INNOVATIVE INDOOR FARMING APPLICATIONS FOR FUTURE URBAN FARMERS

Erasmus+

Social and Environmental Sustainability of Urban Agriculture

Project number: 2019-1-FR01-KA202-062337 “This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein”

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General information about the module

Module n° 3

TITLE: Social and Environmental Sustainability of Urban Agriculture

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Introduction

This module describes the social and environmental benefits of urban agriculture. The ecosystem services approach is used to frame the benefits society obtains from urban agriculture (provisioning, regulating, supporting and cultural services).
First, the module introduces the concept of ecosystem services and define the different types of ecosystem services provided by urban agriculture. It gives examples of ecosystem services provided by urban agriculture and gives some recommendations on urban agriculture planning to improve benefits.

Duration:

8 hours – The duration of this module is four hours of the lesson and four hours the practice of the exercises.

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Learning outcomes

On successful completion of Learning Unit 3 participants should be able to…

Knowledge	Technical skills	Soft skills
● Understand the concept of ecosystem service. ● Know the different types of ecosystem services. ● List potential ecosystem services provided by urban agriculture.	● Design an urban agriculture area to improve the provision of certain ecosystem services such as habitat for species, pollination and seed dispersal, recreation, health, or cognitive development.	● Appreciate the social and environmental benefits of urban agriculture. ● Communicate the social and environmental benefits of urban agriculture.

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Main Content and resources

CHAPTER 1. Urban agriculture and the provision of ecosystem services

Urban agriculture contributes to increase quality of life in cities by generating a diversity of ecosystem services. **Ecosystem services** are the direct and indirect contributions of ecosystems to human well-being (**TEEB, 2010**). For example, climate regulation by urban green infrastructures is a service because it contributes to human thermal comfort, which is a benefit. Examples of urban ecosystem services also include food, habitats for biodiversity or cultural landscapes for human enjoyment, among others.

The term ecosystem services were popularized by the **Millennium Ecosystem Assessment** (**MA, 2005**). Called for by United Nations Secretary-General Kofi Annan in 2000 in his report to the UN General Assembly, *We the Peoples: The Role of the United Nations in the 21st Century*, the Millennium Ecosystem Assessment was carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being.

Figure 1. The Millennium Ecosystem Assessment, published in 2005, is a major assessment of the consequences of ecosystem change for human well-being. Urban ecosystem services are addressed in chapter 27.

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The Millennium Ecosystem Assessment (**MA, 2005**) and The Economics of Ecosystem Services and Biodiversity (**TEEB, 2010**) grouped ecosystem services in four major categories: provisioning, regulating, supporting, and cultural:

- **Cultural services** are the non-material benefits people obtain from ecosystems. Examples include spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience as well as their role in supporting knowledge systems, social relations, and aesthetic values.

- **Provisioning services** include all the material products obtained from ecosystems. Some examples are food and fiber, genetic resources, and fresh water.

- **Regulating services** include all the benefits obtained from the regulation by ecosystem processes, including the regulation of climate, water, and some human diseases.

- **Supporting services** are those that are necessary for the production of all other ecosystem services, such as biomass production, nutrient cycling, water cycling, provisioning of habitat for species, and maintenance of genetic pools and evolutionary processes.

In what follows we will describe how urban agriculture contributes to the provision of ecosystem services. The following table shows a general description of essential ecosystem services provided by urban agriculture using the Millennium Ecosystem Assessment classification framework (**Table 1**):

Table 1. Ecosystem services provided by urban agriculture.

Ecosystem service	Definition	Urban examples	
Cultural	Intangible benefits from ecosystems		Recreation
			Health
			Cognitive development and collective memory
			Social cohesion and integration
Provisioning	Goods obtained from ecosystems		Food supply

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Regulating	Benefits obtained from ecosystem processes		Climate regulation
			Pollination and seed dispersal
			Air quality
			Noise reduction
			Water runoff mitigation
Supporting	Ecological functions underlying the production of ecosystem services		Habitat for species

The following infographic represents a hypothetical urban agricultural area showing the different ecosystem services potentially provided (**Figure 2**).

Figure 2. Ecosystem services provided by urban agriculture.

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CHAPTER 2. Essential ecosystem services provided by urban agriculture

2.1. Cultural services

Cultural services are intangible benefits humans obtain from ecosystems (**TEEB, 2010**). Important cultural services provided by urban agriculture are described below.

Recreation

Recreational aspects of urban agriculture are valued ecosystem service in cities. Urban agriculture provides a great opportunity for physical exercise in a green space, and lets people relax (**Zasada, 2011**).

The use of urban agriculture as recreational areas can be improved by building public infrastructure such as benches or “quiet areas” for nature contemplation. Also, ensuring accessibility by older participants and children with adequate pathways can be a good practice to enhance recreation. Also, including informative panels explaining ecosystem services provided by urban agriculture, and agricultural species and practices being used, can improve both recreation and collective memory (see below).

Health

An important service provided by urban agriculture is the increase of physical and mental health (**Brown and Jameton, 2000**). Participating in urban agriculture enhance human health and well-being since it provides an important opportunity for physical exercise and to reduce stress by providing a sense of peaceful and tranquility.

For example, **van den Berg et al.** (**2010**) found that proximity of an individual’s home to green spaces decreased stress-related health problems. Other study developed in Atlanta (USA) highlighted the beneficial effect of several neighborhood’s biophysical aspects such as trees and green areas with decreased of mental illness (**Brogan, 1980**).

Similar to recreational services, increased physical and mental health provided by urban agriculture can be improved by enhancing the capacity of agricultural areas for physical exercise and reduction of stress. Building pathways to walk around the agricultural area

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and designing specific areas for nature contemplation can be an adequate strategy to achieve this goal.

Cognitive development and collective memory

Urban agriculture provides multiple opportunities for cognitive development. It plays a critical role in recovering practical knowledge related to food production, thus reducing what it is known as the “extinction of experience” of human–nature interaction and a collective ‘forgetting’ of how to grow food and manage the regulatory ecosystem services required to do so (**Barthel et al., 2010**).

Examples include the common practice of protecting insectivorous bird habitats and supporting pest regulation. Knowledge, experience and practice opportunities provided by urban agriculture can be used by environmental educators to develop affective links to urban ecosystems and to restore and maintain social-ecological memory, i.e. the interlinks between human actions and ecological processes.

The benefits of preserving a collective memory of food production have been highlighted in terms of increased resilience and adaptive capacities in urban systems, and the potential to sustain ecosystem services, like food in times of crisis.

As more of the world population live in urban areas with less interaction with the nature and its phenomena, the 21st century children are in need of being taught these cultural, natural and collective heritages. Urban agriculture applications by non-professional city habitants provide an informal learning context for these children. Mentorship training, where older experienced gardeners teach the younger, is especially important for transmission of knowledge related with food production. A diversity of garden typographies helps to attract different age-groups and ethnicities.

Social cohesion and integration

Urban agricultural areas are spaces for social interaction with other gardeners, neighbours and city inhabitants; where relations of solidarity, community cohesion and mutual support are strengthened (**Camps-Calvet et al., 2016**). Thus, participation in urban agriculture can give rise to important societal benefits such as social cohesion (i.e., people’s willingness to cooperate with one another), integration, promotion of shared interests, neighborhood participation, and defining identity and sense of community.

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Imece tradition in Turkey is a good example of enhancing solidarity and social economy through social working. Imece is a labour exchange system without financial payments. Urban agriculture develops social solidarity and collective work by reviving the Imece culture in urban contexts among neighbors.

Promoting participation of low income and older adults is important for the social integration of less privileged social strata and people that are threatened by social exclusion. Urban agriculture is an opportunity to promote social integration of elders and less privileged social groups. An adequate physical design of urban agricultural areas and the promotion of participatory activities can enhance opportunities to reduce social isolation and loneliness.

2.2. Provisioning services

Provisioning services include all the material products obtained from ecosystems (**TEEB 2010**). Food, considered as a provisioning service, is an important good obtained by urban agriculture.

Food supply

Urban agriculture provides a source of food. Although, urban agriculture only produces a small share of urban production, it can play an essential role in food security and resilience, especially during periods of crisis. Also, urban agriculture represents an opportunity to use old or non-commercial varieties of seeds, which is beneficial for the conservation of crop genetic resources.

Increasing knowledge on urban agriculture and production of fresh horticultural goods in urban areas is the first step to enhance the role of urban agriculture in food security and urban resilience.

2.3. Regulating services

Regulating services include all the benefits obtained from the regulation by ecosystem processes. Important regulating services provided by urban agriculture are described below.

Climate regulation

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Vegetation in urban out-door agricultural areas regulates local temperatures and buffers the effects of the so-called “urban heat island effect” which consists of local rises in the temperature of city areas caused by heating and traffic in combination with heat absorption by built surfaces (**Moreno-Garcia, 1994**). Vegetation reduces temperature through shading and through absorbing heat from the air by evapotranspiration.

Urban out-door agriculture is in addition reducing the adverse effects of climate change (**Demuzere et al., 2014**), for example by balancing water flows to alleviate flooding, providing thermal comfort and reduced energy use by shading vegetation, and supporting coping capacities by providing people with opportunities to grow food for themselves. Likewise, urban agriculture contributes to climate change mitigation as its green biomass can function as carbon storage.

Pollination and seed dispersal

Pollination and seed dispersal are critical processes for the long-term durability of natural ecosystems. However, pollinators and seed dispersers are threatened by habitat loss and fragmentation due to urban expansion. Adequate management practices in urban out-door agriculture can host important populations of birds and bees, thus enhancing pollination and seed dispersal (**Andersson et al., 2007**; **Elmqvist et al., 2013**).

Urban agriculture can be also beneficial for the preservation of crop genetic resources by using local and endemic seeds from local farmer and rural enviroment.
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Air quality

Urban agriculture can improve air quality through filtration of pollutant particles through leaves from the atmosphere generated by transport, industry, domestic heating, and waste incineration like including ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 10 μm (PM10) (**Escobedo et al., 2011**; **Gómez-Baggethun and Barton, 2013**). Air pollution is responsible for increases in respiratory and cardiovascular diseases in cites (**Sunyer et al., 2001**).

Noise reduction

Traffic, construction and other human activities make noise a major pollution problem in cities, affecting health through physiological and psychological damages. Agricultural soil

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and trees in urban areas can attenuate noise pollution through absorption, deviation, reflection, and refraction of sound waves (**Fang and Ling, 2003**).

Water runoff mitigation

Urban agriculture vegetation reduces surface runoff following precipitation events by intercepting water through the leaves and stems (**Villarreal and Bengtsson, 2005**). The underlying soil also increase infiltration rates by acting as a sponge by storing water in the pore spaces until it percolates.

2.4. Supporting services

Supporting services refer to all the ecological functions underlying the production of ecosystem services (**TEEB, 2010**). Urban agriculture can play a significant role as habitat for many species.

Habitat for species

Urban agricultural systems can play a significant role as refuge for many species of birds, amphibians, bees, and butterflies (**Melles et al., 2003**; **Müller et al., 2010**) which contribute to the provision of other related ecosystem services such as pollination or recreation.

Biodiversity in urban agricultural areas can be increased by creating diversity of habitats and nesting places, and using management practices compatible with biodiversity conservation such as organic production.

CHAPTER 3. Ecosystem disservices

Urban agriculture not only produce ecosystem services, but also ecosystem disservices, defined as “functions of ecosystems that are perceived as negative for human well-being” (**Lyytimäki and Sipilä, 2009**). For example, some tree and bush species emit volatile organic compounds (VOCs) which can contribute to urban smog and ozone problems through CO and O_3 emissions (**Geron et al., 1994**; **Chaparro and Terradas, 2009**).

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Urban biodiversity can also cause damages to physical infrastructures (**de Stefano and Deblinger, 2005**; **Lyytimäki and Sipilä, 2009**); microbial activity can result in decomposition of wood structures and bird excrements can cause corrosion of stone buildings and statues. The root systems of vegetation often cause substantial damages by breaking up pavements and some animals are often perceived as a nuisance as they dig nesting holes. Green-roof runoff may contain higher concentrations of nutrient pollutants, such as nitrogen and phosphorus, than are present in precipitation inputs.

Further disservices from urban ecosystems may include health problems from wind-pollinated plants causing allergic reactions, fear from dark green areas that are perceived as unsafe, presence of rats, wasps, and mosquitos associated with agricultural areas, diseases transmitted by animals (e.g., migratory birds carrying avian influenza, dogs carrying rabies), and blockage of views by trees.

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Key Concepts and Vocabulary

Biodiversity: Variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity).

Collective memory: Memories or knowledge shared by members of a distinct social group—is maintained and fostered in social groups such as communities, settlements, professional groups and religions.

Cultural services: Non-material benefits people obtain from ecosystems (e.g., cognitive development, recreation).

Ecosystem disservices: Functions of ecosystems that are perceived as negative for human well-being.

Ecosystem services: Benefits humans derive from ecosystems, such as, food, air quality, or recreation.

Extinction-of-experience: Ongoing generational amnesia among city peoples about their relationships to, and dependence upon, diverse ecosystems.

Food security: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports.

Millennium Ecosystem Assessment: Major assessment of the consequences of ecosystem change for human well-being (https://www.millenniumassessment.org).

Provisioning services: All the material products obtained from ecosystems (e.g., food, fiber, genetic resources, fresh water).

Regulating services: Benefits obtained from the regulation by ecosystem processes (e.g., regulation of climate).

Supporting services: Services necessary for the production of all other ecosystem services (e.g., nutrient cycling, provisioning of habitat for species, maintenance of genetic pools and evolutionary processes).

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Resilience: Is the capacity of a system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions.

Social-ecological systems: Are complex, integrated systems in which humans are part of nature. Urban agricultural areas are an example of social-ecological systems.

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Evaluation section

1. The term ecosystem service was popularized by:
    a. The UN Environment Programme
    b. The Economics of Ecosystems and Biodiversity
    c. The Millennium Ecosystem Assessment

2. The term ecosystem service was popularized in:
    a. 1980
    b. 2010
    c. 2005

3. Urban ecosystem services are:
    a. Direct contributions of urban ecosystems to human well-being
    b. Indirect contributions of urban ecosystems to human well-being
    c. Both a and b are correct

4. The Millennium Ecosystem Assessment:
    a. Assess the consequences of ecosystem change for human well-being
    b. Popularized the term ecosystem services
    c. Both a and b are correct

5. Ecosystem disservices are:
    a. Functions of ecosystems that are perceived as negative for human well-being
    b. Factors that reduce the potential of urban agriculture to produce ecosystem services
    c. Neither a or b are correct

6. Cultural services are:
    a. All the material products obtained from ecosystems
    b. The non-material benefits people obtain from ecosystems
    c. Those that are necessary for the production of all other ecosystem services

7. Provisioning services are:
    a. All the material products obtained from ecosystems
    b. The non-material benefits people obtain from ecosystems
    c. All the benefits obtained from the regulation by ecosystem processes

8. Regulating services are:
    a. The non-material benefits people obtain from ecosystems

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b. Those that are necessary for the production of all other ecosystem services
c. All the benefits obtained from the regulation by ecosystem processes

9. Supporting services are:
   a. All the material products obtained from ecosystems
   b. Services required for the production of all other ecosystem services
   c. All the benefits obtained from the regulation by ecosystem processes

10. Resilience is:
   a. The capacity of a system to absorb or withstand perturbations
   b. Similar to the term sustainability
   c. Both a and b are correct

11. Cognitive development is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Provisioning service provided by urban agriculture
   c. Supporting service provided by urban agriculture

12. Collective memory is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Regulating service provided by urban agriculture
   c. Supporting service provided by urban agriculture

13. Social cohesion is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Provisioning service provided by urban agriculture
   c. Regulating service provided by urban agriculture

14. Social inclusion is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Provisioning service provided by urban agriculture
   c. Supporting service provided by urban agriculture

15. Recreation is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Provisioning service provided by urban agriculture
   c. Supporting service provided by urban agriculture

16. Health is an example of a potential:
   a. Cultural service provided by urban agriculture
   b. Regulating service provided by urban agriculture

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c. Supporting service provided by urban agriculture

17. Biodiversity is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

18. Climate regulation is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

19. Human health is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Provisioning service provided by urban agriculture
    c. Supporting service provided by urban agriculture

20. Food supply is an example of a potential:
    a. Provisioning service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

21. Pollination is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

22. Seed dispersal is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Provisioning service provided by urban agriculture
    c. Regulating service provided by urban agriculture

23. Water runoff mitigation is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

24. Air quality is an example of a potential:
    a. Provisioning service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

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25. Noise reduction is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

26. Habitat for species is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

27. Spiritual enrichment is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Provisioning service provided by urban agriculture
    c. Regulating service provided by urban agriculture

28. Aesthetic experience is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Provisioning service provided by urban agriculture
    c. Supporting service provided by urban agriculture

29. Water supply is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Provisioning service provided by urban agriculture
    c. Regulating service provided by urban agriculture
    d. Supporting service provided by urban agriculture

30. Fiber supply is an example of a potential:
    a. Provisioning service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

31. Nutrient cycling is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

32. Biomass production is an example of a potential:
    a. Provisioning service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

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33. Water cycling is an example of a potential:
    a. Cultural service provided by urban agriculture
    b. Regulating service provided by urban agriculture
    c. Supporting service provided by urban agriculture

34. Goods obtained from urban agriculture are:
    a. Cultural services
    b. Provisioning services
    c. Regulating services

35. Benefits obtained from ecosystem processes are:
    a. Provisioning services
    b. Regulating services
    c. Supporting services

36. Ecological functions underlying the production of ecosystem services are:
    a. Cultural services
    b. Provisioning services
    c. Supporting services

37. Intangible benefits from ecosystems are:
    a. Cultural services
    b. Regulating services
    c. Supporting services

38. Urban smog is an example of:
    a. Regulating service
    b. Supporting service
    c. Ecosystem disservice

39. Decomposition of wood public infrastructures is an example of:
    a. Supporting service
    b. Ecosystem disservice
    c. Regulating service

40. Local temperature control is an example of urban out-door agricultural areas regulates local temperatures
    a. Supporting service provided by urban out-door agriculture
    b. Regulating service provided by urban out-door agriculture
    c. Both a and b are correct

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Activities (optional) / Exercises

1. Following the urban agriculture infographic of Figure 2, design your own urban agricultural area and highlight the different ecosystem services provided.
2. Go to a nearby urban agricultural area and think of strategies or infrastructures that could be used to improve the provision of important provisioning, regulating, supporting, and cultural services.
3. Go to a nearby urban agricultural area and find elements important for the provision of provisioning, regulating, supporting, and cultural services.

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Useful resources for the lesson

InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs)

ARIES (ARtificial Intelligence for Ecosystem Services)

Ecosystem Services Partnership (ESP)

Food and Agriculture Organization of the United Nations (FAO)

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

Millennium Ecosystem Assessment

The Economics of Ecosystem Services and Biodiversity (TEEB)

Resilience Alliance: https://www.resalliance.org/

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