The Importance of Urban Eco-gardens in Biodiversity and Human Sustainability: a Case Study From Palestine

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Abstract

There has been increased interest in urban gardens and small botanical gardens as sites for conservation of plants especially in developing countries. This was highlighted by the fact that most countries failed to meet the CBD Aichi 2020 targets and will now restructure to address the post-2020 CBD framework. The situation in Palestine is of concern where global threats of climate change, overexploitation, habitat destruction, invasive species, and pollution are compounded by occupation and conflict. Thus, almost 1/3rd of vascular plant species are rare and over 50 are listed as endangered or threatened. Here we describe the development of a conservation botanic garden that works via research, education, and direct in situ and ex situ conservation of plant species. The garden now boasts 381 species of vascular plants (63 are rare). The team scientifically and selectively introduced some rare and endemic species, developed educational modules, and engaged the community in all aspects of planning and growth of this garden. It acted as a model for nearby threatened areas and for many of the protected areas in the state of Palestine. This has become a national oasis for both wildlife and humans. The lessons learned from this experience included: 1) principles of minimal intervention in eco-friendly ways producing zones of permaculture, gardening towards conservation (ex situ and in situ conservation), while allowing botanic garden functionaliuty, 2) involvement of staff, volunteers, experts, and community in education and conservation efforts, 3) value of research in plants and animals for integrated ecosystem management. The outcome of the work was a maximally utilitarian garden for areas like education, direct conservation, research, and aesthetics (people enjoyment) while ensuring sustainability long term in a nascent state under difficult political situation.

1. Introduction

The global environmental and biodiversity declines are accelerating due to the threats of climate change, pollution, overexploitation, invasive species, and habitat destruction (Butchart et al. 2010; McNeill 2016; Urban 2015). To respond to the looming catastrophic situation, the UN sustainable development goals (see https://www.undp.org/sustainable-development-goals), the Convention on Biological Diversity (CBD), and five other related conventions emphasized issues of sustainability on land and water (Haines-Young and Potschin 2010; Herkenrath 2012; Turnhout et al. 2016). Despite these conventions, the latest reports from COP16 of CBD held in China showed limited progress in achieving the Aichi targets and new post-2020 plan was developed that is more practical and achievable (CBD 2021; Xu et al. 2021). Few countries have been able to comply with the Global Strategy for Plant Conservation (GSPC) developed in 2002 and updated in 2010 (Heywood 2019; Sharrock 2020).

Meeting such global obligations like SDGs and the new CBD post-2020 framework is more difficult in developing countries which lack resources whether financial or human capacity to protect their endangered flora and fauna (Adenle et al. 2015; Allen et al. 2018; Hagerman and Pelai 2016). Developing countries face significant challenges because of their limited resources and their history of being exploited for raw material used by developed countries in ways that harm the global environment (Baatz 2013; Hansen and Sato 2016). For example, the Arab world faces significant environmental challenges

while it is politically and structurally in a vulnerable position (Waha et al. 2017). The nascent Arab state of Palestine is especially challenged in fulfilling conservation targets because 1) it signed the CBD only in 2015 and started working on these issues more intensely then (though it was denied funding based on political considerations), and 2) the Palestinian state in the making is still living under Israeli occupation which carries attendant environmental challenges and inability to meet them (Braverman 2021; Qumsiyeh et al. 2014; Qumsiyeh and Albaradeiya 2022; Tal 2002). Our own report from Palestine (https://chm.cbd.int/database/record?documentID=257520) shows limited progress and currently our team is leading in building the National Biodiversity Strategy and Action Plan which will be in line with the post-2020 CBD targets (CBD 2021) and on national circumstances. The parts that were completed identify challenges and opportunities and propose mitigation and adaptation strategies. Key challenges identified in common with other developing countries include climate change, overexploitation, pollution, invasive species, habitat destruction, and socio-political instability which effect biodiversity conservation and ecosystem services. This is especially true in urban areas were most of our population reside now like in many countries (Sanderson et al. 2018; UN-DESA 2007).

Palestine is part of the Fertile Crescent - the cradle of agriculture and civilization. It is located at the intersection of continents and harbors five phytogeographical zones (Irano-Turanian, Saharo-Arabian, Mediterranean, Coastal, and Sudanese). Threats to natural and cultural heritage range from collection of plants and flowers as souvenirs or spices to Israeli settlement activities to increased Palestinian urbanization (Qumsiyeh et al. 2014; Qumsiyeh and Albaradeiya 2022). The growth in urban areas is significantly increasing worldwide, but it is most destructive in these vulnerable developing countries (Smith 2019). It is not inevitable that it leads to biodiversity decline and habitat loss (Elmqvist et al. 2016). Urban green areas and botanic gardens can become a critical remedy whether via biodiversity maintenance or gardening to produce local supplies for urban areas (Heywood 2017; Hudson et al. 2021; Lohrberg et al. 2016; Lovell 2010; Sperling and Lortie 2010; Westwood et al. 2021). Such areas also contribute to social cohesion and health (Cilliers 2010). Agrobiodiversity is rich in this area but is declining and some efforts at reforestation are underway. Urban gardening and botanical gardens can reconnect people to the land. Few researches on urban gardening are conducted in the neighboring countries (Faruqui and Al-Jayyousi 2002; Lteif and Soulard 2015). Urban gardening in Palestine carries great promise (Slater 2001). The same can be said of botanic gardens which are important especially in developing countries (Heywood 2017; Qumsiyeh et al. 2017; Renu 2018). The botanic garden at the Palestine Institute for Biodiversity and Sustainability was launched in 2017 and was intended to help in conservation efforts (Qumsiyeh 2017; Qumsiyeh et al. 2017). The garden rapidly evolved over the past 5 years and we accumulated data on its uses not just in terms of an urban and community garden but for in situ and ex situ conservation. The data collected show promise for local authorities and stakeholders ability to meet international targets but also can serve as a model for other developing countries especially those facing difficult political and/or socioeconomic circumstances.

2. Materials And Methods

2.1 Site

Bethlehem University has a main campus and a side campus called Mar Andrea. Two buildings in the latter campus were used for a girls' dormitory and a nuns' residence but were mostly abandoned. The 12-dunum land was partly planted with olive and almond trees in the 1970s and partly used to store construction and maintenance items. In late 2014, the area was examined and found to have great potential as an urban garden, a permaculture facility, and a botanic garden. We took two years (from late 2014 to 2016) to observe where plants grew and thus where habitats need to be preserved. During this period the only projects executed in the garden were 1) repair stone terraces already found on site, 2) create a pond in the lowest part of the property to harvest rain water that was already accumulating there and had resulted in significant erosion of rich soil to the neighboring lands (see Fig. 1 where the artificial wetland was created in area 8), and 3) repair the old storage building and extend it with a cage to make it a functioning animal room for rehabilitation of wildlife and also to keep domestic birds (#16 in Fig. 1).

2.2 Collecting data on site

While some data were collected in 2015 and 2016, most of the data discussed in the results were collected in the past 5 years (2017–2021). These included plant phenology and mapping in the garden using traditional plant transect and observation methods. They also included year-round observation of fauna by use of methods unique to each group of animals: a) Sherman live traps for small mammals, b) echolocation recordings for bats, c) camera traps and direct observation for large mammals and birds, d) invertebrate collection methods (Gibb and Oseto 2019).

2.3 Further work on site

Methods for In situ conservation: Data collected on site in terms of presence of species in each square meter of the land were used to determine what and where to conserve existing plants. For example, one area of the garden was noted to have a population of hundreds of *Adonis microcarpa*. The area was marked and maintained and a sign for the plant was introduced. Visitors enjoy this red carpet that comes in late February and early march. The same of the few (dispersed) orchids in the garden (six sites with four in situ conserved species). Further interventions on site included building new stone terraces with minimal disruption in the key areas of the garden, and creating different areas in the garden with the aim of introducing new species to them. The selection of families like orchids and irises for ex-situ conservation was done based on analysis of need for protection (Al Sheikh and Qumsiyeh 2021a). We also planted some endogenous Palestinian trees (carob, hawthorn, oaks, pistacia, sumak). The wild trees were also cultivated between existing olive trees because there is evidence of enrichment of biodiversity around olive groves (Awad and Attum 2017). The olive trees were not well maintained prior to 2014 and by maintaining them, and not plowing but encouraging natural plant growth between them, we saw a significant increase in olive production.

Methods for ex situ conservation: We reviewed the data gathered in the last few years in Palestine on certain protected area plants and on rare and endemic plants collected in the field (Al Sheikh 2019; Al

Sheikh and Mahassneh 2017; Al Sheikh and Qumsiyeh 2021a, 2021b; Pahl and Qumsiyeh 2021). We also reviewed data we gathered on wild growing plant species in the garden to plan translocations for ex situ conservation. Our guiding principles for translocations were followed (Fenu et al. 2019; Guerrant Jr et al. 2014; Heywood et al. 2018):

a. Common and endangered plants were collected in the wild only if there is a population of > 15 individuals an exact location. Often the material was collected from areas facing human development (building roads)
b. Collection and subsequent translocation were scheduled during the optimal season of the year for each species. Whenever possible young plants were selected because they showed a higher rate of successful translocated individuals compared to older individuals. When doing so we found the best time is as the leaves where budding but before flower bud development (Fenu et al. 2019). Further, it is critical to transfer them with a bit of their surrounding soil because of presence of Mycorrhiza (Zhao et al. 2021).
c. Planting of the collected individuals in our garden was done with minimum interventions in existing plant populations.

3. Results

3.1 Biodiversity in Palestine and in the garden

Al Sheikh (2019) noted 1,612 plant species which belong to 117 families in Palestine. However, further surveys are likely to raise that number (Al Sheikh and Qumsiyeh 2021b; Pahl and Qumsiyeh 2021). A preliminary meta-analysis identified 600 plant species either rare or of concern in the West Bank (Al Sheikh and Qumsiyeh 2021a). 187 of these species are endangered, 171 very rare, 238 rare, and four already extinct. The fieldwork done here allowed us to compare data from Mediterranean areas nearby to data on plants found in the garden as well as build our herbarium collection.

An intensive study of the plants of the garden gave us a list of 381 species of which 63 are rare (data available at https://www.palestinenature.org/botanical-garden/PMNH-Flora-List.pdf). This is very high for an area of this size (12 dunum) at this latitude and located inside an urban area. Selected species were introduced into the garden for either education or conservation value including: *Anacamptis papilionacea, Anacamptis pyramidalis, Arbutus andrachne, Calicotome villosa, Cynara scolymus, Laurus nobilis, Myrtus sp., Narcissus tazetta, Neotinea tridentate, Ophrys lutea, Ophrys umbilcata, Orchis papilionacea, Orchis anatolica, Pancratium parviflora, Parkinsonia aculeate, Rosa rubiginosa, Rosmarinus officinalis, Ruscus sp, Salvia fruticose, Stryax officinalis, Wasingtonia*

In addition to the plants, the garden boasts diversity of **mushrooms** (*Coprinellus micaceus, Omphalotus olearius, Psathyrella bipellis, Suillus collinitus, Trametes hirsute, Volvopluteus gloiocephalus*) and rich **animal diversity**. Visitors especially enjoy two groups: butterflies and birds. A total of twenty-nine species of butterflies were documented belonging to five families (Papilionidae, Pieridae, Lycaenidae, Hesperiinae

and Nymphalinae). Three species are noted year-round while most appear during from late February to Early May (Abusarhan et al. 2016). The garden has rich invertebrate biodiversity of over 1500 species.

Reptiles observed include *Testudo graeca, Eiresnis decemlineatus, Eirenis rothi, Platyceps collaris, Dolichophis jugularis, Hemorrhois nummifer, Typhlops vermicularis, Chalcides ocellatus, Heremites vittatus, Ablepharus rueppellii, Ophisops elegans, Phoenicolacerta laevis, Chamaeleo chamaeleon, Stellagama stellio, Hemidactylus turcicus, Mediodactylus kotschyi, Ptuodactylus guttatus, Mauremys rivulata.* 49 species of birds have already been recorded in the garden (list at https://www.palestinenature.org/botanical-garden/PMNH-Birds-List.pdf) including resident, winter visitors, and migratory species (may of the latter were noted after introduction of the artificial pond discussed above. Breeding species in this small area including doves, bulbuls, Palestine sunbirds, house sparrows, hooded crow, and the Syrian woodpecker. Unfortunately, the invasive and damaging Myna bird *Acridotheres tristis* is also nesting here (Handal and Qumsiyeh 2021).

The only resident **amphibian** of the garden was the common *Bufotes sitibundus.* However, when we built the aquatic rain harvesting ecosystem we introduced two more species, *Hyla savygnyi and Pelophylax bedriagae.* A native fish species was also introduced (*Garra rufa* from Wadi Qana). Mammals observed here include rodents (*Acomys cahirinus, Apodemus mystacinus, Mus musculus*), shrews (*Crocidura Leucodon*), red foxes (*Vulpes vulpes*), mole rat (*Spalax leucodon*), and four species of bats (*Pipistrellus kuhli, Pipistrellus savi, Rhinopoma hardwiki, Tadaria teniotis)*.

3.2 Structure of the garden

The garden operates as part of the Palestine Institute for Biodiversity and Sustainability (PIBS) at Bethlehem University whose vision is sustainable human and natural communities. The garden project fits within the mission of PIBS to preserve the natural and cultural heritage of Palestine by research, education, and actions of conservation. The structure for PIBS and for its garden was developed collectively with volunteer and expert participation. A desktop study was followed by meetings with people concerned and input from visits to more than 15 global botanic gardens both in developed and in developing countries. Two of the authors also attended in person and online a management program held by International Association of Botanic Gardens held in Shanghai, China. These extensive consultations were distilled in the **general goals of the garden**:

1) Develop Applied research that guides policy: To study the flora of Palestine including phenology, ecology, ecosystem, and threats with the aim of protection. The acquired knowledge, books, database and samples produce applied research that guides policy (for example our work with the Environment Quality Authority on national strategies and action plans). We set up a herbarium and engage in field trips to produce both data and ideas which also served in development of the garden.

2) Conserving plant species that are rare and threatened in Palestinian by in situ and ex situ conservation. This includes propagation of such species in the garden and a scientifically aided into their restored native habitats (combination of in-situ and ex-situ measures)

3) Mainstreaming: Providing the public, researchers, and decision makers information on plant diversity in Palestine. That task will be achieved by programs of environmental education and awareness using the plants and animals of the garden as examples. We also expanded our visits to marginalized communities and refugee camps in the past three years and in 2021 acquired a mobile educational unit that will allow us to take the museum and herbarium specimens, brochures and other educational modules to more communities.

4) Clearing house mechanism: The institute is indexing data collected at its website http://palestinenature.org and was contracted to collect the data for the clearing house mechanism for the whole state of Palestine. The collected and indexed data cover the fauna, flora, protected areas, ecosystems, environmental threats and more. This will increase access to information and benefits the exchange with and between other institutions

6) An oasis of tranquility in an area of conflict and increased urbanization: The garden provides a peaceful and beautiful aesthetic green space in strongly urbanized and environmentally stressed region. In the urbanized areas of Palestine, public green-spaces are rare and that the human population faces daily tense situation inflicted by the existing conflict. Visitors may use the garden to relax and recover from daily stress.

We will develop the garden further by creating functional productive units that serve the sustainable use of the ecosystem services provided by the environment to humans and also act as educational modules. Human interventions will be planed and applied in a way that enhances the existing biodiversity while maximizing use of space:

1) The horticultural work in the garden is rooted in both **permaculture and utilitarian principles**. For example, a highly disturbed area was recently (2018–2019) developed as a children community and exploration area because it harbored minimal biodiversity. The playground added plants that enriched biodiversity in that corner of the garden. To reduce soil erosion in this hilly area, we repaired and enhanced existing **stone terracing and introduced the use of trenches** running perpendicular to the run-off direction.

2) As reaction to the limited availability of water and space we build a greenhouse with **aquaponics and hydroponic systems.** We use it to produce fish and plant products while educating visitors about horticulture, aquaculture and the underlying nutrient cycles. Farmers and engineers from Gaza were trained here as multipliers. One graduate student from Switzerland used our system to conduct his master thesis on the subject (Kessens 2016).

3) In order to enhance the number of pollinating insect species and individuals, **insect hotels and local beehives** were introduced.

4) **Ex-situ conservations**: Palestine has a large number of endemic, rare and endangered species highly impacted by habitat destruction in the Palestinian areas (Al Sheikh and Qumsiyeh 2021a, 2021b; Pahl

and Qumsiyeh 2021). Some (especially from the orchid family and the genus *Iris*) were translocated into the garden for ex situ conservation.

5) A **mushroom room** was created in an abandoned warehouse area. This acts to diversify volunteer food sources and acts as an educational model.

6) The rain harvesting **aquatic ecosystem** was built in 2014 in the lowest area of the land. As noted above (3.1) this attracted migrating birds and we did introduce few aquatic plants and animals.

7) **Medicinal and herbal plant areas** were developed and are popular with visitors (as biocultural heritage and ecosystem service).

8) **Hugelculture systems and community garden** were developed to provide agricultural space for 30 families from 3 refugee camps and city residents from the surrounding area. These people are trained here on the principles of environmental-friendly plant production and benefit from the production of their own vegetables. Organic waste forms a large part of the outcome of managing gardens and farms. The proper disposal of such material is often neglected and done in a environmentally unfriendly way (thrown into the environment and hereby reducing the area of agricultural land or area for the botanical garden To avoid such situations in future we educate visitors on the proper disposal mechanism of organic waste and its use in sustainable production as fertilizer. The **Compost and vermiculture areas** are critical educational and utilitarian tools in our botanic garden. Organic waste in Palestine constitutes 60–65% of the generated waste and increasingly visitors, school, and university groups adopted these methods for home and institutional use.

9) The **exploration playground** was constructed using recycled material like tires and olive oil press mats. It contributes space for children to play and learn about the biodiversity and agriculture. The space is popular especially in light of shortage of such spaces for children in urban areas of Palestine.

10) Our garden introduces the development and use of **sustainable energy (solar power and biogas).** That system provides on one hand energy for the garden and on the other hand it also serves and educational purposes. Motors for the hydroponic and aquaponics systems as well as the pumps of the wells are powered by solar energy. Biogas is used by volunteers for cooking (partially).

Other amenities for visitors, researchers and workers of the garden include storage for work equipment of the staff (tool shed), bathrooms (including a compost toilet), molecular laboratories, herbarium, and three greenhouses. The **pathways** serve as the underlying structure of the garden and are planned to preserve biodiversity while being utilitarian. The garden plan, its design and the subsequent construction of pathways facilitates the movement of staff, volunteers and visitors. Seven **rest areas** provide space for visitors and volunteers to sit during their visits or work-sessions in the garden while at the same time enjoying the scenery and the surrounding biodiversity.

During the COVID19 lockdowns, we did a video and shared it over social media and with our large email list (nearly 50,000 emails). You can see this at https://youtu.be/7cBiI5ahC6o

4. Discussion

4.1. Lessons learned from management of the garden

Many lessons were learned by establishing and maintaining gardens:

1. Conducting a survey on the wild flora of the garden for two years prior to decisions about necessary interventions allowed us to decide what are areas where key species are growing and that aided the planning for paths and amenities
2. Our area is located in the Mediterranean vegetation zone. However, taking into account the effects of climate change we noted already desertification encroaching from the east. We introduced rain harvesting system (the eco-pond) and tree planting to mitigate the effects of reduced rainfall. We also implemented measures to reduce soil erosion (see above). We realized that simple stone terracing and shallow trenches make a difference in reducing soil erosion and enhancing biodiversity. This enhanced the quality of the habitats for wild life (including birds and pollinators) by having access to water and enhanced the Mediterranean character of the area (e.g. introduction of oak and pistacia trees).
3. We managed to protect and enhance the proliferation of native dicotyledonous plants as well as the overall biodiversity by ceasing plowing in the olive orchards. Instead we used a simply sickle and grass-cutting tools to reduce grasses which tended to outcompete the desired dicotyledonous plants in certain areas.
4. We managed to reduce our shortage in man- and womanpower because of lack of funding by recruiting volunteers from abroad using platforms like *Workaway* and *Volunteermatch.* These volunteers conducted much of the garden maintenance work. In addition to that, the involvement of volunteers from different places and cultures greatly benefited the social and cultural exchange for us and between the volunteers. In that way taking care for the environment led to knowledge about cultural diversity and to cross-cultural mutual understanding.
5. The community garden experiment was relatively successful as evidenced by feedback from users including from the nearby refugee camp and by the annual increase in its production (over 40% annual increase between 2018 to 2021). Being the first such garden in Palestine, people are starting to get used to it and more people have been using it. For the future we aim to expand the idea to other cities in Palestine and to emulate great strides in these areas like those found in Italy (Rusciano et al. 2020).
6. Negative experiences: A visitor brought an invasive freshwater snail *Planorbella duryi* among the roots of an aquatic plant. This and a leak in the pond forced us to restructure the eco-pond and restock it with the native flora and fauna species. As a result of that situation we adapted our policy for the introduction of plants to the garden and applies now a minimum of three-month isolation (in greenhouse in pots for plants newly introduced into the garden).

4.2 How does the garden contribute to the UN Sustainable Development Goals?

SDG1 (no poverty) and SDG2 (no hunger): The garden acts as an educational center to show people the value of food sovereignty and control of production by using innovative actions like community gardening, aquaponics, hydroponics, biogas etc. We act as multipliers aiming to transferred these measures to homes and schools.

SDG3 (Good health and wellbeing): The conflict in our region creates numerous stresses both physical and mental. The garden acts as an oasis of tranquility, healthy air (among plants) thus providing an environment to promote people's health.

SDG4 (Quality Education): The Palestine Institute for Biodiversity and Sustainability improves science education and love for exploration and innovation. This includes issues like education on recycling and upcycling as well as education on how to reduce the use of harmful products. Furthermore, university students (both undergraduate and graduate students) use the garden for their theses and other educational course projects.

SDG5 (Gender Equality): We have specific activities for girls and women almost on a weekly basis. With expert facilitators, we give them space to make their own products for the home in areas like nutrition, health, and cosmetics wellness from the natural garden ingredients.

SDG6 (Clean water and Sanitation) and SDG 7 (Affordable and Clean Energy): The benefit to visitors to the garden is seeing such projects in operation at the institute (compost toilets, solar energy, biogas production, rain harvesting system).

SDG10 (reduced inequality): The community garden and other facilities and empowerment programs and workshops are open to marginalized communities. This includes the refugee camps, remote villages, and poor people.

SDG11 (Sustainable cities and communities): Urban gardens like our ensure sustainability of the community by providing green infrastructure including in our case a community garden and other permaculture productive facilities that sustain volunteers and community.

SDG12 (Responsible Consumption and Production): The garden provides over 20 modules and periodic workshops for education and awareness about the sustainable use of food and the reduction of waste and negative effects on nature. From composting to recycling to solar energy and biogas systems, the facilities empower and inspire.

SDG13 (Climate action): In addition to what was mentioned under SDG12, we have special emphasis on climate change mitigation and adaptation. For example, six educational modules focused on climate change were designed and distributed to 14 schools in the Bethlehem and Hebron district in addition to distribute them to thousands of museum visitors. The well-researched material was later translated into short educational animated videos targeting all social groups (found at https://www.palestinenature.org/education/)

SDG 15 (Life on land): The garden builds a natural oasis in the center of the city for both people and wildlife acting as a small and protected area with 381 wild growing species of plants and many species of vertebrates as well as invertebrates.

SDG 16 (peace, justice and strong institutions): The Palestine Institute for Biodiversity and Sustainability and its garden are an attractive place for volunteers and visitors from all over the world, from different cultures and religions. The site thus contributes to mutual understanding and peace. The motto for us is respect: for ourselves, for others, and for nature. The front garden is considered as a peace garden for gatherings as well as for peaceful meditation. Finally having created this institute on a bedrock of volunteerism and local contribution, it acts as social incubator with global influence. Tens of thousands people have already been influenced in directions of peace and sustainability through this facility.

SDG17 (partnerships for the goals): PIBS and its gardens work in close cooperation with the Environment Quality Authority (EQA) and other governmental and nongovernmental agencies to develop programs that serve sustainability. We were selected to build the National Biodiversity Strategy and Action Plan for Palestine.

4.3 The Garden in local and global context

Museums and their gardens when developed can significantly contribute to education about ecosystem services and the awareness for environmental issues in general (Cavender et al. 2019; Qumsiyeh 2017; Qumsiyeh et al. 2017). Increasingly, the Western World is cognizant that biodiversity valuation (ecosystem services) can only be done with collective work involving indigenous communities (see also https://localbiodiversityoutlooks.net/) (Bohensky and Maru 2011; McElwee et al. 2020; Reyes-García et al. 2021). Palestine is part of the Fertile Crescent, where the earliest forms of domestication of animals and plants were documented. In this area one can find important and rich genetic diversity of wild species that gave rise to domestic species (e.g. wheat, barley, lentils, and chickpeas). Threats to biodiversity in Palestine are the same threats identified elsewhere by the global community (e.g. see CBD, 2021 (CBD 2021)) with some added ones. The significant global and more restricted global threats discussed above and in the 6th National CBD report (EQA 2021) are partially addressed via botanic and urban gardens and community involvement. At the Mar Andrea Campus of Bethlehem University, we have a 12 dunum area that was not used for 70 years. In the past seven years, we established a museum of natural history (including ethnobotany) in the existing building and made small improvements in the area (like adding a rainwater collecting). The garden as noted has rare Mediterranean ecosystem (considered part of the global biodiversity hotspots) that is available only in one other area in the Bethlehem District of Palestine (which is Al-Makhrour area to the west). Being to the East and at the edge of an encroaching desert with overall decline in biodiversity, the area provides a buffer zone and a decent chance for ex-situ and in-situ conservation.

Urban gardens are important to benefit the local communities (Cox et al. 2017) (Krasny and Tidball 2009) but can bring back the diversity of fauna and flora into cities, as a consequence it enhances ecosystem services (McLain et al. 2012). Yet, some urban gardens enhance biodiversity but many don’t (Lin et al.

2015; Lin and Fuller 2013; Loreau et al. 2001). In a study of several French urban gardens of similar size to ours (Shwartz et al. 2014) showed significant enhancement of biodiversity in gardens that has some positive interventions. In our case, the data provided above show indeed significant enhancement to biodiversity in this small garden over the seven years of its establishment. Yet, the involvement of people in our case via having educational modules and having a community garden and children exploration playground was significant. Thousands already benefited. As noted by others (Mougeot 2006; Pearson et al. 2010), this creates ecological citizenship, environmental restoration and remediation.

Wildlife/native friendly gardening can increase biodiversity including in urban and even backyard gardens (Goddard et al. 2013; Good 2000; Pardee and Philpott 2014; Sperling and Lortie 2010). Our garden has been free of pesticides since its founding and this resulted in increased pollinators and overall biodiversity including soil biodiversity. It also acted as an educational and community garden, which enhanced gardening both at PIBS and locally in gardens, balconies, walls, and roofs among the local communities/families. Avian study shows 49 species includes increase in breeding and population of native birds like the nectar and insect eating national bird (the Palestine sunbird) and other insectivorous birds (Andersson et al. 2007; Daniels and Kirkpatrick 2006). For non-avian vertebrates persistence in urban areas is based on garden size and management style (Baker and Harris 2007; Braaker et al. 2014; Goddard et al. 2010). Our results noted above showed significance mammalian and reptile species including locally threatened species like some insectivorous bats and the gecko *Mediodactylus kotschyi*.

The future plan for the garden includes a section were domesticated varieties are planted next to their ancestral varieties which emphasize development of these varieties, expansion of our existing molecular work on orchids to include studies of molecular phylogeny of local agrobiodiversity, and potential domestication of other food crops from this Fertile Crescent.

Declarations

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Figures

Figure 1

The Mar Andrea area that includes botanic garden. Key to areas: 1 Wild plants 2, rare plants, 3 orchids, 4 irises, 5 bird watching, 6 bee hives, 7 tortoises, 8 wetland and rain harvesting, 9 greenhouse 1, 10 animal rehabilitation, 11 Community garden, 12 exploration playground, 13 nurseries, 14 greenhouse with aquaponics, 15 compost, 16 green wall, 17 herbarium (in building), 18 rest areas, 19 amphitheater, 20 biogas, 21 tortoise area, 22 biogas and kitchen and tool areas.