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# Ecosystem Services Provision from Urban Farms in a Secondary City of Myanmar, Pyin Oo Lwin

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**Abstract:** Urban farms provide a large diversity of ecosystem services, which collectively have a positive effect on different constituents of human wellbeing. However, urban farms are facing increasing pressure due to accelerated urbanization and socioeconomic transformation, especially in rapidly developing countries such as Myanmar. There is an increasing call to harness the multiple benefits that urban farms offer in order to foster urban green economic transitions and increase the wellbeing of urban residents. This study examines how different types of urban farms provide ecosystem services, focusing on Pyin Oo Lwin, one of the secondary cities of Myanmar. We conduct household surveys with urban farmers representing the three main types of urban farms encountered in the city, namely seasonal crop farms (N = 101), coffee farms (N = 20), and nurseries (N = 20). The results suggest that all types of urban farms in our sample provide multiple provisioning, cultural, regulating, and supporting ecosystem services, which collectively contribute directly to different constituents of human wellbeing such as (a) food security, (b) livelihoods and economic growth, and (c) public health and social cohesion. Food crops and commercial crops (e.g., coffee) are the major provisioning ecosystem services provided by our studied urban farms, with some farms also producing medicinal plants. These ecosystem services contribute primarily to farmer livelihoods and economic growth, and secondarily to household food security (through self-consumption) and health (through nutritious diets and medicinal products). Food sharing is a common practice between respondents for building social cohesion, and is practiced to some extent by most seasonal crop farmers. Almost all surveyed urban farms in our sample provide diverse cultural services to their owners, ensuring the delivery of intangible benefits that have a further positive effect on human wellbeing. It is argued that efforts should be made to ensure the continuous supply of these ecosystem services in order to contribute to urban green economic transitions in Pyin Oo Lwin and other similar secondary cities.

**Keywords:** urban farming; urban sustainability; food security; food sharing; cultural ecosystem services; Myanmar

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## 1. Introduction

Urban farming is the practice of cultivating food crops and, to a lesser extent, commercial crops in urban environments. Urban farming is undertaken through various production systems including neighborhood allotment gardens, family farms, community farms, rooftop gardens, and even intensive and commercial production units integrated within the urban fabric [1]. Urban farms (and especially family farms) are often engulfed in the urban fabric during the gradual expansion of cities in peri-urban areas [1]. However, urban farms are sometimes established deliberately to grow crops within the urban fabric, with this approach being common for communal farming areas in neighborhoods/allotments, farming in vacant lots and roofs, and recreational farming [1]. Apart from conventional agricultural practices, some types of urban farms increasingly utilize advanced production techniques to maximize output considering the space constraints in urban contexts [2,3].

Urban farming is performed in practically all parts of the world, but the actual status of production systems and the underlying drivers vary widely between regions, countries, and even cities [4–12]. For example, even though urban farming in many developed cities was used for subsistence and income generation in the past, it has lately gained popularity for recreational purposes and other social reasons [5,7,10]. On the other hand, in many rapidly urbanizing cities of the developing world, urban farming remains a major source of subsistence and income, including in cities in southeast Asia that are the focus of this paper [6,9,11,12].

Urban farms provide multiple provisioning, regulating, cultural, and supporting ecosystem services that contribute to the wellbeing of urban residents [13]. The main provisioning ecosystem services are associated with the production of food crops, industrial crops (e.g., coffee), aromatic plants, flowers, and medicinal resources [14]. In many cities of the developing world, including Southeast Asia, such provisioning services from urban farms are strongly linked to food security and income generation [6,9]. For example, studies have found that urban farms in Hanoi and Manila provide a substantial amount of the food consumed by urban residents [15,16]. Likewise, studies in Malaysia and Indonesia have also pointed to the significant contribution of urban farms to urban food security and income generation [3,11,12]. Although urban farming in southeast Asia is mostly undertaken in conventional ground level farms, allotments, and vacant lots, there are current efforts to explore the potential of novel methods such as vertical farming systems to overcome space constraints [2,15,16]. It is worth mentioning that several scholars have argued that food produced in urban farms and consumed locally has a lower environmental footprint (and is thus more sustainable) due to the reduced distance between producers and consumers [17].

An emerging body of literature has focused on the cultural, supporting, and regulating services provided by urban farms, and their positive outcomes for the quality of life of urban residents [18]. Urban farms can provide very diverse cultural services, ranging from biophilia [19], to education [20,21], recreation [22,23], and social cohesion [22,24], among others. Key supporting and regulating services include carbon storage [25], habitat for biodiversity [24,26], storm-water run-off regulation [27,28], and temperature regulation [29], among others.

Considering the above, urban farms can be perceived as agricultural systems in which environmentally conscious cultivation practices, the local economy, and relationships between people can intersect fruitfully, thus creating a thriving local food system and strong communities, and ensuring greater access to healthy, seasonal, and local food [30,31]. It has been argued that urban farms, due to their great potential to provide ecosystem services [18,32], can become integral parts of green infrastructure [5,13,14], not least by promoting green production activities (e.g., organic and nutritious food with a low environmental footprint) and social inclusion. In fact, urban farming has been identified as a possible intervention to foster green economic transitions in cities and a tool to address urban social, economic, and environmental challenges [33–35]. These multi-dimensional benefits of urban agriculture are becoming increasingly important considering rapid global urbanization, which poses a serious threat to sustaining cities in relation to food security, social services, human wellbeing, and environmental quality [36]. However, due to the rapid economic change and urbanization in many parts of the world, urban and peri-urban farmland is under pressure [37–39], including in many Southeast Asian cities [15,40].

Such an example has been Myanmar, which has been undergoing a major socioeconomic transformation and urbanization, in tandem with efforts to transition to a green economy [41,42]. Currently, approximately 30% of the total national population (51.48 million) lives in urban areas (increasing from 24.8% in 1983) [43], with this population projected to increase to 32.9% by 2025 [44]. Although urbanization rates are close to the regional average [45], urban population density increased rapidly from 6200 people/km$^2$ in 2000 to 7500 people/km$^2$ in 2010 [46]. At the same time, the Myanmar government has embarked on an effort to transition to a green economy [41,42,47,48].

There is an emerging evidence base that the extensive land use change in urban and peri-urban areas of Myanmar has taken a toll on urban and peri-urban agriculture in many cities [25,49]. Uncontrolled urban expansion and land use change in Myanmar cities can potentially affect the ecosystem services provided by urban green spaces (including urban farms) [25], thus having important ramifications for the wellbeing of urban residents [49]. Yet, there is a major lack of evidence about the social, economic, and environmental benefits of urban farming in Myanmar, which is amplified by its under-appreciation in current policies and strategies that are mainly geared towards commercial agriculture [50–52].

The overall aim of the study is to examine how different types of urban farms provide ecosystem services, focusing on Pyin Oo Lwin, one of the secondary cities of Myanmar. In particular, through household surveys with different types of urban farmers we identify their general characteristics and assess the provision of different provisioning, cultural, regulating, and supporting ecosystem services. We focus on a secondary city as these cities (a) are particularly important in urbanization transitions in developing countries (including Myanmar), and (b) receive much less attention in academic research considering the very few relevant empirical studies, especially in Myanmar.

Section 2 outlines the methodology and introduces the main characteristics of Pyin Oo Lwin, and the study sample. Section 3 highlights the type and level of ecosystem services provision from the studied urban farms, namely seasonal crop farms, coffee farms, and nurseries. Section 4 puts these findings into perspective discussing some of the main implications for urban planners, decision makers, and city authorities for maintaining the provision of ecosystem services from urban farms, and how it can contribute to green economic transitions in Myanmar.

## 2. Materials and Methods

### 2.1. Site Description

This study was conducted in Pyin Oo Lwin, one of the secondary cities of Myanmar. Pyin Oo Lwin is located in the Shan Highlands, 67 km east of Mandalay, at an altitude of about 1000 m. The city has a municipal area of approximately 102 km$^2$, with a population of 158,783 [53]. It is characterized by favorable climate condition with fair temperature but high rainfall and humidity. Between 2008 and 2017 the average maximum and minimum temperatures were 27 °C and 14 °C, the average annual rainfall 1523 mm, and the average humidity 77% [54].

Due to its pleasant climate, environment, and accessibility to scenic landscapes in its surroundings, Pyin Oo Lwin has become a major tourism destination and a booming market for second home ownership within Myanmar. Furthermore, the city was awarded with the 2nd ASEAN Environmentally Sustainable Cities Award in 2011 for its good air quality [55], and has been designated a green city pilot project by the Myanmar Government [56].

However, despite the large contribution of the tourism sector to the city's economy, urban agriculture is still quite prevalent in the city. The city contains many areas where urban agriculture is performed on a variety of farm types, including many conventional small family farms used mainly for food crop production (e.g., carrot, Chinese broccoli, mustard, radish) and flower production. The city also contains larger coffee farms are owned both by the private sector and the government, producing shade-grown coffee. Coffee farming was introduced by the Roman Catholic missionaries in the 1930s, with the city known as the coffee capital of Myanmar due to its ideal growing conditions [57].

However, Pyin Oo Lwin has experienced significant expansion during recent decades. In particular, land use change associated with urban expansion converted large amounts of urban and peri-urban green spaces, including agricultural areas [25]. A recent study estimated that food crop farms declined from 2966.53 ha in 1988 (29.2% of urban area), to 1410.71 ha in 2018 (13.9% of urban area) [25]. On the contrary, net changes in coffee area have been miniscule, with the overall extent of coffee farms standing at 756.58 ha (7.5% of urban area) [25].

*2.2. Data Collection and Analysis*

To assess the ecosystem services provided from urban farms we carried out surveys of the three major types of urban farms encountered in Pyin Oo Lwin, namely (a) seasonal crop farms (N = 101), (b) coffee farms (N = 20), and (c) nurseries (N = 20). Due to the lack of comprehensive registration records for urban farms we could not adopt a probability sampling approach [58]. However, based on the best available information we followed a purposive expert sampling approach to systematise the selection of the study areas and respondents, as outlined below [58].

First, we identified the main types of urban farms (i.e., seasonal crops, coffee, nurseries) and the major areas of concentration through extensive field observations, and discussions with the city authorities (city municipality office) and a local key informant (agricultural supply owner) (Figure 1). Second, we verified these agricultural land clusters through a comprehensive land use change analysis for the entire city using remote sensing techniques (refer to [25] for the full analysis). Third, and considering the much higher number and disaggregated distribution of seasonal crop farms, we surveyed such farms in all identified clusters to avoid biases due to location and topography. It is worth noting that the family farms in the study clusters were practically integrated in the rapidly expanding city during recent decades, rather than developed specifically for farming within the city [25]. To ensure the randomization of the sample we selected individual seasonal farms in each cluster through transect walks using constant selection rules (i.e., selection of every 3rd household along the transect). Farmers were interviewed subject to their availability and willingness to provide access to their property (Figure 1). For nurseries and coffee farms we used a snowball sampling method considering their lower numbers compared to seasonal crop farms [58].

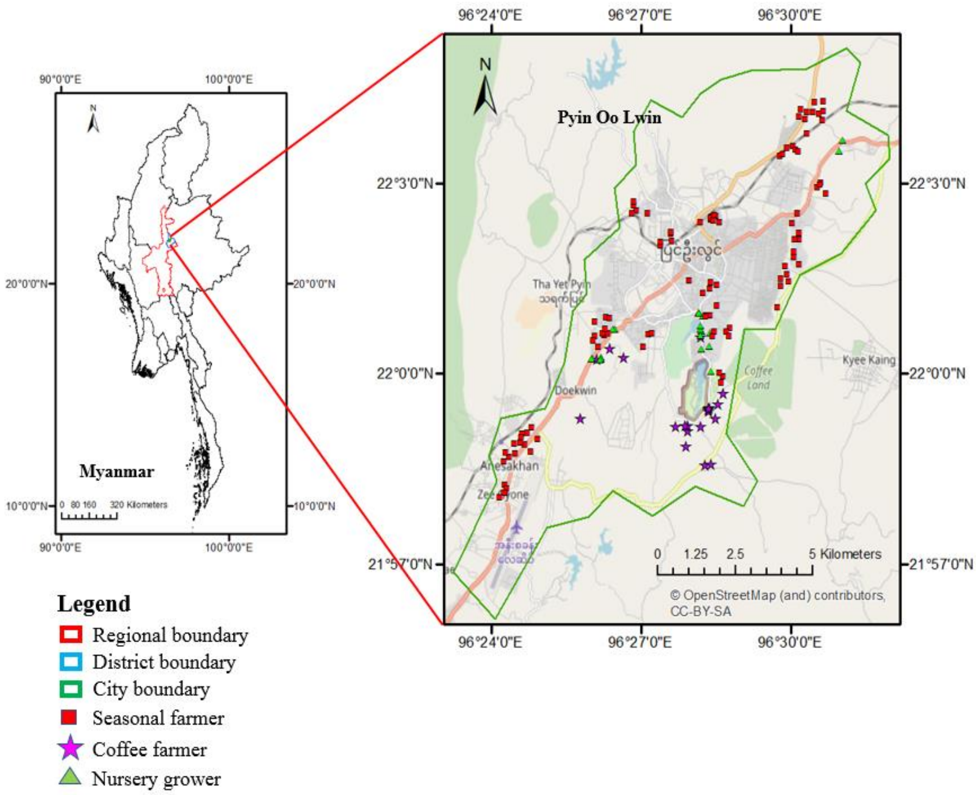


**Figure 1.** Location of Pyin Oo Lwin and the surveyed farms.

To obtain accurate information, we targeted as respondents those household members mostly involved in farming activities (usually the household head or spouse for family farms and nurseries), or owner/person in-charge (for commercial farms). The survey questionnaire was structured, and consisted of four major parts: (a) demographic information, (b) general farm characteristics, (c) provisioning services and associated issues (e.g., food production, agricultural inputs, economic benefits, nutrition), and (d) perceived cultural services (and related social benefits), regulating services (i.e. climate regulation, pollution regulation), and supporting services (i.e., habitat for wildlife). Each survey lasted 45–60 minutes and all surveys were collected between August and September 2017.

The provisioning services were captured based on the actual output of the farm during the previous growing season. Collected variables included types of farm products, production quantity for each product, farm area allocated for each product, market price per unit for each product, and major market for each product. To assess the provisioning ecosystem services associated with crops we estimated product yields (ton/ha) by averaging for each product the observations from each farm. We estimated the monetary value of provisioning services (i.e., production quantities) through the market prices for each farm product as quoted by farmers, and cross-referenced with prevailing prices in city markets. We estimated the net economic output per unit area (ha) by subtracting the expenditure for farm inputs (i.e., fertilizers, agrochemicals). The monetary values were captured in Myanmar Kyat (MMK) and converted into US dollars (USD) by using the average exchange rate during the collection period (1 USD = 1353 MMK).

In addition to estimating the quantity and economic value of farm products, we also collected information about the production of medicinal plants and other plants with traditional uses (e.g., in local dishes, decorative) and the possible benefits of provisioning services to diets and social cohesion through the self-consumption and sharing of farm products, respectively. We also assessed the provision of some regulating and supporting ecosystem services, as well as intangible benefits associated with cultural ecosystem services. The studied cultural ecosystem services included (a) aesthetical pleasure, (b) biophilia, (c) education and personal development, (d) exercise and physical recreation, (e) leisure, (f) mental and psychological benefits, (g) spiritual experience, and (h) social cohesion and integration. The regulating and supporting services included (a) habitat for biodiversity, (b) climate regulation, and (c) air pollution regulation. These possible benefits were identified through a literature review (see Section 1) and discussions with local experts and residents during the development of the survey.

To elicit the provision and importance of these services we followed a two-stage process. First, we asked respondents whether they derive these benefits (for diet, medicinal plants, traditional plants, and cultural ecosystem services) or they believe that their farms provide these benefits (for regulating and supporting services). Subsequently we asked the participants that answered "Yes", what is the importance of these services for themselves or their households. Responses were captured using a 5-level Likert scale where: 1 = Not important at all, 2 = Slightly important, 3 = Moderately important, 4 = Very important, and 5 = Extremely important. This 2-step process followed many other studies seeking to elicit the non-monetary value of ecosystem services, including from urban agriculture [22].

## 3. Results

### 3.1. Main Farm Characteristics

We performed surveys with 101 seasonal crop farmers, of which 52 were males (51%) and 49 females (49%). Most seasonal crop farm respondents fell in the 46–55 years age category (34% of respondents), and had mostly finished middle school (47%). The average family size was 5 people per household and the total monthly household income for 57% of seasonal crop farmers was MMK 100,000–500,000 per month (USD 80–400/month), while only 8% earned less than MMK 50,000 per month (USD 40 per month) and 6% earned more than MMK 1,000,000 per month (USD 800 per month). Approximately, 63% of the respondents were undertaking urban farming only for commercial purposes, 28% for both commercial purposes and household consumption, and only 9% only for household consumption (i.e., subsistence).

The sizes of the seasonal crop farms ranged from 0.004–3.86 ha, and 63% were family-owned farms, with the rest being owned by single individuals (26%), trusts (10%), private firms (1%), and the government (1%). Figure 2 outlines the size distribution of the seasonal crop farms, showing the relatively large variability of farm size. These farms mainly produce seasonal vegetables and flowers (Section 3.2) following different patterns within the growing season. In particular, three major cultivation cycles were reported among the different farms, namely (a) the 6-6 pattern (i.e., two 6-month periods, each for growing flowers), (b) the 6-3-3 pattern (i.e., one 6-month period for growing flowers, and two 3-month periods for growing seasonal vegetables), and (c) the 4-4-4 pattern (i.e., three 4-month periods solely for growing seasonal vegetables). The latter growing pattern is associated mostly with farms that cater to the national market.

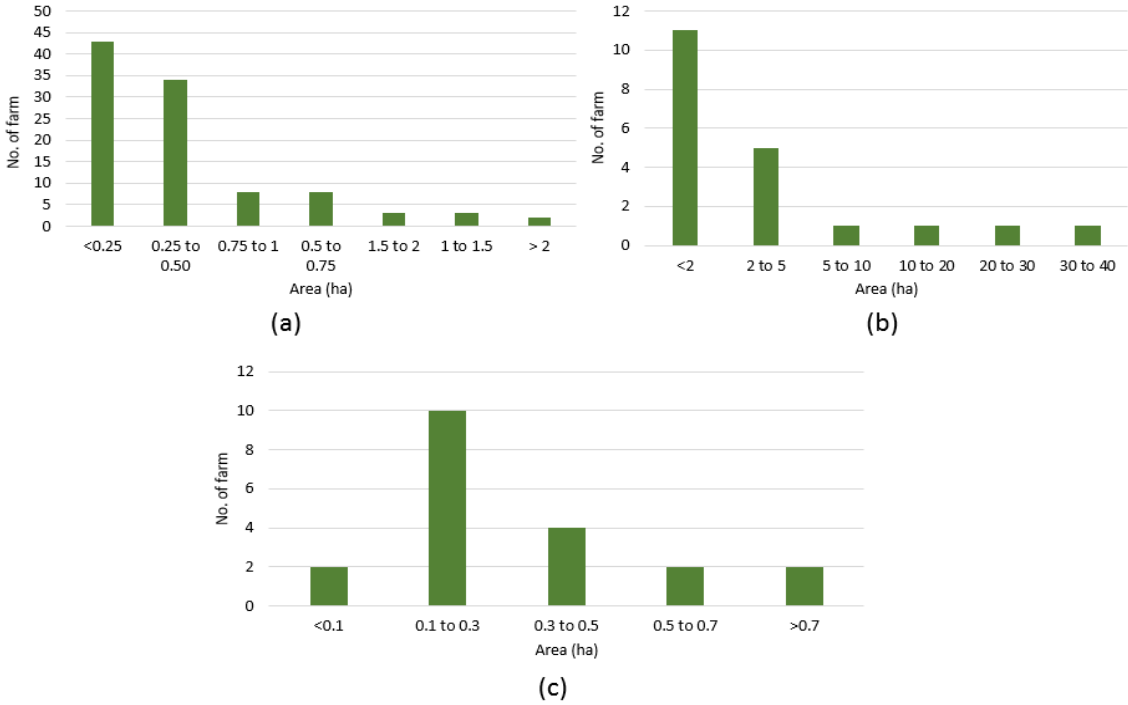


**Figure 2.** Size distribution of (**a**) seasonal crop farms, (**b**) coffee farms, and (**c**) nurseries.

We also performed surveys in 20 coffee farms. The respondents were 14 males (70%) and 6 females (30%), mostly falling in the 36–45 years age category and being middle school graduates (47%). Approximately half of the respondents (50%) earned MMK 100,000–500,000 per month (USD 80–400 per month), 30% earned more than MMK 1,000,000 per month (USD 800 per month), and only 5% below MMK 50,000 per month (USD 40 per month).

Farm sizes ranged between 0.2–40 ha (Figure 2), with 50% described as commercial family farms, 35% as company-owned commercial farms, 10% as research farms, and 5% as institutional farms (all research farms and institutional farms were owned by the national government). All coffee farms produced shaded-grown coffee, with practically all of them containing fruit trees for shade. As a result most coffee farms produced avocado, jackfruit, and macadamia as a secondary product (Section 3.2). The coffee products were geared both towards the national and international market.

Finally, we surveyed 20 nursery respondents, 10 of which were male (50%) and 10 were female (50%). Most fell in the 26–35 years age category, and approximately 40% were educated at the post-graduate level. Approximately 40% earned MMK 500,000–1,000,000 per month (USD 400–800 per month), 30% earned more than MMK 1,000,000 per month (USD 800 per month), and only 5% earned less than MMK 50,000 per month (USD 40 per month). All nurseries were commercial, targeting the national market, and had sizes ranging between 0.04–0.81 ha (Figure 2).

### *3.2. Provisioning Ecosystem Services*

The results suggest that a total of 44 crop varieties are grown in seasonal crop farms across the city (i.e., 25 varieties of vegetables, 8 varieties of fruits, 2 varieties of grains, 4 varieties of legumes), and 5 types of flowers, while coffee farms produce 2 coffee varieties, Arabica and Catimor (Table 1). Nurseries produce a very large variety of species that for reasons of simplicity are categorized into four groups namely: ornamental plants (e.g., flamingo lily (*Anthurium andraeanum),* butterfly palm *(Dypsis lutescens),* Chinese perfume plant or Chinese rice flower *(Aglaia odorata*)); (b) shaded/commercial plants (e.g., *Gmelina arborea*, padauk (*Pterocarpus Indicus*), silver oak); (c) herbal plants (e.g., aloe vera, *Melastoma malabathricum,* red sandalwood); and (d) edible plants (e.g., avocado, Diamond mango, jackfruit, drumsticks (*Moringa oleifera*)) (Table 1).

For crops of seasonal crop farms, Chinese broccoli, mustard, and carrot (non-hybrid) are the most popular crops in terms of the number of farms growing them. However, an appreciable number of seasonal farms produce high value crops such as strawberries (Table 1). The chrysanthemum is the most widely grown flower followed by the chrysanthemum 'Stella' (Table 1). In coffee farms the two coffee varieties are the major output, with average yields of 1.07 t/ha (Arabica) and 0.99 t/ha (Catimor). Furthermore, a few farms produce an estimated 0.49 t/ha of various fruits as a secondary product from the shade trees, usually jackfruit, avocado, and macadamia. In nurseries, herbal plants are the most prevalent in terms of number of plants (6984 plants) followed by ornamental plants (5811 plants), shaded/commercial plants (3495 plants), and edible plants (3001 plants).

**Table 1.** Average yield and economic value of urban farm products.

| | **Products** | **Number of Farms** | **Average Yield (t/ha)** | **Economic Value (USD/ha)** |
|---|---|---|---|---|
| | **Seasonal crop farms** | | | |
| 1 | Ash pumpkin | 1 | 20.00 | 277.16 |
| 2 | Avocado | 2 | 3.34 | 831.49 |
| 3 | Banana | 2 | 3.63 | 315.96 |
| 4 | Basil | 1 | 0.01 | 1.85 |
| 5 | Bean | 1 | 9.04 | 1670.36 |
| 6 | Cabbage | 5 | 25.42 | 2297.92 |
| 7a | Carrot (hybrid) | 8 | 27.58 | 3393.55 |
| 7b | Carrot (non-hybrid) | 16 | 20.30 | 3984.16 |
| 8 | Chayote shoots | 2 | 4.59 | 4525.44 |
| 9 | Chayote squash | 2 | 4.75 | 905.40 |
| 10 | Chili | 5 | 3.05 | 616.68 |
| 11 | Chinese broccoli (Gai lum) | 34 | 10.76 | 1241.24 |
| 12 | Chives | 1 | 0.03 | 447.15 |
| 13 | Coriander | 8 | 2.97 | 487.81 |
| 14 | Cow pea | 2 | 5.62 | 953.74 |
| 15 | Dill | 4 | 0.64 | 1007.02 |
| 16 | Dragon fruit | 2 | 1.65 | 638.84 |
| 17 | Eggplant | 1 | 1.20 | 237.57 |
| 18 | Flower (Chrysanthemum 'Stella') | 22 | 13,626 bundles | 3670.24 |
| 19 | Flower (Chrysanthemum) | 44 | 11,900 bundles | 8026.42 |
| 20 | Flower (Gladiolus) | 2 | 4594 bundles | 3757.85 |
| 21 | Flower (Globba) | 4 | 62,475 bundles | 3410.69 |
| 22 | Flower (Ester) | 1 | 358 bundles | 297.95 |
| 23 | French bean | 5 | 6.16 | 1048.04 |
| 24 | Garlic | 16 | 3.50 | 1036.49 |
| 25 | Green pea | 3 | 12.12 | 1108.03 |
| 26 | Green pea leaves | 1 | 5.70 | 1123.43 |
| 27 | Guava | 1 | 3.22 | 264.23 |
| 28 | Lettuce | 7 | 10.10 | 562.40 |
| 29 | Lychee | 1 | 0.57 | 19.15 |
| 30 | Maize | 3 | 1.82 | 1002.40 |

**Table 1.** *Cont.*

| | Products | Number of Farms | Average Yield (t/ha) | Economic Value (USD/ha) |
|---|---|---|---|---|
| 31 | Mustard | 19 | 6.41 | 979.55 |
| 32 | Onion | 3 | 1.52 | 167.91 |
| 33 | Paddy rice | 3 | 3.13 | 266.90 |
| 34 | Papaya | 1 | 2.00 | 46.19 |
| 35 | Persimmon fruit | 1 | 7.59 | 47.87 |
| 36 | Potato | 3 | 25.80 | 1597.96 |
| 37 | Radish | 13 | 5.99 | 954.47 |
| 38 | Roselle | 1 | 0.15 | 9.24 |
| 39 | Snow pea | 2 | 8.31 | 3694.59 |
| 40 | Spring onion | 2 | 4.37 | 384.45 |
| 41 | Stem lettuce | 3 | 30.35 | 1713.35 |
| 42 | Strawberry | 16 | 17.74 | 4077.93 |
| 43 | Tomato | 1 | 11.44 | 479.17 |
| 44 | Water spinach | 1 | 3.38 | 124.72 |
| | | **Coffee farms** | | |
| 1 | Coffee (Arabica) | 10 | 1.07 | 27,827.56 |
| 2 | Coffee (Catimor) | 10 | 0.99 | 4119.17 |
| | | **Nurseries** | | |
| 1 | Ornamental plants | 12 | 5811 plants | 2759.10 |
| 2 | Shaded/commercial plants | 18 | 3495 plants | 4059.47 |
| 3 | Edible plants | 13 | 3001 plants | 1694.87 |
| 4 | Herbal plants | 4 | 6984 plants | 2120.37 |

By using market prices (Table S1, Supplementary Material), it is possible to estimate the monetary value of the provisioning services provided by the different types of urban farms (Table 1). By subtracting the expenditures for farm inputs (e.g., fertilizers/pesticides, seed, other material) it is possible to estimate the net economic value generated per unit area. Seasonal crop farms generated on average 4,544,089.00 MMK/ha (3365.99 USD/ha), coffee farms 3,367,882.00 MMK/ha (2489.20 USD/ha), and nurseries 9,346,639.58 MMK/ha (6908.09 USD/ha) (Table 2). However, the cost of farm input is highly variable between farm types and accounts for a large fraction of the total generated value, especially for nurseries and seasonal crop farms (Table 2).

**Table 2.** Economic output of provisioning services provided by different types of urban farms.

| | Total Economic Output (MMK/ha) | Expenditure for Inputs (MMK/ha) | Input Expenditure (% Total Production Output) | Net Economic Output (MMK/ha) | Net Economic Output (USD/ha) |
|---|---|---|---|---|---|
| **Seasonal farms** | 7,252,017.00 | 2,707,929.00 | 37.3 | 4,544,089.00 | 3365.99 |
| **Coffee farms** | 4,063,284.00 | 695,402.00 | 17.1 | 3,367,882.00 | 2489.2 |
| **Nurseries** | 23,163,106.25 | 13,816,466.67 | 59.6 | 9,346,639.58 | 6908.09 |

Commercial crop species dominate urban farming in the city but a small minority of seasonal crop farmers (28%) and coffee farmers (30%) grows some small quantities of traditional edible plants, seasonings, and plant varieties that are uncommon in some markets. For example, some seasonal farmers reported the production of mint, *Centella asiatica*, *Crateva religiosa*, turmeric, and wild ginger, while coffee farmers planted some rarer plant varieties, such as agarwood, *Cissus discolor* Blume, sandalwood, and petai beans. However, the majority of nursery growers (85%) planted traditional plant varieties such as *Cissus discolor* Blume, with only a small minority using the nurseries to grow common commercial plant species. Nursery growers considered these traditional varieties to be much more important compared to seasonal crop farmers (Figure 3)

Approximately 57% of seasonal crop farmers and 67% of coffee farmers used some small parts of their farms to grow plants with local medicinal uses such as aloe vera, *Centella asiatica*, *Crateva religiosa*, *Cissus discolor* Blume, dill, turmeric, roselle, wild ginger, agarwood, and petai beans, among others. The vast majority of nursery growers (85%) produced and sold many different medicinal plants, such as *Melastoma malabathricum*, *Rauvolfia serpentian*, Indian snakeroot, and *Alysicarpus vaginalis*, among others. In this case, the nursery growers perceived these medicinal plants as important for their households compared to seasonal crop farmers (Figure 3).

Finally, most seasonal crop farmers (93%) and coffee producers (90%) attested that consuming some of their farm products helped them achieve balanced nutrition and/or a healthy diet, especially in terms of fresh vegetables and fruits that use low amounts of chemicals (or are grown under purely organic conditions). However, this applies to only 30% of the nursery growers. Seasonal crop farmers and coffee farmers perceived these dietary benefits as very important to their households compared to nursery growers, who perceived them as moderately important (Figure 3).

It is worth noting that many urban farmers reported the sharing of some crops with family, neighbors, and friends, as well as their donations to monasteries (Table S2, Supplementary Material). Although these amounts are relatively low compared to those for self-consumption and selling, they might have a direct relationship with some cultural ecosystem services such as social cohesion (see Sections 3.3 and 4.1).

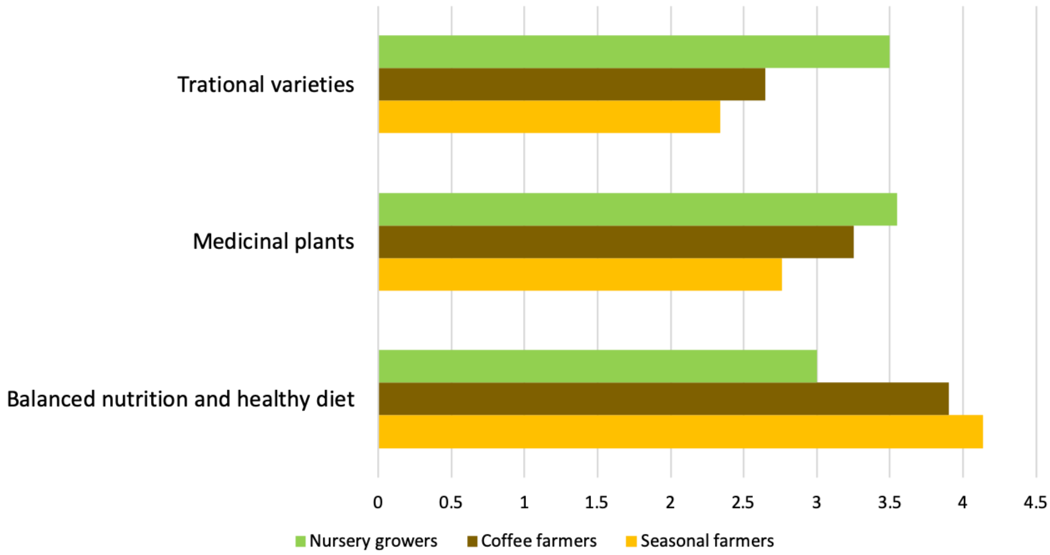


**Figure 3.** Farmer perceptions about the importance of medicinal plants, traditional plant varieties, and balanced diets.

### 3.3. Cultural Ecosystem Services

Most respondents report that they receive different cultural ecosystem services from their farms (Figure 4). Coffee farmers and seasonal crop farmers report rather similar patterns regarding cultural ecosystem services, with aesthetical pleasure, mental/psychological benefits, and nature and spiritual experience being the most prevalent (Figure 4). Similarly, all nursery growers obtain almost all cultural ecosystem services through their engagement with their farm, including aesthetical pleasures, biophilia, education and personal development, leisure, mental/psychological benefits, nature and spiritual experience, and social cohesion and integration (Figure 4). In terms of the importance of these intangible benefits, respondents across all groups assigned high importance to these cultural ecosystem services to them and their families (Figure 5).

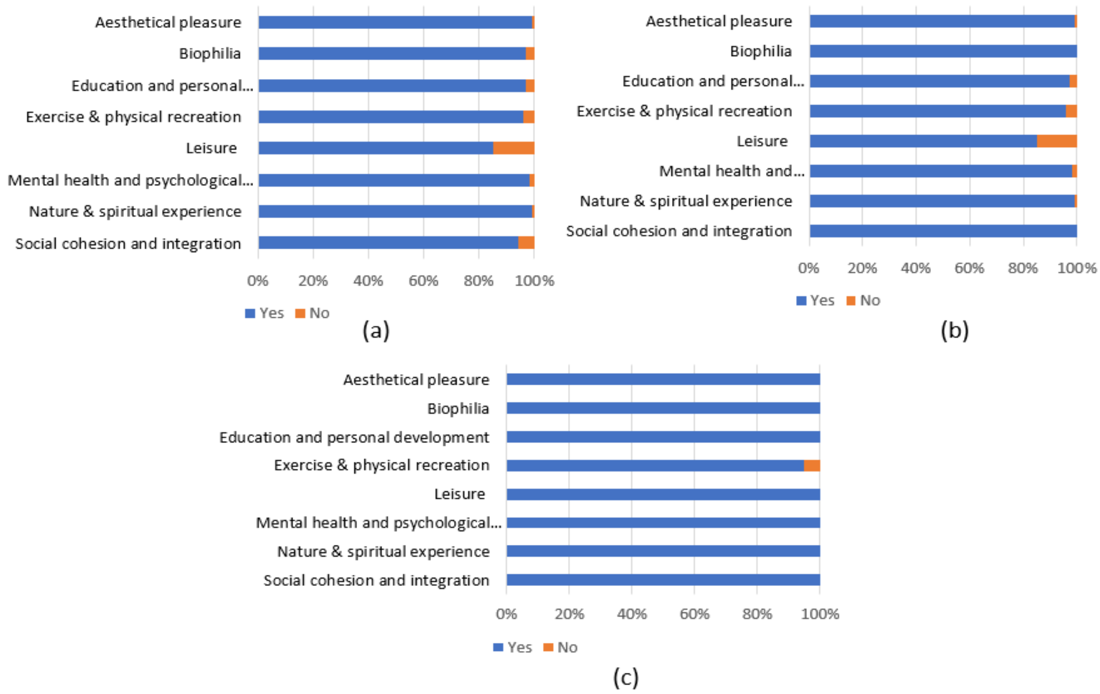


**Figure 4.** Cultural ecosystem services perceived by (**a**) seasonal crop farmers, (**b**) coffee farmers, and (**c**) nurseries.

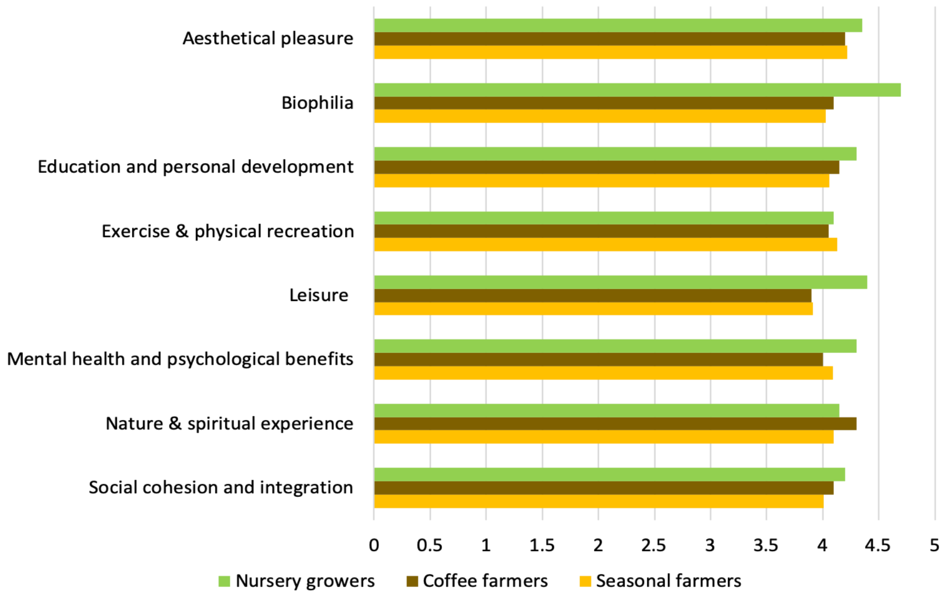


**Figure 5.** Farmer perception about the importance of cultural ecosystem services derived from urban farms.

### 3.4. Supporting and Regulating Ecosystem Services

Approximately 96% of seasonal crop farmers, 100% of coffee farmers, and 90% of nursery growers stated that their farms were providing a habitat for wildlife. Many respondents confirmed that seasonal crop farms attract small animals such as birds, bees, butterflies, rats, snakes, moles, and squirrels. Similarly, the coffee farms were identified as habitats for different bird species such as pheasants, junglefowls, doves, and crows. Less commonly, animals such as rabbit, squirrels, cobras, and butterflies, were encountered in coffee farms. Nurseries were mostly identified as bird habitats rather than habitats for other types of wildlife. About 41% of seasonal crop farmers indicated that they benefited from bees through pollination services. Some seasonal crop farmers (35%) noted that they enjoyed bird songs and observing small mammals playing in their farms, while more than half of the nursery growers (55%) mentioned that they felt really peaceful due to interaction with birds and mammals. This suggests strong links between supporting and cultural services (see Section 4).

However, not all farm biodiversity was considered to be beneficial. For example, 59% of seasonal crop farmers complained about harmful insects and mammals, including caterpillars that consumed vegetables and flowers, moles that dug burrows and destroyed roots, and rats that ate fruits and other crops. Many coffee farmers (65%) identified squirrels and some birds that eat coffee fruits as harmful species. Similarly, 45% of the nursery growers stated that some insects and mammals consumed the tender leaves of their plants, and considered them as pests.

Most seasonal crop farmers (88%) perceived that farm vegetation regulates the local climate by lowering air temperature, noting that they enjoy the fresh and cool air when they are in their farms compared to areas without green spaces around the city. Conversely, 12% of seasonal crop farmers stated that they do not experience any such benefits due to the fact that their farms contain only small plants rather than big trees. All coffee farmers (100%) agreed that their farms provide substantial climate regulation services (e.g., fresh and cool air, lower temperature) due to the substantial tree cover in coffee farms. However, far fewer nursery growers (55%) experience such local climate regulation benefits. The average importance score of this climate regulation service was 4.14 for seasonal crop farmers, 4.00 for coffee growers, and 2.65 for nursery growers.

Finally, we explored possible air pollution regulation benefits. Compared to other services, the fraction of respondents that identified such benefits is much lower, standing at 54% for seasonal crop farmers, 60% for coffee farmers, and 65% of nursery growers. In terms of importance, scores were 4.06 for seasonal crop farmers, 3.95 for coffee growers, and 4.05 for nursery growers.

## 4. Discussion

### *4.1. Synthesis of Findings*

Our analysis suggests that the studied urban farms in Pyin Oo Lwin provide multiple and very diverse ecosystem services (Section 3), which collectively contribute directly to various constituents of human wellbeing such as (1) food security, (2) local livelihoods and urban economic growth, and (3) public health and social cohesion. This reflects the emerging literature about the multiple benefits derived from urban farms and its substantial contribution to the wellbeing of urban residents, e.g., [59] (Section 1).

In terms of food security, the studied seasonal crop farms produce a substantial amount of food crops (44 varieties, Table 1) that are sold in the market and/or consumed within households (Table S2, Supplementary Material). Although coffee is the main crop produced in the studied coffee farms, some minor food products (mainly fruits, nuts) are produced through intercropping with shade trees (Section 3.1). Collectively, these food crops can contribute to balanced and nutritious diets not only within the producer households, but possibly also within the city more broadly as has been argued in other studies, e.g., [59,60]. It should be noted that compared to national average crop yield data, the non-representative sample of the surveyed urban farms in Pyin Oo Lwin has similar yields for some crops (e.g., paddy rice, tomato, coffee) but there are some discrepancies for other crops [57]. It is not clear why these discrepancies emerge, but can possibly depend on multiple non-sampling-related factors, such as crop varieties, soil nutrient weather conditions, location and farming techniques, among others, as studies in other urban agriculture contexts have suggested [61].

The output of the studied seasonal crop farms is mostly sold in markets, especially local, regional, and national markets (9%, 29% and 63%, respectively). Similarly, the output of the surveyed coffee farms and nurseries is completely sold in markets. Thus, farming is the major livelihood activity for most of the interviewed urban farmers, but generating different levels of economic output (Section 1). Nurseries generate the highest net economic output per unit area (6908.09 USD/ha), followed by seasonal crop farms (3358.53 USD/ha) and coffee farms (2489.20 USD/ha) (Section 3.2). Furthermore, based on field observations during data collection some of the larger surveyed commercial farms (especially coffee farms) provide employment to agricultural laborers and experts, but the overall employment generation was not estimated as it was beyond the scope of this study. The above suggests that urban farms can possibly contribute to urban economic growth through income and employment generation, a phenomenon that has been observed in many other studies on urban agriculture [62,63]. It can be argued that urban farms could also contribute to public health and social cohesion through both provisioning and cultural ecosystem services. In our study sample, this is achieved through different pathways, such as the cultivation of medicinal plants, nutritious diets, and the sharing of food with other community members, as discussed below. For example, many seasonal crop farms and nurseries produce medicinal plants that are used either directly (seasonal crop farms) or sold (nurseries) (Section 3.2). Some respondents indicated that the use of these medicinal resources is very important (Figure 3, Table 1), suggesting their appreciable positive effects for the health and wellbeing of some households. Similarly, many seasonal crop farmers indicated that the self-consumption of their own fresh farm products offers balanced nutrition and a healthy diet (Figure 3) (see also [64,65]).

Many respondents across all farm types pointed to some of the intangible health-related benefits derived from their farms, some of which can linked to specific cultural ecosystem services. For example, nearly all farmers within our sample reported that they derive cultural ecosystem services from their farms related to exercise, physical recreation, leisure, and other benefits that contributed to their mental and psychological health (Figure 4). The importance of these ecosystem services varies substantially between farms, suggesting that these cultural services might be very important for some farmers and less so for others. Nevertheless, the rather uniform agreement between farmers regarding the provision of cultural ecosystem services linked to positive health outcomes reflects the emerging literature about the health-related intangible benefits of urban farming (e.g., [66,67]).

One interesting finding is that many respondents share their products with family, neighbors, and friends, or donate to monasteries (Section 3.2). Although the shared amount of crops is relatively low compared to the overall farm output (Table S2, Supplementary Material), such activities can have a substantial benefit in improving good social relations and forging social cohesion (Figure 4). Many studies have indeed suggested similar findings, with sharing of food [68] and urban agriculture more generally playing a major role in building a harmonious co-existence and social cohesion, e.g., [22,24,69].

Even though the survey respondents alluded mostly to the positive effects of urban agriculture, some respondents mentioned some negative effects such as harmful pests and animals (e.g., snakes, insects) (Section 3.4). In fact, an emerging body of literature has pointed to some of the negative effects of urban agriculture on: (a) water scarcity through irrigation in water-constrained environments [70]; (b) public health risk through grey-water irrigation or water pollution from agrochemical use in densely populated areas [71]; (c) disease risk through inducing pesticide resistance to harmful insects (e.g., mosquitoes) [72]; (d) food safety risks through the accumulation of harmful substances on crops due to atmospheric and soil pollution [73,74]; and (e) social conflicts and loss of cohesion through urban land grabs and gentrification [75,76]. Such negative trade-offs need to be considered properly in efforts to promote farming to enhance urban sustainability (Section 4.2).

Finally, it should be noted that due to the lack of comprehensive farmer lists we could not adopt a probability-based sampling approach (Section 2.2). For seasonal farms our study focused on the main agricultural land clusters identified though site observation, expert interviews, and remote sensing, while for nurseries and coffee farms we used snowball sampling (Section 2.2). Even though it can be argued that the clusters are responsible for the bulk of the seasonal farmers and farms' output, and that it is appropriate to use snowball sampling due to the low number of coffee farms and nurseries, it is possible that the samples are not perfectly representative of the entire urban agricultural practices in the city. In this sense the results outlined in Section 3 should be interpreted and generalized with caution. Future research should seek to expand the scope of this study by (a) capturing a representative sample of farmers, (b) considering the possible negative effects of urban agriculture, and (c) eliciting the perceptions (and possible benefits) of urban agriculture to surrounding non-farmer households.

*4.2. Policy and Practice Implications and Recommendations*

As mentioned in Section 1, Myanmar has embarked on a coordinated policy effort to transition to a green economy [41,42,47,48]. Investing in natural capital and sustainable cities are two of the three key priority areas in the ongoing green economy efforts [42]. It has been argued that safeguarding the flow of ecosystem services from urban green spaces, such as urban farms, can contribute positively to multiple elements of the green economy, such as economic growth, employment/occupation generation, health and food security [34,35]. In this sense, "investing" in the natural capital contained in urban farms can possibly ensure the continuous delivery of the diverse ecosystem services from urban agriculture (Section 3), and thus contribute positively to green economic transitions in Myanmar.

To ensure the continuous delivery of provisioning services from urban agriculture it would be necessary to ensure both high farm productivity and economic benefits to producers. This would most likely require some sort of mechanism to enhance the economic gains from engagement in urban agriculture, such as improving market linkages and providing economic support to mitigate the high economic costs of agricultural inputs. Regarding the latter, and considering the high expenditures on farm inputs in seasonal crop farms and nurseries in our sample (37.3% and 59.6% of total economic output respectively, Table 2), there might be a need to mitigate such costs through subsidies or tax exemptions. However, further research would be needed to identify the potential sums and payment modalities for such economic incentives.

Furthermore, considering the relatively small size of many farms within our sample (Figure 2), the promotion of advanced farming techniques and knowledge about product branding and marketing could help maximize agricultural output and/or value addition, without compromising the ability of the land to provide sustained levels of ecosystem services considering the intensive cultivation regime in some farms (Section 3.1).

When considering the broader farm benefits in terms of cultural and regulating services, it might be worthwhile to explore the possibility of integrating urban farms into broader green infrastructure [13,14]. Indeed, many scholars and international organizations have argued that green infrastructure can contribute to green economic transitions in urban contexts [34,35]. However, to achieve this there is a need to build appropriate capacity among the different local government departments tasked to design green spaces and develop and implement appropriate urban plans. This capacity is currently lacking in most cities of Myanmar, and especially the smaller secondary cities such as Pyin Oo Lwin (pers. comm. Sein Lann, Pyin Oo Lwin). Building such capacity at the local level would require, among other achievements, the training of city officials and a closer interaction with national and international research institutions about the multiple benefits of urban farms, as well as how to integrate them into green infrastructure for the broader benefit of urban residents.

Notwithstanding the above, efforts to promote urban agriculture in Myanmar or integrate it into green infrastructure should also consider any possible negative effects related to water scarcity, water pollution, public health, and social cohesion (Section 4.1).

## 5. Conclusions

This study examined how urban farms in Pyin Oo Lwin (a secondary city of Myanmar) can provide different ecosystem services, which collectively contribute to multiple constituents of human wellbeing, such as food security, economic growth, health, and social cohesion. We surveyed farms representing the three different types of urban farms (i.e., seasonal crop farms, coffee farms, and nurseries), but due to information constraints it was not possible to adopt probability-based sampling. Nonetheless, we identified that nearly all of the surveyed farms provide multiple provisioning, cultural, regulating, and supporting ecosystem services.

Food crops and commercial crops (e.g., coffee) are the major provisioning ecosystem services associated with the sampled urban farms, with a few farms also producing medicinal plants or other traditional plant varieties with niche markets/uses. These ecosystem services contribute primarily to farmer livelihoods and secondarily to household food security (through self-consumption) and health (through nutritious diets and medicinal products). Interestingly food sharing with family, neighbors, and friends is a common practice among our seasonal crop farmers, with many respondents claiming that it increases social cohesion. Almost all surveyed urban farms also provide very diverse cultural services to their owners, thus ensuring the delivery of intangible benefits that have a positive effect on human wellbeing.

It is argued that ecosystem service delivery from urban farms such as those studied in this paper could contribute positively to the ongoing efforts of the Myanmar government to transition to a green economy. In this sense, ensuring the continuous supply of ecosystem services from urban agriculture would be a pre-requisite, and would entail various actions related to enhancing the profitability of urban farms, avoiding their degradation, and, if possible, integrating them into larger urban planning interventions such as green infrastructure. These would most likely require the coordinated action of urban planners, decision makers, and city authorities to develop proper policies and urban plans that consider and internalize the multiple benefits offered by urban agriculture.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2077-0472/10/5/140/s1, Table S1. Urban farm products and average market prices reported by farmers (in MMK), Table S2: Different uses of urban farm products.

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## References

1. Winkler-Prins, A. *Global Urban Agriculture*; CABI: London, UK, 2017.
2. Al-Kodmany, K. The vertical farm: A review of developments and implications for the vertical city. *Buildings* **2018**, *8*, 24. [CrossRef]
3. Armanda, D.T.; Guinée, J.B.; Tukker, A. The second green revolution: Innovative urban agriculture's contribution to food security and sustainability—A review. *Glob. Food Secur.* **2019**, *22*, 13–24. [CrossRef]
4. FAO. *Profitability and Sustainability of Urban and Peri-Urban Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2007.
5. Lohrberg, F.; Lička, L.; Scazzosi, L.; Timpe, A. *Urban Agriculture Europe*; Jovis: Berlin, Germany, 2015.
6. Orsini, F.; Kahane, R.; Nono-Womdim, R.; Gianquinto, G. Urban agriculture in the developing world: A review. *Agron. Sustain. Dev.* **2013**, *33*, 695–720. [CrossRef]
7. Mok, H.F.; Williamson, V.G.; Grove, J.R.; Burry, K.; Barker, S.F.; Hamilton, A.J. Strawberry fields forever? Urban agriculture in developed countries: A review. *Agron. Sustain. Dev.* **2014**, *34*, 21–43. [CrossRef]
8. Zezza, A.; Tasciotti, L. Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries. *Food Policy* **2010**, *35*, 265–273. [CrossRef]
9. De Bon, H.; Parrot, L.; Moustier, P. Sustainable urban agriculture in developing countries. A review. *Agron. Sustain. Dev.* **2010**, *30*, 21–32. [CrossRef]
10. Matthew, P. Scaling-up: An overview of urban agriculture in North America. In *Sustainable Landscape Planning in Selected Urban Regions*; Springer: Berlin/Heidelberg, Germany, 2017; pp. 199–213.
11. Aisyah Salim, S.; Alaa, M.; Mohammad Yusof, Z.; Farhana Md Ibharim, L.; Hajar Salim, S.; Hashim, F. Urban farming activities in southeast asia: A review and future research direction. In *MATEC Web of Conferences*; EDP Sciences: Jules, France, 2019. [CrossRef]

12. Yeung, Y. *Urban Agriculture Research in East & Southeast Asia: Record, Capacities and Opportunities Cities Feeding People Series Report*; Chinese University of Hong Kong: Hong Kong, China, 1993.
13. Artmann, M.; Sartison, K. The role of urban agriculture as a nature-based solution: A review for developing a systemic assessment framework. *Sustainability* **2018**, *10*, 1937. [CrossRef]
14. Russo, A.; Escobedo, F.J.; Cirella, G.T.; Zerbe, S. Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. *Agric. Ecosyst. Environ.* **2017**, *242*, 53–66. [CrossRef]
15. Hara, Y.; Murakami, A.; Tsuchiya, K.; Palijon, A.M.; Yokohari, M. A quantitative assessment of vegetable farming on vacant lots in an urban fringe area in metro manila: Can it sustain long-term local vegetable demand? *Appl. Geogr.* **2013**, *41*, 195–206. [CrossRef]
16. Lee, B.; Binns, T.; Dixon, A.B. The Dynamics of Urban Agriculture in Hanoi, Vietnam. *Field Actions Sci. Rep.* **2010**, *1*, 6.
17. Kulak, M.; Graves, A.; Chatterton, J. Reducing greenhouse gas emissions with urban agriculture: A life cycle assessment perspective. *Landsc. Urban Plan.* **2013**, *111*, 68–78. [CrossRef]
18. Aerts, R.; Dewaelheyns, V.; Achten, W.M.J. Potential ecosystem services of urban agriculture. *PeerJ Prerints* **2016**, *4*, e2286v1. [CrossRef]
19. Lin, B.B.; Egerer, M.H.; Ossola, A. Urban gardens as a space to engender biophilia: Evidence and ways forward. *Front. Built Environ.* **2018**, *4*, 79. [CrossRef]
20. Gregory, M.M.; Leslie, T.W.; Drinkwater, L.E. Agroecological and social characteristics of new york city community gardens: Contributions to urban food security, ecosystem services, and environmental education. *Urban Ecosyst.* **2016**, *19*, 763–794. [CrossRef]
21. Krasny, M.E.; Lundholm, C.; Kobori, H. Urban landscapes as learning arenas for biodiversity and ecosystem services management. In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment*; Springer: Berlin/Heidelberg, Germany, 2013; pp. 629–664.
22. Sanyé-Mengual, E.; Specht, K.; Krikser, T.; Vanni, C.; Pennisi, G.; Orsini, F.; Gianquinto, G.P. Social acceptance and perceived ecosystem services of urban agriculture in southern Europe: The case of Bologna, Italy. *PLoS ONE* **2018**, *13*, e0200993. [CrossRef]
23. Swapan, M.S.H.; Iftekhar, M.D.; Li, X. Contextual variations in perceived social values of ecosystem services of urban parks: A comparative study of China and Australia. *Cities* **2017**, *61*, 17–26. [CrossRef]
24. Woods, M.E.; Ata, R.; Teitel, Z.; Arachchige, N.M.; Yang, Y.; Raychaba, B.E.; Kuhns, J.; Campbell, L.G. Crop diversity and plant-plant interactions in urban allotment gardens. *Renew. Agric. Food Syst.* **2016**, *31*, 540–549. [CrossRef]
25. Helen; Jarzebski, M.P.; Gasparatos, A. Land use change, carbon stocks and tree species diversity in green spaces of a secondary city in myanmar, pyin oo lwin. *PLoS ONE* **2019**, *14*, e0225331.
26. Nilon, C.H.; Aronson, M.F.J.; Cilliers, S.S.; Dobbs, C.; Frazee, L.J.; Goddard, M.A.; O'neill, K.M.; Roberts, D.; Stander, E.K.; Werner, P.; et al. Planning for the future of urban biodiversity: A global review of city-scale initiatives. *BioScience* **2017**, *67*, 332–342. [CrossRef]
27. Gittleman, M.; Farmer, C.J.Q.; Kremer, P.; Mcphearson, T. Estimating stormwater runoff for community gardens in New York city. *Urban Ecosyst.* **2017**, *20*, 129–139. [CrossRef]
28. Richards, P.J.; Farrell, C.; Tom, M.; Williams, N.S.G.; Fletcher, T.D. Vegetable raingardens can produce food and reduce stormwater runoff. *Urban For. Urban Green.* **2015**, *14*, 646–654. [CrossRef]
29. Tsilini, V.; Papantoniou, S.; Kolokotsa, D.D.; Maria, E.A. urban gardens as a solution to energy poverty and urban heat island. *Sustain. Cities Soc.* **2015**, *14*, 323–333. [CrossRef]
30. Azunre, G.A.; Amponsah, O.; Peprah, C.; Takyi, S.A.; Braimah, I. A review of the role of urban agriculture in the sustainable city discourse. *Cities* **2019**, *93*, 104–119. [CrossRef]
31. Pearson, L.J.; Pearson, L.; Pearson, C.J. Sustainable urban agriculture: Stocktake and opportunities. *Int. J. Agric. Sustain.* **2010**, *8*, 7–19. [CrossRef]
32. Clinton, N.; Stuhlmacher, M.; Miles, A.; Uludere Aragon, N.; Wagner, M.; Georgescu, M.; Herwig, C.; Gong, P. A global geospatial ecosystem services estimate of urban agriculture. *Earth's Future.* **2018**, *6*, 40–60. [CrossRef]
33. FAO. *Greening the Economy with Agriculture*; Food and Agriculture Organisation: Rome, Italy, 2012.
34. Gasparatos, A.; Willis, K.J. *Biodiversity in the Green Economy*; Routledge: London, UK, 2015.

35. UNEP. *Pathways to Sustainable Development and Poverty Eradication: A Snthesis for Policy Makers towards a Green Economy*; United Nations Environment Programme (UNEP): Nairobi, Kenya, 2011.
36. Satterthwaite, D.; McGranahan, G.; Tacoli, C. Urbanization and its implications for food and farming. *Philos. Trans. R. Soc. B Biol. Sci.* **2010**, *365*, 2809–2820. [CrossRef]
37. Matuschke, I. *Rapid Urbanization and Food Security: Using Food Density Maps to Identify Future Food Security Hotspots*; Food and Agriculture Organisation: Rome, Italy, 2009.
38. Gomes, E.; Abrantes, P.; Banos, A.; Rocha, J.; Buxton, M. Farming under urban pressure: Farm$ers' land use and land cover change intentions. *Appl. Geogr.* **2019**, *102*, 58–70. [CrossRef]
39. Bren D'amour, C.; Reitsma, F.; Baiocchi, G.; Barthel, S.; Güneralp, B.; Erb, K.-H.; Haberl, H.; Creutzig, F.; Seto, K.C. Future urban land expansion and implications for global croplands. *Phil. Trans. R. Soc.* **2010**, *365*, 2809–2820. [CrossRef]
40. Pribadi, D.O.; Pauleit, S. The Dynamics of peri-urban agriculture during rapid urbanization of Jabodetabek metropolitan area. *Land Use Policy* **2015**, *48*, 13–24. [CrossRef]
41. WWF. *Unveiling a Green Economy in Myanmar*; World Wide Fund for Nature: Gland, Swiss, 2017.
42. Green Lotus. *Myanmar Action Plan for Green Growth*; Green Lotus: Yangon, Myanmar, 2015.
43. Ministry of Labour Immigration and Population. *2014 Myanmar Population and Housing Census Policy Brief on Migration and Urbanization*; Ministry of Labour Immigration and Population: Naypyitaw, Myanmar, 2018.
44. UN-Habitat. *State of the World's Cities 2016: Urbanization and Development: Emerging Futures*; United Nations Human Settlements Programme (UN-Habitat): Nairobi, Kenya, 2016.
45. Chen, M.; Sui, Y.; Liu, W.; Liu, H.; Huang, Y. Urbanization patterns and poverty reduction: A new perspective to explore the countries along the belt and road. *Habitat Int.* **2019**, *84*, 1–14. [CrossRef]
46. World Bank Group. *East Asia's Changing Urban Landscape Measuring a Decade of Spatial Growth*; World Bank: Washington DC, USA, 2015.
47. Miyazawa, I.; Usui, K. *Enhancing Readiness for Green Growth: A Preliminary Assessment of Myanmar's Policies and Institutions*; Institute for Global Environmental Strategies (IGES): Hayama, Japan, 2013.
48. GGGI. *Green Growth Potential Assessment Myanmar-Summary for NDC Implementation*; Global Green Growth Institute (GGGI): Seoul, Korea, 2017.
49. Wang, Y.C.; Hu, B.K.H.; Myint, S.W.; Feng, C.C.; Chow, W.T.L.; Passy, P.F. Patterns of land change and their potential impacts on land surface temperature change in Yangon, Myanmar. *Sci. Total Environ.* **2018**, *643*, 738–750. [CrossRef]
50. EuroCham Myanmar. *Agriculture Guide 2019*; European Chamber of Commerce: Yangon, Myanmar, 2018.
51. Fujita, K.; Okamoto, I. *Agricultural Policies and Development of Myanmar's Agricultural Sector: An Overview*; Japan External Trade Organization Institute of Developing Economies (JETRO): Tokyo, Japan, 2006.
52. Ministry of Agriculture and Irrigation. *Myanmar Agriculture in Brief*; Ministry of Agriculture and Irrigation: Naypyitaw, Myanmar, 2014.
53. Ministry of Labour Immigration and Population. *The 2014 Myanmar Population and Housing Census Mandalay Region Census Report Volume 3-l Department of Population Ministry of Immigration and Population*; Ministry of Labour Immigration and Population: Naypyitaw, Myanmar, 2015.
54. Ministry of Planning and Finance. *Myanmar Statistical Yearbook 2018*; Ministry of Planning and Finance: Naypyitaw, Myanmar, 2018.
55. Gianna, B.Y.; Herrera, G.; Shrestha, M. *Cities and Climate Diplomacy in the Asia Pacific*; Climate Diplomacy: Berlin, Germany, 2015.
56. Zaw, M. New Initiatives for Greening Cities in Myanmar. In Proceedings of the Asia LEDS Partnership Forum, Ho Chi Minh City, Vietnam, 5–6 December 2017.
57. Winston, E.; Op De Laak, J.; Marsh, T.; Lempke, H.; Aung, O.; Nyunt, T.; Chapman, K. *Arabica Coffee Manual for Myanmar*; FAO Regional Office for Asia and the Pacific: Bangkok, Thailand, 2005.
58. Daniel, J. *Sampling Essentials: Practical Guidelines for Making Sampling Choices*; SAGE Publications: Lonon, UK, 2014.
59. Goldstein, B.P.; Hauschild, M.Z.; Fernández, J.E.; Birkved, M. Contributions of local farming to urban sustainability in the Northeast United States. *Environ. Sci. Technol.* **2017**, *51*, 7340–7349. [CrossRef]
60. Kortright, R.; Wakefield, S. Edible backyards: A qualitative study of household food growing and its contributions to food security. *Agric. Hum. Values* **2011**, *28*, 39–53. [CrossRef]

61. McDougall, R.; Kristiansen, P.; Rader, R. Small-scale urban agriculture results in high yields but requires judicious management of inputs to achieve sustainability. *Proc. Natl. Acad. Sci. USA* **2019**, *116*, 129–134. [CrossRef]
62. Pölling, B.; Mergenthaler, M.; Lorleberg, W. Professional urban agriculture and its characteristic business models in metropolis ruhr, Germany. *Land Use Policy* **2016**, *58*, 366–379. [CrossRef]
63. Vitiello, D.; Wolf-Powers, L. Growing food to grow cities? The potential of agriculture foreconomic and community development in the Urban United States. *Community Dev. J.* **2014**, *49*, 508–523. [CrossRef]
64. Guitart, D.A.; Pickering, C.M.; Byrne, J.A. Color me healthy: Food diversity in school community gardens in two rapidly urbanising australian cities. *Heal. Place* **2014**, *26*, 110–117. [CrossRef]
65. Corrigan, M.P. Growing what you eat: Developing community gardens in Baltimore, Maryland. *Appl. Geogr.* **2011**, *31*, 1232–1241. [CrossRef]
66. Litt, J.S.; Schmiege, S.J.; Hale, J.W.; Buchenau, M.; Sancar, F. Exploring ecological, emotional and social levers of self-rated health for urban gardeners and non-gardeners: A path analysis. *Soc. Sci. Med.* **2015**, *144*, 1–8. [CrossRef]
67. Soga, M.; Cox, D.T.C.; Yamaura, Y.; Gaston, K.J.; Kurisu, K.; Hanaki, K. Health benefits of urban allotment gardening: Improved physical and psychological well-being and social integration. *Int. J. Environ. Res. Public Health* **2017**, *14*, 71. [CrossRef]
68. Saito, O. *Sharing Ecosystem Services: Building More Sustainable and Resilient Society*; Saito, O., Ed.; Springer: Singapore, 2020. [CrossRef]
69. Cabannes, Y.; Raposo, I. Peri-urban agriculture, social inclusion of migrant population and right to the city. *City* **2013**, *17*, 235–250. [CrossRef]
70. Garcia, X.; Llausàs, L.; Ribas, A.; Saurí, D. Watering the garden: Preferences for alternative sources in Suburban areas of the Mediterranean coast. *Local Environ.* **2015**, *20*, 548–564. [CrossRef]
71. Barker, S.F.; O'Toole, J.; Sinclair, M.I.; Leder, K.; Malawaraarachchi, M.; Hamilton, A.J. A probabilistic model of norovirus disease burden associated with greywater irrigation of home-produced lettuce in Melbourne, Australia. *Water Res.* **2013**, *47*, 1421–1432. [CrossRef]
72. Antonio-Nkondjio, C.; Fossog, B.T.; Ndo, C.; Djantio, B.M.; Togouet, S.Z.; Awono-Ambene, P.; Costantini, C.; Wondji, C.S.; Ranson, H. Anopheles gambiae distribution and insecticide resistance in the cities of Douala and Yaoundé (Cameroon): Influence of urban agriculture and pollution. *Malar. J.* **2011**, *10*, 154. [CrossRef]
73. Säumel, I.; Kotsyuk, I.; Hölscher, M.; Lenkereit, C.; Weber, F.; Kowarik, I. How healthy is urban horticulture in high traffic areas? trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany. *Environ. Pollut.* **2012**, *165*, 124–132. [CrossRef]
74. Antisari, L.V.; Orsini, F.; Marchetti, L.; Vianello, G.; Gianquinto, G. Heavy metal accumulation in vegetables grown in urban gardens. *Agron. Sustain. Dev.* **2015**, *35*, 1139–1147. [CrossRef]
75. Carolan, M. "Urban farming is going high tech": Digital urban agriculture's links to gentrification and land use. *J. Am. Plan. Assoc.* **2020**, *86*, 47–59. [CrossRef]
76. Aptekar, S.; Myers, J.S. The tale of two community gardens: Green aesthetics versus food justice in the big apple. *Agric. Hum. Values* **2020**. In Press. [CrossRef]