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Making Cities Net Zero Carbon,
Modelling Tools for Assessment of Sustainability,
Re-imagining Tourism Potentials of Shimla, etc.

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Editorial

This fourth issue of 19th Volume of Journal of the ITPI, presents selected papers received for 70th National Town and Country Planners Conference, held at Bhopal in April 2021, except last paper.

Climate change impacts are becoming visibly apparent globally as well as locally, which has led to the development of global and national focus on climate change adaptation strategies. Accordingly first two papers focus on this theme, the first paper titled "Planning for a Resilient and Low Carbon Urban India" written by A.K. Jain, contends that urban India is passing through rapid socio-economic transformations leading to increasing carbon footprints, climate change and disasters. There are conflicts among spatial planning and sustainability due to chronic peripheralization, increasing pollution, transport, and energy and water consumption. It needs re-looking at the repertoire and processes of urban development. While Jit Kumar Gupta writing on "Making Cities Net Zero Carbon: Issues and Options" says that despite distinct advantages cities hold, they have also emerged as large consumers of resources, energy and generator of wastes. Consuming large amount of resources, polluting environment and ecology, history has shown that cities remain an ideal breeding ground for disasters. So, cities need to work with the nature, and accordingly need to be planned, designed, developed and managed rationally and innovatively to make them work as promoters of environment and ecology.

In the paper on the theme "Analyzing Issues pertaining to Cantonment Areas in Indian Context" S. G. Sonar, and A. S. Petkar, mention that Cantonment Areas - the military stations, though primarily meant for army personnel, attracted the civil population to reside in Cantonments thereby attracting economic spin-offs and other activities. The authors after visiting various literatures pertaining to Cantonment planning in Indian context, studied socio-economic and spatial parameters pertaining to Khadkee, Kamptee and Deolali Cantonments and analyzed the important issues associated with them.

The paper by Ajay Kumar and Ashwani Luthra on "Re-imagining Tourism Potentials of Shimla: Tourists' Perceptions" underlines that tourism is a significant global industry contributing over 10 per cent to the world GDP. By examining perceptions of tourists, this paper shows that the current scenario of tourism in Shimla is not very encouraging both for policy makers and tourists as growth rate of tourists to the city has come down. The paper also underscores the reasons for the current condition of tourism in Shimla by highlighting inadequacies of tourist infrastructure and attempts to re-imagine tourism potentials of Shimla.

The paper titled "Coping with Data Deficiency for Post Pandemic Local Area Planning by Using Open Source GIS and Image Analysis" written by Pallavi Prakash Jha, highlights that most cities in India are data deficient when it comes to planning at

local level and need emergency city level data repository during times of pandemic. As an alternative, the study tests a method to estimate areas of various land uses and volumes of built density from satellite images using raster classification and interpolation methods on open source platforms like QGIS and GIMP image analysis software. The paper while concluding gives planning recommendations to suit LAP from pandemic point of view overviewing the prevailing acts, byelaws and guidelines.

"Modelling Tools for Assessment of Sustainability: Urban Metabolism and Circular Cities" written by Nirmita Mehrotra, explores the possible pathways and links of input-output at macro, meso and micro levels in different sectors viz. water, energy, carbon and other pollutants, and investigates pathways to circularity for equity, efficiency and wellbeing of community at both urban, and regional levels.

In the light of the Vedic sciences Niranjan Lal Mangla, in the paper titled 'Sustainable Solutions for global peace and prosperity' states that the causes of the distressing climate change; pollution; pandemics like COVID-19; violence in the form of wars and terrorism; the emerging personal and social problems are - the combustion of petroleum products, the disposal of sewage and industrial waste into water, the release of inconsistent vibrations into the atmosphere, unlimited and over populated towns and cities. The author claims that living in self-dependent properly sized villages surrounded by forests, and the use of animal powered small machines, can only solve all these problems, and not the solar power and electric vehicles.

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Content

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Planning for a Resilient and Low Carbon Urban India

A. K. Jain

Abstract

Urban India is passing through rapid socio-economic transformations leading to increasing carbon footprints, climate change and disasters. There are conflicts among spatial planning and sustainability due to chronic peripheralization, increasing pollution, transport, and energy and water consumption. It needs re-looking at the repertoire and processes of urban development which should shift from fossil fuel era to the circular concepts of urban planning, renewal, recycling and conservation of natural resources. Leapfrogging in the areas of fourth industrial revolution would help in making the cities resilient, pollution free and carbon negative.

1. INTRODUCTION

Climate change has become an imminent reality with a rise in global temperatures, changes in rainfall, floods, droughts, air pollution and water shortages. With increasing traffic, wastes and stubble incineration, fossil fuel usage, carbon footprints and growing air conditioning, it is projected that the ambient temperature can increase by 3°C to 4.8°C, adversely affecting population's health and productivity. This may cause a 30 per cent decline in agriculture yield and an increase in incidences of droughts, floods, cyclones, earthquakes, pandemics, urban heat islands and changes in microclimate due to radiant energy in the earth's atmosphere. India continues to suffer from deadly air pollution in the North, while the South is inundated by catastrophic floods (November 2021). This calls for re-thinking about paradigms of urban development so as to deal with the threats of climate change, pollution and disasters.

2. INDIA'S PERSPECTIVE AT THE COP 26 (2021)

In 2015, the Sustainable Development Goals (SDGs) were adopted by the United Nations, which were signed by 193 countries, including India. As a follow up, the United Nations Conference of the Parties (COP 26) in Glasgow (November 2021) resolved to limit global warming to 1.5 degree Celsius by the year 2100. Indian delegation led by the Prime Minister put forward the need to scale up clean technologies and formation of the International Solar Alliance (ISA). Under the ISA One Sun, One World - One Grid envisions an interconnected trans-national solar energy grid. The COP 26 agreed to reduce the use of fossil fuels and coal by new sources, such as green hydrogen, green metals, carbon capture, solid state batteries, electric fuels, heat pumps and next generation

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solar PV. PM Modi put forward his five-point agenda at the conference, and informed that India's non-fossil fuel energy will be raised to 500 GW by 2030 and 50 % of the power requirement will be met by renewable energy. This will reduce the carbon intensity of the economy to less than 45 per cent. India will achieve net zero emissions by 2070 by clean technologies, like electric transport, ethanol blending in gasoline, solar photovoltaic and batteries. The green and zero carbon technologies would play a critical role in India's decarbonization. India has also led the formation of a global Coalition for Disaster Resilient Infrastructure (CDRI) and Clean Energy Ministerial Industrial Deep Decarbonization Initiative (IDDI). The Prime Minister underlined at the COP 26 that there is a need for a balance between development and environment.

3. RE-IMAGINING URBAN PLANNING

Carbon footprint is the total set of greenhouse gas (GHG) emissions. According to the Indian Network for Climate Change Assessment, 58 per cent of the total emissions are caused by the energy sector, followed by the industrial sector at 22 per cent, and remaining 20 per cent by solid and liquid wastes, agriculture and forestry. Linked with it is the phenomenon of climate change and disasters, which impact infrastructure services, housing and livelihoods.

The urban and community development should be complemented by a shift in our way of life, which is resilient, sustainable and equitable. It is not just economic but aligns with the humane, environmental, cultural and socio-economic dimensions of development.

Resilience is defined as "the ability of a city as a socio-ecological infrastructural system and its components to absorb and recover from shocks whilst retaining the essential functions and adjust to stresses to reorganize, develop, and transform in order to adapt to socio-economic and environmental changes, over temporal and spatial scales".

This implies certain basic changes in the planning and urban processes, which are resilient and reduce the use of natural resources and energy. Carbon-intensive technologies can help in mitigating climate change. These should conform to net-zero energy and water standards, thrift consumption and doing more with less.

According to UNISDR, the Disaster Risk Reduction (DRR) related activities comprise 10 essentials, which cover planning regulations, plans and development activities; setting up institutional structures dedicated to DRR; constructing or enhancing hazard-mitigating infrastructures; and setting up education / awareness / training programs (Table - 1).

Table 1: UNISDR's 10 essentials for Making Cities Resilient

Sr. No.	Essentials	Details
1.	Institutional and administrative framework	• Put in place organization and coordination to understand and reduce disaster risk based on participation of citizen groups and civil society; • Build local alliances; • Ensure that all departments understand their role in disaster risk reduction and preparedness
2.	Financing and resources	• Assign a budget for disaster risk reduction and provide incentives for home owners, low-income families, communities, businesses and the public sector to invest in reducing the risks they face.
3.	Multi-hazard risk assessment	• Maintain up-to-date data on hazards and vulnerabilities; • Prepare risk assessments and use these as the basis for urban development plans and decisions; • Ensure that this information and the plans for your city's resilience are readily available to the public and fully discuss with them.
4.	Infrastructure protection, upgrading and resilience	• Invest in and maintain critical infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.
5.	Protect vital facilities: education and health	• Assess the safety of all schools and health facilities and upgrade these as necessary.
6.	Building regulations and land use planning	• Apply and enforce realistic, risk-compliant building regulations and land use planning principles; • Identify safe land for low-income citizens and develop upgrading of informal settlements, wherever feasible.
7.	Training, education and public awareness	• Ensure that education programs and training on disaster risk reduction are in place in schools and local communities.
8.	Environmental protection and strengthening of ecosystems	• Protect ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which your city may be vulnerable; Adapt to climate change by building on good risk reduction practices.
9.	Effective preparedness, early warning and response	• Install early warning systems and emergency management capacities in your city and hold regular public preparedness drills.
10.	Recovery and rebuilding communities	• After any disaster, ensure that the needs of the survivors are placed at the centre of reconstruction, with support for them and their community organizations to design and help implement responses, including rebuilding homes and livelihoods.

4. INDIA'S URBAN MISSIONS

Since 2014, the Government of India has launched several new urban missions, viz. Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Pradhan Mantri Awas Yojana, Historic City Development and Augmentation Yojana (HRIDAY) and Swachh Bharat Mission (SBM). The SBM 2.0 and AMRUT 2.0 continue to operate with effect from October, 2021.

These missions aim at low carbon urbanization and the provision of core infrastructure services like water supply, sanitation and solid waste management, efficient urban transport, affordable housing for the poor, 24x7 power supply,

IT connectivity and e-governance. These missions emphasize upon participatory planning and governance, livelihoods, connectivity and providing better education, healthcare, urban safety and smart services, which are intelligent, inter-connected and instrumented. These Missions also encourage issue of Municipal Bonds, public-private partnership (PPP), Value Capture Financing, Transfer of Development Rights (TDR) and Tax Incremental Financing. Town Planning Schemes and GIS based Land Pooling have been proposed for planned development and management of land.

5. RESILIENT AND LOW CARBON CITIES

The cornerstone of making a city resilient and low carbon is to adopt an integrated approach towards ecology, the conservation of the natural resources and sustainable urban development, including the services like drainage, water supply, air, sewerage, solid waste management, transportation and energy. These involve the action on following:

- Local economic promotion and Jobs;
- Urban restructuring for socio-economic growth, decentralization, economy of scale, better quality of life, mixed land use, and compact urban form;
- Biodiversity and greenery;
- Urban heat island mitigation;
- Water conservation and management;
- Decentralized and intelligent services;
- Air quality;
- Clean transport and transit-oriented development;
- Energy;
- Green and Resilient buildings;
- Gender equity; and
- Low carbon lifestyle.

5.1 Local Economic Promotion and Jobs

In India, the cities generate the country's 60 per cent of GDP and 70 per cent of the jobs. With COVID-19 pandemic, climate change and diminishing jobs, the factors of public health, creation of jobs, environmental sustainability and climate resilience are the emerging key issues. A target of 10 million jobs in urban areas can be achieved in the next five years by development of *janta* markets, workshops or sheds, kiosks, shops, small offices, etc. At least 10 per cent of city's commercial area may be reserved for the informal sector for street vendors, kiosks, fruits and vegetable stalls, etc. The urban areas also need a higher level of mixed use and the rationalization of FAR, height and densities.

5.2 Urban Restructuring

The urban restructuring can lead to travel reduction, economy of services and conservation of agricultural areas. The Indian cities have an overall density of 100 to 240 PPHa, which can be selectively doubled along public transit corridors, excluding the archaeological, heritage and conservation zones. The focus has to be on redevelopment of the brown fields, infrastructure services, transportation, public greens and facilities. The urban eco-system must be compact and dense. The urban planning, governance, businesses and industries have been transformed by fourth industrial revolution. The processes need to change which are compatible to circular economy by adoption of new technologies, such as combinatorial and discrete optimization, algorithms, complexity theory, artificial intelligence, big data, and the ubiquitous cloud. The new development strategies are essential for a green, clean, smart and emissions free urbanism.

5.3 Biodiversity and Greenery

A study of the present land use pattern in India indicates shortfall of land under forests and greens, while the lands under agricultural use are being increasingly converted for the highways, airports and settlements. It is estimated that an additional 2 to 3 million hectares would be required for human settlements during next 10 years. Sacrificing agricultural land for habitation implies reduction of land for producing food. The lands that sustain agriculture, biodiversity, surface water and groundwater, fragile and sensitive areas, coastal zones, etc., need protection and conservation.

In a city an overall area of 10 sq m of greens per capita should be reserved for public greens at city, zonal and local levels. A system of landscaped linkages connecting various parts of the city, water bodies and monuments can provide a sense of oasis and shelter from oppressive climate. Peripheral green belts can act as wind breakers, filters of SPM and dust-storms. The green buffers with indigenous trees, land formations, mounds, embankments, etc., also provide effective barriers to transmission of noise.

The development of green ways can be integrated with the water bodies, drainage corridors and harvesting ponds, reservoirs and by sediment traps in the catchment zones. In water deficient, dry areas the landscape can be in the form of Xeriscaping, which can reduce total water demand by as much as 50 to 90 % by micro- just in time-irrigation. Vertical gardens and urban farming can provide relief in the dense areas.

5.4 Urban Heat Mitigation

In a dense built-up area air rises over the warmer city and settles down in the cooler environs. The hot air dome and its effect on microclimate may persist until wind or rain disperses it. Increased aerodynamics of built-up areas cause rapid

deceleration of wind compared with open countryside. It has been calculated that wind velocity within a city is half of what it is over open land. At the town edge, it is reduced by a third. The mutations and reservation of greenery and open space in windward direction and cooler surface materials (roads, parking, buildings, roofs, etc.) help in mitigating the effects of urban heat island.

5.5 Water Conservation and Management

Water scarcity has become a persisting problem in Indian cities due to massive construction and unplanned development. The average annual per capita water availability in the country has gone down from 5,236 cubic meters in 1951 to 1800 cubic meters in 1991. Several cities in India have become water stressed. Only 18% of the renewable water resource is being recycled, while 10 per cent of the annual rainfall is being harvested in India. The issues of concern are increasing coliform levels and Bio-chemical Oxygen demand (BOD) in surface waters and increased concentration of nitrates in the groundwater. To overcome these problems, water sources need to be protected by interception, recycling and treatment of wastewater. Water resources can be augmented through recharging of groundwater and by rainwater harvesting (not only in building, but also on roads, parks and parking areas) along with conservation of rivers and water bodies, water efficient taps / fittings, dual plumbing, curbing non-revenue water and recycling of wastewater. Block chain and SCADA systems can help in 24x7 water supply, which is of potable quality.

5.6 Decentralised, Intelligent Services

Surveys reveal that approximately 40 per cent of urban population in India is not covered by sewerage, sanitation, drainage and solid waste disposal. Various alternative technologies, based on decentralized systems should be explored. The use of IT, simulation, block chain and automation can make the services smart and intelligent. The common method of land filling for solid waste disposal is an environmental disaster. Instead, decentralized systems based on 5 R strategy of reduce, refuse, reuse, recover and recycling should be explored. Three bins-provide separate bins for trash, recyclable and compost. Collection charges drop as trash drops. Biotechnology, enzyme based STP, bio-remedial treatment vessel system, sludge gas/energy recovery, vermi-culture, fossilization and composting options can be adopted for solid and liquid waste management. Underground pneumatic conveying systems can be adopted, which are more hygienic, economical and avoid movement of trucks for transportation of wastes.

Common utility ducts or tunnels carrying electricity, water, sewerage, wastes, cables and broadband internet minimize damage from traffic, road repairs, rains, etc. A series of low carbon zones across the city with co-located tri-generation energy systems (combining power, cooling and heating), and automated, segregated waste collection and recycling can lead to bundling ‘green infrastructure’ together.

5.7 Air Quality

Air quality in Indian cities is deteriorating due to indiscriminate use of fossil fuels and vehicular and industrial emissions. According to the surveys conducted by the CPCB ambient air quality in more than 20 Indian cities have reached a very critical situation. Relatively high levels of suspended particulate matter, dust, SPM, SO_2, NO_2, CO_2 and heavy metals, including lead content in the exhaust of automobiles and scooters have been observed. The recent changes in the fuel like electric and hydrogen powered vehicles, adoption of clean technologies, new emission norms, development of shared taxis, NMTs and mass rapid transport system can reduce the pollution levels due to vehicular emissions. Airshed planning, continuous ventilation, use of cooler and light shaded materials and water spray are some other methods to reduce air pollution.

5.8 Clean Transport and Transit Oriented Development

The Prime Minister, while inaugurating the Global Mobility Summit in September 2018, encapsulated 7 Cs of mobility - common, connected, convenient, congestion free, charged, clean and cutting-edge. He underlined the need to use clean energy for transport as a powerful weapon against climate change, along with pollution-free clean drive. He championed the idea of clean kilometers which could be achieved through bio-fuels, electric charging and hybrid electric vehicles.

The Ministry of Housing and Urban Affairs (MOHUA), Government of India has recently issued Metro Rail Policy (2017) and Transit Oriented Development Policy (2017), which provide guidelines for preparing comprehensive proposals for promoting urban public transit with private sector participation.

As urban transport contributes nearly two-thirds of the total suspended particulate matter and 18 per cent of carbon emissions, it is time to think of sustainable modes of transit. It may be necessary to provide Integrated Transit Corridors (ITC) integrating BRT, Metro and trains together with pedestrian and cycle lanes. These can be flanked by public, semi-public, high-density developments. Metro, trains, sub-way and primary roads can run underground for easy bike and pedestrian traffic on the grade. Multi-modal integration, last mile connectivity and e-governance are the pillars of sustainable urban mobility. River / water transport and ropeways can be explored which are almost pollution free and cost-effective. Besides controlling growth of private vehicles, it is necessary to explore parking space in stilts, multi-level puzzle / skeleton structures, on roofs and in underground spaces. Seamless multi-modal public transport system comprising bus rapid transit and rail-based mass transport system would work better by adoption of single ticketing and restructuring of land uses by transit-oriented development. Subterranean garages near commuter destination reduce the need for ground parking. Digital parking meters tell mobile phone when a space opens up, reducing traffic caused by drivers trolling for space. The concept of walk to work should be the basis of urban structure and city size.

The concepts of cordon pricing, minimum occupancy vehicles, ceiling on new registration of private vehicles and establishment of a Unified Metropolitan Transport Authority can contribute towards a sustainable and clean urban transport.

5.9 Energy

Energy scenario in India is characterized by its increasing demand, which has been growing at the rate of about three times the population growth rate in the last two decades. Low carbon energy can be derived from renewable sources, such as bio-fuels, wind, tidal and solar power. The concept of energy efficiency, renewable energy and Zero-fossil Energy Development (ZED) can reduce the energy demand and consequential pollution. The renewable energy not only helps in energy generation, but also in a pollution-free environment. Smart Micro-Grids, Distributed Energy Systems (DES), Micro-Districts and Anchor Micro-grids should be linked with renewable energy network and energy efficiency.

The energy guzzling air-conditioning can be avoided by innovative methods like net zero energy design, variable refrigerant volume (VRV) system, earth air tunnel (EAT) and thermal storage. By HVAC and EAT systems inside temperature of a building can be maintained within 27 degree Celsius during summer and 19 to 24 degree Celsius during winter. Lower ambient lighting with bionic controls and integration of natural light with high performance glazing combined with light sensors can save energy use in a building. Optimum glazing design can also help to reduce glare. Synchronized lighting and bionic climate control systems can be designed to match building loads and schedules, which are segmented into multiple zones to allow intelligent controllability. Green roof, light colored finishes and insulation can help to reduce energy demand.

5.10 Green and Resilient Buildings

A low carbon and green building aim to be comfortable and energy efficient. The heating, lighting, cooling, ventilation and powering of buildings are responsible for approximately 40 % of the total energy use. As buildings are the largest energy users, incorporating energy storage into them will increase the resilience of the total energy distribution network and enable widespread use of renewable energy.

By passive design the building can be more climatically comfortable. It is necessary to specify building materials which are locally sourced and re-cycled from construction and demolition wastes, that have low embodied energy and require less energy for production and transportation to the site. Such materials include carbon-negative cements, low carbon steel, fiber the alternatives to steel reinforcement for bridges and buildings with low carbon emissions include basalt, fiber composite bars, bamboo, etc.

Building Information Models (BIM) can simulate the entire construction sequence beforehand addressing sustainability issues and reducing carbon emissions. Computer-Aided Manufacturing (CAM) and Computer Integrated Manufacturing (CIM) are useful in reducing emissions, dust and GH Gases. The simulation of construction process enables better control of time, machine, expenditure and the manpower, and could reduce carbon emissions, costs and time by half to one-third.

5.11 Gender Equity

Low carbon and resilient strategies can not work without involving the women, who comprise nearly half of the population and use energy for everyday work, mobility, cooking, etc. However, they often face the 'gender service gap' in terms of access to energy, water and toilets. A low carbon city has to be gender sensitive with adequate, safe and affordable spaces for living, working and vending by the women.

5.12 Low Carbon Lifestyle

Low carbon lifestyle is a cluster of habits, embedded in a social context and enabled by efficient infrastructures that minimizes the use of natural resources and generation of emissions, wastes and pollution. Creating sustainable lifestyle requires a change in social norms and rethinking the ways of living based on the principles of organicity, non-accumulation (aparigraha), minimalism and slowing down. It is also about caring, sharing, recycling and living in balance with the natural environment. Education, capacity building and participation of civil society, business and industry are necessary to develop pragmatic and innovative practices of sustainable lifestyles.

6. CONCLUSIONS

A resilient and low carbon city comprises smart and green transport, energy, water, sanitation, drainage and buildings with net zero carbon emissions. It produces surplus energy from renewable sources that compensates for all carbon emissions associated with transport, construction, industries and buildings. Net zero energy development goes beyond carbon neutral and creates environmental benefits by decarbonization. Such a city promotes creation of jobs, urban variety, gender equity, digital planning and governance, adoption of micro-climatic design approach and intelligent services. Optimum use of land and other resources and smart systems along with new partnerships are critical elements of a resilient, low carbon habitat.

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Making Cities Net Zero Carbon: Issues and Options

Jit Kumar Gupta

Abstract

Despite distinct advantages cities hold, they have also emerged as large consumers of resources, energy and generators of wastes, consuming large amounts of resources, polluting environment and ecology. History has shown that cities remain an ideal breeding ground for disasters. Cities have emerged as the major cause of the large number of adversities facing humanity and the planet. Cities are known to be originator and promoters of large greenhouse gas emissions. Climate change and global warming besides damaging the environment and bio-diversity are the gifts of cities to the mankind. So, cities need to work with nature. Cities need to be planned, designed, developed and managed rationally and innovatively to make them work as promoters of environment and ecology; consumers of minimum resources and energy; generators of minimum pollution and waste; promoters of carbon neutrality; minimizing travel and traffic; creating sustainable built environment ; ensuring uninterrupted provision of basic and essential infrastructure; creators of opportunities of gainful employment; and supporters of the urban poor.

1. INTRODUCTION

Cities remain most valuable among human settlements for the contribution they make to the economic development, generation of employment, promoting innovations and providing state of art infrastructure and facilities. As places for concentration of activities and human beings, cities not only create supportive environment for businesses to thrive but also enable residents to have gainful employment. Cities drive economic wealth, promote competitiveness, invest in local economies ensure health, safety, and welfare of the people and maintain infrastructure, which are known to be the prime mover of social and economic development. Studies made by UNO indicate that cities globally housed 4.2 billion people, or 55 per cent of the world's population in 2018. By 2050, the urban population is expected to reach 6.5 billion. Accordingly, cities will script the future of communities and nations.

Considering the critical role and importance of cities; Goal 11, out of 17 SDGs mandated by UNO to make this planet livable, is exclusively dedicated to improving cities and making them sustainable, livable, resilient and safe. This goal looks at the options and opportunities to make cities, as entities generating minimum carbon footprints, promoting energy, water, resource efficiency; creating optimum level of living, promoting safe and affordable housing; building resilient societies and economies; making investment to create safe, cost-effective, eco-friendly, affordable public transport; creating appropriate levels of green public spaces, and improving urban planning.

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Fig. 1: Sustainable Development Goals (SDGs)

Years 2020 and 2021 will be known in the urban history as the most challenging and difficult years, which transformed cities dramatically in their structure, operations and communication, impacting adversely human health, economy, productivity, mobility, trade and commerce, quality of life, etc. Holding enormous capacity to face disasters, both man-made and natural, even in troubled times, communities and cities of today are facing twin challenges of healthcare, precipitated by the CO-VID-19 pandemic and global warming perpetuated by large consumption of energy and generation of the carbon footprints. Synergizing and working in collaboration, communities and cities need to, evolve, devolve and create productive partnership at all levels to respond effectively to emerging challenges and implement strategies to rebuild and make cities happy, healthy, livable and carbon neutral places.

2. ISSUES AND OPTIONS

Cities have been and are going to be the future of all nations because of the high proportion of national population they will be holding; large employment they will be generating; major contribution they will be making to the economy; quality infrastructure they will be providing and supporting and innovations and state of art technologies they will be introducing. However, despite distinct advantages cities hold, they have also emerged as large consumers of resources, energy and generators of waste. Consuming large resources, polluting environment (Figure - 2) and ecology, history has shown that cities remain an ideal breeding ground for disasters to come and go, the way they evolve, devolve and operate.

Cities have emerged as the major cause of the large number of adversities facing humanity and planet. Cities are known to be originator and promoters of large greenhouse gas emissions. Climate change and global warming besides damaging the environment and bio-diversity are the gifts of cities to the mankind. Cities,

Fig. 2: Polluting Industries, Climate Change and Global Warming

as man-made entities, have emerged as anti-thesis to the nature and natural resources. In order to empower and build capacity to face these natural and man-made disasters and make this planet livable and sustainable, cities need to work with nature. Cities need to be planned, designed, developed and managed rationally and innovatively to make them spaces for, promoters of environment and ecology; consumers of minimum resources and energy; generators of minimum pollution and waste; promoters of carbon neutrality; minimizing travel and traffic; creating sustainable built environment ; ensuring uninterrupted provision of basic and essential infrastructure, services, and amenities; create opportunities of gainful employment; supporting urban poor, etc.

If cities have emerged as the root cause of all prevailing environment and climatic ills, they also offer the best of solutions to make this planet sustainable, safe, happy and healthy place to live. Looking at the entire urban context, attempt has been made to define options, which cities must focus on and exercise, to make them low-carbon, safe, resilient and inclusive to counter the prevailing challenges of climate change and global warming.

3. URBAN PLANNING

As per UNDP, 'The cost of poorly planned urbanization can be seen in some of the huge slums, tangled traffic, greenhouse gas emissions and sprawling suburbs all over the world. By choosing to act sustainably we choose to build cities where all citizens live a decent quality of life, and form a part of the city's productive dynamic, creating shared prosperity and social stability without harming the environment'. Accordingly, urban planning holds enormous capacity and provide numerous options for making cities emerge as sustainable and dynamic spaces for living and working; empowering them to become consumers of minimum energy and generators of minimum carbon neutral, provided cities are planned, designed, constructed and managed with vision, innovation and flexibility. Planning has enormous capacity to rationalize and minimize travel and traffic behavior and make buildings sustainable, which are the two prime causes and reasons of cities emerging as the major agents of climate change, global warming and emitters of greenhouse gases. Bringing flexibility in cities will be critical for creating spaces, opportunities and options to house all basic and daily essentials for residents and communities. This would require all basic services and amenities to be planned and designed differently, in order to enable cities and communities reinvent and cater to all exigencies created by large travel and consumption of conventional energy.

For enabling cites to effectively counter the problem of having large carbon footprints, cities would need de-centralization and division into self-contained neighborhoods, duly planned and supported with basic facilities and infrastructures related to basic daily needs involving healthcare, education, etc. These neighborhoods should be planned and developed on pedestrian / human scale, based on walkability. Norms for these amenities / facilities will need periodic review, revision and re-definition, keeping in view the fast changing needs of the community.

Cities, as areas of large concentration of population or activities, remain hotbeds of global warming. In order to make existing cities safe against current and impending natural and man made disasters, caused by global warming and climate change, cities need to adequately address the issues facing the core or congested areas, which are known to be major contributor to problems of environment, pollution, congestion and traffic. Devoid of flora, fauna, open spaces, parks, green areas, and basic supportive infrastructure, core area has historically remained areas promoting large congestion and pollution. They remain major cause of generating large carbon footprints in urban context. Efforts need to be made to decongest the core areas on priority to empower cities to remain healthy. However, considering the concentration of population, existence of non-compatible uses and major business activities located in these areas; it becomes difficult to decongest them. Accordingly, for promoting sustainability and carbon neutrality in the existing cities, it will be vital to explore options like, minimizing the entry of mechanical and fossil fuel-based vehicles; promoting pedestrianization; shifting the wholesale trade to the areas identified in the master plan; using the area vacated by shifting trade for creating open spaces, which remain always at premium in all the core areas. With large scale landscaping of the areas, core areas will have reduced congestion, reduced vehicles count, reduced noise pollution and reduced fossil fuel consumption. This will help cities becoming low carbon, least emitter of greenhouse gases and promoters of environment and ecology due to changing options of travel and creating space for bringing nature in the core areas.

4. COMPACT CITY

Studies made globally, have showcased that form, shape, and size of cities remain major drivers and determinant of sustainability, greenhouse gas and carbon emissions by the cities. Occupying merely 3 per cent of the planet earth, cities account for 60 per cent of energy consumption and 75 per cent of carbon emissions. As consumers of large global energy and generators of greenhouse gas emissions, cities are becoming major players in climate change, promoting global unsustainability. Large concentration of people coupled with large dependence on mechanical and fossil fuel driven travel and constructing energy intensive buildings are making cities guzzlers of large energy and resources besides generating large carbon footprints. Looking at the way cities are growing and operating, achieving sustainable development and making cities carbon neutral

appears to be a mirage and remote possibility, without significantly transforming and redefining the way cities and urban spaces are being planned, designed, built and managed.

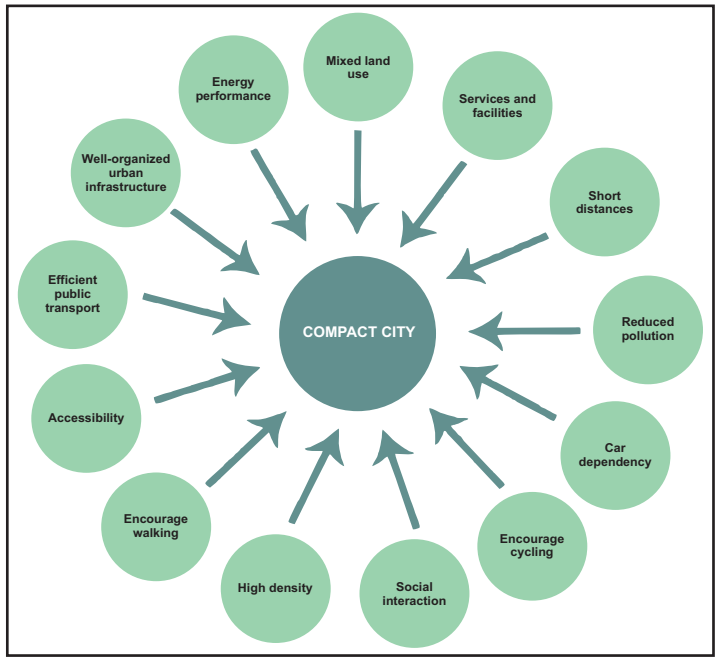
The prevailing pattern of rapid urbanization, is bringing numerous dualities, contradictions in cities involving irrational spatial distribution of people and resources; irrational land use and consumption of land; less dense and more inefficient land use patterns; car-centered urban models with pure land use zoning dividing urban spaces into residential, commercial, and industrial areas. All these have led to melting of city, resulting in promoting large conurbations, urban sprawl and cities face large negative externalities, making these horizontally spreading cities large consumers of energy and resources.

In order to achieve and promote sustainability, cities need to be made least consumers of energy, low carbon entities and generators of minimum greenhouse gases. Making cities low-carbon, would require ushering an era of compactness in form and area. All energy efficient and low-carbon cities have to be planned, designed and developed as compact settlements, because compact cities minimize distances between living and working; make people live in small area; promote walking and cycling besides eliminating the need for using mechanical and fossil fuel-based vehicles. Compact cities remain effective and efficient because they are known to be cities of small distances. Compact cities are also known to offer numerous advantages and options in terms of; making people happy and healthy; consumers of minimum land; reducing service networks; reduced distances, reduced travel, shorter commuting time; less vehicles, reduced pollution and reduced use of fossil fuel besides making cities safe and socially positive because compactness permit high degree of mutual interaction at community level.

However, planning compact cities would require new normal and state of art approach to urban planning. It would require change in travel behavior; intent, content and scope of the way, cities and buildings are planned and designed; putting in place new planning norms and standards for land use and supportive amenities and basic services to be provided in urban setting. Planning compact cities would ensure that basic principles of city planning are not sacrificed and city would be planned and designed to promote highest order of quality of life, provide high order of productivity and ensure availability of basic services / amenities for all the residents to lead an optimum life. Planning compact city would essentially involve; promoting high density development, supporting and protecting the environment; rationalizing urban open spaces; suburban densification, area redevelopment, planning new areas with higher densities, promoting brown field development; promoting building conversions and transit-oriented development.

Planning of compact cities must invariably incorporate densification strategies allowing mixed land use and taller buildings and providing adequate public spaces such as parks, green areas, and streets. Well-designed public spaces not only reduce the carbon footprints and greenhouse gas emissions but also contribute positively to achieve carbon neutrality and improve the overall visual character, invigorating not only economic activities but also enhancing the functionality and health of the city.

Fig. 3: Main Elements of Compact City



Densely populated neighborhood's duly supported by adequate public spaces, infrastructure and public transport facilities encourage walking, cycling, and other forms of eco-friendly non-motorized mobility, reducing reliance on fossil fuels, minimizing carbon emissions and global warming besides promoting social connectivity and diversity, thus making them more sustainable, cohesive and lively. For promoting urban sustainability city planning must be geared and made to gravitate around minimizing dependence on fossil fuels, incorporating low emission strategies so as to make city development resilience to climate change.

Cities of Singapore and New York have clearly demonstrated the distinct advantages of compact development in promoting quality of life and promoting higher order of operational efficiency. In search for optimum solutions to make the city development compact, Singapore adopted the mechanism of using digital survey to identify low-rise buildings, evolved a policy and provided incentives to owners to put high rise buildings in order to overcome the problem of high cost of living besides providing more space for housing. City of New York permitted the sub-division of

Fig. 4: Conceptual Framework for Compact City

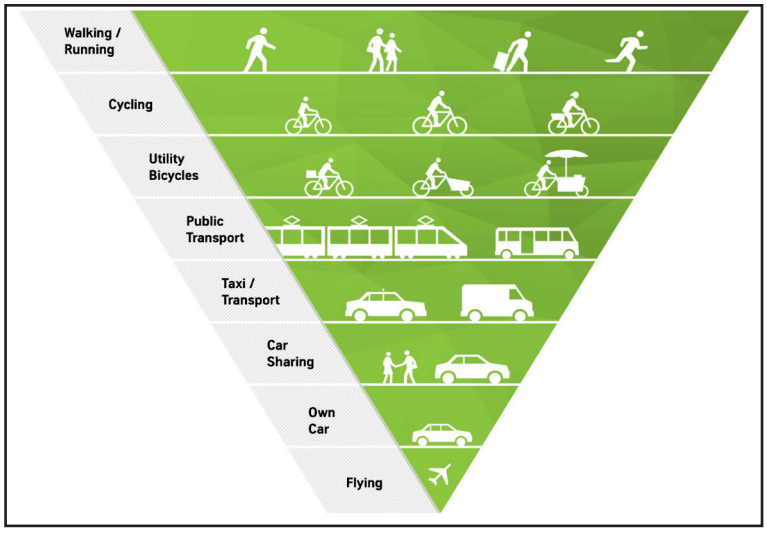
land and construction of studio apartments on the large terraces of the existing buildings, to create more housing space in the city.

Though re-densification and making existing cities compact may be slow and cumbersome but new and green field cities offer enormous opportunities to be planned and developed as compact cities. Planning compact and vertical cities would be most desirable and essential in the Indian context, for the reason, having only 2.4 % of global land and holding / supporting 17.6 % of global population, India would require land resource to be preserved, conserved, protected and used in the most optimum manner for ensuring sustainability and survival of the country. Compact cities would help India in minimizing global warming, greenhouse gas emissions and generating an era of carbon neutrality in the country.

5. CIRCULAR ECONOMY CITIES

In addition to changing the typology of the city to make them compact, cities also need to be planned, designed and constructed based on the principle of circular economy, to make them not only energy and resource efficient but also generators of least waste and carbon footprints. Operating and functioning on linear principle of take-make-waste economy, existing breed of cities have emerged as large consumers of natural resources, store house and breeding grounds of the waste, making them highly unsustainable and inefficient. Adopting circular approach for all urban operations, offers distinct advantage and potential to eliminate all waste and bring enormous economic, social, and environmental benefits besides decarbonizing cities and making them vibrant, and sustainable. Converting waste into wealth will require the support of innovative technologies and accordingly, circular economy can lead to creating large variant of jobs and a different typology of urban economy. Cities planning and development based on the circular economy will usher a new regime of change in which construction of buildings will be based on materials made entirely from waste; cities producing their own energy from non-conventional resources; minimizing consumption of water based on using principles of multiple use, reduce, recycling and reuse. Concept of multiple use of goods and services will become the underlying principle of human living duly supported by the principle of minimalism and co-operative living. Leveraging technologies for converting waste

Fig. 6: Objectives of Sustainability of Green Transportation



into wealth will make cities more livable, productive, and sustainable affordable, economical with improved air and environmental quality. Cities will ultimately head towards becoming zero-energy, zero-water, zero-waste, zero-car and zero-carbon cities, on the analogy and pattern followed in the planning and development of Musdar city in Abu Dhabi.

6. PLANNING SUSTAINABLE MOBILITY

Transportation scenario in India is highly complex and is marked by large number of dualities and contradictions. Despite low holding capacity of road network, numbers of both mechanized and non-mechanized vehicles are increasing rapidly. Despite lack of parking areas, more and more vehicles are being added into the cities occupying every available road space including all possible open spaces. In the process, cities are marked with high degree of vehicular congestion leading to long delays and raising the cost of business; extremely low vehicular speed; high degree of air pollution threatening the life or health of the people; large number of road accidents leading to loss of precious life and property and emission of large volume of greenhouse gasses and global warming. Instead of providing high degree of mobility and operational efficiency, urban transportation has emerged as the major roadblock and threat to the economy, environment and sustainability of majority of cities. With millions of precious man-hours lost in everyday travel, transportation is adversely impacting the productivity of human beings. In the process, travel and traffic blues are fast emerging as major threat to the effective and efficient functioning of the urban centers Making cities zero-carbon appears to be a fallacy and a mirage without putting in place on priority different options of sustainable - transport because cities are, primarily and essentially, known to contribute 75 per cent of global greenhouse gas emissions, with majority of contribution coming from transport sector and buildings. With traditional fuels, transportation sector alone contributes 45 per cent of total carbon emissions. Challenges posed by transportation sector accordingly remain both daunting and formidable in creating sustainable and low-carbon cities. To overcome these challenges one of the best options would be to promote sustainable and green urban transport in order to make cities cleaner, greener and smarter. Promoting sustainable urban transport would accordingly form integral and essential part of any strategy to promote carbon - neutral cities. Zero-carbon cities would focus on minimizing travel and have different order of priority for transportation led by pedestrianization, cycling and public transport with least priority going to personal transport. Low-Carbon cities will be planned with basic philosophy of achieving twin objectives of planning and prioritizing people and not vehicles and promoting accessibility and not mobility. Accordingly, urban planning taken on this philosophy would essentially call for minimizing use of personalized vehicles; promoting non-mechanized or non-fuel-based options for travel; using public transport with large capacity, run essentials on non-polluting fuels or electricity; using state of art technologies, making vehicles zero-emission; limiting the need

of mechanized travel; using land use planning to rationalize the travel pattern, etc. It would also involve use of information technology to reduce travel by using homes as offices, schools, libraries, etc.

Increased use of environment friendly public transport systems and halting of urban sprawl in cities can substantially reduce emissions at city level and make cities cleaner, greener, smarter and sustainable. Study made by Central Road Research Institute (CRRI), has revealed that Delhi Metro, having daily ridership of 27 lakh, has helped in replacing 3.9 lakh vehicles off the Delhi roads in 2014 besides saving Rs. 10,364 crore in terms of fuel, pollution and passenger's time. In absolute terms, the annual reduction in fuel consumption has been recorded at 2,76,000 tones, as against the corresponding figures of the year 2011, besides bringing down the travel time of commuters by 32 minutes. In addition, promoting operational efficiency and making Delhi cleaner and green, study furthers states that metro has made the city safer by reducing the number of fatal accidents.

No energy efficient and low-carbon city should be without a bicycle plan. The bicycle is the most economical and most energy efficient form of human transportation ever invented. Cycling as a mode of transportation has played an important role even in societies with high income. Cycling accounts for 20 % of passenger trips in Basel, 25 % in Tokyo; 50 % in Groningen, Netherlands and up to 77 % in Chinese cities of Tianjik and Shenyang. India on its part has also taken a pro-active initiative to make urban areas low carbon by promoting use of bicycle as a preferred mode of urban transport by creating dedicated cycle-tracks and cycle-sharing under AMRUT.

However, creating sustainable and low-carbon urban transport would require a multi-pronged strategy based on leveraging the advantages of all modes of travel, involving communities and stakeholders besides involving professionals engaged in urban / transport planning, development and management. Our priority and capacity to create sustainable urban transport, through state of art cleaner and greener technologies; state of art vehicles run on hydrogen fuel and electricity, with innovative city planning, development and management, would hold the key to the productivity, economy, quality of life, sustainability and operational efficiency of human settlement besides making them supportive of the UNO mandated SDGs.

7. CONCLUSIONS

Adopting and achieving the Sustainable Development Goal - 11, mandated by UNO, should remain the guiding principle and agenda for the growth, development and management and policy framework dictating the policies and program of cities and towns to make them safe, resilient, inclusive and sustainable besides better places to live and work. UN-Habitat's new report 'Cities and Pandemics: Towards a more just, green and healthy future' showcases, how cities can reduce the

impact of future pandemics and become more equitable, healthy and environment friendly. UNO has also stated that, for making cities safe against disasters, new normal for urban planners and managers would be to make cities places where health, housing and security are prioritized and a new urban order needs to be built to reduce disaster risk and address climate change by developing nature-based solutions by investing in sustainable infrastructure to create low carbon options.

In order to effectively deal with disasters and global warming at the local level, cities need to prepare detailed zero carbon and carbon neutral plans involving local communities and stakeholders. Appropriate climate responsive / mitigation strategies need to be created and made operational in all human settlements. Improving cities and making them more sustainable should involve - building resilient societies; making investment in public transport; improving road safety providing universal access to safe, inclusive and accessible, green and public spaces and making urban planning inclusive and sustainable by significantly transforming the way we plan, build and manage our urban spaces.

However, each city and urban settlement remain unique and distinct, socially, structurally, physically and economically, and accordingly needs to develop, adapt and implement its own operational plans to effectively counter the environment and other natural disasters and making cities zero carbon and zero waste.

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Analyzing Issues Pertaining to Cantonment Areas in Indian Context

S. G. Sonar, Ph.D. and A. S. Petkar, Ph.D.

Abstract

Historically, Cantonment areas though primarily meant for army personnel, attracted the Civil Population to reside in Cantonment Areas and economic spin-offs attracted other activities. The Cantonments as Local Self-Government organizations have always remained a puzzle. The civilian population wants to be in it; however, is uncertain about their status and their future. In this research paper, various literatures pertaining to Cantonment Areas in Indian context including historical perspective, statutory provisions, organization structure, development and planning issues have been analyzed to enlist important issues associated them. Also, information pertaining to socio-economic and spatial parameters pertaining to Khadkee, Kamptee and Deolali Cantonment Areas have been analyzed to enlist important issues associated with them. It is observed that analysis of issues pertaining to Cantonment Areas in Indian context based on literature reviews and study of selected Cantonment Areas gives different perspectives.

1. INTRODUCTION

Cantonment Area is a place or places along with boundaries in which any part of the Armed Forces is quartered in a region amidst civil population. Historically, Cantonment Areas were places, where the army of Colonial Government had to be exclusively quartered in an effort to keep the armed forces totally insulated from the ruled. Cantonment Areas meant quarters assigned for lodging troops, a permanent military station created by the Colonial Government in India for the location of military formation away from the civilian towns. The military stations, though primarily meant for army personnel, attracted the civilian population to reside in Cantonment Areas and economic spin-offs attracted other activities. The civilian population included categories, like, grocer, milk seller, vegetable and fruit vendor, cook, helper, sweeper, ayah, butcher, etc. This population is support systems, such as, for commercial activities, manpower support as formal or informal and to fulfill some of the institutional requirements. Within the Cantonment Areas, military based development and civilian based development took place simultaneously. All these developments were segregated in separate areas. The Bazaar Area was recognized and the anatomy of the Cantonment Area got clearly defined with Military Area, the Bungalow Area and Civil Area. Creation of Civil Area brought some problems in its wake, like, unhygienic and insanitary conditions leading to diseases like diarrhea, malaria, cholera and even venereal diseases. A need was therefore, felt to regulate the social life as well as to set

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some Municipal Standards to regulate construction of roads, drains, latrines, residential buildings and quality of items of consumption. No deviation in land use was allowed except with the approval of the government even in those times when land was not scarce. The Central Government is further responsible to release grant-in-aid or special grant-in-aid to deficit Cantonment Boards so as to enable them to meet the establishment cost as well as take up maintenance or original works. The structure of Cantonment Boards is being maintained keeping in view the fact that Cantonment Areas were and are primarily meant to accommodate the military population and their installations. The Cantonments as Local Self-Government organizations have always remained a puzzle. The civilian population wants to be in it; however, is uncertain about their status and their future.

2. STATUTORY PROVISION

In 1924, the Cantonments Act was enacted to introduce Local Self-Government in Cantonment Areas which contained substantial civil population. Local Self Governance in the Cantonment Area is multifaceted and is different in approach and style as normally understood in the context of municipalities. Maintenance of health, welfare and security of the troops underlies the administration in the Cantonment Area and to keep this requirement uppermost, the Military administration as well as the Municipal Administration in the Cantonment Area has been unified in the appointment of the Station Commander. The Cantonment Area is divided into Civil Area and Bungalow Area (Outside Civil Area) for the purposes of assigned roles and functions. Cantonment Board, though largely concerned with the Civil Area, is responsible for providing civic amenities of general nature to the civilian residents in the entire Cantonment Area. Though, the demarcation is done for respective roles of Cantonment Board and Military Station, there are certain common areas which affect all the residents like roads, common drains, street lighting, parks, gardens, markets, etc. The act was the first Model Municipal Act for Cantonment Areas, but in its implementation, decentralization and democratic norms were largely compromised because of the status of the residents who occupied the property only as licensees of the government. Recently in year 2006, the Cantonments Act, 1924 was replaced by the Cantonments Act, 2006 with a view to introduce greater decentralization and improve the financial base of Cantonment Boards to make provisions for developmental activities and management of Defence land and audit. As per the Cantonments Act, 2006, the Cantonment Areas are categorized into four types based on the population residing within the Cantonment limit. Cantonment Areas having population more than 50,000 categorized as Type - 'I', Cantonment Areas having population 10,000 – 50,000 categorized as Type - 'II', Cantonment Areas having population 2,500 – 5,000 categorized as type - 'III' and Cantonment Areas having population up-to 2,500 categorized as Type – 'IV' respectively. According to the Cantonments Act, 2006, land in Cantonment Area is classified under the following major categories for the purpose of development:

- **Class A**
  - A-1: The land under the active occupation of Army; and
  - A-2: The land reserved for future expansion of the Cantonment.
- **Class B**
  - B-1: The land belonging to Central Government;
  - B-2: The land belonging / under the possession of various State Governments;
  - B-3: The land leased out to Private Individuals / Other Organization / Government Undertaking; and
  - B-4: Vacant land.
- **Class C**
  - C: Cantonment Board land for its use under the Cantonment Property Rules 1945.

3. ORGANIZATIONAL STRUCTURE

The overall Municipal Administration of the notified Cantonment Areas is the function of the Cantonment Boards which are Statutory Bodies comprising democratically elected representatives of the residents of the Cantonment Area as well as official members on equal basis. Cantonment Boards are Statutory Bodies - a body corporate having perpetual succession and a common seal with power to acquire and hold property. Their main functions are, more or less, the same as those of Urban Local Bodies. Legislated composition of the Cantonment Board under the act has two components as Local Self-Government Institution. One part consists of ex-officio and nominated members including the State Government nominees. The Station Commander is the ex-officio President of Cantonment Board. The Senior Executive Medical / Health Officer and the Garrison / Executive Engineer are the ex-officio members of the Board. The nominated members consist of three Military Officers and a Magistrate of First Class nominated by the District Magistrate. The Cantonment Areas are not formations of the army but are Local Self-Government Institutions under the accountability of the Government of India. The General Officer Commanding-in-Chief (GOC-in-C) Command and the President of the Cantonment Board continue to be in enigma in the administrative set up of Cantonment Administration. Functioning of Local Self-Government in Cantonment Areas is discharged through appointment of the Chief Executive Officer (CEO) at the Board level. The other part consists of purely elected representatives from the various wards of the Cantonment Area. The elected members elect one amongst them as the Vice-President of the Board. The term of the board members is five years. The elected component is supposed to be the voice of the people in

the Local Self-Government Institution. The nominated members are supposed to look after the army interest. The District Magistrate representative looks after the law and order component and the interest of the State Government in this area.

4. ASSOCIATED ISSUES IN CANTONMENT AREAS

Various literature pertaining to Cantonment Areas in Indian context including historical perspective, statutory provisions, organization structure, development and planning issues have been studied to enlist important issues associated with Cantonment Areas and their developments as mentioned below:

- Cantonment Areas are always considered as high-security areas. The Cantonment Area is like a Union Territory, a political sub-division and agency of the Central Government and exercises the state function;
- The administration of Cantonment Areas is a union subject, placed in List - I of VII Schedule of the Constitution. The Municipal administration of Cantonment Areas is regulated under the provisions of the Cantonments Act, 2006;
- Most of the Cantonment Areas are situated in the territorial jurisdiction of respective State Governments cannot also be overlooked. The aspiration of the people of Cantonment Areas will be at par with the aspirations of the people of the State in which the Cantonment Areas are situated;
- The Cantonment Land Administration Rules, 1937 permitted lease option for civilian population, who initially settled within the limit of Cantonment Area for the purpose of residential and commercial activity. Illegal occupancy on Defence land due to uncertain General Land Records (GLR) is one of the major issues in Cantonment Areas;
- According to Cantonments Act, 2006; the Cantonment performs most of the mandatory functions of the Urban Local Body as per the 74th Constitution Amendment Act. It has provision for Town Planning Scheme (TPS), but there is no provision for a Comprehensive Master Plan;
- Cantonment Areas are further lacking in consolidated and appropriate Planning Norms to guide the development of civilian areas and private lands in Cantonment Areas;
- Haphazard development in the surrounding areas of Cantonments due to lack of Master Plan / Development Plan, and lack of land use specifications, resulting into unplanned formal and informal commercial establishments;
- Cantonment Areas which were originally located at a distance from the city are now within its limits or on its fringe which creates planning problems related to security and planned urban development of the city;

- Another important planning issue in Cantonment Area is urban sprawl / out growths;
- Cantonment Areas are lacking in integration with their adjoining city as a whole due to paucity of funds and non-implementation of central and state sponsored schemes in the Cantonment Areas;
- In most cases, Cantonment Areas draw services from the adjoining city especially water and power, this creates a dependence on City Municipality which needs to be planned carefully and with higher standards than that set for the city;
- Management of high waste generation in the surroundings of Cantonment Areas due to uncontrolled and undeveloped open spaces is one of the major challenges for them;
- Within the Cantonment Areas, military based development and civilian based development takes place simultaneously. However, the management of this development faces the similar issues as those by the Urban Local Bodies, and Development Authorities;
- Cantonment Areas are lacking of sufficient funding due to dependency on the central and state government policies and permitted or abolished finance revenues;
- In case of Cantonment Areas, only those Cantonment Areas which are running in deficit, receive grants from Ministry of Defence;
- Residents of Cantonment Areas cannot access development funds because the Ministry of Defence and the army are in the non-plan sector;
- The state governments do not share their resources with Cantonment Boards even though these are allocated based on population;
- Resources of the Cantonment Boards are limited, as the bulk of the property in the Cantonment Area is government-owned on which no tax can be levied;
- The nature of Cantonment Areas is such that there is only limited trade and business activity and practically no industry. Thus, Cantonment Boards are devoid of the resources that are normally available to any municipality of comparable size;
- Because of the restrictive nature of the land policy regarding the re-development of old properties there has been very little building activity in Cantonment Areas. This has, further, reduced the possible income from property taxes, which, normally, constitutes the major source of income for local bodies; and
- Cantonment Areas are spread over large areas and costs of providing civic amenities in them are, therefore, significantly more than in the Municipal Areas.

5. BACKGROUND OF SELECTED CANTONMENT AREAS

There are total 62 Notified Cantonment Areas in India occupying an area of 63,536 ha. (635.36 sq km). These Cantonment Areas have been mainly clubbed into five Command Areas on the basis of their geographical location in India. These Command Areas include Central Command (25 Cantonment Areas), Eastern Command (04 Cantonment Areas), Northern Command (01 Cantonment Area), Western Command (13 Cantonment Areas) and Southern Command (19 Cantonment Areas). Out of 19 Cantonment Areas in Southern Command, seven are in the Maharashtra State. Khadkee, Kamptee and Deolali Cantonments from Maharashtra State have been selected and studied in details to understand their Socio-economic and spatial aspects of development. Brief information about these selected Cantonment Areas is presented in following paras.

5.1 Khadkee Cantonment

Khadkee Cantonment is one of the oldest Cantonment Areas in India established in 1817 by British East India Company after the battle fought between the Marathas and the British at Khadkee. It is situated far away from the Pune (Poona) city at that time, but now after independence in present scenario, it acts as an important part of Pune city. Presently, Khadkee Cantonment Area (KCA) is forming part of Pune Municipal Corporation (PMC) along-with Pune Cantonment Area (PCA). As per the 2011 Census, population of Khadkee Cantonment Area is 70,399 and falls under Category – I. Pune City and its adjoining areas are known for its diversified economic base at the national level and international level. Pune is the eighth largest city in India. It has the sixth largest metropolitan economy and the second highest per capita income in India, with the least income disparity between the rich and poor. Khadkee Cantonment Area being part of Pune Municipal Corporation and bordering with Pimpri-Chinchwad Municipal Corporation experiencing effects of ongoing economic development. It is also an army base having two ordinance factories and its borders are flanked by two other large army establishments – the College of Military Engineering and the Bombay Engineering Group. The nature of Cantonment Area is such that there is only limited trade and business activity and practically no private industry.

5.2 Kamptee Cantonment

Kamptee Cantonment was founded in 1821, when the British established a Military Cantonment on the banks of the Kanhan river. The town quickly became an important center for trade, but trade dwindled with the arrival of the railway in the late 19th Century to Nagpur City. Kamptee Cantonment Area (KCA) is bordering with Nagpur city and forming part of Kamptee Urban Agglomeration (KUA). Kamptee Cantonment Area is well connected with Nagpur city and

Kamptee town through National Highway - 7. Located at the center of the country, Nagpur city is the natural logistics hub for the Indian Sub-continent for movement of domestic and international cargo. It is the converging point of the nations' railway and road network linking a vast hinterland. Nagpur city is an emerging metropolis of India and the fastest growing Millionaire city also. Nagpur city has been the main center of commerce in the Vidarbha Region since early days and is an important trading location. The Butibori Industrial Estate is the largest in all of Asia in terms of area. The Hingna Industrial Estate located on the Western fringes of the city is made up of around 900 small and medium industrial units. Multi-modal International Cargo Hub and Airport at Nagpur (MIHAN) is a State Government initiative to support the economic development in and around Nagpur Region.

5.3 Deolali Cantonment

Deolali Cantonment is one of the oldest Cantonment Areas in India established in 1869. In 1941 during the World War-II, with the move of School of Artillery from Kabul to Deolali, it mainly became the Training Centre predominantly for the Regiment of Artillery. Deolali Cantonment Area (DCA) is forming part of Nashik Urban Agglomeration. As per the 2011 Census, population of Deolali Cantonment Area is 54,027 and falls under Category – I. Nashik City and its adjoining areas are known for its diversified economic base at the national level. Nashik is the 24th largest city in India and fourth largest city in the State of Maharashtra. The economy of Nashik city is one of the fastest growing in Maharashtra State. Nashik is the third most industrialized city in Maharashtra State after Mumbai and Pune. Nashik has a reputation of the holiest pilgrimage in the Maharashtra State. Maharashtra Industrial Development Corporation (MIDC) has developed major Industrial Zones at Ambad, Satpur, Gonde, Igatpuri and Sinnar which are in and around of Nashik city. The city's economy is driven mainly by the engineering, manufacturing and pharmaceutical industry as well as the progressive agriculture in area surrounding the city. Away from the city area, a popular place for street shopping is the Levitt's Market in Deolali Cantonment Area. It is one of the major shopping areas for the residents from adjoining areas.

6. ANALYSIS OF SELECTED CANTONMENT AREAS

Information pertaining to socio-economic and spatial parameters have been collected from various literatures and analyzed in the context of selected Cantonment Areas. Social Parameters, such as, population, population density, civil population, slum population, sex ratio and literacy rate pertaining to these Cantonment Areas are complied and presented in Table - 1. Census data for last five decades for these Cantonments along-with Maharashtra State has been compiled and population decadal growth trends have been computed and presented in Table - 2. Land use classification in these Cantonment Areas as per

Cantonments Act, 2006 has been presented in Table - 3. Actual receipts and expenditures for five consecutive financial years in Rs. in selected Cantonment Areas have been compiled and presented in Table - 4. Analyses of this information

Table 1: Social Parameters of Selected Cantonment Areas

Sl. No.	Parameters	Khadkee Cantonment	Kamptee Cantonment	Deolali Cantonment
1	Population (2011 Census)	70,399	12,457	54,027
2	Area in sq km	13.25	15.11	54.38
3	Density per sq km	5,313	8,24	994
4	Civil population	58,431	5,845	42,239
5	Slum population	9,896	NA	12,309
6	Sex ratio	806	550	911
7	Literacy rate in %	92.56	94.47	90.05

Source: Census of India, 2011

Table 2: Population Decadal Growth Trends in Selected Cantonment Areas

Sl. No.	Census Year	Maharashtra State		Khadkee Cantonment		Kamptee Cantonment		Deolali Cantonment	
		Number	% Growth	Number	% Growth	Number	% Growth	Number	% Growth
1	1971	50.40	27.27	0.065	--	0.010	89.76	0.030	-
2	1981	62.80	24.60	0.080	23.07	0.015	38.92	0.057	88.59
3	1991	78.90	25.64	0.078	- 2.50	0.012	-19.72	0.044	- 23.22
4	2001	96.80	22.57	0.077	- 1.28	0.013	7.28	0.050	14.18
5	2011	112.37	16.08	0.070	- 9.09	0.012	-5.08	0.054	6.73

Source: Census of India, 1971 to 2011 (Population in millions)

Table 3: Land Use Classification in Selected Cantonment Areas

Sl. No.	Land Type	Khadkee Cantonment		Kamptee Cantonment		Deolali Cantonment	
		Area (Ha.)	Area %	Area (Ha.)	Area %	Area (Ha.)	Area %
1	A-1	1098.56	84.28%	654.39	43.30	2,515.32	46.25
2	A-2	21.33	1.64%	0.09	0.01	71.02	1.31
3	B-1	20.58	1.58%	36.31	2.40	78.27	1.44
4	B-2	58.95	4.52%	288.09	19.10	130.13	2.39
5	B-3	60.50	4.64%	153.39	10.15	17.16	0.32
6	B-4	19.97	1.53%	313.09	20.73	13.65	0.25
7	C	18.86	1.45%	47.88	3.16	52.06	0.96
8	Civil Area	4.65	0.36%	17.12	1.13	28.57	0.53
9	Private Land			0.59	0.04	2,532.52	46.56
	Total Area	1303.42	100 %	1,510.95	100 %	5,438.7	100 %

Source: Science and Technology Park, India (STPI), 2015 and respective Cantonments

Table 4: Actual Receipt and Expenditure (in Rs.) for Five Financial Years

Sl. No.	Financial Year	Khadkee Cantonment		Kamptee Cantonment		Deolali Cantonment	
		Receipts	Expenditure	Receipts	Expenditure	Receipts	Expenditure
1	2011-12	874.26	843.84	132.52	73.77	235.17	211.76
2	2012-13	832.55	786.42	159.44	74.30	227.13	98.58
3	2013-14	811.44	730.10	209.37	89.80	478.25	349.69
4	2014-15	818.63	770.74	215.52	88.34	678.51	665.94
5	2015-16	1,329.74	1,254.81	237.83	97.68	838.02	682.04

Source: Respective Cantonment's Website (Rs. in million)

have been carried out, and observations based on the same have been presented below:

- Spatial perspective has played significant role in the development of selected Cantonment Areas. This is clearly reflected in Population size, and population density of selected Cantonments Areas;
- However, there is no significant impact of spatial perspective on literacy rate and sex ratio in selected Cantonment Areas;
- Effect of urbanization and stress on existing land has reflected in the formation of slums in these selected Cantonment Areas;
- Restriction on height of buildings, non-availability of intensive FSI and land owner-ship issues have acted as major hurdles in redevelopment of civil area and improvement of slum areas in these Cantonment Areas;
- Population growth trends in these Cantonment Areas are fluctuating; whereas, same is following increasing trends at state level;
- Civil population is having about two-third share in population of selected Cantonment Areas and same is showing decreasing growth trends due to lack of development opportunities and employment opportunities in them;
- Restricted trade and commerce activities and absence of private industries have resulted into lack of employment opportunities into these Cantonment Areas;
- Selected Cantonment Areas are having issues with their adjoining Urban Local Bodies particularly in terms of transportation network and public transport system due to difference in their priorities;
- Selected Cantonment Areas are having poor quality of telecommunication services due to non-permissibility of communication towers due to security reasons and land ownership issues in selected Cantonment Areas;
- Smaller population size of these Cantonment Areas many times acting as deterrent in availing funds allocation under various central government schemes, as it is mainly governed by population size;

- Selected Cantonment Areas have not availed any financial assistance through loan, mortgage, share, bond, etc., and at the same time could not receive any grants from central government being budget surplus;
- Selected Cantonment Areas having privately owned land are facing problems due to absence of policy regarding their utilization or development;
- Commercial Vehicle Entry Tax forming as one of the major source of income to these selected Cantonment Areas;
- Expenditure on establishments under various heads is more than 50 per cent which is not desirable one in selected Cantonment Areas;
- Higher expenditure on establishments has resulted into non-availability of sufficient fund allocation for new development; and
- Increasing expenditure on pension, gratuities and amenities is the matter of concern in the selected Cantonment Areas.

7. CONCLUSIONS

Analysis of issues pertaining to Cantonment Areas in Indian context based on literature reviews and study of selected Cantonment Areas gives different perspectives. Issues observed based on literature reviews are general in nature and lacking in terms of its reasoning. These issues are mainly pertaining to historical perspective, statutory provisions, organization structure, and development aspects. Issues observed based on detailed analysis of socio-economic and spatial aspects in selected Cantonment Areas, gives understanding about their specific issues and reasoning behind the same. These issues give understanding about problems and prospects pertaining to them. Understanding of problems and prospects are helpful to frame policies and proposals for development in these Cantonment Areas. It further underlines development potential of privately owned lands in these Cantonment Areas. Analyses of these issues are helpful to understand importance of spatial perspective and connectivity in regional context for development. It further emphasizes integration with various authorities in the regional context for the optimum utilization of resources and minimizing financial burden. It's understanding is also useful to restructure various means of receipts and expenditures to improve financial condition of these Cantonment Areas.

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Re-Imagining Tourism Potentials of Shimla: Tourists' Perceptions

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Abstract

Tourism is a significant global industry contributing over 10 per cent to the world GDP. India has numerous places of tourist interest, Shimla in Himachal Pradesh being one of the prominent place of tourists' interest. By examining perceptions of tourists, this paper however, shows that the current condition of tourism in Shimla is not very encouraging both for policy makers and tourists as growth rate of tourists to the city has come down. The paper underscores the reasons for the current condition of tourism in Shimla by highlighting inadequacies of tourist infrastructure and attempts to re-imagine tourism potentials for the city, and also proposes to augment tourism infrastructure to meet requirements of future Indian and global tourists.

1. INTRODUCTION

Tourism has gained exponential importance since the end of the Second World War. It is identified as an important activity and major industry across the globe. As per the Report of World Trade Tourism Council, in 2018 about 8.27 trillion US$ has been spent in the tourism sector across the World, which accounts for 10.4 per cent of global gross domestic product (GDP) in 2017. It is expected to increase to 12,450 billion US$ by 2028, which will be 11.7 per cent of GDP. In 2017, tourism sector created 0.19 billion direct and 0.12 billion indirect jobs (WTTC, 2018). Increased tourism tends to change the lifestyle of the natives of places visited by the tourists. The physical, environmental, socio-cultural and economic conditions undergo changes of vivid nature and directly or indirectly impact their livability conditions. Resultantly, many individuals, businessmen and government agencies concerned with tourism have only recently begun to pay serious attention to it's implications on quality of life of the local inhabitants.

Shimla, the capital city of Himachal Pradesh, is considered as the embodiment of tourism on earth. It is a major tourist destination in North of India inviting about 0.13 million foreign and 3.03 million domestic tourists in 2019. The tourists' visiting the city and its surroundings come with a perception about better tourists' infrastructure. However, an empirical study carried out for the tourists of Shimla reflects a gloomy picture. Therefore, the paper makes an attempt to

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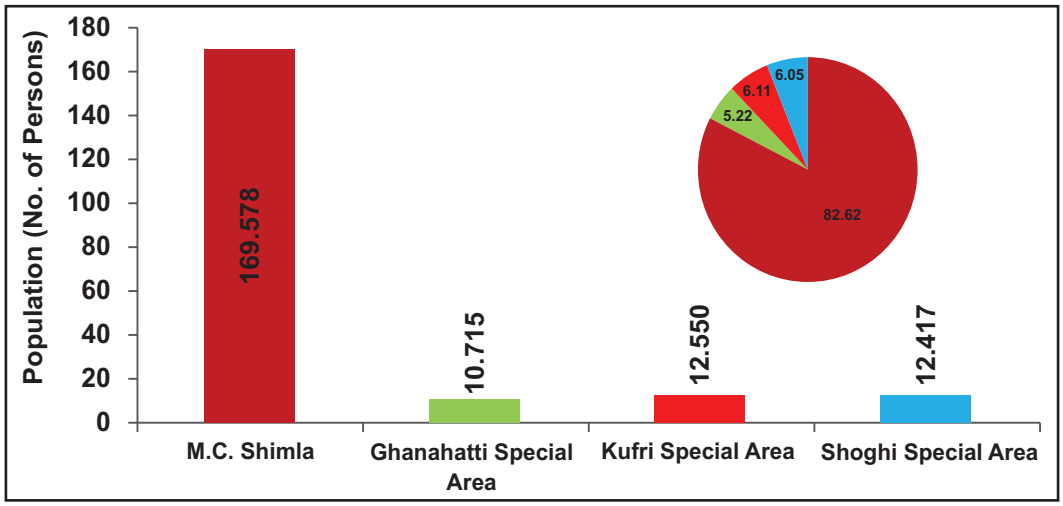
highlight the tourist infrastructure gaps and suggests the desired infrastructure to meet requirements of tourists.

2. SHIMLA – LOCATION, TERRAIN AND DEMOGRAPHY

Shimla is located at 310.61' North Latitude, and 770.10' East Longitude on the National Highway - 5 and is about 115 kilometers away from Chandigarh. It is connected by narrow gauge railway line from Kalka and by air from Delhi, Chandigarh and Kullu. It is surrounded by Mandi and Kullu districts in north, Kinnaur district and Uttarakhand state in the east, Sirmaur district in the south and Solan district in the west. It is situated in the range of the outer Himalaya and the lesser Himalaya with an average altitude of 2,206 metres above the mean sea level. The highest point in Shimla is Jakhoo hill, which is at a height of 2,453 metres (Shimla-Wikipedia, 2020). It is spread over seven spurs viz., Summer hill, Jakhoo hill, Bantony hill, Inverarm hill, Elysium hill, Observatory hill and Prospect hill. Shimla is characterized by rugged topography, steep slopes, deep valleys and elongated spurs.

Consequent to its high administrative, educational, trade status and high accessibility through road, rail and air, Shimla has experienced high strides in its population growth since 1971. As per Census of India 2011, Shimla agglomeration (Shimla Planning Area) inhabits 2,05,000 people, which account for 25.21 per cent of total population of Shimla district. Shimla Planning Area comprises of four urban local bodies namely - Municipal Corporation Shimla, Ghanahatti Special Area, Kufri Special Area and Shoghi Special Area. Municipal Corporation Shimla accommodates the highest number of people (82.62 per cent) within its jurisdiction (Figure - 1). Other special areas accommodate 5 to 6 per cent of the

Fig. 1: Population of Shimla Planning Area (2011)

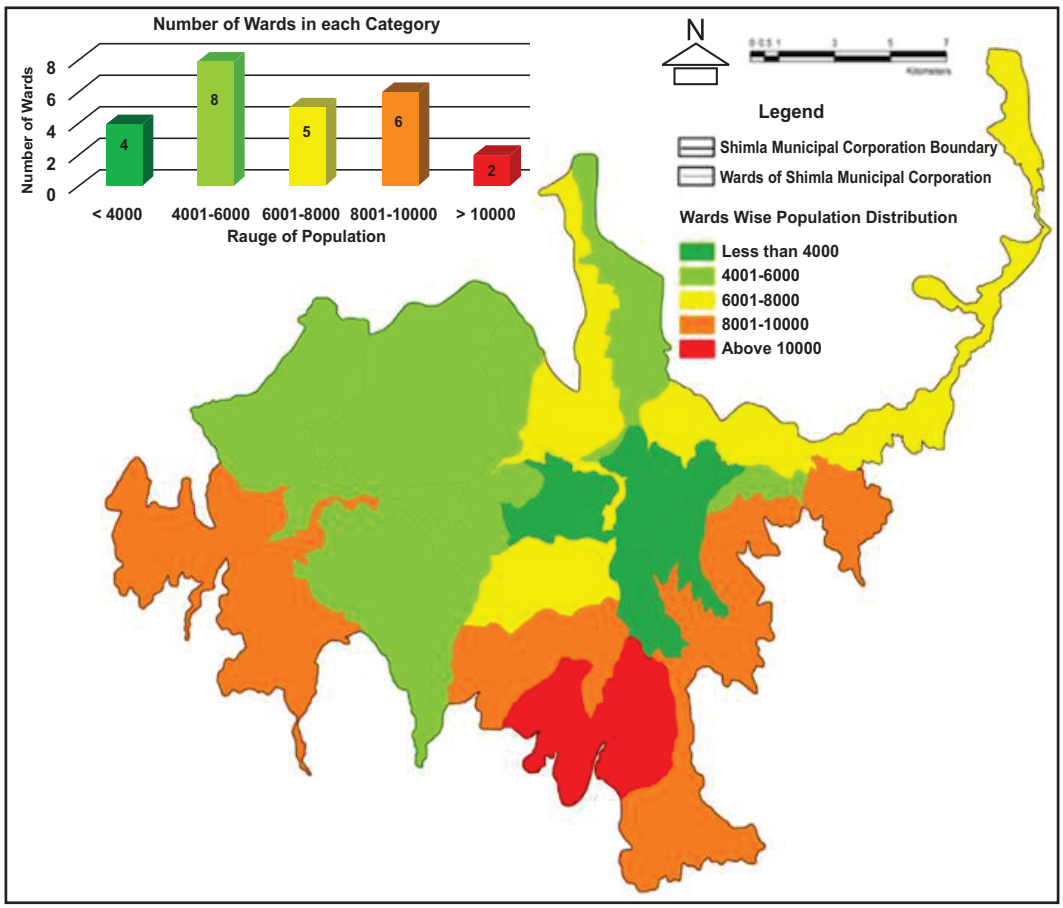


Source: Town Planning Department, Shimla

total population of Shimla Planning Area. The primary reason for polarization of population in Shimla city area has been the concentration of activities and infra-structure for tourists and the natives within its municipal limit. High migration of population into these areas can be attributed to high potential for employment and better infrastructure.

Distribution of population in the city reveals that about 50 per cent wards (12 in number) have population less than 6,000 persons (Figure - 2). These are the wards that fall in the heritage zone or have less of residential properties. They also reflect the impact of land use change in the central wards, which is on account of increased demand for land to fulfil infrastructural needs of tourists. About 32 per cent wards (8 in number) are high population wards. It is clear from Figure - 2 that these high population wards are on the outskirts of the city, indicating the impact of urban spillover for decades. Rising rate of growth of tourist inflow can be cited as a potential reason for the rising population in the Shimla Planning Area and within the city limits. Further, rising demand for tourism infrastructure in the central area can be cited as

Fig. 2: Distribution of Population of Shimla City



a reason for urban spillover effects towards the outskirts and peripheries of Shimla. This fact will be better appreciated after examining the growth trends of tourist inflow.

3. TOURISM CHARACTERISTICS OF SHIMLA

Shimla is an important entry point to rest of the State. The tourists visit tourist destinations at Dharmshala, Kullu, Manali, Chamba, Kinnaur, Sangla Valley, Lahaul and Spiti and Sarahan. But Shimla is one of the most preferred tourist destinations amongst all in the State because of it's better connectivity and infrastructure available for the tourists. It is blessed with mesmerizing mountains, scenic beauty, fresh natural air, lush green orchards of apple and pine, the mighty forest land, water bodies, green valleys, and beautiful architectural buildings of traditional and British style.

3.1 Tourist Destinations

Different tourist destinations within city and outside city are shown in Figure - 3. These destinations are identified for their historical, cultural, social, architectural, natural, religious, wars and sports character. It is worth noting that the tourists visiting Shimla have the chance to visit about 26 tourist spots, though their visit to these spots is restricted to their choice, interest, taste and time. Few tourists keep Shimla as their transit city and visit the tourist destinations far off from the city.

Fig. 3: Location of Tourist Destinations in and around Shimla

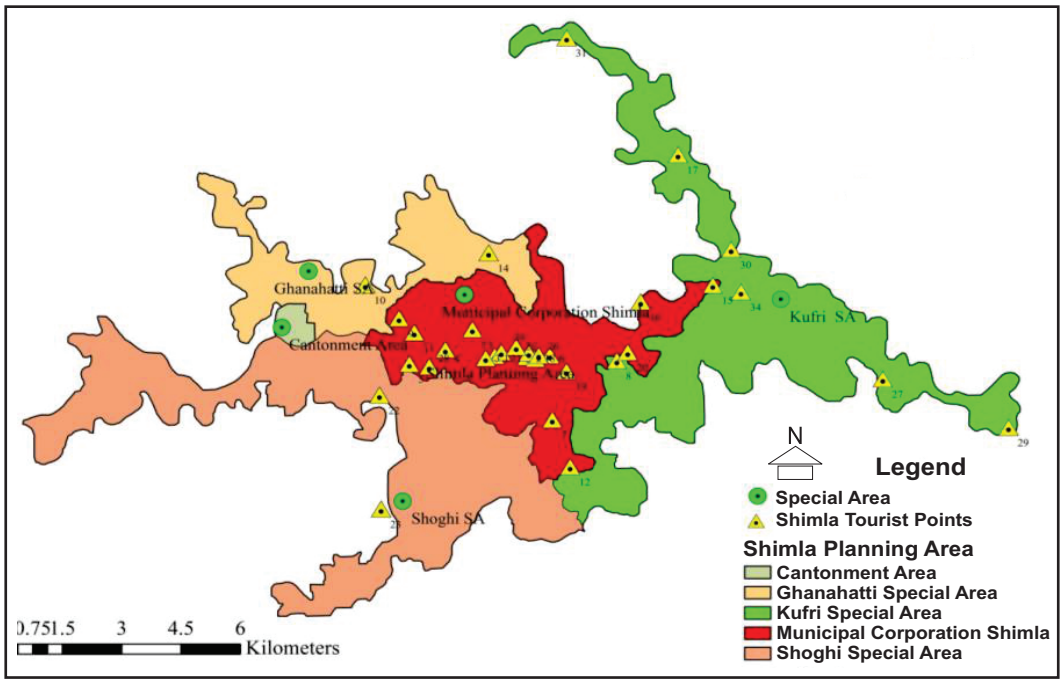
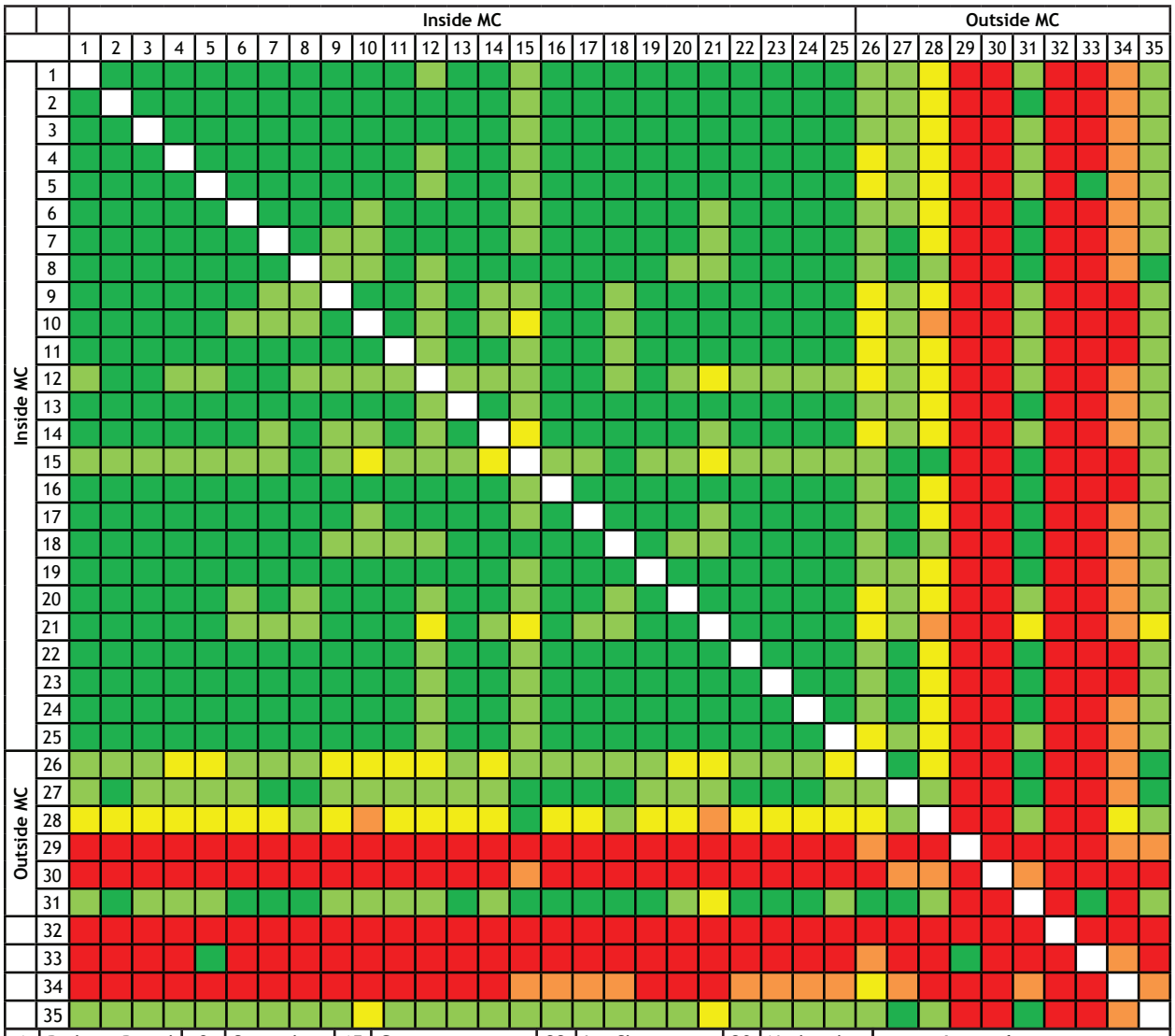


Table 1: Inter-Tourist Spot Distance Matrix (Kilometers)



1	Railway Board Building	8	Sanjauli	15	Craigneno	22	Ice Skating Rink	29	Narkanda
2	Gaiety Theatre	9	Summer Hill	16	Christ Church at the Ridge	23	The Mall	30	Tatta Pani
3	Gorton Castle	10	Potter Hill	17	Jakhoo Temple	24	Roller Skating Rink	31	Sippy fair of Mashobra
4	Glan	11	Thandi Road	18	Dhingu Temple	25	Himalayan Bird Park Kufri	32	Lavi Fair Rampur
5	Vice Regal Lodge (IIAS)	12	Kusumpti	19	Kali Bari Temple	26	Fagu	33	Hatoo Peak
6	Rothney Castle	13	Annandale	20	Kamna Devi	27	Mashobra	34	Kiar
7	Chotta Shimla	14	Shimla Heritage Walk	21	Tara Devi (5 Kilometre Track)	28	Naldehra	35	Kufri

Legend

< 10	Very Good
10-20	Good
21-30	Average
31-50	Bad
> 50	Very Bad

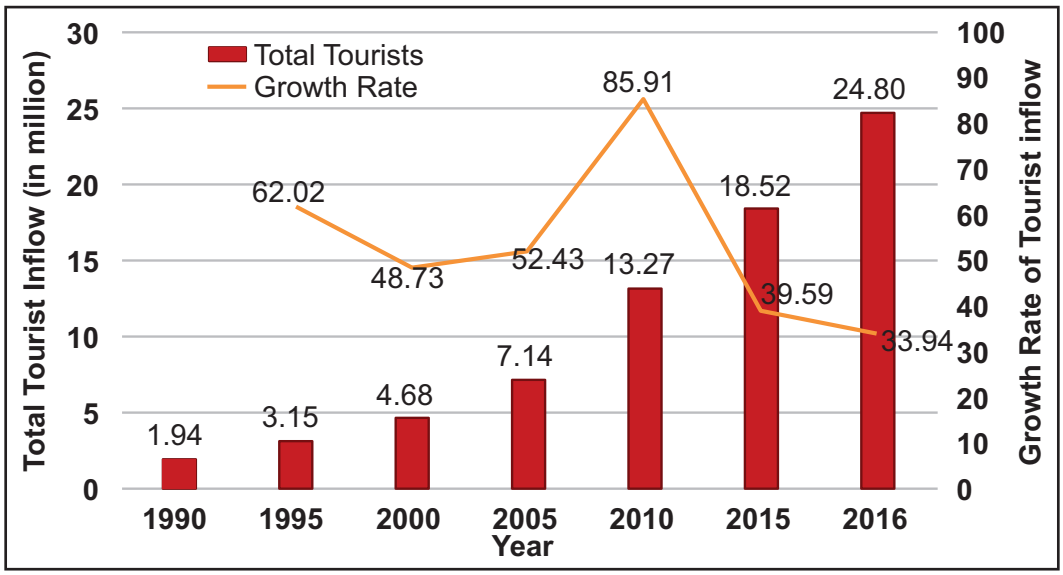
Accessibility to a tourist places plays an important role in the development of tourism. A study done at five point scale reflects very good (five points), good (four points), average (three points), bad (two points) and very bad (one point) accessibility dimensions of the tourist places (Table - 1).

As per the tourists' satisfaction survey, the tourist spots outside the municipal corporation limits of Shimla such as Narkanda, Tatta Pani, Sippy Fair of Mashobra, Lavi Fair Rampur (world famous), Hatoo Peak and Kiar are considered less accessible by the tourists. Tourist destinations within the municipal corporation limits are more accessible and hence visited more by the tourists. Bus frequency to these destinations is good compared to the destinations outside the municipal corporation limit. Mostly tourists hire taxis to reach these destinations. Based on the interviews with the officials of the Tourism Department of Himachal Pradesh and the tourists, it is observed that the tourists are interested in visiting 9 tourist spots beyond the Shimla city limits. They travel up to 20 kilometers to visit 5 such tourist spots and 4 spots are more than 30 kilometers away from Shimla. Thus, Shimla city has remained the central focus to tourists in the past decades. The tourist spots outside municipal corporation limit are less visited by the tourists for the reason that they are located at a relatively longer distance from Shimla city and have little infrastructure facilities. So, the tourists are more concerned with the tourist destinations within the municipal corporation limits.

4. TOURIST INFLOW IN SHIMLA

Shimla is one of the most attractive places for domestic and international tourists for its physical, climatic and heritage and historic features. Increasing volume of

Fig. 4: Tourist Inflow Trends in Shimla



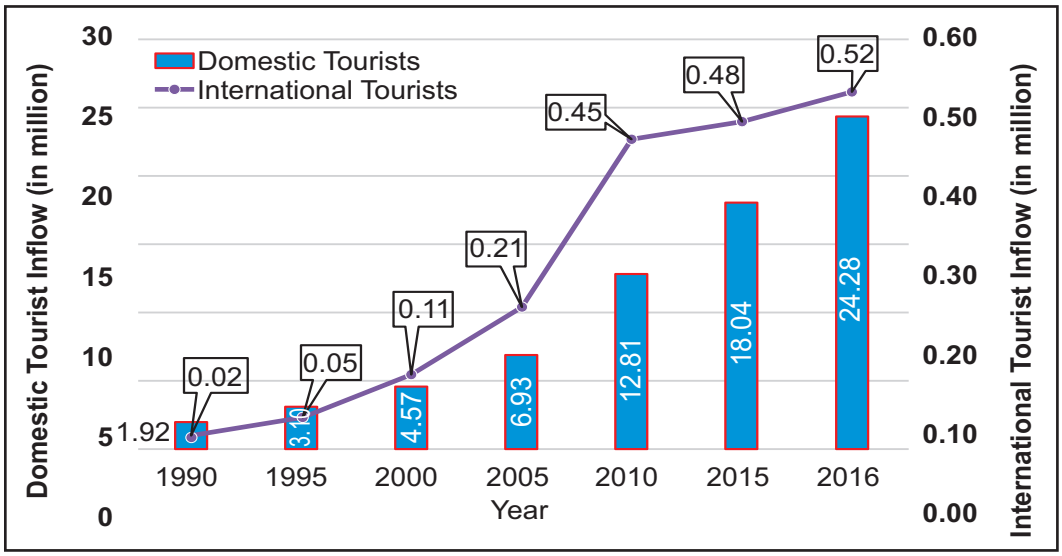
Source: Civil Aviation and Tourism Department, Shimla

tourist inflow can be seen as potential of the city and its region for migration in search of employment and income generation to better their livelihoods. Figure - 4 clearly shows that the total tourist inflow has increased by more than twelve times since 1990. Till the late 20th Century, tourist inflow was increasing steadily by about 1 million every five years. But since the beginning of 21 century, the city witnessed huge strides in the tourism industry. Shift of tourists from neighboring states is seen as a major reason for increased tourist inflow. It is clear from Table that in the initial fifteen years of 21st century, there has been fourfold increase in the tourist inflow. The number of tourists visiting Shimla has increased from 4.68 million in 2000 to 18.52 million in 2015. In 2016, 24.80 million tourists visited the city. Interesting to note is that whereas during 2005-2015 the tourist inflow increased by about 1.14 million annually, in 2015-2016 it has risen by 6.28 million. Government's initiatives to better tourism infrastructure, especially the widening of National Highway - 5, apart from improving the cleanliness at and around the tourist places, have been the major cause of rapid increase of tourist inflow. Although tourist inflow has been increasing very fast in Shimla, but examination of growth rate data (Figure - 5) reveals that the tourist inflow has been increasing at a decreasing rate since 1990. Whereas it was increasing at 62.02 per cent in 1990-1995, 52.43 per cent in 2000-2005, and increased to 85.91 per cent in 2005-2010, has seen a declining rate since 2010. A strong reason being cited for the decline is faster transport, which is cheap to reach international and domestic destinations by air and rail.

4.1 Composition of Tourist Inflow

For it's beautiful landscape and heritage Shimla has been a popular tourist destination for the international and domestic tourists for various reasons. It

Fig. 5: Tourist Inflow in Shimla



Source: Civil Aviation and Tourism Department, Shimla

is also clear from Figure - 5 that it is visited more by the domestic tourists compared to the international tourists. But it is interesting to note that whereas the footfall of domestic tourist has increased by twelve folds during 1990-2016. The number of domestic tourists visiting Shimla has increased from 1.92 million in 1990 to 4.57 million in 2000, which further increased to 12.81 in the next ten years i.e. 2000-2010. But in next six years i.e. 2010-2016 the inflow of domestic tourists has almost doubled and has touched 24.28 million mark. Such sharp rise in tourist inflow is surely a boost to the local economy of the city, which in turn is good enough to impact the quality of life of the natives.

Similar trends are visible for the rising footfall of international tourists. The number of international tourists has increased from 0.02 million in 1990 to 0.11 million in 2000. During 2000-2010 the foreign tourists increased very steeply and reached to 0.45 million in 2010 from 0.11 million in 2000. But since then, the increment has been very gentle, revealing other options coming up to the international tourists. The footfall of international tourists has risen by twenty six folds during 1990-2016.

Shimla is blessed with tourist inflow for the whole year. But March to June and September to November are the peak months for tourism industry for the city. About 8,000-10,000 international tourists visit the city every month. In the peak season domestic tourists come in large numbers and spend extra money for accommodation, food and other commodities, which gives boost to the local economy. But, increased tourism is responsible for increased demand for water, electricity, generating additional solid waste and sewage. Entry of more tourist vehicles is responsible for traffic jams and increased vehicular emissions. All this is affecting the quality of life of the local people.

4.2 Tourists' Characteristics

The tourists visit Shimla for adventure, recreational, sports, educational, administrative, medical, and business purposes. Correspondingly, their interests and infrastructure requirements also vary. Survey of sample tourists revealed the following characteristics of the tourists visiting Shimla:

- A majority of tourists (32.35 per cent) visiting Shimla belong to 36-40 years of age followed by 41-45 years of age (22.35 per cent). Another 17 per cent, 11 per cent and 7 per cent belong to 46-50, 31-35 and 26-30 years of age respectively. Thus, about 89 per cent of the tourists visiting the city are youth. These tourists visit the city largely for recreation and are concerned about their safety and security through eve-teasing and increasing cases of drug abuse. Thus, the socio-cultural life of the city is at stake.
- It is validated by the fact that 49 per cent of the tourists visit the city for leisure purposes. About 28 per cent and 16 per cent come here for adventure and

research work. These people are largely serious tourists who are concerned about their specific motives. Only 5 per cent visit the city for administrative reasons and remaining 2 per cent come for admission to higher educational institutions. Out of the total tourists visiting the city, about 79 per cent, 13 per cent and 8 per cent are working, involved in research work and are students respectively. Majority of the tourists (71 per cent) visit the city in groups while other come individually.

- About 41 per cent, 34 per cent and 19 per cent tourists stay in Shimla for three, two and four days respectively. This reveals that about 60 per cent of the tourists have longer halt at the tourist places leading to more demand for infrastructure of varying kind.
- About 71 per cent tourists have used cars or taxis and remaining rely on bus and rail transport to travel to Shimla. Foreign tourists prefer to use private taxis to reach Shimla. Dependence on private modes is also on account of certain routes rail or bus transport service being not good. Entry of high volume of private vehicles in Shimla tends to result in high congestion, traffic jams, parking problems, and noise and air pollution. Ultimately all these problems lead to deteriorating quality of life of Shimla in terms of physical infrastructure.
- As high as 41 per cent tourists prefer to stay in hotels. Only 7 per cent tourists prefer to stay in guest houses. But about 34 per cent tourists like to stay in tent houses. Trend of staying in tent houses is picking up in the surroundings and on forest lands of Shimla. Both domestic and foreign tourists prefer the same to enjoy the natural environment of hills of Shimla. But it is observed that these tourists are spreading garbage and filth in the forests and natural water channels, which is disturbing the ecological system of the natural resources.

5. TOURISM INFRASTRUCTURE – TOURISTS' PERCEPTIONS

Tourism development is closely associated with the nature and condition of infrastructure available to the tourists. Increased tourism also tends to develop social and physical infrastructure required by the tourists. The tourism infrastructure is divided into two categories viz., social and physical (Table - 2). Social infrastructure includes accommodation, financial services, health facilities and recreational spaces.

Survey of sample tourists reveal that the perception of tourism infrastructure differ hugely for international and domestic tourists. International tourists demand adventurous tourist destinations, good food, peace for yoga and meditation and comfort at any cost. They demand good connectivity, availability of taxis, tourist guides and tourist information centres so that they can explore more and more places. They highly appreciate interactions with native people and exchange of ideas.

Table 2: Tourism Infrastructure

Parameters	Indicators	Variables
Social Infrastructure	Accommodation	Hotels
		Home Stay
		Sarayen / Guest Houses
	Financial	Bank and ATM
	Health Facilities	Health (Hospitals, Dispensaries)
	Recreation Spaces	Parks, Play Grounds, Tourist information Centres
Physical Infrastructure	Connectivity	Roads Conditions
		Frequency of Public Buses
		Signage's
		Way Side Amenities
	Energy	Water Supply
		Power Supply
	Solid Waste Management	Generation of Solid Waste from Tourist Spot

Domestic tourists visit tourist spots in and around Shimla to admire the scenic beauty, the climate and to worship in religious places. They demand medium type of hotels (three stars or two stars), good food, high connectivity, frequent public transport, and most importantly parking spaces at every tourist's destination.

Physical infrastructure is the key to promote tourism in a region. As per the survey, the tourists identify accessibility, energy, and solid waste management as the key elements to promote tourism in the region. Accessibility includes better roads, high frequent bus service, signage to guide the tourists and way side amenities. Energy includes provision of uninterrupted power supply and communications at the tourist destinations. Solid waste management include generation of solid wastes from tourism places. One of the most critical challenges posed by the tourists has been spreading litter at the tourist spots, adding to total solid waste generation. In 1981, solid waste generation was 102 grams per person per day which increased to 262 grams per person per day in 1991. In 2011 solid waste generation rose to 316 grams per person per day, which has further increased to 350 grams per person per day in 2016. As per the records of Municipal Corporation Shimla 93 MT per day of solid waste is generated out of which 70-75 MT per day is collected by the Shimla Municipal Corporation, registering an efficiency level of 75-80 per cent. As per the projections of city Sanitation Plan Shimla (2011), solid waste generation is expected to increase to 124.91 MT per day by 2021.

Tourists have shown their concern over the organic growth, exotic development, and deficient infrastructure of the city. Survey of tourists reveals that 24 per cent tourists have shown their concern for concrete structures, traffic jams and over constructions in core area of the city (Table - 3). Another 23 per cent have

Table 3: Difficulties faced by Tourists

Sr. No.	Problems Statement	Tourists
Statement 1	Concrete structure, traffic jam and other problems and more (over) construction in core area.	48 (24.00)
Statement 2	Increasing built up area, cutting of trees, land degradation and pollution in the city.	46 (23.00)
Statement 3	Concrete structure, increasing built up area, more pollution, declining of heritage and traffic problems.	31 (15.00)
Statement 4	Heritage is declining, overcrowded, traffic congestion, eve teasing, alcohol (drunker problems).	28 (14.00)
Statement 5	Traffic jam, Crowd is every where.	22 (11.00)
Statement 6	Urban infrastructure in not up-to mark, public transport is hit by (jam and accidents) tourist's vehicles, lack of integration between various departments.	13 (6.50)
Statement 7	Traffic congestion, eve teasing, alcohol (drunker problems).	12 (6.00)

Source: Primary Survey
Note: Figures in parentheses are percentages from their total

registered their concern about increasing built up area and cutting of trees, land degradation and pollution is rapidly increasing in the city, which in no way present in the traditional pictures of Shimla to the tourists. About 15 per cent tourists have added that there is hardly any care for heritage of the city. Another 14 per cent have added that cases of eve teasing and drug consumption have increased, which is not a good reflection of socio-cultural life of Shimla as a tourist city.

Tourists have been interviewed to assess the deficiencies in the existing infrastructure in Shimla. Their opinions have been weighted and are categorized into five groups i.e. very good (5), good (4), average (3), bad (2) and very bad (1) (Table - 4). On the basis of responses from tourists, the infrastructure in Shimla has got average to very bad rating. Most of the infrastructure problems are found at regional level. Therefore, there is an urgent need to match the infrastructure requirements without compromising the quality of life indicators of the natives. Generation of solid wastes, bad roads, deficient bus transport service and inadequate health facilities are ranked as bad to very bad by the tourists.

5.1 Suggestions of Tourists

While suggesting for the provision of infrastructure, majority of the tourists (54 per cent) have suggested that administration should provide parking facilities outside the city limits and private vehicles must be banned in the city (Table - 5).

Table 4: Tourists' Perception about Tourism Infrastructure Gap

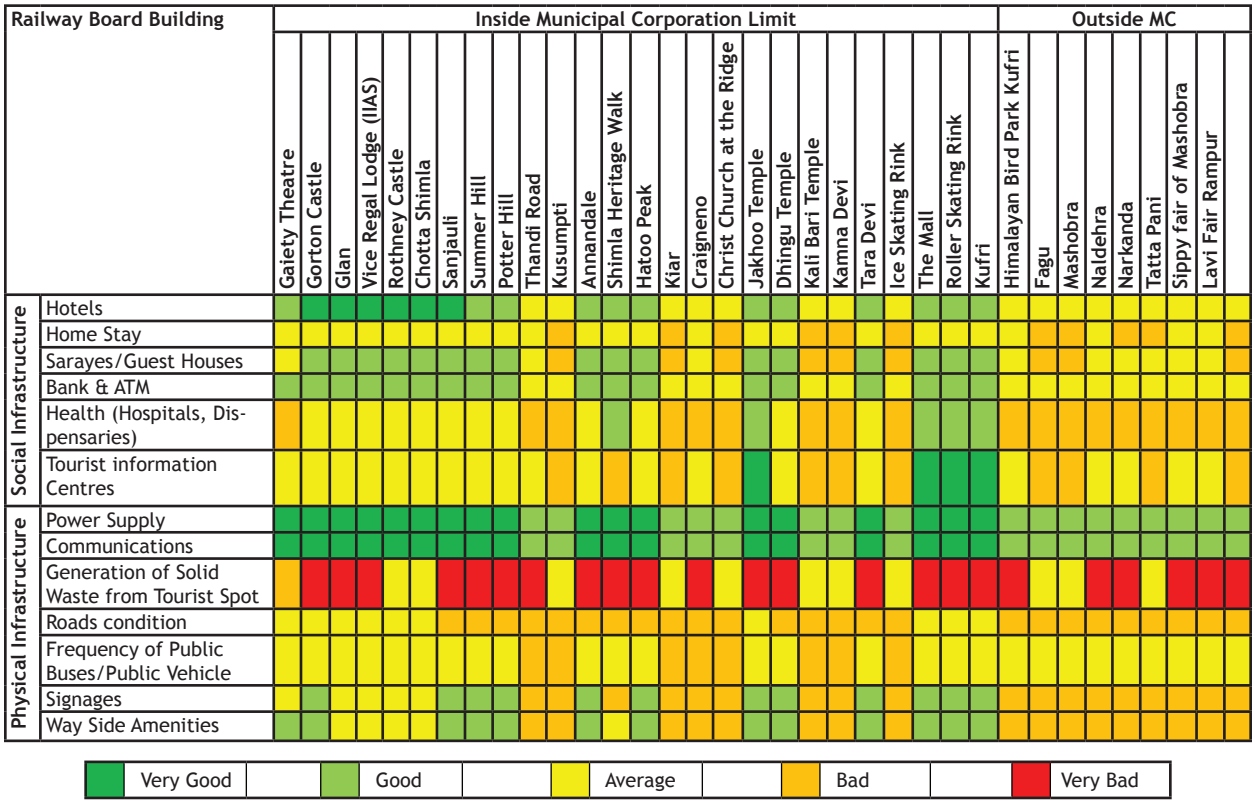


Table 5: Suggestions by the Tourists

Sr. No.	Suggestions / Comments of the Tourists	Tourists
1.	Character of the city was on foot that must be remain.	14 (7.00)
2.	No more concrete structure in the core area.	21 (10.50)
3.	No more concrete structure in the core area, hotel must be outside the core area.	28 (14.00)
4.	Parking facility outside the MC limit, small busses take tourist to hotel or tourist places and character of the city was on foot that must be remain.	58 (29.00)
5.	Personal vehicles must be banned in the city and parking of vehicle outside city limits.	50 (25.00)
6.	Truck terminal and wholesale market must be outside the city limits. No more construction of parking places.	29 (14.50)

Source: Primary Survey
Note: Figures in parentheses are percentages from their total

About 29 per cent tourists have suggested that small sized buses should be operated within the city to facilitate movement of tourists and reduce the pollution in Shimla. About 14.50 per cent tourists have advocated that in order to solve the problem of traffic congestion in the city, truck terminal and wholesale market

should be shifted outside the city limits so that no heavy vehicle enters the city. Certain tourists suggested that no more concrete structures should be allowed in the core area and new hotels must be constructed outside the core area so that overcrowding of the core can be avoided and heritage can be conserved. Some tourists have viewed that old character of the city i.e. walkability must be retained to reveal its true image.

It is clear that Shimla is visited more for leisure and adventure tourism by the youth, tending to generate opportunities for commercial activities, tourist guides, travels and sports activities. Apart from staying in hotels, tent housing concept is fast picking up among the domestic and foreign tourists. But increased tourist footfall is deteriorating natural and physical environment apart from putting extra pressure on infrastructure.

6. CONCLUSIONS

Shimla region has large variations in terrain, climate and vegetation across its surroundings. Tourists are attracted to it for its rich and varied natural, cultural, business, entertainment, sports and other attractions. Increased tourism has improved the economic condition of the region and the State. But deficient tourism infrastructure and tourists' behavior has deteriorated the environs of the city and its surroundings. More opportunities and better social and physical infrastructure, consequent to development of tourism, have attracted migrants from rural hinterlands and far flung places. Thus, urban sprawl and increased hotel industry and its allied units have converted green hills into concrete hills. The natural beauty is at stake and tourists are facing numerous infrastructure challenges, especially lack of accessibility to different tourist destinations. Tourists' suggestions, as discussed, may be incorporated in the policy and planning decisions to attract tourists in a sustainable manner.

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Coping with Data Deficiency for Post Pandemic Local Area Planning by Using Open Source GIS and Image Analysis

Pallavi Prakash Jha

Abstract

Most cities in India are data deficient when it comes to planning at local level and need emergency city level data repository during times of pandemic. As an alternative, the study tests a method to estimate areas of various land uses and volumes of built density from satellite images using raster classification and interpolation methods on open source platforms like QGIS and GIMP image analysis software. The interpolated raster values are used for estimating building heights which play important role in designing flexible vertical use of built forms. City Building Byelaws control urban sprawl and expansion by allocating a standard Floor Space Index (FSI) which is an important instrument in trade of FSI while implementing schemes like Local Area Plan (LAP). The study uses raster fetched data for developing a rational tool using multi criteria evaluation for determining dynamic FSI allocation in urban areas using GIS based map algebra and image analysis that further segregates land as donor and receiver plots for planned FSI consumption in local area plans.

1. INTRODUCTION

Ranchi, the capital of Jharkhand State comprises geographical area of 652 sq km, having population of 10,70,000. And study area - Hindpiri is situated at the core of Ranchi, having a dense area with cultural diversity and mixed socio-economic fabric, which was first hit by COVID-19 in March, 2020. It is estimated in this study with raster math on satellite image analysis that more than 10 per cent of city population may be dwelling in this area.

Hindpiri may qualify to have implemented planning schemes launched by Government of India like Local Area Plan (LAP) mainly to curb dense urban sprawl, which intensifies most challenges during pandemic times. Land pooling, assembly and readjustment for redevelopment through such schemes would require a different strategy due to prevailing CNT and SPT Acts like - Chhotanagpur Tenancy Act, and Santhal Pargana Tenancy Act on tribal lands that impose restrictions on land transfers.

Clear land title is an important requirement for land pooling and readjustment towards successful implementation of Local Area Plan (LAP) or Town Planning Scheme (TPS) under the sub-scheme of Atal Mission for Rejuvenation and Urban Transformation (AMRUT). Illegal land encroachment creates a deadlock for

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planning and redevelopment initiatives leading to time taking litigation process and inconveniences to residents of the plot. Separate study needs to be taken up on a web based GIS platform for sorting land titles and creating accurate cadastral maps with attributes of sale deeds and ownership records towards smooth implementation of government schemes such as LAP or TPS formulation under AMRUT.

Under Section - 20 of Ranchi Regional Development Act, there is a provision for transfer of land leased by the Authority. Under this section the authority may grant permission for transfer of land to an allottee by charging mutation fee but with applied conditions. The land use may also be changed for the implementation of Local Area Plan taking prior permission from the Authority (Malhotra, 2006). In order to avoid delay with litigations on disputed or encroached lands or having issues with unclear land titles, the Authority can take initiatives of providing clear titles to the existing genuine allottees as appropriate, based on income criteria, education and qualification, citizenship records, etc., as prescribed in Acts.

There is a need to carefully plan and allocate FAR. The planning system needs to be more flexible with land use changes in order to allow mixed use development. Allowing vertical mix of use may become an alternative approach for promoting flexible use. Developing citizen's charter for better process of approval for change in land use through regulatory bodies at State and local area planning levels shall bridge the gap between approval and implementation (URDPFI 2015: 21). The study introduces a systematic GIS based algorithm for multiple criteria participatory planning process for change of land use and re-allocation of revised dynamic FAR towards instilling flexible land use and vertical mix use.

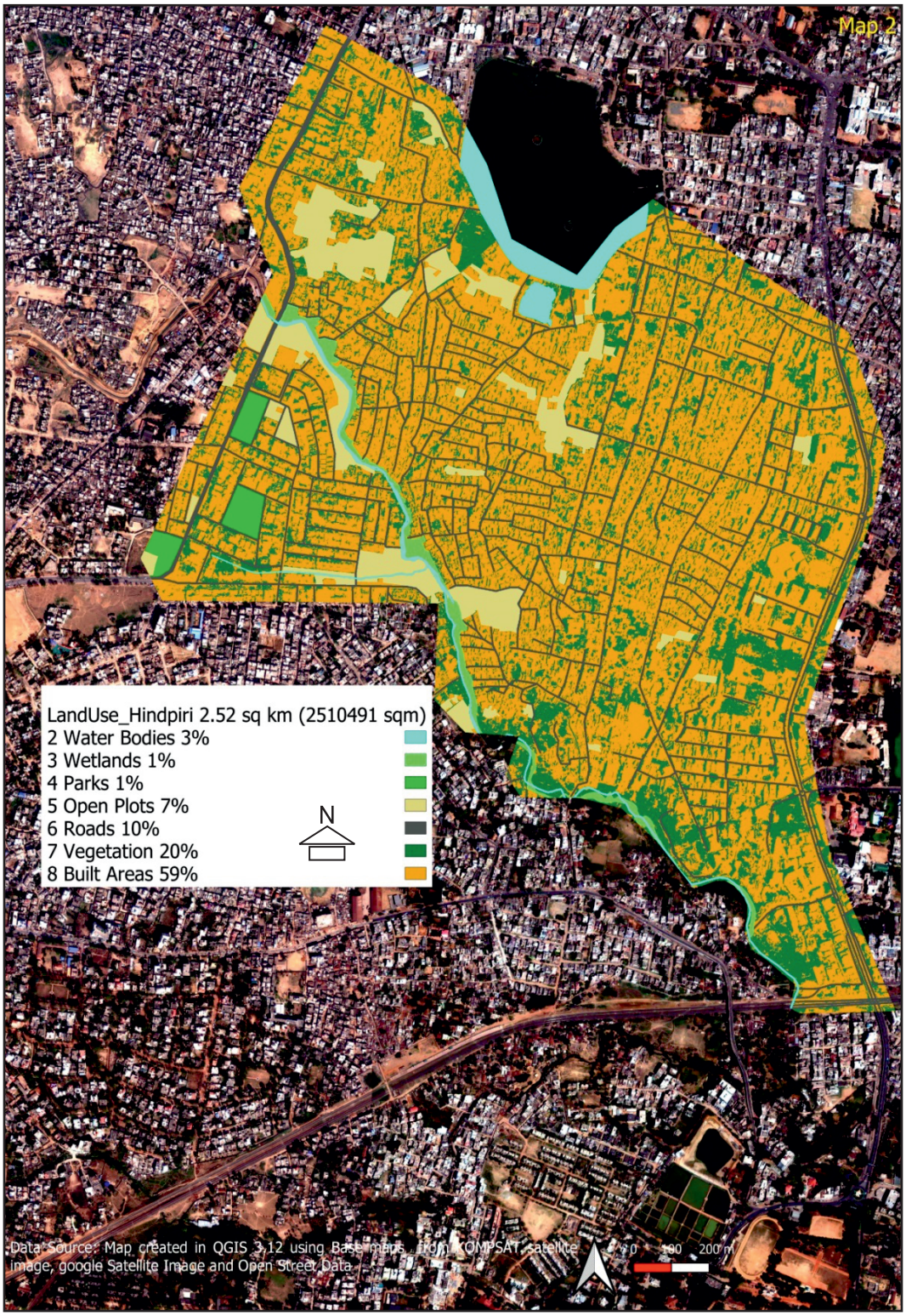
2. OPEN SOURCE GIS AND IMAGE ANALYSIS

The study aims at developing a scientific, multi criteria and participatory planning algorithm, leveraging the strength of GIS and remote sensing for fetching information from imageries that allow addressing issues of data deficient cities related to demographics, existing infrastructure, urban sprawl due to unplanned FAR consumption, lack of multipurpose and flexible urban open spaces, built environment unmatched for emergency planning and unfavorable land use. Having quoted the prevailing Acts, Byelaws and Guidelines in support creates further scope for amendments favoring implementation of LAP with pandemic point of view.

Point data of places were created on Google map and imported to QGIS and categorized (Figure - 1). Categorized data illustrates that area has mixed use

Fig. 1: Point Data created on Google Map and Imported on QGIS

Fig. 2: Raster Analysis (2-10-12)



and broad socio-economic background having various religious places, shops, retail, institutions, Banks, restaurant, etc. Further the Kompsat data was used in extracting land use of the study area using classification tool.

Single band Kompsat data was used each time in Land use data categorization estimating vegetation cover of about 20 per cent, Built areas is about 59 per cent and area under roads is about 10 per cent of the total study area *(*Figure - 2*)*. Comparing with URDPFI guidelines (Table - 1) the study area has occupied large built foot print area with relatively smaller and haphazard built density allocation. The roads making 10 per cent still remains congested and unplanned leading to narrow streets and lanes.

2.1 Existing Land Use and Scope for LAP with Emergency Planning during the Pandemic

With image analysis it is observed that though the percentage break up of land use is close to the URDPFI guidelines (Table - 1), the existing Land use of the study area has cramped urban spaces with no flexible open spaces making quarantined sites unmanageable during pandemic. This calls for strategic planning to accommodate emergency healthcare services to public. Corona Virus is difficult to contain in crowded areas having narrow lanes and streets that makes social distancing a real challenge during times of pandemic and restricts access to light, ventilation and outside view for psychological well-being of people during such times. Paper discusses rational GIS based model for Local Area Plan Formulation from pandemic view point that allocates reserved areas with flexible land use, decongesting areas by re-organizing built forms on segregated donor and receiver plots by consumption of planned FSI.

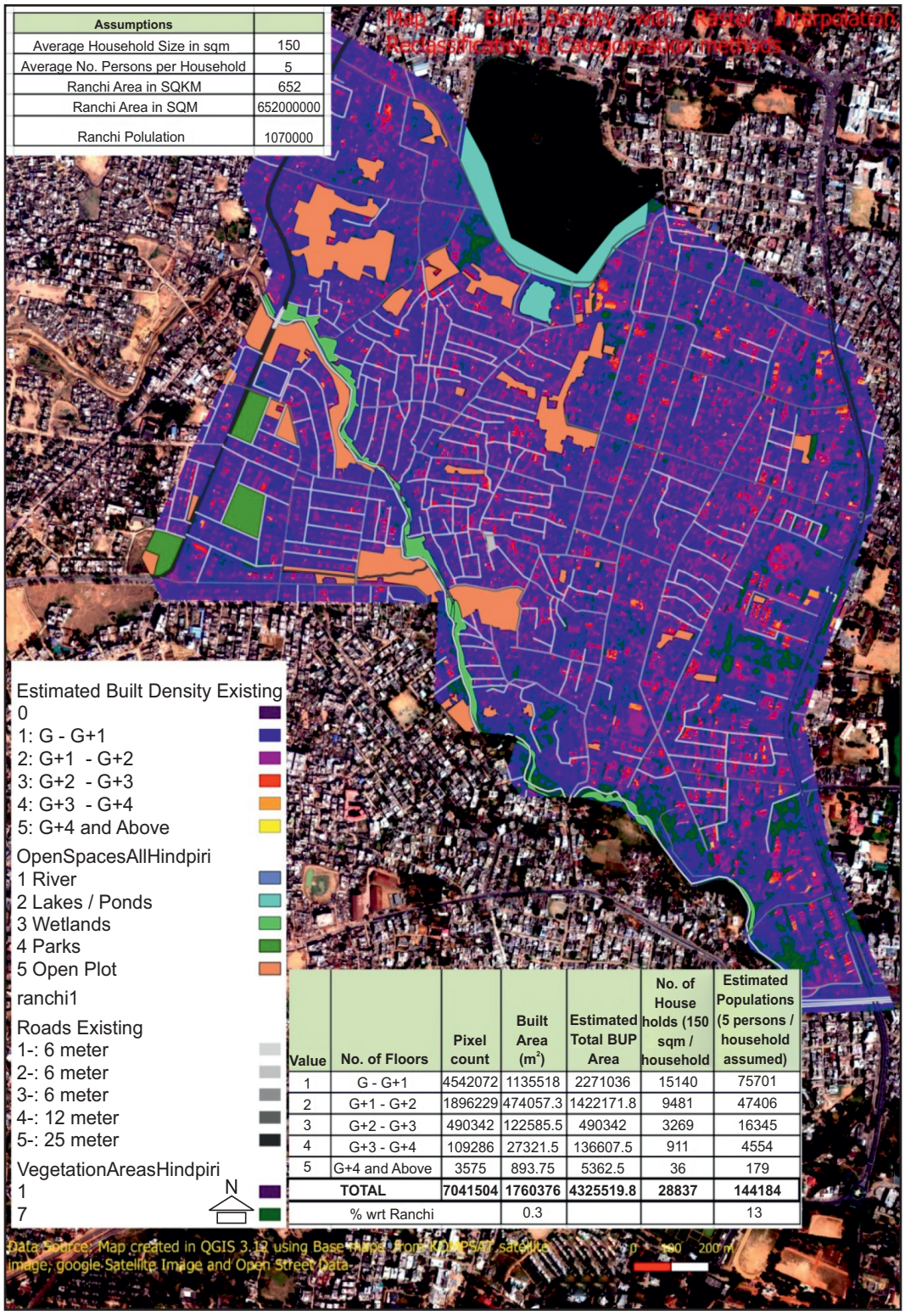
Table 1: URDPFI Guideline 1996 – Land use Structure for Developable Area in Urban Centres

Sl. No.	Land use Category*	Per centage of Developed Area			
		Small	Medium	Large Cities	Metropolitan Cities and Megapolis
1.	Residential	45-50	43-48	36-39	36-38
2.	Commercial	2-3	4-6	5-6	5-6
3.	Industrial	8-10	7-9	7-8	7-8
4.	Public and Semi - Public	6-8	6-8	10-12	10-12
5.	Recreational	12-14	12-14	14-16	14-16
6.	Transport and Communication	10-12	10-12	12-14	12-14
7.	Agriculture, Water bodies and Special areas	Balance	Balance	Balance	Balance
8.	Total Developed Area	100	100	100	100

Source: Revised based on UDPFI Guidelines, 1996

Fig. 3: Bump Map using GIMP

Fig. 4: Raster Values Created with Bump Map



Value	No. of Floors	Pixel count	Built Area (m^2)	Estimated Total BUP Area	No. of House holds (150 sqm / household	Estimated Populations (5 persons / household assumed)
1	G - G+1	4542072	1135518	2271036	15140	75701
2	G+1 - G+2	1896229	474057.3	1422171.8	9481	47406
3	G+2 - G+3	490342	122585.5	490342	3269	16345
4	G+3 - G+4	109286	27321.5	136607.5	911	4554
5	G+4 and Above	3575	893.75	5362.5	36	179
TOTAL		**7041504**	**1760376**	**4325519.8**	**28837**	**144184**
% wrt Ranchi			0.3			13

2.2 Approximation for Data Inaccuracies

It was observed during raster analysis that the shadows on image lead to inaccuracy in the built up cover estimation. For better approximation, certain extracted shapes were digitized by tracing.

3. RASTER INTERPOLATION FOR HEIGHT ESTIMATION

A Bump Map using GIMP 2.10.12 graphic software uses an algorithm creating embosses effect with buffers on a raster by John Schlag, was used on Kompsat image. Thus, the heights were estimated by interpolating raster and performing raster math and image analysis on the imported bump map in QGIS *(*Figure - 3*)*.

Raster values created with Bump Map were put in five categories ranging 0 to 5. Comparing foot prints of these ranges with actual built foot prints these values were assigned building heights ranging G to G+4 and above, where G means ground (Figure - 4).

4. DATA CRUNCHING FOR BUILT UP (BUP) AND POPULATION ESTIMATION

Average household size of 150 sq m and average persons per household of five was assumed for calculating the built up area and population estimation. The 0.5 m resolution pixel counts in each of the categorized values were taken to estimate building foot print area. These were multiplied by number of floors assigned with each of the categorized values derived from raster interpolation imported from Bump Map for BUP calculation *(*Figure - 3*)*. Further, an area of 652 sq km of Ranchi and Total population of 10,70,000 was considered in estimating population. Though not absolutely accurate, but the method of height and total built up area estimation from available imageries can be helpful for emergency planning in urban local bodies. Based on these calculations, the study outlines process for making recommendations for Local area Plan (LAP) formulation and emergency planning during pandemic in data deficient cities.

Study area being 25,10,491 sq m and as per the estimation with reference to Table - 2, it is observed that the total built foot print area and total built up area comes around 70% and 172% respectively. The former makes 0.7 in ratio and later makes a ratio of 1.7 with total study area. Population estimate in study area is 1.4 lakh which is used in calculating emergency healthcare services further in this study. Inferences of estimation help anticipate planned built density (existing being 1.7) by reallocation of FAR designed on a rational model for the study area in implementing LAP under the sub-scheme.

GIS based spatial planning with overview of legal framework for implementing LAP accommodating Emergency Planning:

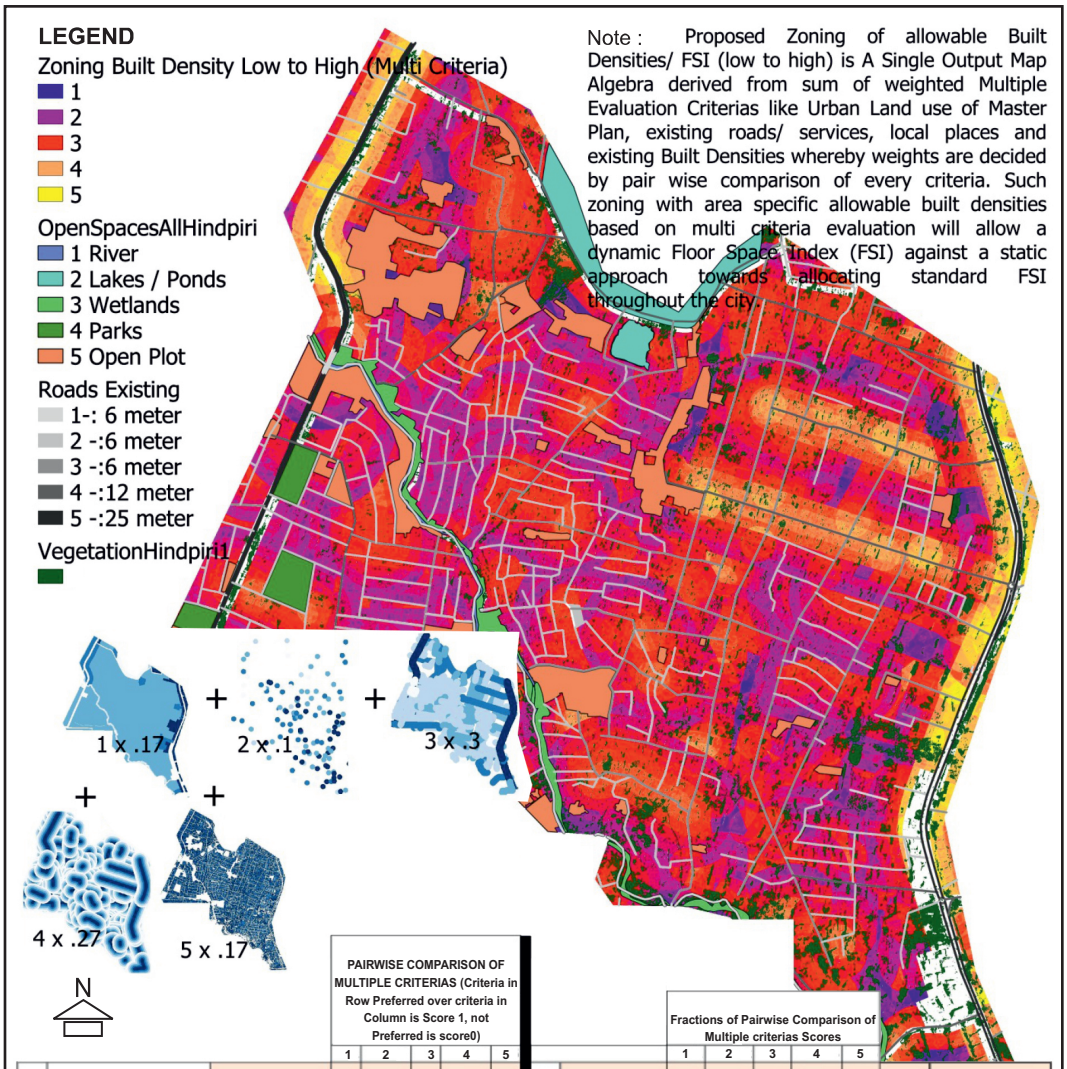
Table 2: Built Up and Population Estimation Post Raster Analysis

A - Categorized Value from Bump Map	B - No. of Floors	C - Pixel count (.5 X.5 size)	D = C x 0.25 = Built foot print Area (m^2)	E = D x B = Estimated Total BUP Area	F = E/150 = Estimated no. of House holds (150 sq m / household size assumed)	G = F x 5 = Estimated Population (5 persons/ household assumed)
1	G - G+1	4542072	1135518	2271036	15140	75701
2	G+1 - G+2	1896229	474057.3	1422171.8	9481	47406
3	G+2 -G+3	490342	122585.5	490342	3269	16345
4	G+3 - G+4	109286	27321.5	136607.5	911	4554
5	G+4 and Above	3575	893.75	5362.5	36	179
TOTAL		7041504	1760376	4325519.8	28837	144184
% with reference to Ranchi			0.3			13.5
% with reference to Study Area			70.12079	172.29776		
Area in column to Study Area Ratio			0.7	1.7229776		

The Municipality has power to pass the resolution for Local Area Plan formulation through Area improvement scheme under Section - 393 complying with structure plan for which the prevailing master plan forms the base (Jharkhand Municipal Act 07 of 2012 2011, pp. 603,604). Local Area Plans (LAP) under the sub-scheme of AMRUT can adopt form based codes to provide enhanced public spaces, services, roads by enabling redevelopment of the existing built-up environment (Pilot on Formulation of Local Area Plan and Town Planning Scheme of July 2018).

The municipality may use transferable development rights (TDR) for land assembly / land pooling for implementing scheme (Jharkhand Municipal ACT 07 of 2012 / 2011, p. 478). The ULB can provide TDR certificate and extra Floor Area Ratio (FAR) to the study affected persons with permission of the State Government in case of land acquisition for implementation of a development scheme (Jharkhand Municipal ACT 07 OF 2012 2011). For plots affected by new roads / widening of roads / parks / public utility, etc., TDR (Transfer Development Right) scheme implemented by the Government as per the Bye-Law may be used on the remaining plot calculated on the basis of the FAR as applied to the total area prior to surrender. (Jharkhand Building Bye-Laws 2016, p. 61). Further the study discusses using TDR tool to help de-densify congested areas and densify under utilized areas with respect to build density consumption, creating improved setbacks / open spaces for formation of LAP based on rational GIS based algorithm using multi criteria participatory planning approach.

Fig. 5: A Single Output Map



PAIRWISE COMPARISON OF MULTIPLE CRITERIAS (Criteria in Row Preferred over criteria in Column is Score 1, not Preferred is score0)

Sr. No.	Criterias (Components Scored on a scale of 1 to 5)	Layer Names	1 ULUhindpiriScore	2 BuffLocalHindpiri_00@1	3 BuffRoad_0	4 MBufferRoad1Rclass	5 BuiltAreaScore
1	Land Use Categories (Master Plan Ranchi)	ULUhindpiriScore	0	1	11	0	0
2	Significant Local Places (Google address points)	buffLocalHindpiri_00@1	0	0	1	0	0
3	5 Road's Buffers creating walkable ranges	BuffRoad_0	0	0	0	1	1
4	Roads as per ROW (existing width)	MBufferRoad1 Rdass	1	1	0	0	1
5	Low to High Builtup Densities of Areas	BuiltAreaScore	1	1	0	0	0
	SUM		2	3	2	1	2

Fractions of Pairwise Comparison of Multiple criterias Scores

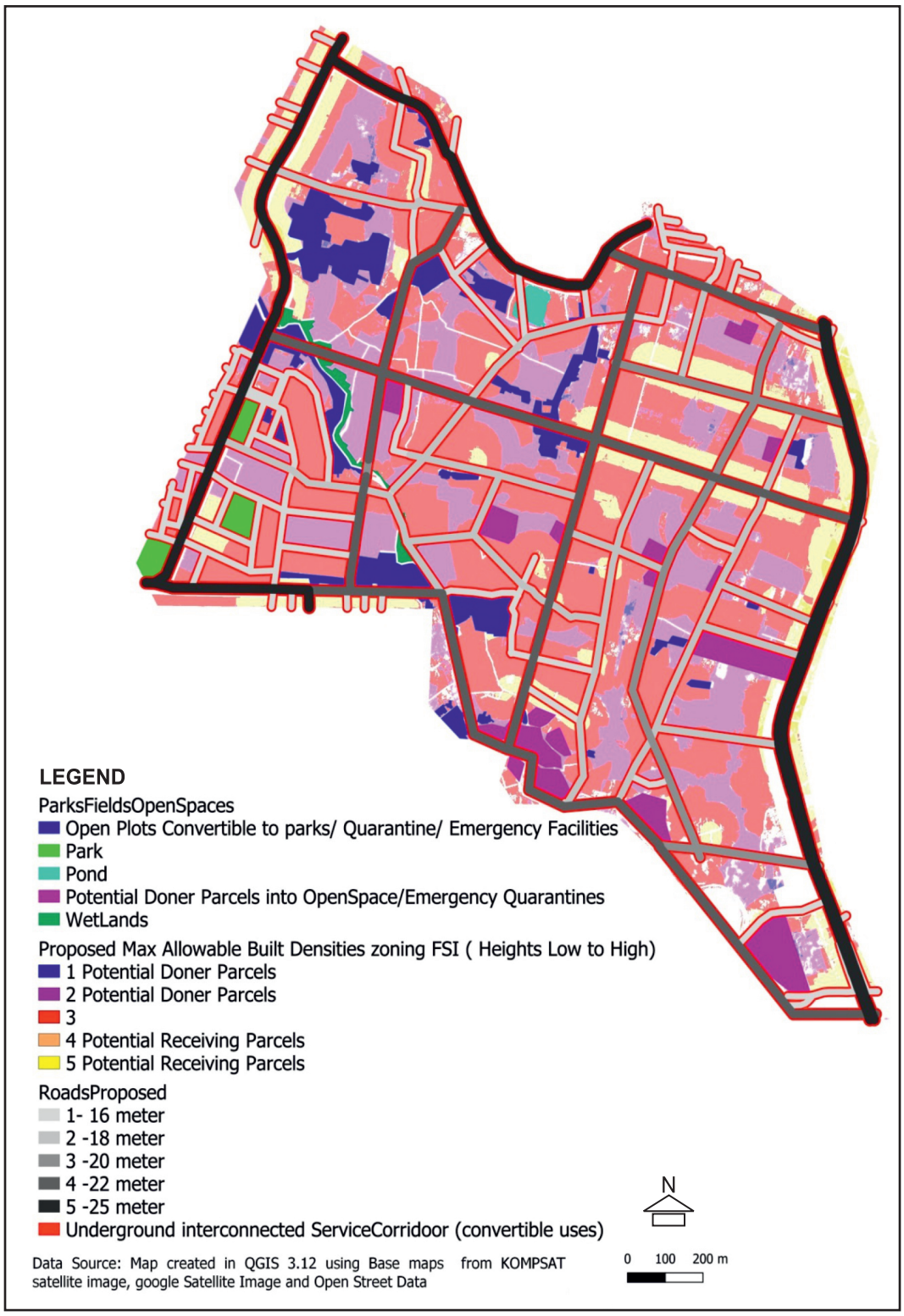
Sr. No.	Layer Names	1 ULUhindpiriScore	2 BuffLocalHindpiri_00@1	3 BuffRoad_0	4 MBufferRoad1Rclass	5 BuiltAreaScore	SUM	Average (Weights for Multiple Criteria Evaluation for deriving GIS Based Proposed Low to High Builtup Densities)
1	ULUhindpiriScore	0	0.33	0.5	0	0	0.83	0.17
2	buffLocalHindpiri_00@1	0	0.00	0.5	0	0	0.50	0.10
3	BuffRoad_0	0	0.00	0	1	0.5	1.50	0.30
4	MBufferRoad1 Rdass	0.5	0.33	0	0	0.5	1.33	0.27
5	BuiltAreaScore	0.5	0.33	0	0	0	0.83	0.17
		1	1.00	1	1	1	5	1

Final Single Output Map Algebra for Multiple Criteria Evaluation for deriving Proposed Low to High Builtup Densities:-

.17 • "ULUhindpiriScore@1" + 01 • "buffLocalHindpiri_00@1" + .3 • "BuffRoad_0@1" + .27 • "MBufferRoad1Rclass@1" + .17 • "BuiltAreaScore@1"

Data Source: Map created in QGIS 3.12 using Base maps from KOMPSAT satellite image, Google Satellite Image and Open Street Data

Fig. 6: Reconstituted Open Spaces by Using TDR

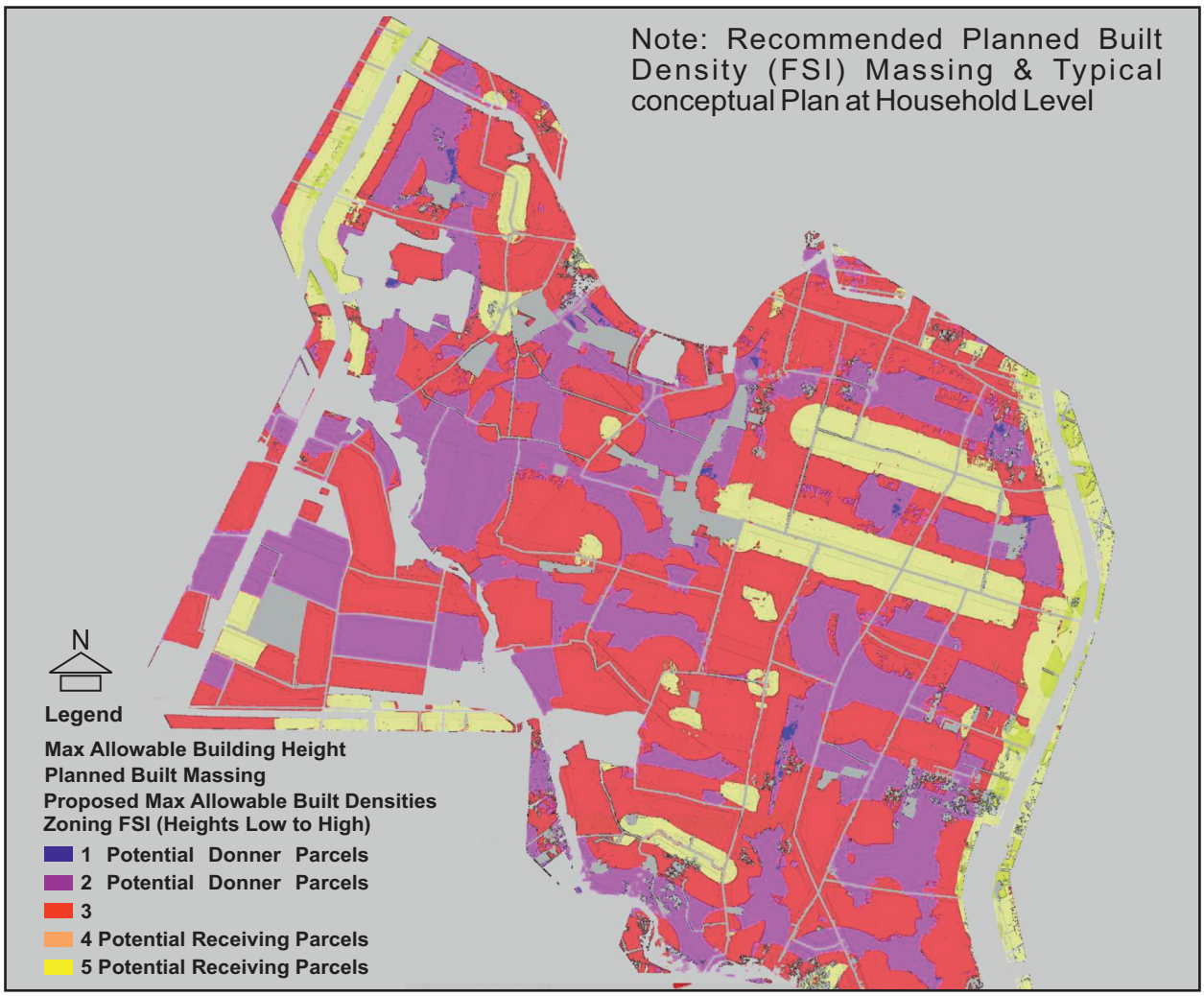


As per the Jharkhand building Bye-laws the FAR for buildings are decided based on road width on which the plot abuts and upper FAR limits for various ULBs have been set. The Master Plans or the Zonal Plans may also regulate FAR and height of buildings in Jharkhand (Jharkhand Building Bye-Laws 2016). The Proposed Zoning with revised Built Densities (low to high, Figure - 5) is a Single Output Map Algebra derived from sum of weighted Multiple Evaluation Criteria like Urban Land use of Master Plan, existing roads / services, local places and Existing Built Densities whereby weights are decided by pair wise comparison of every criteria. Such zoning with area specific allowable built densities based on multi criteria evaluation will allow dynamic FSI against a static approach towards allocating standard FSI throughout the city (Figure - 6). Such dynamic FSI would attribute to FBC (form based codes) in controlling maximum limits of building heights while strategically instilling TDR for trade of FSI for implementing value capture finance. In accordance the state can make relevant modifications / amendments as necessary in acts/ byelaws to enable this tool backed with Multi criteria GIS based rational algorithm for reallocation of FSI. As per the area segregation / zoning done with multi criteria evaluation for re-allocating proposed built density. It is recommended to instill trade of FSI through TDR (Transfer Development Rights) within the study area allowing 'de-densification' of identified potential donor land parcels (having low allowable built density) and 'densification' of identified receiving land parcels (having higher allowable built density) as illustrated in proposed built density maps (Figure - 7). The trade of FSI may be limited within the study boundary of LAP whereby the identified receiving parcels can only be densified by borrowing improved FSI of donor parcels within the reallocated maximum FSI limits that is better than existing 1.7 (Figure - 6, and Figure - 7).

Land parcels identified as donor and receiving areas for consuming proposed dynamic FSI may be incentivized in exchange to reconstituted government's land bank providing public amenities in lines with LAP scheme.

The Municipality holds power to acquire and hold by gift, purchase or otherwise, movable and immovable properties or any interest therein, whether within or outside the limits of the municipal area (Jharkhand Municipal ACT 07 OF 2012 / 2011, p. 477). The tribal lands in Jharkhand cannot be sold to non-tribal people as per the prevailing CNT and SPT tenancy Acts. It is noticed in this study that such land may be gifted to the government for land pooling / acquisition / readjustment for providing better amenities, healthcare facilities, and public spaces at Hindpiri in return to incentives, enhanced services and accommodation. The proposed planned built density would allow more open spaces / improved setbacks and frontage, broader street networks for safe pedestrian friendly access, dedicated bicycle tracks, child friendly and Universal access concepts mandated on main ground access (Figure - 7).

Fig. 7: Planned Built up Density at Household Level

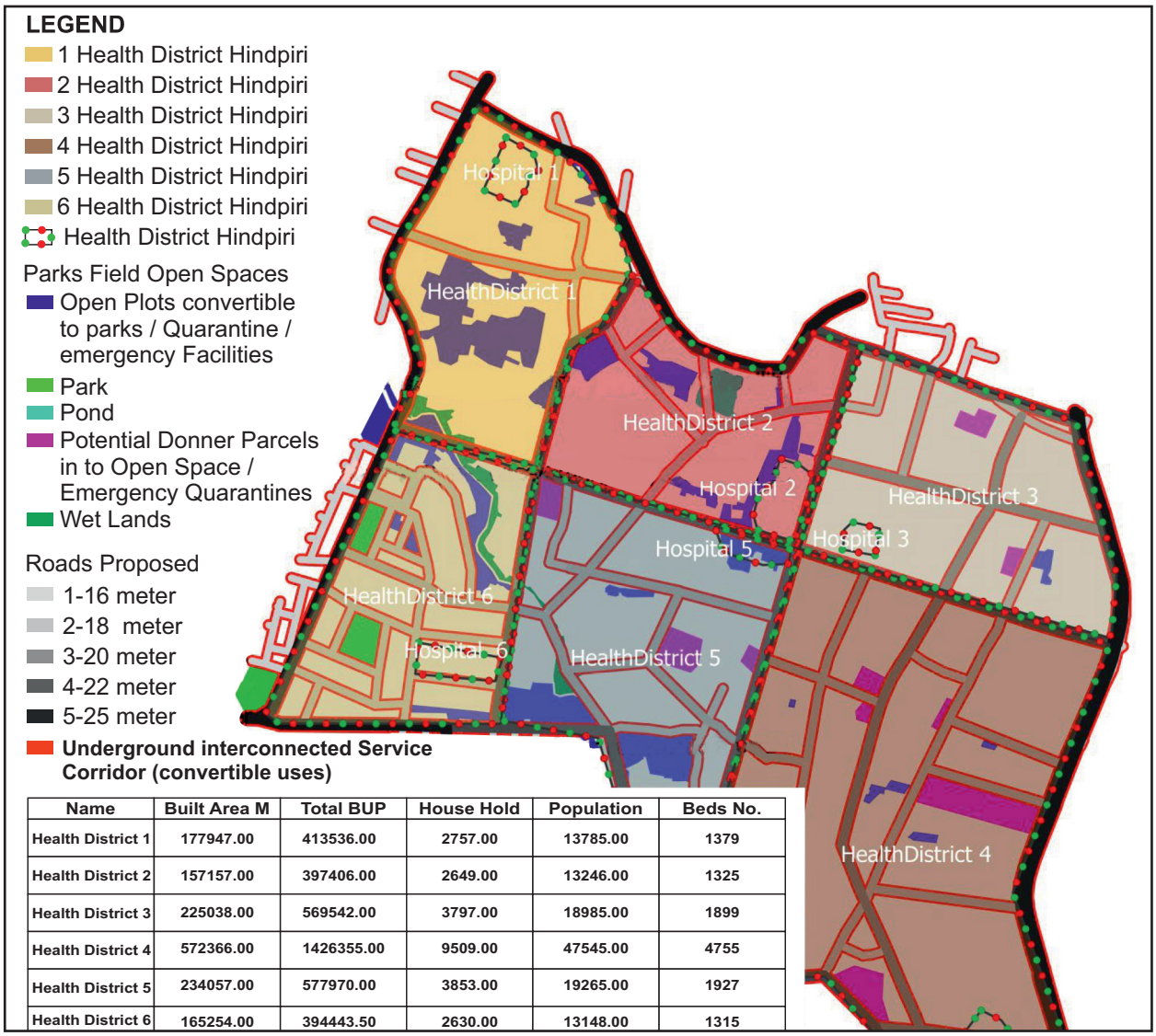


5. CONCLUSIONS

GIS based process can help implementation of Local Area Plan formulation under the sub-scheme of AMRUT clubbing with other Municipal functions for development of the Scheduled Caste and Scheduled Tribe, beneficiary-oriented schemes under Special Component Plan (SCP) and Tribal Sub Plan or TSP (Jharkhand Municipal Act 07 of 2012 2011).

The study concludes with design recommendations in GIS based maps that illustrates example of data fetching, crunching, estimation and spatial analysis on a GIS based model that can be used in data deficient urban areas creating scope for emergency planning in Local Area Plans and Town Planning Schemes. Cities have limited space hence urban spaces need to be convertible / flexible, transformable and multipurpose. Re-constituted open spaces by using TDR tool

Fig. 8: Hindpiri subdivided in to Six Health Districts



Name	Built Area M	Total BUP	House Hold	Population	Beds No.
Health District 1	177947.00	413536.00	2757.00	13785.00	1379
Health District 2	157157.00	397406.00	2649.00	13246.00	1325
Health District 3	225038.00	569542.00	3797.00	18985.00	1899
Health District 4	572366.00	1426355.00	9509.00	47545.00	4755
Health District 5	234057.00	577970.00	3853.00	19265.00	1927
Health District 6	165254.00	394443.50	2630.00	13148.00	1315

on identified donor and receiver plots, parks, existing malls, offices, hotels, etc., may convert into quarantine facilities or emergency health care facilities with use of prefab construction techniques / 3D printing technologies in construction (Figure - 8).

The design of LAP proposed at Hindpiri sub-divides the study area into six manageable local Health Districts based on estimated population, available open spaces and scope for convertible spaces for providing emergency health care services during pandemic. The estimated population helped calculate required number of beds for planning hospitals. These beds for hospitals are calculated at 10 % of estimated population from Satellite Imagery which can be positioned

in identified flexible open spaces, expandable in identified feasible receiver parcels. Access to interconnected underground service corridors for delivering emergency services like providing supplies, transporting bio-waste / hazardous waste, dead bodies to cemeteries and safe access to infected persons without disturbing ground level activities is worked out on axis along 6 local Health Districts proposed. These underground access corridors may be used for city services and delivery of goods during normal times. Robots operated driverless transportation and deliveries may equip these underground service corridors using artificial intelligence and GIS based location tracking.

Recommended sites for 6 Hospitals are identified in potential receiver parcels that may be used by Government with Higher FSI for providing health care facilities. All other design elements are proposed in accordance, comprising sub-division of study area into manageable local Health Districts having special access to interconnected underground emergency service corridors, identification of potential convertible or flexible urban spaces for transforming into quarantine facilities / Hospitals.

The GIS based planning technologies need to be web based on an integrated dashboard enabled platform enabling participatory planning process. The data fetching tools need to be aided on web based server application giving access to standardized data repositories to planners for taking decisions. Various open source / proprietary platforms for GIS and graphics should easily interact with one another to provide seamless support. Cities should bring emergency data from various line departments to planners on a common standardized platform for better crisis management during times of pandemic and for community development goals at local levels.

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Modelling Tools for Assessment of Sustainability: Urban Metabolism and Circular Cities

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Abstract

Urban metabolism studies have gained momentum in recent years as a means to assess the environmental performance of cities and to point to more resource-efficient strategies in order to curb environmental degradation and initiate restoration of ecological balance. To incorporate and validate Urban Metabolism (UM) as a modelling and assessment tool, we need to design circular economy and create smart sustainable cities. This paper explores the possible pathways and links of input-output at macro, meso and micro levels in different sectors viz. water, energy, carbon and other pollutants. The paper conceptualizes urban metabolism in complex system setting and emergence of closed loop sustainability. The paper also embarks on different methodological approach for input output analysis of carbon, water and energy. The paper further investigates pathways to circularity for equity, efficiency and wellbeing of community at both urban and regional level. UM can be seen as metaphor for flows and stocks of goods and service, when these parameters additionally combined with quantitative and qualitative environmental and socioeconomic parameters; and develop a comprehensive framework for evaluation of urban sustainability.

1. INTRODUCTION

Global Policy Framework require assessment of carbon footprint in measurable approach in order to promote Zero Carbon Buildings (ZCB). Much work has been done on Energy Efficient practices (EEP), Green Building Rating System, Energy Conservation Building codes (ECBC) for residential and commercial buildings, but municipalities role is limited to issue building permits for new constructions and fails to actualize implementation of ZCB goals due to lack of modeling and assessment tools for different urban development choices and decisions undertaken time to time.

According, to the United Nations' forecast, by 2050, 70 per cent of the world's population is expected to be living in the cities. Accordingly, the high population concentration in urban areas pose threats to economic, social, and environmental well-being and puts pressure on these systems. In context of Green House Gas (GHG) emissions, building sector accounts for one third of total global energy related to Co2 emission in 2019 (UNEP 2020). Rising emission in buildings and construction sector emphasize urgent need to decarbonize power sector and usage of carbon neutral building materials. Urban Metabolism has gained momentum in recent years as a tool to assess

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environmental performance of cities; to point to more resource efficient strategies for urban development.

Sustainable development refers to the goal of fostering adaptive capacities while simultaneously creating opportunities for future. With cities are striving hard to meet sustainable Development Goals, systematic approach to understand and assess inflow and outflow is very necessary. Focus of the world is shifting from linear to circular systems where former consumes an infinite supply of new resources; later take input of used resources, produce waste (output) towards circular system, in which resources are reused, recycled and recovered

Technological development has intensified use of natural resources to limits of exploitation and extinction. Intensified urbanization induced severe stress to ecological balance, creating various types of vulnerabilities in the settlement. Built environment puts major pressure on natural environment particularly if not perceived harmonious to the nature. In this perspective role of cities and built environment is vital for reuse and re-cycling of resources and to see its transition to circular economy. A city can be seen to have four essential metabolism flows; water, material, energy and nutrients (Kennedy 2007). In cities today, these flows are becoming increasingly complex due to large stocks and high exchange rate of flows. Cities are unique in their specific metabolism but a common trait is the linear flows where reuse and re-cycling are rare. As the goal of circular economy is to optimize the system as a whole, not individual parts, system thinking is very important to epitomize circularity through urban metabolism.

Though, globally Municipalities and utilities are adapting Energy Efficient Practices (EEP), limited work is evident in India in this regard. Headquarter of Ministry of Environment, Forest and Climate Change, New Delhi is the first Net Zero Building in India and Kochi Municipal Corporation is first city, developing a city wide road map for achievement of ZCB for all building types. (ZCB) are resilient against climate change induced impacts on energy supply and demand. By Carbon offsetting newer and more collaborative approaches for adoption of energy on emission of the whole ward and neighborhood can be maintained to net zero.

2. IMPLICATION OF TOOLS OF URBAN METABOLISM

In the current climate of unprecedented urbanization and increased uncertainty, environmental goals for sustainability are resource efficiency and climate responsibility. Particularly it is important to re-configure energy system through its production and consumption patterns. The environmental pressure arising from the extraction of these materials and from their discard, after processing and use is threatening global sustainability. High carbon embodied materials which have adverse environment impact may be omitted and replaced with local,

less energy intensive and green materials. Our latest problem is not scarcity of materials but its abundance. Usage of recycled building material with cradle to cradle (C2C) approach is not only saving on raw material, but it also save carbon emission during manufacturing and transportation. Integration and synthesis of material flow accounting (MFA) is required at multiple levels to improve environmental sustainability through data driven decisions. Additionally building code must be strengthened to accommodate ZCB requirements.

Carbon footprint is the total amount of Green House Gas emission, including carbon dioxide and methane that are generated by our action.

With the growing concern of climate change and environment degradation, the urban metabolism modeling and assessment is the key to determine and maintain levels of sustainability and health in cities around the world. Materials and tools, such as solid waste, air, water pollutants, water and energy flows, can provide significant insight and help identify sustainable urban development. In this respect, the three pillars of sustainability (Table - 1) have to be looked forward which include:

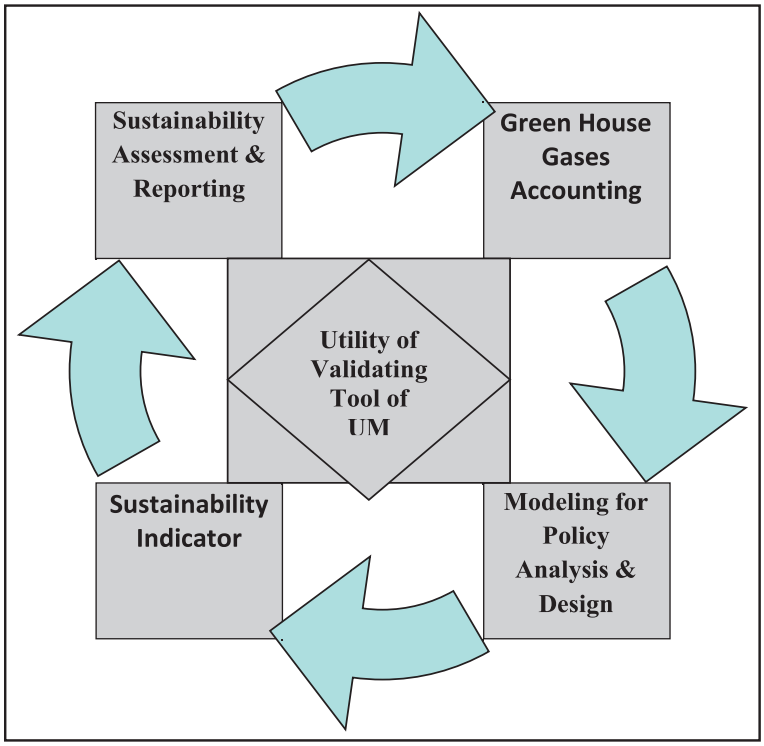
Table 1: Linkages of Metabolic Concept to Sustainability

Dimension	Criterion	Units
Environmental Dimension	Resource Use	Renewable, Non-Renewable, Reuse, Recycle.
	Water resource	Efficiency of use, Waste Management, Metering, Recycling, Harvesting.
	Waste disposal	Reuse, Waste Collection, Management.
Social Dimension	Green Coverage rate	Creation of green areas.
	Open Space	Land Recycling, organized open spaces.
	Public Health	Access to health infrastructure, Healthy life years, Exposure to health risk like Indoor Air Quality (IAQ), Safe Drinking Water.
Economic Dimension	Energy Use Efficiency	Alternate Energy Sources, Green Fuel.
	Green Transportation and Mobility	Pedestrian and Cycle Track, Mixed Use, TOD, Mass Transport.
	Green Infrastructure, STP, Waste to energy	Green Investment, PPP Models, Flexibility of usage.

Source: Author

- **Environmental Sustainability** that incorporates best practices in the management of the energy, transportation, waste, and pollution;
- **Social Sustainability** related to green business and service activities and promoting the responsibilities of individuals in the community; and
- **Economic Sustainability** that includes self-reliance and equality and also de-coupling environment degradation with economic growth.

Fig. 1: Four Uses of Urban Metabolism Tool



The development of cities not only entails a fundamental change in human settlement patterns but also a dramatic transformation of the physical environment. Thus, urban areas and their development are at the centre of all discussions on sustainability. Urban metabolism provides a unified or holistic viewpoint to encompass all of the activities of a city and their eco-footprint in a single model. It can be argued that understanding the processes of urban metabolism provides the possibility of more sustainable development by optimizing the use of available resources and increasing environmental protection. Energy and material flows exist in cities, inter-acting to create economical and societal patterns as well as spatial and geographical patterns. There are four main uses of urban metabolism tool that are globally utilized today by urban planners and designers (Figure - 1)

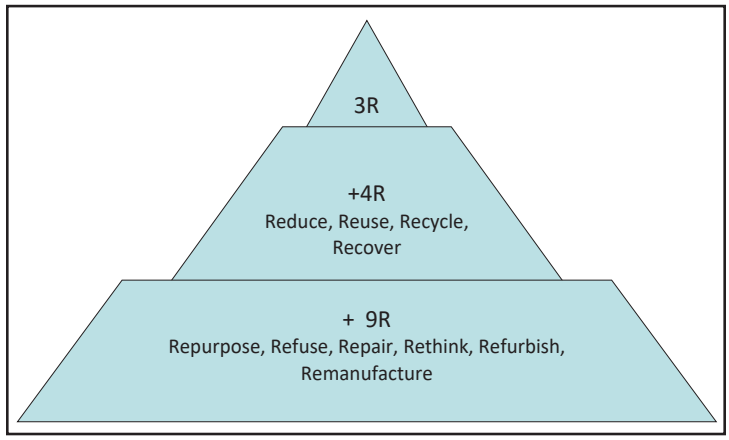
- Sustainability assessment and reporting;
- Urban greenhouse gas accounting;
- Mathematical modeling for policy analysis and urban design; and
- Development of Sustainability Indicators.

Carpintero (2005) put forward use of UM to analyze potential existing measures and break the links between urbanization, economic growth and resource consumption with the focus of concern on depletion of natural resources and environmental damage. Princetl and Bunje (2009) summarized benefits of the urban metabolism framework for having explicitly defined system boundaries having accounts for system inputs and outputs, which can analyze of policy and technology outcomes with regard to sustainability goals, integrates social sciences with biophysical sciences and technology, enables a hierarchical research approach, undertakes input-output analysis in different urban sector i.e. water, carbon, etc., with reductionist approach, finally enables adaptive approach to heterogeneous solutions, and their consequences.

The objectives of this research are:

- Conceptual understanding of Urban Metabolism and its application on different urban sectors for building Resilience;
- Conceptualizing need of circularity at city (Fig. 2) and Regional Level through system approach; and
- Development of framework for UM modelling and assessment tool to measure eco-footprint by industrial corporations, municipalities neighborhoods, impact of regional policies on environment degradation versus economic growth.

Fig. 2: Development Framework for Circular Cities



Source: Author

3. LITERATURE REVIEW OF URBAN METABOLISM

Metabolism is derived from the Greek word (Metabol) and has been used in a variety of contexts, including medicine, sports, psychology, politics, society, and architecture. Lin et al. (2012) argue that Burgess (1925), a sociologist, first utilized the term with no formal definition to analogize urban growth to the anabolic and catabolic processes. Barles (2010) pointed on bio-geo-chemistry processes to a tool to address sustainable development challenges and the requirements to achieve de-materialization, de-carbonization and the closing of material loops.

Biologically, the city acts as a living organism using vital resources such as air, water, and food, and also releasing by-products which requires handling through recycle and reuse. In urban metabolism larger the city, the more it demands from its surroundings, and thus increasing the risk of environmental degradation. Factors such as urban structure, shape, climate, quality, and age of buildings, biodiversity, plant life, and transportation technology affect the rate of metabolism and the magnitude of by-products released in the immediate environment of the city. Urban metabolism provides a unified or holistic viewpoint to encompass all of the activities of a city in a single model. Urban metabolism (UM) is a model to facilitate the description and analysis of the flows of the materials and energy within cities. For many UM studies in Industrial Ecology, Urban System are similar to organism that metabolize material and energy flow within the city, considered as a bounded unit where inputs and outputs are eventually transformed. Kennedy et al (2007) produced a clear definition on 'The Changing Metabolism of Cities' claiming that urban metabolism is "the sum total of the technical and socioeconomic process that occur in cities, resulting in growth, production of energy and elimination of waste'.

Sanguin (2019) connects UM roots to Industrial ecology where study of material and energy flows associated with production and consumption activities and seeks to reshape the character of environment economy relations. The normative goal of UM studies is to contribute to the reduction of material throughput and resource consumption in cities. As such, industrial ecologists have developed frameworks such as mass-balance accounting and energy, and a variety of methods to quantify resource flows that feed urban growth. The Ellen Mac Arthur Foundation (EMF) developed Resolve for circular economy and eventually moving to circular cities for creation of smart sustainable cities. Resolve defined circular economy as one that provides multiple value creation mechanism de-coupling from consumption of finite resources through six actions:

- Ecological regeneration through shift to renewable energy and materials, along side the re-covered biological resources to biosphere;
- Keeping components and materials to closed loop (reuse, recycle, recover) prioritizing inner loops and thus reducing waste;
- Sharing resources to keep production loop speed low and maximize the utilization of products to reduce waste;
- Optimization in performance and efficiency of products, waste reduction in production and supply chain;
- Dematerialize resource use by delivering utility virtually; and
- Replacing existing products and services with lower resource consumption options.

Shahrokni et al (2015) provide real time feedback on energy and material flow of Sweden and Stockholm Royal Seaport through Smart Urban Metabolism (SUM) model, integrating ICT and smart city technologies which worked from household level to urban district. Andreoni V. (2020) used Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) approach to compare profile of 18 countries and enumerate relationship between economic growth, energy efficiency and energy use. Economic crisis of 2008 gave opportunity to investigate the relationship between energy and economy, not in framework of growth, but in the framework of decelerated growth. MuSIASEM compared Metabolic profiles of countries with varied socio-economic conditions and varied policy implications.

GD Amico et al (2022) advocated digitization tools like sensors, real time monitoring system, actuators, digital cameras, real time tracking system, Big data Analysis, Artificial Intelligence, Cloud Computing, Smart Grids, IOT infrastructures, Augmented reality, Block Cain, 5G wireless communications, social media platforms and other information and communication Technology for Smart and sustainable cities deriving circularity of Urban Metabolism. The

intensive and evasive use of digital technologies have changed the thinking paradigm from traditional linear system to systematic and circular perspective, characterizing co-design initiatives, decentralized monitoring and multi-level governance. In this purview Kissinger and Stossel (2019) identify and confirm correlation between quality of Urban Metabolism and resilience of city.

Presently the concept of sustainability in urban planning and policy making has been focusing on urban metabolism mainly through infrastructures for sewage, water, energy, and waste management within the city. Urban Metabolism emphasize on goals of resource efficiency; generating opportunities for Circular Economy; de-coupling environmental degradation from economic growth and addressing need of poor through circularity. In this respect, Urban Metabolism emphasizes on both policy focus and investment shift towards reduction in consumption of raw materials. For example, the consumption of construction materials has been growing exponentially with urbanization, where construction material contributes to 75 per cent of the material which are mostly non-renewable in nature. UM is thus shifting from a descriptive picture, from understanding of how an urban system works to a planning and design tool capable of providing operational strategies for more sustainable urban development (Kennedy et al. 2011). Municipality of Parato under European Union circular cities project created web portals to connect people in need of construction materials to people having construction and demolition waste.

Though Material and Energy Flow Analysis (MEFA) is comparatively easy in comparison to MuSIASEM, which is more integrative and comprehensive. This approach has advantage over other methodologies used to investigate metabolism of societies:

- Ecological footprint;
- Energy Use;
- Input-Output Analysis;
- Consumer Approach;
- Simulation Approach; and
- Hybrid Approach.

An urban metabolism tool is an accounting system that can manage, quantify, and process metabolic flow data. This could be a single accounting tool or a combination of different tools, each of which is specialized in a part of the metabolism. One typical characteristic of urban metabolism tools is their integrative nature, i.e., their ability to integrate a variety of data sources and provide a systems perspective, based on a relevant theory (Holmes and Pincetl, 2012). Accounting tools range from paper-based in simpler models to spreadsheet-based, or tailored software in more advanced models.

4. CONCEPT OF URBAN METABOLISM (UM)

Urban metabolism (UM) is a concept, directly borrowed from biology and biochemistry and applied to urban studies, that today suggests new paths towards city sustainability (Castán Broto et al. 2012). Developed in 1965 Wolman describes UM as the impact of the urban system on the environment and is defined as the total sum of processes for which cities mobilize, consume, and transform the resources they need to function and develop, together with the resultant waste and pollution (Barles 2008).

Metabolism has a socio-ecological concept having deep roots to 19th century. Karl Marx used as a central metaphor for material transformation of human / non-human nature and social reproduction. It provides researchers with a metaphorical framework to study the interactions of natural and human systems in specific regions. It has been noted that policies implemented in the last two decades focused exclusively on Energy and Carbon emission reduction, whereas consumption of materials have been allowed to grow unchecked. Increase in material consumption also causes increased indirect embodied CO2 emissions and additional waste. Furthermore, in urban planning and policy making, the concept of sustainable city has tended to focus mainly on infrastructures for urban metabolism sewage, water, energy, and waste management within the city and thereby fall short in considering smart solutions and sophisticated methods in relation to operational functioning, planning, and design.

As Christian Saigun addresses urban metabolism broadly refers to the socio-ecological exchange processes and transformations in cities. Several schools of urban metabolism deploy the term in multiple ways i.e. as a metaphor, a paradigm, or a methodological tool. Each school is under-pinned by distinct understandings about urban natures and nature–society relations. The field of industrial ecology prioritizes a systems-framed accounting of material energy flows in what are termed urban metabolism (UM) studies, while Marxist ecologies mobilize the metaphor more loosely highlight unequal production of urban natures. Despite diverging and contested definitions, “urban metabolism remains a rich concept for discussing socio-ecological processes in urbanization.” Pistoni and Bonin (2017) analyzed two case studies on different scales viz. Metropolitan level and Neighborhood Level.

4.1 Concept of Circular Cities

The concept of the Circular Economy has been gaining momentum since the late 1970s. Circular cities are the urban system in which resources are looped in a way to regenerate ecosystem balance and the socio-technical system. Circular Economy (CE) appears a positive and acceptable concept to address environmental challenges particularly Sustainable Development Goals (SDGs) 11 and 12. Circular cities integrating the CE and UM approach has potential urban

framework which simplifies the complexity of Urban system and realization of sustainable cities. Circular Economy (CE) principles can be applied at different scales from material to products and from individual to different supply chains. SDG - 12 aims to ensure sustainable consumption and production patterns. Urgent actions are required to make urbanization sustainable and to avoid over extraction of resources and degradation of environment, which is possible through combined use of Circular Economy and Urban Metabolism. Kalmykova and Rosado used three alleys of systematic research namely:

- UM description, analysis;
- Sustainable UM design- quantifying resource flows at the product and material levels; and
- Identifying possible links between stakeholders with suitable materials and infrastructure.

Circular Economy (CE): Close loop (circular) economy first emerged in the sixties (Boulding 1966) influencing German and Japanese economic policy during 1980's and 1990's. Circular economy is a model of production and consumption (with an emphasis on production) whose ultimate goal is to achieve de-coupling of economic growth from natural resource depletion and environment degradation (Jackson 2009).

Area of environmental hazards is naturally the first to be impacted and this is especially evident in the metropolises of the developing countries. In these countries, due to the weak economic structure and the pressure of population irreparable damage is induced to the environment; resulting from widespread migration from other parts of the country in metropolitan areas. While this trend is intensifying with the concentration of industries, cars, and other environmental pollutants, Delhi NCR is not either far from the above trends. The successful implementation of the CE could, in principle, benefit both the global natural environment and economy. The CE aims to maximally retain economic value in products, materials, and resources over time (Kalmykova et al., 2018). It has been estimated, for instance, that CE could annually generate 1 trillion USD globally (over the linear economy) (Korhonen et al., 2018). CE focused on economic policy of following sectors like - food, construction and electronic goods implemented at three functional level (Yung 2016) first as Firms and Companies second eco-industrial park, and third as. eco-city / municipality.

In relation to the ongoing efforts for smartening up sustainable urban forms using big data technology and its application, Bibri (2018a) points out that the key scientific and intellectual challenges pertaining to smart sustainable urban forms is to relate the underlying design concepts and typologies and thus urban infrastructures to their operational functioning and planning through monitoring and control, automation, management, and optimization. Belon Saint Pierre

et al (2016) conducted Urban Metabolism based reviews of 112 cities using common assessment methods, from accounting approach, input output analysis, ecological footprint analysis life cycle analysis, simulation methods and hybrid methods. Urban Metabolism circularity applicable to single city units to regional scale as adopted in Netherlands and European Commission (2020b). MEFA, VAM, EVSM have been used historically where set of Sankey Diagram used to depict material and energy flow separately, besides the pen and paper-based approach.

Generation of Data is very important aspect of Urban Metabolism study. This requires Agricultural Aerial Survey, Fossil fuels and emission, Freight demand Model, Illegal Dumping Data, etc. Ko and Chiu (2020) used fuzzy Delphi method to develop evaluation factor for circular metabolism and integrated it with analytical Network Process (ANP) decision making tool to determine the priority weights of each policy. This may help to evaluate development strategies for Urban Development based on Metabolism Concept. Fuzzy Delphi method is conventional Delphi method combined with fuzzy set theory. Based on the three pillars of sustainability, nine indicators obtained in each of Environment, Social and Economic dimension. Pistoni and Bonin (2017) discussed framework and by conducting semi structured interviews with architects, urban planners, designers and environmental engineers for UM framework at Metropolitan and Neighborhood scale of Rotterdam and Amsterdam respectively. Circular Economy is a multi-dimensional and multi level concept. Analysis is given in two overlapping approaches - systematic and hierarchical (R-framework). Former emphasize different levels in circularity whereas later identifies best practices at Micro, Meso and Macro Level, as given below:

- Micro Level - Products, companies, consumer;
- Meso Level - Inter firm Network, symbiosis association, eco-industrial parks; and
- Macro Level- Green Supply, chain management, City Province, region, nation.

Life Cycle Assessment: Life cycle assessment (LCA) is a standardized method which aims to quantify environmental impacts of products and avoid burden shifting from one environmental impact or life cycle stage to another. It requires identifying and quantifying material and energy flows throughout a product's life cycle, which consists of technological processes from raw materials extraction to the product's end-of-life processing. The analyst must define the life cycle's boundaries during the initial scoping step of the LCA.

Environmentally Extended Input-Output Analysis: Environmentally extended input-output analysis (EEIOA) shares the same goal as LCA i.e. to quantify environmental impacts linked directly or indirectly to a product or service, including production (but not always including the use or end-of-life phases).

Material Flow Analysis: Urban Metabolism (UM) approach, as deduced from international literature, has been applied several times to assess and describe urban flows and impacts related to them, using different tools such as Material Flow Analysis (MFA) (Ioppolo et al., 2014). The MFA technique has become the mainstream school of urban metabolism because it uses more practical units that the public, workers, government officials and researchers can understand. Baccinni and Brunner (1990) described MFA as measures the materials flowing into a system, the stocks and flows within it, and the resulting outputs from the system to other systems in the form of pollution, waste, or exports. UM studies have developed increasingly complex quantification and mathematical modelling to measure resource consumption and trace material energy flows within a bounded urban system.

Material flow Analysis (MFA) qualifies resource flows by physical weight and volume. It can be conducted on multi-scales providing basis for material flow management and de-materialization strategies on regional and city scale. Material flow analysis (MFA) describes a system such as a city or a country in terms of its input and output physical flows of materials in space and time. The goal of MFA is to understand the material processes of a system to inform better decisions related, to waste management, material availability constraints, or material disposition, etc. MFA is used to define general circularity metrics such as a cyclical use rate (measuring recycling) and the shares of secondary materials in the system's inputs and outputs. Rosales et al (2011) used material flow analysis for Mexico city, reveal that its regular requirements of water, food, raw material and fuel regard its urban metabolism is linear. That means city consume more natural resources than it can regenerate, importing a large quantity of raw material (food and other material from other region, while generating waste, gases, waste water that expands the negative impact of the city at regional level. The analysis also demonstrate that city has exceeded it's carrying capacity making it unsustainable urban system.

Emergy and Exergy (Qualitative aspects of Energy): Rooted in ecology and thermodynamics, emergy is defined as the sum of all inputs of available energy directly or indirectly required in a system (or embodied energy) (Pan et al., 2016) Exergy, on the other hand, is defined as the maximum usable energy of a material and can be computed for both combustible and non-combustible materials (Jamali-Zghal et al., 2015). Some researchers have suggested that exergy could be a relevant metric to assess circularity.

Chrysoulakis et al, (2010) enumerated BRIDGE Project – Sustainable Urban Planning Decision Support accounting for Urban Metabolism through GIS based platform to integrate component of Urban Metabolism into environment Impact Assessment Process. BRIDGE project focuses on specific Urban Metabolism components i.e. energy, water, carbon and pollutants as given below:

- Water – Water balance, risk of flooding, surface runoff, evo-transpiration;
- Air and Climate- air quality in terms of pollutants, concentration and dispersion, CO2 emission, carbon sinks and energy balance; and
- Material Assets – energy and fuel consumption, associated heat fluxes including heat island effect.

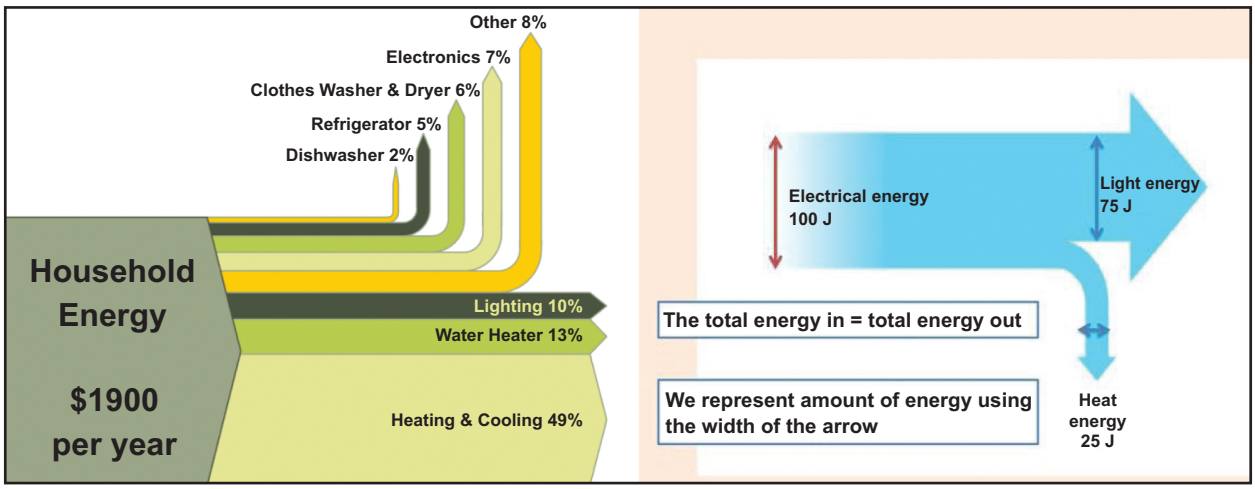
The Multi-scale Integrated Analysis of Societal and Ecosystem Metabolism: (MuSIASEM) is a trans disciplinary approach that has been developed to investigate the existing relationships between environmental elements, economic variables and human time allocation. Based on the concept of metabolism, generally defined as the way in which energy and materials are used by systems to keep running and develop. This approach investigates the process of material and energy transformations that are functional to sustain the structure of societies.

Valeria Andreoni discusses how the deceleration of economic growth, that followed the financial crisis of 2008, influenced the energy efficiency, allocation and use of 18 European countries. By using a Multi-scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM), the relationships between energy requirements, economic trends and population are investigated for the years 2008 and 2015. The analyses are performed on three scales viz for the entire society, for the household and for individual sectors like agricultural, industrial and the service activities. Results show that two main groups of countries performed the largest energy reductions, namely - the country most affected by the global financial crisis, such as Greece, Romania and Spain, where the total energy throughput decreased by −19.6 per cent, −15.8 per cent and −12.1 per cent, respectively; and the countries, such as Ireland and United Kingdom, that experienced the largest energy intensity reductions (−38.7 per cent and −19.2 per cent), together with the highest GDP increases (+44.8 per cent and +10.2 per cent). By providing an overview of the relationships existing between varied energy use among different strata of society (Andreoni 2020).

Paolo et al (2016) evaluated a synthetic urban efficiency index (UEI) through modelling of local input and output flows for 904 municipalities of Milan. On the basis UEI and input output model, clustering is used which can be further utilized by planner and policy makers. Research presented an understanding of metabolic profile at regional scale and how the whole urban region shows interesting behavior in terms of production and consumption of easy resources.

Sankey Diagrams: EVSM Sankey generator (II) - A professional software tool, e!Sankey® is used to generating EVSM Sankey diagrams (Figure - 3). This tool is widely used for diverse applications, and it has been considered as an affordable

Fig. 3: Sankey Diagram



option among participated SMEs. The LivLinks® feature allows e!Sankey to use a predefined COM (computer object model) interface to work with data from Microsoft Excel®. Thus, the formatted data layer can be directly communicated with the Sankey diagram which contains Nodes and Links that cross inter wine and have different width. These named after captain Sankey and have been in use since 1800. He first created these flow diagram to visualize steam engine efficiency. These have been in se for mapping out energy, water distribution and flow. Sankey diagrams are also recently used to display web traffic for customers reaction and action through Links, nodes, drop off links and transaction; and may visualize the energy accounts on regional or national level including cost breakdown. Sankey diagrams used in Rotterdam to visualize emissions through construction and demolition (C and D) material waste, and highlighted potential intervention on reduction of dependency on fossil fuel in construction sector, design of buildings for renovation or disassembly rather than demolition. Aside from the two accounting applications above, urban metabolism has begun to develop mathematical models to quantify and predict levels of particles and nutrients within the urban metabolism model. Such models have mostly been created and used by MFA scholars and are helpful in determining present and future sub-processes and material stocks and flows within the urban environment.

The Emergy Method: Developed in 1970's Howard T. Odum, a systems ecologist, wanted to emphasize the dependence on the source of almost all energy on the planet - the sun. Odum believed that previous research and development on urban metabolism was missing and did not account for qualitative differences of mass or energy flows. Odum's study took this into count and he coined the term "emergy" to track and account for the metabolic flows (Table - 2) by measuring the solar energy used directly or indirectly used to make a product or deliver a service. This method also emphasizes the use of a standard unit of measurement

Table 2: Metabolic Flow by Mesuring the Solar Energy

Method	Scale of Application	Remark
LCA	Micro and Meso (Products, Supply Chain)	Model Technological processes and their various impact on environment Socio-economic view, Systematic view.
EEOA	Macro	Model economic sector and their various impacts on environment, incorporates systematic boundaries.
MFA (Exergy/ emergy)	Macro (World, Country Region)	Account for stocks.
Complex System (System Dynamics)	Macro / Meso	Can model market potential, explore relationship between system structure and Market dynamics.
Sankey Diagram	Meso to Micro Level	Carbon Accounting and GHG Emission, Energy input-output.

to calculate energy, nutrient and waste movement in the biophysical system; the unit chosen was "solar equivalent joules" (sej).

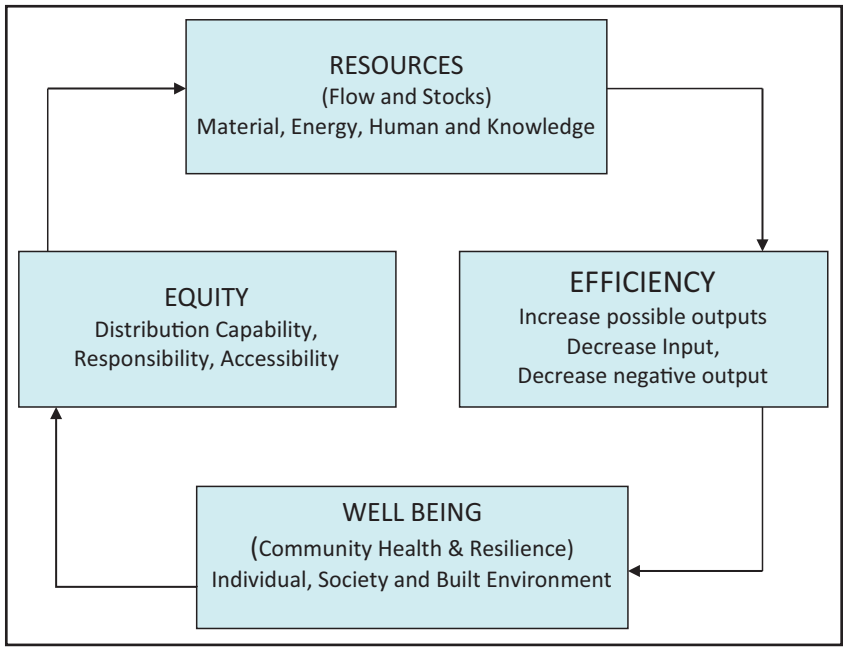
5. APPLICATIONS

Different scholars globally used the UM and CE concepts for various sectors like:

- **Waste to Energy Simulation**: Safe and Environmentally sustainable waste management has been a growing challenge in purview of climate change adaptation. Haraguchi et al, 2020 analyzed nexus of waste management, energy and environment policy for three Metro city, Tokyo, New York and Taipei through WERA Framework. He used Monte Carlo Simulations to stochastically analyze feasibility of Waste to Energy facilities in Urban regions over life time and with Cost- benefit Analysis.
- **Efficiency in Building Material and Resource Use:** Urban Metabolism has gained momentum in recent years, as a tool to assess environmental performance of cities; to point to more resource efficient strategies to urban development. Smart Urban Metabolism (SUM) Model by Shahrokni et al. (2015) provide real time feedback on energy and material flow from level of household to urban district through case of Sweden and Stockholm Royal Seaport through Integrating ICT and smart city Technologies. Urban metabolism has also been used in reconstruction of New Orleans after hurricane Katrina, by john Fernandez and students at MIT with use of material flow analysis to produce more ecological sensitive design for the city.
- Venktask G. et al 2015 suggested framework of assessment of water system using concept of urban metabolism. Study of heat accumulation in pavements and rooftop, and nutrients deposited in soils or waste sites, was the detailed study conducted in urban metabolism. Two key nutrients, nitrogen and phosphorous were studied for Bangkok (Ferge et al. 2001) and Stockholm (burstrom et al, 2003).

- **Risk to Resilience:** UM has power to earmark the causes of increasing vulnerability and inversely point on existing risk and directions to enhance resilience. Kissinger and Stossel (2019) identify and confirm correlation between quality of Urban Metabolism and Resilience of city by equity, efficiency, resource optimization and well-being of community Figure - 2).

Fig. 2: Governance of Urban Metabolism



- Ghiselline et al (2021) claim that implementation of CE at macro level (Table - 3) is about eco-cities, it focuses eco-industrial parks at meso level and adoption of cleaner production and eco-design at micro level.

Table 3: CE at Macro Level

Criterion	Sub - Criterion	Indicator	Units
Land Cover	Urban area	Total value of the constructed area.	Hectare
	Land use	Reconstructed urban areas.	Hectare
	Built Environment	Area of constructed lands.	
	Open space	Green space per capita.	
Water	Water consumption	Water consumption per capita by residential sector	Liter/number/day
	Wastewater production	Water consumption per capita.	Liter/number/day
		Population connected to the domestic sewage network.	Per capita
Air-pollution	Suspended particles less than 10 microns Suspended particles less than Micrograms emissions per year	Direct annual CO2 emissions from the per capita residential sector.	Per capita ton of CO2/SO2/ NiO2
Material	Waste materials	Per capita of solid waste collected per year.	M3 /person/year
		Share of buried solid wastes.	Kg/person/year
	Recycling	Share of recycled waste materials.	Ton

Criterion	Sub - Criterion	Indicator	Units
		Per capita of waste production per year.	
	C and D Reuse	Volume of construction waste materials.	%
Energy	Transportation	Transport Access to the public transport	
	Ratio of renewable energy sources, to total energy consumption	Parking lots availability	
	Energy consumption per capita		KWh
	Energy consumption per constructed area		

6. DISCUSSION

Presently the concept of sustainability in urban planning and policy making has been focusing on urban metabolism mainly through infrastructures for sewage, water, energy, and waste management within the city. Material flow Analysis (MFA) qualifies resource flows by physical weight and volume. It can be conducted on multi-scale providing basis for material flow management and dematerialization strategies on regional and city scale. Urban Metabolism emphasize on goals of resource efficiency, generating opportunities for Circular Economy. In this respect, it's time for both the policy focus and investment shift towards reduction in consumption of raw materials. For example, the consumption of construction materials has been growing exponentially with urbanization, where construction material contributes to 75 per cent of the material which are mostly non-renewable in nature.

Online Material Flow Analysis Tool is a open source tool. Generation of data is very important aspect of the study. Constituents of urban sustainability need to be rethought and re-construed. Asian Development Bank (2014) conducted study of Urban Metabolism of six Asian Cities, Bangalore, Bangkok, Ho Chi Minh City, Metro Manila, Soul Metropolitan Area, Shanghai Metropolitan Area. China has circular economy promotion laws with implementation at three functional levels viz. eco-industrial parks, firms / companies and Municipalities (Yung 2006)

Digitization Efforts (Amico et al 2022) pointed on resource efficiency and circularity achieved in different sectors, viz energy, environment, citizens engagement, etc. In the environmental dimension, digital technologies mainly focus on real-time control of air and soil quality through monitoring systems from an energy point of view, smart grids have improved the management of circularity during failures, malfunctions and maximum power transmission. Initiatives like cloud-connected tracking sensors and smart meters allow administrators to identify any leaks or

failures in public buildings to improve the quality of supply and the capacity for reuse through tracking and monitoring sensors. Digital platforms such as blogs, social networks, and forums to strengthen user engagement in public spaces like libraries, museum, etc.

With the issue of sustainability at the core of many environmental issues today, one of the main uses of Urban Metabolism in the modern era is to track and record levels of sustainability in cities and regions around the world. Material flow analysis can provide a basis for material flow management and dematerialization strategies on a regional or city-scale, and can contribute to the definition of public environmental policies. Understanding drivers of resource flow, including the life styles and consumption patterns, pollution levels, climate change, assessment of their impacts can help understand implication of Circular economy (CE) in various sectors for long term policy formulation.

Urban metabolism collects useful information about energy efficiency, material cycling, waste management and infrastructure in urban environments. Though data collection, synthesis and integration, a very useful information about energy efficiency, material cycling, waste management and efficiency of urban infrastructure may be assessed. Resource flow may be designed to be circular, fossil free and climate positive. Quantification of in and out flow of resources at the product and material level and may guide for de-coupling resources from Economic / GDP growth. Analysis of trends and material / energy flows can be better understood and intervened to connect the loose end in circularity instead of linear. The urban metabolism model records and analyzes environmental conditions and trends which are easy to understand by policy makers and consequently over time making it easier to find unhealthy patterns and develop a plan of action to enhance the level of sustainability and prioritize technologies to support circular economy, by identifying clusters of exchange., which in turn will reduce the eco-footprint of cities.

7. CONCLUSIONS

UM can be seen as metaphor for the flows and stocks of goods and services through the city network. Unsustainable consumption of resources is one of the society's major challenges today, which has been highlighted by Sustainable Development Goals particularly SDG - 11 and SDG - 12. Former aims to make cities and human settlement inclusive, safe, resilient and sustainable, later aims to ensure sustainable consumption and production patterns. In this purview, urgent actions are required to make urbanization sustainable and curb over extraction of resources and degradation of environment, it is very essential to assess the impact of each and every development, in it's scale, features,

constituent components and their eco-footprint through material flows back to environment.

UM has power to earmark the causes of increasing vulnerability and on existing risk and inversely point on directions to enhance resilience. Circular Economy and Urban Metabolism both have been centered on a paradigm from an unsustainable, wasteful linear model, to one that is more closely looped symbiotically. By exploring fluxes of energy and resources, it is possible to focus on geographies that go well beyond traditional metropolitan and city boundaries, linking rural-urban as well global-local networks. Circular solutions are understood to replace existing linear solutions involving different stakeholders at corresponding level, with idealized solutions to reduce raw inputs to system and waste emission output from the system.

Sustainability is created if urban development is such that the rate of resource utilization is not more than the rate of their regeneration. In order to achieve stability in the cycle of urban metabolism, it is necessary to establish a balance between it's input and output, and also, it is required to achieve this balance by paying attention to the proper functioning of the urban systems. Positive results reveal that there is no balance between input and output of the urban metabolism model in the study area, and the main problems are evident in the output sectors, especially in the material and water recycling sector. The goal of urban sustainability is to reduce the use of natural resources and decrease waste production to improve its livability and not only the consumption of natural materials in the area in terms of energy, water, and food, but also the amount of waste generated, if ineffective for reuse cycle.

Bryto et al (2012) stated the critical perspective on urban metabolism to open up new ways of conceptualizing cities through social relations and flow of resources calling for structural transformation organizing flow of material, energy and people. Finally, the general measures that can be taken to improve the metabolism of city could be expressed as follows:

- Optimizing energy consumption, maximizing energy efficiency, maximizing the share of renewable energy sources, and using clean energy in the public transportation;
- Development of green spaces and paying attention to their extent and distribution in the area, renovation of old structures, and non-destruction of buildings until they are completely out of service;
- Brown field development and changing the industrial uses to green uses and mixed residential-commercial areas;

- Minimizing water consumption, minimizing damage to the natural water cycle, optimizing water recycling, and reuse; and
- Minimizing waste production, optimizing material recycling, proper use of recycled materials for consumption and energy production, and minimizing land filling.

Participatory Metabolism is another recent development shifting from top down to bottom up approach, in which co-design (Sven Eberlein 2018) can take place in collaboration with society not for society. Communities can be more resilient, equitable and ecologically healthy settlements by adopting participatory metabolism. Neighborhood metabolism diagram co-evolved become guide to help community as well planners to make informed decision about how to redirect flows from linear to circular.

In summary, research highlight the following key points - first Urban metabolism can be effectively undertaken through deployment of real-time digital technologies ie. Sensors, cloud computing, AI, augmented reality, IOT and other ICT measures; second environmental impact of using mobility options, materials choice, construction technology, processes, and urbanization can be monitored, regulated and controlled through real time data capturing and analysis. Though it is required to generate awareness and participatory engagement about concept of metabolism and circularity of cities, development should induce Clean Urban Technology (CUT) in order to improve the resource effectiveness and quality of urban footprint. Needs of the poor can be simultaneously addressed while ensuring circularity through systematic interventions. Digital monitoring of urban metabolism can help to understand and assess increasing vulnerability or decreasing resilience of the settlement as an impact of development policy.

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Sustainable Solutions for Global Peace and Prosperity: The Vedic Village and City Planning

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Abstract

In the light of the Vedic sciences the causes of the distressing climate change, pollution, pandemics like COVID-19, violence in the form of wars and terrorism, and personal and social problems are - the combustion of petroleum products; the disposal of sewage and industrial waste into water; the release of inconsistent vibrations into the atmosphere; unlimited and over populated towns and cities; and heavy machinery. Living in self-dependent, properly sized villages surrounded by forests, the use of animal powered small machines, and the man of character (via Vedic education) will solve all these problems. Air and space travel, self defence and medicine can still be achieved with the environmental friendly Vedic science and technology. The paper argues that this is the only sustainable solution to global peace and prosperity and not the solar power and electric vehicles.

1. INTRODUCTION

Global warming is clearly visible by the use of fans in traditionally cold regions, the melting of glaciers and increasing wild fires. Cyclones and heavy rains are occurring at improper times. Many regions are having rains much less than the normal. According to the Inter-governmental Panel on Climate Change, 2019, the climate change is impacting men, animals, birds, and sea creatures (United Nations - Climate Change Poses a Threat to our Oceans, 2021) alike. Shortages of drinking water and healthy food, air and water pollution, and various diseases such as blood pressure, diabetics, mental stress, etc., have become common. Every day men, women, and children are being killed by wars, terrorists, road accidents, and viruses like COVID-19. Scientists are alarming us for the dooms day (The Doomsday Clock Announcement, 2020). Distressed humans want to abandon this earth and go to Mars (Simon Worrall, 2018). This will be the pursuit of a brainless coward. The intelligent and brave would like to find the causes and solve the problems.

In this article the main causes of climate change, pollution, pandemic, violence through terrorism and wars, and personal and social problems have been highlighted in the light of the Vedic sciences. Then, it has been shown that *Vedic* village and city planning with animal generated power along with man of character solve all these problems. Air and space travel, self defence and medicine can still be achieved with the environment friendly *Vedic* sciences and technology. In the end, it has been concluded that this is the only sustainable

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solution to global peace and true prosperity and not the solar power and electric vehicles.

2. THE VEDIC SCIENCES ON THE CAUSES OF CLIMATE CHANGE AND POLLUTION

The main causes of climate change and pollution are discussed in this section, in the light of the Vedic sciences.

2.1 Causes of the Climate Change

Global Warming: More than 100 million barrels of petroleum products are being consumed daily in the world (The International Energy Agency - Oil Information, 2019). Most of these i.e. around 2/3 portion are burnt as petrol, diesel, aviation fuel, etc., in cars, trucks, ships, and aeroplanes. One litre of petrol or diesel liberates around 35 MJ of energy on complete combustion (ACEA, 2016). All of it directly in the form of heat or indirectly in overcoming friction / drag goes into the atmosphere. Therefore, every day, (2/3) x $100x10^6$ b x 159 l/b x 35 MJ/l = 37 x 10^{10} MJ of energy is being released into the atmosphere. This is equivalent to 89 mega ton of TNT or 5,911 Hiroshima bombs being exploded daily (Wikipedia – TNT, 2020). Thus, the atmosphere is getting warmer every day. Our earth is not directly open to space to dissipate this amount of heat. It is surrounded by dark matter as per the *Vedic* sciences (Mangla, 2018; Charles, 2009). Therefore, the Earth's temperature has risen by 0.08^0 C per decade since 1880, and the rate of warming is more than twice that is 0.18^0 C per decade since 1981. Year 2020 was the second warmest year on record for the globe. (NCEI_NOAA: Annual 2020 Global Climate Report). For 2020, the average temperature across globe including land and ocean surface was 0.98^0 C above the twentieth century average. The melting of glaciers (Figure - 1) and the increase in wild fires (Figure - 2) are the direct result of global warming.

Fig. 1: Melting of Glaciers

Source: NASA Climate 365

Fig. 2: Yes, Climate Change is driving Wild Fires

Source: unep.org/…/Yes -climate…- 2.10.2020

Excessive Use of Oxygen: One litre of petrol or diesel requires 2.2 to 2.6 kg of oxygen for complete combustion (Rogers and Mayhew, 1992). One hundred million barrels of petroleum products consume more than (2/3) x 100 x 10^6 x 159 x 2.2 = 2.33 x 10^{10} kg of oxygen daily. The trees, with the continuous reducing forest cover, cannot compensate for this loss, especially in the polluted local areas. Though the global oxygen level on 15 November, 2021 was 0.06 per cent less than that on 13 December, 1990 (oxygenlevels.org), it has adversely affected the ozone (O_3) layers in the atmosphere and the dissolved oxygen in water in the oceans. High intensity of the sun rays in winter, at least in Faridabad, Haryana, India, points towards this change. Though the scientists consider the air pollution (halogens) responsible for the ozone depletion (britannica.com, Ozone depletion), the oxygen concentration in the atmosphere also affects it. The nature wants to keep the oxygen level in the atmosphere almost constant for the safety of it's inhabitants. The loss of oxygen in the atmosphere is compensated by the oxygen in the oceans or the ozone layer. Ozone (O_3) is basically oxygen (O). As a result of holes in the ozone layers, many processes taking place in the environment are getting distorted. Harmful rays come to the earth's surface. Cyclones and untimely rains are the result. Reduced level of oxygen in water leads to the destruction of marine life (nationalgeographic.com, Oceans are Loosing Oxygen). Breathing has become difficult in polluted towns and cities due to lack of oxygen. That is why *Veda* tells: 'My life breadth (*Prāna*) may not be afraid of' (Atharvaveda (Śaunaka) Samhitā, Kāndam 2, Sūktam 15).

Air Pollution: Combustion of petroleum products leads to the formation of toxic gases like CO, NO, SO_2, etc. A person standing near a petrol or diesel vehicle can sense it. One can imagine the scale of air pollution when sixty seven million barrels of petroleum products are being burnt daily. Life has become unbearable in a city like Delhi. The air quality index at 3 PM on 14 November, 2021 in Pusa, Delhi was 187 AQI (aqicn.org). It should be 0-50 AQI for healthy air. Breathing, heart, and brain diseases have sprung up (World Health Organisation, 2018). Polluted air also affects the trees (Encyclopedia of the Environment, 2019). Therefore, Lord Manu says: "Do not throw *amedhya* into fire" (Manusriti, Kullukbhatt, 1983 – 4.53; Śrīman-Manusmritih, Purified, 2020 – 3.66).

Petroleum is amedhya because its products on combustion generate amedhya gases. Therefore, combustion of petroleum products, even on a small scale, in a reciprocating jet engine, etc., is not virtuous i.e. sin.

Pollution by Electromagnetic Waves and Vibrations: The sound of a horse gallop - 'tap- tap' is pleasing. The sound of a scooter or truck engine is harsh. The unpleasant sound waves and vibrations adversely affect the environment

(Australian Academy of Science, 2017). The microwave frequencies used for communication through mobile phones, etc., is also harmful (Donald I. McRee, 1972). It is instructed by the seer Patanjali (Vyākarana-Mahābhāshyam, 1962) "The use of incorrect words (non - Sanskrit words) is non-virtuous" (Paspaśāhnikam-2). The selected Vedic terminologies used in this paper are given in Box - 1

Box 1: Selected Vedic Terminologies

1. Agnihotra: A short yajnya that is performed daily at sunrise (or before sunrise) and at sunset.
2. Amedhya: A substance that destroys intelligence and blocks the nervous system.
3. Āyurveda: A branch of Vedas that deals with long living (health, diagnose of diseases, and cure).
4. Chāpa (bow): A unit of length measurement equal to the length of a bow (= 4 hasta = 8 ft, Samarāngana Sūtra Dhāra).
5. Dhanurveda: A branch of Vedas that deals with weapons and warfare.
6. Dwija (twice born): A person who has studied at least one Veda following rigorous Vedic procedures of Brahmacharya Āshrama (student life). He follows the Vedic rules (like Agnihotra, etc.) as a house holder (married life).
7. Gavyūti: A unit of length = 2 krośa (Samarāngana Sūtra Dhāra).
8. Krośa: A unit of length measurement = 1000 Chāpa (= 8000 ft, Samarāngana Sūtra Dhāra).
9. Mahābhāshyam: A commentary on Pāninīya Grammar (Ashtādhyāyī) by the great seer Patanjali.
10. Manusmriti: The extract of Vedas for righteous actions preached by Lord Manu. The Manusmriti available at present (Manusmriti – Kullukbhatt) is highly adulterated. Attempts are being made to purify it (Śrīman-Manusmritih – Purified, Niranjan Lal Mangla).
11. Samarāngana Sūtra Dhāra: Text on Vedic town planning / architecture and machines (edited by Mahārājādhirāja Śrī Bhojadeva).
12. Srīmad Vālmīkīya Rāmāyanam: It depicts the character of the great king Rāma. It was written by the great seer Vālmīki. It shows the Vedic virtues put in practice.
13. Vaiśeshika Darśanam: Vedic physics and chemistry compiled by the great seer Kanāda. Praśasta Pāda Bhāshyam is a commentary on it by the great scholar Praśasta Pāda.
14. Vedas: Eternal knowledge revealed by God. Vedas are the oldest texts of the world. They are divided into Rigveda, Yajurveda, Sāmaveda and Atharvaveda. Each has several branches. Their commentaries (Brāhmanam) by the great seers are also part of Vedas
15. Yojana: A unit of length = 4 krośa = 4 x 2.44 km.

The waves and vibrations generated by the use of Sanskrit words are in tune with the environment and the structure of the universe: '(Lord Brahma) created

separate names, functions and institutions from the words of Veda' (Manusmriti, Kullukbhatt – 1.21; Śrīman Manusmritih, Purified - 1.10).

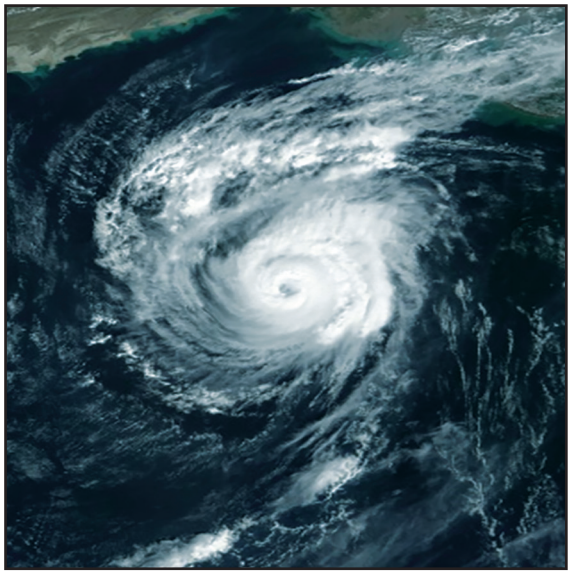
In this regard the wave nature of matter (Halliday, Resnick, and Krane, 1994) is worth seeing. The waves and vibrations generated by the use of non-Sanskrit words (macro or micro - starting from the engine noise till 5G) produce an adverse effect. The excessive use of electro-magnetic waves for telecommunication (mobile phones, internet, etc.) creates havoc.

Water Pollution: The main reason for water pollution is the discharge of excreta, industrial wastes, etc., into water. Around eight liters of water are used in one time use of flush in the toilet. Around five liters of water are used for one time urination. A man uses toilet at least once and urinates around five times a day or 24 hours. He uses 1 x 8 + 5 x 5 = 33 liters of water daily. Even if, half the population of India uses flush toilets, $(1.36 \times 10^9/2) \times 33 = 22.4 \times 10^9$ liters of water are being used and polluted daily. The water, used for bathing and washing, is also mixed with this dirty sewage water. Thus, one can see the dirty foul smelling streams flowing on the outskirts of towns and cities every where in India. These then fall into the main rivers and oceans. One feels ashamed of the dirty Yamuna River near Delhi or the sewage water streams falling into the Ganges near Varanasi. All the river water gets polluted.

Common man receives polluted sewage water in the rivers instead of the invaluable Himalayan water. Sewage treatment plants cannot purify water completely. Subtle toxic particles still persist. Therefore, the pure drinking water is getting scarce. Sufficient water is not available even for common use. Contaminated water used for irrigation contaminates food. Hence food is generating diseases. Intelligence, to differentiate right from wrong, is deteriorating. Polluted water contaminates the soil and even the air after evaporation. There is deterioration of the environment (Science Aid, 2019). Therefore, Lord Manu says: "Do not discharge urine or faeces or spit into water, anything stained with amedhya, blood or poison (into water)" (Manusmriti, Kullukbhatt - 4.56; Śrīman-Manusmritih, Purified - 3.67).

Chemical Fertilizers and Pesticides: As per the Food and Agricultural Organization of the United Nations, the world consumption of the three chemical fertilizer nutrients i.e. Nitrogen, Phosphorous, and Potassium is estimated to reach 200 billion kg (Food and Agriculture Organization of the United Nations, 2017). This degrades the soil and pollutes water, air, and food (Serpil Savci, 2012). Similarly chemical pesticides are being used in large quantities. They are endangering the environment and the health.

Fig. 3: Cyclone-maha-4.11.2019



Source: https://worldview.earthdata.nasa.gov

Deforestation: Deforestation and forest degradation continue to take place at alarming rates, which contribute significantly to on-going loss of biodiversity. Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year (Food and Agricultural Organization of the United Nations – The State of the World's forests 2020). This has a serious impact on the environment (World Wild Life- The Effects of Deforestation, 2021). Forests are a great carbon sink and emitters of oxygen. The increasing number of cyclones (Figure - 3), extra ordinary heat and cold and the untimely heavy rains are signs of climate change.

2.2 Causes of Pandemics, Violence, Personal and Social Problems

Causes of Pandemics and Other Diseases:

Pollution of the environment and climate changes are responsible for various infectious diseases (World Health Organization - Climate Change and Infectious Diseases, 2020) like - Corona virus and other diseases. Insects, worms and viruses breed in dirty water and polluted air and space. Climate change stimulates their growth. The immunity of living creatures decreases with climate change and unhealthy environment. It is clearly mentioned in Āyurveda: 'Due to the result of the bad actions of men (Adrishta) the distorted winter, summer, winds, and rains distort the food grains, herbs and water. Their use results in various diseases or pandemic' (Suśruta, Sūtra-sthānam 6.16, 17).

Thus, even organic and pesticide free food and mineral water are not going to help us because the food grains, vegetables, and water lose their inherent germ fighting potentials due to climate changes.

Though it is a matter of investigation, it appears that the abundance of electro-magnetic waves being used for telecommunications is also helping in the generation and nourishment of the viruses like Corona. Veda tells: 'The sun, which is visible to all and is reaching the invisible, is rising in the East and is killing the visible and invisible germs and thus removing all of them' (Atharvaveda Śaunaka) Samhitā 5.23.6).

The sun rays i.e. electro-magnetic waves are not probably killing germs these days because of the hindrance by so many man made electro-magnetic waves used for

telecommunications such as 4G and now 5G. Absence of physical exercise further leads to decrease in immunity to diseases. Thus, diabetes, blood pressure, sugar, etc., has become common.

Causes of Violence in the World: The cruelty towards nature (a non-virtuous act or sin) by human beings indirectly generates violence. Lord Manu says: "A non-virtuous act is not immediately fruitful … . It slowly returns back and cuts the roots of the sinner" (Manusmriti, Kullukbhatt - 4.172; Śrīman-Manusmritih, Purified - 3.85).

Therefore, there were 40 million casualties in the First World War (Wikipedia: World War - I Casualties) and 80 million casualties in the Second World War (Wikipedia, World War - II Casualties). Let there be no third world war with God's grace. Many people are being killed by terrorists world over (BBC News, 2019) and accidents every day. Approximately 1.3 million people die each year as a result of road traffic crashes. Between 20 – 50 million more people suffer from non-fatal injuries with many causing disability (WHO - Road traffic injuries, 2021). Now, the viruses like Corona are killing us. There were 249 million confirmed cases of COVID-19 including more than five million deaths as of 8 November 2021 (WHO – Coronavirus, 2021). Atomic war is frightening the world (International Committee of the Red Cross (ICRC) – Nuclear weapons an intolerable threat to humanity, 2018; (Figure - 4). The violence of pollution towards the environment and humanity (abortions) indirectly generates violence.

Fig. 4: Nuclear (Badger-18.4.1953) Explosion

Source: https://en.wikipedia.org/nuclear_explosion

Causes of Personal and Social Problems: Power operated heavy machinery (i.e. industrialization, this indirectly includes automated machinery and computers) has thrown the hand skilled labour out of job (Park Young Jin, 2008; Michael A Peters, 2016). Jobless or under paid villagers, migrated to cities, are facing all the problems.

Oversized and over populated towns and cities have generated many personal and social problems like shortage of housing, availability of healthy and nourishing food like milk, grains, vegetables, etc. Distance from the natural environment has given rise to mental stress, anger, greed, etc. Insecurity, social problems like theft, oppression of the women (eve teasing, rape, extra

marital relationship, etc.) and many other crimes (John Braithwaite, 1975) have come into existence. Reasons are that the residents live in oversized and over populated towns and cities lacking intimacy and personal contacts. Administration and control are also difficult. The causes of the problems of orphans and widows are accidents, wars, diseases and terrorism. The problems of the aged persons (as is clear from the old age homes all over), corruption and rent seeking (which is hollowing the nations) are due to the absence of the men of character.

3. THE VEDIC VILLAGE AND CITY PLANNING

3.1 Living in a Proper Sized Village with Forests

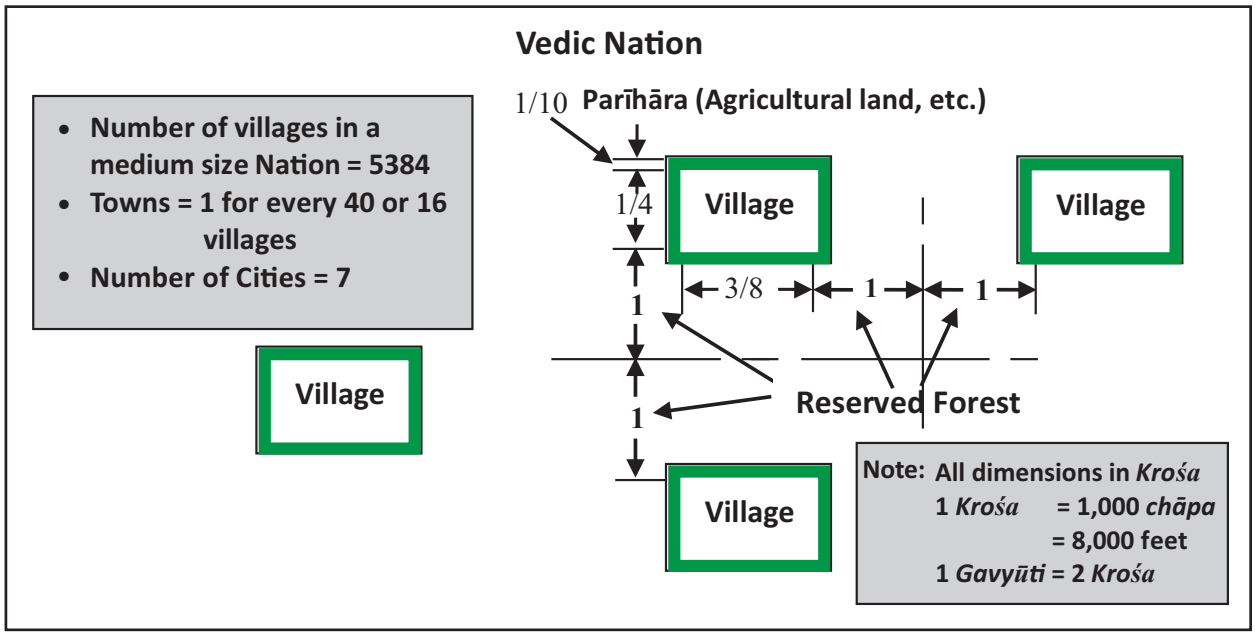
As per Samarāngana Sūtra Dhāra, Lord Vishwakarmā verse tells

1. 'Comforts, riches, special achievements, and offsprings are always dear to the people. Everything should be well designed to achieve it';
2. 'The width of the large city is desired to be 4,000 chāpa, the medium i.e. 2,000 chāpa, and small 1,000;
3. Area of each (city) should be in the form of a rectangle whose length is 1/8th, 1/4th, or 1/2 greater than the width respectively;
4. The division of a city has been suitably told. The diagonal of a town is said to be half of that of a city; (the diagonal) of the village is half of that of a town;
5. A town should be a yojana from the city and so should be a village from the town. One village should be one gavyūti from a village; and
6. A middle size nation is said to be five thousand and three hundred and eighty four villages. (Samarāngana Sūtra Dhāra 1.2; 10.2, 3, 79, 80, 84).

Explanation of Verse - 1 is clear. The sizes of a village, town, and city are well defined. A city cannot be larger than the large city mentioned above and a small village cannot be smaller than the small village mentioned above (Verse - 2, 3, and 4). There is sufficient forest cover around each village, town, and city (Verse - 5). The size of a medium nation is also defined in Verse - 6. A large nation comprises of nine thousand, one hundred and fifty four (9,154) villages. A small nation consists of one thousand, five hundred and forty eight (1,548) villages (*Samarāngana Sūtra Dhāra* - chapter 10). A medium nation has seven cities. A large and a small nation also have seven cities each (*Samarāngana Sūtra Dhāra* - 10.87). Number of towns is also less. There is one town for every 40 or 16 villages as one can infer from Verse - 5. Hence there is abundance of villages in a nation (Figure - 5).

As per "Samarāngana Sūtra Dhāra", the size of a village (small) is 2000 x 3000 ft^2 (Verses - 2, 3, and 4). There is a forest cover of two krośa (16,000 feet = 4.88

Fig. 5: Dimensions and Surroundings of a Small Village



km) all around the village (Verse - 5). There is *parīhāra* (Manusmriti, Kullukbhatt – 8.237; Śrīman-Manusmritih, Purified – 6.164) of 1/10 krośa (800 feet). Parīhāra is reserved land for agriculture, etc.

Question arises – how the population (say in India) will be accommodated with such a large forest cover around each village? Be assured, population will be accommodated. Let us take the example of India. Area of India is 3,287,263 sq km (Wikipedia - Geography of India, 2020). Let us leave one fourth of it for rivers, uninhabitable mountains, and dense forests, etc. Left over is 2,465,447 sq km.

The area occupied by a small village along with the forest cover is (8000 x 2 + 2000) x (8000 x 2 + 3000) = 342 x 10^6 sq feet = 31.7718 sq km (Figure - 5 and Box – 2).

Box 2: Population of a Small Village

The area of a village = 2000 x 3000 sq feet (Fig. 7). Let us leave one third of this area for roads, sports, culture, and other public facilities.

Left over area = (2000 x 3000) x 2/3 = 4 x 10^6 sq feet = 444444.4 sq yd.

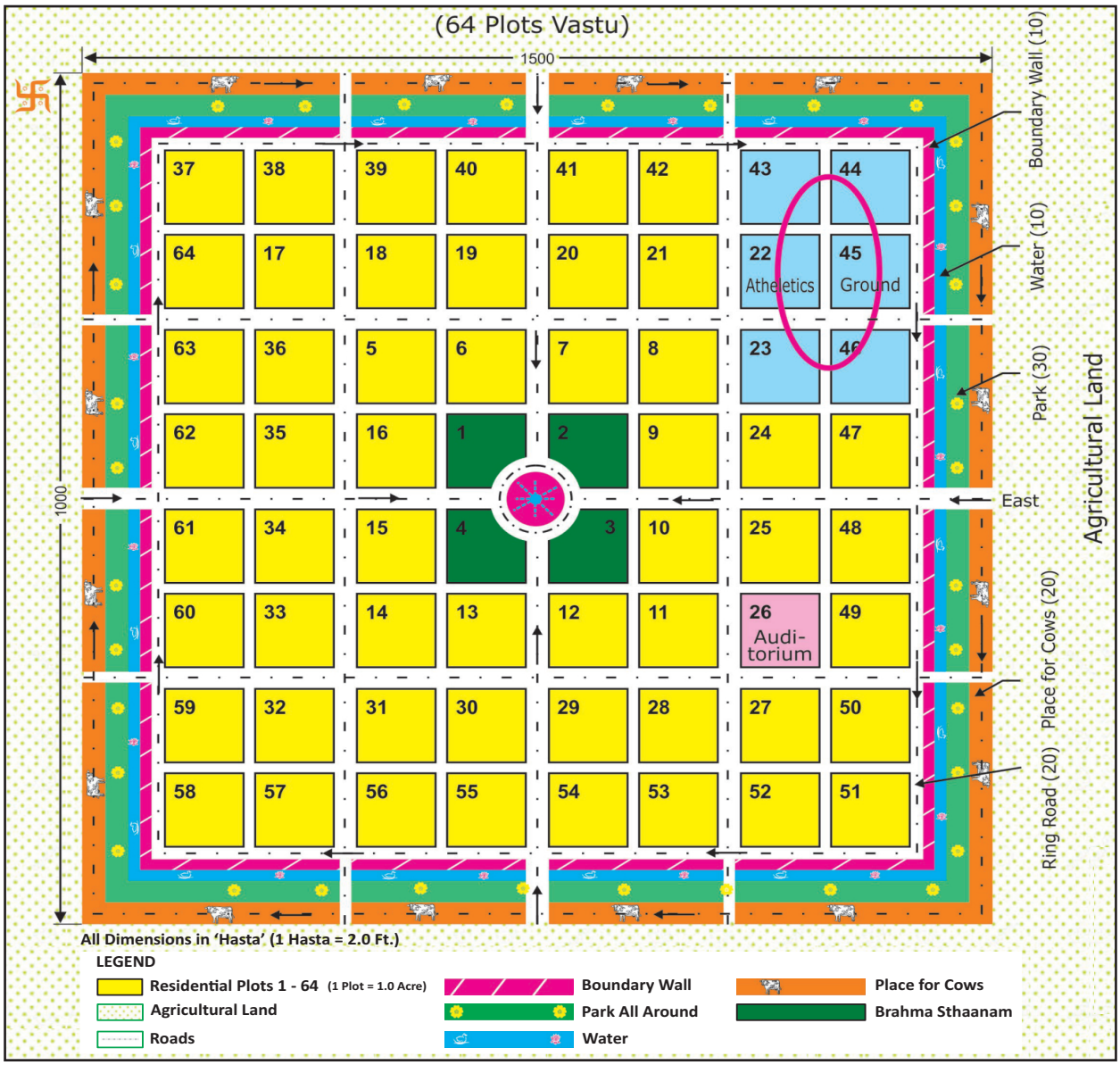
Number of 250 sq yard plots = 444444.4 / 250 = 1777.

Twelve (12) people (including children, women, and elderly people) can easily stay in a two storied building in a 250 sq yd plot.

Total number of people who can be accommodated in a village = 1777 x 12 = 21324 > 21,000.

Number of villages possible in India is equal to 2,465,447 / 31.7718 = 77,598. The number of people who can comfortably stay in a village (2,000 x 3,000 feet^2) with two storey buildings is 21,000 (Box 2). Total number of people who can be accommodated in the whole of India = 77,598 x 21,000 = 1.63 billion. This is greater than 1.34 billion, population of India in 2018 AD (The World Bank – world development indicators, 2020). Two times the present population can be accommodated by using medium size villages as mentioned in Verses - 2 and 4. In fact, the present population is itself unnatural. Similarly, population can be accommodated all over the world. The Vedic village is not like a present day

Fig. 6: Layout of the Vedic Village



Indian village. Its layout is better than that of a modern city sector (Figure - 6) *Samarāngana Sūtra Dhāra* - 10.4 – 79). One can easily refer to *Samarāngana* Sūtra Dhāra for details of the construction of the houses, roads, etc.

The Vedic town is similar to a Vedic village except that it's area is four times the area of the village as mentioned in Verse - 4. There is a forest cover of 9.76 km around it (Verse - 5). There is one town for every 16 or 40 villages as stated above. A Vedic city is similar to a Vedic village except that it's area is sixteen times the area of the village (Verse - 4). There are only seven cities in the nation as stated above. Thus, there is abundance of villages in a Vedic nation. This is also supported by the following verse of the Lord Manu: "(The king should) appoint the head of a village, the lord of ten villages; head of twenty, head of hundred and the lord of thousand villages." (Manusmriti, Kullukbhatt – 2.104; Śrīman-Manusmritih, Purified – 2.48). The above verse is also a golden rule for the control or administration of a nation.

The sizes of the Vedic village, town and city are well defined. A village cannot be smaller than the size shown above and a city cannot be larger than the size mentioned above. The sizes of the nations are also well defined. A nation cannot have less than 1,548 villages and more than 9,154 villages as explained above. This is required for the proper management of resources and subjects. The management of the present day over sized nations is tough. Resources are not optimally used in an under sized nation.

3.2 Solutions to Pollution and Climate Change

Use of Animals (oxen and horses) Power

Twenty one thousand (21,000) oxen and five hundred (500) horses can be supported by the forest measuring 30.2 sq km around the village. There will be around five thousand oxen. Two oxen can easily provide 10.9 KWh in one day (Box - 3). Hence, 5,250 oxen can provide 28.6 MWh of energy in one day. This is equivalent to more than 1 MW power plant. This much energy is sufficient for a village of population 21,000 with reduced energy requirement. It is not necessary

Box 3: Work done by Two Bullocks

Two normal bullocks can easily pull a bullock cart laden with 20 sacks of grain (each sack weighing 100 kg) for 10 km in one day (say 8 hours).

Taking effective coefficient of rolling friction between the steel rim of the wooden wheel of the cart and the unmetalled road to be 0.2 (Raghavan and Nagendra 1979), the work done:

= 0.2 x (20 x 100) x 10,000 kgf m*
= 0.2 x (20 x 100) x 10,000 x 9.81 Joules = 39.24 x 106 Joules
= 39.24 x 106 / (1000 x 3600) kWh (kilo watt hour) = 10.9 kWh (Box - 4).

* Neglecting the weight of the bullock cart. Work done will be more if that is also taken into account.

Box 4: Abbreviations Used

b	-	Barrel (158.9 liters)	MWh	-	Mega Watt Hour
kWh	-	Kilo Watt Hour	Mt	-	Mega Ton
MJ	-	Mega Joul (106 J)	O2	-	Oxygen
MW	-	Mega Watt	O3	-	Ozone

to generate this much amount of electricity. The oxen will run small machines for the blacksmith (machinist), for lifting water for irrigation, for grinding, rolling, and agriculture, etc. They will also carry loads in carts, so trucks are not required. The oxen can be used for tilling land, so tractors are not required. Chariots run by horses will be the intelligent cars for carrying people from one place to the other. In this way all essential works can be accomplished by animal power and small machines.

An ox or horse needs much less oxygen as compared to a car or truck for the same payload. The carbon dioxide released by them is easily accepted by the plants.

Reduced Energy Requirement

The ban on tractors, trucks, cloth mills, and earth moving machines will enable all the villagers in getting jobs for their livelihoods in the village. For example – cobbler, earthen potter, barber, mason, weaver, blacksmith, metal potter, goldsmith, tiller, gardener, forester, guard, physician, administrator, businessman, teacher, carpenter, chariot maker (due to the use of bullock carts, chariots, etc.), engineer, leaf plate makers (due to ban on plastic plates), laborers, etc. Most of them will be working from their homes and the houses will be suitably designed. The length of the small size village is around 750 m (Figure - 5). Thus there is no need to travel to a distant place via scooter or car for work. Lot of time and energy, wasted in travel in a modern setup, will be saved.

Small scale industries will be there in almost every house. Animal power will be used as required. Medium size industries will exist in towns. Large scale industries with heavy equipment are non-virtuous (Manusmriti, Kullukbhatt – 11.63; Śrīman-Manusmritih, Purified – 7.9). Cool, moist, and fresh air will be obtained from the forest all around the village. There will not be any requirement for air-conditioning with green conservative buildings. Thus energy requirement will come down drastically.

Thus, the use of horses for travel, the use of oxen for carrying goods, animal powered small scale industries, and the reduced requirement of energy will ensure that petrol and diesel are not needed. Hence global warming, excessive use of oxygen and air pollution will cease to exist. In fact, there will be abundance of oxygen due to the large number of trees in the forests. Engineering; ships for oceans; air and space travel; and distant communication can still be achieved with environmental

friendly Vedic sciences (Vaiśeshika Darśanam) and technology (Rasāyana Śāstra – Kheychari Gutikā, Samarāngana Sūtra Dhāra) as explained ahead.

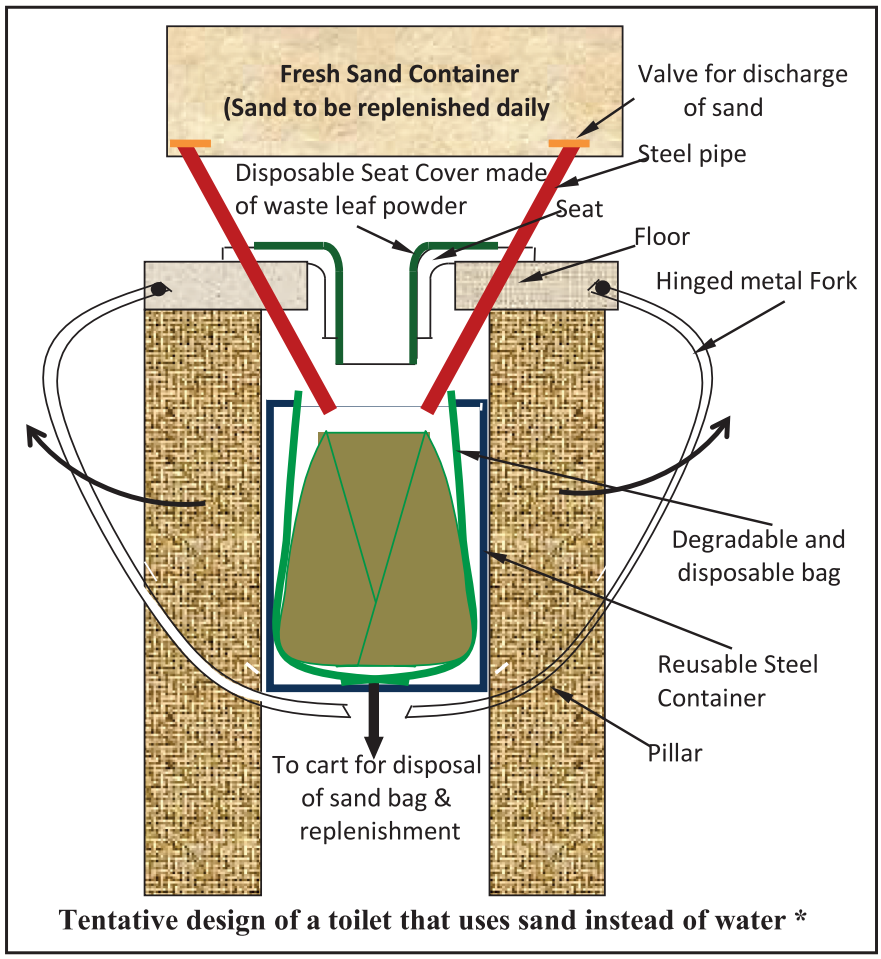
Space Free of Inconsistent Vibrations

The need for mobile phones will drastically come down due to the limited size of the village, absence of travel to distant places for work, and small scale industries with localized marketing. Therefore, high frequency microwaves used for communication will not be released into the atmosphere. Shrill sound waves and vibrations will be absent due to the absence of petrol and diesel engines and jet engines in the skies. Thus, the atmosphere will be free of inconsistent vibrations.

Conservation of Water

Use of Sand in Toilets: The limited size of the village measuring 2,000 x 3,000 feet will make it easy for the inhabitants to go outside the village for toilets and bathing. There will be toilets outside the village. Sand will be used in the toilets instead of water flushes (Figure - 7). Dirty sand with excreta will be dumped into ditches and it will turn into manure around a month. It can be used to enrich agricultural land. There will be beautiful wells, ponds, and lakes outside the village for bathing. This was the practice in olden times. The villagers will have a healthy walk and daily contact with nature while going outside the village for their morning duties. Breathing exercise *(prāṇ*āyāma*)* will automatically be done. This will keep the inhabitants physically fit. Water used for bathing

Fig. 7: Tentative Design of a Toilet using Sand instead of Water



will be soaked locally by the land around the well. In the absence of the use of water flush in the toilets, misuse of water and its contamination by excreta will be avoided. The Yamuna, the Ganges, other rivers, lakes, seas, and oceans will not be polluted in the absence of sewage water being drained into them. The little waste water in each household in the village will be used for irrigation of the jungle outside the village.

Forest Cover on both Sides of the Rivers: The river is also an entity like a village or city. There has to be a reserved forest cover of one *krosh* i.e. 2.44 km on both sides of the river. Thus, the river will not dry up or get polluted by the villagers. Pure herbal Himalayan water will be available in plenty for drinking in the Yamuna and the Ganges. Similarly the other rivers of the world will be preserved.

Timely Rains: The yajnya will bring timely rains. The rain water will be used for the crops. Thus, tube wells will not be needed. Tube wells have lowered the ground water level. The wells and ponds in the villages are drying (Causes and Implications of ground water depletion in India: a review - Dangar, Asoka and Mishra, 2021; U.S. Geological Survey – Ground water Decline and Depletion, 2021). The ground water level will not decline in the absence of the tube wells. The land will remain wet. Drinking water will be available in abundance.

In this way, water pollution and its misuse will be avoided. Plentiful water for drinking, irrigation will remain available throughout the year.

Organic Fertilizers and Pesticides

Every village has 21,000 cows (he and she). The cows' dung and cows' urine will generate lot of organic manure or bio-fertilizer. Sand will be used in toilets as explained above. This will also give a lot of natural manure. Chemical fertilizers will not be needed and thus, soil degradation will not take place. Similarly organic pesticides will be used. They will protect crops from any ill effects on the environment and the health of the living beings.

Forestation

There is a reserved forest cover of 30.2 sq km around each village (Figure - 5) and 2.44 km wide reserved forest cover all along both banks of rivers. A Vedic nation or nations are supposed to have an extra virgin forest (Dandakāranyam). Thus, there is abundance of forests in the Vedic nation. This keeps maintaining a healthy environment.

3.3 Solution to Pandemics and Other Diseases

With the conservation of land, air, water and space, the environment will be preserved in its natural state. Pollution will no longer be there. The climate

change will disappear due to the absence of environmental pollution. The infectious diseases like corona and others will vanish due to clean and healthy environment. The daily morning walk for toilet and bathing of the inhabitants to outside the village will keep away their mental stress and common diseases like diabetes, blood pressure, sugar, etc.

3.4 Solution to Violence in the World

Absence of violence towards the environment will lead to the absence of violence towards mankind in the form of wars or terrorism or pandemics. In the absence of the daily movement to distant places for jobs, road accidents will come down. The conflict and violence between communism and capitalism will come to an end due to the absence of large scale industries, decentralization of money and the presence of the men of character. There is only one set of human values for all human beings i.e. the Vedic virtues (Fountain Head of Religion, Ganga Prasad Upadhyaya, 1909). Some of the Vedic virtues are Yamas - nonviolence, speaking the truth, to abstain from stealing, celibacy for unmarried and timely mating of the married, non-hoarding; Niyamas – Cleanliness, satisfaction after putting in all efforts; tapah – bearing heat and cold while carrying out the virtuous acts, meditation, and firm belief in the almighty. Vedic virtuous person or the ārya has to abstain from drinking wine, adultery and abortion. The conflict and violence between various religious sects will end with the Vedic education. Fifteen million abortions were accessed during 2015 in India (The incidence of abortion and unintended pregnancy in India, 2015, Susheela Singh et al). Abortion is a big terrorism against humanity (Great sin: Manusmriti, Kullukbhatt – 11.87; Śrīman-Manusmritih, Purified – 7.14). It will end with the Vedic education.

3.5 End to Chemical Pollution

The disposal of Chemical Wastes (during manufacturing and after use) into air, water and earth is a growing peril and potential catastrophic risk to the environment and humanity (Ravi Naidu and Robert John Aitken, 2021). This chemical pollution will come to an end due to the absence of the petroleum products, the chemical fertilizers, pesticides, chemical drugs and the use of natural organic paints.

3.6 Solution to Personal and Social Problems

Dwelling in a proper size village surrounded by forest and the close proximity to nature will keep the mental stress out. Anger, greed, etc., will decrease. The problems of accommodation, healthy food, medicine, security (due to close proximity and fraternity of residents in the village) will be solved. Social crimes like theft, oppression of the women (eve teasing, rape, and extra-marital relationships), etc., will come down due to proximity, fraternity and

easy administration and control by dwelling in a proper size village surrounded by forest. The problem of the orphans, widows will disappear due to minimum accidents, wars, diseases, and terrorism. The problems of the aged persons and corruption, which is hollowing the nations, will vanish due to the presence of the men of character. The problem of unemployment will be solved as the villagers will get jobs in the village itself. They will not have to move to the cities for livelihood. Thus, the villagers will not face the miseries of the exodus to the cities.

3.7 Other Advantages of Forest Cover

There are other advantages of living in a proper size village with forest cover all around. Some of these advantages are described below:

Herbs for Medicine: Various herbs naturally come up in the jungles. They have great medicinal value as per Āyurveda. People will be medically benefitted.

Cow's Milk and Butter Oil: Each village shall have 21,000 he and she cows out of which around one fourth i.e. 5,250 will be delivering milk. Thus, milk will be available in abundance to everyone. The grazing of cows in the forest that has herbs of different kinds will yield milk and butter that will be nourishing and have disease fighting properties. Thus, inhabitants will be healthy. The ladies will be healthy by manually churning curd daily.

Leather: Hide will be available in abundance due to continuous but natural death of animals. Plenty of leather will be there for shoes and containers. Leather and other natural materials such as leave, cotton, jute, twigs, etc., will be used for packaging and thus, making plastics unnecessary. Ban on the plastics will eliminate the plastic wastes and it's ill effects on the environment and health of the man, animals and water creatures (Thompson, et. al 2009). Fat and horns of the dead animals are also of use.

Fuel for Cooking: Twenty one thousand cows will generate a lot of cow dung cakes. They will be used as fuel for cooking, yajnya, baking of earthen pots, etc. Proper burning of the cow dung cakes does not pollute the atmosphere as the cow dung is medhya (Manusmriti, Kullukbhatt – 4.53; Śrīman-Manusmritih, Purified – 3.66). The fumes from the burning of cow dungs with proper cooking procedure do not harm the cook either. Lakshmī resides in cow dungs (Śri Sūktam – 9). The food cooked on cow dungs is in fact healthier and tastier. LPG gas will not be required for cooking.

Natural Surroundings for Meditation: People will be able to do meditation in a peaceful, quiet, and natural environment with fresh air by going to the forest surrounding the village. This will enable them to proceed speedily towards

self-realization, the highest aim of life. Mental diseases and stress will not even come closer. Forest bath fills man with new vigor and energy. That is why Lord Manu instructs a dwija: "Do meditation (and chant Sāvitri mantra) by going to the forest" (Manusmriti, Kullukbhatt 2.104; Śrīman-Manusmritih, Purified 2.48).

Administration and Control of Subjects

It is easy to administer and manage a small village as compared to an oversized and over populated town or city. Crime rates will come down drastically. Isolation of small units in case of emergencies is easy. Similarly there are many other advantages, at the personal and social level, of living in a proper size village surrounded by forests.

Global Peace

Thus, with the solution of climate change, pollution, pandemics, violence of wars and terrorism, and many personal and social problems (mental stress, accommodation, food, medicine, security, livelihood, crimes, etc.) and with the men of character, there will be peace amongst the nations and in the world.

Economy and Prosperity

The use of diesel, petrol, heavy machinery, and over-sized and over-populated towns and cities have given rise to all the problems like climate change, pollution, pandemics, violence and personal and social problems. Thus, the economy and prosperity generated by these elements is fictitious. The economy and prosperity generated through non-virtuous means brings misery ultimately. It is a disillusion that the economy and prosperity will crumble without petrol and diesel. The use of oxen and horses generates real, virtuous, comfortable, and sustainable prosperity. That is why the Vedas underscore: "Ox, the carrier; fast horse may be there in the nation" (Śukla Yajurveda - 22. 22). It has been told so by the Vedas because it is highly analyzed optimal solution.

Air and Space Travel, Self Defence and Medicine

Flying and fast moving chariots, ships, and other environment friendly machines are needed for defence, administration, education, business and efficient and fast actions. Air and space travel (for flying chariots see purified Śrīmad-Vālmīkīya-Rāmāyanam 5.16.3, 4, 13) with anti-gravity materials, non-stop motion machines, robots, communication, etc., could still be achieved with environmental friendly Vedic sciences (Praśastapāda-bhāshya, 1984) and technology (Samarāngana Sūtra Dhāra). It is clearly mentioned in the machine chapter of Samarāngana Sūtra Dhāra (31.2, 68, 95 – 98) and the processes of antigravity materials have been laid out in Rasāyana Śāstras (like Rasa-hridayatantram) of *Ayurveda*. Divine weapons, such as *Āgneyāstra* (similar to atomic bomb), *Varunāstra*, etc., for self

defence can come into existence once again using *Dhanurveda*. They existed at the time of the great emperor Rāma (Śrīmad-Vālmīkīya – Rāmāyanam, 1991 Bāla-Kāndam - 28.4, 6; Śrīmad-Vālmīkīya –Rāmāyanam, purified - 14.2, 3). They could destroy the localized enemy and have no side effects. All diseases including the ones involving surgery can be suitably cured using *Charaka Samhitā, Suśruta Samhitā*, etc., of *Āyurveda* which goes hand in hand with nature.

4. CONCLUSIONS

There is no need to run away to a different planet for survival. This earth will again become a paradise for living in self-dependent proper sized villages surrounded by forests and use of small machines run by power generated by animals. The present day oversized and over populated cities, the use of petroleum products for power, large scale and heavy industries, and high frequency electromagnetic waves for communication must go for sustainable development.

The use of alternative fuels like methanol in internal combustion engines will not solve the problem of global warming and the excessive use of oxygen. Solar energy coupled with the use of electric vehicles will eliminate air pollution and the excessive use of oxygen. However, it is a temporary solution. Various personal and social problems crop up in oversized towns and cities. Administration and control becomes very difficult. Health, food and medicinal herbs become ineffective. There shall be water pollution due to the disposal of sewage and industrial wastes into water, air pollution due to airplanes, and the space pollution due to the electromagnetic waves for mobile phone communication. Pumping of water by tube wells will lower ground water table. Oversized towns and cities hinder the daily routine of the men of character and deprive them of benefits of forest cover and meditation. The use of solar plants also leads to problems in course of time (U.S. Energy Information Administration, 2019; Theocharis D Tsoutsos et al, 2005). Their efficiency is around 15 percent. The ground surface gets covered. The forests around the village are, in fact, nourished by solar energy. Grass and trees tap solar energy even under cloudy conditions when the solar plants fail. They also generate life giving oxygen. Therefore, living in a proper sized village surrounded by forests and the use of small machines run by animal power is the only sustainable solution to climate change and other problems faced by the humanity. This is healthy and nourishes good conduct.

The first priority for humans is that they need pure air to breathe, clean water to drink, healthy food to eat, health, shelter, security, and virtuous life. Everything else is secondary. All this is easily accomplished through the *Vedic* sciences. The aims of World Health Organization and the World Bank about climate change will be also met. The *Vedic* science and technology is for the welfare of all human beings and all living creatures. The real world peace, however, cannot be achieved by material management alone.

Virtuous and non-virtuous actions of humans are equally important. Virtues such as speaking truth will have to be followed and non-virtues (*adharma*) like drinking wine, premarital sex, adultery, and abortions will have to be abandoned (see purified Śrīman-Manusmritih - the essence of virtuous actions and purified Śrīmad-Vālmīkīya–Rāmāya*nam* - virtuous actions put into practice). Any system on earth cannot be successful without the man of character. Hence man-making via the *Vedic* education is essential.

Currently, the global situation is critical as explained in the causes of the climate change, pandemic and violence. The scholars, administrators, and heads of the various states needs to act immediately as per solutions outlined above for world peace (United Nations, UN Card) and durable prosperity.

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