

*Urban Agriculture Promotes Rooftop Farming  
Context of Food Security in Order to Encourage  
and Enhance Economic Value, One of the  
Smart City Bhubaneswar in India*

Kartik Chandra Sahu and Mahendra Kumar Satapathy

Research Journal of Agricultural Sciences  
An International Journal

P- ISSN: 0976-1675

E- ISSN: 2249-4538

Volume: 13

Issue: 04

*Res. Jr. of Agril. Sci. (2022) 13: 953–958*

 C A R A S



# Urban Agriculture Promotes Rooftop Farming Context of Food Security in Order to Encourage and Enhance Economic Value, One of the Smart City Bhubaneswar in India

Kartik Chandra Sahu\*<sup>1</sup> and Mahendra Kumar Satapathy<sup>2</sup>

Received: 07 May 2022 | Revised accepted: 30 Jun 2022 | Published online: 05 July 2022  
© CARAS (Centre for Advanced Research in Agricultural Sciences) 2022

## ABSTRACT

Population of cities suffers numerous problems out of them urban people meet to essential needs for natural foods. This study refers to urban agriculture promote rooftop farming for food security and economic balance. The proper utilization of rooftops for agricultural propose. Now a day's urban peoples are acquainted for the food problem and going to perceived rooftop garden which is very useful for resident of cities. The rooftop agriculture reduces accelerate economic and food security. The economic benefits from rooftop agriculture to use of building, obtained organic foods, environmental aspects, cooling effect of building, carbon concentration, rain and dew water management, recycling of used water on the rooftop agriculture is the new technology of water management. The recycling and production of bio-fertilizer (compost) from household garbage. Bio-fertilizer is used on rooftop agriculture. Rooftop gardens yield verities of vegetables, flowers, medicinal plants and ornamental plants which is very specious. It promotes the economic sustainability and save the excess expensive money (Cost saving plan). rooftop agriculture is perfect production of natural organic food from rooftop of buildings. The other foods are contaminated from market containing excess and uncontrolled use of pesticides and chemical fertilizers harm for the health. Organic based vegetable obtains from rooftop so we called it food of kitchen. Organic food reduces the diseases and save the money. Research method is carried out by survey and questioner method, the primary data collected by direct contact with the rooftop practitioners and stakeholders of Bhubaneswar city. The secondary data are collected from internet, virtual mode. Traditional production of compost. Temperature record. Monthly expenses of the gardeners, Vegetable grow in rooftop are the objective of this study. This study rooftop agriculture the economic value-added system and food security of the urban people. Bhubaneswar is the one of the advance cities in order of tremendous growth of rooftop agriculture. Large number of people perceived rooftop gardening in Bhubaneswar and promote food security and economical sustainability.

**Key words:** Urban agriculture, Container-garden, Organic food, Rooftop farming, Bio-fertilizer

Urban Farming (UF) produces vegetables on rooftop gardens. Almost all vegetable varieties are grown in Rooftop Gardens (RTGs). Rooftop gardens are small and have a diversity of vegetable gardens. The vegetable cultivation occurs in container and lane methods. Involvement of all the members of the family in the rooftop garden can provide fresh vegetables to the kitchen in the morning [1]. Organic fertilizer is used in Vegetable Garden (VG) to increase their nutritive value. Following opportunities of the rooftop vegetable gardens are described as used water management obtaining uncontaminated

chemical free vegetables. High production, land less cultivation. Labourless cultivation, leisure time engagement and entertainment, position in society and self-satisfaction, Conservation of plants, production and use of organic fertilizers (bio-compost, vermi-compost, coco peat) made from household garbage etc. [2]. High yielding vegetables gives us more production to full file our daily needs. Urban people are adopting rooftop vegetable garden in all city of world scenarios [3]. I have selected Bhubaneswar as a research area because of the large number of rooftop gardens present in the building of Bhubaneswar. The main objective of the study is implementation and perception of rooftop farming among urban people in urban area. Brinjal, cauliflower, Raphanus, ladyfinger, beans, pumpkins, tomato, cabbage, cucumber, bitter gourd, and leafy vegetables are chrysanthemum, spinach, amaranths, coriander, spice vegetables are onion, garlic, ginger, coriander, fennel, cumin, curry leaf, mint all are cultivated in rooftop garden [4]. Rooftop garden cultivated in a container called a container garden [5]. Different types of containers are

\* **Kartik Chandra Sahu**

✉ kartiksahu9909@gmail.com

<sup>1</sup> Department of Botany, Utkal University, Bhubaneswar - 751 022, Odisha, India

<sup>2</sup> Regional Institute of Education (NCERT), Bhubaneswar, Odisha, India

used for rooftop gardens such as polythene bags, plastic jars, grow bags, protocol, plastic drums, etc.

## MATERIALS AND METHODS

Bhubaneswar [20.270N 85.840 E] is a smart city in India's eastern state Odisha and also called as temple city. Rooftop garden smart farming is growing on the building is one of the interesting cultivations in Bhubaneswar. Bhubaneswar is a densely populated city of India. Its climate is temperate temperature about 27°- 42° Celsius and humidity about. Nowadays Bhubaneswar has large numbers of buildings. In landless urban areas, it is difficult to cultivate vegetables. In this situation rooftops are suitable for cultivation. Space availability on roofs and climatic conditions and other opportunities the people are interested in cultivating rooftop, terrace and balcony farming. Large numbers of Rooftop gardens are found in different zones of Bhubaneswar. The research on rooftop gardens was carried out from Bhubaneswar due to practitioner interest and an opportunity for me to survey. The research work is done at Regional Institute of Education, Bhubaneswar in the year 2020-21.

This research work was carried out all over the year since 2018-2021 at Regional Institute of Education, Bhubaneswar, Odisha. The collections of data are gathered by field survey and field experiment. The primary data collected from the field (on the rooftop) of the 10 practitioners' door to door survey method. The secondary data collected from literature as reference section and internets, Journals, organizations Etc. The experiment was done about the preparation of organic compost in traditional methods and cultivation of vegetables in general process. Irrigation facility is purely controlled by a pipe and dripping system. All data is collected from rooftop gardeners on a daily basis. The data obtained by structured, semi structured questionnaire. The data analyzed by the statistical methods of variance as described by [6]. The baseline study of RTGs were selection of area, sampling, extensive and intensive methods. 100 rooftop Gardens visit to the evaluated gardens we conducted structured and semi structured interview with all key stakeholders involved in the gardens who wanted to participate in this part of questioner and evaluation study [7].

## RESULTS AND DISCUSSION

A sample collection by 100 respondents of Bhubaneswar, provides sample techniques, maintenance, reason of perception, production of vegetables in rooftop gardens and vegetable demand [8]. Out of 100 respondents and rooftop gardens ( $G_x$ ) =  $G_1, G_2, G_3, G_4, G_5, G_6, G_7, G_8, G_9, G_{10}$ , only 10 are taken for random sampling for analysis. The study was carried out on the basis of a survey. The observations of vegetable plants were recorded in random sampling of well-organized practitioners separately in different zones of Bhubaneswar. Data is collected from door to door. The questionnaire method used by data collection for vegetable cultivation on rooftop garden by direct physical as well as online. Integral scale questions from all gardeners and non-gardeners. Structured and semi structured interviews with participants, intervention groups, educators' technicians, researchers, expertise and local people. Semi structured interviews were guided by prepared open-ended questions that include all aspects of rooftop garden activities [9]. The collected quantitative data we used statistical analysis. The structured interviews are prepared by the comparison basis of time period, place and situation, environmental condition, constraint, opportunity, future reference of the rooftop gardens

[10]. The methods of vegetable cultivation on rooftop gardens are as follows:

I- Preparation of bio-compost; II- Selection of containers; III- Selection of seeds; IV- production of seedling and plantation; V- Maintenance; VI- Harvesting

Preparation of the bio-compost preparation happened by the traditional manner. Household garbage and leaves (biodegradable waste) as a raw material along with cow dung, molasses, jiggery, leaves powder, cow urine, beans flour, and some soil and sand mixed well and put in a closed tank or big mud pot for 15-30 days. After that this mixture is purely decomposed and forms a past of compost. This compost is dried in the sunlight and used directly in the containers (grow bags) [11]. Different types of light weight containers are used in rooftop vegetable gardens. These are poly bags, plastic buckets, drums, pots, and protocol and soil pots [12]. The lane is made in cement which is permanently fixed on the rooftop floor of the building [13]. The selective seeds for rooftop gardens should be high yielding varieties and short periods of life cycle, Field survey and observation of rooftop gardens in different area of Bhubaneswar.

Pots, beds and lanes are used for seedling production. These are made for cultivation in the rooftop [14]. Directly planted and transplanted the seedling for cultivation. Maintenance of pots, poly bags and the beds are very important in rooftop gardens. Water management is needed for rooftop gardens. Excess water may harm the crop and building as well. It should be a spray and dripping system. Excess water is release from holes of pot and poly bags. It is taking care of the water seepages and heavy load to the roof of the building [15]. Green vegetables are harvested on rooftop garden.



Fig 1 *Solanum melongena* and *Solanum lycopersicum*

*Diversity of plants cultivated in RTGs:* The diversity of plants cultivated in rooftop garden are Trees (9,4,8) Shrubs (33,27,26) Herbs (47,109,204) Twiners (16,7,9,) Climbers

(13,11,6) and epiphytes (Orchids) (8,26,4). These include vegetables, ornamental, flowering and other plants are cultivated in RTGs. A large number of herbs are cultivated in RTGs of Bhubaneswar city (Fig 4). The vegetable gardens are increasing from the year 2018 to 2021 as 17.2%, 26.7%, 21.5% and 34.5% respectively. In the middle of 2020 little vegetable cultivation will decrease because of covid-19 pandemic.

In 2021 increasing RTGs vary tremendously due to cultivation safety from contamination of covid-19. We took sampling of 10 (Ten) stakeholders for a structured interview in questionnaire and collection of data in different RTGs in different areas of Bhubaneswar. 10 numbers of vegetables taken as sampling within 10 gardens for their taxonomic study and use of different parts of the vegetables. It is observed that fruits and leaves are extremely used. Most of the vegetables in RTGs are cultivated Solanaceae, Brassicaceae and Cucurbitaceae families (Table 1).

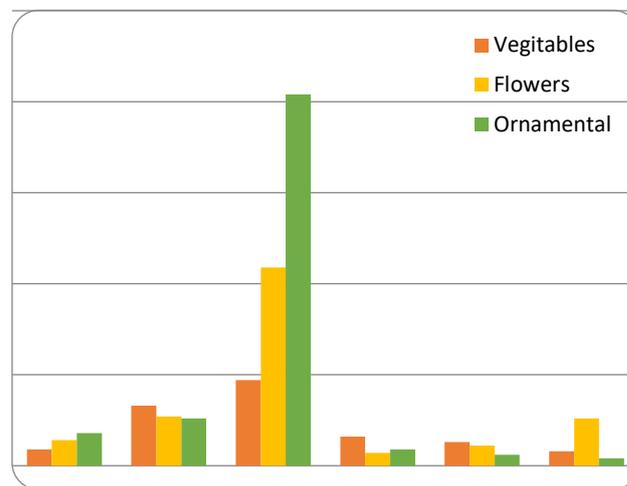


Fig 2 Diversity of plants cultivated on rooftop farming

Table 1 Observation important sampling of vegetables and parts use

S. No.	Vernacular name	Local name	Scientific name	Family	Parts use
1	Cabbage	Kobi	<i>Brassica oleracea capitata</i>	Brassicaceae	Bud, leaves
2	Brinjal	Baigana	<i>Solanum melongena</i>	Solanaceae	Fruit, Flower, Leaves
3	Cauliflower	Phulkobi	<i>Brassica oleracea botrytis</i>	Brassicaceae	Flower, Leaves
4	Laddy finger	Vhindi	<i>Abelmoschus esculentus</i>	Malvaceae	Fruit
5	Beans	Jhudanga	<i>Phaseolus vulgaris</i>	Legumenaceae	Cotyledon, Seed
6	Bitter Gourd	karella	<i>Momordica charantia</i>	Cucurbitaceae	Fruit, Leaves
7	Pumpkin	baitalu	<i>Solanum melongena</i>	Cucurbitaceae	Fruit, Flower, Leaves
8	Tomato	patala	<i>Lycopersicon esculentum</i>	Solanaceae	Fruit
9	Potato	Alu	<i>Solanum tuberosum</i>	Solanaceae	Tuber, Leaves
10	Cucumber	Kakudi	<i>Cucumis sativa</i>	Cucurbitaceae	Fruit



Fig 3 Rooftop vegetable garden and *Momordica charantia*

*Vegetables production in different seasons:* The vegetables are grown in different seasons. The maximum of growing of vegetable in winter season. 30 types of vegetables were grown in rainy season. 44,54,37, and 4 variety of vegetable grown in autumn winter, spring and summer respectively. Fruits are grown 12,16,8,14,6 in rainy, autumn, winter, spring and summer [16]. The spice grows 23,22,11,27,2 types cultivated in respective seasons (Fig 2).

In comparison, in winter and autumn vegetables grow well and produce the highest output due to the suitable environmental conditions. The main findings are that the cultivation of vegetables is maximum grow in winter about 54 types in rooftop gardens of Bhubaneswar. Minimum of vegetables production in summer season because of scarcity of water and high temperature of the buildings. The fruits and spices are also grown in rooftop gardens in all seasons (Fig 4).

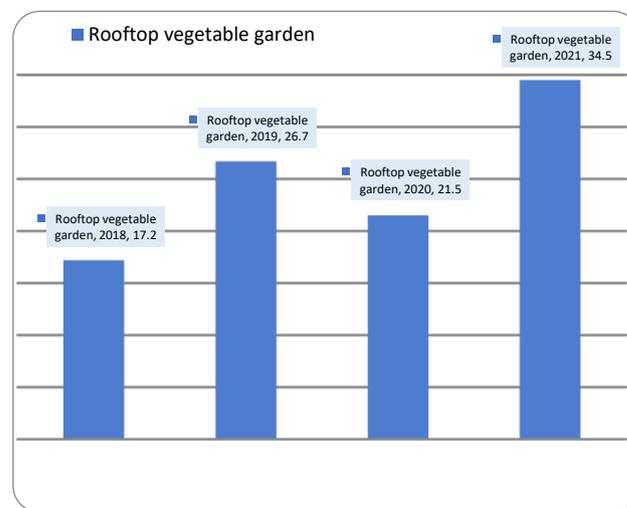


Fig 4 Grow of rooftop vegetable garden from 2018-21

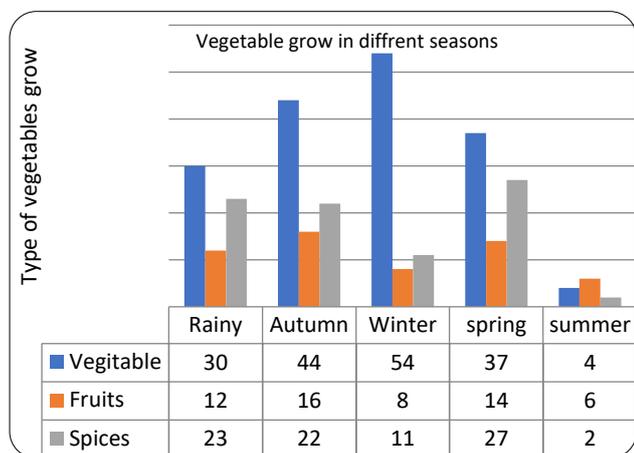


Fig 5 Vegetables, fruits and spices grows in different seasons on Rooftop gardens of Bhubaneswar

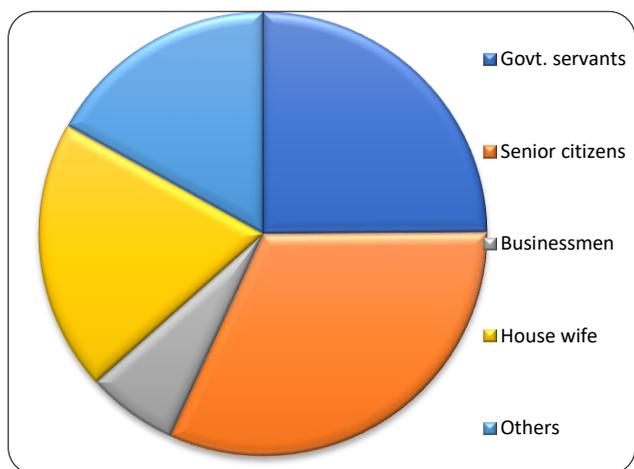


Fig 6 Urban people participate in rooftop garden in Bhubaneswar

**Urban people participation in RTGs:** The professional’s engagement on rooftop farming is categorized as government servants (25%), senior citizens (32%), Businessmen (6%), House wives (20%), and others (17%) are participating in

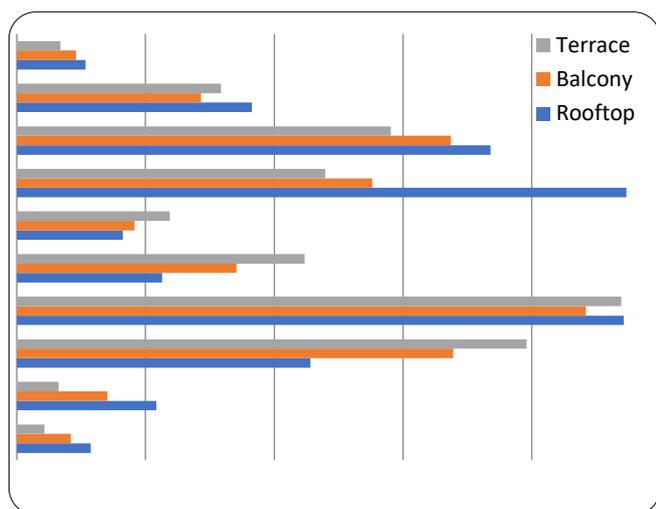


Fig 7 Reason of perception among urban people for rooftop gardens in Bhubaneswar

**The statistical data analysis:** The survey given 10 (ten) gardens (G<sub>1</sub>, G<sub>2</sub>, G<sub>3</sub>, G<sub>4</sub>, G<sub>5</sub>, G<sub>6</sub>, G<sub>7</sub>, G<sub>8</sub>, G<sub>9</sub>, G<sub>10</sub>) and ten sampling vegetables selectively given in (Table 2) in different zone of the Bhubaneswar. The data individual number of plants collected per garden calculated by statistical analysis by mean

rooftop gardening. As per an open field survey of 100 stakeholder’s data, the pie chart shows senior citizens (32%) engaged in rooftop gardens (Fig 5). The opportunities of rooftop garden promote the perception for urban people by following aspects [17]. Leisure time, entertainments, organic farming and yield pure food, fresh vegetables, hobby, engagement, lack of cultivated land, toxic and chemical fertilizer free vegetables, management and production of bio-compost and reuse in RTGs, Good will in society and creates relation among the urban people (Fig 6).

**Plants grow on RTGs:** Gradually growing of rooftop farming in Bhubaneswar showing different plant in different years [18]. Field survey gather different types of plants are grown rooftop in 2018,2019,2020,2021 such as vegetables 46,57,66,84, flowering plants 105,147,158,184, ornamental 204,260,290,305, medicinal plants 106,121,124,164, fruits 44,49,53,58, and spices 12,27,45,52 respectively ornamentals plants grow maximum than flowers. In 20 century, the vegetable grow is tremendously changed of vegetable cultivation on rooftop. In recent record in 2021 about 84 types of vegetable grow in Bhubaneswar. Now maximum people are perceived to grow vegetables on rooftops (Fig 7). The sampling of vegetable cultivation and demand of vegetables 10 vegetables (Cabbage, Brinjal, Cauliflower, Lady Finger, Beans, Bitter gourd, Pumpkin, Tomato, Potato, Cucumber) are taken as sample grown in 10 different rooftop gardens in different zone of Bhubaneswar. The record of four consecutive years 2018, 2019, 2020, 2021. Cabbage 13%, 14%, 9%, 11%, average 11.75%. Brinjal 10%, 9%, 12%, 13%, average 11%. Cauliflower 8%, 6%, 7%, 8%, average 7.25%. Lady finger 10%, 9%, 9%, 11%, and average 9.75%. Beans 11%, 14%, 12%, 13%, average 12.50% Bitter gourd 7%, 10%, 8%, 9% average 8.50%. The pumpkins grow 4%, 7%, 6%, 5% average 5.50%. Tomato 21%, 16%, 20%, 17%, average cultivation of tomato is highest in four consecutive years (18.50%). Potatoes 6%, 7%, 6%, 4% average 5.75%. Cucumber 10%, 8% 11%, 9% average 9.50%. Beans (12.50%), Cabbage (11.75%), Brinjal (11%). The average vegetable cultivation is lowest in pumpkin (5.50%) (Fig 8).

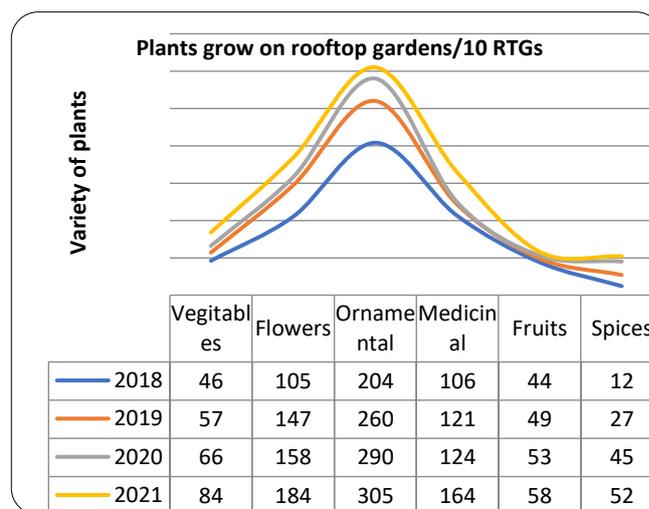


Fig 8 Types of plants grow on rooftop farming in 2018-21

variation and standard deviation. The mean shows average production of vegetables and number of plants (Fig 9). The statistical method for analysis of variation is calculated as 13.844, 32.666, 18,233, 59.777, 15.166, 3.377, 4.055, 22.544, 25.177 and 3.833. Lady finger has the highest variation 59.777

among the vegetables (Fig 10). The standard deviation of above vegetables is 3.529, 5.422, 4.050, 7.334, 3.694, 1.743, 1.910, 4.504, 4.760, and 1.857. The calculation of standard deviation highest in lady finger is 7.334. The lady finger is comparatively maximum cultivation of rooftop gardens (Fig 11).

Implementation of vegetable cultivation in rooftop farming will grow fast due to the future demand and use. The rooftop garden promotes food security and urban sustainability in future perspectives in cities around the world. It is a big planning challenge to the urban people [19].

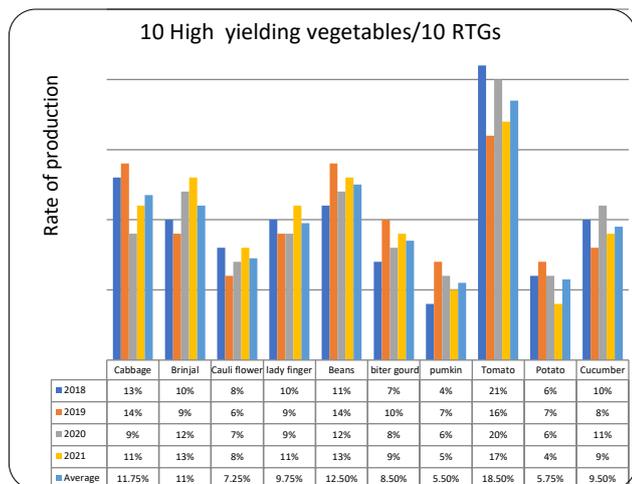


Fig 9 Sampling of 10 vegetables cultivate on rooftop garden in 2018-21

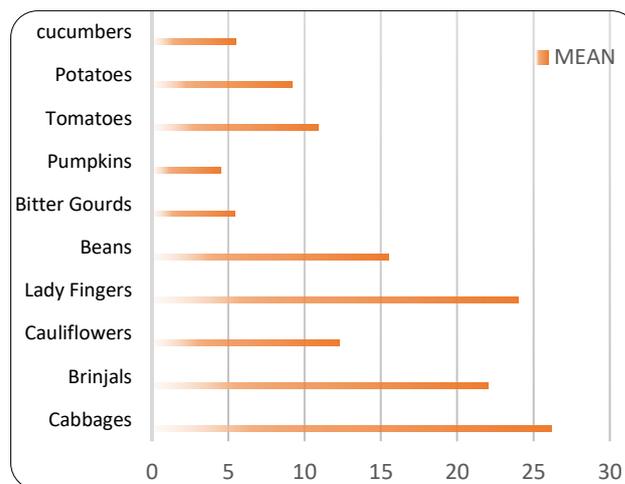


Fig 10 Mean sampling of 10 vegetables in 10 rooftop garden

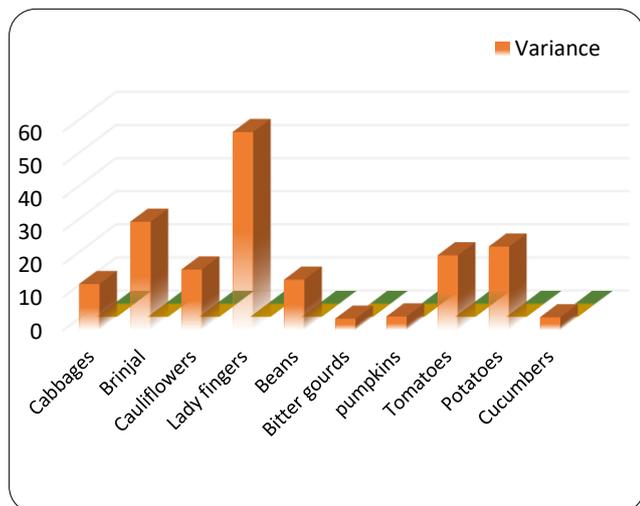


Fig 11 Variation of vegetables in 10 sampling gardens

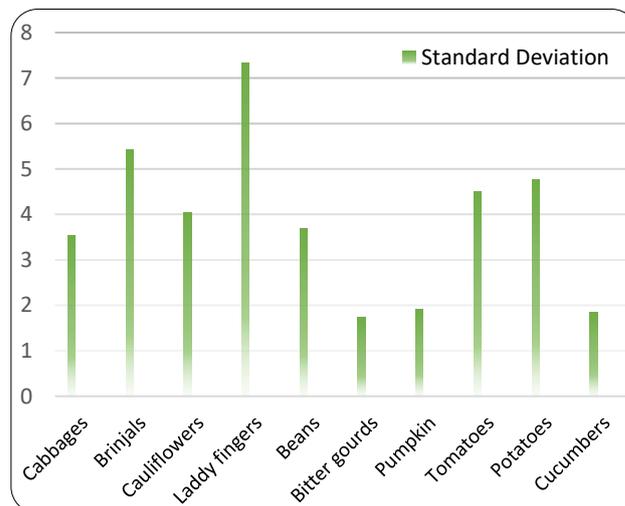


Fig 12 Standard deviation of sampling vegetables and gardens

Table 2 Statistical data analysis of Standard deviation of 10 vegetable sampling in 10 vegetable gardens

S. No.	Vegetables	G <sub>1</sub>	G <sub>2</sub>	G <sub>3</sub>	G <sub>4</sub>	G <sub>5</sub>	G <sub>6</sub>	G <sub>7</sub>	G <sub>8</sub>	G <sub>9</sub>	G <sub>10</sub>	Total	Mean	Variance	Deviation
1	Cabbages	27	24	21	28	34	26	29	24	22	27	262	26.2	13.844	3.529
2	Brinjals	16	25	19	13	28	27	24	29	18	21	220	22	32.666	5.422
3	Cauliflowers	18	13	6	17	12	8	11	7	15	16	123	12.3	18.233	4.050
4	Lady fingers	26	35	24	17	29	37	18	21	14	19	240	24	59.777	7.334
5	Beans	15	12	18	20	8	13	16	19	14	20	155	15.5	15.166	3.694
6	Bitter gourds	6	4	5	7	3	6	5	6	9	3	54	5.4	3.377	1.743
7	Pumpkins	4	6	3	2	6	8	2	5	6	3	45	4.5	4.055	1.910
8	Tomatoes	8	12	6	7	18	6	14	18	13	7	109	10.9	22.544	4.504
9	Potatoes	5	7	8	4	6	9	21	14	10	8	92	9.2	25.177	4.760
10	Cucumbers	4	5	7	3	7	9	5	5	7	3	55	5.5	3.833	1.857

### CONCLUSION

The growth of urban people of India enhances the demand for vegetables. Urban agriculture is one of the most important cultivations of demanding urban people in all

professions. Rooftop garden is resulting as a kitchen garden. Maximum variety of vegetables can be cultivated on the rooftop. The proper water management in rooftop farming due to the presence of container gardens is one of the economic values. The rooftop garden includes a vertical garden, green

houses RTGs, ploy house RTGs. rooftop vegetable gardens grow in all seasons. This study 10 species of vegetables taken as samples which are most demandable and highly productive. Increasing the rate of urban population rooftop gardens can solve the vegetable demand. Economic balance is supported by rooftop gardens for urban people. This study results in the increase of the Rooftop vegetable gardens every year in Bhubaneswar. Rooftop vegetable gardens are important for obtaining fresh organic vegetables on door steps. Self-satisfaction and self-engagement in rooftop farms is a new concept of organic farming. It has grown different types of vegetables for daily needs for the family. Rooftop farming enhances personal development, physical, emotional, social inclusion, economical balance, interpersonal relation and general quality of life. As per the data analysis and calculation of variation and deviation is increased regularly. The rooftop gardens increase every year along with types of vegetables plant and production are also increased for good result. The qualitative and quantitative studies of rooftop farming in Bhubaneswar enhance food security and economic sustainability.

#### Authorship contribution

*Dr. Mahendra Kumar Satapathy guides me to prepare this manuscript of the original research article. He was helped in collection of data and statistical data analysis. Kartik Chandra Sahu carried out the research work and field experiment and collection of data through questionnaire and survey.*

#### Acknowledgment

*I would like to express my profound thanks and sincere gratitude to my guide Dean, Professor (Dr). Mahendra Kumar Satapathy, Department of Botany, Regional Institute of Education, Bhubaneswar. For this enthusiastic guidance with reference for his abide Jeal, moral support and immense help in every step of this research work, prepared an article and considered it to publish in 'Research journal of Agricultural Science: An International Journal'. I am grateful to all the participants, permit me into his rooftop garden for observation and survey, and eventually give me accurate data about the work. Also, thanks to all technicians, educators, researchers, and other teachers who helped me to prepare this manuscript.*

### LITERATURE CITED

- Mathews SA. 2011. Development concept of modern garden in different states in India. *Thesis* submitted to Visva-Bharati for the Degree of Doctor of Philosophy in agriculture (horticulture). <http://hdl.handle.net/10603/101041>. pp 11.
- Asad KM, Roy MR. 2014. Urban greening and rooftop gardening, Scope and opportunity in Bangladesh, Retrieved from gobeshona.net:<<http://gobeshona.net/wp-content/upload/2015/01/urban-greening-and-rooftop-gardening-scope-and-opportunities-in-Bangladesh-pdf>>.
- Islam R, Siwar C. 2012. The analysis of urban agriculture development in Malaysia. *Advance in Environmental Biology* 6(3): 1068-1078.
- Carter T, Keeler A. 2008. Life-cycle cost benefit analysis of extensive vegetated roof systems. *Journal of Environmental Management* 87(3): 350-356.
- Dubbeling OF, Zeeuw M, Prosdociami H, Gianquinto G. 2017. Rooftop urban agriculture, New York (NY). Springer International Publishing.
- Gomez KA, Gomez AA. 1984. *Statistical Procedures for Agricultural Research* (2<sup>nd</sup> Edition). John Willy and Sons, New York. pp 680.
- Islam KM. 2004. Rooftop gardening as a strategy of urban agriculture for food security: The case of Dhaka city, Bangladesh, Retrieved from teiep.gr: [http://www.lib.teiep.gr/Image/stories/acta/Acta%20643/643\\_31.pdf](http://www.lib.teiep.gr/Image/stories/acta/Acta%20643/643_31.pdf).
- Wardard Y. 2014. Rooftop gardening can meet Dhaka's 10pc of vegetable demand. Retrieved from the financial express-bd.com <<http://www.the-financial-express-bd.com/2014/11/19/66659/print>>.
- Zhang XL, Shen VW, Tam, Lee WWY. 2012. Barrier to implement extensive green roof systems. *A Hong Kong Study* 16(1): 325-334.
- Cohen N, Reynolds K, Sanghvi R. 2012. Five Borough Farm: seeding the future of urban agriculture in New York City. New York (NY): Design Trust for Public Space.
- Harada Y, Whitlow TH. 2020. Urban Rooftop Agriculture, Challenge to Science and practice, *frontiers in sustainable food system*. Doi.org/10.3389/fsufs2020.00076
- Jafari NM, Yunos M, Yazid MAO, Mydin, Mohdo T. 2015. Assessing the resident's preference of awareness regarding urban agriculture at rooftop garden. *Applied Mechanics and Materials* 747: 180-186.
- Hui SC, Chan MK. 2011. Biodiversity assessment of green roof for green building design. *Symposium* 32(4): 492-516.
- Clarke P. 2015. The world's largest rooftop farm sets the stage for urban growth. Retrieved from <http://waldenlabs.com/world-largest-rooftop-farm/>.
- Safayet M, Md Faqru, A. Md Musleh, Hasan U. 2021. Present practice and future prospect of rooftop farming in Dhaka city: a step towards urban sustainability. *Journal of Urban Management* 10(1): 84-85.
- Sommerfeld AJ, McFarland AL, Waliczek TM, Zajicek JM. 2010. Growing minds: evaluating the relationship between gardening and fruit and vegetable consumption in older adults. *Horttechnology* 20(4): 711-717.
- Korn A, Bolton SM, Spencer B, Alarcon JA, Andrews L, Voss JG. 2018. Physical and mental health impacts of household gardens in an urban slum in Lima, Peru. *Int. Jr. Environ. Res. Public Health* 15(8): 1751.
- Siebert SK, Hartmann R, Freisinger I, Sawicka UB, Werner A. 2014. Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. *Agric Human Values* 31(1): 33-51.
- Willem VE. 2005. Rooftop gardening: A big step to the future, Research gate, Retrieved from <https://www.researchgate.net/publication/290435387>. **Error! Hyperlink reference not valid.**