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Urban Agroecosystems for Future Food Self-Sufficiency in Cities: Dynamics of Yamuna River Sandbars in Delhi

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Abstract

Present paper discusses the possibility of using urban agroecosystem for self sufficiency in food supplies in cities. It throws light on possibility of using river sandbars in Delhi for growing food. Already these sandbars are being used for different purposes including growing vegetables and for animal husbandry. The river provides free space through silt deposition every year which may be used for agriculture. The leasing system may be streamlined and question of justice needs to be brought into the overall management system. Interestingly the NGT has kept a ban on agriculture in Yamuna sandbars due to cases of pollution.

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Yamuna sandbars in Delhi

During the process of erosion and sedimentation, new fragile lands emerge in between the flow channels and banks of some rivers. These lands are called as channel deposits or channel bars or sandbars. These channel bars do not remain stable and normally has a longitudinal migration. They emerge, submerge and re-emerge continuously [1]. Vegetation succession on channel bars can increase the stability of these semi-stable lands [2] and take the form of a riverine island. In middle Ganga plains of eastern Uttar Pradesh and Bihar states of India, these islands are known as *Diaras* and are made of coarser sands and gravels [3]. In the Indus plains in Pakistan, these lands are described as*Kuchha* (wet and

fragile, as opposed to *Pucca*, or more permanent lands) and *Baet* (rising like mounds between the two branches of rivers). In Bengal, north eastern states of Assam and Tripura, and in Bangladesh these are called as *Chars (Charlands)* or river islands [3]. Yamuna is one of the important rivers in India along which lie cities of greatest historical and cultural importance. The river enters into National Capital Territory (NCT) of Delhi at Palla in the north and exits at Jaitpur in the south travelling a distance of around 52 kilometres within Delhi. Like many other rivers, Sandbars are observed within river Yamuna and its banks also. It is evident from satellite imageries, field observations, and from various studies that these shifting channel deposits support numerous agroecosystems and socio-economic activities along its stretch within and near NCT of Delhi ([4][5][6][7][8][9]).

Sandbar dynamicity

Sandbars are found both in the braided river and meandering river channel. Floating sandbar is completely surrounded by water and is away from the mainland while the attached sandbar remains attached to the mainland. Although transient in nature, these sandbars are very fertile due to occurrence of frequent floods, and they support population and agriculture. People residing or dependent on these sandbars are vulnerable and therefore they do suffer with loss of life and livelihood due to the flood and dynamic nature of these lands. The socio-economic activities supported by the sandbars are fishing, farming, pastoralism, grazing and collection of different types of grass. River sandbars are dynamic in terms of area cover by both through reduction and increase across time. For example, the sandbar areas in Brahmaputra river in Assam increased 23% during 1988 to 2018 [10]. Sandbar's suitability however as agricultural land depends on various factors such as flow pattern, seasonality, location, bridges on the river, river training works, particle size, and nutrient richness etc. [11].

Urban agriculture

Urban agriculture is available in various lands worldwide such as school grounds, housing facilities, rooftops, vacant lands, etc. [12][13]. Urban agroecosystems also involve private gardens, urban farms, orchards, and community garden [14]. Various ideas are also observed such as urban food forests, urban agroforestry, permaculture gardens etc. [15]. Agroecosystems in urban lands have potential for meeting human needs along with other ecosystem services [15]. Urban agriculture is seen as a sustainable alternative to increase food security considering increases in food prices, increasing energy costs, demographic pressures, and corporatisation of food markets. [16][17]. In urban agroecosystems, focussing on agricultural yield only however, often overlook inequitable food access and other associated challenges which are result of historic faults such as pollution and soil contamination, land access and tenure system, developmental pressure etc. among others [18]. Such conventional way of defining urban agriculture often fails to identify the problems within the system [19]. Urban agriculture would require thirty percent of the total urban area to meet the global demand for vegetables which is not possible due to land tenure systems and urban sprawl issues [20][21]. Urban river sandbars may play a major role in providing the additional land across the globe. As estimated by De Zeeuw et al. [22], a city with 10 million people or more, over 10,000 tons of food has to be imported every day, traveling an average

of 1,000 miles. Delhi's population is roughly around 20 million. Present paper studies about these agroecosystems in some of the Yamuna river sandbars/islands in two locations in Delhi. These sandbars legally come under the local administration and are used by people for different activities like agriculture, fishing, collection of various types of grasses, and grazing of livestock.

The three sites

Three sites were involved in this study to understand the use of land piece created by river Yamuna in Delhi (Fig.1). The study was conducted during the years 2016, 2018, and 2020. It involves field surveys, desk-based study, and secondary literature. Focussed group discussion and meetings were arranged with people living in different sandbars in Delhi. Secondary data has been studied from various research articles, published reports, and various other documents on the related topics, for better understanding of the existing property-rights, socio-economic activities, agroecosystems and the dynamicity of the channel deposits.

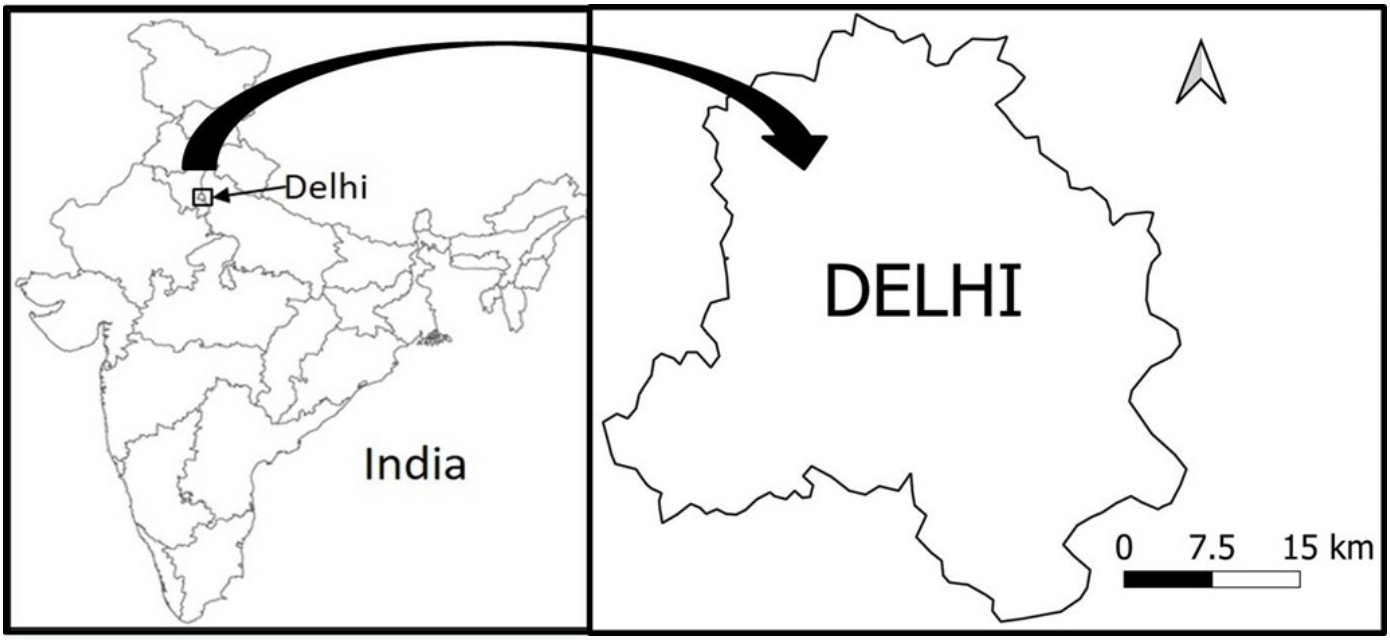

Figure 1. The study sites in River Yamuna in Delhi

Changing sandbars

The sandbars showed continuous change in area from 56 acres in 2006 to 21 acres in 2020. This decrease was not gradual but kept changing from year to year. First showed a decrease from 2006 to 2008 and after a small increase upto 2016, it again showed a decrease till 2020. From 2018 till 2020 the overall area decreased. The southern sandbar in 2008 was not completely attached with the right bank till 2016-2018 when it started coming towards the bank. After the last massive floods in Yamuna River in 20120, this has completely attached to the bank and a new comparatively smaller bar emerged parallelly towards upper left side roughly around first half of 2020. Another channel bars have encountered many

changes both spatially and temporally between 2018 and 2020. From around 6-8 bars between 2006 and 2018, there were only three bars in 2020. The area coverage also changed from around 21 acres to 64 acres in 18 years. In 2006 the study area was divided into fragments and also there was a difference in its shape as compared to the present study area. In 2006, the shape was quite irregular. The channel deposit was near to the right bank of the river. The sandbar was much closer towards the top of the island – north side of it. The larger island had much smoother boundaries than the small islands. The shape of the channel deposit was broader towards the upper and narrower from the lower side.

The sandbars under study had a tenure-system until 2006, particularly the land which was not attached to banks. That was the time when there were around 40 farmers practicing agriculture on the attached part of the sandbars since last 30 years. Delhi Peasants Co-operative Multipurpose Society Ltd. used to give land on lease to them and each received patches of different sizes/expanse on the sandbar for agricultural purposes. The sandbars attached to banks was leased-out by a locals. Out of these 15-18 farmers, some used to take land for farming from both of them, i.e., the Society and the. The land they used to get from the local community was situated on the mainland and that for Rs.2000-3000 per bigha. Whereas, the land they get from society was situated on the sandbar area and the lease/ rent amount for the floodplains was for Rs.1000 per bigha. It is observed that there is a role of a middle-men who lease out the channel deposits to people for various use. These middle-men are apparently powerful, wealthy, and elite, and since they live near these unstable newly emerged sandbars, they claim a sort of ownership to them. Delhi Development Authority (DDA) seems to pay some compensation to these claimants for the crops and seeds which is planted there although they do not compensate for the land, as the land belongs to DDA. The *claimants* seem to decide the price of the sandbar after inspecting (if the area of the sandbar has increased or decreased) the land area in October. They examine the area of the land and accordingly raises or lowers the price of the land to the farmers. Other users of the sandbars are such as those who collects grass which is available here, also pays a fixed monthly amount of Rs 2000/month to these middle-men.

Agroecosystems in channel deposits

There are two sandbars, one is attached to the main land, whereas, the other one is a floating sandbar or a riverine island. Only two small patches are under cultivation on the bigger attached sandbar. However, a rather very large area is being cultivated each year by the three families of farmers on the floating sandbar. Farming of mainly vegetables is being done in both the sandbars from around twenty years now. In the upper deposit the farming is going on since 2014. For doing farming on this channel bars and to move to and fro, families had three boats with them, made out of thermocol. It is observed that large patches on these channel deposits are also seemingly barren, although patches of grasses were also observed. The families owned small land area in the lower channel deposit, growing different kinds of vegetables. The amount of land that is cultivated in a season depends on the economic condition of a family i.e., how much are they capable of putting in the money in terms of seeds, fertilizers and various other farm needs, and the number of family members that are available in that season to carry out farming. No external labours are used and the dependence is entirely on family members. To buy seeds, fertlizers, insecticides, tools etc. the farmers depend on '*arhatiya'* or the wholesale retailer in the whole-sale market, who charges an extra 7-15 percent interst on the money lended by them. By

lending this money the farmers are bound to sell the harvested crop to that particular "*arhatiya*" only. It was observed that the large part of the sandbar was used for the purpose of agriculture which is stable. External labours are used here and moneylenders play important role. Pasturage are the land which are used for pastures. But, its not always the case that they are visited/used by pastoralists only. There could be many types of people who could be rearing livestock, and therefore be dependent on a particular land to graze them on it. The sandbars under study were also being visited by people who practice livestock rearing. The criteria of differentiation for the usage of the sandbars as pastures is based on the location; either they live on the sandbar or are from outside, rearing type (direct or indirect). It is observed that the maximum usage of the sandbar, was done mainly by community involved in dairy farming. The farmers use to graze their animals etc. farmer uses grass to feed the livestock including buffaloes, goats and hens. Another user of the pastures is the grass gatherers family from the sandbar. Pastoralists use the maximum proportion of grass on the sandbar. The reason of this being the huge number of cattles, elephant and camels graze the grass.

The total population dependent on the sandbar for various activities are over 160. Out of which 87% are labourers who are engaged in agricultural fields of the farmers. These labourers are dependent on the island for 6-7 months after which they migrate to their hometown in Bihar. Farmers who have the agricultural field on the sandbar, including their family members are 23 in number. These involve fishermen, pastoralists, and grass gatherers, and florists. Salt cedar sellers who are dependent on sandbar for whole year (except in days of flood) are 7 out of the total. Just like the cattle grazers, people with their camels and elephant visit the study area and leave them for grazing there for six to eight hours, during June to September. The fishermen who visit the island frequently have the licenses which are issued to them by the government itself. These fishermen look for the stretch of river in which they can easily spread their fishing nets. The study of the area revealed that 6 people come alternate days on the island to catch the fish. The species of fish which they trap from the island is Catfish, whose price depends on the size and weight of the fish. For a normal 2 kg fish they get 100-200 rupees from the. The income of fisherman fluctuates per month as it depends on the availability of fishes. A rough estimate suggests 150 kg. Among inputs (Table 1), the seeds are brought by farmers. The price varies depending on the type of seeds. The fertilizers are brought by from other areas ranging from 11 to 18 kms. They use 5-15 bottles in fertilizers for one cropping season. Urea is not used it the agricultural fields at all or used in a very small quantity. Pesticides used in the field are- Profex, Nagraj, Blotinax, Atabron in different quantities. The farmers used to spray the weedicide in the farmland. The weedicides are first mixed with water before spraying. They need to spray one – three bottles of it in a season. Fertilizers are being sprayed in a good quantity in the field. It is observed that an amount of 2-7 lakhs rupees were spent for labour, seeds, and fertilizers in total. 20000 - 60,000 rupees were invested on the seeds of all crops.

Table 1. The input-output in the agroecosystem

Input	Site 1	Site 2	Site 3
Seed	7 kg	8 kg	12 kg
Pesticide	0	64.25 liters	51 liters
Output			
Vegetables	31345 kg	81000 kg	730000 kg

Food self sufficiency

It is important to bring urban agriculture within the design of cities to address issues related to environment and economics [23]. As urban farming provides beneficial ecological, social, and educational services, it needs similar importance like schools, museums, parks, modern infrastructure in the city planning [24]. Studies indicate that between 76 and 90% of vegetables are provided by urban agriculture in Dar es Salaam, Tanzania, Shanghai and Beijing. Dakar produces around 60% of Senegal's vegetables. In Vietnam, 80% of fresh vegetables comes from Urban areas [17]. Overall, global estimates of available space for urban agriculture ranges from 1-7 million hectares or 1.4%–11% of the urban area [25]. Urban food production has increased around 30% between early 1990s and mid-2000[20]. For a proper food planning in urban areas, Deh-Tor [26] forwards two ideas; first is to stop separating agriculture from urbanisation conceptually, which he suggests is driven by capitalistic mindset and is not real. Second, the land for food production, and its quality, in urban areas needs to be the one of central point of focus in urban planning. This would mean proactive policies for land protection in urban areas.

Power dynamics

Lahiri [3] explains that people who live adjacent to the newly emerged sandbar, or people who are richer or have better political affiliations mobilise higher sentries and gain control over these islands particularly of cropping and harvesting on these lands. This further leads to disputes over the ownership of lands. In the present study it is observed that when the sandbar has emerged close to the land of the claimant who being powerful and rich, have taken control of the sandbar and has given the land on lease to the two farmers for practising agriculture on it. In Bangladesh however, it is observed [27] that these charlands belong to government but illegally taken over by the people living close to these. These unusable lands once approached/accessed by poor people can be put to use by providing them with livelihood and food security. Hammelman et al. [28] in a study in Argentina mentioned about the power dynamics embedded in sustaining agroecological projects in urban areas. In the present study also, we can observe power dynamics in a very different setting.

Suitable for different vegetables and crops

Agriculture is being practiced inside the urban areas of Delhi, and its outskirts and it plays a significant role in contributing towards the urban economy. Agroecosystems in river sandbars establishes various linkages in local markets and fulfils local needs through agricultural output. Dynamic channel deposits in both the study areas are located amidst the urban landscape of Delhi and contribute towards city's economy. A great part of its share is sold by farmers in the nearby Azadpur *mandi* or wholesale market, from where it is bought by different local retailer which in turn sell their produce to various parts of Delhi and in NCR region. Also, the farmers themselves sell their vegetables to the residents of the neighbouring areas. Krishnamurthy [29] and Chowdhury [30] has elucidated how Bangladesh is relying upon sandbar cropping growing pumpkin and squash as a means to achieve multiple goals, in large quantities on sandbars. Pimental [31] has discussed agroecosystem, and how the resources derived from them when used as input, could bring efficient results and therefore, output in the crop production system. The author has argued that the energy input, in case of agroecosystem has evolved and became very demanding over time. The inputs and outputs in the present study includes use of fuelwood, fertilizers, pesticides, tractor, use of livestock/ animal energy, labor/manpower in the farms, and other modern intensive agricultural management tools to carry out farming. The paper by Rahman and Reza [32] has emphasized upon the cultivation of the "palej" crop on the charlands (sandbars) specifically pumpkin, similar to the present study area. The pumpkin cultivation was practised on the charlands formed by the Brahmputra river which were earlier considered barren. The crop of pumpkin is grown on these lands as the crop is more adapted and requires low water for irrigation. Similar technique of digging furrows in the ground to grow '*palej*' is observed in the present study where crops can pull the ground water on their own. Randhawa [33] mentions that one of the methods to sell the crops in small town is through brokers or *dalals* who help the farmers to dispose of their produce to the wholesalers known as *Arhatiyas*. Ashraf et al.[34] explains that the lease system on the charlands are very complex. These lands belong to the state legally but in reality, are owned by the powerful elite who acts as feudal lords to the people living on the sandbars. The average farmer is so poor and indebted that he sells his produce to *Arhatiya* so as to clear his previous debts and therefore plays important role. Moreover, the farmers do not have warehousing facilities to store the produce longer, therefore brings the produce to the mandi on the same day and sell it to the *Arhatiya*. He works both as moneylender cum trader [35]. In the present study it is observed that farmers do not get the actual price of their produce. The rate of the vegetables depends on the market. If they harvest the vegetable on the day when the price of that vegetable is low in the market, they have to anyway sell it to the *arhatiya*. If they would keep the vegetable for long, the vegetable may get rotten. The *arhatiya* is not fixed. Once the money taken from*arhatiya* is paid back to him by the farmers, the farmers can even switch to other *arhatiya*.

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