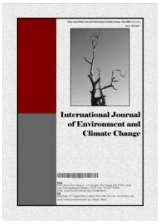

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Rooftop Gardening: Estimation of Income from a Score of Socio-Ecological Variables

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Authors' contributions

This work was carried out in collaboration among all authors. Author KM wrote the first draft of manuscript and managed the literature searches. Author SKA designed and guided the whole research study. Authors AP, MH and RC managed the statistical analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the relationship of total income was incurred from the rooftop gardening with various socio economic and behavioural aspects and elicit the future opportunity for this innovative method in this global warming situation where the world is facing the increasing crisis of availability of the land resources, support sustainability, contamination of ground water, food accessibility, and economic sustainability.
Study Design: The locale was selected by purposive sampling technique and the respondents following rooftop gardening had been interacted and was selected by the snowball sampling method.
Place and Duration of Study: The study was carried out during 2017 and 2018. The place, Janai Road of Srirampur, Khanakul-I and Khanakul-II block of Hooghly district, Budge Budge-II, Bishnupur-I and Bishnupur-II of South 24 Parganas and various areas in Kolkata were selected for the study.

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Methodology: In this present study 50 respondents following rooftop gardens have been interacted and are selected by the snowball sampling method. A semi-structured schedule has been administered to generate women information regarding family composition, the rationale for opting rooftop gardening, the ecological views on roof gardening, and the cost opportunity analysis. The gathered data had been put into multivariate analysis (Statistical Package for the Social Sciences V20.0 (SPSS) of IBM was used for analyzing the Coefficient of Correlation, Stepwise Regression and Path Analysis).
Results: Education (X_2), rooftop area (X_4), diversity of plants (X_6), labour charges (X_8), organic manure (X_{11}), fertilizer (X_{13}) variables have been found to exert strong and determining contribution to total income. Respondents revealed that it had provided a certain amount of income in addition to the conventional farming income.
Conclusion: The study had revealed that Rooftop gardening is not only eco-friendly horticulture but also a successful enterprise, having all the three critical echelons viz. economy, ecology, and equity as well.

Keywords: Climate change; eco-design; family labor; income; rooftop gardens; social ecology; wastage recycle.

1. INTRODUCTION

Roof gardening can also be defined as 'environment or nature in the sky'. It is an art and science of growing plants on the fallow spaces within, surrounding or adjacent to the roof of the residence. Other conventional areas of roof gardening include atrium, balcony and window boxes [1]. Across the world, the rooftop gardens are a common feature of the modern city. To reduce pollution and noise, the absorption of CO_2 emissions and controlling the urban heat, need to contribute to the biodiversity enhancement in the urban environment, meeting the scarcity of vacant land for cultivation. The idea of Rooftop Gardening is the only proven an effective measure being practiced and developing day by day throughout the globe. The concept of ecological citizenship uses the metaphor of "ecological footprint" [2]. Though the history and existence of rooftop gardening are very ancient, today rooftop gardening covers one in every ten buildings in Europe and America. One of the important advantage to have the rooftop gardening is that the women of the family can have a good opportunity to utilize their leisure period in one way and in other way they can keep generating some family income. Another advantage is that rooftop gardening being an elevated cultivation process, it will keep the microclimate cool and add the air buffer. Plants in rooftop gardens can help to mitigate climate change by sequestering carbon in the atmosphere, insulating buildings, and microclimate cooling. Green roofs also offer an opportunity to promote inner-city biodiversity on underutilized, empty roofs and to address food security issues through the production of food. Productive green roofs combine food production with ecological benefits, such as reduced rainwater run-off, temperature benefits such as potential reduction of heating and cooling requirements, biodiversity, improved aesthetic value, and air quality. Rooftop gardening can be placed on individual homes, institutional and office buildings and roofs of restaurants and serve either home consumption, use of fresh produce in restaurants or institutional kitchens or commercial production [3-10]. Overheating cities of due to the dense concentration of asphalt (including rooftop and pavements) and global warming that absorbs solar radiation. Rooftop gardening is undoubtedly is much more essential and viable method especially for the cities overcrowded. Today, successful income-generating rooftop horticulture experiences have been reported in a number of countries, including Senegal [11], Peru [12], Egypt [13], China and India [14]. In the face of urbanization & population explosion per capita availability of agricultural land has been squeezed to 0.8/ha due to unplanned construction of concrete jungles here and there throughout the globe as well as in India and West Bengal. The availability of per capita land in West Bengal again is the lowest in India, which is around 0.8 ha/family against a national average i.e.1.41 ha/family. Due to the scarcity of land and population explosion, people mostly like to utilize the land other than cultivation. To meet sufficient nutritious food a huge quantity of green vegetable in required to 3rd world countries like India where the average income of common people is so poor. In order to avail and cater to the high potential export market for vegetables, flowers, herbs, etc. Due to the concentration of people in urban areas needs transport for food production and supply. It is considered that urban

enforcement as a source of a possible organic and universal growing substrate using only local urban waste for a productive rooftop. A sufficient number of green roofs would result in an improvement in environmental conditions, contributing to a reducing pollution and cushioning the effects of climate warming [15]. Keeping ecology resilient and incubated the space management to a new elevation rooftop gardening is one of the viable options to mitigate all above crisis. The brunt of climate change can be reduced by creating or covering this space with greeneries and it will repress the induction of air conditioners and likewise it can stop the emissions of green house gases from usage of air conditioners [16]. This study was conducted for elucidating the operational and conceptual analogy with income generation vis-à-vis future prospects and the potential benefits of a rooftop garden. If rooftop gardening comes with a plethora of advantages like sustainable production, decreasing family monthly costs, improving the quality of air in roofs and providing healthy nutritious vegetables straight from roofs to plates, it certainly deserves some efforts.

2. METHODOLOGY

For analyzing and assessing the total income from the rooftop gardeners, a qualitative eight-step approach was chosen–

A. Identifying the locale of research for specific respondents who are actively engaged in rooftop gardening. For this Janai Road of Srirampur, Khanakul-I and Khanakul-II block of Hooghly district, Budge Budge-II, Bishnupur-I, and Bishnupur-II of South 24 Parganas and various areas in Kolkata were selected for the study. Those areas have been selected by the snowball sampling method.
B. Before taking up actual fieldwork a pilot study was conducted to understand the area, its people, institution, communication, and extension system and the knowledge, perception, and attitude of the people towards climate change and rooftop gardening concept.
C. After that in sampling design purposive as well as simple random sampling techniques were adopted for the study. For the selection of state, district, block, and gram panchayat purposive sampling techniques were adopted. In the case of selection of villages and respondents simple random sampling technique was taken up.
D. After reviewing various literature related to the field of study and consultation with the respected chairman of the Advisory Committee and other experts, a list of variables was prepared for the empirical measurement of the variables. Based on the selected variables, a schedule was formed.
E. Preparation of Interview Schedule.
F. Pre-testing of Interview Schedule: More than 40 in-depth interviews with pioneers in rooftop farming in these selected areas were conducted. The interviews addressed questions related to green rooftop gardening and climate resilience.
G. Techniques of Data Collection through snowball sampling method and questionnaire.Snowballing is a unique, non-probabilistic sampling method for identifying an apparently less known event or person. This is a cross-referencing method as well. Since the respondents of rooftop gardening are dwelling in a sparse and scattered distribution, this method works well.
H. Statistical Tools used for Analysis of Data: Statistical Package for the Social Sciences V20.0 (SPSS) of IBM was used for analyzing the Coefficient of Correlation, Stepwise Regression and Path Analysis.

Appropriate operationalization and measurement of the variables are helped the researcher to land upon the accurate conclusion. Therefore, the selected variables for this study are operationalized and measured in the following manner: (1) Independent variables and (2) Dependent Variables.

(1) Independent Variables:

- Age (X_1): It denotes the chronological age, years, and the months elapsed since the birth of the respondent. It was measured by counting the chronological age.
- Education (X_2): Education status of the respondents has been considered for the study and denoted by the real numbers (i.e. 1, 2, 3…etc.)
- Family size (X_3): No of family members of the respondents has been considered for the study and denoted by the real numbers (i.e. 1, 2, 3…etc.)
- Rooftop area (X_4): Area of the rooftop which was used for the gardening has been taken into consideration.

- Days of growth of rooftop plants (X_5): The total number of days required for growing the plants in the rooftop has been considered for the study.
- Diversity of plants (X_6): Diversify plant species growing into the rooftop has been considered for the study.
- Cost of cultivation (X_7): The overall cost of cultivation in terms of rupees has been taken into consideration.
- Labour charges (X_8): The charges of labour for cultivation in the rooftop garden has been taken into consideration.
- No. of labours (X_9): Number of labours engaged in the rooftop garden for management of the garden has been taken into consideration.
- Rooftop height (X_{10}): The height of the rooftop where the garden is established has been taken into consideration.
- Organic manure (X_{11}): The number of organic manures applied in the garden has been taken into consideration.
- Pesticide application (X_{12}): The number of pesticides applied in the garden has been taken into consideration.
- Fertilizer (X_{13}): The number of fertilizer applied in the garden has been taken into consideration.

(2) Dependent Variables:

- **Total income (Y):** Total income earned from the rooftop garden has been taken into consideration.

Fig. 1. Rooftop gardening in Hooghly, South 24 Parganas and Kolkata districts. Image no. 1,5 & 6 showing cultivation of various flowers and medicinal plants like Aloe vera, Tulasi, Basak etc. Image no. 2& 4 showing cultivation of different vegetables on rooftop only for home consumption. Image no.3 showing the involvement of family woman in rooftop gardening

3. RESULTS AND DISCUSSION

Food production and consumption in urban areas has become a global concern due to the brunt of climate change and global warming as well as increasing number of people living in and moving to urbanized living spaces, which challenges food security [17]. Another more obvious effect of urbanization is widespread habitat loss and fragmentation. With approximately 50% of the Earth's land area altered or controlled by human activity, the current species extinction rate significantly outpaces expectations [18]. A consequential and detailed discussion on the findings of the scientific research study has been presented in this research article. Data obtained from house owners through interview were measured, analyzed, tabulated and statistically treated according to the objectives of the study.

Coefficient of correlation between total income and 13 independent variables are represented in Table 1. It has been found that the following variables Education (X_2), Rooftop Area (X_4), Diversity of Plants (X_6), Labour Charges (X_8), Organic Manure (X_{11}) and Fertilizer (X_{13}) have been recorded positive and significant correlation with Total Income (Y).The results revealed that the respondent having higher education they have been more successful than others. Higher education leads people to more ecologically conscious and more concerned about the global warming and climate change. The respondents having more rooftop area, diversity of plants have been able to earn better income from the rooftop garden. Utilization of enough rooftop area in diversified plantation can reduce the economic risk. In other way, whenever the diversity of plants are more, the rooftop ecology will be more enriched and higher resilient. The associations of labour charges, application of organic manure and fertilizers applied have been in compliance with income changes in a positive direction.

Table 2 again has illustrated that the variances explore on Rooftop Area (X_4), Organic manure (X_{11}), No. of labours (X_9), Rooftop Height (X_{10}) has got the strong decisive effect on Total Income (Y). For rooftop gardening a minimum amount of rooftop area is necessary. So, strategically when rooftop areas are wider, the better diversity can be accommodated. The higher altitude of the rooftop also can create an ideal situation for making rooftop gardens a successful enterprise. As higher altitude for rooftop means more exposure to sunlight and air, safer distance from ground level contamination and more assured yield, both in qualitative and quantitative terms. Application of organic manure from regular domestic disposal, wastage recycling and intense involvement of family labour can increase the income systematically. The R^2 value being 58.40 per cent, it was significant to note that these four variables together have explained 58.40 per cent of the variance in the consequent variable Total Income (Y).

The Table 3 presents the path analysis and evinces that the variable organic manure has got the highest direct effect on Total Income (Y) from rooftop gardening. So, organic manure has both selective and decisive impact on income from rooftop gardening. It also defines that the variable, Diversity of Plants (X_6) has got a tremendous indirect effect on income from rooftop gardening. Organic manure is the basic input for rooftop gardening as it increases the plant health with more nutritive value. So, logically when organic manure is applied, quality of the product will be better and it will be more sustainable in an ecological set up. The residual effect being 31.90 per cent, It was to conclude that even with the combination of 13 exogenous variables around 32 per cent of the variance in the consequent variable could not be explained.

A positive significant relationship with their education regarding roof top garden with IPM in crop production and Rooftop Area have been found by Akhter [19], Mia [20] with Income of the respondent. Strong rooftops with diversified plant species would have the most potential for generating an economic return. As it depends upon a number of parameters (dimensions, drought resistance, pH, exposure etc.), the choice of plant species for a roof garden is very important [21]. It may take an experienced gardener or skilled labor to know which perennials plants will perform best in such a special environment. Low-maintenance plants are grown in a multi-layered lightweight system, which includes a root-repellent membrane to prevent plants from rooting in the roof, a drainage system and a growing medium that is lighter than the soil used on the ground [22]. Huge amount of kitchen wastes are generated through all urban populations, which degrades environment in absence of proper treatment and management. The roof-top technique of farming may be proved as very easiest and cheapest method to reduce the kitchen waste in the environment, because it utilizes this waste to produce beneficial substance as organic manure

and vermicomposting. Compost is a preferred source of an organic amendment for green roof substrates due to its high nutrient content, microbial populations and recycling value. However, nutrient use efficiency from these products is probably low for several reasons, including problems of nutrient leaching and non-plant available forms. The application of nutrients from compost teas may prove over several years to be a useful fertilizer delivery method since it may build green roof soils through increasing soil microbial populations and cation-exchange capacities of plant available nutrients [23,24], High and consistent fertility levels in the growing medium is required during the growing season to produce high yields for most vegetable crops, and a strategic fertilizer management plan is critical to match the requirements of specific vegetable crops grown, so that either under-or over-fertilization does not occur. Moreover, the

Table 1. Coefficient of correlation between total income (Y) and 13 independent variables (X_1-X_{13})

Sl. no.	Variables	R value	Remark
1	Age (X_1)	0.164	
2	Education (X_2)	0.456	**
3	Family size (X_3)	0.108	
4	Rooftop area (X_4)	0.614	**
5	Days of growth of rooftop plants (X_5)	0.019	
6	Diversity of plants (X_6)	0.304	*
7	Cost of cultivation (X_7)	0.170	
8	Labour charges (X_8)	0.460	**
9	No. of labours (X_9)	0.275	
10	Rooftop height (X_{10})	0.040	
11	Organic manure (X_{11})	0.522	**
12	Pesticide application (X_{12})	0.240	
13	Fertilizer (X_{13})	0.346	*

**Correlation is significant at the 0.05 level*
***Correlation is significant at the 0.01 level*

Table 2. Stepwise regression analysis of total income (Y) with 13 casual variables (X_1-X_{13})

Sl. no.		Unstandardized coefficients		Standardized coefficients	t	Sig.
1	Rooftop area (X_4)	22.890	4.960	0.513	4.615	0.000
2	Organic manure (X_{11})	2.928	0.800	0.391	3.661	0.001
3	No. of labours (X_9)	1713.775	627.711	0.267	2.730	0.009
4	Rooftop height (X_{10})	-271.838	119.917	-0.234	-2.267	0.028

Dependent Variable: Y_1
R^2: 58.40 per cent
Std. Error of the Estimate: 4253.049

Table 3. Path analysis of total income (Y) vs. 13 exogenous variables (X_1-X_{13})

Sl. no.	Variables	Total effect	Direct effect	Indirect effect	Highest indirect effects
1	Age (X_1)	0.164	0.040	0.124	0.040, X_1
2	Education (X_2)	0.073	0.224	0.029	0.224, X_2
3	Family size (X_3)	0.081	0.064	0.017	0.064, X_3
4	Rooftop area (X_4)	-0.072	0.353	-0.425	0.353, X_4
5	Days of growth of rooftop plants (X_5)	0.267	0.206	0.061	0.206, X_5
6	Diversity of plants (X_6)	0.662	0.131	0.531	0.131, X_6
7	Cost of cultivation (X_7)	0.172	-0.175	0.347	-0.175, X_7
8	Labour charges (X_8)	0.059	0.114	-0.055	0.114, X_8
9	No. of labours (X_9)	0.232	0.196	0.036	0.196, X_9
10	Rooftop height (X_{10})	-0.013	-0.202	0.189	-0.202, X_{10}
11	Organic manure (X_{11})	0.152	0.397	-0.245	0.397, X_{11}
12	Pesticide application (X_{12})	0.176	0.040	0.136	0.040, X_{12}
13	Fertilizer (X_{13})	0.053	0.057	-0.004	0.057, X_{13}

ability to recycle mineral nutrients is an essential part of fertility management systems to create optimal growing conditions for vegetable crops on rooftops [25].

4. CONCLUSION

Vertical farming is one of the significant innovations of the present time agricultural science and technology, to combat the brunt of global warming and at the same time to re-engineer the agricultural and horticultural production. In this direction, rooftop will act as good as a piece of land. So, the new perceptions stand the concept that rooftop is nothing but a converted land at the same time which is elevated. From the study, it is elicited that the variables like organic manure, durations of the rooftop gardening, rooftop areas, cost of cultivations and diversity of plants have decisively characterized the different dependent variables, and, another interesting thing is that women get finding it a pleasant and creative way of engaging themselves with the rooftop gardening and at the same time it is concluded that the approach and practice of rooftop gardening is gaining fast momentum especially in the sub-urban areas of Kolkata covering 24 Parganas South. The wider application and practice of rooftop gardening is certain to curb the brunt of global warming, and at the same time will be adding both economic and aesthetic values to our everyday life and living as well. Rooftop garden is basically a prop of a dwelling ecology. Application of agri-chemicals and pesticides will not only damage the crop plant also can affect those who are dwelling inside the home. Domestic disposal can be reused and toilet water can be recycled. In rooftop gardening most of the family members rather it can say women are more engaged in maintenance. When pesticide hazards will be there, women including the pregnant women may be exposed. So, this gardening is not only productive or economic but also safe in terms of health of family members including the laborers. In this critical pandemic situation, people need not have only sufficient food, but also the same with nutrition and immunity property. And the rooftop gardening can be the best destination for getting all these things together.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this paper.

ETHICAL APPROVAL

All experiments have been examined and approved by the appropriate ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sajjaduzzaman M, Koike MA, Muhammed N. An analytical study on cultural and financial aspects of roof gardening in Dhaka metropolitan city of Bangladesh. Int J Agri Biol. 2005;7:184-187.
2. Wackernagel M, Rees WE. Our ecological footprint: Reducing human impact on the earth. New Society Publishers, Philadelphia, PA, USA; 1996.
3. Hamm MW, Bellows AC. Community food security: Background and future directions. Journal of Nutrition Education and Behavior. 2003;35(1):37-43.
4. Bennett AF. Linkages in the landscape: The role of corridors and connectivity in wildlife conservation. Gland: International Union for Conservation of Nature and Natural Resources; 2003.
5. Miller JR. Biodiversity conservation and the extinction of experience. Trends in Ecology and Evolution. 2005;20:430-434.
6. Maas J. Green space, urbanity, and health: How strong is the relation? Journal of Epidemiology & Community Health. 2006;60(7):587–592.
7. Khandaker MSI. Rooftop gardening as a strategy of urban agriculture for food security: The case of Dhaka City, Bangladesh. Acta Horticulturae. 2004;643: 241–247.
8. Sanyé-Mengual E, Cerón-Palma I, Oliver-Solà J. Environmental analysis of the logistics of agricultural products from roof top greenhouses in Mediterranean urban areas. J Sci Food Agric. 2013;93:100–109.
9. Orsini F, Dubbeling M, de Zeeuw H, Gianquinto G. Rooftop urban agriculture. Cham, Switzerland: Springer International Publishing; 2017.
10. Dubbeling M, Massonneau E. Rooftop agriculture in a climate change perspective. Urban Agriculture Magazine. 2014;27:28-32.
11. Saydee G, Ujereh S. Rooftop gardening in Senegal. Urban Agr. Mag. 2002;7:16–17.

12. Mezzetti M, Orsini F, Fecondini M, Michelon N, Gianquinto G. Women and simplified hydroponics: Community gardening as a way of emancipation in Trujillo, Peru. Acta Horticulturae. 2010;881:169–172.
13. Gertel J, Samir S. Cairo: Urban agriculture and visions for a 'modern' city. In Growing Cities, Growing Food: Urban Agriculture on the Policy Agenda (Feldafing, Germany: Deutsche Stiftungfür Internationale Entwicklung (DSE), Zentralstellefür Ernährungund Landwirtschaft). 2000;209-234.
14. Doshi RT, Doshi S, Shah V. City farming – the natural alternative, experiences in India. Urban Agric. Mag. 2003;10:18-19.
15. Herrera-Gomez SS, Quevedo-Nolasco A, Pérez-Urrestarazu L. The role of green roofs in climate change mitigation. A case study in Seville (Spain). Building and Environment. 2017;123:575–584.
16. Wasim J, Nine AKMHJ. The effects of rooftop garden on energy consumption of an industrial building in Bangladesh. International Conference – Green Urbanism. 2016;1-9.
17. Samangooei M, Sassi P, Lack A. Soil-less systems vs. soil-based systems for cultivating edible plants on buildings in relation to the contribution towards sustainable cities. Future Food J. Food Agric. Soc. 2016;4:24–39.
18. Sushinsky JR, Rhodes JR, Possingham HP, Gill TK, Fuller RA. How should we grow cities to minimize their biodiversity impacts? Global Change Biology. 2013;19:401-410.
19. Akhter S. Comparison between knowledge and skill of women led FFS of RDRS and Non-FF farmers. M.S. (Ag. Ext. Ed). Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University; 2003.
20. Mia MAT. Adoption of Integrated pest management (IPM) practices by the vegetable growers of Magura District. M.S. Thesis, Department of Agricultural Extension & Information System, Sher-E-Bangla Agricultural University, Dhaka; 2005.
21. Sperry A. The best plants for rooftop gardens; 2010.
Available:http://voices.yahoo.com/the-best-plants-rooftop-gardens-6299814.html
(Accessed 13.05.2013)
22. Willem VC. Rooftop gardening a big step to the future. Conference Paper, First International Summit for Aforestation Roof Gardens in China; 2005.
23. Mather D. Compost utilization goes through the roof. Biocycle. 2006;47:37.
24. Adi AJ, Noor ZM. Waste recycling: Utilization of coffee grounds and kitchen waste in vermicomposting. Bioresour. Technol. 2009;100:1027–1030.
25. Whittinghill LJ, Rowe DB, Ngouajio M, Cregg BM. Evaluation of nutrient management and mulching strategies for vegetable production on an extensive green roof. Agroecol. Sustain. Food Syst. 2016;40:297–318.

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