Environmental effects of vegetable garden space the introduction of the city in Hanoi, Vietnam

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Abstract. Urban Farming, defined as the growing of crops in and around the perimeter of cities, is implemented at terrace, balcony. Besides vegetable and fruit production, urban farming provides many other benefits. For example, prevent storm water runoff. When planning a garden on a terrace and balcony, it will focus in vegetables production, thermal insulation and soil permeability. Therefore, calculation the effect of urban farming on city's environment.

1. The background of the research
Vietnam has achieved rapid growth in recent years, especially in urban areas such as Hanoi city and Hochiminh city, many developments are ongoing. On the other hand, the urban areas got overcrowded, the living environment got worse, and the gap between rich and poor is growing behind economic growth. Also, in recent years environmental problems including global warming have been largely as serious problem.
In response to such a situation, as one solution, in this research, pay attention to the green building which is currently spreading in Southeast Asia, and what kind of environmental effect can be expected by planting vegetables and fruits, especially on the roof of a building and the balcony etc. We quantify many effects and examine the possibility as a policy to reduce the environmental impact of Hanoi city.

| General information of Hanoi city |
|----------------------------------|
| Region                           | Hanoi city delta |
| Area                             | 3.329 km²        |
| Population                       | 7,587,800        |
| Population density              | 1,943/km²        |

2. The purpose of the research
By planting vegetables and fruits on the rooftops and balconies of Hanoi's buildings, we will promote the comfort of our living space, bring various economic effects, contribute to the improvement of the environment throughout the city, and cease an environmentally symbiotic city play a role.
Also, in this research we are hoping that large amounts of vegetables and fruits can be offered to Hanoi citizens. That is to say that citizens plant vegetables and fruits on vacant rooftops and balconies without much use, to be able to harvest fresh vegetables and fruits, and to be able to protect food quality and safety.

Hanoi city is a big city of Vietnam, with no rain falling throughout year but focusing mainly on the rainy season. We plant a large amount in vegetables and fruits planted on the roof of the building and the balcony etc and think that the ability to prevent flooding will be improved respectively. For this reason, it aims to be able to reduce the pressure of the old drainage system of Hanoi city in the capital every year.

3. Environmental problems in Hanoi city

3.1. Land be used in Hanoi city

Hanoi city has developed and expands at a faster speed than any other city in the country. The city speed is 3.8% annually for Hanoi city. Figure 2 shows the trends in land be used and population in Hanoi city. Agricultural land and green areas are decreasing year by year with the tendency of population increase.

![Figure 2. Land be used in Hanoi city and population of Hanoi city.](image)

3.2. Flooding

Figure 3 shows the number of occurrences of heavy rains and floods, which are assumed to be the effects of climate change, in Hanoi city in an increasing trend in recent years. It exceeds the reservoir capacity of Hanoi city river, especially SONG HONG, causing flooding. The number of typhoons also has been on an upward trend, which has great influence on people's lives.

![Figure 3. Flooding and temperature changed in Hanoi city](image)
3.3. Temperature change in Hanoi city
Climate change is occurring in many parts of Vietnam. As shown in Figure 3, the winter season in Hanoi city has been delayed, and the temperature tends to be lower than a few years ago. The minimum temperature in 2016 was 4 °C. Meanwhile, in summer, the maximum temperature is rising and it is 41.5 °C in the summer of 2015. Also, energy consumption for cooling tends to increase.

3.4. Problems of agricultural products in Hanoi city
In recent years, the agricultural land area of Hanoi city is decreasing. On the other hand, citizen's demand for food is increasing. Therefore, in Hanoi city, many foods are imported from overseas. Under such circumstances, citizen's concern about the safety of food is rising, due to problems such as the use of chemicals in imported foods.

![Graph showing transition of agricultural land and agricultural products in Hanoi city](image)

Figure 4. Transition of agricultural land, agricultural products in Hanoi city.

4. Survey on the current situation of BACHMAI ward in Hanoi city
4.1. Overview
In this research, when investigating the town of BACHMAI ward in Hanoi City, we investigated house area, business area, administrative area, etc., area of BACHMAI ward by area classification. At the same time, we investigated the area, structure, materials, roof and the area of the balcony of 5 typical houses in BACHMAI ward (A, B, C, D, E typical house) and investigated the thermal environment inside the residence by measuring temperature and humidity. On that basis, we make questionnaire survey about residents of BACHMAI ward. We also collected information on consumption of vegetables and fruits for 1 month in BACHMAI ward.

| Type building       | Amount | Number of residents | Consumption of plants (g/day) | Consumption of vegetable (kg/year) | Number of balcony and rooftop | Area of balcony and rooftop |
|---------------------|--------|---------------------|------------------------------|-----------------------------------|------------------------------|------------------------------|
| Business area       | 58     | 670                 | 335000                       | 122275                            | Balcony: 115                  | 920                          |
|                     |        |                     |                              |                                   | Rooftop: 24                   | 620                          |
| House area          | 118    | 561                 | 280500                       | 102382.5                          | Balcony: 354                  | 2700                         |
|                     |        |                     |                              |                                   | Rooftop: 64                   | 1230                         |
| Administrative area | 7      | 145                 | 72500                        | 26462.5                           | Balcony: 21                   | 126                          |
|                     |        |                     |                              |                                   | Rooftop: 4                    | 105                          |
| Religious area      | 1      | 36                  | 18000                        | 6570                              | Balcony: 0                    | 0                            |

Table 1. The situation of the entire house in BACHMAI ward
4.2. House to be surveyed

BACHMAI ward: We conducted a current situation survey on the area classification of BACHMAI ward in Hanoi city. Many of the existing wastewater in BACHMAI ward was built before 1954, so it is a region where flooding is likely to occur in the rainy season. In this research, we analyzed the environmental effect of BACHMAI ward by introducing greening of buildings.

A, B, C, D, E: 5 typical houses in BACHMAI ward. The outline of the object is shown in Table 2, and the area of the housing to be investigated, the insulation, the room temperature, the rooftop and the balcony area are shown in Table 2. More than one case of greening introduction was specifically set in the target housing, and the effect of each case was analyzed.

5. Method of green building

5.1. Set up rooftop and balcony

In this research, we assumed that greening with vegetables and fruits etc is done using the vacant space of the rooftop of the A, B, C, D, E typical houses and the balcony as the representative residence of BACHMAI town. Estimated effects such as rainwater storage amount and thermal environment improvement by planting vegetables and fruit trees on the rooftop and balcony.
| Typical house | Floor | Insulation | Area (m²) | Room | Room's highest temperature (°C) | Room's lowest temperature (°C) | Balcony | Rooftop | Number of residents |
|---------------|-------|------------|-----------|------|---------------------------------|---------------------------------|---------|---------|---------------------|
| A             | 4     | No         | 195       | 1F   | Business 28                     | 28.5                            | Quantity : 3 | Area : 24.8 (m²)   | 4       |
|               |       |            |           | 2F   | Kitchen 27.5                    | 28                              |                      |         |                     |
|               |       |            |           |      | Livingroom 29                   | 30.5                            |                      |         |                     |
|               |       |            |           | 3F   | Bedroom 1 30.5                  | 31                              |                      |         |                     |
|               |       |            |           |      | Bedroom 2 30                     | 31                              |                      |         |                     |
|               |       |            |           |      | Bedroom 3 31                     | 31.5                            |                      |         |                     |
|               |       |            |           |      | Bedroom 4 31                     | 33                              |                      |         |                     |
|               |       |            |           | 4F   | Laundry 32                       | 34                              |                      |         |                     |
| B             | 4     | Yes        | 312       | 1F   | Storage 26.5                    | 27                              | Quantity : 3 | Area : 13 (m²)   | 6       |
|               |       |            |           | 2F   | Livingroom 26.5                 | 28                              |                      |         |                     |
|               |       |            |           |      | Diningroom 27                   | 29                              |                      |         |                     |
|               |       |            |           | 3F   | Bedroom 1 27.5                  | 30.5                            |                      |         |                     |
|               |       |            |           |      | Bedroom 2 29                     | 32                              |                      |         |                     |
|               |       |            |           |      | Bedroom 3 31                     | 32.5                            |                      |         |                     |
|               |       |            |           | 4F   | Laundry 31.5                    | 33                              |                      |         |                     |
| C             | 4     | No         | 250       | 1F   | Kitchen 26                       | 27                              | Quantity : 4 | Area : 23 (m²)   | 5       |
|               |       |            |           | 2F   | Livingroom 27                   | 28.5                            |                      |         |                     |
|               |       |            |           |      | Bedroom 1 28                     | 29                              |                      |         |                     |
|               |       |            |           |      | Bedroom 2 28.5                   | 30                              |                      |         |                     |
|               |       |            |           | 3F   | Bedroom 3 29                     | 30                              |                      |         |                     |
|               |       |            |           |      | Bedroom 4 29                     | 32                              |                      |         |                     |
|               |       |            |           | 4F   | Bedroom 5 31                     | 32.5                            |                      |         |                     |
|               |       |            |           |      | Business 28.5                   | 29                              |                      |         |                     |
|               |       |            |           |      | Bedroom 1 28                     | 28.5                            |                      |         |                     |
|               |       |            |           |      | Bedroom 2 28                     | 30                              |                      |         |                     |
| D             | 1     | No         | 189       | 1F   | Livingroom 29                   | 31                              |                      |         |                     |
|               |       |            |           | 2F   | Room 1 29.5                     | 32                              |                      |         |                     |
|               |       |            |           |      | Room 2 31                       | 32.5                            |                      |         |                     |
| E             | 2     | Yes        | 184       | 1F   | Business 1 27                    | 29                              |                      |         |                     |
|               |       |            |           | 2F   | Room 1 29.5                     | 32                              |                      |         |                     |
|               |       |            |           |      | Room 2 31                       | 32.5                            |                      |         | Company            |
|               |       |            |           |      | Meeting room 29                  | 31                              |                      |         |                     |
5.2. Harvesting volume of vegetables and fruits
As shown in Table 2, supposing that setting the area of the roof of a typical house and the balcony planted vegetables and fruit trees in an area of 35 to 45%. We set cabbage and cucumber on the rooftop to set balcony (15.4 m²) and rooftop (25.7 m²), and set onion, tomato, vegetable flower and lettuce on the balconies of each floor.

Table 3. Harvesting volume of vegetables and fruits, Rainwater storage

| Typical | Area of balcony and rooftop (m²) | Balcony and rooftop cultivation area (m²) | Total rainwater storage (l/m²) | One season yield (kg) |
|---------|----------------------------------|------------------------------------------|-------------------------------|----------------------|
| A       | Balcony: 24.8                    | 15.4                                     | 485                           | 212.9                |
|         | Rooftop: 58.8                    | 25.7                                     | 1055                          |                      |
| B       | Balcony: 13                      | 9                                        | 194.4                         | 36                   |
|         | Rooftop: 0                       | 0                                        | 0                             |                      |
| C       | Balcony: 23                      | 14.7                                     | 317.52                        | 51                   |
|         | Rooftop: 0                       | 0                                        | 0                             |                      |
| D       | Balcony: 0                       | 0                                        | 0                             | 0                    |
|         | Rooftop: 0                       | 0                                        | 0                             |                      |
| E       | Balcony: 0                       | 0                                        | 0                             | 112                  |
|         | Rooftop: 80                      | 54.5                                     | 1308                          |                      |
| Total   | Balcony: 60.8                    | 39.1                                     | 996.92                        | 411.9                |
|         | Rooftop: 138.8                   | 80.2                                     | 2363                          |                      |

There are four seasons in Hanoi during the year, and we set the quantity and type of vegetables and fruits planted according to the season. For example, cabbage in winter, lettuce etc in summer. If you plant tomatoes, the yield per m² will be about 8 kg. Each seasonal yield of the whole A house is 212.9 kg.

5.3. Rainwater storage
It is the purpose of reducing the energy consumption of the sewage treatment system and reducing the flooding frequency by the rainwater storage effect of the rooftop and the balcony. If the rainfall rate is about 100 mm/h for 2 hours with raging rain, the sewage flow rate was calculated.

6. Set up green space in BACHMAI ward
6.1. Result of rainwater storage
The thickness of the 25 cm soil is 31.5l/m² of average vegetables and fruits. Rainwater storage rate: highest (38.2%), lowest (12.1%) (Plant type of plant almost 25 cm thick soil).
With the rooftop of the A, B, C, D, E typical house and the area of the balcony are 199.6 m² and cultivation area is 119.2 m², if the rainfall flow rate is about 100 mm/h for 2 hours with raging rain, the
total rainwater storage amount will be 3395.92 (l/day). The cultivation area of rooftop and balcony of BACHMAI ward is 4050.9 m² (70% area of rooftop and balcony of BACHMAI ward), the total rainwater retention amount is 140878 (l/m². Day) after planting, and the sewage reduction amount is 27439.72 m³. (Table 4)

6.2. Harvesting volume of vegetables and fruits
The outline of the target is shown in Table 2, and the consumption of plants was calculated based on the population of the houses to be investigated. The consumption of plants in BACHMAI ward is 407 kg / day. From the calculation of the target housing, the yield of vegetables and fruits on the rooftop of the A, B, C, D, E typical house and the balcony was 5.2 kg/m² of cabbage, 4 kg/m² of lettuce, 2 kg/m² of radish, 3.5 kg/m² of tomato Set and calculate. (Table 3) The average yield of vegetables and fruits per 1 m²/1 season is 12 kilograms.

6.3. Result in Bachmai ward
Based on the calculation results of A, B, C, D, E typical house, we calculated the effect of introducing vegetable garden space throughout BACHMAI ward. For the calculation, we used the numerical values of A, B, C, D, E typical house on the rooftop area of BACHMAI ward and the balcony area.

Table 4. Harvesting volume of vegetables and fruits, Rainwater storage in Bachmai ward

| Type building      | Cultivation area of balcony and rooftop (m²) | Total rainwater (l) | Total rainwater storage (l/m²) | Consumption of vegetables (kg/year) | Sewage reduction (l) |
|--------------------|---------------------------------------------|---------------------|--------------------------------|-------------------------------------|----------------------|
| Business area      | Balcony : 644                                | 16848              | 41529                          | 122275                              | 11137.896            |
|                    | Rooftop : 434                                | 24681              |                                 |                                     |                      |
| House area         | Balcony : 1890                               | 49680              | 92114                          | 102382.5                            | 28423.332            |
|                    | Rooftop : 861                                | 42434              |                                 |                                     |                      |
| Administrative area| Balcony : 88.2                               | 1922.4             | 5473                           | 26462.5                             | 1670.6844            |
|                    | Rooftop : 73.5                               | 3550.6             |                                 |                                     |                      |
| Religious area     | Balcony : 0                                  | 0                  | 0                              | 6570                                | 0                    |
|                    | Rooftop : 0                                  | 0                  |                                 |                                     |                      |
| Education area     | Balcony : 33.6                               | 591.2              | 1760.3                         | 912.5                               | 621.9864             |
|                    | Rooftop : 26.6                               | 1169.1             |                                 |                                     |                      |
| Traffic area       | Balcony : 0                                  | 0                  | 0                              | 0                                   | 0                    |
|                    | Rooftop : 0                                  | 0                  |                                 |                                     |                      |
| Total              | Balcony : 2655.8                             | 69041              | 140876                         | 258602.5                            | 27439.7256           |
|                    | Rooftop : 1395.1                             | 71834.7            |                                 |                                     |                      |

7. Conclusion
In this research, we will grow rooftops and balconies in BACHMAI ward in Hanoi city. It contributes to the improvement of the environment of the whole city and plays an important role for realizing urban development that is symbiotic to the environment. The greening introduction effect is as follows. Rainwater retention in BACHMAI ward is 27439.7(l), reduction rate is 56.2%, harvest volume is 47482 (kg/year).

8. Reference
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