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Strengthening Urban-Rural Resource Flow through Regional Circular and Ecological Sphere (R-CES) Approach in Nagpur, India

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Abstract: Urban and rural areas within a regional space are closely linked through a variety of linkages including the flow of people. The increasing pace of development transformations with discrete planning of urban and rural areas has raised serious concerns for achieving coordinated development at the regional level. In that regard, the concept of Regional Circular and Ecological Sphere (R-CES) has recently been introduced by the Government of Japan to localize the flow of resources between urban and rural areas. To understand the applicability of the R-CES approach, this study aims to visualize the flow of people within a defined cluster of Nagpur Metropolitan Area (NMA) in India. A "home interview method" Origin-Destination survey was adopted to analyze the flow patterns of people and their key purposes. Based on the collected information, flows of people were represented using a desire line diagram in ArcGIS 10.4.1. The study results revealed that the maximum flow of the rural and forest population is directed towards nearby or distant urban settlements to avail the higher-order urban services. Based on the key R-CES principles of a low-carbon society, circular economy, and harmony with nature, the authors suggest feasible directions for localizing the urban–rural flow of people in NMA.

Keywords: urban-rural linkages; regional circular ecological sphere; flow of people; Nagpur Metropolitan Area

1. Introduction

Urbanization is a transformative force that alters an individual's occupation, lifestyle, culture, and behaviors, as well as the demographic and social hierarchy of both urban and rural areas within a regional space [1]. In that regard, the anticipated rates of urbanization have raised concerns among policymakers around the world. By 2050, around 7 billion people are estimated to live in urban areas, which will account for more than two-thirds of the world's population [2]. As per the 2018 Revision of World Urbanization Prospect [3], the maximum increase in the size of urban population is likely to be experienced in a few countries of Asia (India, China) and Africa (Nigeria). Among these, growth in urban population is projected to be highest in India. The UN-Habitat [4] stressed that such rapid urbanization trends have the ability to transform the surrounding peri-urban and rural areas, in both positive and negative manners. The recognized benefits of urbanization certainly include economic growth, poverty reduction, and human development. However, if the urban development trends

continue with the traditional and outdated urban-rural dichotomy, it has the propensity to create polarization and divergence which can exacerbate the existing development inequality among urban and rural areas [4]. Thus, to ensure holistic urbanization in the long term, it will be imperative to strengthen the existing economic, social, and environmental ties between the fast-growing urban areas and their surrounding peri-urban and rural areas.

Urban and rural areas are geographically dispersed and are discretely governed, but they are closely linked through a variety of spatial and sectoral linkages in terms of flows of resources like people, food, water, finances, etc. Urban-rural linkages basically refer to the complementary functions of urban and rural areas of different sizes, and their intermediate flows of people, goods, services, etc. [4]. These functions and flows operate in forms of economic dynamics, social links, and environmental synergies that have universal prominence. The relevance of urban-rural linkages has for long been realized since the first United Nations Conference on Human Settlements (UN-Habitat I) was held in 1976. However, their interdependencies were explicitly recognized only during the UN-Habitat II in 1996, as it emphasized treating the urban and rural areas as complementary ends of a human settlement continuum [5]. Since then, the UN-Habitat policies have tried to nurture and strengthen urban–rural linkages with the support of its member organizations. Like for instance, the Food and Agriculture Organization of the United Nations (FAO) launched the "Food for the Cities" initiative to build a dynamic city region food system by strengthening urban–rural linkages [6]. Similarly, the United Nations Development Programme's (UNDP) Sustainable Development Goals (SDGs) identify urban–rural linkages as a key intervention to achieve the desired goals. Goal 11 of SDGs (Target 11a) specifically emphasizes realizing positive economic, social, and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning [7]. The report on "Implementing the new urban agenda by strengthening the urban rural linkages" in 2017 by UN-Habitat III emphasized sustainable urbanization and highlighted 10 potential entry points to strengthen the urban-rural linkages [8]. Of these, the entry point 7, "Regional and territorial planning for integrated rural and urban development", specifically focuses on strategizing territorial and spatial planning strategies/tools to promote regional balance between urban and rural areas [4].

Based on these guidelines, several other works have also been undertaken by various international and national agencies. For instance, in the recent years, six European countries located in the transnational Alpine region established a RURBANCE Transnational Regional Cooperation in the Alpine region to develop a corporative and integrated governance model to improve the economic, social, environmental, and cultural cooperation between urban and rural areas [9]. Likewise, URBACT III is a European territorial cooperation program financed by the European Union, which aims to promote integrated sustainable development and improve the effectiveness of regional and cohesion policy by sharing the knowledge and good practice between cities and the governments [10]. Recently, the government of Japan introduced the idea of a Regional Circular Ecological Sphere (R-CES). R-CES is mainly an integrated policy approach that involves three recognized concepts of (1) a low-carbon society, (2) resource circulation, and (3) living in harmony with nature [11]. R-CES represents a self-reliant and decentralized society, which utilizes and circulates its regional resources, complementing and supplementing another region according to its unique characteristics, and makes sustainable, equitable, and efficient utilization of resources available in urban and rural areas [12]. Moreover, this approach could be implemented in all scales ranging from a community or municipal scale to a river basin or country scale. Since the concept of R-CES is relatively new, there is very limited understanding about the ease of its application for development planning.

With an aim to understand the relevance and applicability of the R-CES approach at a local level, this study focuses on a specific case of the Nagpur Metropolitan Area (NMA) in India. The NMA is one of the largest urban agglomerations in central India that is comprised of a range of urban and rural settlements [13]. The city of Nagpur and the surrounding blocks (tehsils) within the NMA have experienced significant urbanization in recent decades. Nagpur is also identified to be one of the

fastest-growing cities in the world from 2019–2035 [14]. Under this study, the urban–rural (flow of people) linkages within a defined corridor of the NMA were visualized and emphasis was put on localizing the flow of people through the application of R-CES. The key objectives of this study are (1) to understand the urban-rural people flow linkages within the defined corridor in NMA and (2) to determine suitable directions in line with R-CES principles for localizing the flow of people in NMA. It is important to note that this study mainly tries to understand the people flow linkages within the defined corridor in the NMA. The key research questions that this study tries to address are the following. What are the key reasons for the flow of people? How can we localize the distant flow of people? This study is motivated by what the authors believe is the urgent need for localizing the flow of resources.

The remaining paper is structured as follows. Section 2 provides a theoretical foundation for the conducted research. The case study area of the NMA (India) is briefly introduced in Section 3, before highlighting the key characteristics of the defined study corridor comprising of urban, rural, and forest settlements. The detailed research methodology adopted for the study is explained in Section 3, and the study results have been presented in Section 4. Building on the principles of R-CES, Section 5 provides specific suggestions to localize the flow of people within the NMA. The last section, Section 6, summarizes the key conclusions and limitations of the conducted research.

2. Literature Review

2.1. Overview of the Urban-Rural Linkages Concept

Until the 1960s, the majority of development policies were largely surmounted around the urban–rural dichotomy, wherein urban and rural areas were identified based on the size and density of population, and their respective economic activities. Then, the development planning investments were either diverted towards "growth center" policies of urban areas or the "integrated rural development program" for rural areas [15]. However, the failure of such discrete policy approaches, alongside the alteration in global macro-economic policies, led to a paradigm shift in development trends [16]. Thereafter, the urban–rural discrete planning approach no longer corresponded with the prescribed notions of coordinated development, and the new perspective of urban-rural linkages gained prominence [17].

As per Tacoli [15], "urban-rural linkages" are categorized as spatial and sectoral. The spatial linkages include the flow of people, goods, money, information, and wastes while sectoral linkages include urban activities in rural areas (like industrial development) and vice versa. Amidst the shifting development policies in the 1990s, particularly after the UN-Habitat II, a wide range of empirical studies was conducted to study urban-rural linkages and their related opportunities and challenges. According to reference [18], the majority of urban-rural linkages studies primarily focus on the three themes of (1) the twin process of urbanization and urbanism, (2) the backwash effect which benefits urban areas, and (3) commuting flows. Among the several methods established for studying urban-rural linkages, Peeters and Marinho [19] underlined that flow analysis has so far been the most commonly used approach. As per Kim [20], urban-rural flows are basically categorized into three types. (1) Flow of people: These flows are further categorized as temporary or permanent flows. The temporary flows of people generally refer to the journey to work, which largely depends upon the transportation and communication and the location of the workplace. On the other hand, the permanent flows depend upon a range of social and economic determinants like distance, wages, public services, cost of travel, etc. (2) Flow of products and commodities: The "production and commodities" flows form part of the market network through which raw materials manufactured commodities, and money flows between the urban and rural areas. (3) Flow of knowledge and information: These flows broadly include the transmission of technology, equipment, and procedures and methods of production.

2.2. Urban–Rural Resource Flows and Assessment Methods

To study these varying types of urban-rural resource flows, an array of studies have been conducted worldwide from the perspectives of economics, the environment, and societal wellbeing. Peeters and Marinho [19] assessed the urban-rural relationship of Kampong province in Cambodia by combining the spatial flow analysis and econometric modeling, mainly to study the commercial flows. Further, reference [21] attempted to understand the economic inter-dependencies and diffusion patterns among the urban-rural areas of Crete, Southern Greece. By applying a three-area interregional social accounting matrix (SAM) model in the rural areas of Archanes, N. Kazantzakis, and adjacent urban area of Heraklion, the study revealed that the rural areas offer significant economic benefits to the urban areas, but they do not receive proportionate returns. Dabson [22] also highlighted the contribution (food, workforce, energy, waste management, congestion-free) made by rural America to metropolitan America for national prosperity. Further, in the Indian context, Bari and Munir [23] attempted to understand the urban-rural linkages of Basti city of Uttar Pradesh (India) by analyzing their dependency on the city for various purposes such as agriculture and education. This study also found that the quality of roads and distance from urban areas largely governs the intensity of urban–rural linkages.

Apart from the economic perspective, few studies have also tried to study the environmental linkages between urban and rural areas. For example, Schmitz et al. [24] tried to explain the socio-ecological linkages in the surrounding of Madrid (Central Spain) metropolis by developing a multiple linear regression model while considering the influence of the metropolis in the network of surrounding municipalities. Xiao et al. [25] also tried to quantify urban–rural linkages based on ecological networks, wherein the energy and material flows were utilized and visualized with a Sankey diagram to examine the metabolic process which connects the natural environment and urban-rural system.

Ali [26] investigated the urban–rural linkages in the Amhara region of Northern Ethiopia and their impact on the wellbeing of the women in rural areas. By analyzing the economic parameters using the statistical techniques and digital cartography, the study found that urban-rural linkages have provided economic opportunity to the females in the rural areas. Sivaramakrishnan and Sar [27], in their study in Nalhati municipality of Birbhum West Bengal (India), tried to understand the role played by transportation linkages along the urban-rural continuum. The study concluded that the rural areas which are connected with state highways have a better educational, cultural, and economic environment.

2.3. Concept of Regional Circular and Ecological Sphere (R-CES)

In line with recent global policy agreements, like the SDGs and the Paris Agreement, the Ministry of Environment of Japan, in its fifth Basic Environment Plan, introduced the concept of a Regional Circular and Ecological Sphere (R-CES). The concept has been increasingly promoted as a guiding principle to build future environmental policies in Japan and globally [28]. As per the Central Environment Council, the idea of R-CES evolved through the previous concepts of "Regional Circular Sphere" ("Chiiki-Junkan-Ken") and the "Society in Harmony with Nature" (Shizen Kyousei Shakai) proposed by the Japanese government [29]. Earlier, in the second Basic Environment Plan, the Government of Japan introduced the concept of Regional Circular Sphere and adopted the 3R (reduce, reuse, and recycle) principles of material recycling to establish a sound material-cycle society. Notably, the National Biodiversity Strategy (2012–2020) of Japan had also laid the foundation for establishing a society in harmony with nature. It recognized the relevance of enhancing urban-rural engagement and exchange based on the idea of the socio-ecological sphere [12].

The idea of a Circulating and Ecological Economy (CEE) provides a theoretical foundation for the R-CES approach. The principles of a circular economy and low-carbon society are largely based on the ideas of recycling, minimizing resource consumption, and generating renewable sources of energy. As per reference [29], a circular economy focuses on "closing the loop" where the value of a

resource is circulated as long as possible and waste is minimized, and even eliminated. Conceptually, it has evolved from technological innovation to reduce or recycle the waste to foster connections across stakeholders and different sectors. It also stresses the use of renewable resources to achieve the supporting principle of a low-carbon society. The concept of a "low-carbon society" fosters low greenhouse gas emissions by switching to energy-efficient means and low-carbon sources, and altering the consumption pattern [30]. Overall, both these concepts help to promote the idea of resilient societies and revitalization by harnessing the underutilized regional resources. The last principle focuses on a "society living in harmony with nature", which focuses on economic restoration while conserving natural resources. It emphasizes maintaining synergy between urban and rural areas by providing financial and human assistance to aging and shrinking rural areas in terms of limited natural resources and ecosystem services. Simultaneously, the idea of R-CES also encourages the need to find ecosystem-based solutions for climate change and disaster risk reduction.

Earlier, several prefectures in Japan have taken wide-ranging initiatives to address their specific issues through R-CES-related approaches. For instance, Nagano prefecture has successfully implemented the R-CES by framing a Nagano Comprehensive Five-Year Plan (2018–2022) to achieve 100 percent renewable energy and bio-economy through de-carbonization and resource circulation [12]. The plan highlights the three key points to achieve R-CES which include (1) coordination among stakeholders ranging from municipal to regional, (2) a community-driven resource conservation project, and (3) promotion of knowledge exchange. Likewise, in Kanagawa prefecture, water quality was deteriorating due to poor maintenance of forests in its water source areas. So, the prefectural government formulated a new annual tax to support multipurpose activities such as water environment monitoring, awareness-raising, and river and groundwater conservation to preserve and restore the source of water. R-CES tends to build a symbiotic relationship between the regions through the utilization and circulation of the unique resources of each region [28]. Several other good practices of urban–rural partnerships and R-CES in Japan have also been highlighted by Sukhwani et al. [31].

3. Materials and Methods

3.1. Case Study Area: Nagpur Metropolitan Area (NMA), India

Nagpur city, situated at the geographical center of India, is a major political and commercial center of the Vidarbha region in Maharashtra [13]. It is the third-largest urban agglomeration in Maharashtra and 13th overall in India [32]. To manage the haphazard growth of urban agglomeration outside the Nagpur city limits, the Government of Maharashtra created the NMA in 1999 (location as shown in Figure 1). The NMA has undulating topography which is typically of deccan traps. The wider region enjoys dry and tropical climatic conditions with an extreme daily mean temperature of 43 degrees centigrade during summers, moderate rainfall of about 1200 mm during monsoon season, and cold winters during the months of December and January. Broadly, the NMA is drained by the Kanhan and Pench rivers in the center, and Wardha in the west and Wainganga in the east which are tributaries of the Godavari river. The natural drainage pattern in the NMA makes 66 percent of the region suitable for agriculture. Notably, around 14.5 percent of the NMA is under reserved and protected forest areas [33]. Furthermore, the NMA has a rich resource base which makes it suitable for agriculture, mineral extraction, mining, forestry activities, animal husbandry, and other activities.

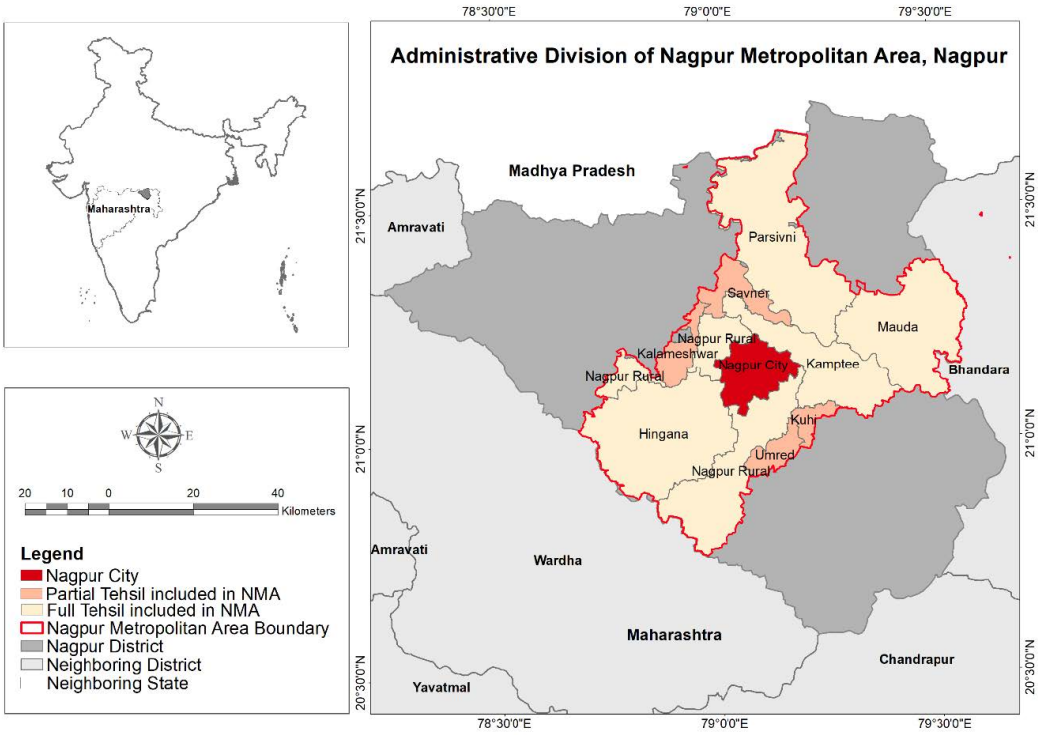

Figure 1. Location map of Nagpur Metropolitan Area (NMA) in Maharashtra state of India (image source: author).

With the notified boundary, the NMA presently is comprised of nine tehsils or blocks (five full and four part tehsils), namely, Nagpur Rural, Hingna, Kamptee, Parshivni, Mauda, Saoner, Umred, Kalmeshwar, and Kuhi. Within these blocks, the NMA further consists of 24 census towns and 726 villages [34]. As per Nagpur Metropolitan Area Development Plan, the NMA has a total population of 1,037,172 persons, 62 percent of whom are concentrated in rural areas. In recent decades, a significant change has been observed in the NMA in terms of urban-rural demographic characteristics. The region has consistently experienced a positive decadal growth rate in urban areas, especially in the tehsils of Saoner, Kamptee, and Mauda due to the reclassification of rural areas into census towns [33]. Moreover, due to its central location, Nagpur city continues to serve as the main economic and cultural center in the NMA. However, the urban and rural areas in the NMA are discretely governed under separate administrative jurisdictions in terms of planning and development. While the city is presently undergoing phenomenal transformations in terms of infrastructure development and economic growth, the city is bound to attract large populations from surrounding rural areas. As such, it becomes imperative to develop a comprehensive understanding of people flow and migration patterns in urban and rural areas for the coordinated development of the region.

3.2. Delineated Study Corridor in the NMA and Settlement Selection

With an objective to understand the urban-rural flow pattern of people in the NMA, a specific research corridor spanning from the central to northern parts of NMA was defined (as shown in Figure 2 and Table 1). The corridor was strategically defined to cover a unique mix of urban, peri-urban, rural, and forest settlements along the urban-rural interface between Nagpur city and Pench forest. Among the settlements falling within the defined corridors, two specific criteria, namely, "distance from Nagpur city" and "population size" were applied to further shortlist the number of settlements for the study.

- Distance from the city: As already explained, the NMA has a distinct land use and land cover, with a varying landscape covering forest, agricultural, and built-up areas. The good road connectivity

and the resource richness has attracted many investments around the city within the range of 25 to 40 km. Notably, Pench reservoir in the northern part of the NMA, located at a distance of approximately 70 km from the city serves as a key source of water. In reference to the urban-rural transect along the Pench river belt in the NMA, three concentric buffers of 10, 30, and 60 km were plotted around Nagpur city using Proximity toolset (Buffer) of ArcGIS 10.4.1 (shown in Figure 2). Similar buffers of 12 km were also drawn along the Pench river belt. These specific buffer lengths were determined based on the ongoing developments along the urban-rural transect in the NMA and Pench river belt. The key purpose was to demarcate specific urban, peri-urban, rural, and forest settlements along the defined NMA corridor.

- Population size: In consideration to the five population ranges (less than 1000; 1001–2000; 2001–5000; 5001–10,000; above 10,000) identified by the Nagpur Metropolitan Area Development Plan 2012–2032 [33], specific settlements were selected for the study under three different categories: forest settlements (500–1000 population size); rural and peri-urban settlements (1000–5000 population size); and urban settlements (5000–10,000 and above population size). Notably, the peri-urban settlements have been included under the "rural" category for the study, due to the lack of any major differences in the population sizes within the defined corridor.

Table 1. Characteristics of study settlements.

Category	Total	Name of the Settlements	Total Population
Urban	1	Nagpur city	2,405,665
Rural	12	Amadi, Bakhari, Bhilgaon, Dahegaon, Gondegaon, Kawtha, Khairy, Parshivni, Palora, Naikund, Nanda, Warda	31,770
Forest	6	Dahoda, Ghoti, Jamuniya, Kirangi, Pipriya, Sillari	3504

Source: the author, based on reference [33].

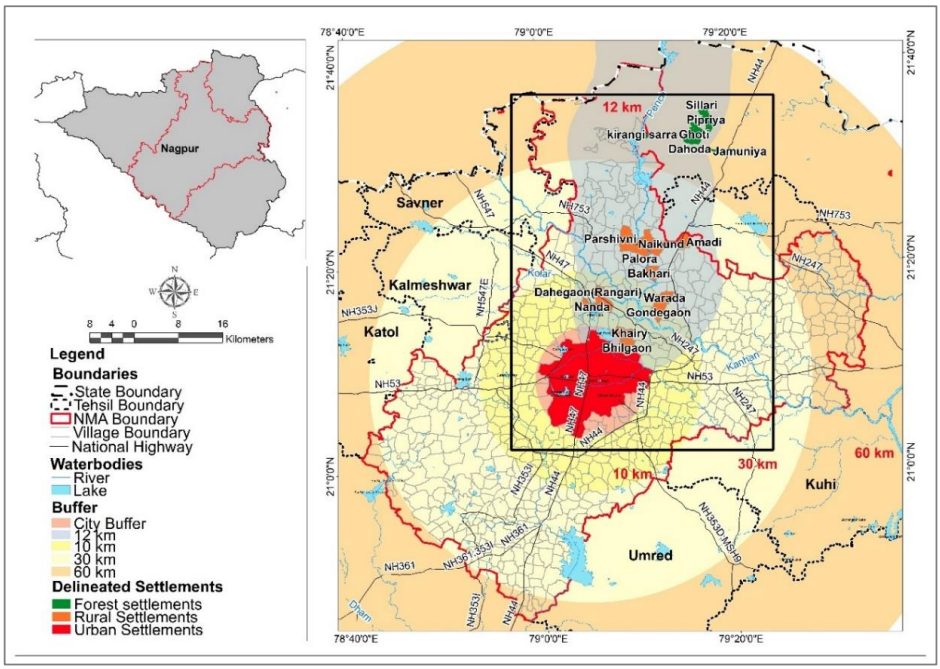

Figure 2. Boundary of the research corridor defined for the study (image source: author).

Based on these criteria, 54 settlements were identified in the rural and forest settlement categories, within the defined corridor. For the urban category, Nagpur city was selected as the only settlement.

Thereafter, by applying a stratified random sampling method, 12 rural and 6 forest settlements apart from Nagpur city (urban settlement) were identified. Table 1 highlights the names of selected settlements in different categories and their overall populations. In line with the varying population sizes of settlements in the identified categories, a different number of samples were used for conducting the home interviews (as per the Origin-Destination home interview method). In the forest areas, which comprise 6 of the settlements, a total of 82 households were surveyed. In urban and rural areas, a total of 135 and 220 households were surveyed, respectively. The survey was conducted in May–June 2019.

3.3. Research Methods

3.3.1. Flow Analysis

Origin destination surveys were conducted in identified forest, rural, and urban settlements (refer to Section 3.2) to analyze the flow of people in reference to their frequency, purpose of travel, and mode of transportation. A home interview method of Origin-Destination survey was adopted to analyze the flow patterns of people. The survey questionnaire included a set of questions related to the trip information about the households.

The trip information was collected about the place of origin, destination, distance traveled, purpose of trip, mode of transportation, and frequency of trip. Herein, the purposes of trips were categorized into five classes, namely, education, employment, health, market, and recreation. The modes of transportation were classified as bus, auto rickshaw, 2-wheeler, 4-wheeler, bicycle, and walk. Further, the frequencies of trips were arranged into five time periods, i.e., daily, weekly, biweekly, monthly, and biannual.

Thereafter, the trips' information collected from the selected forest-rural-urban settlements were processed using the statistical functions in Microsoft Excel 2013 and spatially represented using desire line diagram, graduated circles, and choropleth map in ArcGIS 10.4.1 software.

3.3.2. Settlement Hierarchy Analysis

As per Madjevikj et al. [35], functional development of a settlement is largely determined by geo-physical, social, economic, and political factors. By assessing the flow of people, in relation to their settlement hierarchy, this section tends to provide the base for the flow of people for various purposes.

Referring to the 2011 village directory available in the Census of India, the hierarchy of settlements were calculated using a Manual Scalogram in terms of availability of services and facilities. The scalogram was prepared using Microsoft Excel 2013, where the left row of the worksheet contains the list of settlements and the top column lists the facilities in order of their decreasing availability. With reference to the purpose of trips determined from the home interviews in selected settlements (origin of trips), the range of services, and facilities available in different settlements (destination of trips) were listed in the scalogram, for example, amenities relating to education include government primary, middle and secondary schools; degree arts and science, engineering, medical, and management colleges; primary and community health centers, dispensaries, allopathic and veterinary hospitals for health; commercial and cooperative banks, agriculture credit societies, and Automated Teller Machines (ATM) to perform financial transactions for employment; and public distribution systems, mandis, weekly haats, and agricultural marketing societies for market purposes. In the matrix of rows and columns, "1" represents availability and "0" represents un-availability of facilities in a settlement. Weights were derived from the ubiquity and rarity of the facilities. Weights were determined by dividing the sum of the available facilities by total numbers of settlements. By multiplying the derived weightage with settlements having the facility, the centrality of the settlements were derived by aggregating them.

To analyze the settlement hierarchy, the authors referred to the village directory of 2011 available in the Census of India. Herein, a total of six categories of settlement hierarchy classified under the

Nagpur Regional Plan (1991–2011) were used as a reference to identify the hierarchy of the selected settlements. Based on the size of the population and threshold of influence, the Nagpur Regional Plan (1991–2011) has categorized settlements as follows.

- Regional Metropolitan Growth Centre: Settlements that have a zone of influence beyond the district boundary.
- Regional Urban Growth Centre: Settlements that are self-sufficient in nature with a large population base.
- Growth Centre: Settlements that have significant urbanization and economic activity.
- Sub-Growth Centre: Settlements that serve larger population bases.
- Central Village: Settlements which are centrally located villages, and which include public amenities of a secondary school, college, weekly market, bus-stop, police station (junior), co-operative bank, and sub-post office.
- Upgraded Village: Settlements which include a secondary school, police outpost, primary health sub-center, co-operative bank, and a sub-post office [33].

4. Results

4.1. Frequency and Purpose of People Flow from the Selected Settlements

Figure 3 shows a spatial representation of the aggregated trips made by the surveyed people in selected settlements (rural-forest-urban) for various purposes. The flow of people is represented in the form of lines, wherein the thickness of a line corresponds with the frequency of trips (higher the frequency, thicker the line) made to a particular settlement and vice versa. Referring to Figure 3, the maximum trips from rural and forest settlements are found to be directed towards Nagpur city, which serves as an administrative and commercial center of the NMA. In addition to Nagpur city, other settlements such as Kamptee, Parshivni, Kanhan, Ramtek, and Bachhera were found to be the most visited settlements from all three categories of selected areas. From a broader perspective, the flow pattern of rural-forest-urban settlements is found to be confined to the neighboring settlements of higher hierarchy. The specific observations made through the flow analysis of people in three defined categories of settlements are explained in the following paragraphs.

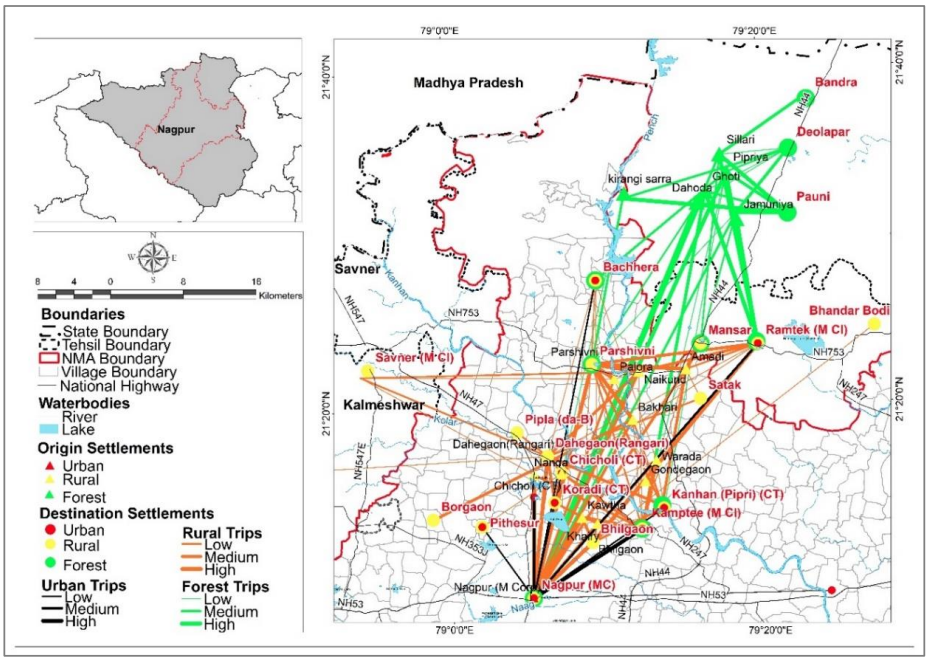

Figure 3. Visualizing the flow of people for selected settlements in NMA (image source: author).

In the selected rural areas within the defined study corridor, the highest percentage of trips were found to be generated for availing market, education, and employment services as shown in Figure 4. Herein, the local people travel an average distance of 15 km to attain education and health services in nearby settlements of Parshivni, Kamptee, Ramtek, etc. To receive other market, employment, and recreation services, the travel distance increases up to 37.6 km as explained in Table 2. For traveling these distances, the local people utilize different modes of transportation (auto rickshaw, 2-wheeler, 4-wheeler, bus, and bicycle) to commute to different settlements. Of these modes of travel, bus (40.3 percent) and 2-wheeler (39.7 percent) are the most commonly used modes of transportation. Although 4-wheelers (8.87 percent) are also used by the rural populations, they are stated to be largely used for long-distance recreational purposes.

Figure 4. Percentages of trips made by surveyed rural population for different purposes (image source: author).

Table 2. Average distance traveled by the surveyed population from the selected rural settlements.

Purpose	Travel Destination for Selected Rural Areas in the Defined Study Corridor	Average Distance * (in Kilometers)
Market	Bhilgaon, Kalmana, Kamptee, Kanhan, Mansar, Lakadganj, Nagpur, Parshivni, Ramtek, Saoner	21.71
Employment	Kalamna, Kamptee, Kanhan, Khaperkheda, Koradi, Nagpur Parshivni, Pipla, Ramtek, Saoner	23.93
Health	Dahegaon, Kanhan, Mansar, Parshivni, Kalmana, Nagpur, Ramtek, Satak, Kamptee	15.58
Education	Borgaon, Kamptee, Kanhan, Parshivni, Dahegaon, Koradi, Mansar, Ramtek, Sadar, Kalamna, Nagpur	15.95
Recreation	Kamptee, Koradi, Kanhan, Nagpur, Takarghat, Khaperkheda, Parshivni, Pench, Ramtek	37.66

* The average distances do not correspond to any specific time duration like daily or monthly.

Further, the frequencies of these trips were also studied to analyze the cyclical flow of people. Through that, it has been observed that the maximum daily trips are intended for the purposes of education (65.9 percent) and employment (63.8 percent). On the other hand, the maximum weekly trips (31.3 percent) are generated towards the markets. For the other purposes of healthcare (31.7 percent) and recreation (49.2 percent), biannual trips were generated.

In the selected forest settlements, the majority of the trips were found to be made for healthcare, market, and educational purposes. It has been noted that the trips for recreation are very rare in forest areas as shown in Figure 5. Unlike the rural areas, forest people travel longer average distances for different purposes, as shown in Table 3. For attaining different services such as education and employment which generate daily trips, people travel an average distance of 53.1–51.8 km. Similarly,

for recreation purposes, people travel longer distances of 61.5 km, although recreation generates insignificant trips. Moreover, the travel distances for availing health (27.2 km) and market (21.3 km) services are comparatively less in comparison to other purposes.

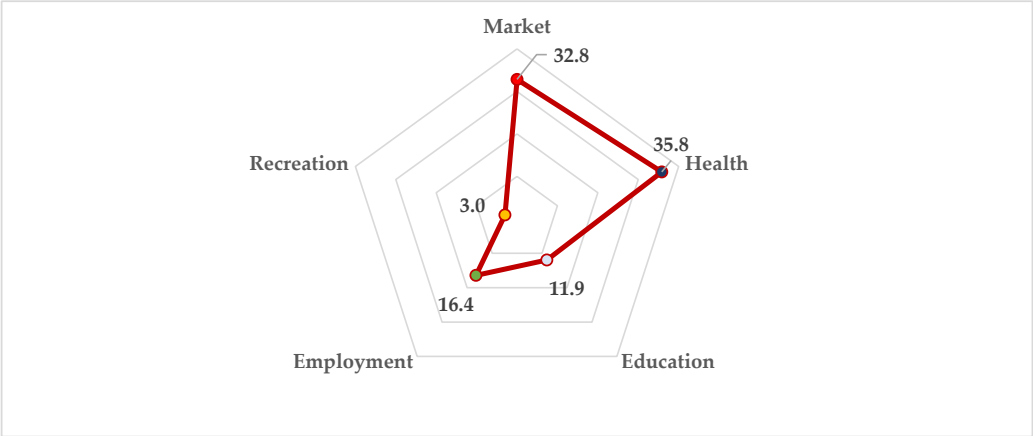

Figure 5. Percentages of trips made by surveyed forest population for different purposes (image source: author).

Table 3. Average distance traveled by the surveyed population from the selected forest settlements.

Purpose	Travel Destination for Selected Forest Areas in the Defined Study Corridor	Average Distance * (in Kilometers)
Market	Kanhan, Nagpur, Parshivni, Ramtek, Paoni	21.31
Employment	Bandara, Kamptee, Pench, Mansar, Nagpur Parshivni, Ramtek	51.82
Health	Deolpar, Parshivni, Pauni, Nagpur, Ramtek, Kamptee	27.22
Education	Parshivni, Mansar, Ramtek, Nagpur	53.19
Recreation	Nagpur, Ramtek	61.5

* The average distances do not correspond to any specific time duration like daily or monthly.

The modes of transportation used for commuting these long distances are primarily bus (50.7 percent), 2-wheeler (37.3 percent), and auto rickshaw (8.9 percent). In forest areas, education and employment generate the highest numbers of daily trips. In contrast to the context in selected rural areas, the forest areas produce maximum weekly frequency trips (31.8 percent) for education and monthly frequency trips (37.5 percent) for employment instead of daily trips. On the other hand, weekly trips are made for health (39.6 percent), as well as market (68.2 percent), and recreation (50 percent) produce maximum biannual trips.

In contrast to rural and forest areas, urban areas create a limited inter-regional (forest–rural) flow; it limits most of the people flow within the urban limits. For the surveyed population in the Nagpur city area, the maximum numbers inter-region of trips were found to be made for recreational (88.2 percent) and employment (11.8 percent) purposes shown in Figure 6. Notably, in urban areas of Nagpur, people travel longer average distances for recreation (67.5 km) and employment (51.5 km) purposes as shown in Table 4. Unlike the rural and forest areas, variation is visible in the usage of mode of transportation in Nagpur city. The urban people mostly use 4-wheelers (56.1 percent) to travel for recreational and employment services. Like other areas, the frequency of recreational trips is largely biannually (43.64 percent) and for employment it varies from daily (36.3 percent) to monthly (31.8 percent).

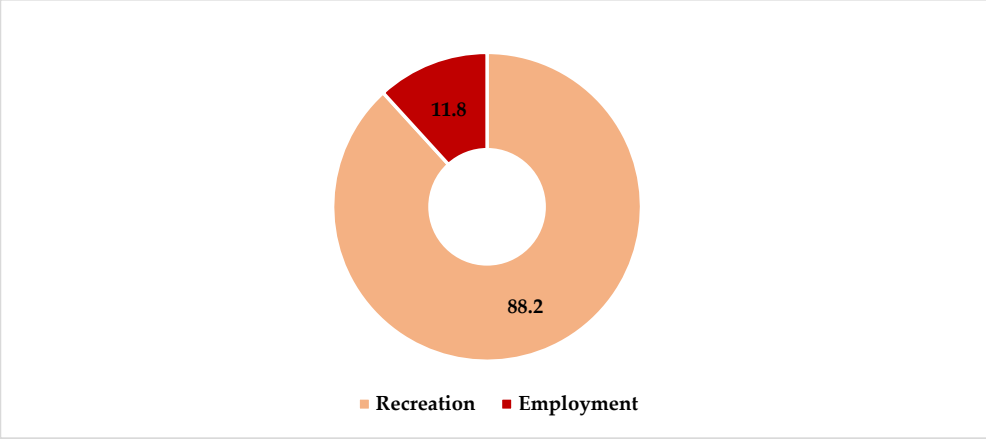

Figure 6. Percentages of trips made by surveyed urban population for different purposes (image source: author).

Table 4. Average distance traveled by the surveyed population from the selected urban settlements.

Purpose	Travel Destination for Selected Urban Areas in the Defined Study Corridor	Average Distance * (in Kilometers)
Employment	Gorewada, Itwari, Kamptee, Khindsi, Koradi, Shegaon, Nagpur, Mahadula, Ramtek, Pench	51.54
Recreation	Akola, Mravati, Chandrapur, Chicholi, Gorewada, Kamptee, Kanhan, Kasturchand, Telang khedi, Khindsi, koradi, Mouda, Tadoba, Tekarghat, Pench, Ramtek	67.55

* The average distances do not correspond to any specific time duration like daily or monthly.

Based on the flow characteristics of the survey population in the study corridor, it has been realized that people from forest and urban settlements travel longer distances to avail basic services, specifically for education and employment purposes. Moreover, one of the key observations from the study results has been that the level of services in settlements of different hierarchies are the key determinants of the people flow.

4.2. Settlement Hierarchy for Forest-Rural-Urban Settlements within the Study Corridors

As observed through Section 4.1, the flow of people is found to be largely directed by the availability of services. To further substantiate the flow analysis of people, the settlement hierarchy analysis of the NMA has been conducted for understanding the functional capacity of the settlements and their influence on surrounding areas. A detailed analysis of the settlement hierarchy within the NMA boundary is presented in Supplementary Materials. However, this section emphasizes its discussion for the selected settlements (forest-rural-urban) defined within the NMA.

Figure 7 depicts the settlement hierarchy of the NMA, wherein the settlements are categorized into different classes based on the size of the population and their Centrality Functional Index (CFI). The CFI mainly signifies the availability of higher levels of facilities within the settlements. Within the NMA, Nagpur city clearly ranks the highest in the hierarchy of settlements. It has a major influence in the entire Vidarbha region of the state and often serves as a regional metropolitan growth center. It is clearly evident from Figure 7 that the urban growth in the NMA has been along the major transport corridors, i.e., national and state highways.

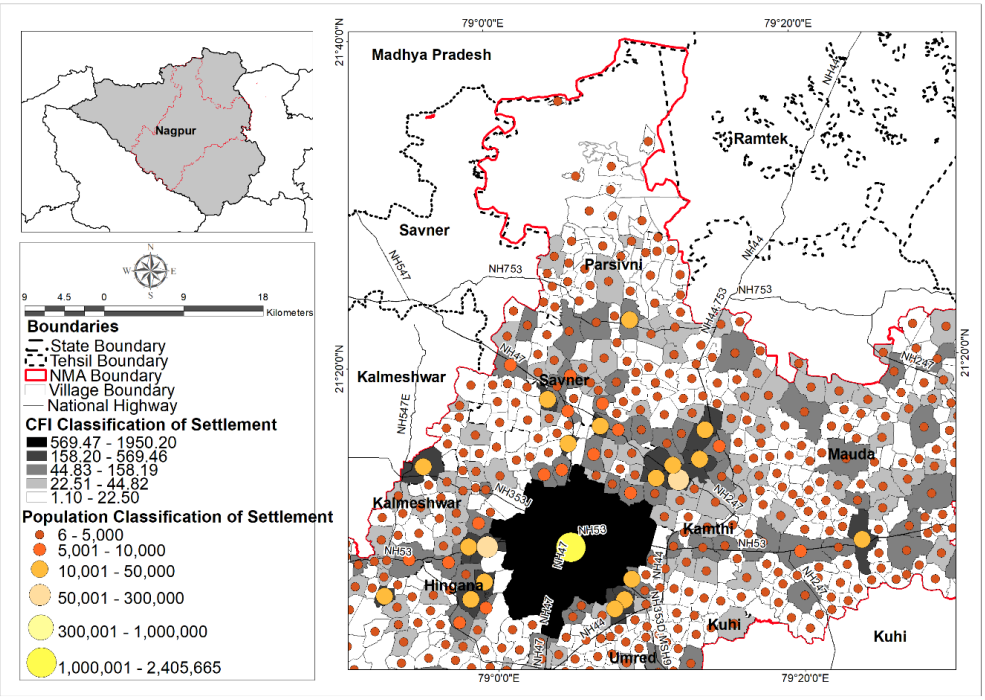

Figure 7. Settlement hierarchy of Nagpur Metropolitan Area, 2011 (image source: author).

As per the census definition in India [36], the settlements with a population size of more than 5000 are classified as urban settlements. Based on the settlement hierarchy of all settlements (Supplementary Materials), the NMA has a total of 24 urban areas, of which 16 have a population of over 10,000; six of them have a population of between 5000 and 10,000; and two of them have a population of up to 5000 [33]. Among these urban settlements, the key settlements that lie within the identified study areas are Kamptee Municipal Council (M Cl), Kanhan Census Town (CT), Ramtek (M Cl), Mahadula (CT), Koradi (CT), Chicholi (CT), etc. As earlier observed from Figure 3, these same settlements were also been found to be the most preferable destinations of people from rural and forest settlements for availing higher-level facilities. Further, in the following paragraph, socio-economic characteristics along with the settlement hierarchy of the selected forest-rural-urban settlement were analyzed to understand the availability of various facilities.

4.2.1. Forest Settlements

The forest settlements in the northern boundary of the NMA are largely located in the protected forest area of Pench National Park. As per Census of India 2011 [37], the six settlements selected for the study have a combined population of 3504 persons, which largely is comprised of tribal populations (around 68.8 percent). Notably, the workforce participation rate in these settlements is only 53.8 percent. Of these, 81.8 percent of workers fall within the category of main workers, who remain employed for more than six months in a year. Main workers of the forest settlements are largely agricultural laborers (55.3 percent), cultivators (34.3 percent), and "others" workers (9.6 percent), whereas a very insignificant percentage are involved as household industry workers (0.9 percent). Accounting for the geophysical conditions in the northern part of the NMA and the socio-economic conditions of the local populations, most of the selected forest settlements mainly fall below the lowest order of settlement hierarchy with limited amenities (refer to Supplementary Materials). However, some of the settlements serve as upgraded villages with limited public amenities. For instance, certain public amenities (primary-middle-secondary schools, sub-post office, cooperative banks, and primary health sub-center) categorized under upgraded villages are available in the villages of Dahoda, Pipriya, and Sillari.

4.2.2. Rural Settlements

The rural settlements selected for the study are mostly situated in the transition zone between the forest and fertile alluvial track of the Pench river belt. These settlements have a total population of 31,770 persons and their workforce participation rate is 41.6 percent [37]. Out of these, 84.1 percent are comprised of main workers, which are largely other workers (43.9 percent), agriculture laborers (38.9 percent), cultivators (15.8 percent), and household industry workers (1.5 percent). Similar to forest settlements, the majority of the selected rural settlements were found to lack the basic public amenities (refer to Supplementary Materials). However, some of these settlements provide the services of both upgraded villages and central villages. For example, Bhilgaon has facilities of primary-middle-secondary-senior secondary schools, weekly markets, and a primary health sub-center. Similarly, Dahegaon (Rangari) has primary-middle-secondary-senior secondary schools, sub-post office, and weekly markets, which form part of the hierarchy of settlement. In comparison to these settlements, Parshivni provides full-fledged service of a sub-growth center which includes a government degree college, community health center, commercial and cooperative bank, and regular markets and attracts the maximum flow of people from its surrounding areas.

4.2.3. Urban Settlements

Nagpur city forms the heart of the NMA and serves as a regional metropolitan growth center which has its influence all over the Vidarbha region of Maharashtra [33]. According to Census of India 2011 [37], the city has a total population of 2,405,665 persons. Surprisingly, Nagpur city has a workforce participation rate of 35.1 percent with 92.4 percent being main workers. Herein, "other" workers significantly contribute 95.4 percent, followed by household industrial workers (3.4 percent), agricultural workers (0.7 percent), and cultivators (0.4 percent). Being highest in the settlement hierarchy, Nagpur city provides all the major public amenities and even attract people beyond the state boundary (refer to Supplementary Materials).

It could be inferred that the flow of people from rural and forest settlements to nearby locations is largely due to the unavailability of higher-order basic facilities of education, health, and employment. It is, therefore, inferred that the functional hierarchy of the settlements is one of the key determinants that direct the flow of people towards nearby towns, large villages, and urban settlements.

5. Discussion

The results of the people flow analysis in the selected (forest-rural-urban) settlements (refer to Section 4.1) and the settlements hierarchy analysis (refer to Section 4.2) together provide important insight on the significant role of intermediate settlements. As noted from the results of people flow analysis, the majority of the people flows in rural and forest settlements are directed towards nearby intermediate settlements to avail of the higher-level services. These study results are also in line with the findings of earlier studies (like Kim [19]), which highlighted the importance of intermediate towns. From the results of flow analysis, it has also been revealed that the populations in forest and urban settlements have to travel longer distances to avail the of basic services like education, employment, and healthcare, compared to rural areas.

Particularly in the case of forest settlements, maximum distances are traveled by the local people to avail basic services, specifically for education and employment purposes. Through the settlement hierarchy analysis (Supplementary Materials), it has also been noted that the school facilities in these areas are limited only until secondary level. Additionally, a considerable amount of the workforce is engaged in the tertiary sector, as people travel significantly to other higher-order settlements to avail of these services.

In the rural settlements within the study corridor, the average distance traveled by people is comparatively lesser than those of the forest settlements, justifiably due to their relatively close proximity with a higher order of settlements. Further, it was noted that rural settlements like Parshivni

have a significant influence of their own, other than that most of the flows were directed towards the urban settlement of Nagpur city, Kamptee (M CI), Ramtek (M Cl), Pipri Kanhan, Koradi (CT), and Saoner (M Cl).

From Nagpur city (urban settlement), the inverse flow of people towards rural and forest settlements was largely observed for the purposes of recreation and employment opportunities. The tourist destination of Pench National Park and the historical sites in Ramtek particularly attract huge populations from the city, whereas the Koradi and Khaparkheda thermal power plants provide for jobs and employment to the city residents.

Moreover, in regard to the study results, the authors theorize that the long-distance flows of people from rural and forest settlements could be minimized if the functional capacity of small and intermediate urban settlements are enhanced. The following subsection suggests specific recommendations for localizing the flow of people in a selected settlement and to enhance the intermediate settlement with the application of two out of three key principles of R-CES.

5.1. Achieving a Low Carbon Society by Upgrading the Level of Services in the Intermediate Settlements

The idea of a low-carbon stress society stresses the need to reduce carbon emissions either by technological innovation or by adopting renewable sources of energy to promote a resilient society. This idea can be promoted in the selected (forest-rural-urban) settlements by restricting the flow of people by providing a higher level of services in the intermediate urban settlements. As per the study, it has been observed that people of forest and urban areas travel comparatively longer average distances for educational and employment purposes. The frequency of the trips generated to avail of these services varies between daily to monthly. The modes of transportation used for commuting these long distances are primarily buses and 4-wheelers in forest and urban areas, respectively (refer to Section 4). This long-distance flow of people can be reduced by facilitating the higher level of services in intermediate urban settlements which cater to larger areas. By developing the residential town or upgrading the intermediate urban settlements with vocational centers, community health centers, and agricultural marketing societies, it may absorb the population from urban and forest areas. This can possibly lead to high-quality employment in forestry, agriculture, and the tertiary sector while simultaneously promoting the concept of a low-carbon society by reducing the daily distance traveled by the forest and urban populations. By enhancing the level of services in intermediate urban settlements, the goal of a low-carbon society can be justifiably achieved in the selected (forest-rural-urban) settlements.

5.2. Enhancing Nature-Based Livelihoods for Living in Harmony with Nature

By maintaining the synergy between urban and rural areas, the idea of living in harmony with nature can be successfully achieved. As each urban or rural area has its strengths, utilizing its unique characteristics, a self-reliant-decentralized society can be built. It has been observed from the study that forest settlements generate long-distance trips for employment but, simultaneously, it also attracts trips for recreational purposes primarily due to the location of Pench National Park, Khindsi Lake, and historical sites. Although the frequency of recreational visits is not so frequent, it gives scope for developing the alternative source of livelihood in the forest areas as the majority of the forest settlements are inhabited by indigenous tribal communities, who make long-distance movements towards nearby urban settlements in pursuit of livelihoods (as discussed in Section 4). Considering the natural richness of forest areas, there is a need for generating alternative employment opportunities to confine the flow of people living within the forest areas. Avenues like eco-tourism in forest areas can potentially empower the tribal population and can simultaneously maintain and preserve the local ecosystem of the forest area. Forest dwellers can also promote and sell their local forest products in intermediate urban settlements to generate livelihoods. This will help to achieve one of the principles of R-CES (living in harmony with nature) by promoting economic restoration while conserving the natural environment.

6. Conclusions

In view of the rapid urbanization trends in the NMA and the expanding Nagpur city boundaries, it is imperative to strengthen the linkages between Nagpur city and surrounding peri-urban and rural settlements. By focusing on the people flow linkages, this study attempts to study the urban-rural linkages in the NMA and determine pathways to enhance the resource flow in the long term. Based on a literature review, the study underlined that the idea of urban-rural linkages is gaining increasing recognition in academic research for sustainable urbanization. However, their policy-level application is still very limited and there is a need for evidence-based research to support decision making.

In reference to the recently introduced concept of R-CES, this study emphasized its applicability for localizing the flow of resources and stimulating integrated resource management. For this study, the authors identified a specific cluster within the NMA that was comprised of urban, rural, and forest settlements. An analysis of the flow of people was conducted by the home interview method of Origin-Destination survey which included a set of trip information questions for the households. Through the analysis of primary data collected through origin and destination surveys in selected settlements, it was found that most of the flows in rural and forest settlements were made towards small and intermediate urban towns for availing higher-order facilities. Within the set context, this study has generated substantial evidence to interpret the flow patterns of people in different settlements. Further, by suggesting suitable directions for localizing the flow of people in the NMA, the authors have addressed the two key objectives defined at the beginning of the study.

The authors acknowledge that this study has certain limitations and the findings may not generalize to other contexts. The study conducted is largely based on the primary survey conducted on a limited sample size to understand the flow of people. There is also a need for further study at the regional scale in the NMA and with a large sample size of the population. Alternatively, different categories (age or gender) of the population could fall into the future scope of this study. There is also a need for further study of the regional scale in the NMA and with a large sample size of the population, which falls in the future scope of this study. In reference to the concept of R-CES, future studies should also explore other parameters of spatial and sectoral linkages. Further study could also be done in the field of applying the principles of R-CES in other natural resource flows including food, water, and waste. Although, several researchers have previously put forward their original research on the importance of urban–rural linkages for sustainable urbanization. However, to the authors' knowledge, this is one of the first attempts to apply the concept R-CES in strengthening urban–rural linkages in an Indian context. It is, therefore, hoped that this study's findings will provide valuable insight to strengthen urban–rural linkages in the NMA.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/20/8663/s1, in Table S1.

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