Article

Vegetation in Bangalore's Slums: Boosting Livelihoods, Well-Being and Social Capital

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Abstract: Urban greenery provides ecosystem services that play an important role in the challenging context of urban deprivation and poverty. This study assesses the social importance of vegetation through empirical assessment of 44 urban slums in the rapidly developing southern city of Bangalore, India. Vegetation played a major role in supporting nutrition by its role in food consumption, and in promoting health through the planting of species with medicinal use. Trees in slums also formed nodes for social activities including conversing and playing, domestic activities such as cooking and washing dishes, and livelihood activities such as the manufacture of broomsticks and tyre repair. Innovative methods of gardening were widely adopted, with kitchen gardens found planted in plastic bags, paint cans, old kitchen utensils and buckets, indicating the importance given to planting in environments with limited finances. Short and narrow trunked trees with medium-sized canopies and high economic value, such as *Pongamia*, were preferred. A greater focus on greening in slums is needed, and can provide an invaluable, inexpensive and sustainable approach to improve lives in these congested, deprived environments.

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1. Introduction

Green spaces occupy an important function in the urban context and provide critical ecosystem services in congested urban environments, where more than half of the world's population is located [1]. Sustainable cities depend on a healthy ecosystem that influences both human well-being and numerous economic activities [2]. Trees in cities absorb vehicular air pollutants, buffer noise, regulate temperature and provide much-needed shade from the sun in tropical and sub-tropical belts [3–5]. Greenery near residential areas promotes walking, thereby improving people's cardiovascular systems and reducing obesity [6]. Green surroundings and home gardens reduce morbidity, increasing mental peace [7]. In countries like India and South Africa, green spaces, including home gardens, are often composed of socio-culturally important medicinal, sacred and culinary plants [8,9].

However, the benefits provided by trees and shrubs are not spatially homogeneous in cities. In particular, the availability of green spaces is limited in pockets of urban poverty, where access to private green spaces is often non-existent. Under such conditions, what is the role played by green spaces in the challenging context of urban deprivation and poverty?

While some studies have assessed the impact of greenery on poverty employing a psychological approach, others have enumerated its role in terms of food security. Kuo [10] suggests that neighbourhood greenery reduces mental fatigue, and provides greater psychological resources that can equip residents in low income districts to cope with poverty in the United States of America. Van den Berg *et al.* [11] in a study in the Netherlands, add that access to green space can help residents cope better with stressful life events, especially those related to poverty. With regard to food security, studies have shown that home gardens and community gardens in low income areas are the most economic and readily available sources of nutrition [12–14]. Thus, it seems possible that greenery within neighbourhoods is of great importance in the context of urban poverty.

Furthermore, Gallaher *et al.* [13] suggest that community gardening in and around residential areas increases social capital. This form of capital refers to the social relationships such as networks, norms and social trust within communities that promote cooperation for mutual benefit [15]. Moreover, it is the social resource upon which people depend while pursuing their livelihoods [16]. Social capital contributes to resilience by strengthening friendship and cooperation with neighbours and promoting household safety and survival [15,17].

We seek to explore the socio-cultural importance of urban greenery in the context of poverty. This aspect of urban greenery has largely been overlooked in research, yet it is especially important in rapidly developing countries like India, where challenges of urban inequality are severe and accelerating. Indian slums are very densely populated, containing at least as many as 40 million inhabitants [18]. Squatter settlements in Indian cities are often small and interspersed among other wealthier neighbourhoods, to which they provide important services, including labour.

Based on empirical assessments of 44 slums in Bangalore, India, we seek to understand the socio-cultural ecosystem services provided by vegetation in the context of urban poverty. Our first objective is to assess the species-specific characteristics (medicinal, culinary, ornamental, shade-giving *etc.*) of the vegetation encountered in slums, relating this to their contribution towards health and well-being. Second, we evaluate the contribution of trees towards social capital, by recording the occupations and activities carried out under their canopy, as well as the role played by trees beyond their inherent characteristics, in providing facilities such as physical support. Third, we assess the cultural services provided by trees in slums that strengthen social capital, by focusing on the sacred species found in slums. Fourth, through interviews with slum residents, we identify their requirements of urban greenery, using these to propose strategies for the improvement of the livelihoods of slum dwellers. Our findings enable us to add to our understanding of the socio–cultural importance of vegetation in the context of urban poverty, an aspect that has been insufficiently characterized thus far.

2. Study Area and Methods

A small village in the 12th century, Bangalore has grown both horizontally and vertically ever since, with a population that has recently surpassed 10 million. The city is dealing with the challenges of rapid and unplanned urbanization, including high traffic density, immense pressure on land, and an increasing number of slums [19]. Although there are more than half a million people living in the slums of Bangalore [20], government datasets lack an updated and complete slum profile. The composition and structure of urban greenery in parks, avenues, residential areas and other institutions in Bangalore have been well described [8,21–23], but there has been little research on the role played by green spaces in poor areas, especially slum settlements.

Surveys were conducted using the administrative boundary of greater Bangalore or the Bruhat Bengaluru Mahanagara Palike. Procuring reliable data on the number of slums in Bangalore and the profile of each slum was challenging, as various assessments have been carried out by a variety of government agencies and NGOs that do not concur with each other. One of the most recent and detailed reports is that published by the National Institute of Urban Affairs [24], with a non-exhaustive but detailed assessment of 114 slums within the city. Using this information, all slums mentioned in the report were visited. Given the extremely dynamic nature of urban growth in Bangalore [19,25], we found some slums to have been legalized and converted to residential areas, and others to have been razed. Furthermore, we found a number of areas that were identified as slums, but were in reality village settlements that had been engulfed by the rapid growth of the city. These locations were excluded from the study. In total, we surveyed a set of 44 slums identified in the report, covering a total area of 51.63 hectares (Figure 1). Field studies were carried out in May and June, 2011.

Typically, the slums in this study had densely packed housing units including shacks, huts, tents, *pukka* (made of durable materials such as concrete and brick) houses and *kacha* (made of natural materials such as mud and thatch) houses with narrow lanes, irregularly interspersed with trees, and with potted plants placed in and around the restricted space associated with most households. A complete census of the vegetation (both trees and plants) within the core structure of the slum as well as that around the slum periphery was carried out, with all trees and plants were identified to the species level.

Figure 1. Location of surveyed slums in Bangalore with reference to the administrative boundary.
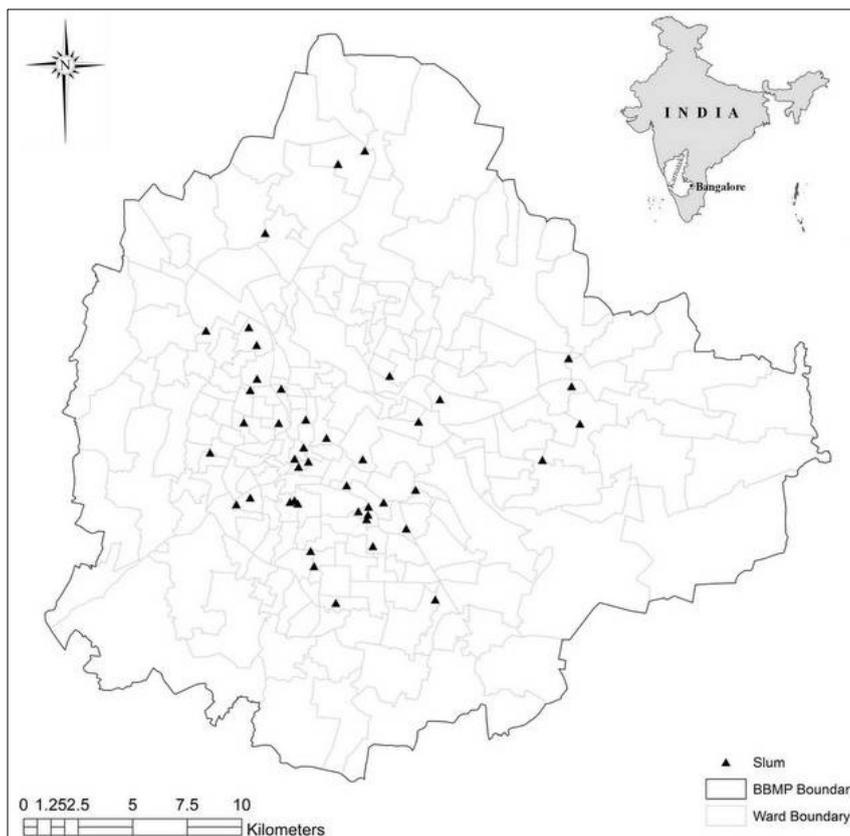
Visual observations of the utility of trees by slum dwellers were documented. Utility refers to the usage of trees as objects that can act as storage space, support, *etc.* as well as a platform for performing various day-to-day activities. These were documented based on our visual observations as well as those mentioned by the slum dwellers. However, the occupations and activities observed were limited to those carried out in the dry summer season. Bangalore receives copious sunshine throughout the year, with about 60 rainy days per annum [19]. Except for the short monsoon period, it is possible that most of the outdoor occupations are carried out throughout the year. Despite this, we acknowledge the fact that certain activities may vary over time and, therefore, limit our claims to the summer months, when the solar radiations are severe and the dependence on tree shade is at a maximum.

A study of the socio–cultural component would be incomplete without including the sacredness of nature in the Indian context. Therefore, sacred trees in slums—those described in sacred texts as well as those with holy symbols (dots of *kumkum* or the holy red powder and turmeric powder) and garlands—were recorded separately, and identified to the species level. Attributes of tree species such as origin and uses were assessed with reference to Neginhal [26] and Krishen [27]. Relative abundance was calculated for the tree species, giving an insight into the overall sum of abundance across the 44 slums.

Shrubs, herbs and creepers (referred to as plants hereafter) were also identified to the species level in each slum—except for nine genera of highly hybridized ornamental plants. The presence of plant species were documented instead of abundance. The species richness, *i.e.* the number of species per study site, was recorded for each slum. Attributes of plants were identified with reference to Kehimkar [28] and Kurian [29]. We also documented the types of pots used to grow these species.

Additionally, we carried out open-ended group interviews in all slums, in order to understand the preferences of slum inhabitants for vegetation in their neighbourhood (*i.e.*, if they want more greenery and the reason for their choice), and preferences for specific species, if any. The respondents were mainly women (primarily homemakers), with a group size of 5–8 individuals per slum.

3. Results

3.1. Species Attributes

A total of 553 trees belonging to 46 species (Table S1) were encountered in the 44 slums that we surveyed. In addition, we recorded 95 species of shrubs, herbs and creepers (Table S2). The most dominant tree encountered was *Moringa oleifera* (drumstick tree), widely consumed as a vegetable (Table 1). It is native to Bangalore and highly valued in southern India. Nearly half the tree population in slums had medicinal properties, while one-third were grown for their fruits. *Muntingia calabura* (Singapore cherry tree) and *Mangifera indica* (Indian mango tree) were the most popular fruiting trees. *Albizia saman* (rain tree) was the most dominant ornamental tree found, while *Pongamia pinnata* (pongam tree) was the tree largely grown for shade. The categories based on attributes, however, were not mutually exclusive, with some species having more than one use (Table 1).

Table 1. Overview of the ten most dominant tree species in the slums of Bangalore—abundance, attributes and activities (non-exhaustive) observed under the canopy.

Scientific Name	Common Name	Relative Abundance	Uses	Activities Observed (Non-Exhaustive)
Moringa oleifera	Drumstick tree	16.0	Fruits Medicinal	Adults playing Children playing Food source Grooming Socializing
Cocos nucifera	Coconut tree	12.9	Fruits Coir Oil, *etc.*	Fruit consumed Cooking fuel Tea stall
Azadirachta indica	Neem tree	8.3	Medicinal Sacred	Children playing Tea stall
Ficus religiosa	Sacred fig	7.6	Sacred Medicinal	Children playing Eating (lunch) Flower vendor Socializing Washing clothes Washing dishes
Albizia saman	Rain tree	6.5	Ornamental Shade	Breaking stones Making incense sticks Playing cricket Socializing Washing clothes

Table 1. *Cont.*

Scientific Name	Common Name	Relative Abundance	Uses	Activities Observed (Non-Exhaustive)
Muntingia calabura	Singapore cherry	6.5	Fruit	Fruit consumed Washing dishes
Pongamia pinnata	Pongam tree	5.6	Shade Medicinal	Fruit and leaves consumed Grooming Making incense sticks Socializing Washing clothes
Mangifera indica	Indian mango tree	4.0	Fruit	Children playing Playing carrom Socializing
Swietenia macrophylla	Big-leaved mahogany	3.3	Shade	Playing carrom
Psidium guajava	Guava tree	3.1	Fruit	Making Brooms

The most common plants were *Ocimum sanctum* (holy basil) and *Aloe vera* (Indian aloe), both with important medicinal properties (the holy basil is also a very important sacred plant in the Indian context). Plants with ornamental and medicinal uses were almost equal in proportion (Figure 2). *Epipremnum aureum* (money plant), *Rosa* species (rose) and *Jasminum* species (jasmine) were the most common ornamental plants, present in more than 60% of slums. A small proportion of plants were grown for their fruits such as *Carica papaya* (papaya), *Musa paradisiaca* (banana), *Momordica charantia* (bitter gourd), *Dolichos lablab* (hyacinth bean) and *Solanum lycopersicum* (tomato). Plants grown for consumption included *Ricinus communis* (castor), *Oxalis corniculata* (common sorrel), and *Piper betle* (betel plant). Notably, almost all the plants encountered were actively planted by the slum residents.

Figure 2. Proportional distribution of attributes of shrubs, herbs and creepers in slums of Bangalore. The second pie is a further breakdown of the plants used for medicinal purposes with multiple uses.
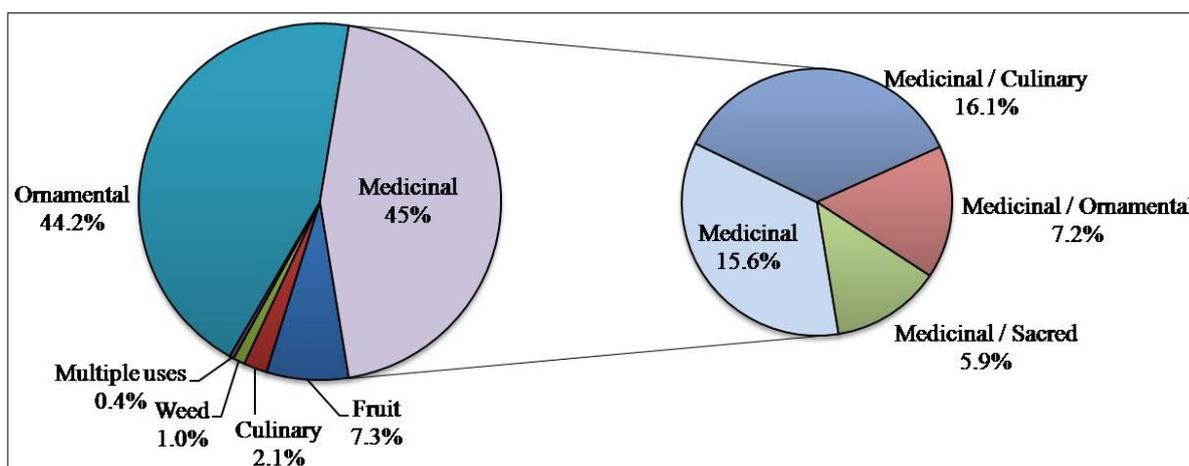
3.2. Sacred Species

There were six species of flora in slums that were sacred (in the Hinduism tradition): four species of trees, and two species of herbs. Sacred trees accounted for about 10% of the total tree population across slums with 63 individuals as enumerated in Table 2. As many as 61% of slums had at least one sacred tree. Sacred trees were most frequently encountered next to temples, and had the largest canopy cover amongst all trees in slums. In addition to the trees known to be sacred in the Hindu religion, we encountered seven individuals from five species of trees: rain tree, pongam tree, *Delonix regia* (gulmohar), *Gmelina arborea* (gumhar) and *Markhamia lutea* (Nile tulip), with symbols of sacred worship such as the presence of garlands, sacred threads, or anointing with vermilion and turmeric. These species are not commonly believed to be sacred, but were being worshipped due to the personal faith/belief of the slum dwellers.

Table 2. Sacred trees in slums of Bangalore.

Scientific Name	Common Name	No. of Individuals
Ficus religiosa	Sacred fig	32
Azadirachta indica	Neem tree	18
Ficus racemosa	Cluster fig	2
Ficus religiosa + Azadirachta indica	Sacred fig + neem	2
Pithecellobium dulce	Manila tamarind	2
Albizia saman	Rain tree	2
Pongamia pinnata	Pongam tree	2
Delonix regia	Gulmohar	1
Gmelina arborea	Gumhar	1
Markhamia lutea	Nile tulip	1

The sacred herbs encountered were holy basil and *Ruta graveolens* (common rue). Of the 44 slums surveyed, holy basil (locally known as *tulsi*) was present in 41 slums, while common rue was present in four. As mentioned previously, holy basil was the most commonly found species of plants across the slums. The wide presence of the plant and the fact that it is cultivated by slum residents (and not growing spontaneously) indicates the crucial role it plays in the Indian culture.

3.3. Utility of Tree Species

Trees appeared to have an important utility function as physical entities, beyond their species-specific sacred, cultural or other properties. Most trees were observed to support clotheslines. Other practical uses include supporting tents, wires, and more (Table 3). About 10% of the trees supported multiple uses (supporting a combination of clotheslines, tents and/or wires, and bearing holy symbols). Tree shade is a sought-after quality in slums, providing respite from the hot tropical sun. A range of occupations were observed taking place under tree canopies, including the sale of flowers, making of brooms and incense sticks, and the operation of mechanic shops, tea stalls and telephone booths. Women in slums were observed conducting domestic chores such as cooking (using fuel wood), washing clothes and dishes, and grooming (such as oiling each other's hair, combing and removal of lice) under tree canopies; while children were often found to be playing under the shade of

trees. The most commonly observed activity, however, was of groups of people sitting under tree canopies and conversing/socializing. These activities were tabulated against the tree species under which they were observed, some mentioned in Table 1. *Ficus religiosa* (sacred fig) was the tree species with the most number of activities observed, followed by pongam tree and rain tree.

Table 3. Overall utility of trees in slums of Bangalore.

Utility	Percentage of total tree population
Clothesline	35.3
Holy symbols	6.9
Wire support	4.9
Tent support	4.5
Photograph stand	0.5
Switch board support	0.5
Hoardings	0.2
Lamp post	0.2
Puncture shop	0.2
Storage area	0.2

3.4. Green Preferences

The slum dwellers responded positively to the survey regarding their preferences for a green neighbourhood. Most respondents were women who were keen on improving their neighbourhood. About half of the respondents wanted more trees in their surroundings, and largely preferred the pongam tree. Others did not desire more trees, citing land issues such as lack of space and ownership (Table 4). However, all the respondents preferred potted plant species and desired more of these in their neighbourhood.

Table 4. Tree preferences in slums of Bangalore—response of slums dwellers to an open-ended survey.

Tree of Choice	No. of Slums	Reason
None	23	No space/Ownership issues/Plenty of trees
Pongamia pinnata	14	Shade
Azadirachta indica	7	Shade/Health
Mangifera indica	3	Fruits
Michelia champaca	2	Fragrance/Flowers
Cocos nucifera	1	Compact tree with small basal area
Flowering trees	1	Flowers
Muntingia calabura	1	Fruits
Shade-giving	1	Shade
Syzigium cumini	1	Fruits

3.5. Innovative Gardening

With space constraints being a characteristic feature of slums, there were more potted plants than those growing directly from the ground. The pots used were highly innovative addressing key issues

such as limitation of space and finances. The types of pots seen were earthen pots, plastic pots, cemented structures, plastic bags, discarded paint containers, earthen water pots, plastic buckets, metallic cans, hindalium pots (an alloy of aluminium), battery cans and aluminium buckets. The potted plants were located on windowsills, parapets, roofs, *etc.* (Figure 3a–c). Although some slums had no trees, all of them had plants with a species richness range of 1–39.

Figure 3. Types of pots for plants in slums of Bangalore—(**a**) Plastic buckets, plastic tub and discarded paint can. (**b**) Hindalium (aluminium) container, earthen and plastic pots. (**c**) Holy basil in an earthen pot with sacred markings.

(**a**)

(**b**)   (**c**)
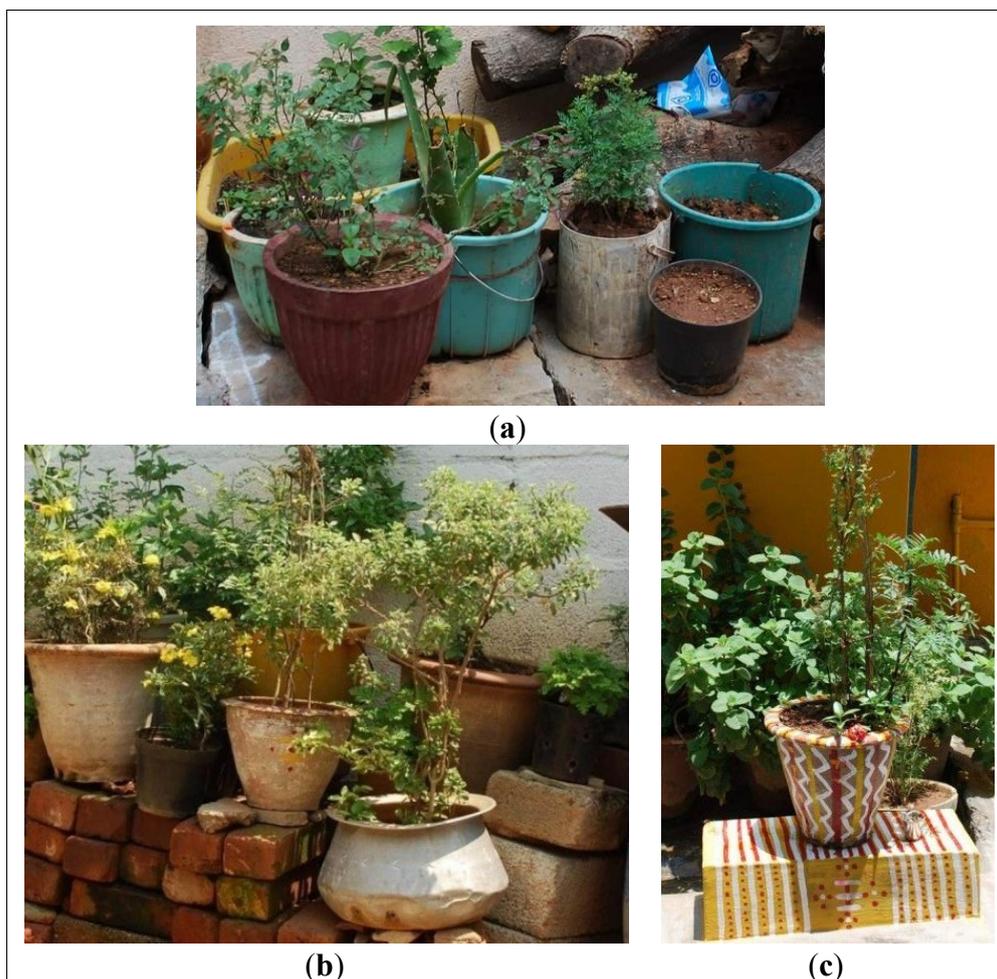
4. Discussion

Our results suggest that species distribution and composition are strongly interrelated with social, cultural and economic activities in slums. Urban greenery is evidently a resource that benefits the urban poor as well and is not limited to the upper strata of the society [7,30]. Our results also seem to refute the theory that lower socio-economic groups tend to overwhelmingly prefer utilitarian species [31,32]. Although we find a strong preference for utilitarian plants, close to half the plant species are ornamental in nature.

4.1. Health and Well-Being

Urban greenery is often positively correlated with better health and mental well-being for city residents [6,7,11,33]. Nearly half the tree population we encountered in slums has medicinal properties, while every one out of three trees we encountered is fruit bearing. The drumstick tree provides an excellent example of this, being the most frequently encountered species, with medicinal as well as culinary uses. Also known as a "miracle tree", drumstick fruits and leaves provide rich sources of proteins, vitamins and minerals, and are known to play a vital role in meeting nutritional deficiencies and alleviating poverty [26,27,34]. Some slum residents and nature enthusiasts in Bangalore indicate in discussions that drumstick trees were intentionally planted in slums during the 1980s to reduce malnutrition. However, we could not trace any official records that verify this claim. The coconut tree, accounting for 13% of the sampled population, is widely known as "*Kalpavriksha*", meaning the tree which provides everything. It is nutritious, medicinal and provides many products used for various daily needs including coconuts for consumption, coconut husk for fuel, and fibre for constructing broomsticks [26]. The third most frequently found tree species—neem—is sacred and medicinal. Every part of the tree is used in traditional medicine. Thus, we find that the majority of the trees found in slums have multiple uses, and are of high economic value.

This pattern is observed in shrubs, herbs and creepers as well. Most plant species in slums have medicinal properties and are used for treating various discomforts and ailments of the digestive system [29]. The most commonly encountered plant species such as holy basil, Indian aloe and country borage address stomach disorders [29]. Ailments of this kind frequently plague the urban poor in South Asian cities [24,35,36]. According to the World Health Organization [37], nearly 65% of the Indian population is dependent on traditional herbal medicine for primary healthcare. Kassam *et al.* [38] further maintain that the usage of medicinal plants contributes to health security and sovereignty.

Sacred species were important features in most study sites. *Ficus religiosa* is sacred to both Hinduism and Buddhism, and indispensable in many Hindu rituals. The species has been referred to in many ancient holy texts in India. It has therapeutic properties and is extensively used in traditional medicine to treat a wide range of ailments of the nerves, stomach, intestine, skin and reproductive system [26,27,39,40]. The wide prevalence of holy basil can also be attributed to its sacredness. We find that most sacred plants encountered in our study also have important medicinal properties. The presence of trees and plants that heal is important in slums as it provides an inexpensive and readily available source of healthcare for common ailments suffered by the urban poor, and promotes health security and self-reliance at least with regard to minor ailments.

4.2. Boosting Livelihoods

We observe that trees in slums are used beyond their innate qualities and act as livelihood components as discussed earlier. Trees act as pillars of support in such settlements—figuratively and literally by bearing tents, clotheslines, wires, *etc.* The role they play, although basic, is critical in cramped squatter settlements, where community space is at a premium, with over 10% of the trees used for multiple roles. Trees clearly provide important elements in the daily routine of slum residents and can be considered as an extended part of their dwelling area. Tree canopies provide a platform

for residents to carry out various economic activities. Considering the fact that a majority of the below-poverty-line (BPL) population of Bangalore live in slums [24], home-based income generating activities could contribute to improving livelihoods.

Apart from low income, coping with food shortage is an integral part of poverty alleviation and improving livelihoods. For instance, slum residents are known to spend over 60%–80% of the monthly household income on basic food in the Lima slums of Peru and the Kibera slums of Nairobi [12,13,41]. However, in both countries, urban agriculture has contributed positively towards food security in slums. In the Lima slums, families involved in urban agriculture have been able to add an indirect income of almost 10% with their garden produce, which is significant in relation to the household economies. However, urban agriculture is difficult to practice in densely populated slums with lack of space. The residents of the congested Kibera slums have adapted to space constraints by actively pursuing a new form of urban agriculture called sack gardening, where vegetables are planted into large sacks filled with soil. Similar to the Kibera slums, there is severe space constraint in Bangalore's slums. This form of agriculture might be of relevance to Bangalore as glimpses of innovative gardening were observed in the city's slums too. Apart from using readily available materials for creating small home gardens, the slum residents showed enthusiasm for increasing potted plants in their neighbourhoods. Moreover, our results suggest that close to 25% of plants encountered were grown for food or had other culinary uses. Recognizing this affiliation with home gardening, Bangalore's slum inhabitants could be introduced to techniques such as sack gardening that may help enhance self-sustenance, ultimately improving livelihoods.

4.3. Social Capital

Social capital encompasses social relationships that nurture mutually beneficial actions within communities, improving productivity [15]. Studies suggest that social capital contributes to economic growth and household food security, consequently reducing poverty [13,15]. Strong social relationships within communities facilitate resource sharing, ultimately benefiting the community and facilitating the access to financial, natural and human capital [42]. In some poor communities in Bangkok, both environmental targets and social development goals were met at the same time due to high social capital [43].

Socializing with neighbours is an important aspect of increasing social capital [15]. Slum dwellers in Bangalore were often seen gathering together under tree canopies and communicating. Social interaction in green spaces can improve bonding and create a better sense of community [44,45]. Greenery in low income areas of the city provides a platform for older residents to integrate socially, improving their mental health and longevity [44]. Both greenery and social interactions in such surroundings can significantly reduce aggression [30,46], which can be quite high in the urban slum context in South Asia [47]. Cattell *et al.* [45] further suggest that social ties can improve tolerance among neighbours and increase vitality of the community as a unit. Our research demonstrates the importance of tree canopies in providing community spaces for socializing in cramped urban slums, thus potentially increasing social cohesion in the context of urban poverty.

Apart from normal social interactions amongst communities, knowledge sharing is a crucial resource that may aid community building [48]. Traditional ecological knowledge can be an important

tool in resource management and distribution [49]. Social learning is necessary in collaborative management of resources [50]. In the context of Bangalore's slums, this knowledge could range from information on farming/gardening to sharing health wisdom. Usage of traditional medicine within households is informally acquired knowledge, passed on from one generation to another [51]. Similar to the importance of social-ecological memory for better management of urban gardens [52], health remedies in squatter settlements might be rooted in such memory. Although there are several texts that describe ailments and the appropriate remedies for the same, this knowledge is not inclusive as illiteracy is high among the poor [24]. Health wisdom in India is often an oral tradition, with community structure and social interactions being imperative for its existence and transmittance [51]. Tree canopy-created community centres in Bangalore's slums may play a major role in facilitating the survival and transmittance of this wealth of knowledge. However, further research is needed to know precisely the nature of interactions, including what is discussed, with whom and when, in these green community spaces.

5. Conclusions

Vegetation in slums of Bangalore appears to play a significant role in improving social capital, livelihoods, health and nutrition. Yet despite the evident socio–cultural dependency of slum dwellers on greenery, vegetation in slums remains low. With severe space and financial constraints, the urban poor still manage to grow potted plants using innovative resources. Sacred fig and pongam tree were noticed to be hotspots of social activities and most slum residents indicated a preference for planting more pongam trees in their surroundings. Pongam has a narrow trunk combined with medium-sized, dense canopy that enables it to be planted in limited space, and yet to provide respite from heat in Bangalore's slums. Policy makers, government agencies, NGOs, and other agencies working towards the alleviation of urban poverty need to acknowledge the significance of greenery and include a green agenda in the strategies they employ. For instance, policy makers could organize workshops on sack gardening and other forms of urban agriculture that might further enhance the livelihoods of the city's poor. A well-thought-out and inclusive strategy of greening should be employed wherein the preferences of slum residents are used to guide interventions and to monitor programme sustainability and success. Vegetation in slums functions as a common pool resource and should be expanded and managed accordingly.

Acknowledgments

Author Contributions

Divya Gopal conceived and designed the study, collected and analyzed the data, and wrote the paper. Harini Nagendra jointly designed the study, assisted in analysis, and co-wrote the paper.

Supplementary Materials

Supplementary materials can be accessed at: http://www.mdpi.com/2071-1050/6/5/2459/s1.

Conflicts of Interest

The authors declare no conflict of interest.

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