as well as acute threats such as droughts, floods, and storms.

To overcome the challenges, the path of intelligent and innovative sustainable urban development will drive the economic growth which is socially inclusive and environment friendly. World Commission on Environment and Development suggests these principles as essential features of a sustainable city: (a) Increasing economic and social opportunities for all citizens; (b) Decreasing energy contribution in urban growth trend; (c) Optimum usage of water, earth and other vital resources (Kalhor and Mahdisoltani 2015).

Agroforestry and Urban agroforestry:

Agroforestry has become an important topic in international political and scientific discourse, extensively propounded in most of the developing countries. Technically agroforestry refers the intentional integration of tree vegetation, with crops, herbs, shrubs and/or livestock simultaneously or sequentially on a land management unit (Brown *et al.,* 2018). This integration is intended to diversify production systems to create environmental, economic, and social benefits through complementary interactions between the system components (Leakey, 1996; Atangana *et al.,* 2014). Agroforestry refers the sustainable land use system that combines arable crops with tree crops and/ or livestock on the same land management unit, either spatially or temporally. Trees of urban agroforestry improve air, water and land resources, provide habitats for wildlife, control erosion, protect watersheds for urban water supply and can be an outlet for safe disposal of urban wastes. Agroforestry have tremendous potential to serve as a tool in combating climate change, protecting people and livelihoods, and creating a foundation for more sustainable economic and social development. Trees have probably been a part of cities and peri-urban areas since their first development. Thus most of the urban agroforestry are characterized by presence and/or use of tree species and crops/livestock can be simultaneous or can be organized on a perennial basis.

Urban House yard Garden:

Houseyard Garden or Home gardens represent intimate, multi-story combinations of various perennial and annual crops, sometimes in association with domestic animals, around the homestead which serves as permanent or temporary (Kumar, 2017; Kumar and Tripathi, 2017). Houseyard garden is also known as mixed garden, backyard garden, kitchen garden, farmyard garden, compound or homestead gardens, family food production systems etc. Earlier it was considered as rural practice but presently it is a need of both rural and urban areas for food security and better environment. The most common crops grown by house yard gardeners are tomato, chilli, cucumber as well as some ornamental plants like- Ipomia, Marigold, Snake plant, Begonias, Pancy, Hyacinth, Bougenvilla *etc.* and some medicinal plants like- Aloevera, Gotu kola, Tulsi, Lavender *etc.* However type of cultivated plant in these gardens is totally depends on choice and need of owner. Area of garden, lay out, crops selected etc. depend on availability and nature of land and intension of family members. Though in rural area, land will not be a limiting factor and scientifically laid out garden can be established but in urban areas, land is a limiting factor and very often crops are raised in limited available area or in terraces of buildings or in pots, cemented bag *etc.* Species found in home gardens do not show a pre-determined spatial arrangement and the location of plants species are random and conveniently determined by the owner's needs (Bantihun, 2019). In urban areas, home gardens are part of a landscape mosaic and can play a significant role in pollination and ecosystem services which involve the remaining landscape, such as seed dispersal and pest control (Kearns *et al.,* 1998; Biesmeijer *et al.,* 2006). From the ecological point of view, home garden agroforestry are considered as sustainable systems of management, can house endangered species,

contributing to the conservation of native species and can serve as experimental and observation areas of recently acquired species (Fernandes and Nair 1986; Ninez 1987; Alcorn 1990; Blanckaert *et al.*, 2004; Kumar & Nair 2004; Aguilar-Stoen *et al.*, 2009). The trees and crops planted in a houseyard garden are usually carefully arranged to provide for specific functions and benefits, which are primarily economic in nature. A notable portion of the plants found in home gardens have some medicinal value and they can be used to treat many common health problems in a cost-effective manner. There is no specific management plan for the home garden agroforestry and most of the plants grown in homestead garden have multiple uses.

Innovative approaches of Agroforestry and House yard Garden in improvement of urban life and Urban Ecosystem:

Urban houseyard garden and urban agroforestry assume greater relevance in the context of innovation and sustainability. Both the practices deal with the cultivation of planned and intensively managed trees, crops, and livestock and known for sustainability and economic development of local community. Diversity and composition of houseyard garden and agroforestry differ from place to place. In comparison to rural areas houseyard garden and agroforestry is less complex in composition. Though both of the agroforestry and houseyard garden itself is an innovation of more conventional models of agriculture, which are situated in rural rather than urban areas, but in the urban context, the needs as well as the opportunities for innovation are high, leading to a higher intensity of technical or social innovation. From a sociological standpoint, an innovation is an idea, practice, or object that an individual perceives as new; however from an economic viewpoint, an innovation is a technological factor of production with perceived and/or objective uncertainties about its impact on production. There are countless innovative ways of these practices used for the betterment of urban life as well as earth ecosystem.

(a) Cultivation of plant without permanent use of land:

A big challenge for urban agroforestry is high pressure on the land and insecurity of land tenure in urban areas. Innovations encompass simple landless cultivation techniques, such as plantation in sacks, large drums, container etc. In addition free lands of urban institutions, clubs, hospitals, offices can be utilized for agroforestry and houseyard gardens. Due to shortage of free space for home yard gardening people can utilizes indoor space, roof garden, vertical gardening. Inorganic wastes such plastic bottles, tanks, containers, car tires *etc*. can be used for soilless cultivation of plants. Organic wastes of kitchen can be converted into fertilizer for such plants. Many successful programmes of agroforestry and houseyard garden have increased the food security of local residents.

(b) Labour saving Innovations:

Both agroforestry and house yard gardening are usually part time occupation of urban people. Thus many labor-saving innovations are adopted to reduce labour requirements. Cultivation of perennial variety of horticultural crops in home gardens needs reduce labour efforts. These systems are considered as diversity enhancing land use system especially in the context of inter-species diversity as it brings together crops, shrubs, trees and in some cases livestock on the same piece of land (Atta-Krah *et al.,* 2004). Thus there is no need to expense much labour for obtaining various types of resources. Use of some bio fertilizers like Plant Growth Promoting Rhizobacteria (PGPR), Plant Growth Promoting Fungi (PGPF), *Arbuscular Mycorrhizal* Fungi (AMF) also reduces the labour to some extent as these bio fertilizers enable the plant to cope up with environmental stresses such as heat, drought, low nitrogen etc.

(c) Vertical gardens on boundary wall between two lands:

Boundary wall is very common around any urban construction. It will be very effective for urban environment if the simple boundary wall can be replaced by pre-vegetated panels, vertical modules or planted blankets. Such vegetated wall surfaces are also known as green wall or living wall or bio walls (Timur and Karaca, 2013). Green walls can absorb heated gas in the air, lower both indoor and outdoor temperature, providing a healthier indoor air quality as well as a more beautiful space (Yeh 2012). Concrete neighborhoods interlaced with home garden agroforestry can also naturally detain and filter water which mitigates the risks global warming. Many edible and medicinal plants are naturally adapted to grow on concrete wall like *Amaranthus viridis* L., *Calotropis procera* (Aiton)

Dryand., *Alternanthera sessilis* (L.) R.Br. ex DC. *Eclipta prostrata* (L.), *Commelina benghalensis* L., *Coccinea cordifolia* (L.) Cogn., *Leucas aspera* L., *Cleome viscose* L., *Ocimum gratissimum* L., *Ocimum basilicum* L., *Oxalis corniculata* L.., *Momordica charantia* L., *Momordica cochinchinensis* (Lour.) Spreng, *Piper betle* L., *Piper longum* L. *etc.* (Singh 2011; Sarkar *et al.*, 2018; Mazumder and Sarkar, 2019; Sarkar and Dey 2021). Vertical gardens on boundary wall can bring diverse green infrastructure back into the urban system by providing vegetative structure and biodiversity for ecosystem functions and services across fragmented habitats and spatial scales.

(d) Production of edible and medicinal Mushroom in Housyard Garden and agroforestry:

Mushroom production can be meaningful to the extent that non-agricultural job and income opportunities for small family enterprises of urban area as they do not have adequate land to produce crops and raise animals. Intensive type of mushroom production in urban houseyard garden could provide good alternative income opportunities. The most cultivated edible mushroom worldwide is *Agaricus bisporus* (common mushroom) followed by *Lentinus edodes* (shiitake mushroom), *Pleurotus spp.* (in particular oyster mushroom), and *Flammulina velutipes* (enoki mushroom) etc. (Feeney *et al.*, 2014; Valverde *et al.*, 2015). In different research, urban people and home garden farmers identified and familiarized themselves with their preferred mushroom species which were used for food, medicines and other purposes. It is true of the mushroom growers that they focus solely on growing button mushrooms and far less on oyster mushrooms but the demand for these mushrooms in less than the demands for them, while the demands for medicinal mushrooms has increased exponentially over the past few decades. Thus cultivation of medicinal mushroom along with edible mushroom is profitable as well as sustainable.

(*e) Cultivation of biofuel producing Microalgae within house yard garden:*

Next to food, fuel is very essential for all countries. Globally one third rural population is dependent upon firewood to supply their energy needs. On the other hand urban people are completely dependent on fossil fuel. In future the ever-increasing population, depleting fossil fuel reservoir and need for alternative energy at competitive rates are going to be important issues. There is a need for further development in biomass-based fuels given the current dependence on liquid fuels for machineries and transportation. Algae, particularly microalgae, offer a new potential for biofuels that does not appear to have negative externalities like fossil fuel. The cultivation such micro-algae are one of the lucrative jobs which can create ample employment opportunities both in urban and semi-urban areas. Microalgae can be used to recover nutrients from various organic waste streams, like manure digestate, and can be used this way as a slow-release fertilizer. Through anaerobic digestion microalgae converts carbon compounds present in manure (or other organic feedstock's like sludge) into biogas (CH4) and produces thereby a digestate, which contains non-digestible fiber, nutrients and water (Mulbry *et al.*, 2006). Cultivation of microalgae in house yard garden can convert nutrients from refuges of plants in addition with the production of biofuel.

(f) Conservation of wild varieties of agricultural crops:

Houseyard garden can be act as ex-situ conservation for wild varieties of many agricultural crops. The conservation of wild varieties of crop plant has received considerably less attention than the conservation of hybrid varieties perhaps because wild varieties lack the popular appeal due to low yield. But conservation of such wild varieties is much more important to us as they retain some gene pool which expresses some good agronomic characters. There is a high demand of local varieties from the researches. Wild varieties can easily be conserved by regular cultivation in houseyard garden both in urban and rural areas. The combination of a well-designed, well-monitored, and well-managed system of urban houseyard garden can protect local extinction of the wild varieties from a city or peri-urban areas. Similarly many undescribed plant taxa, which cannot receive targeted protection, can be cultivated in urban agroforest.

(g) Cultivation of heavy metal scavenging plants in degraded land:

Urban agroforestry can help to improve soil quality, prevent soil erosion, minimize negative impact of drainage water and regulate

microclimate. Urban soils are usually compacted, have low levels of organic matter, altered soil moisture characteristics, and sometimes have heavy metals like lead, zinc etc. due to urban lifestyles and environmental processes (Beniston and Lal 2012). Agroforestry and houseyard garden with some specialized plants can improve such condition through a number mechanism like cover cropping, mulching, producing in raised beds, and changing subsurface drainage through piping. Some of the common plants are *Populus euphratica*, *Salicornia europaea*, *Medicago sativa*, *Atriplex lentiformis*, *Atriplex amnicola*, *Bassia indica*, *Chenopodium album*, *Clerodendron inerme*, *Cynodon dactylon*, *Glycyrrhiza glabra*, *Haloxylon recurvum*, *Helianthus annuus*, *Heliotropium curassavicum*, *Heliotropium eichwaldi*, *Ipomoea pes-caprae*, *Kalidium folium*, *Kosteletzkya virginica*, *Lactuca sativa*, *Leptochloa fusca*, *Lotus corniculatus*, *Medicago sativa etc.* (Devi *et al.,* 2008, Hamidov *et al.,* 2007; Ravindran *et al.,* 2007; He *et al.,* 2020).

(*h) Cultivation of plant and allied organisms for bio-monitoring*

Pollution has tended to cause anxiety among all living beings from small-sized microorganisms to big sized elephant (Pavlidis and Tsihrintzis, 2018). Bio-monitoring of such pollution is very essential in urban areas as there are many sources of pollution. The liquid runoffs from urbanized cities, industries, and agricultural fields contains highly noxious elements like long persisting heavy metals, poly-aromatic hydrocarbons (PAH), plastics and polymers, pesticides, chemical and reagents, atmospheric depositions, bio-aerosols, pollen grains, microorganisms, biodegradable residues, which creates serious environmental and health issues in the living beings (Nilsen *et al.,* 2019). Some plants and lichens are widely used in bio-monitoring studies as they provide cost effective tools for estimating spatial and temporal patterns of atmospheric contamination. The presence or absence of some specific plants or other vegetation provides ample information about environmental health. They indicate the level of pollutant either by overgrowth or extinction. Some of them can accumulate the pollutants from the atmosphere. Cultivation of such plants in urban home garden or urban agroforest can improve air. Several researchers reported that *Ficus benghalensis* L., *Ficus religiosa*, *Polyalthia longifolia*, *Ficus glomerata* (Roxb.), *Anthocephalus indicus*, *Mangifera indica*, *Cassia fistula* L., *Drypetes roxburghii*, *Terminalia arjuna*, *Psidium guajava* L., *Millingtonia hortensis*, and *Dalbergia sissoo* can be used for development of urban forests to reduce air pollution (Pandey *et al.,* 2015). Cultivation of some lichen communities on tree trunks also provides more information about the environment. Lichens play a key role in natural ecosystems, as they can function as primary producers, recycle minerals and fix nitrogen. Technically lichens are peculiar living organisms since they are mycobionts (fungi) living in symbiosis with one or even two photobionts, usually a green alga, but sometimes also a cyanobacterium, thus representing a unique association of two or sometimes three different kingdoms (Loppi, 2019). They react to ecological changes in any habitat and mild increase in environmental stress can be indicated by their disappearance. Bio-monitoring with lichens is based on the detection of changes in the community composition, in trace element content and in the physiological status, providing useful evidence for spatial and temporal trends in ambient pollution burdens (Loppi, 2014).

(i) Plantation of noise absorbing plants:

People of urban area regularly suffer from detrimental effects of noise pollution. It reduces the quality of urban environment and human health. Policy maker and urban planners currently implement several tactics in their work to combat noise pollution, utilizing trees and vegetation to absorb noise from all sorts of sources such as air and road traffic, construction, and trains. Some plants can reduce noise through reflection, refraction, absorption, interference, and diffraction (Zhiyi *et al.,* 2010).

(j) Beautification of Urban area and Promote Urban Tourism:

Agroforestry and Houseyard garden claim to support urban beautification and enhance urban tourism. Tourism is considered to be a factor that leads towards a management of all the resources in a way that economic, social, and aesthetic necessities can be satisfied. Tourism should also careful to preserve in the cultural integrity, essential ecologic processes, biological diversity and retaining systems of life. Systematic arrangements of some houseyard garden in a city or establishment of houseyard garden based green

space can offer new opportunities of development of ecotourism that should support conservation, keeping and improving the local economy. Such practices of urban agriculture also have high educational values by representing nature and natural processes in cities and towns, and they have often been used as testing and education areas for agroforestry nutrition, geography and other disciplines related to Biological Sciences. This can be converted in to an important place for socializing, where children learn cultural, ethical and social values from their elders.

Achievements of Urban Agroforestry and Houseyard Garden:

• Houseyard garden and urban agroforestry provides enormous direct economic benefits, an array of indirect essential services through natural ecosystems, and plays a prominent role in modulating ecosystem function and stability

• Urban houseyard gardening and urban social movements can build local ecological and social response capacity against major collapses in urban food supplies, helping to ensure food security in times of crisis (Barthel *et al.,* 2013)

• Urban agroforestry and houseyard gardening may also provide recreation and leisure opportunities that contribute to the quality of life

Challenges and opportunity of urban Agroforestry and Houseyard Garden:

At present, the transformation through the development, adoption and adaptation of agroforestry and houseyard garden are not widespread. Still there is very little systematic knowledge on the human–environment impacts of agroforestry practices and interventions.

• Recently, home garden agroforestry has been challenged by demographic, economic, technological, and social pressures (Habtamu and Zemede 2011).

• Vegetables grown on heavily contaminated urban soils can accumulate some contaminant like lead, but the accumulation is very limited and varies with plant species.

• Although home gardens are viewed as subsistence-low production systems, they can be structured to be more efficient commercial enterprises by growing high-value crops and animal husbandry (Torquebiau, 1992).

• The increasing urbanization of rural areas leads to a strong development of horticultural flora, which is the main source of alien and invasive plants. But the effects of horticultural flora on native plants and wildlife are not good for most cases (Marco *et al.,* 2008).

• Besides many potential benefits provided by urban farming, some potential negative impacts are also seen on ecosystem functioning and human health.

• Some researchers concluded that special attention needs to be paid to the location of urban agroforestry in relation to traffic roads and railroads, which have a negative impact on soil quality (Koroļova and Treija, 2018).

Conclusion

In many cases, sustainability can be a game changer as it can drive innovation by introducing new design or method that shape how basic resources like energy, carbon, water, food, materials and waste—are used in products and processes. In urban area now sustainability-driven innovation mostly goes with plant and allied organisms. House yard garden agroforestry in urban area is one of the monumental marks of the sustainable use of plants and plant based products. These can reduce household food expenses through food production, contribute low cost healthy nutrition, generate employment and more importantly conserve ecosystem and biodiversity. Investment on urban house yard garden agroforestry can improve the lifestyle and healthy environment in a sustainable manner. Proper implementation of these systems can optimize the biological, physical and ecological interaction of the different components. In total it helps to connect the livelihood income and conserved natural ecosystems by linking commercial cultivated species with conserving species diversity and genetic diversity. During pandemic crisis house yard garden agroforestry is critical to support vulnerable smallholder farmers and food workers as well as the entire food supply especially in for vulnerable urban areas. In order to achieve actual goal, the government has introduced several initiatives aimed at improving the livelihoods and healthy environment by addressing all aspects of house yard garden and urban agroforestry.

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