

Sustainable cities: an overview of the urban and peri-urban agricultural production in Mumbai Metropolitan Region (MMR)

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Abstract

Urban and peri-urban agriculture provide income generation to urban poor making the cities more sustainable. With a population of around 21 Million people, UPA activities play a crucial role in supporting people's life in Mumbai. A wide range of agricultural production systems with maximum utilization of resources can be seen in Mumbai Metropolitan Region (MMR). Fast urbanization and rapid population growth have resulted in declining agricultural activities in eastern side of MMR. Marketing of agricultural commodities is easy inside MMR with a well connected network of wholesalers, retailers and street vendors. The usage of sewages and wastewater for UPA production in MMR has to be studied in detail for the health benefits of consumers and producers. With the help of a baseline survey this paper tries to reveal an overview of UPA production in MMR with an insight into the pros and cons.

Keywords: Urban and peri-urban agriculture; Mumbai Metropolitan Region; Urbanization; Sewages; Baseline survey.

1 Background

Urban and peri-urban agriculture (UPA) contributes significantly towards increasing the food security and the employment rate of the urban poor, particularly in developing countries (Hill et al., 2007; Sinha, 2009). UPA offers new potentials for the waste recycling and the use of limited land in and around the vicinities of cities and increases the access of poor people to basic nutrition (Ezedinma and Chukuezi, 1999; Ruel et al., 1999). On the other hand, biological and chemical contamination of UPA products can be contaminated with heavy metals, fecal pathogens and helminthes by the use of untreated sewage (Howorth et al.,

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2001; Bryld, 2003). The Indian cities are vulnerable to environmental pollution due to population explosion, urbanization enhancement, rapid economic development and inadequate planning. (Krishna; Govil, 2004; Roy, 2008). All these factors affect the quality of UPA products (Yasmeen, 2001; Singare et.al., 2010) causing health risk to the consumers.

2 Introduction

Mumbai³ (18o53' - 19o04' N 72o48' - 72o53' E), known as the commercial capital of India, is a heavily populated industrial city with population reaching up to 21 millions in 2009 and thus becoming the fourth largest urban agglomeration of the world (Krishna and Govil, 2005; United Nations, 2010). The Mumbai Metropolitan Region (MMR)⁴ consists of 8 Municipal Corporations and 9 Municipal Councils with an area coverage of 4,355 km² (MMRDA, 2010; Table 1). The various land use patterns in MMR are shown in Figure 1. Due to the rapid population growth and urbanization, there have been changes in urban land use patterns with the manifestation of hazard-prone areas (Acharya, 2004; Nijman, 2009). The illegal constructions aggravate the effects of frequent flooding during the monsoon season (Byahut; Parikh, 2006). Air pollution load due to combustion of fossil fuels amounts to 459 metric tonnes (MT) per day whereby an estimated 60% of air pollution is caused by automobile emissions (MPCB, 2005).

Traditional farming incorporating crop rotation and intercropping is still practiced in places like Arnala, Virar, Vasai, and Nallasopara area (North Western region of Mumbai) which are quite close to the Arabian Sea. Agriculture in Kalyan, Kulgaon-Badlapur and Panvel (Eastern region of Mumbai) are getting less attention due to fast urbanization and increasing real estate business. An extensive system of animal dairy production called as Tabelas⁵ (meaning stable) which are common in Greater Mumbai and the rest of MMR. These production systems are close to highly inhabited areas, also characterized by keeping buffaloes and cows which fulfill the needs of local people. Goats are also raised in Greater

(3) Mumbai is formerly known as Bombay and included in the municipal corporation of Greater Mumbai covering an area of 468 km² with a population density of 27366 per km².

(4) MMR includes Mumbai and its satellite towns with a population density of 4065 km².

(5) Tabelas are sheds made with wood and low quality building materials to keep animals including buffaloes and cows. These stables are sometimes located close to the urban dwellings and houses. The employees also stay there to look after the animals and start milking the animals in early morning.

Mumbai which mainly feed on vegetable and fruit waste from the street vendors and market residues.

A new form of city farming in Mumbai was initiated and patented by Padmashree Dr. R.T. Doshi with an economical technology of farming in open terrace and balcony which uses limited resources and inputs. Dr. Doshi's method requires high-density polyethylene (HDPE) bags tightly packed with 50% biomass (sugar cane residues), 25% compost and rest with garden soil amended with organic manure (Figure 2). The idea of city farming and community city farming are gaining attention by the involvement of governmental organizations and non-governmental organizations (NGO's) like Marathi Vidnyan Parishad (MVP), Mumbai Port Trust (MPT) and Urban Leaves (community garden) and with committed personnel's like Mrs. Preeti Patil (MPT) and D.N. Herleker (Director, MVP). Terrace and balcony gardens are gaining more importance among educated middle class and upper class families (Personal communication, Mrs. Preeti Patil).

The farming activities in the city are also encouraged by the government. The Indian Railways is a key player in the UPA production of MMR. The unutilized lands near railway tracks and stations are rented out to outside people and railway class IV employees (gang men, gate keepers and khalasis). These contracts are renewed yearly and the railway authorities provide protection and shelter for the involved. This scheme was started by the Indian Railways promoting "Grow More Food" especially vegetables, thus securing the railway land being encroached by outside slum people (Indian Railways, 2007).

Government of Maharashtra spends a lot of money for the disposal of urban wastes (Chaudhari, 1999) and Brihanmumbai Municipal Corporation (BMC) spends 6.5 to 7.0 Billions of Indian Rupees (INR) per annum for waste disposal (144 to 155 million US Dollars⁶). 7500 tones of garbage per day are being generated in Greater Mumbai and 40% of these wastes are completely biodegradable (Davis, 2010). This could be a useful source of nutrients for the city farming and could contribute to the increase of urban crop production when properly handled and applied.

According to the United Nations, more than 50% of the people in the world lives on urban areas and the population of the urban people continues to increase in the following years. UPA productions play a major role in reducing

(6) Conversion rate, 1US Dollar equivalent to 45 INR.

the influxes of products and resources into the urban areas, making the cities more sustainable and thus alleviating poverty among the marginalized and poorer strata of the society.

3 Materials and methods

High resolution Google Earth images (Google Inc, 2010) were used to track the area of agricultural production in MMR and the areas were marked with the help of ArcGis software (ESRI Inc, 2006). These images were used to locate the position of the farms especially in suburban areas.

A baseline survey was conducted with semi-structured questionnaires covering socio-economic aspects, details of the crop and the animal production, the production costs and produce marketing. A total of 80 interviews were conducted in the Municipal Corporation of Greater Mumbai, Thane, Kalayan-Dombivilli, Vasi-Virar and Municipal councils like Kulgaon-Badlapur and Panvel. All selected areas are under the jurisdiction of MMR and snowball method (Biernacki and Waldorf, 1981) was used to conduct survey. Three railway lines including the Western, Central and Harbor line were selected to get informations about production systems near railway tracks. Interviews were conducted in English, Hindi and Marathi. Additionally, the locations of the farms and gardens were recorded using Trimble GeoExplorer II (Trimble Navigation Ltd, 2002). The data were consequently transferred using GPS Pathfinder Office software (Trimble Navigation Ltd, 2002) and were used for construction of a GIS map.

4 Results

Preliminary results from the baseline survey showed that the farming is declining and getting less importance in suburban areas especially in the eastern part of MMR. Since the MMR is increasing with the implementation of new roads, railway line, skyscrapers and other infrastructures, a lot of traditional villages and salt pans are in the brim of transformation. The baseline study results detected six types of production systems. They are railway gardens, balcony gardens, terrace gardens, farms, goat keepers and Tabelas (Figure 3). The most common farming systems were farms, representing 50% of the interviewed households. Most of them were characterized by growing rice in rainy season (July till October), vegetables in winter and summer seasons (November till June) and

some intercropping with flowers and fruit trees. A total of 18 farming units were located near the railway tracks producing mostly vegetables. Production systems of “Tabelas” (see below), goat keepers, terrace and balcony production units were found in 10, 6, 2 and 2 cases, respectively (Table 2).

The farms outside Greater Mumbai have a size ranging from 0.3 to 20 hectares. They are characterized by seasonal rotation of rice with vegetables, intercropping with coconut trees, flowers and fruit trees. They are also characterized by the involvement of family and outside labor, and irrigation using clean water. The majority of farms produce rice for self-consumption while fruits, flowers and vegetables are grown for markets inside MMR. The fruits such as mangoes, papaya and vegetables (Table 3) are grown following the market demand. The main vegetables grown in farms include lady’s finger (*Abelmoschus esculentus*), snake gourd (*Trichosanthes anguina*), brinjal (*Solanum melongena*), cabbage (*Brassica oleracea*) and bitter gourd (*Momordica charantia*).

An extensive flower production system was found in the north-western region of Mumbai especially in Arnala and Akashi. During festival seasons (Ganesh Chaturthi, Diwali and Navratri) the demand for flowers increases since a variety of flowers (Table 4) is used in temples for Pooja (worship) and Pushpanjali (offering flowers to temple deities in India). Most of the flower growing farmers try to maximize the benefit of the festival seasons by regular irrigation, increased foliar applications of fertilizers and the use of hormonal sprays.

The railway gardens are characterized by intensive market based vegetable production with maximum utilization of land and limited natural resources such as water and manure. The rent charged by the Railway authority can vary between 3000 to 6000 INR (65 to 130 US Dollars) depending on the size and the location of the land. Further renting of the land by the railway class IV employees to the migrant people from Uttar Pradesh and Madhya Pradesh is also a common practice.

Terrace and balcony gardens are highly popular in urban middle and upper class families and were found as a sort of leisure activity for some people. The interview discovered that suspicion about the quality of vegetables available in urban markets and recycling of household waste is the main motivation for these farming.

According to our results, 80% of farmers use clean water from wells and ponds while the rest uses sewage or wastewater. Many households in railway production systems and commercial vegetable production in Thane use wastewater. Some of the poor people in the railway vegetable production system have stated not having any access to the clean water but having advanced and powerful motor pumps to irrigate the fields with waste water.

“Tabelas” can be seen quite dispersed through out MMR region. Tabela’s herd size range from 30 to 120 buffaloes and also comprises a few heads of cattle. The price of buffalo milk is higher than from cattle’s. The Tabelas supply milk and other dairy products to the markets in MMR. Due to environmental and pollution concerns from neighboring people and from the governments, the Tabela’s animal keepers complained about the problems of relocation and also enforcement from the government for closing down of their enterprises. In spite of the opening of Aarey milk colony in Goregon (which was aimed at relocating the wandering cows and buffalos from the city in 1972), the farmers still want to keep animals inside the city due to lower feeding cost (Table 5) and the availability of cheap labor from urban poor and slum people.

The UPA products are easily sold in the markets in MMR contributing considerably to the income of the households. Constraints mentioned by 90% of the flower growing farmers included the fluctuation of the prices of ornamental flowers reaching up to 20 fold increase during the festival seasons and a dropping down rapidly afterwards. 70% of the surveyed farmers, who are mainly from peri-urban areas, involved in farm production system conveyed about the shortage of labor. The farmers involved in railway production systems and the Tabelas reported about the easily accessible cheap labor.

Goat keepers were located mostly in Greater Mumbai supplying the predominant Muslim population with animals for their religious rituals. These production systems are mostly extensive with a maximum of 15 heads kept on small areas near the scrap or small shops fed with market wastes and leftovers from the kitchen. These goats are sacrificed to god during Bakrid (Eid al-Adha) and later offered to poor people.

5 Discussion

Urban and peri-urban agriculture production in MMR provides a lot of opportunities to the urban poor, the slum people and the middle class families.

The recycling of organic waste within the city and supplying the local markets with fresh vegetables, milk, meat and flowers contribute to the self-subsistence of the agglomeration and increase the sustainable use of resources. Nugent (1999) argued that peri-urban vegetable production could utilize the under-employed work force, while Midmore and Jansen (2003) suggested that UPA production especially peri-urban vegetable crop production is less competitive to rural vegetable production due to increasing cost of labor. Proximity to urban areas, reliable irrigation supply from waste water during summer season, accesses to local urban markets and high urban market demand allows the farmers to obtain income throughout the year (Bradford et al., 2003). Urban wastes can be efficiently used as a natural resource (Smith, 1996) which significantly reduces the nutrient input in urban agriculture especially in vegetable production (Nunan, 2000).

Wide diversity of vegetables grown in MMR indicates the huge demand and preference of the consumers. Most of them are grown seasonally and targeting the market demands in MMR especially for the month of Shraavan . There is a high fluctuation in market prices during festival seasons for vegetables and flowers were the price can reach many folds than the normal price.

Labour shortage and fast urbanisation in peri-urban areas of MMR in a severe problem.

A recent study in Bangalore city, India by Mahdavian and Somashekar (2008) revealed the high levels of heavy metals in fruits. The main reasons for the presence of heavy metals in fruits were due to irrigation with wastewater, the pollution from vehicles and industries, the contaminated food transport and supply chain, and the poor market sanitary conditions. A study conducted by Gunale et al. (2005) reports that the rivers in MMR were highly polluted due to urbanization and industrialization. Urban agriculture production with the use of sewage increased the yield up to 50% with lower fertilizer input (Bradford et al., 2003; Bakhsh; Hassan, 2005). However these production systems suffer from high weed growth, pest and diseases to plants and often cause skin diseases to the workers (Hunshal et al., 1997; Drechsel et al., 2005; Gupta et al., 2010).

Due to rapid industrialization and tremendous expansion of MMR, there may exist potential problem of heavy metals and fecal pathogens in the UPA products. Lack of proper treatment of sewages can lead to containment with the heavy metals and fecal pathogens (Sadovski et al., 1978; Bhosale and Sahu, 1991;

Melloul et al., 2001; Binns et al., 2003; Abdu et al., 2010). Presence of heavy metals in the irrigation water leads to the biomagnifications and accumulation of them in plants, soils and environments. Most of the heavy metals inhibit the growth of plants and induce toxicity. Due to frequent irrigation especially in the railway gardens, there is more chance of accumulating the toxic metals in produce and soils. During the rainy seasons they may also get leached down with other nutrients and contaminate the ground water.

Higher loads of coliforms and fecal coliforms in the irrigation water makes it unfit as drinking water. However these can be still used to serve the agricultural demand, but more risks for the consumers and farmers could be expected especially with the green leafy vegetables. Presence of E.coli is a clear indication of contamination of the irrigation sources with fecal matter. This also raises the existence and risk of parasitic helminthes which should also be considered.

Intensive vegetable production using sewages and wastewater in railway gardens can lead to excess application of plant nutrients which makes the production system less efficient. Strong positive nutrient balance were reported in urban and peri-urban vegetable and millet cultivation in Niamey, Niger .These can result in large gaseous and leaching losses of nutrients and environmental pollution (Graefe et al., 2008; Diogo et al., 2009; Predotova et al., 2010a; Predotova et al., 2010b).

Production systems near the railway tracks are hampered by concrete debris, stones, plastics, broken glass pieces and lack of good water resources. According to Indian Railways, it was estimated that a single commuter generates 60 g of wastes thrown onto railway tracks. Furthermore the lack of closed toilet system in trains and the usage of railway tracks and open spaces close to tracks by local poor people for waste disposal also increase the risk of fecal pathogen contamination in railway track agricultural production systems. Open defecation by Mumbai's four million slum dwellers releases about 1000 tonnes of human excreta every day. These people have no accesses to toilet facility and hence use open spaces, beaches and railway tracks (Sule, 2010).

Government authorities promote urban agriculture and city farming as a tool for decreasing the cost of waste disposal. In addition numerous NGO's are supporting urban farming in order to provide a source of income for the

urban poor. Terrace garden can only be maintained by rich families who own independent flats or houses. Community city farming initiatives are gaining much importance in MMR as these can considerably reduce the cost of garbage disposal and allows the maximum utilization of space and resources. The main intension is to promote city farming in the community including school children. Community city farming also encourage the production of Amruth Jal and Amruth Mitti, highly nutritious organic fertilizer for the rapid growth of plants. These are usually made from cow dung, cow urine, jaggery and biomass and composted for some time. Amruth Mitti is characterized by superior properties like high water holding capacity, neutral pH and higher microbial activity.

Marketing channels in Mumbai are often well organized and have an established network of wholesalers, retailers, commission agents and street vendors. Preference of the railway garden peoples in green leafy vegetable suggests the market potential and the demand towards these locally cultivated products which are offered fresh and at low prices due to short distance to the market and low transportation costs.

Livestock diversifies the opportunities of urban poor, provides nutrition with improved food security (Shiere; Van der Hoek, 2001) and recycles wastes (Richardson; Whitney, 1995). Tabelas and goat keepers in MMR play a vital role in providing nutrition and food security to urban people. By many consumers, buffalo milk is preferred to cow milk given its higher fat content. Goat keeping involving market wastes, minimize the generation of organic wastes. In spite of all these advantages, the key issues associated with livestock keeping in urban areas includes pollution from animal wastes, health risks associated to human populations, smell, and traffic hazards (Lewcock, 1996; UNDP, 1996).

UPA activities provide employment for a lot of people especially the migrant people. The street vending of agricultural products in MMR is very common and requires less capital investment and space. UPA activities in MMR can sustainably fill the gaps of unemployment created by the informal sector and provide livelihood strategies for urban poor.

In Latin America, urban and peri-urban malnutrition and volatility of food prices make the local, regional and national governments to implement UPA programs. Cuba and Brazil have national level promotion plans for UPA. Ministry of Social Development and Combating Hunger (Brazil) invest 5 million

US Dollars per year in various UPA activities. In Curitiba, Brazil more 200 hectares of land were used for UPA production generating 4,100 tons of food (FAO, 2011).

UPA provide better management of urban spaces, mitigate the effect of climate changes, and resilience of urban areas. In Sao Paulo (Brazil) and Bogota (Colombia) UPA improves aquifer recharging and reduces runoff. In Porto Alegre (Brazil), the organic wastes from restaurants are used for feeding material for pigs and in Lima (Peru) treated waste water is used for agro-forestry (FAO, 2011).

Urbanization and urban growth creates a mixture of problems involving social and environmental aspects including crime, congestion, pollution, child labor and social injustices (WorldBank, 2002). UPA could be linked with the microfinance programs which aim to empower the urban poor economically and it could be transformed as a key tool to accomplish the Millennium Development Goals (MDGs) of United Nations.

Conclusions

Despite the rapid expansion and population growth of MMR, many people are involved in UPA production of dairy products, vegetables, fruits and flowers. The distribution of these production systems are widely dispersed through out the MMR and shows unique identities and different mode of productions. The UPA production does generate income not only to farmers but also to local street vendors who reap multiple benefits from this activity since they can procure the products easily and sell them fresh. Terrace and balcony farming are considered as a leisure activity that marginally reduce the garbage and help to recycle bio-wastes generated in kitchens. Commercial vegetable production systems near to the railway tracks raise the question of possible health risks for consumers and producers which must be further studied. Despite of all these, the products can easily sold inside MMR due to a large market demand. UPA activities certainly, act as a vital tool in providing income generation provision for migrant people and hence reduce urban poverty. UPA production in MMR should be also studied in depth to discover the role in supporting food security and contribution to socially and environmentally sustainable development.

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List of abbreviations

- BCPT - *The Bombay Community Public Trust*
BMC - *Brihanmumbai Municipal Corporation*
GPS - *Global Positioning System*
HDPE - *High-density polyethylene*
INR - *Indian Rupees*
MCGM - *Municipal Corporation of Greater Mumbai*
MDGs - *Millennium Development Goals*
MMR - *Mumbai Metropolitan Region*
MMRDA - *Mumbai Metropolitan Regional Development Authority*
MPCB - *Maharashtra Pollution Control Board*
MPT - *Mumbai Port Trust*
MPV - *Marathi Vidnyan Parishad*
MT - *Metric ton*
NGO's - *Non-governmental organizations*
UNDP - *United Nations Development Programme*
UPA - *Urban and peri-urban agriculture*

Table 1
Basic statistics on Corporations and Councils in MMR

Municipal Corporations				
Name	Area (sq.km)	Population		
		1981	1991	2001
Greater Mumbai	468	8,243,405	9,925,891	11,978,450
Kalyan-Dombivali	137	329,870	820,089	1,193,512
Navi-Mumbai	163	96,824	318,447	704,002
Thane	128	431,667	803,389	12,62,551
Ulhasnagar	28	273,668	369,077	473,731
Mira-Bhayandar	89	45,421	175,605	520,388
Vasi-Virar	NA*	11,089	224,437	469,526
Bhiwandi-Nizampur	28	115,289	379,070	598,741
Municipal Councils				
Alibag	2	14,051	16,289	19,496
Ambernath	35	99,655	125,801	203,804
Karjat	8	7,970	19,904	25,531
Khopoli	30	32,102	45,039	58,664
Kulgaon-Badlapur	49	30,775	52,154	97,948
Matheran	7	3,920	4,708	5,139
Panvel	12	37,073	58,986	104,058
Pen	10	14,772	21,588	30,201
Uran	2	15,168	17,775	23,251

*Not Available.

Source (MMRDA, 2010).

Table 2
Structure of the UPA activities in MMR

Production system	No. of households	Locations	Products
Railway garden	18	Dadar, Thane, Kanjurmarg, Goergaon	Vegetables
Balcony garden	2	Dadar	Flowers, vegetables
Terrace garden	2	Chembur	Fruits, vegetables
Farm	40	Arnala, Vasai, Thane, Akashi, Kalyan	Flowers, fruits, vegetables
oat keeperss	6	Santacruz, Kurla	Milk, meat
Tabela	10	Santacruz, Gass, Thane, Badlapur	Dairy products

Table 3
Major vegetable crops grown in MMR

Common name (English)	Local name (Hindi)	Botanical name	Production system*	No. of households**
Lady's finger	Bhindi	<i>Abelmoschus esculentus</i>	RG, F, TG,	30
Snake Gourd	Chichonda	<i>Trichosanthes anguina</i>	F	18
Brinjal	Baingan	<i>Solanum melongena</i>	F, TG, BG	16
Cabbage	Pattagobhi	<i>Brassica oleracea</i>	F	9
Spinach	Palak	<i>Spinacia oleracea</i>	RG, F	24
Red Amaranth	Lal Maat	<i>Amaranthus cruentus</i>	RG	20
Fenugreek	Methi	<i>Trigonella foenum-graecum</i>	RG, BG	15
Bitter Groud	Karela	<i>Momordica charantia</i>	F	21

* RG: Railway Garden; F: Farm; TG: Terrace Garden; BG: Balcony Garden

** Persons growing a particular type of vegetable, not the sample size.

Table 4
Details of the flower production in MMR

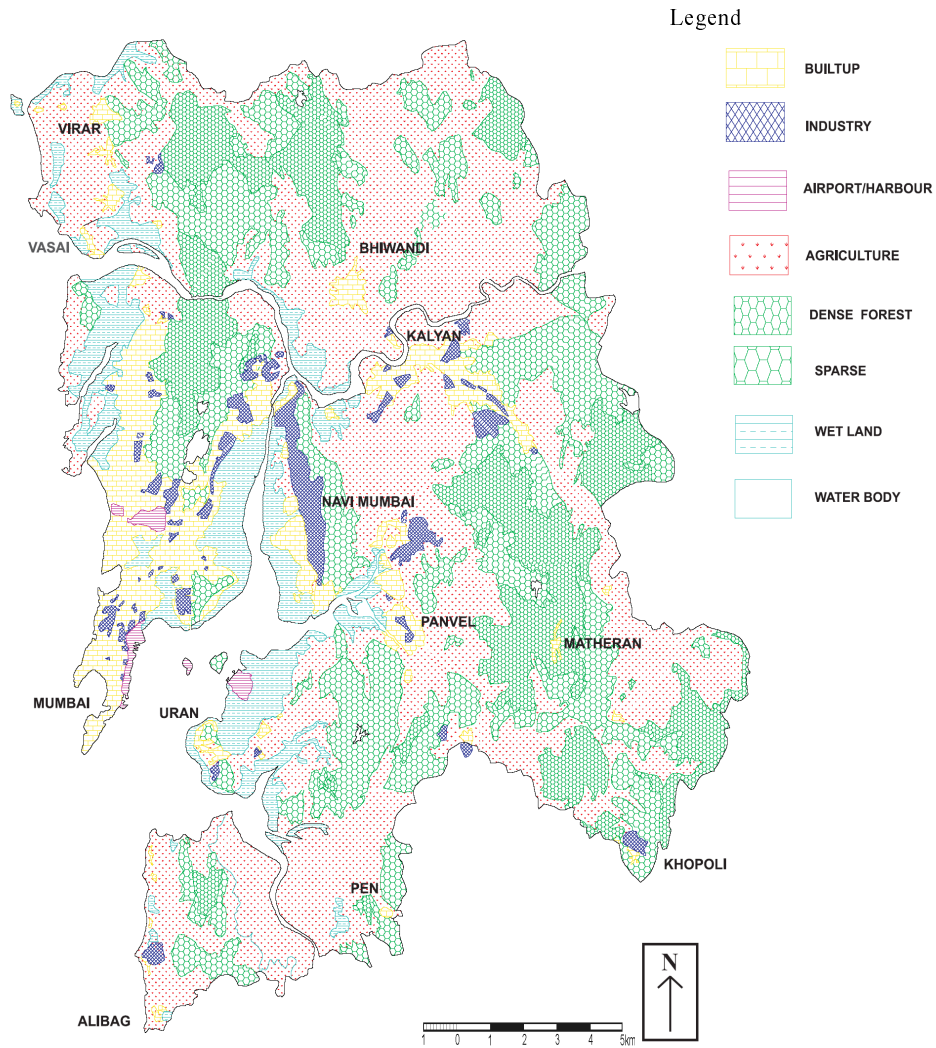
	Common name (English)	Local name (Hindi)	Botanical name	No. of households*
1	Jasmine	Mogra	<i>Jasminum sambac</i>	10
2	Marigold	Genda	<i>Tagetes erecta</i>	7
3	Heliconia	Heliconia	<i>Heliconia pendula</i>	3
4	Shoeflower	Gurhal	<i>Hibiscus rosa-sinensis</i>	4
5	Chenbagum	Chafa	<i>Michelia champaca</i>	12
6	Crape Jasmine	Chandni	<i>Tabernaemontana coronaria</i>	10

* Persons growing a particular type of flower, not the sample size

Table 5
Feeds and feed supplements used in Tabela's in MMR.

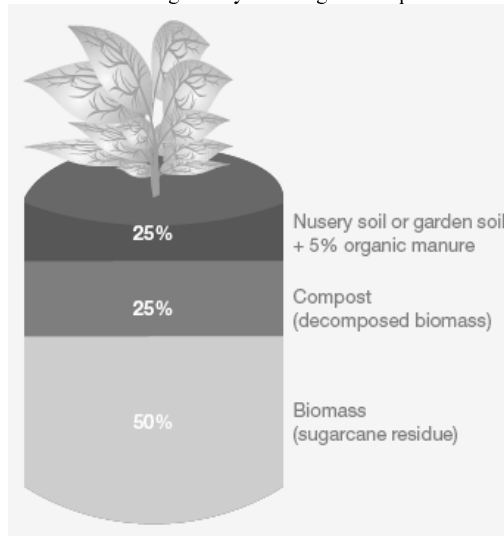
	Name of the feed/ feed supplement	Procurement source	Market price in INR per Kilo
1	Rice bran	Flour mill	10
2	Cotton seed cake	Mill	20
3	Cut maize	Farm	18
4	Hay	Farm	7
5	Green grass	Farm	8
6	Oil	Oil mill	25

Figure 1
Land use pattern in MMR



Source: MMRDA (2010).

Figure 2
The layers required in containers for growing plants according to city farming techniques



Source: Doshi et al. (2003).

Figure 3
Different type of production systems in MMR and proportion of production (%) in each group

