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The economic performance of urban gardening in three European cities – examples from Ljubljana, Milan and London

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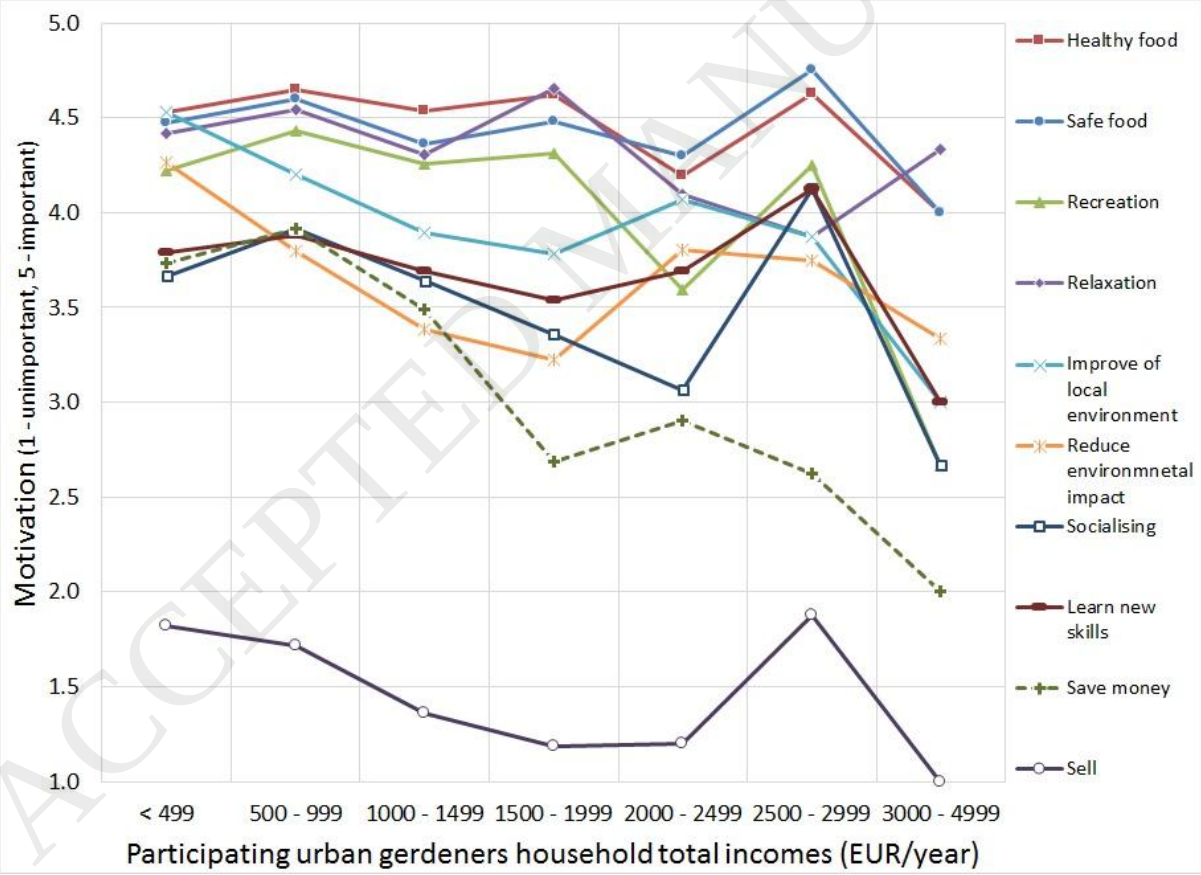
Graphical abstract



Highlights

- Labour is a non-monetised resource invested by citizens in to ecosystem services.

- Natural conditions in cities enable productivity comparable to market farming.
- Increased garden areas, productivity and labour input generate self-sufficiency.

INTRODUCTION

Urban gardening in allotments and back gardens is an increasingly popular subject in scientific literature, receiving considerable attention in various scientific disciplines: geography (28% of reviewed literature), spatial planning and the environment (24%), society and culture (23%), health (12%), education (9%), economy (3%) and natural sciences (1%) (Guitart et al., 2012).

Practical examples of urban gardening show that it can serve as a solution to urban challenges such as social inclusion of marginalised groups, health issues, accessibility to green spaces, and restoration of degraded urban areas (Alaimo et al, 2010; Flachs, 2010; Barthel et al., 2015; Veen et al., 2016; Cabral et al., 2017). It also increases awareness of food quality, food safety and the importance of self-sufficiency (Kortright and Wakefield, 2011; Eigenbrod and Gruda, 2015; Cabral et al., 2017; Langemeyer et al., 2018). The potential of urban gardening was recognised by the World Food and Agriculture Organization (FAO, 2007) as it can directly and indirectly contribute to meeting the Millennium Development Goals (MDG), especially Goal 1, by sustainably impacting poverty alleviation and food security, and Goal 5, environmental sustainability.

Urban food cultivation is generally associated with markets and farmers' markets, limited land space, a fierce contention for land, as well as a reliance on urban organic solid waste or water for soil efficiency (van Veenhuizen, 2006). It can also potentially use various agricultural inputs such as mineral fertilisers, plant-protection products, water (waste and fresh) and soils. However, institutional regulations and designation in city spatial plans are advised in order to avoid the potential risks of contamination of produce and drinking water resources (Mougeot, 2000).

According to the FAO (2018), urban gardening is well suited to cities, as vegetables with a short production cycle can be harvested in as little as 60 days after planting; "garden plots can be up to 15 times more productive than crop fields as one square metre can provide up to 20 kg/year" of vegetable produce; cost of transportation, packaging and storage can be lower and with direct accessibility, the food chain is shorter. Growing food in cities is made difficult by a number of threats like consumption of fruits and vegetables grown in more polluted environment, pressure on already (potentially) limited water resources, and the introduction of invasive plant species.

Nonetheless, a review of studies on this subject, show that only a minority deal with detailed economic analyses of urban gardening. Studies made on three West African cities, Kano (Nigeria), Bobo Dioulasso (Burkina Faso) and Sikasso (Mali), indicate that urban and peri-urban vegetable gardens show a high variability in economic performance among these cities and countries (Abdulkadir et al., 2015). High variability in productivity was attributed to dynamic processes often driven by business models, socio-economic models in the city or country, and weather conditions between seasons. Gardeners from Guelph, Ontario, Canada, overpay to grow their own food (as much as 39% more) not even taking into account labour hours (CoDyre et al., 2015). To grow a year's supply of vegetables for one adult person, Guelph gardeners would need to invest 3.5 weeks of full-time labour at the current rate of production efficiency. Average yields produced by gardeners in Laramie, Wyoming, USA, in the majority of cases, are not enough to supply a family or even one adult person with the recommended daily amount of vegetables for a year (Conk and Porter, 2016). Gardeners from

Melbourne, Australia, produce an enormous diversity of harvested food, as well as obtaining extremely high levels of productivity from relatively small domestic spaces with notable surpluses from 10% to 25% (Zainuddin and Mercer, 2014). The production of tomatoes in urban community gardens and intensive commercial production systems in Cleveland, Ohio, over a period of two years, showed no differences in tomato fruit yields between both production types (Reeves et al., 2014). Results similar to intensive production – producing 15 kg/m^2 and a savings of 14.6 EUR/m^2 – were found by Wieneke (2017) in a controlled experimental urban garden in Lincoln, Nebraska. Even though urban gardening provides many opportunities and benefits, which are well documented (Guitart et al., 2012), there is a knowledge gap specifically on the economics of food crop production in European urban systems.

The main aim of this study is to analyse European urban gardeners' economic performance and self-sufficiency on a household level, as well as to reach a better understanding of their contribution to food self-provision and food security in the metropolitan areas. To detail the goal further, specific research questions were set to investigate the productivity of gardens, invested labour hours in garden management, avoided costs or savings, self-sufficiency potential per household and self-provision potential per city level, and the importance of gardeners' motivation and skills for the cities' social capital. To this end, we make use of case-study cities to explore the economic dimension and estimated production potential of their allotment gardens

MATERIALS AND METHODOLOGY

Study areas

The selection of case-study cities was made to meet the wider goals of the EU FP7 research project 'Food Planning and Innovation for Sustainable Metropolitan Regions' (FoodMetRes). The selected cities represent three different climatic regions (Atlantic, Mediterranean and Continental) as well as three historically different urban gardening backgrounds.

Ljubljana (164 km^2) with 0.28 million citizens is the capital of the Republic of Slovenia and administratively, a part of the Municipality of Ljubljana. Urban gardens are an important feature of the city with a long and interesting past that makes them a coherent part of urban space, particularly as the oldest gardens are protected as cultural heritage. Organised urban gardening started at the end of the 19th century and expanded between the First and the Second World Wars and even further after the Second World War, due to the expansion of residential areas and inflow of newcomers from rural areas, making it necessary to provide a minimum subsistence level for economically vulnerable social groups. In 1984, allotment gardens spread across 200 ha of the city area, in 1995, 257 ha, in 2005, 186 ha, and in 2008, 130 ha (Jamnik et al., 2009). A decrease in the surface area of allotment gardens was recorded when a new municipal spatial plan came into force that clearly defined areas on public land suitable for allotment gardens. Unsuitable areas were developed as city parks, industrial zones or new housing areas. Most recent spatial analysis of aerial images in 2014 (Figure 1) shows that allotment gardens (excluding home gardens) cover a gross area of 159 ha (with infrastructure, pathways, storage areas) and a net production area of 143 ha (Glavan et al., 2015; Volk, 2017).

Greater London (1,595 km^2) has a population of about 8.8 million people and about 14 million in the metropolitan area, and it is one of the largest and most ethnically diverse cities in Europe. Although urban gardening dates back hundreds of years, the allotment model of today is a result of rapid industrialisation, with land given over to the labouring poor for the

provision of food growing (NSALG, 2015). The first Allotments Act came into force in 1908, placing duties on local authorities to provide sufficient allotments to meet demand. In 1996 and 2006 the number of allotments sites in London was 769 and 737 respectively; most of which had waiting lists. Most recent spatial analysis of aerial images in 2014 (Figure 1) show that allotment gardens, approximately 661 sites, (excluding home gardens) cover a gross area of 895 ha and a net production area of 806 ha (Glavan et al., 2015; Volk, 2017). The decrease in the number of sites is connected with major development projects. In recent years, the City of London Capital Growth project observed an increase in the number of community gardens, balcony gardens and rooftop gardening; however, allotment gardening still prevails (CG, 2014).

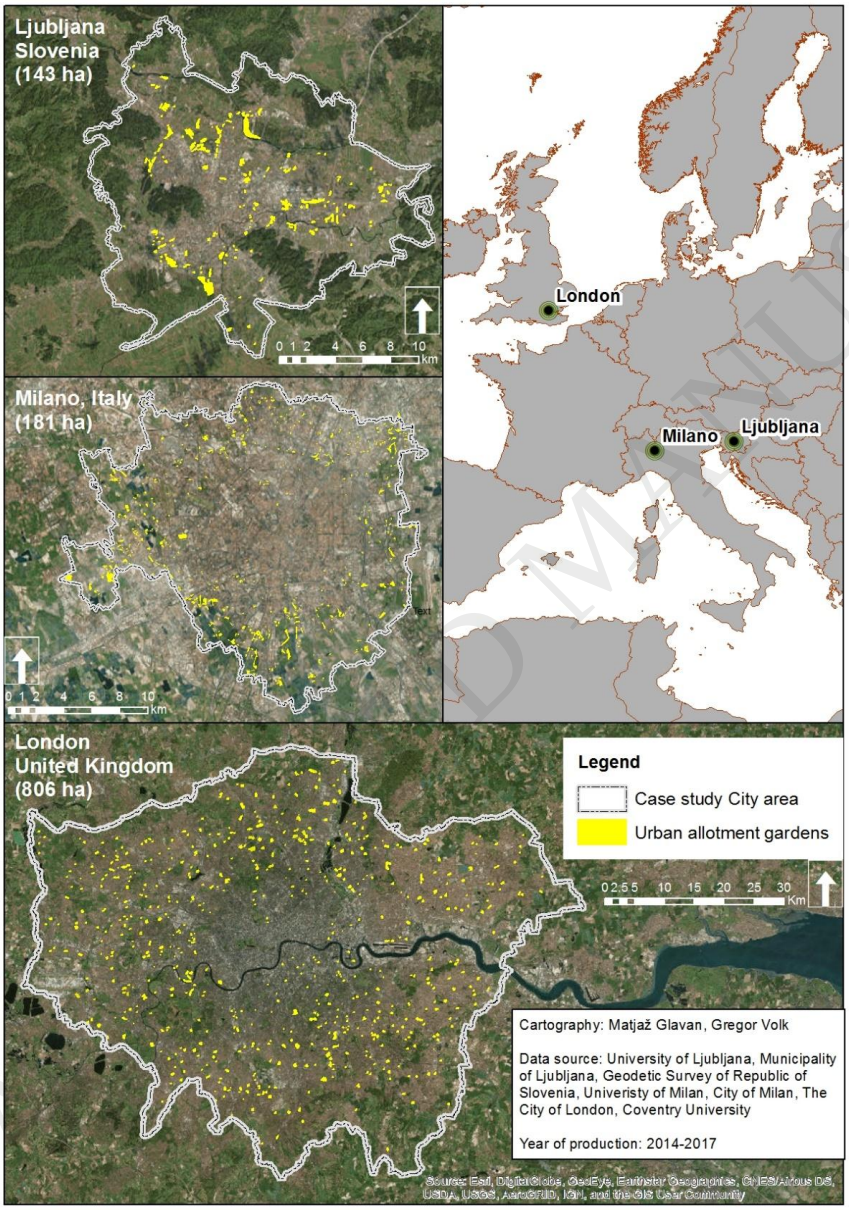


Figure 1: Study areas with from aerial images identified locations of urban allotment gardens in 2014

Milan (182 km^2) has a population of about 1.3 million people, and over 4 million in the metropolitan area. It is divided between the densely populated and highly urbanised north of the city and the more rural southern part. Urban gardening in Milan traces back to the first decades of the 19th century. Between the two World Wars an expansion of home gardens was

observed, from 800 in 1933, to approximately 4,000 in 1941, in response to a self-sufficiency policy (Roditi, 1982). After the Second World War, gardening declined until the 1960s, when it started to increase again. In the 1980s gardens accounted for more than 254 ha in the early 2000s, 180 ha and in 2014, 170 ha (Pollastri, 2008; Cattivelli, 2014; Cognetti et al., 2014). Most recent spatial analysis of aerial images in 2014 (Figure 1) shows that allotment and family gardens cover a gross area of 201 ha and a net production area of 181 ha (Glavan et al., 2015; Volk, 2017).

All three cities are members of the Milan Urban Food Policy Pact with the aim of developing sustainable food systems that are inclusive, resilient, safe and diverse, and that provide healthy and affordable food to all people (MUFPP, 2015). While London already had the London Food Strategy published in 2006 (LDA, 2006) with new strategies in preparation, and Milan, the Milan Food Policy from 2015 (CM, 2015), Ljubljana had no initial preparations in place.

Data collection methods

Data on land currently dedicated to urban allotment gardening was partly obtained from local municipalities (public land), while for the remaining gardens (private land) it was generated from high resolution digital aerial images (DOF) using ArcGIS (Figure 1). Detailed characterisation of urban allotment gardens was a two-stage process: (1) the visual analysis of aerial images by municipalities of documented urban gardens; and (2) the manual identification and land use classification of newly documented sites from high-resolution aerial images of the cities at a scale of 1:200 for evidence of allotment gardens (Glavan et al., 2015; Volk, 2017). Allotment gardens were defined as a garden area where a group of individually managed garden plots can be found. The gross and net area of allotment gardens was defined. The net area is calculated by subtracting the infrastructure (pathways, garden sheds, sanitary facilities, compost, car parks, bins, etc.) from the gross area, leaving only areas with actual food production.

The survey was performed via internet questionnaires (112), and with on-site personal interviews (68) to capture a population that is not used to the internet. In the analysis we included 180 participants (urban gardeners) – 105 from Ljubljana, 33 from Milan and 42 from London. Internet questionnaires were used in Ljubljana and London with a response rate of 14% and 22% respectively. In the case of London, we gathered data with the help of the online project Harvest-o-meter run by Capital Growth (CG, 2014). Recruitment of urban gardeners in Ljubljana and Milan was handled by the authors of this paper, with the help of conveniently selected responsive local garden associations, at their workshop events and via e-mail lists supplied by their administration. The survey was carried out between June and December of 2014. Community farms and city farms were excluded from this research as they are predominantly managed as businesses with employees and would skew averages drawn from urban gardening.

The questionnaire with 44 questions was developed to analyse the phenomenon of urban gardening with the aim of getting insight into specific positive and negative socio-economic externalities that urban gardening is bringing to their metropolitan areas. Questions were grouped in seven sub-groups, which addressed different perspectives: (a) growing space and type of production, (b) growing methods and behaviour, (c) skills and knowledge, (d) motivations for gardening, (e) contribution of gardening to food supply and household budget, (f) impacts of home growing, and (g) household demographic characteristics. The average time for completing the questionnaire was 45 minutes to one and a half hours.

In this research paper we focus on specific questions about economic perspectives of urban gardening. Urban gardeners had to specify their garden type: rental or any other fee payment

(EUR/year); garden space (m^2); crop type produced and estimation of produce (kg/ m^2 and number of plants); hours spent working in the garden (hours/week); main reasons for growing own food; proportion of household needs – i.e. percentage of vegetables for their own consumption; variable costs (EUR/year); the fate of surpluses. Socio-economic and other demographic questions included the number of household members, budget earmarked for food supply (EUR), average yearly household income (EUR), gender, age, education, working status etc.

Data analysis and calculation methods

The data on vegetables harvested was the most time-demanding and challenging for the gardeners to compile, as they usually do not measure yields or areas of growing spaces. For this, a reporting table was developed – as part of the questionnaire – where they were able to report on their vegetable production, as a harvested yield (e.g. 1 kg of tomatoes), or as a surface area of production (e.g. 1 m^2 of tomatoes), or as a number of individual plants (e.g. five tomato plants) in the last growing season. If any of the values was missing it was later converted with use of transfer table especially for this research, developed by an agricultural engineer specialised in vegetable production (Table 1). One table was used for all three case cities using numbers as are expected in profitable production with average yields.

The above data further served for the calculation of average harvest yields (kg) and productivity (kg/m^2) for average garden size (m^2). Productivity per area was recalculated to the number of servings produced in an average urban garden by using an adult person's and family's average daily needs for vegetable/fruit (servings/garden).

Labour hours were reported by participating gardeners as hours of work per week in the average growing season, between April and October (28 weeks). Labour costs were calculated as labour efficiency (hour/m2; kg; serving) multiplied by average hourly employee earnings (EUR/hour) for the average garden. Labour hours were recalculated to the total net area of allotment gardens as an estimation of labour value (EUR) invested by urban gardeners into food production in selected cities.

These values were further used to calculate the economic performance in terms of financial output (revenue), financial input (costs) and gross margin of production (excluding labour inputs). Revenue (EUR/year) was defined as the equivalent amount of money generated if produce was to be sold through supermarkets, and was calculated by multiplying yield (kg per average garden) and retail price of produce (EUR/kg). Data for the cost of gardening production, such as fertilisers, seed, seedling plants, plant protection products, rent, water, waste, and small equipment etc., were gathered from questionnaires. Gross margin (EUR/m^2) for the average urban garden was calculated as revenue minus costs. Results are presented for the average garden area, and per m^2 and for the total net area of the allotment gardens as observed from aerial images.

Average retail prices of conventionally (non-organic) produced crops (EUR/kg) were obtained from the national statistical offices of Slovenia, Italy, and the United Kingdom, and from major retail sellers and major local farmers' markets in 2014 (DEFRA, 2015; SURS, 2015; INS, 2015).

The number of servings produced in an average garden to meet the average daily vegetable/fruit needs of an adult person (400 grams – 5 × 80 grams), an average family (2 adults, 2 children) of 1300 grams (each child, 250 grams), was determined by the FAO/WHO recommendations (WHO, 2003).

EU average earnings statistics (EUR/hour) were obtained and combined with the participating gardeners' reported work hours in the garden (hour/week) to calculate the cost of labour (EUROSTAT, 2015).

Socio-economic and demographic characteristics (motivation, source of skills and knowledge, proportion of self-sufficiency, fate of surpluses, employment status, education, household income, budget earmarked for household food supply) were used to discuss their impact on productivity, labour input and the gross margin of vegetable production in urban gardens.

Table 1: Conversion table between average fresh yield (kg), area of production (m^2) and number of plants for selected vegetables grown in case studies

Vegetable type	**Production area (m^2) for 1 kg of yield**	**Number of plants**	**Average area productivity (kg/m^2)**
Cabbage	0.4	1	2.5
Carrots	0.15	15	6.7
Cherry Tomatoes	0.15	0.4	6.7
Courgettes	0.25	0.25	4
Cucumbers (salad)	0.125	0.5	8
Eggplant	0.25	1	4
Lettuce	0.25	3	4
Onions	0.2	10	5
Paprika	0.25	1	4
Potatoes	0.33	2	3
Radicchio	0.5	4	2
Squash/Pumpkins	0.5	0.5	2
Tomatoes	0.20	0.7	5

Uncertainties and limitations

Due to the data collection being based on online replies from a convenient sampling of urban gardeners, and due to the limited sample size in each case study, it is possible that the data reported by participants could limit how the data will represent averages for gardens in the case-study cities. The comprehensive and time-demanding reports on crop production has limited the number of other questions that could be asked, which is a weakness, while the details on crop production may be seen as a strength.

To ensure and improve the reliability of internet-collected data, researchers from case studies performed data cross-checks data with on-site personal interviews, e.g. out of 211 responses of urban gardeners in our database 180 was recognised as appropriately reported and submitted, while 27 participants from Ljubljana and 9 participants from Milan were excluded from further analysis because they didn't report sufficient details about type of crops and quantity of produce.

Uncertainties connected with the vegetable production conversion table can be due to the fact that the table is based on average productivity including normal weather conditions and that gardening is in line with good practice. Meteorological conditions and anomalies in temperature and precipitation always influence production, and in all three case studies the year 2014 was the warmest on record. However, summer temperatures were near normal in London and colder in Milan and Ljubljana, and precipitation amounts above normal, in comparison with the 1981-2010 climatology graph (EURO4M, 2015).

As this work was funded by a research project within the 7th EU Framework Program, it is possible that selection of the study areas was politically motivated (by the EU commission). Grounding the initial construction of a research object in such politically motivated initiatives or in certain discourses is not illegitimate in itself. However, such circumstances should call for increased conceptual and methodological awareness in the process of analysis the results.

RESULTS AND DISCUSSION

Socio-economic characteristics

Urban gardeners of both genders are active, with prevailing female participants in Ljubljana and London, and male in Milan (Figure 2a). In London, the average age of the participating gardeners was 46 years old (Figure 2b), who were mostly actively working in other jobs, either self-employed or as employees (Figure 2d). Conversely, gardening in Ljubljana and Milan is mainly the activity of 58 and 65 year old pensioners, respectively. Participants in Ljubljana and London had a higher level of education than those in Milan (Figure 2c). The gardeners' households belong to various income groups with London participants belonging to slightly lower income groups than in Ljubljana and Milan, where persons with relatively high incomes also grow their own food (Figure 2e). A high similarity between the three cities was observed regarding the distribution pattern of the household budget earmarked for supplies as shown in the graph (Figure 2f).

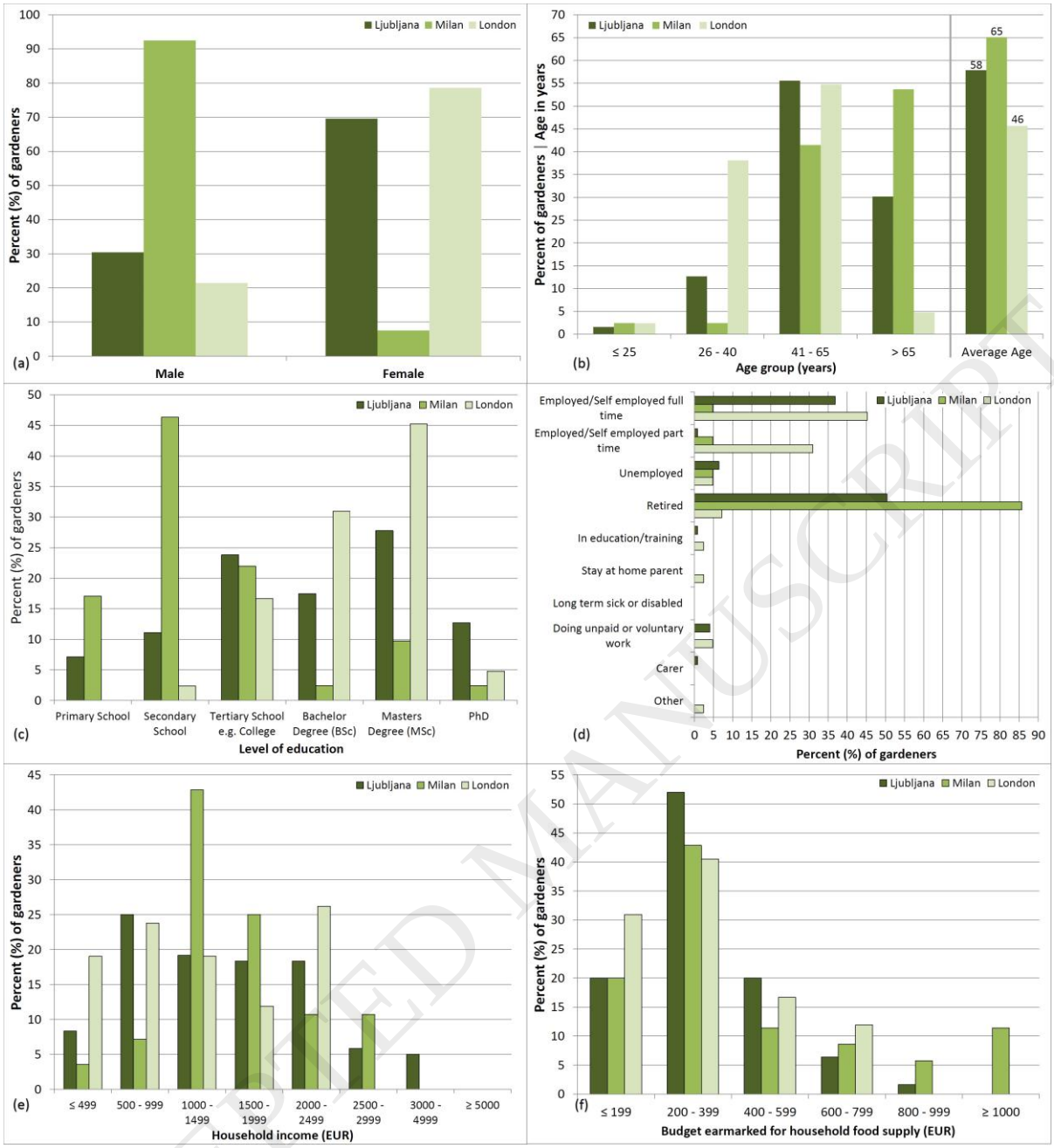


Figure 2: Socio-economic situation of participating urban gardeners in Ljubljana, Milan and London case studies with percent (%) by: (a) sex group, (b) age groups, (c) level of education, (d) employment status, (e) household income groups and (f) budget earmarked for household food supply

Garden types, production areas, crop types

Over 90% of the participating gardeners from Milan cultivate plots on public land away from their homes, and with a legal contract (Table 2). In Ljubljana and London the gardening locations are more varied: a considerable share of gardeners (47% and 52%) in both cities grow their own food in home gardens. In Ljubljana 25% of gardening plots is on private land, while in London, it is 10%. Garden sizes vary considerably in the cities studied: participating gardeners in London have on average larger plots of about 133 m^2 compared with the plots in Ljubljana, of about 104 m^2 and particularly, with those in Milan of about 29 m^2.

The prevailing type, size and location of urban gardens in these cities is a reflection of the spatial planning history and attitude of city authorities (local councils) towards urban

gardens. A past positive attitude of authorities is reflected in London with the largest allotment garden plots ranging between 125–150 m^2 (up to 250 m^2) (NSALG, 2015), which can be found even in the boroughs close to the city centre (Figure 1). The city of Milan has a Mediterranean spatial design with detached houses with no back gardens, for that reason majority of urban gardens are in the peri-urban areas of the city (Figure 1) with public gardens ranging between 20 and 80 m^2 (CM, 2017). In Ljubljana spatial planning, conditions for private houses were, and are still, quite loose allowing owners to have larger home vegetable gardens. In the last ten years, city authorities have also established a standard size for public garden plots within plots of between 25 to 125 m^2 (MOL, 2017).

Table 2: Garden type, number of gardens and area (m^2) in case studies

	Number of urban gardens and area (m^2)								
	Ljubljana			**Milan**			**London**		
Garden type	**No. (%)**	**m^2**	**avg. m^2**	**No. (%)**	**m^2**	**avg. m^2**	**No. (%)**	**m^2**	**avg. m^2**
Home garden	49 (46)	5,537	113	0 (0)	-		22 (52)	526	24
Away from home on private land with legal contract	26 (25)	3,840	148	1 (3)	70	70	4 (10)	1,630	408
Garden plot away from home on public land with legal contract	25 (24)	1,363	55	31 (94)	797	26	9 (22)	2,119	235
Garden plot away from home on private or public land without legal contract	3 (3)	90	30	0 (0)	-	-	1 (2)	400	400
Other (balcony, rooftop)	2 (2)	47	24	1 (3)	100	100	6 (14)	918	153
Total	105	10,877	-	33	967	-	42	5,593	-
Average	-		104	-		29	-		133

Vegetable crop types grown by the participating gardeners are numerous, between 34 and 41 (Figure 3). Based on reported quantities (kg) in Ljubljana and London, potatoes prevail, especially early varieties, which after harvesting, allow gardeners to plant second crops such as lettuce, radicchio (red chicory), cabbage, and green beans. In Ljubljana, lettuce and radicchio are traditionally grown all year round and both fall into the second category (13%). In London, squash, pumpkin, and courgette are abundant as they are very easy to cultivate in temperate climates with colder and wetter summer periods (UIE, 2018). Since the gardens in Milan are much smaller, this is less promising for more stable crops such as potatoes and squash, which need larger spaces to grow even on a domestic gardening scale.

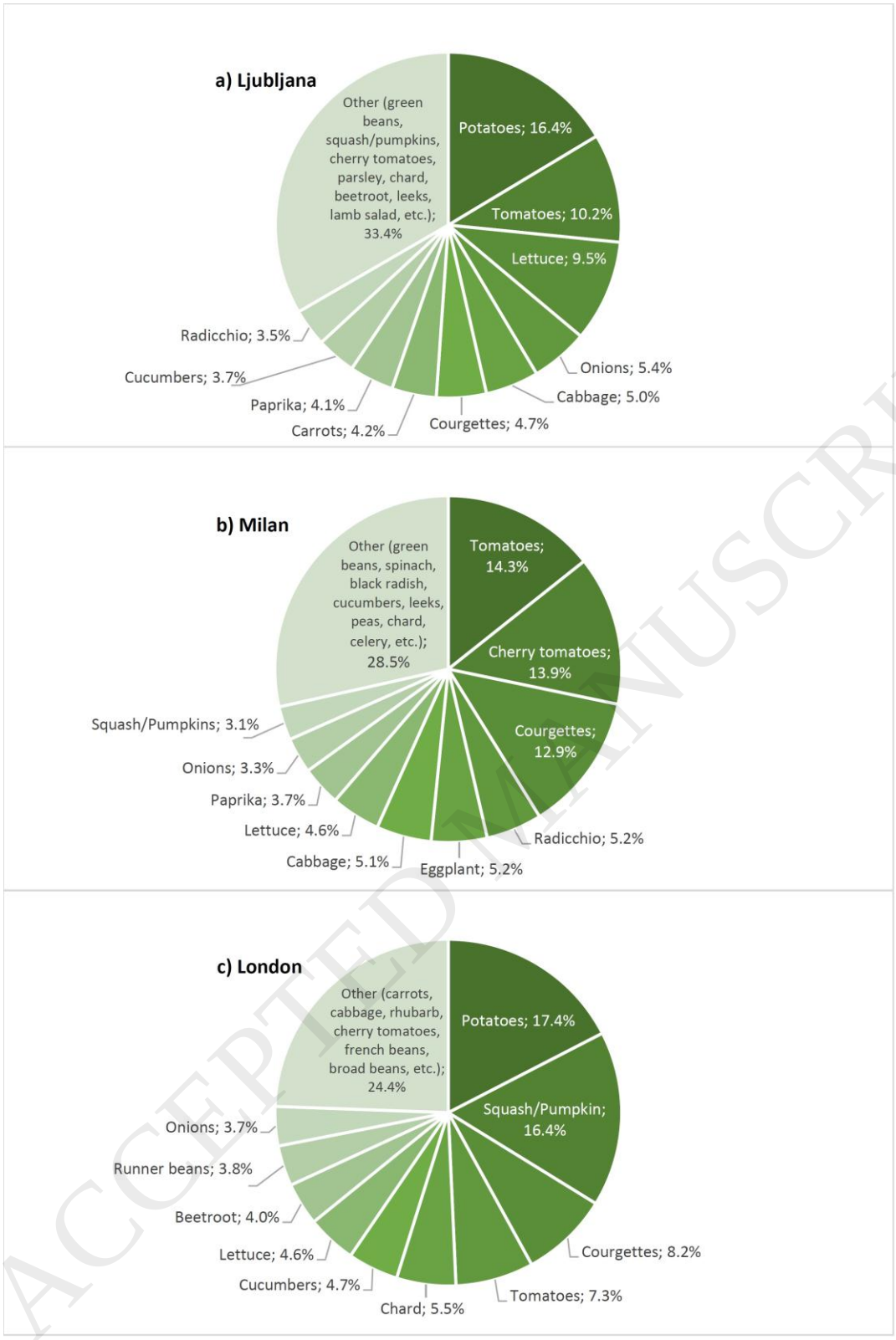


Figure 3: Comparison of crop types grown, as percent (%) of total weight of produce cultivated by case studies urban gardeners in (a) Ljubljana, (b) Milan and (c) London

Productivity of urban gardens

The average productivity by area (defined as the fresh weight of all food produced per square metre) for all the 180 participating urban gardeners was 2.10 kg/m^2, with a median value of

1.95 kg/m^2. The highest average productivity by area was observed in Milan (2.59 kg/m^2) and the lowest was in London (0.95 kg/m^2) (Table 3). There was considerable range in the productivity among the participating gardeners. The highest was recorded in London (8.23 kg/m^2). The best 10% of gardeners reached productivity levels of 5.46 kg, 5.56 kg, and 5.99 kg/m^2 in Ljubljana, Milan and London, respectively. As an example, the 6 kg/m^2 is the equivalent of 60,000 kg/ha or 60 t/ha, this is more than the average market farm yield as reported in the UK conventional and organic farm management handbooks (Redman, 2017). The similarity between best practices indicates that climate conditions and soil properties in all three cities enable high production yields. The possibility of high productivity has been confirmed in several other studies (CoDyre et al., 2015, Conk and Porter, 2016; Wieneke, 2017). On the other hand, the considerable range in productivity among participating gardeners can be explained by their skills and motivations. Refer to the Motivation and Skills chapter for further detailed discussion.

Table 3: Productivity and servings produced of average urban gardens in case studies

	Case study (CS)											
	Ljubljana				**Milan**				**London**			
Results	**avg.**	**min.**	**max.**	**st.dv.**	**avg.**	**min.**	**max.**	**st.dv.**	**avg.**	**min.**	**max.**	**st.dv.**
Average urban garden												
Area (m^2)	104	2.0	1000	150	29	12.5	100	17	133	1.0	1300	281
Produce (kg)	149	10	675	136	76	18.3	262	46	126	0.6	848	207
Productivity (kg/m^2)	1.44	0.06	7.66	1.50	2.59	0.40	6.65	1.44	0.95	0.01	8.23	1.94
Servings (No.)	1867	125	8438	1700	950	229	3269	575	1580	7	10602	2588
Servings No./m^2)	18	0.8	96	19	32	5.1	83	18	12	0.1	103	24
Servings (day/adult)	373	25	1688	340	190	45.8	654	115	316	1.5	2120	518
Servings (day/family)	115	7.7	519	105	58	14.1	201	35	97	0.4	652	159
Estimation for CS allotment gardens												
Area (ha)	143				181				806			
Produce weight (tonne)	2,058				4,690				7,647			
Servings (total No.)	25,726,246				58,624,486				95,582,365			
Servings (day/adult)	5,145,249				11,724,897				19,116,473			
Servings per capita (day/citizen)	18				9				2			

The majority of participants (61%) manage gardens in an organic or agro-ecological way (though non-certified), followed by integrated (20%) and conventional (13%) methods. Definitions of the management types are part of the questionnaire, which can be found in the appendix. Within the organic management there is a further distinction of biodynamic (12%) and permaculture methods (7%). Organic tops garden management in all three cities with 67% (Ljubljana), 62% (Milan), and 40% (London). Although variability between gardeners is high, data for across all case studies shows that the highest average productivity was reported for gardens managed as permaculture (3.16±2.41 kg/m^2), followed by conventional (2.81±1.12 kg/m^2), integrated (2.64±1.69 kg/m^2), organic (2.23±1.40 kg/m^2) and biodynamic (1.94±0.85 kg/m^2). In other comparative studies of organic–conventional management, it was found that the yield gap between organic and conventional production is on average 20%, but

differs between crops and regions (de Ponti et al., 2012). This study found a small yield gap between organic and conventional, but even more interestingly, between all the methods that can all be grouped under organic practice (permaculture, organic and biodynamic). The data set is too small to make a definitive conclusion, but it is clear that differences within organic methods can be as large as between organic and conventional.

The number of servings produced varies among case studies and individual gardeners. Results indicate that on average 18, 32 and 12 servings/m^2 of garden vegetables were produced annually in Ljubljana, Milan and London, respectively (Table 3). The highest production from an average garden was in Ljubljana with servings for 373 days for one adult person and 115 days for a family of four. The gardeners with lower productivity (kg/m^2) (London) balanced the number of servings with a larger garden size, while gardeners with smaller plots (Milan) with increased productivity. Individual productivity levels are remarkable, with a record from London with enough produce to last a family of four for 652 days.

If the results are upscale to the total CS allotment gardens area and presented as servings per capita in days (disregarding the age) we can see that all mixed vegetables produced from CS allotment gardens would last for only 2 days (London), 9 days (Milan) and 18 days (Ljubljana) if it were to be shared among all citizens to cover their daily vegetable intake (Table 3). If the current production of mixed vegetables in allotment gardens were to be redistributed over a year, it would cover the daily intake of approximately 14,000 (5.1%), 32,000 (2.4%) and 52,000 (0.6%) adult citizens in Ljubljana, Milan and London, respectively.

Based on past experiences when urban allotment gardens were established as a response to food shortages, our results indicate possible future development of the cities. Investments in green infrastructures like urban allotment gardens and the introduction of soft measures like upgrading urban gardeners' skills could lead to better resilience in cities in case of possible future food crises.

Labour costs

Average labour hours invested in garden management do not differ greatly between the CS unless labour efficiency per square meter and kilogram are taken in to account (Table 4). Milan had the lowest labour efficiency of 7.5 h/m^2, 2.9 h/kg and 0.2 h/serving; while London had the highest per m^2 (1.6 h/m^2); and Ljubljana had the highest per kilogram (1.2 h/kg) and per serving (0.09 h/serving). If total labours (h/year) are divided by total servings (No./year), gardeners had to work 0.47 (Ljubljana), 1.16 (Milan) and 0.65 (London) hours to produce vegetables for an adult's daily intake (400 g) (Table 4).

Average earnings in Slovenia with mean gross hourly earnings of 8.84 EUR/h are approximately half of those in Italy (15.42 EUR/h) and United Kingdom (18.76 EUR/h) (Table 4). In regard to produced yields (EUR/kg) labour costs in Milan were 0.5 and 4 times higher than in London and Ljubljana, respectively. Mean annual labour costs for the average garden are highest in London with approximately 4,000 EUR, followed by Milan with 3,400 EUR, and Ljubljana with 1,500 EUR, which represent 121%, 127% and 101% of their average national gross monthly wage, respectively.

With the extrapolation of labour value, calculated out of low gross hourly earnings and labour input, to the CS allotment area, the estimated labour costs are 10.76 million EUR/year in Ljubljana and ten times higher in Milan (113.13 M EUR/year) and London (105.52 M EUR/year) (Table 4).

Rather than as a cost, labour should be seen as the gardeners' investment in their physical and mental health, personal growth; in better social cohesion between different age and ethnic

groups; and in improving their knowledge and skills (Eigenbrod and Gruda, 2015). City authorities should recognize this and incorporate it into the city food policy to strengthen a city's social capital and resilience in times of crisis (Conk and Porter, 2016).

Table 4: Labour efficiency of average case studies urban gardeners

	Case study (CS)								
Results	**Ljubljana**			**Milan**			**London**		
Average urban garden									
Area (m^2)	104			29			133		
Produce (kg)	149			76			126		
Productivity (kg/m^2)	1.44			2.59			0.95		
Labour (h/year)	175			221			209		
Labour effic. (h/m^2)	1.69			7.53			1.57		
Labour effic. (h/kg)	1.17			2.90			1.62		
Labour effic. (h/serving)	0.09			0.23			0.13		
Labour efficiency (h/1 day servings)	0.47			1.16			0.65		
Employees earnings (€/h)	low	mean	high	low	mean	high	low	mean	high
	4.45	8.84	14.35	8.31	15.42	26.23	8.53	18.76	32.65
Labour (€/m^2)	7.54	14.97	24.31	62.56	116.09	197.47	13.41	29.49	51.32
Labour (€/kg)	5.23	10.38	16.85	24.12	44.76	76.14	13.80	30.35	52.82
Labour (€/year)	781	1551	2518	1833	3402	5786	1786	3927	6835
Labour (€/serving)	0.42	0.83	1.35	1.93	3.58	6.09	1.10	2.43	4.23
Estimation for CS allotment gardens									
Area of cultivation (ha)	143			181			806		
Weight of produce (tonne)	2,058			4,690			7,647		
Labour input (M h/year)	2,42			13,61			12,37		
Labour value low-high (M €/year)	10.76	21.37	34.69	113.13	209.92	357.08	105.52	232.07	403.90

Economic calculation

Production costs are similar in all three CS cities, ranging between 102–106 EUR per average garden (Table 5). When production costs per kilogram of mixed vegetable of 0.69 (Ljubljana), 1.43 (Milan), 0.82 (London) EUR/kg are compared to average retail prices of conventional produce in supermarkets (Table 5), savings of 0.66 (Ljubljana), 0.17 (Milan) and 1.75 (London) EUR/kg can be observed. This first indicates that average gardeners from all CS's can save money in comparison to average retail prices in stores.

Costs are also lower in comparison to gardeners in Guelph, Canada who spend 121 EUR (9.6 EUR/m^2) in an average garden of 12.55 m^2 (CoDyre et al., 2015) and higher in comparisons to commercial urban gardens in African cities, such as Kano, Nigeria (673 m^2) with 236 EUR (0.35 EUR/m^2), and Sikasso, Mali (2112 m^2) with 287 EUR (0.11 EUR/m^2) (Abdulkadir et al., 2015). Integrating all findings we can state that the economies of size, where average cost per unit of production decreases as the production area increases, is applicable also to urban gardening of small size.

The highest revenue in Milan (4.24 EUR/year) is in line with its high productivity, while the revenue in London (2.44 EUR/year) is under the influence of the high retail prices. Diversity in revenues indicates that conditions in vegetable markets are variable and dependent on supply and demand, which has a major impact on the fluctuation of vegetable prices, and finally on the economics of production in vegetable gardens. If prices for organic products were to be used, revenue would be 20–40% higher (Skrodzka, 2017).

Positive gross margins (EUR/m^2) (i.e. avoided costs or savings) in London (1.66), Ljubljana (0.95), and Milan (0.54) are secondary indications that the average gardener from CS cities can save a small amount of money of 99, 16 and 221 EUR/year, respectively (Table 5). The extent of savings is mainly dependent on market retail prices, followed by productivity and costs. The potential gross margin for urban allotment gardens, identified from aerial images, in CS are for average productivity and conventional produce retail prices 1.4M EUR/year, 1.0M EUR/year and 13.4M EUR/year, respectively (Table 5).

Table 5: Economic calculation of average urban garden vegetable production in three European case studies

	Urban garden area								
	Ljubljana			**Milan**			**London**		
Results	**avg. (m^2)**	**1 m^2**	**aerial (ha)***	**avg. (m^2)**	**1 m^2**	**aerial (ha)**	**avg. (m^2)**	**1 m^2**	**aerial (ha)**
Area	104	1	143	29	1	181	133	1	806
Produce (kg)	149	1.44	2,058,100	76	2.65	4,792,755	126	0.95	7,646,589
Retail price (€)	1.35			1.60			2.57		
Revenue (€/year)	201	1.94	2,768,539	121	4.24	7,659,424	325	2.44	19,651,734
Costs (€/year)	102	0.99	1,411,409	106	3.70	6,681,659	104	0.78	6,284,263
Gross margin (€/year)	**99**	**0.95**	**1,357,130**	**16**	**0.54**	**977,765**	**221**	**1.66**	**13,367,471**
Labour (h/year)	175	1.69	2,417,191	221	7.69	13,911,911	209	1.57	12,665,149
Mean labour costs (€/m^2)	1,551	14.97	21,367,967	3,402	118.63	214,521,665	3,927	29.49	237,598,190
Gross margin reduced by labour costs (€/year)	-1,453	-14.02	-20,010,837	-3,386	-118.09	-213,543,900	-3,706	-27.83	-224,230,719

*Urban gardening on allotment area defined from digital ortho-photo aerial images in the year 2014

If labour costs were also to be a factor in the calculation of gross margin, then costs of production would rise exponentially to an economically unsustainable level for this type of vegetable production. Lower and mean labour costs, lead economic calculation of gross margin into negative values (Table 5). The gross margin would stay positive if productivity increased and organic retail prices were to be used in the calculation.

Managing urban gardening economics gains in importance especially with rising food prices, unstable labour markets, or in times of a rising unemployment rate (Eigenbrod and Gruda, 2015). Unlike unregulated private gardens, urban gardens on public land in all three CS cities are regulated by the city authorities from an environmental and economic point of view (e.g. organic management type, organic fertilisers and plant-protection products use, type of crops - only vegetable, no trees, and non-profit production). This can lead to higher production costs in public allotments when compared to privately owned gardens.

Self-sufficiency potential and surpluses

Ljubljana has the highest percentage (46%) of participating urban gardeners who cover more than 50% of their household needs for mixed vegetables (Figure 4a). While in Milan and

London only 17%. Results on reported production indicate that in Ljubljana, Milan and London servings for an average family would last for 32%, 16% and 27% of the year, respectively. Suggesting that the average CS household with a garden consumes approximately one to two servings/day of home-produced vegetables over the year, or two to four servings/day during the growing season. Study from Czech Republic showed with 32.5% similar rates of average household self –sufficiency as recorded in Ljubljana (Vavra et al., 2018).

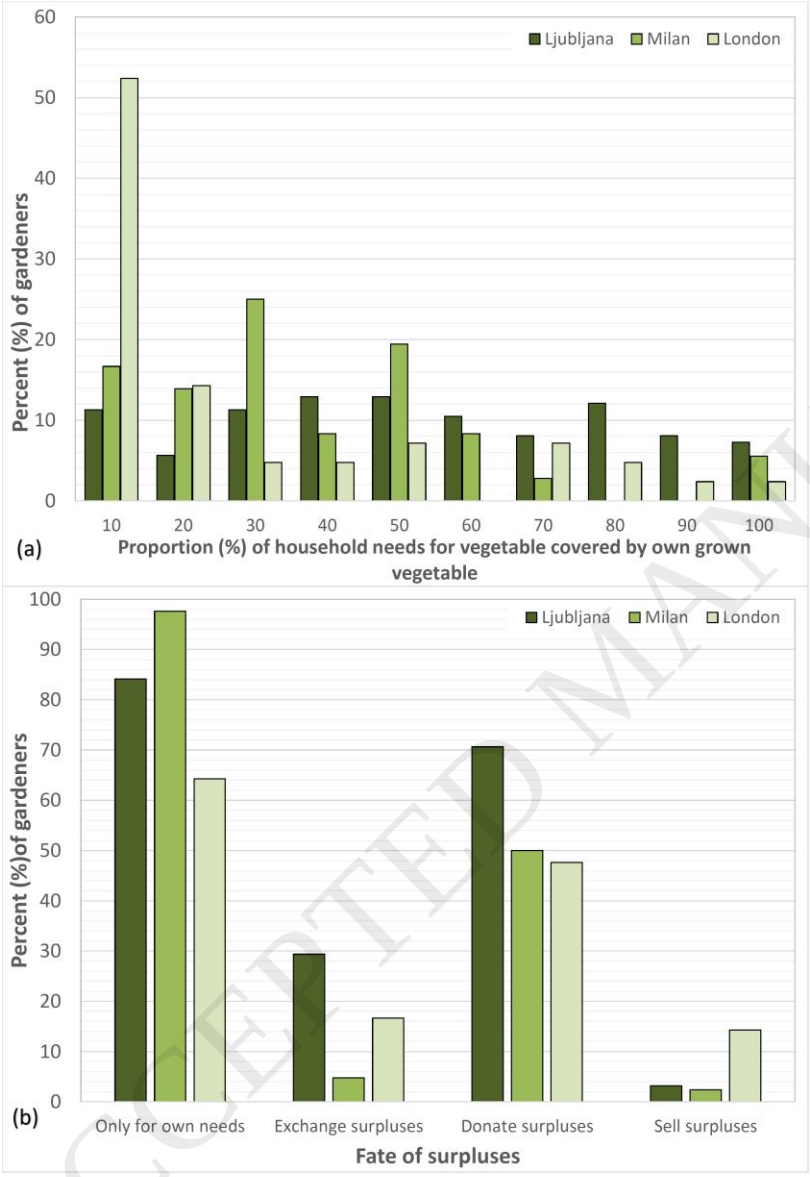


Figure 4: Proportion of (a) household self-sufficiency and (b) fate of surpluses in Ljubljana, Milan and London case studies

Results show that many of the participating gardeners exchange or donate their surpluses, indicating that in the growing season, the majority of gardeners' households (48–71%) for their daily recommended servings of vegetables, consume only produce from their own gardens (Figure 4b). This kind of social behaviour was observed in previous studies pointing out the importance of socialising through sharing, which gives the opportunity of establishing connections with other gardeners, neighbours, friends and family members (Zainuddin and Mercer, 2014; Pourias et al., 2015; Conk and Porter, 2016). Results indicate the unprofitable nature of urban gardening in European cities, where only the occasional urban gardeners sell

their surpluses, in comparison with African cities where it is a widespread activity. (Abdulkadir et al., 2015; Glavan et al., 2015). This might originate from the fact that in Europe, urban gardening is generally defined as non-profit activity (due to the history/emergence, regulations, etc.), whereas profit-oriented forms are called urban farming/agriculture. There were two EU COST Actions: one tackling the urban allotment gardens (COST TU1201) (Bell et al., 2016) and the other tackling urban agriculture (COST TD1106) (Lohrberg et al., 2016).

Although the majority of gardeners produce surpluses, only 5%, 0% and 12% respectively of gardeners are capable of supplying the annual needs of a family of four, and 13%, 0% and 14% respectively, of the growing season needs in Ljubljana, Milan and London. The annual and growing-season requirements for an adult person are well provided for in Ljubljana (35%, 63%), but less in London (19, 26%), and Milan (6%, 36%).

To provide the individual annual needs (fresh or pickled vegetables) for one adult at present productivity, the optimal garden size should be 101 m^2 (Ljubljana), 56 m^2 (Milan) and 154 m^2 (London). To provide all current CS allotment garden holders with the annual vegetable requirements for a family of four, the total area of allotment garden space in CS cities should be 453 ha (Ljubljana), 1,129 ha (Milan) and 931 ha (London). Upscaling to the total city population (a family of four's current productivity), the total allotment area for Ljubljana, Milan and London should be approximately 2.294 ha, 6.088 ha and 109.841 ha respectively - or 14%, 69% and 33% of total city size.

Productivity to provide the needs for one adult person, the average garden should be 1.41 kg/m^2 (Ljubljana), 16.19 kg/m^2 (Milan) and 3.56 kg/m^2 (London) and 3.25 times more for a family of four. An adult gardener would need to invest 171 (Ljubljana), 424 (Milan) and 236 (London) days of full-time labour (8 hours a day) to be able to cover his annual needs for vegetables and 3.25 times longer to cover a family's needs.

Motivation and skills

Average situation in all three cities shows that the limiting factor in higher productivity is mostly connected with knowledge and skills, as for the majority of all the participants (78%), gardening is based on the principle of trial and error with personal observations, followed by family members' advice (64%), books and magazines (57%), friend and neighbours (54%), and other gardeners (52%). School or training courses in agriculture or gardening has only 7% and 20% of participants, respectively (Figure 5a).

The production of healthy food and relaxation are the two main motivating factors and in the top three of all the CS (Figure 5b). This, is in combination with lack of skill, is a serious constraint for the increase of production. Recent research studies from other European cities report that rather than just places of food production, urban gardens are also multifunctional spaces for social interaction, leisure and recreation, which cannot be compensated with harvested production or economic income, and without which the gardeners would perhaps not even participate (Pourias et al., 2016; Trendov, 2018). A stable economic and security situation, in combination with agricultural subsidy payments, keeps food prices low in Europe, and makes food production or saving money as motivation of secondary importance. However, it can participate in other functions of the garden, like contribution to the sense of accomplishment or exchange of both knowledge and produce (Pourias et al., 2016). This can encourage gardeners to make improvements in production, for which new skills would be needed, available through the gardeners' network. More detailed analysis of urban gardeners' motivations in Milan was completed by Ruggeri et al. (2016) under the same project as this study.

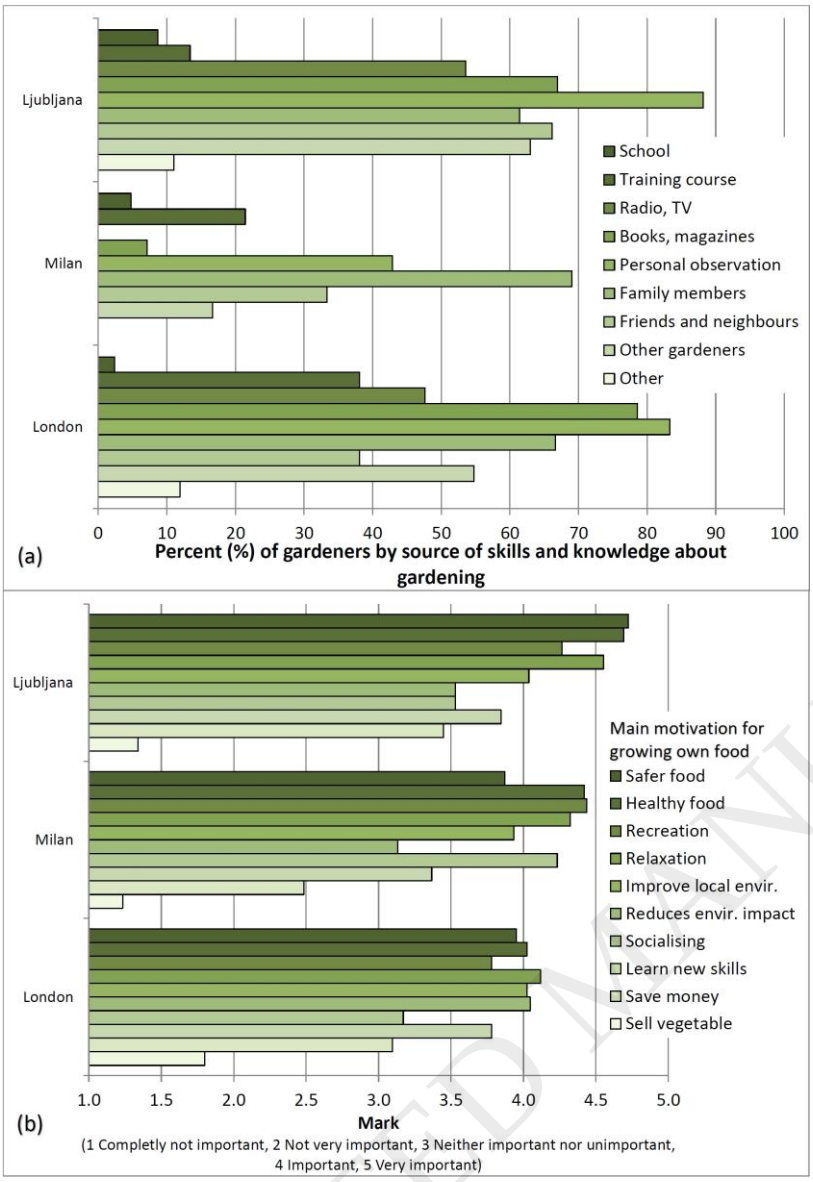


Figure 5: Comparisons in (a) main motivations for growing own food and (b) source of skills and knowledge about gardening in Ljubljana, Milan and London case studies

In Milan, family members are by far the most important source of knowledge and skills in regard to high productivity, and in combination with increased networking through social media, as an important motive for starting gardening, it is the fastest and the cheapest way of obtaining information (Kortright and Wakefield, 2011). A supportive social environment (family, friends, neighbours, fellow gardeners) to help with growing issues, can lead to a relaxed atmosphere in the garden as well as individual and social healing and transformation (Porter, 2018). This kind of sharing and support has the potential to further develop and assist in effective public health intervention for improving food security and nutritional health (Conk and Porter, 2016). However, studies show that sharing spreads not only nutritional benefits but might also be a mechanism of support by which gardens build the social capital (Porter, 2018). This combination should be recognized by healthcare policy as an important health promotion tool and people should be encouraged to participate (Soga et al., 2017).

The high importance of ecological and environmental motivation observed in CS was confirmed by the prevalence of more sustainable growing methods (organic, integrated, permaculture and biodynamic), which accounts for 83% of the participating gardeners. This was supported by the fact that only 14% of all participants used mineral fertilisers.

Urban gardening is recognised as being one of the important pillars for sustainable social development in the cities, and contributing to social cohesion (Veen et al., 2016). It is a part of a city's social capital, where gardeners from public and private gardens, invested labour as well as the citizens' knowledge and skills as a resource, form relationships to construct alternative networks for impacting social growth and the common good (Alaimo et al., 2010; Flachs, 2010).

For a better assessment of social capital on city level it has to be compared with CS cities' budgets. Out of the total annual budget of each city of approximately 0.3 billion (Ljubljana), 7 billion (Milan), and 19 billion (London), labour input at mean employee cost (Table 4) represents 7%, 3% and 2%, respectively, and revenue at mean retail market prices (Table 5) represents 0.9, 0.1 and 0.1, respectively. While revenue shares are relatively low, labour inputs represent a substantial number of currently non-monetised financial resources invested by citizens in different types of ecosystem services, which are not only related to food provision but also to regulating services (carbon sequestration and good conditions for pollinators), cultural services (spiritual and recreational), and supporting services (soil formation and conservation) (Cabral et al., 2017; Langemeyer et al., 2018).

Although desirable from a practical point of view, the motivation to save money is of secondary importance in all CS, despite the fact that knowledge and skills to increase income are available. The level of importance depends on the general socio-economic condition of each household (Figure 2). For example, Pollard et al. (2018) found that home owners from South Australia had less of a desire to save money by growing food than those renting their homes. Our survey indicates that motivation to save money is higher when a household's income is below 1,500 EUR/month (Figure 6).

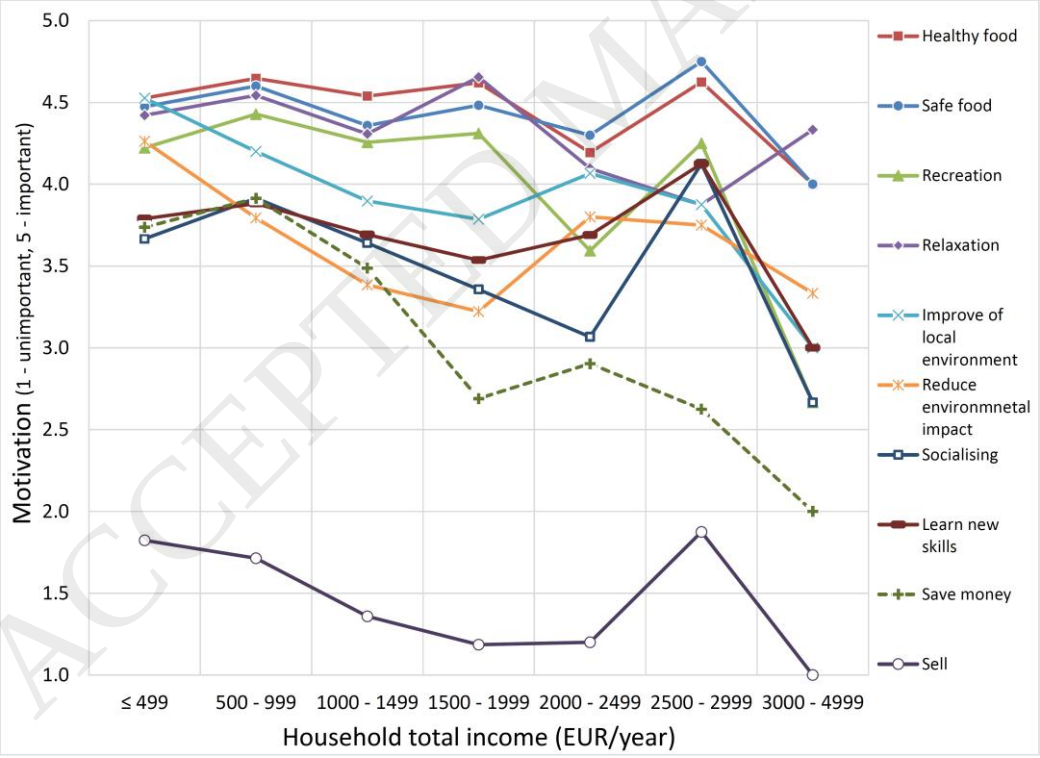


Figure 6: Comparisons between participating urban gardeners' motivations for growing own food – joined for all case studies (Ljubljana, Milan, and London)

CONCLUSION

This study is one of the rare agro-economic comparative studies for European cities illustrating how much urban gardeners economically gain or lose with self-sufficient

gardening in an average-sized garden and in allotment gardens on a citywide scale. Based on findings, urban gardening represents an important social as well as economic activity for part of the population in the cities, Ljubljana, Milan, and London with a large variety in growing spaces, growing methods, and motivations for growing their own vegetables. Results from the survey confirm the thesis of the predominantly hobbyist or health-giving nature of this type of gardening in Europe. Motivation without profit – safe and healthy food, relaxation, environmental impact, and socialising – are well expressed and also mirrored in the analysis of management practices (i.e. majority of organic gardening methods – 83%) and fate of surpluses (i.e. donation – 48%–71%). Permaculture was also found, as management with the highest average productivity among all CS urban gardeners.

Results from the analysis of economic performance show that urban gardening can play an important role for individual households with access to land and available time, to be self-sufficient in the provision of vegetables, especially those vegetables with a relatively short shelf life. Although, profit is of secondary importance, economic calculations show that area productivity of urban gardens can be comparable to market production of even more than 5 kg/m^2. Gardeners can save a considerable amount of money especially when conventional produce retail prices are used for gross margin calculation. With organic retail prices, the savings are even larger. However, if labour costs are included using the current average hourly rates, the growth margins in all three case studies are negative, indicating that as an economic activity on its own with average areas, productivity and labour inputs, it cannot compare to average wages. This may be different for the minimum and living wage especially if the following options to increase the potential of urban gardening are considered.

We propose three major options how to improve the self-sufficient potential of urban gardeners: (1) increase garden plots to optimal size to sustain entire household; (2) increase area productivity by upgrading theoretical knowledge, practical skills and technical innovations such as limited use of greenhouses or better composting of urban household wastes; (3) invest more labour hours, or, better, increase labour productivity with small-scale machinery applied to production methods similar to i.e. small plot intensive farming (SPIN farming).

To increase the cities food self-provisional potential with a positive economic performance, authorities should preferably invest is: (1) increasing designated urban gardening spaces in the city (public and private); (2) providing an optimal size for the average public urban garden based on the number of family members; (3) promoting increased productivity; (4) analysing labour as an investment in the mental and physical well-being of citizens; (5) upgrading gardening knowledge and skills through formal and informal education; (6) raising environmental awareness as directly impacts economic performance; (7) and analysing the impact of market disturbances on retail prices and revenue generated.

Which of these options or combination of options would be easier to reach is for the practitioners to decide and for city authorities to support those efforts with financial and infrastructure support.

One of the general policy recommendations for the cities is to integrate social cohesion (willingness of different groups of citizens to cooperate) as well as social capital (economic or cultural social networks in which people prosper by mobilizing resources of their membership in groups and networks for the common good) into the future cities' food policies. Cities should evaluate the resourcefulness of their citizens, groups and networks in terms of labour availability, land ownership, economic situation, knowledge and skills, etc. As urban gardeners are often part of different social networks (formal or informal), with a variety of expectations, they should be seen as partners in planning the future development of urban gardening. City authorities and urban planners would only need to observe, learn and

integrate the growth potential of these civil groups for the benefit of society. In a given context, a particular emphasis should be put on urban gardeners, following the advocate urban planning process, with an approach that aims to empower marginalised groups.

Finally, we maintain that urban gardeners voluntarily invest millions of euros of working hours in building social capital in urban areas (in 2014, approximately 229.4 million EUR/year on allotment gardens only in CS cities). Besides their investment in personal physical and mental health, and gaining new skills, they indirectly invest in various ecosystem services, social cohesion and the construction of alternative networks for social growth in the cities.

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Appendix 1

URBAN GROWING SURVEY

The purpose of this questionnaire is to analyse the phenomenon of urban gardening depended on local natural resources and to examine the socio-economic benefits of urban gardening beyond the provision of food. Additionally, the aim of this questionnaire is to get insight into specific positive and negative externalities that the urban gardening is bringing to their metropolitan areas.

We would like to ask you some questions about where you grow your own food. We will refer to the space you grow food as a 'plot'. A plot can be your home growing space (e.g. garden or patio) or your allotment or community garden.

A. About your growing space

Q1. Please tell us where you grow your food

1 Home garden
2 Garden plot away from home on private land
3 Garden plot away from home on public land
4 Garden plot away from home on the land of the other owners (e.g. nearby railways, roadsides,…)
5 Other, please specify: _____

Q2. Please provide the street name or postcode of the site where you grow your food

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Q3. How do you get to your growing space(s)?

1 On foot
2 By public transport
3 By bike
4 By car
5 Other: please specify:
7 Not applicable (my plot is at my home) _____

Q4. Do you have a contract with someone to use your garden/allotment?

1 Yes, please indicate with whom: _____
2 No

Q5. Do you pay rent or any other fees in order to use your growing space? If yes please specify the amount. If no please go to Q6

1. Yes, I pay a rent of (in Euro)……..per year

2. Yes, I pay another type of fee of (in Euro)…….per year

Q6. What is the approximate size of the area you grow your food in?

Please specify *in m2:* _____

Q7. Please indicate what you produced on your plot(s) during the last year and estimate the amount of that produce. In doing so, please think about each patch that you have cultivated and all seasons - from spring to winter. *Quantity of the produce should be indicated at least in two of the referred quantities:*

TYPE OF VEGETABLES	The amount of harvested vegetables (in kg)	Harvested area of production (m^2)	Number of seedlings, volume of tubers (in kg)
a) Mangold, b) Asparagus c) Broad bean d) Broccoli e) Brussels sprouts f) Pumpkins g) Zucchini h) Cauliflower i) Onions j) Onion bulbs k) Garlic l) Cherry tomatoes m) Chick-peas n) Black radish o) Pepperoni p) Green beans r) Beans (high) s) Beans (low) t) Peas u) Eggplant v) Kohlrabi z) Carrot aa) Maize ab) Potatoes ac) Cucumbers ad) Cucumbers (for pickling) ae) Corn salad			

af) Dwarf French bean ag) Kale ah) Paprika ai) Tomatoes aj) Parsley ak) Leek al) Chicory am) Beetroot an) Turnip ao) Rucola ap) Sweetcorn ar) Lettuce as) Sunflowers at) Shallots au) Spinach av) Pole bean az) Celery ba) Cabbage bb) Other, please specify : _____			

TYPES OF BERRIES	The amount of harvested vegetables (in kg)	Number of boxes or. Crates	Harvested area of production (m^2)	Number of seedlings, volume of tubers (in kg)	Number of seed bags
ca) Strawberries cb) Raspberries cc) Blackcurrant cd) Blackberries ce) Gooseberries cf) Other, please specify: _____					

TYPES OF HERBS	The amount of harvested vegetables (in kg)	Number of boxes or. Crates	Harvested area of production (m^2)	Number of seedlings, volume of tubers (in kg)	Number of seed bags
da) Basili db) Chives dc) Horseradish dd) Chamomile de) Marjoram df) Melisa dg) Marigold dh) Oregano di) Tarragon dj) Wormwood dk) Peppermint dl) Rosemary dm) Lavender					

dn) Savory to) Thyme dp) Tobacco Dr) Wine rue ds) Sage dt) Other, please specify: _____					

B. Your Growing Methods

Q8. Which term best describes the way in which you principally cultivate your plot(s)?

1. Conventional (I want to achieve the greatest possible yield at lower cost)
2. Integrated (I try to avoid using chemicals such as artificial fertilizers and pesticides)
3. Organic (I use natural methods of pest control, do not use mineral fertilizers and genetically modified organisms)
4. Biodynamic (I take note of ecological principles, the seasons and the lunar calendar)
5. Permacultural (I take note of organic and biodynamic principles and the natural symbiosis between the plant and animal species)
6. Other, please specify: _____

Q9. Roughly how many hours per week during the growing season do you spend growing food?

1. 0-2 hours
2. 2-4 hours
3. 4-6 hours
4. 10 hours
5. _____ (Precise number)

Q10. Do you grow food by yourself or does anyone help you with this?

1 I work by myself
2 Other members of the household help me
3 Other relatives help me
4 My friends help me
5 Other, please specify: _____

Q11. What kind of fertilizer do you use?

	Yes	No
a. Homemade compost	1	2
b. Bought compost	1	2
c. Manure	1	2

d. Mineral fertilizers	1	2
e. Other, please specify: _____	1	2

Q12. Where do you get your seeds and seedlings?

	Yes	No
a. I save my own seeds	1	2
b. I exchange the seeds with others	1	2
c. I buy seeds	1	2
If, yes, specify where: _____		
d. I grow seedlings by myself	1	2
e. I exchange seedlings with others	1	2
f. I buy seedlings	1	2
If, yes, specify where: _____		

Q13. Do you use any old or 'heritage' crop varieties?

1. Yes, please specify types of sorts of vegetables:_____
2. No

Q14. Do you water/irrigate your growing space(s)?

1. Yes, regularly
2. Only if I think it is necessary
3. No **→ please go to Q18**

Q15. How do you decide when to water your crops?

	Yes	No
1. I take into account how well the plants are growing	1	2
2. I take into account the air temperature	1	2
3. I take into account the amount of rain we have had	1	2
4. I look at how dry the soil is	1	2
5. Other reason, specify:_____	1	2

Q16. Where do you get water for your crops?

	Yes	No
a) Collecting rainwater	1	2
b) Use the tap water from my home	1	2
c) Other, specify: _____	1	2

Q17. Would you find the advice for watering/irrigation from a smartphone application useful to you?

1. Yes, it would be helpful to me
2. Yes, if I would have a smart phone
3. No, in any case
4. Do not know what a smartphone application is

Q18. Are you faced with any of the following difficulties in growing your food? If so, how do you solve or manage them?

		Yes	No	
a)	With weeds	1	2	
	If yes, specify solution:_____			
b)	With pests	1	2	
	If yes, specify solution:_____			
c)	With vegetable diseases	1	2	
	If yes, specify solution:_____			
d)	With crop stealing		1	2
	If yes, specify solution:_____			
e)	With lack of water for irrigation	1	2	
	If yes, specify solution:_____			
f)	Any other problems, please specify:_____	1	2	
	If yes, specify solution:_____			

C. Skills and knowledge

Q19. How have you learned to grow your own food?

		Yes	No
a)	Personal observation	1	2
b)	School, university	1	2
c)	Learning from family members and relatives	1	2
d)	Learning from friends, neighbours	1	2
e)	Learning from other gardeners	1	2
f)	Attending a training course	1	2
g)	Learning from books and magazines	1	2
h)	Learning from Radio and TV programs	1	2
i)	Other, specify:_____	1	2

Q20. Would you find a smartphone advice application on gardening helpful to you?

1. Yes, it would be helpful to me
2. Yes, if I would have a smart phone
3. No, in any case
4. Do not know what a smartphone application is

D. Motivations for gardening

Q21. How long have you been growing your own food?

Specify (in years):_____

Q22. What inspired you to start growing your own food?

1. Own motives, a pleasure to work in nature
2. It's a family tradition
3. My friends and acquaintances grow their own food
4. A public notice or information about the possibility to have a growing space
5. Other, please specify: _____

Q23. What are the main reasons you grow your own food? Please indicate the extent to which you agree or disagree with the following statements using a scale of 1 (Completely unimportant) to 5 (very important).

	1 Completely unimportant	2 Not very important	3 Neither important nor unimportant	4 Important	5 Very important
a)I grow food to save money					
b) I think my own grown food is safer than food I buy from shops					
c) I think my own grown food is healthier than food I buy from the shops					
d) Growing my own food is good exercise					
e) Growing my own food helps me relax					
f) Growing food helps improve					

my local environment					
g) Growing my own food is a good way of socializing with other people					
h) I grow food to sell it					
i) I grow food to reduce my environmental impact					
j) I grow food to learn new skills					
k) Other reasons, please specify:_____					

Q24. Do you have enough space to meet your food growing needs?

1 Yes, I have just the right amount
2 No, my space is too small
3 No, my space is too large

E. A contribution of gardening to food supply and household budget

Q25. Please estimate what proportion of your household needs for vegetables is covered by the food you grow:

1. 10%	2. 20%	3. 30%	4. 40%	5. 50%
6. 60%	7. 70%	8. 80%	9. 90%	10. 100%

Q26. Do you think the amount of food you grow justifies the cost of buying seeds, seedlings, fertilizers, pesticides and tools?

1. Yes, entirely
2. Yes, partly
3. No, not at all

Q27. If possible, please estimate your personal expenditure on seeds, seedlings, fertilizers, pesticides and tools per year

Specify the amount (in Euro): _____

Q28. Do you produce only for your own needs and the needs of your household or do you also supply other people and/or sell surpluses from your plot(s)?

	Yes	No
a. Only for own needs	1	2
b. Exchange surpluses	1	2
c. Donate surpluses	1	2
d. Sell surpluses	1	2

F. The impacts of home growing

Q29. Please indicate to what extent you agree with the following statements. Please assign the importance of each statement by selecting a value on the scale of 1 (very strongly disagree) to 7 (very strongly agree)

a) Through mutual exchange of seedlings or crop surpluses home food growers create better interpersonal relationships.

Very strongly disagree Neither agree nor disagree Very strongly agree

1 2 3 **4** 5 6 **7**

b) People who grow their own food lack the right skills to produce vegetables, therefore they contribute significantly to environmental pollution.

Very strongly disagree Neither agree nor disagree Very strongly agree

1 2 3 **4** 5 6 **7**

c) People who grow their own food do not have to transport their food very far; therefore they contribute to the improvement of air quality.

Very strongly disagree Neither agree nor disagree Very strongly agree

1 2 3 **4** 5 6 **7**

d) With their garden beds allotment holders are spread too much into the public areas; consequently they reduce the development of other activities in the area.

Very strongly disagree Neither agree nor disagree Very strongly agree

1 *2* *3* ***4*** *5* *6* ***7***

e) When watering, people who grow their own food conserve water, therefore they contribute to the conservation of water resources.

Very strongly disagree **Neither agree nor disagree** **Very strongly agree**

1 2 3 **4** 5 6 **7**

f) Organic or biodynamic agriculture is the only proper way of healthy food production.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

g) Vegetables grown by allotment holders are healthier than vegetables sold in the store.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

h) With their crop-beds and accompanying facilities (e.g. huts) allotment holders disfigure the appearance of the environment.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

i) While working in the garden by talking and socializing allotment holders strengthen the integration of people in the community.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

j) People growing their own food tend not to use pesticides and herbicides, therefore they contribute to environmental preservation.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

k) Home grown vegetables are tastier than vegetables sold in the store.

Very strongly disagree			**Neither agree nor disagree**			**Very strongly agree**
1	2	3	**4**	5	6	**7**

G. About you and your household

Q30. How many members of your household are supplied by the food you grow?

a) Enter the number of adults: _____ b) children: _____

Q31. Please estimate the share of your household budget earmarked to food supply?

1. 199 € or less
2. 200 – 399 €
3. 400 – 599 €
4. 600 – 799 €
5. 800 – 999 €
6. 1000 € or more

Q32. Please indicate your average yearly household income:

1. 499 € or less
2. 500 to 999 €
3. 1,000 to 1,499 €
4. 1,500 to 1,999 €
5. 2,000 to 2,499 €
6. 2,500 to 2,999 €
7. 3,000 to 4,999 €
8. 5,000 € or more

Q33. In addition to the food you grow by yourself, where else do you get your food from?

	Yes	No
1. From friends or relatives who produce food	1	2
2. From local growers, farm	1	2
3. At a marketplace	1	2
4. In shops and supermarkets	1	2
5. Other, please specify: _____	1	2

Q34. A) Do you buy mostly organic produce?

1 Yes 2 No

B) Do you buy mostly conventional produce?

1 Yes 2 No

Q35. Are you a member of an association?

1 No

2 Yes, specify which ones: _____

Q36. What do you do in your spare time and how often (minutes / week)?

1. Listening to the radio, watching TV
   Minutes / week: _____
2. Browsing, playing on the computer

Minutes / week: _____

3. Reading books, newspapers, magazines

Minutes / week: _____

4. Resting (relaxation, meditation, sunbathing, ...)

Minutes / week: _____

5. Excursions – visits?It referees to visiting domestic and foreign cities and countries

Minutes / week: _____

6. Sports, dance activities

Minutes / week: _____

7. Handiworks – crafts?It referees to sewing, knitting, crochet, ...

Minutes / week: _____

8. Games– aren't all of the categories interest and hobbies?

Minutes / week: _____

9. Volunteering

Minutes / week: _____

10. Visiting theatre and cultural events

Minutes / week: _____

11. Socialising with people outside the home

Minutes / week: _____

12. Other, please specify: _____

Minutes / week: _____

Q37. Gender:

1. Male
2. Female

Q38. How old are you?

In years: _____

Q39. What is your ethnic group?

Q40. What is your highest level of education?

2. Primary School
3. Secondary School
3. Tertiary School e.g. college
4. Bachelor degree (BsC)
5. College or University, 4-5 year program (university degree) Master degree (MsC)
6. PhD

Q41. What is your working status?

1. Employed / self employed full time
2. Employed / self-employed part time
3. Unemployed → please go to Q40
4. Retired → please go to Q40
5. In education/training → please go to Q40
6. Stay at home parent? → please go to Q40
7. Long term sick or disabled
8. Doing unpaid or voluntary work
9. Carer
10. Other

Q42. Please indicate to what extent you agree with the following statements. Please assign the importance of each statement by selecting a value on the scale of 1 (strongly disagree) to 5 (strongly agree)

1.	My job is physically exhausting	1	2	3	4
5					
2.	My job is mentally challenging	1	2	3	4
5					
3.	My job is stressful	1	2	3	4
5					
4.	My job is precarious	1	2	3	4
5					

Q43. Please describe your housing type:

1. Detached house
2. Semi-detached house
3. Multi residential apartments or flats
4. Other, please specify: _____

Q44. Would you like to add something else?

_____

Appendix 2

A SUMMARY TABLE WITH EQUATIONS FOR ECONOMIC CALCULATION

1. PRODUCTIVITY PER GARDEN AREA

$$P_{area} = \frac{HY}{GA} \quad \text{(q1)}$$

Where is:
P_{area} … productivity per garden area in kg/m^2,
HY … harvested yield per garden in kg,
GA … garden area in m^2.

2. PRODUCTIVITY OF SERVINGS PER GARDEN

$$P_{serv} = \frac{Parea}{ADN} \quad \text{(q2)}$$

Where is:
P_{serv} … productivity of servings per garden in servings/m^2,
P_{area} … productivity per garden area kg/m^2,
ADN … average daily needs for vegetable/fruit for adult person of 400 grams (5 × 80 grams) in kg or family (of 1300 grams (2 × 400 grams adults, 2 × 250 grams children) in kg (WHO, 2003).

3. LABOUR EFFICIENCY PER GARDEN AREA

$$LE_{area} = \frac{LH_{GS}}{GA} \quad \text{(q3)}$$

Where is:
LE_{area} … labour efficiency per garden area in hours/m^2,
LH … labour hours as hours of work in the growing season [h],
GA … garden area in m^2.

4. LABOUR EFFICIENCY PER HARVESTED YIELD

$$LE_{yield} = \frac{LH_{GS}}{HY} \quad \text{(q4)}$$

Where is:
LE_{yield} … labour efficiency per harvest yield in hours/kg,
LH_{GS} … labour hours as hours of work in the growing season [h],
HY … harvested yield in kg.

5. LABOUR EFFICIENCY PER SERVING

$$LE_{serv} = \frac{LH_{GS}}{TS} \quad \text{(q5)}$$

Where is:
LE_{serv} … labour efficiency per servings produced in hours/serving,
LH_{GS} … labour hours as hours of work in the growing season [h],
TS … total number or amount of produced servings [unitless].

6. LABOUR COSTS

$$LC_x = \frac{LE_x}{EE} \quad \text{(q6)}$$

Where is:
LC_x … labour cost per selected efficiency (x) in EUR/m^2, EUR/kg, EUR/serving,
LE_x … selected labour efficiency (x) expressed as garden area (h/m^2), harvested yield (h/kg) or serving (h/serving),
EE … average hourly employee earnings [EUR/hour].

7. REVENUE

$$R = HY \times RP \quad \text{(q7)}$$

Where is:
R … revenue is here defined as income that would be generated by selling the goods (average retail prices) on the market [EUR],
HY … harvested yield in kg,
RP … retail price [EUR/kg].

8. COSTS

$$C = VC + FC \quad \text{(q8)}$$

Where is:
C … cost of production [EUR]
VC … variable costs are costs that change in proportion to the level of production (fertilisers, seeds, plants, plant production products, etc.) [EUR],
FC … fixed costs are expenses that remain the same regardless of production output (rent, waste disposal, etc.) [EUR].

9. GROSS MARGIN

$$GM = R - C \quad \text{(q9)}$$

Where is:
GM … labour cost per selected efficiency (x) in EUR/m^2, EUR/kg, EUR/serving,
R … revenue is here defined as income that would be generated by selling the goods (average prices) on the market [EUR],
C … cost of production [EUR].