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Regional Resource Urbanism, Envisioning an Adaptive Transition for the Urbanising Periphery of Kathmandu

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Abstract

Despite a strong tradition of harmony between the landscape and its settlements, Kathmandu's periphery now stands altered due to the contemporary challenges of modernisation. It has become the contested territory where rapid urbanisation and infrastructure projects conflict with the valley's last remaining resources. i.e., fertile soil, floodplains, water sources, forests and agricultural land. The periphery is essential in preserving the remaining agricultural landscape, which is the mainstay of the numerous traditional communities of Kathmandu. Both the occupants and the productive landscape are threatened due to haphazard urbanisation and future mobility projects, resulting in speculative and uncontrolled sprawl. A detailed investigation was conducted on a site 15km south of Kathmandu to address the city's landscape challenges. The chosen investigation frame presented the suitable conditions to study and test strategies posed by the research objectives. The research utilises landscape urbanism and cartography to reveal the landscape's latent capacities, identify the spatial qualities, stakeholders and typologies involved in the production and consumption of resources. The study identifies existing resource flows and their ability to generate future scenarios. Systematic design strategies were applied in resource recovery projects by optimising enterprising capacity building within communities after the earthquake. The research recognises the merit in existing practices, community networks, the ongoing post-earthquake rebuilding efforts in offering an alternative design strategy in which landscape becomes the carrying structure for the sustainable reorganisation of Kathmandu's periphery.

Keywords

Kathmandu; landscape urbanism; periphery; resource management; systemic design.

1. Introduction

Kathmandu served as an important trade centre between India, Nepal, and Tibet and urbanised in capacity by managing natural and cultural resources. Settlements flourished with a careful understanding of the landscape and climate, supported by indigenous water and agricultural systems. Kathmandu, situated within the Central Himalayan region and surrounded by high mountains on all four sides (Korn 1977). Traditionally settlements occupied the higher plateaus, and the productive lowlands were cultivated. Sloping lands were used for cultivating forests, orchards and vegetables. Production and consumption resulted in the valley's socio-cultural development, marked with celebrations linked to sowing, harvesting crops and water management (Korn 1977; Slusser 1982; Tiwari 2001). Significant land-use changes have been observed along the valley's periphery since the adoption of the first land-use plan in 1976, accelerating after the 2015 earthquake (Bhattarai and Conway 2010; Rimal et al. 2017). As one of the crucial employment sectors, the valley's agriculture has now transformed into fertiliser and labour-intensive practice, drawing seasonal migrants from rural Nepal (Pradhan et al. 2007; Rijal, Bansal, and Grover 1991). The gradual occupation of agriculture, forests and floodplains highlight the increasing conflicts between the landscape and the occupants. Haphazard urbanisation and post-earthquake reconstruction have also increased water extraction, removal of topsoil for brick manufacturing, and riverbed sand for construction.

Additionally, fossil fuels used in the construction industry contribute significantly to the valley's deteriorating environmental quality (Raut 2003; Uprety et al. 2019). Declining soil quality, water shortage, climate change and post-earthquake distress are also impacting the traditional farming and animal husbandry sectors. Figures 1a-1f provide glimpses of the ongoing transformation in the form of housing, infrastructure, and urban expansion. The periphery's role is critical, as it preserves the agricultural landscape managed by the traditional farming communities. In addition, Kathmandu is further exposed to water shortages, growing air pollution, and forest cover's destruction (DiCarlo et al. 2018; Pradhan et al. 2007). Increased urbanisation results in waste generation, which further impacts the peripheral landscape (Alam et al. 2008; Dangi et al. 2011). The increasing environmental challenges, underlying risks of recurring earthquakes, and the projected urbanisation of the valley add to its vulnerabilities. This research investigates one of the predominantly agricultural peripheries, transforming rapidly to accommodate the urban growth and located in the southern fringe of the Kathmandu

Figure 1. The vignettes from Kathmandu's landscape; (a) Kirtipur village highlights the traditional logic of occupying higher plateaus for settlements and valley for agriculture; (b) Haphazard urbanisation is consuming the productive farmlands; (c) New mobility infrastructure and brick manufacturing in Bagmati valley; (d) Farmer-craftsmen, engaged in crafts between the planting and harvesting; (e) construction of new road infrastructure gradually consumes the terraced landscape; (f) Small vegetable lots utilising household wastewater provide much-needed employment opportunities to peripheral communities during the post-earthquake rehabilitation. Source: Author.

This research analyses urbanising regions such as Kathmandu within the Himalayan region. It aims to reveal the ecological distress, ongoing contestations and reduced resilience in adapting to climate change in the Himalayas (Eriksson et al. 2009). It attempts to highlight the challenges of mountain communities that require awareness and innovative response towards environmental change. The study contours the critical issues of the landscape in response to the following questions. First, can a landscape-led recovery guide the future urbanisation in Kathmandu? Second, can design research help in capacity building in the post-earthquake rebuilding efforts? The paper builds upon the premise of landscape urbanism's ability to offer alternative land-use planning methods using resource potentials within an urbanising context.

2. Methods and materials

The paper combines interdisciplinary learning, cartography and design research to explore future opportunities within a rapidly urbanising territory. The theoretical lenses of landscape urbanism and concepts of systemic design have been combined to analyse the productive landscape and develop design scenarios. The fieldward and primary data collection for this research was conducted during the post-disaster mission to Nepal after the 2015 Gorkha earthquake. A detailed spatial investigation was conducted on a study frame of 8 km by 6 km. Observations were collected through walking and interviews with farmers, workers, entrepreneurs, artisans, community leaders and local experts. Base maps were prepared by combining open-source geospatial data, archival data and numerous photographs. Interpretative mapping synthesised the opportunities, conflicts, and risks for guiding future urbanisation through spatial design. The statistical and quantitative data was estimated from archival research, case studies, peer-reviewed articles and expert interviews. The author does not claim complete accuracy of the quantitative data presented but provides an accurate representation of the ground conditions and possible opportunities. The results are discussed in two parts. Section 3 provides insights into the dynamic qualities of the landscape and transforming relationships over time. It helps identify typologies, wasted potentials and opportunities that guide design strategies. Section 4 describes the various design strategies that integrate the historical qualities, combining latent landscape qualities and human ingenuity possibilities through cooperation. The research concludes by reflecting on disasters and how post-disaster reconstruction efforts can stimulate urbanisation as a dialectic process between existing and new development.

3. Assessment of landscape resources within a productive periphery

Since its origins, the valley's geography has been instrumental in Kathmandu's resource flows and development. The unique bowl-shaped valley also impacts the availability of essential resources. Figure 2a-2c constructs the flows of resources (energy, fuel, water, food and waste) while allowing us to study the urban functioning of Kathmandu within Nepal. By following the material flows, it is possible to understand the system's functioning and its weaknesses. It can be concluded that the high there is external dependence that is vulnerable due to the valley's position. The material flows are also subjected to the long-distance relationship between material and user through transport corridors subjected to earthquakes and political blockades. Most internal flows are subjected to vulnerabilities due to urbanisation, lack of water, and climate change impacts.

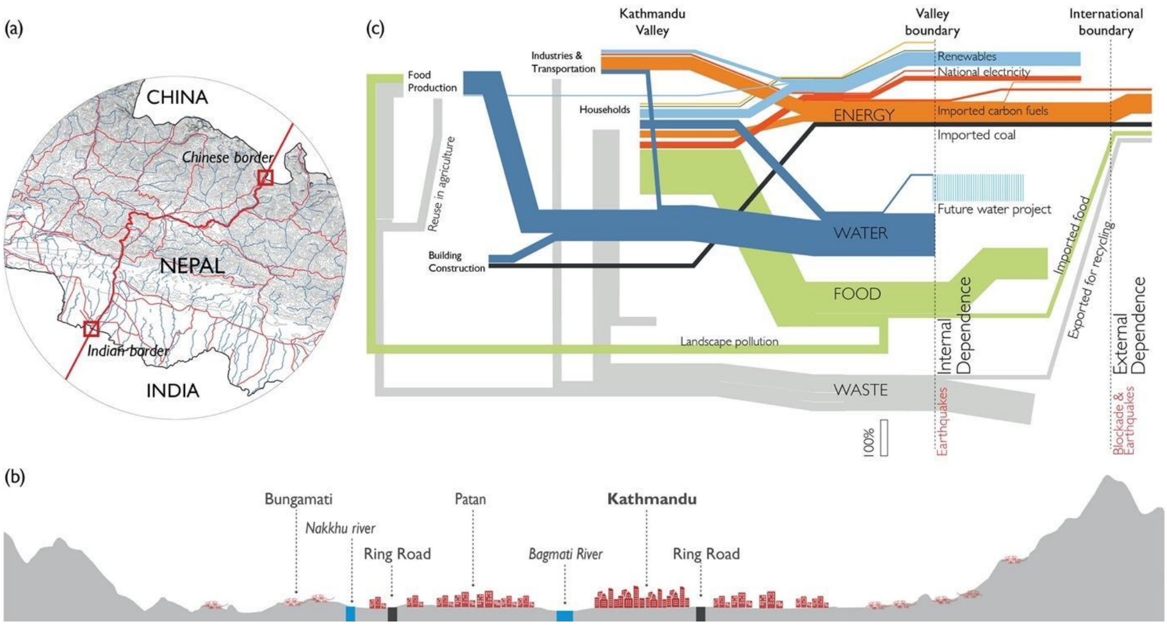

Figure 2. Interpreting the geopolitical landscape and its impact on the resource flows within Kathmandu valley; (a) Nepal's landlocked position; (b) the section of the Kathmandu valley highlighting its unique landscape condition; (c) interpreted flows map of critical resources, i.e. Energy, water, food and waste; Source: Author.

This section investigates specific cases but positions them to critically review the ongoing transformations of landscape typologies within the landscape. A detailed spatial investigation has been conducted upon an urbanising periphery near Bungamati and Khokhana, 15 km south of Kathmandu. The research utilises a 'framework' measuring 8 km by 6 km to explore the research questions and possible design strategies. The frame is bound by the rivers and mobility corridors and defined by the valleys of Bagmati, Nakkhu, Kodhku and Godavari rivers, as shown in Figure 3a. The land use in the frame is mainly agricultural, its population involved in farming and crafts, and its landscape threatened by the uncontrolled, mushrooming practices which induce sprawl. The investigation frame is further threatened by urbanisation and future mobility projects, such as the ring road, the Fastrack expressway and a rapidly growing brick industry to support the post-earthquake redevelopment that rapidly consumes Kathmandu's southern periphery. Figure3b-3e illustrates the composition of the landscape. The agriculture practices alternate between dry and wet seasons, irrigated and non-irrigated and the village slopes. Water needs for agriculture and animal rearing is met chiefly through rainfall, artificial ponds and indigenous water canals. Urbanisation and land-use changes have aggravated the loss of irrigated land by the destruction of the water system. Most of the agricultural periphery present during the 1950s has been consumed by urbanisation along the ring road and continues to date (Shrestha 2013). It further explores the spatial impact of interaction among the natural and human resources. It reveals multiple overlaps of daily and socio-cultural rhythms of life within the valley. The research draws relations between the interplay of ecological and socio-economic activities, intending to highlight associated meanings and collective action related to production and consumption. The periphery produces many products based upon the location of raw materials. Each product has distinct or overlapping cycles due to its manufacturing processes, scales of operations, and labour availability, including its impact on the region's social structure. Yet each product draws upon the capacity of the natural and human resources potential within the study frame.

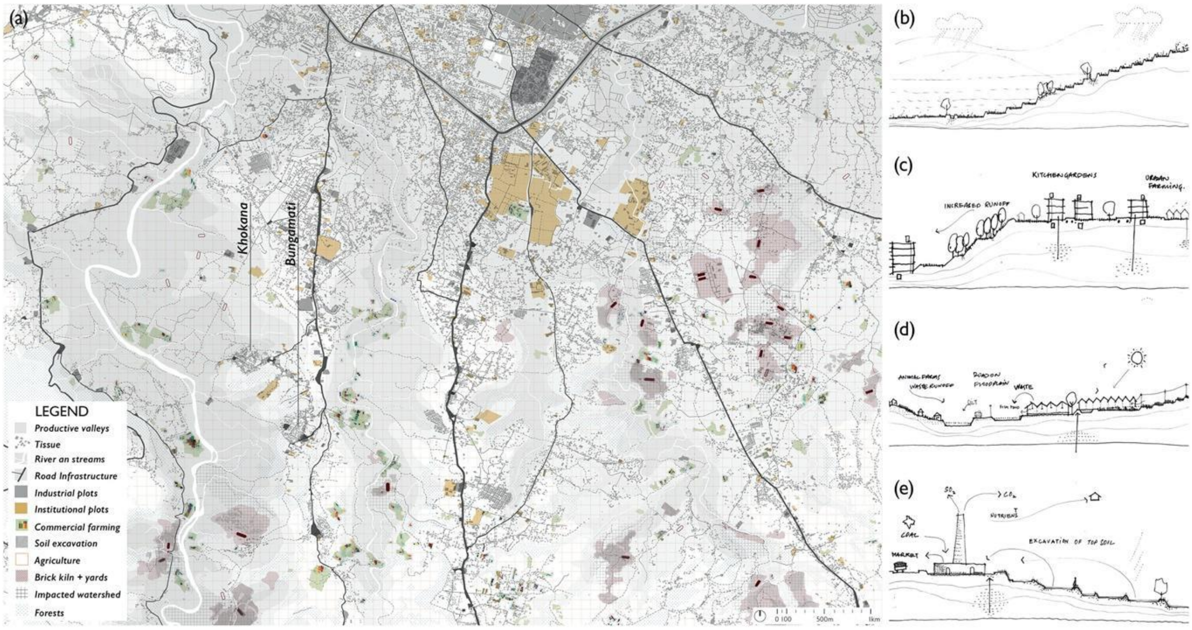

Figure 3. Defining the productive frame & Impact of resource extractions Landscape Impacts; (a) Map; Urban expansions happen quite randomly leading to interesting intertwined urban-landscape morphologies; (b) rainfed farming slopes outside Khokhana; (c) traditional settlements ;(d) farming cooperatives in the along the river valley; (e) Brick Factories within agriculture fields. Source: Author.

Figure 3a, shows the productive valleys, traditional settlements and suburbs along roads, brick kilns and farmland within the 8 km by 6 km investigation frame. Productive flows concentrate along with the villages, and the critical mobility corridors connecting convey the finished products to markets located within the city. The fieldwork and mapping revealed that bricks and sand mining were some of the most harmful practices within the landscape. Many subsistence products and local sales, such as livestock management, floriculture and cooperative farming, require technical upscaling as their efficiency dramatically depends on water and soil. Figure 3b-3e highlight the key typologies related to production and resource management. These typologies were distinguished into subsistence agriculture, small scale animal and vegetable farms, commercial farming, and brick kilns during the fieldwork. These print plates are engaging themselves over the base layer of the valley landscape, and they become the producer, processor and consumer of resources. The resource flows' spatial position can provide clues towards continuities, disruptions, scattered, or concentration. It reveals meanings associated with collective actions related to resource availability and productivity, including workforce patterns provided by individual farming households, often by migrant labourers.

The impact due to resource extraction is increasing daily due to demands for the growing city. The irrigated lands are getting impacted by the soil extraction for bricks. The loss of irrigation is coupled with water extraction of groundwater by commercial vegetable farming enterprises. They reduce farmlands' productivity, and climate change also impacts farmers to opt for fertiliser-based farming practices. The existing production practices are simultaneously removing soil fertility and also depositing chemicals within the landscape. The post-earthquake rebuilding frenzy has already accelerated the brick making and construction industries, further threatening landscape qualities. Yet, these mobilisers of the landscape have significant potential if guided within a framework of cooperation. Further investigation on resources revealed that these landscape mobilisers leave significantly underutilised or wasted opportunities within the landscape. Available as latent, leftover or wasted, these material and human resources can be utilised in meaningful ways. Wasted resources were classified into; crop residues, waste or losses from commercial, cooperatives and animal farms, wastewater from residential areas, residual heat and unutilised workforce from the brick kiln and transport network poor producer-consumer relationships. Figure 4a-4d presents the interpreted wasted potentials, which can be devised into resource-based recovery processes providing the much-needed opportunities for sustainable growth of the valley's periphery. Figure 4a becomes the underlying basis for three key design strategies elaborated in the next section. The resource system analysis highlights the importance of landscape, traditional villages, and specialised markets as equally crucial to the valley's urbanisation. It also highlights environmental degradation, deposition of chemicals, topsoil loss, increased carbon emission, and linear systems creations.

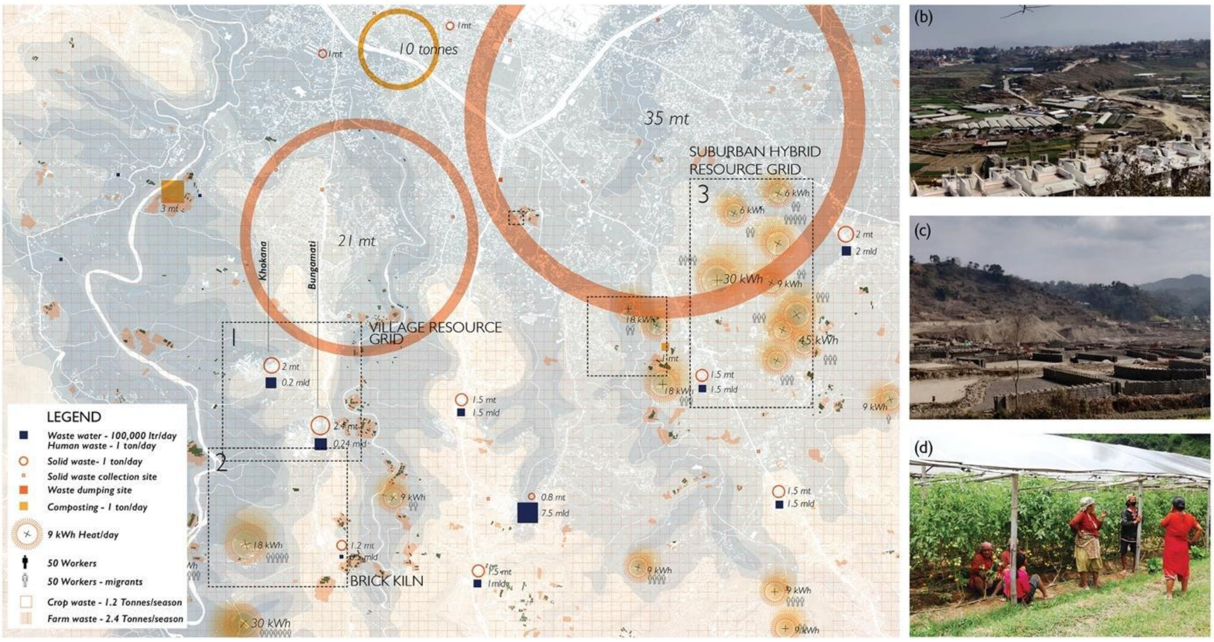

Figure 4. Wasted potentials within the landscape; (a) Map highlighting the capacities of crop residues, waste from farms, and waste produced by human activities and brick kilns, combined with market-transport, and workforce; (b) Occupation of the productive land for housing plots and commercial farming; (c) Soil extraction, removal of topsoil, disruption of irrigation and topography, reduction of farm yield; (d) Commercial-scale vegetable farming, seasonal migrant families come due to lack of employment and low turnover from agriculture. Source: Author.

4. Connecting resources, envisioning a systematic transition through strategic projects

Highlighting the spatial relations and underutilised capacities of the landscape previously, the following section elaborates upon three incremental design strategies linked to resource pooling and community collaborations. These projects combine landscape urbanism and systemic design principles to synergise the desired transition (Berger and Sijmons 2009; Shannon 2009). The village armature project reimagines the existing household-farm relationship into an upscaled resource grid connecting Bungamati and Khokhana. It combines the key public spaces, social and educational institutions, waste collection points, sewage outfalls, and the various crafts/small workshops along its length. Household night soil and biodegradable waste are converted into biogas, and manure for the kitchen gardens are enhanced with an anaerobic digester. The strategy allows an average household of five members to extract usable energy in biogas at 2kwh/household, thereby removing methane from the environment and leaving usable manure of approximately 0.3kg/household. It is estimated that household utilisation of 3 kg of wood per day for energy can be covered by the biogas plant (Rijal and Yoshida 2002). The strategy is scaled from household to village level with the help of the compact urban form of the villages (Thomsen, Woerum, and Haagensen 1968). Village or cluster digestors can replace individual anaerobic digesters, increasing efficiency and reducing capital and operational costs. The centralised facility fosters participation and assists in post-disaster rebuilding efforts through efficient energy-nutrient relationships, as illustrated in Figure 5.

The armature further pools solar energy at the rate of 4kw/10sqm of rooftops as additional electricity to the craftsmen to overcome electricity shortages (Jha, Stoa, and Uhlen 2016). Analysis of energy bill during the fieldwork revealed that the average household and a craft cluster utilised approximately 8 kWh of energy per day. The combined efficiency of the household biogas at 2kWh (Voegeli 2014) and rooftop solar of 4kWh/Sqm (Gautam, Li, and Ru 2015; IRENA 2014) can suffice for most of the energy needs. In the future, the armature can support craft tourism and enable densification. The microgrid allows resource pooling and distribution for energy (solar & biogas), extracting valuable nutrients from human waste as manure for agriculture and promoting agriculture and crafts within energy scarce rural areas. The nature and position of the armature allow us to think beyond its social and spatial capacities, where solid waste, wastewater and energy production, and consumption become the critical elements of the resource armature. It incorporates the existing small-scale infrastructure, with investment from participants and subsidies from renewable energy projects to supply the energy collected from the community biogas digester and rooftop solar harvesting. Solar harvesting through rooftop collection produces power for the production units and institutions. The surplus energy can be conveyed to the micro-energy grid, benefiting the small-scale commercial enterprises along the armature. As a collector and generator, a microgrid enables capacity building through pooling its resources, serve as a future tourist trail and enable incremental densification. It will promote upscaling and new economies along the armature, as visualised in Figure 6a-6c.

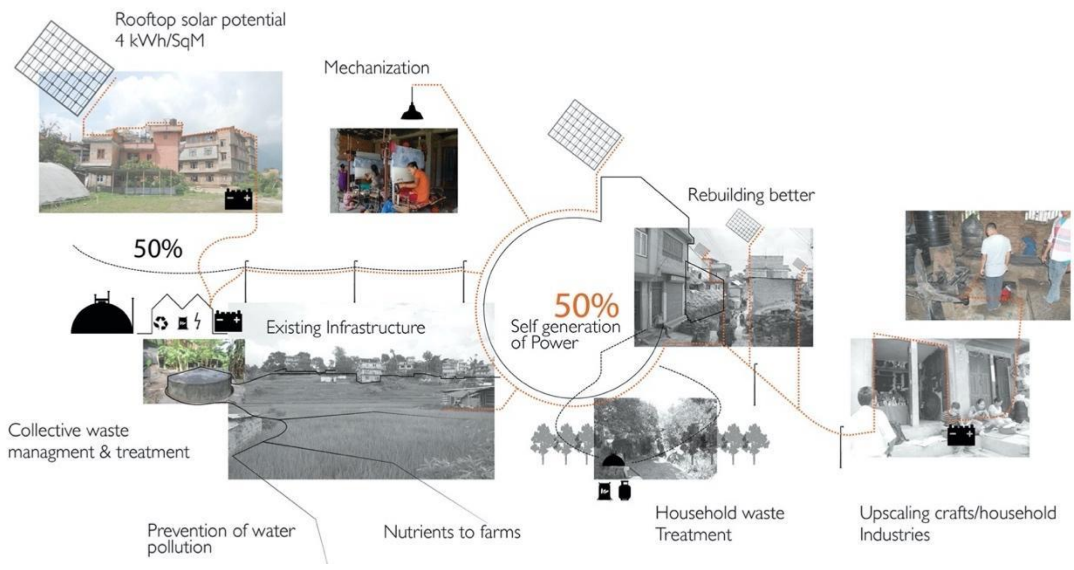

Figure 5. Design Strategy developed around the individual household and scaled up at settlement scale. Source: Author.

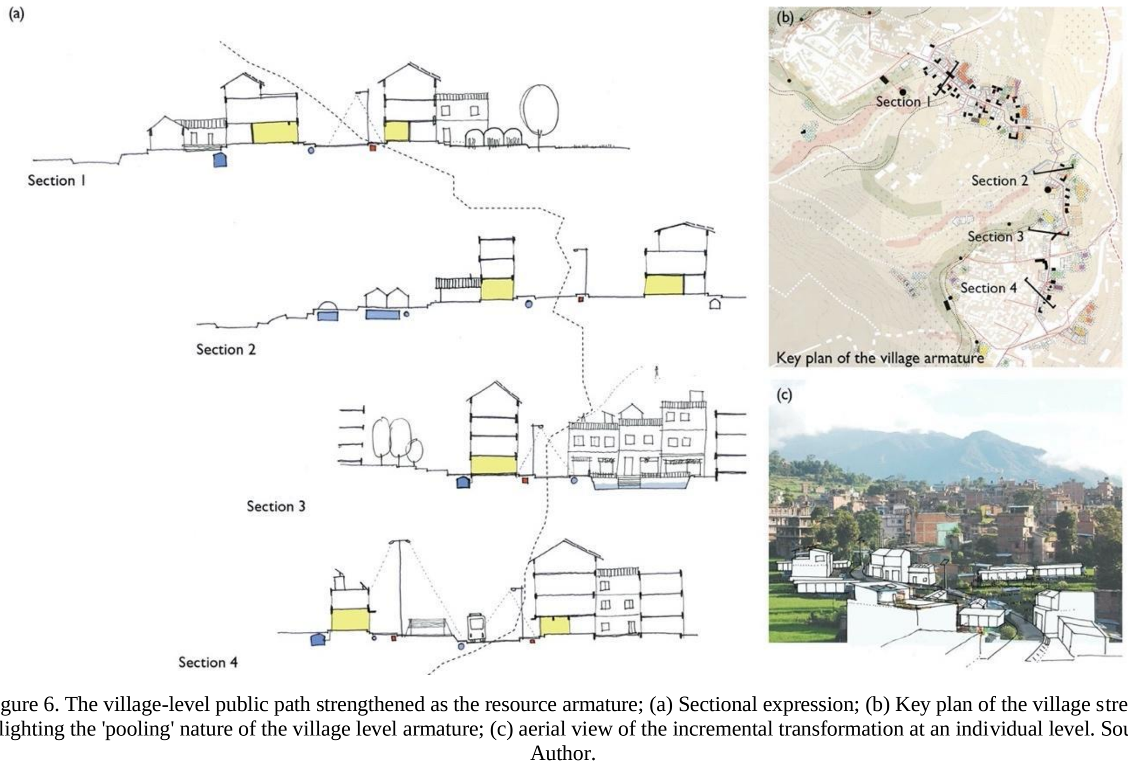

Figure 6. The village-level public path strengthened as the resource armature; (a) Sectional expression; (b) Key plan of the village street highlighting the 'pooling' nature of the village level armature; (c) aerial view of the incremental transformation at an individual level. Source: Author.

The second project demonstrates medium-scale strategies by combining agricultural production, cooperatives, and brick kilns. The brick industry's unidirectional resource flows are a threat to the landscape at large. The brick kilns are temporal and change their location after every seven to ten years. Within this period, they exhaust the fertile topsoil essential to local farmers. The entrepreneurial character of the brick kilns combines capital and workforce in altering the landscape. The brick kilns' position and movement can be structured positively for guiding the flow of resources within the landscape. Two different sites were chosen for demonstration, one close village and the second along the ring road were selected to test the brick kilns as a hybrid resource management centre. The waste heat from the brick kilns can be utilised for dehydrating and preserving farm produce or incinerating crop wastes, farm waste and household biodegradable waste. On average individual brick kilns results in wasted heat of 25,000mj by burning a tonne of coal in producing between 8000 to 10000 clay bricks within Nepal (Shah and Nagpal 1997). It was calculated that this wasted heat could be utilised to dehydrate or process 1.0 to 1.5 mt/hr of agricultural waste into biomass pellets (UNEP 2009). The processed farm wastes can be used efficiently as briquettes for household fuels or even within the brick kiln. It can be further used to generate electricity, produce biomass pellets or even electricity if appropriate technologies can be utilised (Kafle et al. 2016; Nilsson, Bernesson, and Hansson 2011). Cooperative farm units within the proximity can also use the wasted heat and workforce to process the farm produce to increase farm crop longevity. Such economic cycles and sharing process allows the nearby settlements enable the villages to engage in entrepreneurial activities and generate additional incomes to offset food costs, promoting food security. The brick kilns can help recharge the shallow aquifer during the wet season through clay ponds and pump the shallow aquifer during dry season use, cutting dependencies upon water from irrigation channels significant to downstream farmers, as shown in Figure 7.

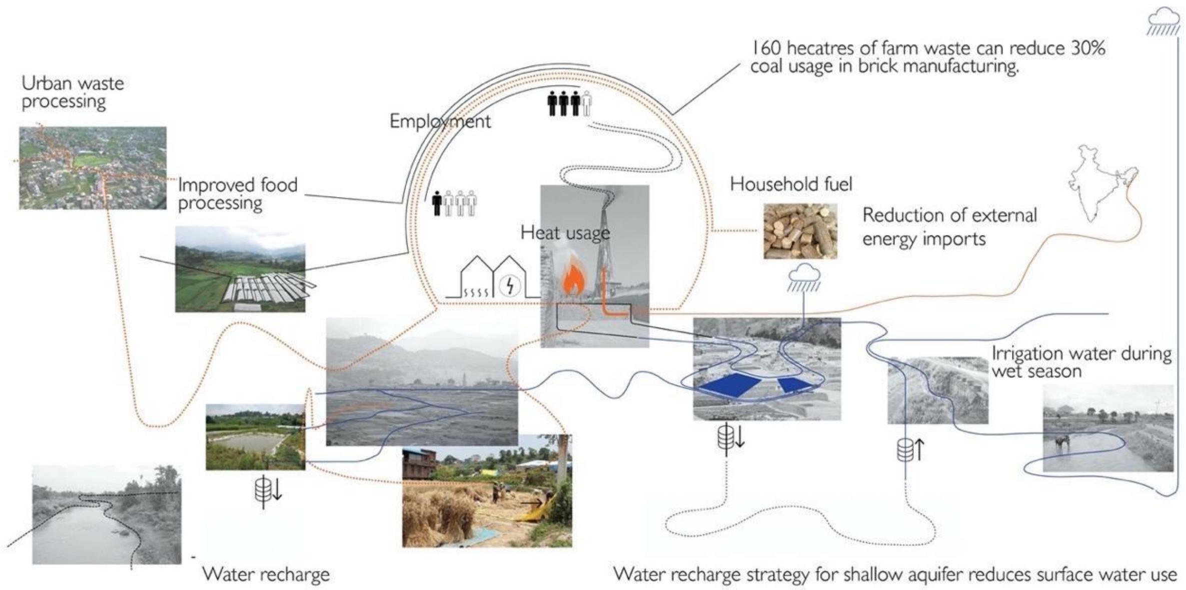

Figure 7. Design Strategy developed around the brick Kiln. Positioning the brick kilns' entrepreneurial nature as a hybrid resource centre for rural and suburban Kathmandu, with capacities to treat agricultural produce, rural and urban household waste. Source: Author.

The suburban demonstration site highlights the potentials of the valley's brick kilns, their resource pooling capacities, and the city's long-term objectives (Bisht and Neupane 2015). Suburban brick kilns can help deal with waste, as their heat capacities can be utilised for incineration, drying, and biomass energy production to meet various needs of the suburban (Shrestha et al. 2014). The energy generated by these kilns can be transferred to the nearby vegetable farms, which can use this energy for cold storage or food processing. The existing transportation system of both brick supply and vegetable farming can connect to the city. The resource armature plays a vital role in the systematic structuring of the landscape. It promotes commercial activities such as recovery from agricultural waste, vegetable processing, and energy by-products. The phasing of armatures aims to achieve the design strategy's dual goals, where the soil excavation results in the creation of developable zones at different levels within the valley. These developable zones can absorb future urbanisation, support the production of high-value crops, and the deepest plinths can be suitable for pisciculture or paddy cultivation. As a collective strategy, we understand the frame study as a dynamic and ever-changing region because of the fast urbanisation and external pressure such as landscape risks. As such, we are foreseeing a flexible and evolving project that has the means to accommodate future and unpredictable scenarios, as shown in figure 8a-8d.

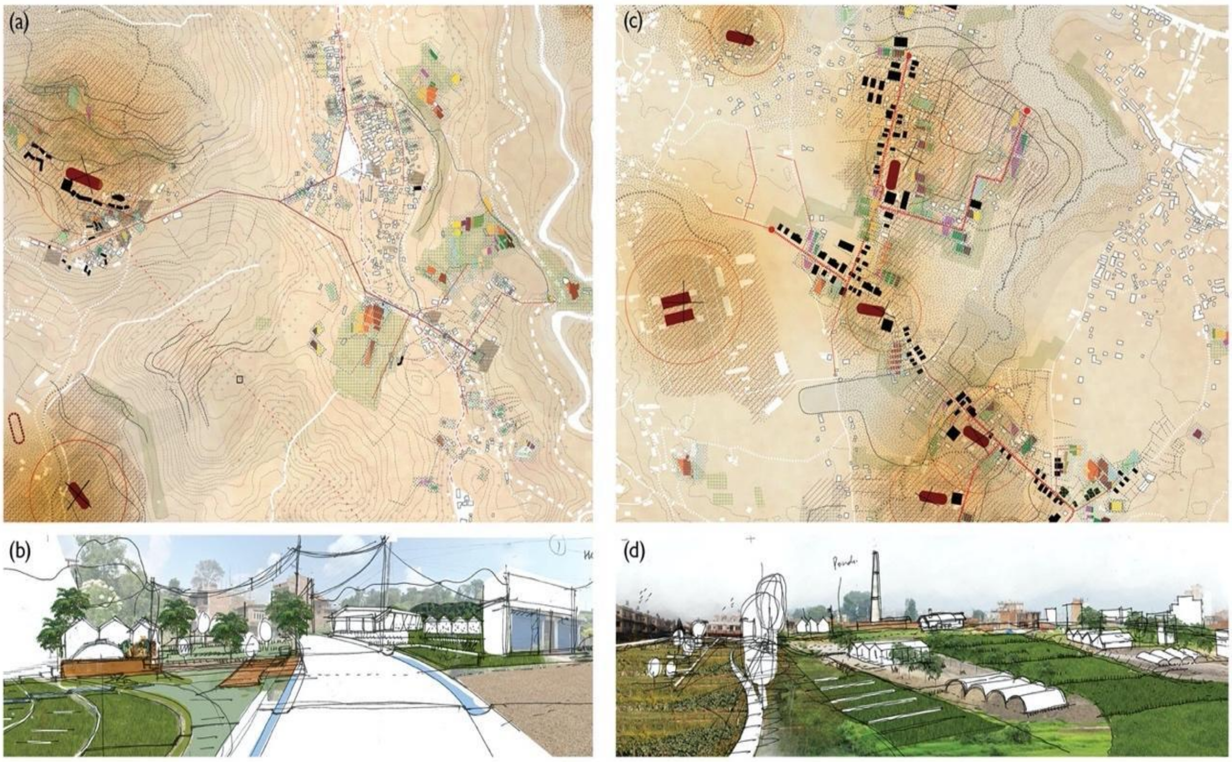

Figure 8. Sequencing the armature of connected resources and strategising village and suburban resource grids; (a) Design plan, highlighting the 'pooling' nature of the armature;(b) view of the central waste collection and processing areas within the village; (c) suburban resource grid and housing; (d) View of the central waste collection and processing areas. Source: Author.

The systemic design strategies combine linear resource cycles into closed or shorter, or recurring loops. They strategize resource management into opportunities for the valley's inhabitants. These strategies draw upon the concept of sharing and producing energy, managing waste, and playing an essential role in the city's southern periphery's structured intensification. Agricultural by-products, waste to resources, permanent employment, landscape management shall provide new livelihood opportunities. Presently increased animal farming and commercial practices are concentrated along the periphery of the traditional settlements and suburban frame. These farms focus on high-value food production to supply the city markets and manage the organic waste. Their position along the city periphery and utilising the market-producer links, the waste can be brought back and converted into helpful animal feed or manure for farms. Such processes manage biodegradable waste, prevent greenhouse emissions, and promote new economies that can absorb both the migrant and local populations. The assembly of the design strategies is imagined as an urban-rural transect. The transect enables resource recovery, fostering cooperation amongst communities, entrepreneurs, producers, consumers, and local and regional scale. Figure 9a & 9b highlights collaborative loops across scales that promote resilience within the rural landscape, enabling the communities to gain self-sufficiency and become a vital partner to the urban areas and provide sustainable resource management alternatives as a critical role for the periphery. Studies have highlighted the importance and benefits of resource recovery, waste management, landscape led opportunities to mitigate urban challenges. Though these initiatives are yet to realise their full potential and can be adopted at large, they highlight appropriate landscape urbanism strategies to help the periphery become a more vital partner in the city's growth (Lohani et al. 2021; Shrestha et al. 2014). Returning to the research site in February 2020 revealed that small and medium-sized entrepreneurial activities have commenced within the study areas to support livelihood and food production. Lack of robust institutional and financial mechanisms has displayed collaborations amongst producers in waste segregation, composting, poultry and fish farming recycling benefit from agricultural and farming wastes.

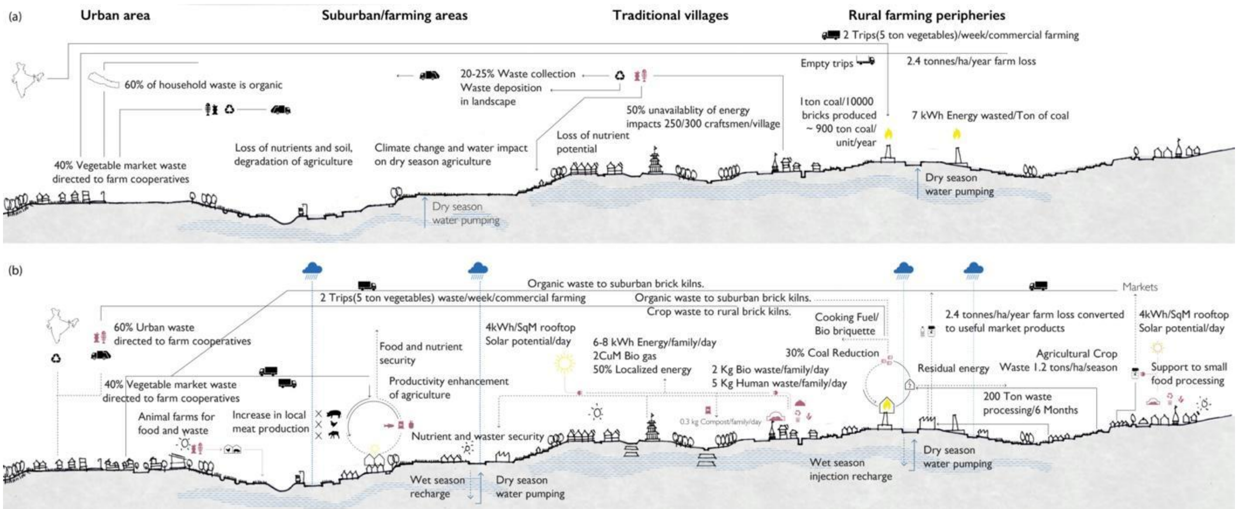

Figure 9. Envisioning a systemic transition to generate shorter loops and directing resource flows into meaningful processes. (a) Existing systemic sections interpreting the existing linear cycles and flows of resources; (b) Proposed systemic change helps in closing resource loops and promote resilience within the rural landscape. Source: Author.

5. Conclusions

The ongoing urbanisation of Kathmandu is a classic example of planning-led expansion in the south Asian context, where the regional landscape is undermined in planning processes. Kathmandu's landscape has been essential to its development in the past, and its absence can expose the city' vulnerabilities, exhaust natural resources and impact livelihoods in future. The transition from a land-use approach into an integrated system requires long term vision, planning and cooperation among society and planning agencies. Disasters or large-scale shocks bring forth resilient capacities which enable collaboration and encourage adaptation towards the crisis (Solnit 2010). The earthquake is an opportunity to reorganise the crisis problem long-term adaptation strategy through planning. Landscape and systemic design approach argue for sustainable interactions amongst ecosystems; resource flows, human linkages, which get disrupted due to disasters and climate change, impacting the 'ambitious' urbanisation processes within the Himalayan region and elsewhere in South Asia. The research advocates urbanism, which evolves like nature, creating opportunities for small, medium, and large-scale activities to sustainably expand the population. The research also points towards the importance of data collection, surveys and mapping, identifying key stakeholders, utilising entrepreneurship and governance structures. Demonstrated design strategies also require the capacity building of the stakeholders, favourable policies, capital and technological investments to foster the sustainable transition. This research advocates an alternative to creating new developments with objectives set to enhance the landscape's capacity by bringing forward its structuring capacity as part of the planning process. The research outlines a possible vision towards avoiding urban sprawl and takes advantage of the ground reality of fostering a 'reimagined' role of the periphery.

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