

Willingness to pay for urban agriculture in Oslo

Authors: Geir Wæhler Gustavsen, Helge Berglann, Elisabeth Jenssen, Signe Kårstad and Divina Gracia Rodriguez

Norwegian Institute of Bioeconomy Research
Box 115, NO-1431 Ås, Norway

emails:

Geir.gustavsen@nibio.no

Helge.berglann@nibio.no

Elisabeth.jenssen@nibio.no

Signe.kaarstad@nibio.no

Divina.rodriquez@nibio.no

ABSTRACT

Urban agriculture is increasingly recognized as an important sustainable pathway for climate change adaptation and mitigation, for building more resilient cities, and for citizens' health. Urban agriculture systems appear in many forms – both commercial and non-commercial. The value of the services derived from urban agriculture, e.g. enhanced food security, air quality, water regulation, and high level of biodiversity, is often difficult to quantify to inform policymakers and the general public in their decision making. We perform a contingent valuation survey regarding four different types of urban agriculture in Oslo. The citizens of Oslo are asked about their attitudes and willingness to pay for non-commercial and commercial urban agriculture. The non-commercial agriculture consists of urban community gardens for the citizens and urban gardens for work training, education and kindergartens. On the other hand, the commercial urban agriculture consists of aquaponics and vertical production. Results show that the citizens of Oslo are willing to increase their tax payments to contribute to further development of urban farming in Oslo.

Keywords: Willingness to pay; community garden; aquaponics; vertical farming; Oslo

1 Introduction

Currently, about 56 percent of the world's population lives in urban areas (World Bank, 2020). Projections show that by 2050, it is expected to increase to 68 percent with an extra 2.5 billion inhabitants occupying urban spaces (United Nations, 2018). Rapid urbanization threatens the sustainability of agriculture in the face of climate change, resource depletion and limited land resources. In Norway, there are pressures to convert land from a green status into constructed urban areas. Due to past and present anthropogenic and industrial activities, soils in the urban areas have become contaminated and cannot be used for food production until remediation measures have been implemented. Moreover, according to sales data for fruits and vegetables in 2018 (frukt.no, 2019) Norway imported more than 70 percent of all fruits, vegetables, berries, and potatoes people consume. The challenge now is for cities, such as Oslo, to be able to feed themselves and provide their inhabitants with appropriate and healthy food, while simultaneously enhancing self-sufficiency, sustainability and resilience.

To address this challenge, there is a growing interest in food being grown locally within cities (Guitart, Pickering and Byrne, 2012). Urban agriculture (UA) is defined as "an activity located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re)using largely human and material resources, products and services found in

and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area” (Mougeot, 2005). Urban agriculture is increasingly recognized as an important sustainable pathway for climate change adaptation and mitigation (Lwasa et. al., 2014; Thebo et. al., 2014); for building more resilient cities (Goldstein, et. al. 2016); and for citizens health (Zasada, 2011). It has become a popular topic for cities to engage in on a program or policy level.

However, the value of the services derived from urban agriculture, e.g. enhanced food security, air quality, water regulation, and high level of biodiversity, is often difficult to quantify. Many human decisions, both of policymakers and the general public, are based on good quantifiable information about the benefits, costs and risks associated in the adoption and/or implementation of urban agriculture. For example, city officials want assessments of local public opinion about urban agriculture in order to make funding decisions. Food production in urban areas needs to be a part of the planning processes and urban designs as administered by local and national governments. Without direct policy and institutional support, it would be difficult to promote and implement urban agriculture as an integral part of the development and planning goals of urban areas in Norway, such as Oslo City.

Hence, the objective of this research is to assess the willingness to pay of Oslo residents towards urban agriculture. The study focuses on the city of Oslo, the biggest city and the capital of Norway. According to the county of Oslo, Oslo is experiencing record growth in population. Its urban development is concentrated within the existing built environment, which requires densification and transformation in prioritized areas. It is encouraged to have public spaces and green amenities within all parts of the city. Oslo has many small and larger pockets of unused land or spaces that could be turned into gardens in the city. However, urban agriculture still plays a minor role in improving food security as there are insufficient economic incentives and limited effective policies in place. Results of this study can inform government officials and city planners in integrating food production in urban areas into city land-use planning and other related activities.

2 Background: Urban Agriculture in Oslo

Urban agriculture can be classified into non-commercial and commercial agriculture. Urban agriculture for educational purposes or for recreational purposes represent non-commercial food production, while aquaponics and vertical farming more often represents commercial food production. When education is considered an important urban agricultural activity, children, kindergartens, local schools and other residents may come and learn about food production. Educational gardens, or community gardens, are often located in a park where it is possible to conduct other leisure activities, such as walks, picnics, sports etc. Community gardens are area of public green space which are maintained by members of community (Dennis & James, 2016) and serve priorities such as leisure and educational activities, social interaction, and provisions of communal open spaces. In other words, community gardens may be used for recreational and for educational purposes.

On the other hand, vertical farming is a type of commercial UA where the plants/crops are grown upwards to save space for growing, and to use technology to make the production of crops efficient and to fully control the environment for the plants. This makes vertical farming ideal for urban areas where space may be an issue. Most vertical farms use hydroponic production systems, where plants grow in a substrate or water with nutrients, instead of soil. Hydroponics makes is easier to regulate the supply of water and nutrients needed for the plants. It also reduces soil-related cultivation problems such as soil-born diseases and decreases the use of fertilizers or pesticides (Al-Kodmany, 2018). When a hydroponic production system is integrated with aquaculture, i.e. fish farming, then it is referred to as aquaponics. The notion of aquaponics is to create a symbiotic relationship between the plants and the fish (Al-Kodmany, 2018). The water from the fish tanks' biofilters is used for fertilizing the greenhouse plants. Also, the hydroponic beds function as a bio-filter that remove gases, acids, and chemicals, such as ammonia, nitrates, and phosphates from the water.

There has been an increased focus on urban agriculture in Oslo over the last decade. Urbanization in combination with limited land resources and an increased focus on food security has made UA a popular topic for the city. As a result, development and facilitation of green spaces and cultivation opportunities has been prioritized. Several different UA-types can be found around Oslo today, for environmentally, recreational, and educational purposes.

In 2019, Oslo Municipality's Urban Environment Agency developed "Spirende Oslo", which is a strategy for UA running from 2019 to 2030. A part of this strategy is to provide subsidies to various UA-projects that will contribute to increased knowledge development and more UA activity in Oslo. These subsidies will come in the form of support for measures to implement UA such as the preparation of communal gardens and construction of growing boxes, beehives and hen houses (Oslo Kommune, 2020a). Spirende Oslo is also currently working on mapping of existing projects and potential areas for UA in Oslo.

According to The Norwegian Allotment Garden Association, there is 9 different allotment gardens with cabins located in Oslo (Norsk Kolonihageforbund, 2020). The three oldest gardens are located near the city center of Oslo, while the others are found in the suburbs. All nine allotment gardens are very popular among the citizens of Oslo, and there are long waitlists for buying a parcel. Allotment gardens without cabins is also found all over Oslo. About 24 gardens are listed in Oslo Municipality's overview of urban agriculture (Oslo Kommune, 2020b). The majority of these allotment gardens also have waiting lists, but as opposed to buying parcels with huts, these parcels is rented on an annual basis (Haavie, 2020). People in the local community is often prioritized.

UA for learning purposes is a part of Oslo Municipality's Spirende Oslo-strategy, where facilitation of school gardens and green schoolyards for both new and existing schools in Oslo is a stated goal (Bymiljøetaten, 2019). Oslo Municipality currently has 30 school gardens, most of them publicly owned, which is used by about 40 schools. In addition to these, Oslo also have 7 visitor's farms where different forms of agriculture are involved – from growing herbs, vegetables, fruits, and berries, to animal husbandry. The visitor's farms invite the public to experience and learn how traditional farming works.

Community Supported Agriculture (CSA) is a concept which has increased in scope over the last years in Norway. According to Andelslandbruk (2020), six different CSAs are located in Oslo. Most of the CSAs are privately owned and driven by unit holders on a voluntary basis. Each CSA has between 60 to 80 members.

Hydroponics, the predominant growing system used in vertical agriculture, is fairly new and not very widespread in Norway. However, there are some operators, and Norway's largest vertical farm is found in Oslo's sub-district Økern. The vertical farms are mostly profit based and owned by a private company. BySpire, an agricultural company located in Oslo, has used an old office building for vertical farming producing herbs to restaurants and online retail, where tall structures with several levels of growing beds, often lined with artificial light are used.

3 Data and Empirical Methods

3.1 Data and Survey Design

Government officials need to know how their constituents feel about their planned government programs in general, and about paying taxes to fund them in particular (Kline & Wichelns, 1994). We use the contingent valuation method (CVM) to elicit general public knowledge and attitudes towards adopting many different types of urban agriculture in Oslo. The CVM uses a survey instrument to ask respondents questions regarding food consumption, attitudes, socioeconomics and willing to contribute to the extension of UA in Oslo. By varying the size of the payment across different respondents, the demand curve for urban agriculture can be traced out and the mean willingness to pay of the respondents can be estimated for urban agriculture. One limitation of this method is that the responses are based on stated rather than observed preferences.

The CVM survey was performed by IPSOS-Norway in September 2020 in a representative sample for the population of Oslo. The sample consists of 1005 respondents with age from 18 to 88 years. The survey questionnaire was carefully designed to provide the respondents with adequate and accurate information related to UA in Oslo. The questionnaire consisted of the following parts: (1) explanation about UA in Oslo and the strategies for UA by the city council of Oslo and the Department of Agriculture in Norway; (2) some information about the benefits (e.g. health, environment, climate, local food and increased self-sufficiency of food in the city of Oslo) and costs (e.g. areas that are used for other purposes need to be adapted to UA, and teaching and guidance of different types of UA are needed) related to the expansion of UA in Oslo; (3) description of assumed scenario and key questions; and (4) questions related to socio-economic information of the respondents, including age, education, income, and membership of environmental organizations.

Respondents were shown pictures related to different forms of UA with a brief explanation:



Figure 1. Community parcels for the habitants of Oslo (Photo: Sebastian Eiter)

This initiative is to arrange suitable areas, run the community gardens and provide teaching and guidance for the users. The intention is that renting a parcel in a community garden should be strongly subsidized to the habitants of Oslo and allocated through a queue system.

This initiative is to arrange suitable areas, run the community gardens and provide teaching and guidance for the users.



Figure 2. Community gardens for kinder gardens, education and labour training (Photo: Ester J. Veen)



This initiative is to arrange suitable areas for vertical farming of vegetables. The production will be done by commercial parties.

Figure 3. Vertical farming of vegetables (Photo: Randi Seljåsen)



This initiative is to arrange suitable areas for production of vegetables with aquaponics. The production will be done by commercial parties.

Figure 4. Vegetable farming with aquaponics (Photo: Randi Seljåsen)

For each of the four types of UA the following question was asked: *Assume that resources for UA may be earmarked, i.e. through a trust, how much will you personally be willing to contribute to each of the four proposed initiatives? Please state the maximum amount you will be willing to contribute through increased taxes.*

A payment card approach was used to retrieve the maximum willingness to pay. Each of the participants checked one of the following: Nothing, 10 NOK, 20 NOK, 50 NOK, 100 NOK, 200 NOK, 500 NOK, 1000 NOK, More than 1000 NOK. Table 1 summarizes the frequencies for the willingness to pay in the four cases.

Table 1. Frequencies of Maximum willingness to pay for each of the four types of UA

WTP (NOK)	UA for the population (%)	UA for education and training (%)	Vertical production (%)	Aquaponics (%)
Nothing	28	24	33	35
10	7	7	7	9
20	8	8	8	7
50	12	14	12	13
100	15	17	15	15
200	13	11	10	9
500	10	12	8	8
1000	4	4	4	3
More than 1000	3	3	2	2

About 50% of the sample is willing to pay between 50 and 500 NOK a year in terms of increased taxes for each of the four types of urban agriculture. Most popular is UA for kinder gardens, educating and training, and less popular is contributing to aquaponics for commercial production of vegetables. Between 24% and 35% are not willing to contribute to some of the four different types of UA.

3.2 Empirical methods

To analyse the WTP from the survey data, we assume that the true value of the WTP for each participant lies somewhere between the indicated value and the value above (Cameron and Huppert, 1989). Since we don't know how much the individuals who responded that they are willing to pay more than 1000 NOK in fact are

willing to pay, we need to take this censored data into account. To find the mean with a censored value, we estimate the expected value and the standard deviation with maximum likelihood.

Assuming that WTP is normally distributed censored values can be included in the likelihood function in the following way: If y_i is the observed value of a variable for person i , y_i^* is the true value and C is the censoring point:

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* \leq C \\ C & \text{if } y_i^* > C \end{cases} \tag{1}$$

The contribution to the likelihood function (the probability of y_i^* greater than the censoring point) is the area above the censoring point of the standard normal:

$$P(y_i^* > C) = \int_C^\infty \phi(y_i^*|\mu, \sigma) = 1 - \Phi\left(\frac{C - \mu}{\sigma}\right) = \Phi\left(\frac{\mu - C}{\sigma}\right) \tag{2}$$

Where ϕ is the probability density function (pdf) of the standard normal, Φ is the cumulative distribution function (cdf) of the standard normal, μ is the expectation of y_i^* , and σ is the standard deviation of y_i^* . Then the likelihood function is given by

$$L = \prod_{y < C} \phi\left(\frac{y_i - \mu}{\sigma}\right) \prod_{y = C} \Phi\left(\frac{\mu - C}{\sigma}\right) \tag{3}$$

In our case, according to Cameron and Huppert (1989), we use the midpoint between the WTP indications as data: Nothing is set to 5, 10 is set to 15,....., 500 is set to 750, 1000 remain 1000. Our likelihood function is given by:

$$L = \prod_{y \leq 1000} \phi\left(\frac{y_i - \mu}{\sigma}\right) \prod_{y > 1000} \Phi\left(\frac{\mu - C}{\sigma}\right) \tag{4}$$

4 Results

To estimate the mean and standard deviation in (4) we modified the algorithm in Gelman and Hill (2007, p 404-405) to maximize the likelihood function for the four UA cases (Table 2). We also include a minimum version of WTP which is estimated assuming that the individuals' maximum WTP is in fact the one indicated. 0,10,20,..., 1000. And we assume the minimum above "More than 1000 NOK" is 1001 NOK.

Table 2. Willingness to pay for urban agriculture in the censored normal model, and the minimum model.

	Censored normal mean (NOK)		Minimum mean (NOK)	
	Mean WTP	sd	Mean WTP	sd
UA for the people of Oslo	227.02	307.98	164.32	262.31
UA for education purposes	235.53	313.55	170.46	263.59
Vertical production	188.33	287.89	136.91	246.51
Aquaponics	173.16	275.58	124.81	233.67

The expected mean WTP among the citizens of Oslo is between 173 and 236 NOK per person per year for each of the four UA cases. The respondents are most willing to contribute for UA intended for education purposes with 236 NOK per person per year. It is assumed that the individuals say yes to the bid they chose, and no to the next highest bid. It means their true WTP is somewhere between the chosen value and the higher value that was not chosen. Here we used the midpoint between the chosen value and the higher not chosen as the true WTP. In case this assumption is not true, we also calculated lower bounds of the mean WTP (Minimum Mean) for each of the four UA cases. This is done by calculating the mean and standard deviation directly from the data using nothing=0, 10=10,, 1000=1000, and more than 1000=1001. The mean and standard deviations are shown in the two columns to the right in table 2. Table 2 shows that the minimum values are 50 to 60 NOK below the expected values from the censored normal mean model.

We believe that males and females may see things differently, and hence may also be the case for their WTP for UA. We also believe that people who have been affected by the Covid-19 pandemic might see things differently than those not affected. Finally, individuals with a positive attitude towards environmental questions might have different WTP for UA than those who don't have that attitude.

To test for differences in gender WTP, the data set was divided into two, one sample consisting of males and one sample consisting of females. For each data set, the likelihood function in equation 4) was maximized to find the WTP for each of the UA cases. The t-test

$$t_c = \frac{\overline{WTP}_1 - \overline{WTP}_2}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{n_1 + n_2}}} \tag{5}$$

where t_c , $c=1,2,3,4$ for each of the four UA cases. \overline{WTP}_1 is male \overline{WTP}_2 is female, σ_1, σ_2 are the standard deviations for WTP in the two samples and n_1, n_2 are the respective sample sizes.

As for the differences in WTP between those who were and were not affected by covid-19, the sample was divided according to the following survey question: "Covid-19 has to a large degree influenced my daily routine." To that question the individuals responded totally agree, somewhat agree, somewhat disagree, totally disagree, and impossible to answer. The individuals who answered totally agree and somewhat agree was placed in sample 1, the others in sample 2, The WTPs were estimated by maximum likelihood and the t-tests in (5) were performed.

On the other hand, to test for differences in WTP between those who care and those who do not care about the environment, the sample was divided according to the following survey question: "I am concerned about what I personally can do to take care of the environment and the natural resources." The individuals responded totally agree, somewhat agree, somewhat disagree, totally disagree, and impossible to answer. The individuals who answered totally agree and somewhat agree was placed in sample 1, the others in sample 2, the WTPs were estimated by maximum likelihood and the t-tests in (5) were performed.

Since the sample is iid, and the two samples in each of the tests are independent, the t-statistics in (5) is t-distributed with $(n-1)$ d.f under the H_0 -hypotheses of no difference between the WTPs. The H_0 -hypotheses is rejected at 0.05 level when $|t| > 1.96$. The expected WTPs and the t-statistics are shown in table 3.

Table 3. Differences in mean WTP between individuals in different groups. Standard deviation in parentheses.

	Gender			Affected by covid-19			Attitude toward environment		
	Male	Female	Diff-t	Yes	No	Diff-t	Positive	Not positive	Diff-t
UA for the people of Oslo	227.72 (301.91)	226.37 (313.73)	0.07	232.97 (306.33)	210.82 (311.82)	1.00	240.38 (312.53)	152.40 (268.61)	3.63
UA for education purposes	231.67 (313.69)	239.23 (313.69)	-0.38	243.34 (312.32)	214.25 (315.83)	1.30	253.05 (322.51)	138.78 (238.91)	5.14

Vertical production	190.66 (293.17)	186.13 (282.83)	0.25	191.81 (289.34)	178.80 (283.55)	0.64	203.21 (296.22)	105.63 (219.13)	4.78
Aquaponics	174.33 (276.09)	172.04 (275.09)	0.13	172.61 (267.71)	174.88 (296.72)	-0.11	185.71 (284.78)	103.52 (204.91)	4.28
n	492	513		735	270		852	153	

The H0-hypotheses of no difference in WTP is not rejected for gender. The same is true for those who are affected/not affected by covid-19. For the tests of differences in WTP between those with positive attitude and those with not positive attitude towards the environment the H0-hypotheses are rejected for all the four UA cases. The differences in WTP are between 80 and 120 NOK per year per person in the two groups.

5 Implications and discussion

According to Statistics Norway (2020), Oslo has 693 494 inhabitants as of January 1. 2020. Of these, 554 352 individuals were between 18 and 88 years old. If we assume that all these persons pay taxes, we can calculate the potential for yearly increased taxes to pay for the expansion of urban agriculture in Oslo. We multiply the mean values in table 2 with the number of habitants in Oslo and get table 4.

Table 4. Potential for increased taxes to pay for urban agriculture in Oslo.

	Censored Normal Mean WTP (Millions NOK)	Minimum Mean WTP (Millions NOK)
UA for the people of Oslo	125.8	91.1
UA for education purposes	130.6	94.5
Vertical production	104.4	75.9
Aquaponics	96.0	69.2

The potential for increased taxes amounts to between 96 million NOK and 131 million NOK for the four different types of UA. Not surprisingly we found a significant positive association between “engagement in environmentally-friendly behavior” and “willingness to support urban agriculture”. Gender differences or differences due to covid-19 affection were not significant. The UA for education seems to be the most favored type of UA among the respondents. Meanwhile the censored mean WTP for the purpose to set aside areas to UA for the people of Oslo gave the second largest score. The technical solutions using “vertical production” and Aquaponics run by commercial firms received the lowest support as revealed by the respondents’ WTP. If there is zero/no support included in the calculated mean WTP (Minimum mean WTP), vertical production WTP and Aquaponics WTP is the lowest. The standard deviation for the mean and censored mean is quite large in all cases. The reason might be the existence of income-effect, where the response might be higher WTP if the family income is high. Moreover, the age of the respondent could have a high impact. Finally, our results hinge on both the correctness of the respondent’s answers and on our model.

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