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Futuristic Urbanism-An overview of Vertical farming and urban agriculture for future cities in India

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ABSTRACT: With Urbanization increasing across world the “State of World Cities” by UN- Habitat (2004) predicts that by 2030, 60% of world population will live in cities and by 2050 this count is expected to reach at 6 billion urban dwellers .Urban cities have major contribution to GDP growth of a country but this too has its sets of drawbacks and shortcomings. With increasing occupational shift fewer farmers will be left to cultivate the food on which cities currently do and will depend in the future. “Over the past 40-50 years, the proportion of humans who farm has dropped by 20% to under 45%.” (A unified theory of urban living Luis Bettencourt & Geoffrey West).

Also with increasing urban sprawl the rural villages are getting converted into urban villages and gentrified in metropolitan cities like Delhi, dependency of it on peri- urban areas for food production has increased. Thus it is quite expected that the supplies service of food production for cities will either have to be sourced from remote surroundings or cities will have to include their own food production. With land constraints increasing in cities. It is difficult to designate land for farming thus in this case for ensuring food security with innovative technologies like roof top gardens (RTG) or vertical gardening can be an alternative option in urban farming. This will not only contribute to food self- reliance and effective survival approaches for future cities but also in reducing urban heat island effect which is projected major issue in the near future due to global warming and climate change.

The aim of this paper is to analyse the urban agriculture (UA) and vertical farming scenario in India, by identifying the need, problems and possible alternative approaches, and based on these factors highlighting the potential of vertical farming as possible optimistic future of India. The cities like Singapore where Urban agriculture has been encouraged and reached at a success that its progression is happening rapidly .Different Indian cities where there is considerable urban agricultural activity but due to lack of financial, technological and institutional support cannot flourish at large scale are also pointed out. The future institutional and policy support needs for promoting urban agriculture along with the existing scenario farming in cities is the need of today for securing future cities food and raw materials demand.

KEYWORDS: Vertical farming, Urban agriculture, Urban farming, Controlled environment agriculture, Food, and security

I. INTRODUCTION

With urbanization increasing at a pace that the UN estimates that by 2050 almost double the population living now will be living in cities then(80% of earth’s population) accounting to about 6.5 billion. With cities are majorly considered the cause of polluting earth(cities contribute up to 70% of total global CO2 emissions- UN Habitat) resulting in climate change and its ill effects (majorly for future cities) thus in future situation when mostly urbanized area would be there ensuring food security for city dwellers could not be only dependent on conventional method of farming.

Innovative methods of urban design which intent to combine food, built form of cities, production and design in a composed way to produce food on a larger scale in and on buildings can be the possible and major incentive for this new type of emerging farming of future urban areas

Vertical farming and urban farming in not a new phenomenon the term "vertical farming"* was created in 1915 by American geologist Gilbert Ellis Bailey architects and since then architects and scientists have been frequently looking into the idea since then. It is said that the concept of integrating agriculture into a built environment was invented in a Danish farmhouse back in the 1950s that attempted to grow cress — a peppery, tangy flavoured herb botanically



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related to mustard — in a factory on a mass scale (October / November 2013 , food & beverage Asia). At present fully controlled indoor urban agriculture is gaining attraction in Europe, Asia, US , Singapore and South Korea.

In spite of the fact that this term is not new to the world but still this phenomena is not recognized in large scale worldwide, and if we talk about India where urban areas are mostly dependent on rural areas nearby for food, thus they face major problems like non- availability and price –fluctuations of daily used vegetables and fruits.

With 50% of Indian population is projected to live in cities by 2050 thus in this situation when climate change and mental illness due to overcrowding, pollution etc. would be at peak and reliance on conventional farming would not be possible then vertical urban indoor farming or Roof Top Garden (RTG) farming would be lucrative option by then.

(* Vertical farming is defined as the concept of cultivating plants or animal life within skyscrapers or on vertically inclined surfaces (Despommier 2010), whereas building integrated agriculture (BIA) is the practice of locating high-performance hydroponic greenhouse systems on and in mixed-use buildings to exploit the synergies between the building environment and agriculture-like energy and nutrient flows)

II. URBAN AGRICULTURE IN INDIA- PRESENT

Urban agriculture and vertical farming might have started becoming popular internationally but in India it has not been very popular. Rural areas are providing food to the country's population traditionally. The reasons behind this dependency are diverse at different places. At some place it is lack of government support and policies while at other places it is lack of interest among people to practice this change and taking time out of their daily life and getting involved in it. Lack of availability of land or open space or interest of government to identify such potential spaces

(New York State Energy Research and Development Authority is working towards it in its Sustainable Urban Agriculture program where it has identified and mapped vacant land and community gardens , public vacant lands and other potential sites for urban agriculture in NYC) are some of the major challenges faced by cities of India in urban agriculture.

Pune City Corporation started its city farming project in 2008, where its citizens were encouraged to grow crops and vegetables on allotted lands but this was not a success (Times of India, 2012) whereas in Cuttack and Nagpur City slum dwellers have taken to organic farming on terraces and small plots at informal level and even sell the surplus produce to the local markets.

In Delhi on the banks of Yamuna as the flood waters make it very fertile, extensive farming is happening in spite of the fact that farmers do not have any legal sanction to do farming there.

Similarly in Hyderabad , farmers use water from the Musi river for urban farming who are living along it. As this river flows through the city it consists of waste water most of the time from housing and commercial spaces. The government did not supported their need of partially treated waste water for irrigation but farmers continued to farm and contributed vegetables and rice to the market.

Thus from various examples quoted above it can be seen that despite the lack of government support in legalization of farming activities in Delhi and Cuttack or demand of partially treated waste water in Hyderabad people continued urban farming while at other places like in Pune even the institutional support could not make the concept of Z-farming or urban farming successful. Thus it is quite clear that there is potential of various kinds at different places in India for urban farming but because of varied reason this still has not been in practice at large and formal scale.

If covered or indoor vertical farming is talked about which works on concept of Aeroponics, or Hydroponics then in India only 30,000 hectares is under poly house or covered cultivation. As stated by Lt Cdr CV Prakash (retd) who pioneered the concept of hydroponics and introduced Soilless Cultivation in India in the year 2008 with his “Pet Bharo” project “The future of agriculture will solely depend upon people who embrace modern technology and have the passion to take it forward.”

According to a Software Engineer who sold His Company to Start a Vertical Hydroponic Farm in Goa , farmers in India are already struggling with finances thus they fear to invest in technology of indoor farming because if their investment in technology does not work out in profit it may turn out to be a huge loss for them. Although some pilot commercial investors are working on it but still this has a long way to go.

(Hydroponics: the collective term for all plant-growing methods that don't use soil and require a nutrient rich liquid to feed the plants. The plants can be grown in anything from simple containers to sand to just hanging in the air.

****Aeroponics:** this entails the use of specialized UV lights and a misting system to grow plants. The plants also gain nutrients from the air around them, so their roots are usually exposed as they hang from a specially-built frame.)

**III. SCOPE OF RESEARCH-WHY URBAN AGRICULTURE IS IMPORTANT?**

With population increasing in urban areas the nutritional requirements of this increasing population has to be met. People living in urban areas has very limited or no control over the supply and quality of food thus in this case organic urban farming or growing own food can be a possible solution to this problem. Urban agriculture has several benefits .It's not only an efficient and effective tool for making use of vacant unused open spaces in urban areas but also a way for generating income and employment and managing freshwater resources in cities. Its benefits are in many dimensions ranging from environmental, social to economic dimension.

Environmental benefits are that it's an step forward towards organic farming and prevention in use of fertilizers and pesticides, (The state of Sikkim is declared fully organic in 2016 and Orissa is taking a big way towards organic farming.) , farmland preservation, reduction in food miles, water management, climate control etc. Social benefits are that it can be a source of leisure activities in urban life and contribute to psychological health and mental well-being of the society. It can be tool for keeping food culture and tradition blooming. With people's participation it can also turn out to be an active public space along with enhancing food security in community. Economic benefits are that it enhances the food growing supply, generate income and employment and can be a reliance food growing supply in case or vertical farming.

IV. PROBLEMS AND POSSIBLE ALTERNATIVE APPROACHES IN VERTICAL FARMING AND URBAN AGRICULTURE IN INDIA

Urban agriculture has a long way to go for getting in effective use in India and abroad as vertical farming is still not a reality as a large scale practice. The two major problems have been financial and technological feasibility. Since vertical farming or indoor farming requires contemporary building materials and renewable energy systems such as light shelves, light pipes and fibre optics which deliver natural light deep into buildings to provide energy for photosynthesis, and skilled workers to run it thus its rate of return does not seem profitable to investors. Where as in other hand conventional farming does not require either of it, but if one see from the point of future then Z-farming (Zero- Acreage) and vertical farming can become the lucrative option for investors too. This is so because in scenario of climate change dependency on outside environment for conventional farming would be unfeasible also with global warming reaching its peak and urban heat island effect increasing in cities urban farming in way of roof top gardening (RTG) can be a possible lucrative option for the future.

There are various types of agriculture and farming system in urban areas now a day. Some of them can be taken for vertical farming as a futuristic vision of India. The Agriculture land is reducing day by day and even its cost is increasing. The farming systems common to urban area can be analysed be the given table 1 as below-

Table. 1. Farming systems common to urban areas

Farming System	Product	Location
Aquaculture	Fish and seafood, water vegetables, seaweed and fodder	Ponds, lakes, rivers, canals, estuaries, sewage lagoons, drainage basins with water, reservoirs and wetlands.
Horticulture	Vegetables including mushrooms, fruit, cereals ornamental plants, compost.	Home gardens, parks, open space, derelict land, abandoned yards, institutional areas, roof tops, roadside, container gardening, greenhouses suburban farms, soilless culture, hydroponics etc.
Agro-forestry	Fuel, wood, fruits and nuts, building material, compost.	Orchards, forest parks, green belts.
Livestock	Meat, milk, eggs, manure. hides and skins.	Open space, grazing area, periurban area, roadside trees, home gardens, slope and hill sides, pens and sheds, animal farms.
Others	Medicinal and house plants, herbs, beverages, flowers, honey, insecticides.	Green houses, Roof tops, beehives, cages, urban forests containers.

(Source: The Urban Agricultural Network, Washington D.C., USA and Centre for Built Environment, Calcutta, India, 1996)

In most of the metropolitan cities like Delhi the land use has been changed in outskirts or per-urban areas with major agricultural land loss. With increasing urban sprawl not only agricultural land is getting reduced but also dependency on rural hinterlands for food and other dairy products etc. is increasing which is causing shortage and price fluctuations of vegetables, fruits and other major daily need sources of food.

Also with increasing urban sprawl development around the farmland has increased its price in many folds thus farmers chose to sell their land to real estate developers than to farm. The problem related to real estate development in India is that there is large amount of investment in plots and housing apartments which remain unused as the money which is invested is mostly black money and the property is brought for investment point of view thus they remain vacant, this large amount of private property can be brought to use for urban farming if regulations like in Singapore vacant land taxes are brought up in India. With numerous benefits that urban agriculture offers in cities it is the future of cities globally.

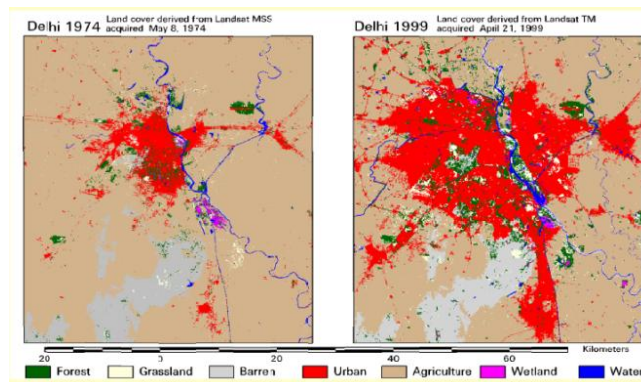


Fig. 1. New Delhi 1974 -1999, Increase in population of 4.2 million with 60,000 hectares of agricultural land lost
(Source: Land Use Change in Developing Countries, DEAS/HUCE, Harvard University Cambridge)

As in Canada the 'Sharing Backyard' project – A popular innovation in urban farming, which connects homeowners and landless city gardeners. In this users have access to website and map of city where landowners and cultivators can connect and farm. This concept is not new in India as in rural villages this practice is there since decades where landowners give farmers their piece of land for cultivation in deal for about half of grains produced in return.

It is not only lack of open spaces in cities but also lack of awareness and thought among people in India that we do not see urban farming in India in practice E.g. - India is a developing country thus lot of construction work in construction of buildings keep on occurring which take a time of about 2- 4 yrs on average(taking group housing as example) thus if in that period vacant lands where construction has not yet started farming is done it too can contribute to food market. Also the builders constructing flats give green open spaces in their colony but only consisting of beautified plants. Thus by giving incentives, raising awareness and promoting interest among people to get engage in urban farming is vital and need for future cities.

V. URBAN AGRICULTURE – THE POSSIBLE OPTIMISTIC FUTURE OF INDIA

The urban population in India expected to grow by 404 million by 2050 (World Urbanization Prospects, 2014). As cities in India like any other cities of the world are continually increasing in size with the increase in population thus it is quite possible in future that the types of land use practices will gradually encroach and engulf onto land which are currently utilized for agriculture.

A. Urban farming as way forward for increasing liability of future Indian cities

If liability in cities is seen in Indian context at present then the condition is not virtuous, many metropolitan cities like Mumbai and Delhi are facing severe shortage of water, food and housing. Also with increasing population in cities its drawbacks related to overcrowding, pollution, lack of social concern and fading community bonding, culture etc. would be at major issue in the of land of diversity and culture. According to a recent report by the World Bank, the economic impact of the ambient air pollution in India is as high as atleast 1.6% of its GDP. The problems of asthma and other lung related ailments are precisely due to the 'lack of lungs' in the cities along with air pollution. Thus reflecting these issues urban agriculture can be a way out to increase the liability index in future cities of India as they can become the lungs of future vertical cities in buildings increasing community bonds in one hand and thus saving the existing forests from being cut due to need of land for conventional farming on other.

B. Urban farming as a water management tool for future.

Water management would be a major issue for future cities of India, even at present cities like Mumbai, Pune and Delhi are facing severe shortage of water. According to the published report of Indian express of October 2015, Mumbai. The total usable water quantity in all the seven lakes supplying water to the city is 11 lakh million litres, three lakh million litres less than what was recorded on the 2014. Thus the city is currently facing a 15 per cent water deficit, which has forced the civic body to continue with the water cuts. With water shortage further degeneration, urban indoor farming can be a way out for ensuring food security in cities as in case of aeroponics farmers use up to 95% less water than traditional farmers for farming thus further resolving issue of shortage of usable water for ensuring food security in the future.

C. Vertical farming a possible replacement to conventional farming in future.

The amount of miles that food travels in cities from source of production will increase many folds in future if this way of dependency of cities for food and nutrition security on rural conventional farming will continue as today(today most of the food in cities is imported from other places).In this situation, future cities would have to produce their own food and with increasing land prices conventional land farming would not be possible but vertical farming or roof top farming(called as Zero –Acreage Farming as they are characterized by non-use of land) would be the possible approach and solution for nutrition to cities.



Fig 2-The Sky Greens vertical farm in Singapore

(Source- The Atlantic email newsletter- Farming in the Sky, Why agriculture may someday take place in towers, not fields)

VI. RESEARCH AND DISCUSSION – A BRIEF CASE STUDY OF METROPOLITAN, NEW DELHI (INDIA)

A first research area could be an exploration of the literature review with cultural and political meanings of urban agricultural initiatives in different historical conjunctures and urban contexts in the Global North. This research track should second look for the specific forms of land regulation, land condition and ownership which determine the set of constraints and opportunities which shapes the initiatives in future of vertical farming and urban agriculture along with their contexts, and then focus on the analysis of emerging urban agricultural practices.

NCT of Delhi is the capital of India. It stands in a triangle formed by the Yamuna river in the east and spurs from the Aravalli range in the west and south. It is surrounded by Haryana on all sides except east where it borders with Uttar Pradesh. The National Capital Territory of Delhi covers an area of 1,483 km² (573 sq m), of which 1114 km² is designated as urban, and 369 km² as rural. It has a length of 51.9 km and a width of 48.48 km.

A. Land holding pattern in Delhi

As economy is moving along-with rapid urbanization, the agriculture holdings in Delhi is also reducing at a speedy rate. This is evident as per the Agricultural Census. The information regarding the agricultural land holding pattern and area operated for agricultural purposes in Delhi, during the last two agricultural censuses is presented in Table 2.

Table. 2. Land holdings & operational area in Delhi: 2005-06 & 2010-11

S.No	Details	Agricultural Census 2005-06	Agricultural Census 2010-11
1.	Operational holdings (Number)		
	a. Individual	11741 (46.39)	8195 (39.98)
	b. Joint	12624 (49.87)	11358 (55.41)
	c. Institutional	946 (3.74)	944 (4.61)
	Total	25311 (100.00)	20497 (100.00)
2.	Operational Area (in Hectares)		
	a. Individual	10590.95 (28.04)	7087.95 (23.92)
	b. Joint	25977.85 (68.78)	21341.82 (72.03)
	c. Institutional	1201.49 (3.18)	1198.44 (4.05)
	Total	37770.29 (100.00)	29628.21 (100.00)

(Sources – Agricultural Census 2005-06 & 2010-11)

It may be inferred from Table 2 that the number of operational holdings in Delhi reduced from 25311 in 2005-06 to 20497 in 2010-11. The reduction in land holdings in Delhi worked out at 3.80 per cent per annum. The reduction of operational holdings by the individual category was highest at 6.04 per cent per annum, while the same in joint and institutional category at 2.01 per cent and 0.04 per cent per annum respectively.

The operational area of Delhi decreased from 37770.29 hectares during 2005-06 to 29628.21 hectares during 2010-11. The reduction in operational area during the last two agricultural censuses in Delhi was worked out at 4.31 per cent per annum. The reduction in operational area of institutional category during the same period was highest at 6.62 per cent per annum. The same in case of joint and institutional category was worked out at 3.57 per cent per annum and 0.05 per cent per annum respectively. The land holdings and operational area of Delhi during the last two agricultural census is depicted in Chart 2

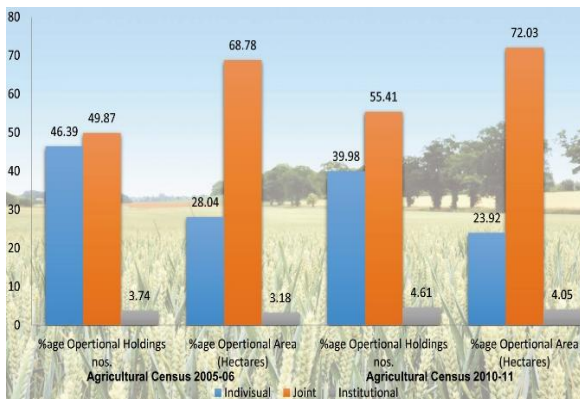


Chart. 2. Land holdings & operational area in Delhi: 2005-06 & 2010-11

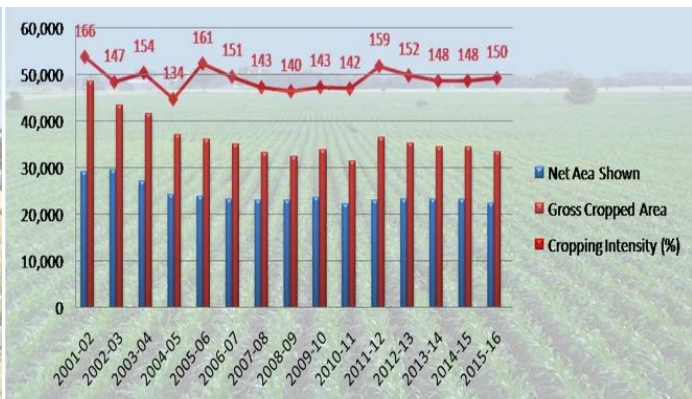


Chart. 3. Cropping intensity of Delhi during 2000-01 to 2015-16

B. Crop Intensity

Crop intensity is an index of agriculture development and is directly related to irrigation facilities. It is the percentage ratio of gross cropped area to net area sown. It may be measured by the formula-gross cropped area/net sown area x 100. The intensity of cropping, therefore, refers to raising a number of crops from the same field during one agricultural year.

It may be observed from Table 3 that the crop intensity was highest at 166% during 2001-02 and lowest at 134% during 2004-05. The crop intensity of Delhi during 2015-16 is estimated at 150%. In addition, area under the food-grain crops have been decreased during this period but the same in vegetables increased being one of the fast growing mega cities in India, showing the status of agriculture activity with the limited available land. The same is also depicted in chart 3

Table 3. Crop intensity of Delhi during 2000-01 TO 2015-16 (in hectares)

S.NO.	Year	Net Area Shown	Gross Cropped Area	Cropping Intensity (%)
1	2000-01	34,034	52,816	155
2	2001-02	29,116	48,445	166
3	2002-03	29,477	43,391	147
4	2003-04	26,971	41,509	154
5	2004-05	24,214	36,957	134
6	2005-06	23,809	36,041	161
7	2006-07	23,109	34,981	151
8	2007-08	23,056	33,078	143
9	2008-09	23,025	32,288	140
10	2009-10	23,575	33,700	143
11	2010-11	22,124	31,366	142
12	2011-12	22,885	36,445	159
13	2012-13	23,118	35,178	152
14	2013-14	23,150	34,341	148
15	2014-15	23,150	34,312	148
16	2015-16	22,300	33,454	150

(Source-Development Department, Govt. of NCT of Delhi)

C. Land use pattern in Delhi

The total harvested area during 2000-01 was at 52816 hectares which reduced to 34750 hectares in 2015-16. The reduction of cropped area during this period was worked out at 2.28 per cent per annum. Simultaneously, the percentage of cropped area from total area (Excluding Forest Area) was reduced from 35.81 per cent in 2000-01 to 23.26 per cent in 2015-16 (table3). The remaining spaces of the Delhi are being used for several other uses such as non-agricultural purposes, forest, fallow land, uncultivable land, etc. as shown in table 4 & chart 4.1. The main causes behind such reduction in agriculture area in Delhi are due to the fast urbanization, and shift in occupational pattern especially during the last two decades. This results in decrease of share of this sector to the Gross State Domestic Product of Delhi.

Table 4 - Pattern of land utilization (in hectares)

Year	Total Area (Excluding forest area)	Fallow Land	Net Area Sown	Area not available for cultivation
1980-81	147488	32707	58551	52077
1990-91	147488	12864	48357	74248
2000-01	147488	11544	34034	89689
2010-11	147488	20043	22124	92700
2014-15	147488	19225	23150	92701

(Estimated Source -Agricultural Department, G NCT of Delhi)



Chart 4.1- Trend in land usage in Delhi

VII. CONCLUSION

As per the above study we can analyse the available spaces in Delhi for vertical farming as the chart is showing the reduced spaces for urban agriculture due to urbanization. So we have limited space for urban farming, so as considering the futuristic urbanism we have to adopt the option for vertical farming as well as incorporation of technology in urban agriculture areas. Farming has been around since early times for around thousands of years and they are as essential for our daily lives as it was since early times and will continue to be vital and more demanding in the future in one or the other way form providing food to supplying industries with much-needed resources including cotton, hemp and lumber to feeding to the mass urban population of the future.

Urban farming whether it is vertical farming or Z-farming or farming on vacant open spaces, all can be a favourable way for ensuring this demand of the future in India and globally. With many countries of Europe, USA and Singapore have already risen to many folds towards this future farming, but in India it still has a long way to go ahead as vertical farming is still restricted to a few individually driven interest projects. With several benefits inherent in this method of farming e.g. It does not need a multi-acre farm as it is vertical, it is good for the environment as it can be used as a water recycler (Some of the most recent vertical farms situated in the United States are also recycling waste material from the cities'- According to report of Vertical Farming: Enter the Urban Farmer 22 January 2017, 19:00), grown food are completely free from pesticides thus organic and healthy, a more reliable and stable production source as it does not depend on the outside environment.

These are few benefits to count thus there is a need of institutional support along with interest in people to participate in it and this possible by spreading awareness of benefits associated with it, strengthening policies like incentivizing farming for making it attractive to the urban dwellers, financial and technological support by government to developers of urban farmers or moving forward to a concept of 'sharing backyard' so that different communities can be reached in need of space or grower.

One can see a progressive growth of urban agriculture in India once all these are done and moving on this way forward this can act as an urban regeneration tool for present and future cities by giving social (creating and enhancing social interaction), economic (enhancing job opportunities in cities) and environmental benefits to the future cities.

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