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Urban Agriculture: A Vertical Approach

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Abstract

"The power of population is indefinitely greater than the power in the earth to produce subsistence for man"[1].

This statement as given by Thomas Robert Malthus in the 18th century in 'An Essay on the Principle of Population', still holds true in this modern world. In the process of urbanization, most of the resources are exploited and the problem of providing food to everyone is soon to arise in the near future.

Agriculture is an intervention of man for his own existence. From hunters and gatherers to growers, the idea of settling down at a place started. The first established historical cities have been the consumers of the produce from the nearest countryside. With respect to the pressure on the habitable land due to urbanization.

Agriculture in urban areas is necessary as it provides primary benefits like food security and nutrition safety. Along with this, other benefits include a reduction in the food miles, reduction of the urban heat island effect, generation employment, waste management and many more. Conventional agriculture is in stress globally. There are farmer suicides across the globe in developed, emerging and nascent economies. Clearly, the sector is facing deep reforms to become 'an industry' much like the other components of the primary economic sector.

Urban Agriculture can be visualized as an industrialized system of food production. The idea has various benefits like more production in the same amount of land and can add to the breathing space as required by the city.

The paper discusses various advantages of practicing agriculture in urban areas. Further, the paper discloses various probable spatial solutions to implement urban agriculture so as to maximize the benefits to the citizens and to the environment.

Keywords: *Urbanization, Food Crisis, Urban Agriculture, Vertical Farming.*

1. INTRODUCTION

Urbanization is the process that includes demographic transition and expansion of the cities, thus giving rise to the need for spatial expansion and leading to encroachment on the rural land.

During expansion, most of the land is taken over, is agricultural. The title explains why a new approach is necessary. Understanding the population trends and the settlement patterns play a vital role in planning the land use and resources. Considering land as an important resource for spatial planning, allocation of land is a major challenge seen in the urban areas as the growth rate is high. This shows a threat to the agriculture and thus food that is produced.

The charts below show the population growth of India and the land under agriculture in India.

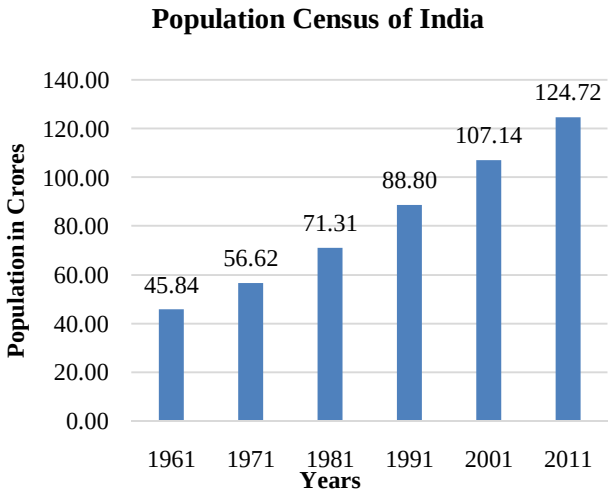

Figure 1 - Population, India

Source: Census of India 2011

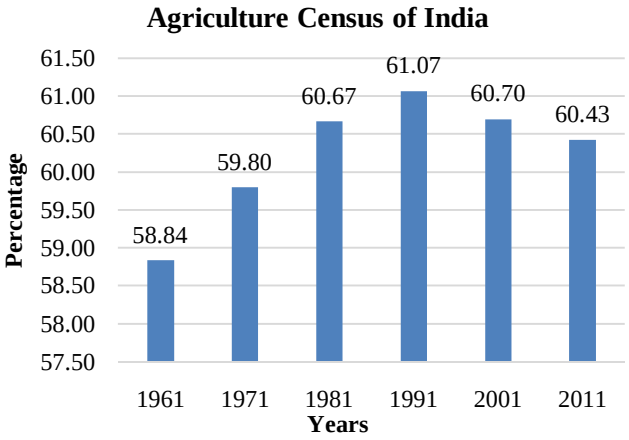

Figure 2 - Agricultural Land, India
Source: World Bank Report 2016

The charts show that the population of India is growing exponentially, whereas the land under agriculture is approximately 60% since independence, thus there is a need for the cities to grow their own food as most of the cities in the future will be built on agricultural land

2. URBAN AGRICULTURE

What is Urban Agriculture?

Urban Agriculture can be defined as the growing of plants and raising of animals within and around cities[2]. The most important feature of urban agriculture is that it is an integrated system in the urban economic and the urban ecological system. Urban Agriculture is the system embedded in the urban ecosystem. It includes the involvement of the urban residents and other resources wherever necessary. Urban Agriculture has a direct link with the urban consumers. It has the first-hand impact on the urban ecology, it is the part of the urban food system, competing for land with other urban functions and is influenced by urban policies, the politics and the development plans.

Urban Agriculture actually reflects the different stages of economic and social development. For the practice of agriculture in urban areas, the key motivators are food security, nutrition, revenue generation and availability of employment opportunities. In addition to the mentioned factors other factors like access to fresh food, reducing the carbon footprint and the food miles through agriculture can actually help us to improve the food safety.

Why is Urban Agriculture Necessary?

Most of the cities around the world are coping with problems like food scarcity, unemployment. They have so far failed to create sufficient employment for the urban poor. These cities are also facing a problem with the waste management, maintaining the water quality, etc.

Urban Agriculture, on the other hand, provides a comprehensive solution to all the problems faced by the cities. It provides a strategy to reduce the urban poverty, it can help to reduce food insecurity and enhancing it. Urban Agriculture also can help in reducing the cost of supplying and distributing the food, as it is imported from the place of production to the end consumer. The whole process of agriculture in urban areas include the reuse of the generated urban waste which in turn leads the greening of the city.

The contribution of Urban Agriculture to Urban Food Security and Nutrition

It is estimated that 96 percent of the additional 1.4 billion people in the developing world in 2030 will live in urban areas. [3].The cost of supplying and redistributing the food in the urban areas is increasing rapidly, this also includes the transportation costs, labor wages and operation,and maintenance of the whole system. Urban Agriculture may improve food intake and improve the food quality. Urban Agriculture compliments the rural agriculture and increases the efficiency of the food system.

Economic Impacts

Besides the cost of transportation Urban Agriculture actually enhances the micro-economy of the city. It stimulates the growth and a scope for the small-scale enterprises that can actually flourish. These small-scale enterprises can be related to processing, packaging, and marketing of outputs. These are not actually or directly related to urban agriculture but can also be associated with other activities like horticulture, bee-keeping or animal husbandry. There is a need to strengthen the linkages between various enterprise chains and the actual agriculture produce. The Urban Local Bodies can play an important role in stimulation of such enterprises and their development.

Social Impacts

Urban Agriculture can work as one of the strategies for the upliftment of urban poor. It has a high potential to involve people who are challenged, Orphans, unemployed and most importantly women, or even elderly people. The whole aim towards the participation of all the mentioned categories of people is to have a community participation and integrate these people who are often ignored in the urban network. It can also provide a sense of relaxation for the people who wish to voluntarily practice their own production. The urban farms can play an important role in creating recreation and thus engaging the citizens. The urban farms have potential to attract more people in the cities as agriculture is a rare phenomenon in the cities.

Environmental Impacts

Urban Agriculture can help in maintenance and recycle the urban waste that can solve problems of waste disposal. This reuse and recycling of waste can actually turn the urban waste into a productive and usable resource. Reuses like composting can help in less use of fertilizers and thus less land pollution. Making compost out of waste is also a viable option to generate employment. The recycling and reuse of urban waste-water in agriculture can involve a partial use in the case of urban agriculture. Urban Agriculture can also positively have an influence on greening the city forming micro-climatic and eco-sensitive zones.

If the population keeps on growing, it will soon be difficult to feed everyone in the country as the land available will be taken over by urbanization. The Solution to this is given by the Columbia University Professor Dr. Dickson Despommier. In his Book 'The Vertical Farm: Feeding the world in the 21st century, he says:

"With a growing world population and shrinking space for growing crops, some argue that cities of the future must generate their own food supply, elegant and simple answer for achieving this goal is Vertical Farming"[4]

3. VERTICAL FARMING

Definitions

Vertical Farming is one of the methods to practice Urban Agriculture. It is seen that the practice has evolved from time to time with the introduction of new technology and has helped many to gain the benefits out of it. There are numerous definitions of the term as given by the experts from time to time. Vertical Farm is any building that grows food inside of it or in which you grow food, which is taller than a single story[5]. Vertical farming is the practice of growing food and/or medicine in vertically stacked layers, vertically inclined surfaces and/or integrated into other structures. [6]

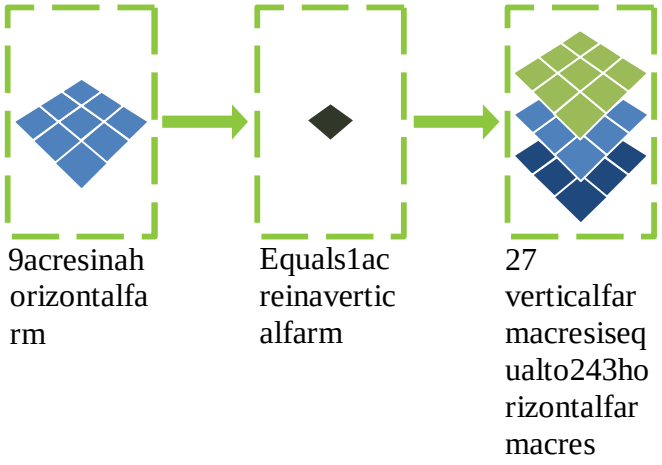

Figure 3 - Concept of Vertical Farms

Source: Vertical Farm Design Feasibility Study [7]

Timeline of Vertical Farming:

1909: The Vertical Homesteads (Skyscrapers as the utopian device for food production.

1915: The Vertical Farm (Term Coined by Gilbert Ellis Bailey in the book 'Vertical Farm'

1950: The Glass House (Documented by John Hix in his text 'The Glass House'

1951: Tower Hydroponics (An agricultural experiment in Armenia)

1964: Vienna Exhibition (Concept of Vertical Farm was exhibited)

1989: Communal Planting (Kenneth Yeang proposed plant cultivation in Sky-Scrapers)

1992: Vertical Farm Concept (Theoretical construct to deal with environmental issues)

Advantages of Vertical Farming:

Vertical Farming is a Self-Sustaining Food Method, as water and waste are recycled by the use of various soilless techniques. Protection of the yield from the weather, during production,and during transportation. Reduction in the carbon footprint per unit food, reduction in spoilage, during transportation and processing. From produce to plate in much lesser time and lesser costs, leading to more healthy, fresh and nutritious food. Year round production in a controlled environment, hence enhancing the food security.

Why Vertical Farms Fail?

Location (Distance from the Consumers) varies, and hence the cost incurred increases, ultimately to reach the as same cost of more than the traditional farm produce. Negligible Benefits to the Producers as compared to the efforts and the investment. Overestimation of the results and the returns from the produce. Use of outdated resources for production and processing, which leads to the delay in the production. High-Costs involved Operation, Monitoring, and Maintenance as the latest technology is not cheap, the cost incurred in manufacturing and installing the necessary equipment. It also involves training to the people involved, to use and handle the technology in the right manner.

What can Urban Planners do?

Reduce the Urban Food Security through improvements in Plans and Policies so as to contribute for sustainable development. Infrastructure facilitation for the benefit of people practicing through Land Use and Zoning Regulations. Increase the amount of land available for the processing and further procedures. Increase the amount of Green Space and the Land under agricultural utilization which was acquired during urbanization. The amount of land to be utilized for Urban Agriculture thus can be identified within the built environment and thus its utility and benefits can be calculated.

Utilization of Building Areas

The buildings can be classified into types to generalize the characteristics including the weight-bearing capacities. The buildings can be modified to uplift the current capacities. The total area of utilization can be determined based on the type of the activities and services that are mandatory.

The services like a fire escape, the area used for water storage tanks, photovoltaic usage and other technologies that consume the area. These areas can help in providing amenities like open spaces, indoor play areas and rooftop gardens that can help by supplying the food to the building. All the benefits can be achieved with minor modifications and have a considerable impact.

In the ideal situations, the refuge areas and the rooftops are most of the times left unused or used for storage. These areas can be identified and thus can provide the benefits to the

residents as mentioned above. The rooftop area is free unless used for the solar power by the residents. Thus this area has the potential to be used as an open rooftop garden and thus can provide other benefits like controlling the temperature of the buildings. The various other benefits social integrity and provision of fresh food.

The available rooftop area of any building can be determined by subtraction of the setbacks from the plot area. Yet a further detailed study is required as per the form of the building. The percentage of utilization of the rooftoparea with the plot size can be given by Equation

Equation 1 - Rooftop Utilization

$$\% = \frac{1 - [\,Plot - (\,Setback * 2\,)\,] * [\,Length - (\,Setback * 2\,)\,]}{(\,Width * Length\,)}$$

Source:Department of Housing and Urban Development[8]

The percentage thus derived has to be further subtracted from the area after the consideration of the setbacks, and thus arriving at the effective utilizable are on the rooftops.

4. THE STATEMENT OF RESEARCH

Vertical farming, to the world, is not a new concept. However, it is seen that only in few cases it was considered in the process of policy and spatial planning. Despite the contribution to food security, generation of employment and making communities sustainable, it seems very rare that it was incorporated in the spatial planning process. The study contributes to understand and integrate the land use planning and the process of vertical farming, its implications, and options to integrate the process in the planning and policy-making aims and objectives

Hypothesis:

The spatial land use and the management, if not modified can hamper the practice and growth of Vertical Farming, and thus hamper the livelihoods and cities will continue to consume the agricultural land. This will, in turn, affect the people by ongoing impacts of food security in future.

Objectives and Methodology:

Based on the Hypothesis mentioned above, the thesis has following main objectives that focus the study and the inferences from each will be used cumulatively for the proposal.

- Study Best Practices of Vertical Farming adopted on various land uses.
- To assess the potential to introduce Vertical Farming based on the land use pattern and existing policies in the selected study area.
- To identify the various factors affecting the successful implementation of Vertical Farming in the study area.
- Formulation of Policy that will help the practice of Vertical Farming in an economically feasible and technologically viable manner.

5. SCOPE AND LIMITATIONS

This study can be linked to schemes like NULM (National Urban Livelihood Mission) where the migrants from the encroached villages can be trained into new technology for Vertical farming and the allied processes and NMSA (National Mission for Sustainable Agriculture) which can help in making the whole process and sustainable. Modifications in the existing Control Regulations so as to allow the practice of vertical farming in the residential areas, thus allowing to introduce a new component in the Mixed Land Use category. This modification will allow the users to develop a sustainable model in terms of production, processing,and selling, also a new typology of buildings that produce food for the community and thus governing the urban form. The study also allows to explore the demand-supply chain and shorten it.

The paper explores various advantages and possibilities of Urban Agriculture, however for the operational purpose the other factors like land economics and urban management can be studied separately.

6. SITE SELECTION PARAMETERS

Practically, the concept of urban agriculture can be implemented anywhere with the help of residents and the institutions. The concept being relatively new the residents and the urban local bodies need an external guidance from the experts.

The parameters to select the area should be the socio-economic status of the residents, as they will have the major benefits in term of the food security at a micro level. The area should have a scope of development and urbanization, as the reason it gives an opportunity to introduce a new set of development control regulations which can help in better implementation.

7. TOOLS AND TECHNIQUES

Secondary and Primary Data Collection sources can be used for exploring various cases and achieve the objectives. Along with the Secondary Data, Literature supporting overview of the concept and theories of the research area, following tools and techniques can be used in support:

Documents Review:

Includes the documents regarding the different land use policies, regulations,and legislative framework.

Observations on site:

Use of eye observations and unstructured interviews with the farmers and vendors. Likewise, feedbacks on the change in the

existing land use can be recorded. In addition, photographs can be shot as a support to show the impacts of urbanization on the farmlands.

Mapping:

Development plans and Land use documents can be observed so as to map the temporal changes in the land utilization pattern

Interviews:

Interviews with the stakeholders and the local residents as a willingness survey to undertake the practice of vertical farming.

Quantitative Data Analysis:

The data might include numbers and percentages on the responses given by the interviewers. This can berepresented by various types of charts and graphs.

Stakeholders Analysis

The Stakeholders play an important role in the successful implementation of any policy. They have an important role in the policy formation. The stakeholders identified for the process of implementation of Urban Agriculture are the residents who will be participating in the actual process, various organizations and institutions that will play a key role in the policy formulation process and other departments like Fire and Safety department, water supply and agricultural department that will help in the related activities.

The involvement of all the stakeholders at the earliest stage in the process, with residents, organizations and other private companies in the process of preparation, implementation, and policy formulation stage in the related action plan to avoid further complications. One can arrive at the Multi-Stakeholder policy Formulation and Action Planning, for sustainable Urban Agriculture it is essential that multi-stakeholder approach is preferred as it involves a large variety of activities. These processes are considered to be extremely important elements of the implementation process.

Multi-Stakeholders Approach is facilitated by various cities and these can be characterized by the participation of a variety of the non-governmental organization s in the policy-making process. All the non-governmental organizations should be given an equal chance in the policy-making and formulation process. All the inputs and the opinions of the various stakeholders is considered to be equal and the policy to be formulated.

The main output of the Multi-Stakeholders Policy Analysis and Action Planning is the Joint Development of the city. The Multi-Stakeholder Analysis is based on the inferences from the meetings conducted with various stakeholders. The analysis leads to the classification in the following phases

Preparatory Activities

The preparatory activities start with the selection of the Urban Local Body and identification of the policy if present.

Situation Analysis

The analysis of the existing situation and the review of any other policies for adverse effects. The review of the various land use plans form the previous years

Institutional Commitment

The Institutional capacity and a broad Urban Agriculture framework and identification of various stakeholders and their influence on the implementation and the residents.

Operationalization

The actual stage of operation involves duties and support from each of the stakeholders at various stages in the process. It includes the support, motivation at various levels, responses and opinions at various stages of the policy formulation and positive role in the actual activity stage.

Implementation and Monitoring

After the start of the action stage, the implementation and the monitoring in terms of integration of the programs laid out by the urban local body and impact assessment and then revision so as to reduce the negative impacts on the society.

Power versus Interest Analysis

The stakeholders identified in the process to support the implementation process had specific interest to support the activities. The Power Interest analysis helps one to understand the capabilities and the power of the person against the interest to arrive at the possibility of any task getting done. The power and the Interest helps us to assign specific tasks to different people at different stages so as to have an efficient work influence over the designated process.

The Power Interest Analysis classifies the stakeholders in the categories like Subjects, Players, Crowd and Context Setters. The network of the clusters leads to the political influence in the association of the interests with the issues. The Players have both interest and power towards mitigating the issue. The Subjects are the ones with less or equal power and comparatively less interest as compared to the players. The Context Setters have less interest than the players but have more power than the crowd. And finally, the crowd is left with less interest and less power to any of the groups mentioned

The power versus the interest of the stakeholders can be illustrated as

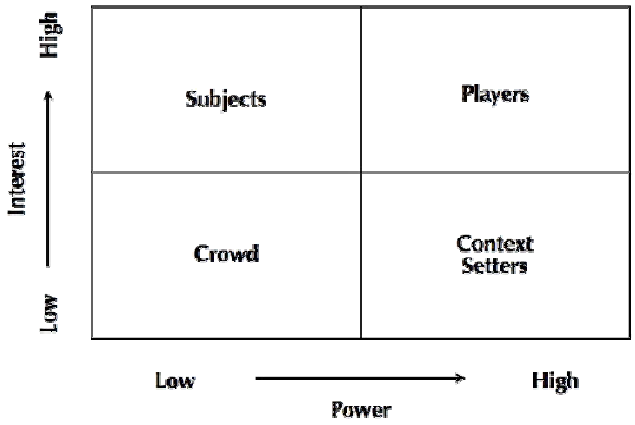

Figure 4 - Power versus Interest Matrix

Role of the Stakeholders

The operation of the concept depends on the facilitation mechanism so as to encourage the stakeholders in the process for maximum participation. The Stakeholders are assigned their role in the process as per their interest and the power.**Error! Reference source not found.**

8. EXPECTED OUTCOMES

Policy and Plans to encourage the practice of Vertical Farming through Incentives and Subsidies for the residents. Equipment can be provided at subsidized rates for the residents who are interested, and to encourage more participation people engaged in vertical farming can be given exemptions in terms of property tax and maintenance.

A return-generating model that will encourage the Stakeholders involved and the Urban Local Bodies to contribute for in the solution to reduce the problem of Food Security. Implementation Mechanisms for the availability advance technology and Infrastructure.

A land use plan to demarcate a space for food production in the Urban Land use. This can be done by adding a component of food production in the mixed land use, zoning that will be distinguished by the activities related to vertical farming including permission for the sales and productions.

Modifications the in existing Development Control Regulations so as to permit the food production and processing and the necessary changes in the urban form to support it. Emphasis will be on the soil and water management strategies. Guidelines for recycling of water and waste.

The planning and policy for vertical farming will cater to the urban form and will deal with specific new developments in the urban areas in the demarcated zones.

The proposed plans and policies can help the urban local bodies to solve the problem of food security and nutrition safety to a certain extent. It is utmost necessary for the people to understand the importance of food availability in the present and its assurance in the future. Policies should be beneficial to the whole community who can actually eat food that is grown in their backyard rather than edible polymer that was manufactured in any processing unit.

9. CONCLUSION

The proposed solution for implementation of the practice can be helpful with other benefits if facilitated with inducing the morale of self-realization. The practice will enable many of the urban poor to achieve a social status in the society. Therefore, it needs a facilitation at the institutional level and participation at an individual level. Both the things required are complimenting as a part of man's responsibility towards the environment.

Looking at the theoretical frameworks, it is suggested that these urban farms can be profitable and it can be predicted there are after effects of this practice in on the current food producing places. It is also predicted that, if the driving forces of any society are given a part of the policy and the process, the implementation will be better and smooth.

Urban Agriculture can support local food systems and can help to overcome the social inequality and cohesion. It is seen that the farms restructure the urban agriculture and the urban form around it. If the ways in which the Urban Local Bodies allocate the land and prioritize the development continue, the lack of urban greens and food security can be supported partly through this.

Way Forward

As seen in the previous studies all over the world, the farms are relatively new and not much in the trend, therefore are unexplored about various benefits that they offer. Looking at the population growth rate, it can be said that there is a need to integrate these farms in the city, and further it should be seen that how well these farms fit into the natural setting. However, it should also be studied that how the allocation of the land use for this type of farms is affecting the land use in the immediate vicinity. Moreover, it should be noted that there are too many advancements in the field of agriculture and the main objective is to maximize the productivity.

Along with the additional concerns above, it should be further researched upon what is the future of the traditional agriculture and the land associated with it? What are the impacts of the Urban Agriculture on the rural dynamics, how the concept should be implemented without hampering the urban-rural dynamics in the society? As one can see there is still more to be explored and time with technology will help to overcome the problem soon. This thesis, therefore, serves as a basic policy framework and possibilities that can help one to understand the feasibility of the idea and various possibilities and the need for the concept.

10. ACKNOWLEDGMENTS

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