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Abstract:

Environmental and urban social concerns have generated a flair of ideas about what can be done to solve seemingly unresolved and ever re-emerging urban problems. Concepts have been coined to draw clear pathways and framework under which possible solutions can be formed and applied. However, many of the concepts are derived from alternative fields, muddling urban issues, and generating failure to separate underlying technical details for example from infrastructure design, planning and placement as opposed to social concerns the urban infrastructure creates. This article will therefore be examining the fusion and raptures in what is meant by green urban infrastructure.

Introduction

Concern with globalisation, climate issues, health concerns, and digitisation, to unlock society from current society infrastructure configurations, some scholars have suggested that entrepreneurship (Harvey, 1989), innovation, networks (Healey, 2006) and participatory administrative and governance structures (Bevir, 2011) could drive change. These arrays will with little certainly generate new urban infrastructure quite different from what is known today.

The old planning methods based on statutory laws are condemned for entrenching the wicked problems (Weber and Khademian, 2008) unemployment, resource depletion, climate concerns, economic issues, and unsustainable resource flows (Anderberg, 2012). To overcome these issues a new set of planning methodologies are proposed.

Urban infrastructure that emerged from 1800s, developed specifically from public health concerns as a result of British Industrial urban social malaise and unhealth urban environment. Subsequent infrastructure emerged such as collective housing, transport networks, sewerage system, food supply etc. These industrial conditions were interpreted as sanitary conditions that generated two important documents: the Public Health Act of 1848 legislating on the sanitary conditions of England and Wales (Fee and Brown, 2005). The Town and Country Planning Act of 1947 preceded the above law, 100 years later, that emerged as a regulatory frame of the built environment based on the public health act of 1870 that will provide green spaces and community facilities (see Hugh Ellis, Head of Policy, 2017). The philosophies around urbanism became the pedestal on which garden cities concept gained prominence. Derived policies heralded systematic interventionists policies by the state, into people's health conditions, where and how people lived in urban and rural spaces. This was intended to improve urban living and working environments for better life qualities. Town and Country planning, became a benchmark that guided infrastructure placement that

overlooked the current environmental and sustainability concerns. Sustainability is multifaced as ecological, conservational, economic, cultural, and environmental planning.
Though, the two laws culminated into a wider appreciation of stage managed urban forms, with varying degrees of design and subsequent development of the industrial urban morphology, accrued urban infrastructure have instead generated enormous urban concerns such as, invisible environmental and health problems, urban crime, poverty, homelessness, and unstainable urban metabolism.

Theoretical disposition

In 1933 Walter Christaller development what came to be known as the Central Place Theory refining the geography of scales, concentrating productive infrastructure at certain scales. The theory is based on two assumptions:

a. The average population required for the supply of the provision of certain good or services
b. The average distance people travel for the supply of a range of goods or services

Christaller observation were based on geographical scale from location of households, industrial establishment, location of goods and services, and working population densities. The industrial urban forms were gathered around areas of work that later culminates into urban centres for the supply of the daily provisions like; food, telephony, transport corridors from and to work and homes, sewerage networks, entertainment centres and housing provisions. Some of these infrastructures are quite problematic in terms of economic, environmental, and social costs.
An anthesis to central place theory is the theory of 'nested redundancy' Keeffe, (2014) where systems and processes are close looped perpetuating sustainability and circularity of the green and blue economy in all scales of architecture and urbanism. These scales come in all forms, from individual through to individual dwellings, streets and neighbourhoods (Keeffe Garden cities: Roggema, 2019) transitioning into micro gardening, mini grids etc. Nested redundancy aims to scatter infrastructures at a range of scales, supported with smart grid technology thus creating "delocalisation" geography of scales different from what Christaller envisaged.

Aim and research question

How Green Infrastructure Changes Urban Morphology, is the research question with an aim of exploring how entrenched, the emerging green infrastructure, aid society transition from present industrial urban infrastructure. Derived pathways and drivers of green infrastructure processes are central in understanding, how planning schemes will change and guide subsequent urban morphology. The article specifically explores, evolving urban theory from: Central Place to Nested Redundancy Theory as an underlying *technical* infrastructure network planning and placement. Note, that green infrastructure is associated with historico-geographical (Firehock, 2015) space, rather than process typology of (Albrecht, 2015), and mathematically oriented space planning of (Batty and Longley, 1994).

Methodology

Ferreira et al., (2021: 6) asserts that green infrastructure planning still has no defined methodology to guide its development while Firehock, (2015:14) emphasises that green infrastructure planning is practiced differently according to the landscape and the scale people wish to plan for. Given the fact that emerging green infrastructure are in experimental phases, the methodology will examine what has been done so far from research through design (RtD) a current preferred methodology based on scenario building by Larjosto, (2019) of the urban landscapes. It weighs risks against benefits in explorative variances and builds visions. Larjosto, (2019) claims that the methodology is a transformative science where constant landscape changes can catalyse multiple disciplinary ideas.

Concept definition

Green infrastructure has multiple definitions depending on which articles, books and authors one is reading. Green infrastructure is perceived differently according to the context into which it is used (Ferreira et al., 2021). Green infrastructure can be green walls, roofs or simply design incorporating plants and architecture in built environments. (Briz, et al., 2019) writes that such designs are directed to urban problems of flooding, carbon capture, urban heat mitigation, rainwater retention, mini gardening, and biodiversity. (Firehock, 2015) writes that "natural resources" are 'green infrastructure' that provide life-sustaining functions, along with tangible economic and social benefits, thus at landscape-level evaluation of natural assets for a region, county, town, or city. (Hislop, et al., 2019) cite Wright (2011:1004) who observes; that a single fixed definition of "green infrastructure" is problematic because the concept is evolving, divided and gravitating toward socio-economic centres".
Ferreira et al., (2021) define green infrastructure as urban planned network of natural and semi-natural areas integrating blue spaces and other physical features in terrestrial and marine areas that are designed to offer ecosystem services. In this respect there is green energy, food, streets, buildings and what have you. The above conceptualisation of green infrastructure it should be noted, lack technical details.

Perspective on current conditions

Firstly, it is important to understand what is meant by form or urban morphologies. The distinction is vital to understand the categories that differentiate nature and human habitats and associate infrastructures whether green, blue, yellow and what have you. Form is shape, and in that regard, industrial cities attained shapes that were associated to the functions of the city shape and space mainly related to manufacturing of goods, placement of utilities, hence the accrued industrial urbanism. The spatial patterns thus generated, gave a structure Christaller explains in his CPT. It is associated to economies of scale to ground the processes and functions that created it – majorly the industrial economies.
The statement above is diametrically different to the proposed green infrastructure and subsequent urban form. Fatone et al., (2016) sum the arrays of environmental urban spaces as comprised of; densification, interventions for clean water, healthy soils, energy, spaces free of electromagnetism, seismic where it applies, access to public facilities, free of domestic waste, provision for mobility, less noise, and clean air. This is where the real issues of urban infrastructure can be understood in many other ways other than merely green infrastructure description.

Webb and Khademian's et al., (2008) wicked problems this article looks at, is referred to as assemblages[i] by (Nicholas and Powell, 2021:5) and nature assemblages by (Firehock, 2015), the industrial infrastructure urbanism erased. Discrepancies in this definition should be on the outset, made clear. Right from implicit technicalities associated with the present infrastructure and accrued socio-economic and environmental problems.

This is vital to close a created disconnect between the natural and urban environment. As an example, using research through design (RtD) this article use example in green infrastructure, specifically the four areas in green energy resources: wind, solar, nuclear, and hydro energy as a practical example. All the above four sources, apart from solar energy cannot be reduced to an ecological scale, the 'nested redundancy' (Keeffe, 2014) describes. However, solar cells with reduced scale are limited, in that energy thus generated has to be stored, is still a major hinderance and its use is limited, unlike wind, nuclear and hydro energy that require a distribution grid infrastructure. If there is extensive use of solar energy, the question arises of resource use and the waste problem from decommissioned solar cells. Nuclear energy on the other hand, and its problematic use have been thoroughly studied and knowledge derived from the accidents that have occurred in Russia and Japan.

Technology development, is progressing very fast, reforming and restructuring the world in very many unimaginable ways. Boserup,(1981:5) observers that "many inventions – today as well as in the past have been demand-induced." It becomes pertinent to ask to what extent this demand pull is associated with the new energy infrastructure. Moreover, besides mini-grid solar energy with localised distribution infrastructure other energy sources has similar infrastructure distribution algorithm and configuration.

The current technologies are not necessarily demand-induced but rather driven by what has been termed as design through research, mainly driven by enterprises (Harvey, 1989). The platform economies around the globe being experienced today have virtually disrupted Central Place Theory but are neither demanded nor driven by population growth[ii]. They are simply unfolding events of scientific discovery and virtual infrastructure logics. Their implication on urban form might be completely different and difficult to (Keeffe, 2014) envisage. To note too, energy distribution requires secured corridors - if these corridors are the same as green infrastructure corridors that is yet to be established.

In scenario planning, scenarios are said not to be end-states of the future, but narratives about how future or current unfolding events based on variance theory as (Burton-Jones, et el., 2014:4), writes are consistent with ongoing correlations between variables in new emerging urban infrastructure forms. These can be associated to emerging process and functions of organically emerging cities.

This is a major concern whilst their claim to new planning models and methodologies as pathways that are laid out in climate sciences of Wolfram and Frantzeskaki, (2016); Hjerpe et al., Ambio Electronic Supplementary Material (2020), and Wolfram, (2016). The same might be associated with (Ferreira et al., 2021) green infrastructure definition. Given the fact that demand-inducements and population change are minimal, it might appear that research through design scenario-based planning leads in different direction and outcomes but not really focused on the identified urban infrastructure planning problems associated with green infrastructure this article is about.

The Green Infrastructure Turn

Conserving natural assets has led to the field of green infrastructure planning so writes (Firehock , 2015:1). As seen from above, current urban morphologies were largely derived from urban health (Fee and Brown, 2005) concerns in industrial Britain. These are two standpoints on planning that are implicitly different, one principally conserving nature and the later improving health. Health concerns, culminated into building and designing of the current urban infrastructure based on mathematically aligned space planning of CPT.

There are ways the urban infrastructure can be described descriptively, but also normatively. Industrial urban infrastructures have existed since mid-1700 to date. They have become part of the urban life and daily goings. These infrastructures are categorical entities, in the urban social and society fabric. People wherever they might be found, need energy for basic reasons: cooking, cooling, heating homes, production etcetera. This makes energy provisions unconditional. So far energy sources are limited to nuclear, hydro, and wind energy. Solar energy is still limited in use.

The lack of assemblages Karen, (2015); Nicholas and Powell, (2021:5) and Fatone et al., (2016) mentioned above can't be reduced to mere events as claimed in scenario-based planning since they are effects of intricate technical urban infrastructure designs. It is in this article's meaning therefore, that urban morphologies thus derived from industrial infrastructure placement are not an end in themselves compared to what existed before them. If current society structure is based on; sustainability, digitisation and globalisation, the events that have disrupted the central place theory categorised as normative in the current time framework, should be appreciated, and understood but also situated in desired urban forms associated to the said green infrastructure.

If there is an appreciation of the facts above, that green infrastructure can generate new urban forms, then the configurations must be different from the existing urban infrastructure to resolve sustainability concerns. There must be a real problem definition in the first place that are well defined as so did (Fatone et al., 2016) and (Nicholas and Powell, 2021:5) one technical and social respectively.

This hypothesis is in contradistinction with the fact that platform economies (digitisation) and appended infrastructure are the drivers of emerging urban form and processes. To situate strategic spatial planning into scenario-based planning calls for a clear definition and categorisation of what is meant with green infrastructure presaged on identified society concerns (Nicholas and Powell, 2021:5; Fatone et al., 2016; Wolfram and Frantzeskaki**,** 2016).

Merely having an anthesis, to central place theory as the 'nested redundancy' (Keeffe, 2014) where systems and processes are closed looped, perpetuating sustainability and circularity of the ecology economy in all scales of architecture and urbanism might be a mirage since the principals i.e., energy distribution infrastructure network remains the same calling for the same urban form irrespective of associated green infrastructure. May be, that can explain why ecological farming is not really progressing and gaining traction as planned since the cattle mouth disease. It doesn't mean that carbon free infrastructure i.e., green energy will most likely be totally carbon free. Wind and Solar energy have to be stored if the entire idea of green energy makes sense. It is in this connection one wonders how networks (Healey, 2006) and governance theories (Bevir, 2011) will bring about the needed transformative arrays.

Green infrastructure tends toward fractal **(**Batty and Longley, 1994) or organic city growth with green infrastructure that works at a smaller range of geographical scales, from city region to site. Through industrial infrastructure, health concerns, modelled an urban system of

networks which are interconnected. Green infrastructure, therefore, and can be claimed is a disentanglement of the social techno-system (Wolfram and Frantzeskaki, 2016). But this too, doesn't mean urban infrastructure changes. As existing networks and new ones are formed driven by digitisation and environmental concerns, it requires understanding of how system dynamics engraved in urban infrastructure are layered and which new green infrastructure are required (see Fatone et al., 2016; Wolfram and Frantzeskaki, 2016) to meet critical society needs.

The new urban landscapes are essentially not only for natural assets as claimed by (Firehock, 2015), but also for humans and her complex multiple social activities that survive on it. In the built environment human settlements, and wildlife habitats are radically different, as the associated corridors people use to move through landscapes are typically different from wildlife use.

Val Kirby: Hugh et al., (2015:386-402) writes that

"Green infrastructure is an attractive label for a complex approach to environmental planning and management that brings together landscape, networks, infrastructure and multifunctionality…..working across landscapes, at a range of scales from strategic to local, using an understanding of the dynamism inherent in natural and cultural networks and systems to bring benefits to the environment, to the economy and to people –especially to their health and well-being".

Kirby's analogy is interesting but totally inadequate in explaining complex human activities on the landscape with current society configuration. Humans are not going back to caves to survive as hunters and gathers. Human habitats unlike wildlife habitats are different and categorical an evolution process that has taken millions of years. A theory therefore can be described as a characterisation of a phenomenon. If the assumption is that the urban form (see Scheer, 2015:2*)* is a system and networks of infrastructure as in central place theory defining industrial urban-rural morphology, then characterisation of the infrastructure on scale, the nested redundancy alludes to, must be very clearer and not merely habitat corridors or simple green infrastructure (Firehock,2015). Homes need lighting, cooking fuel, heating, water, food, housing, transport and what have you – this is what is meant by infrastructure and where the green comes in must affect the current urban infrastructure transformation.

Unlike nested redundancy theory, central place theory offers a raft of geographical scales in terms of provisions and services. Nested redundancy aims to scatter infrastructures at a range of scales, linked with smart or mini grid technology thus creating organic urban spaces of scales without clearly describing the associated configurations. Nested redundancy theory is neither an urban village. Urban space scales come in all forms, from individual through to individual dwellings, streets and neighbourhoods (Keeffe Garden cities: Roggema, 2019:90-105) now in micro gardening, platform economies and mini grids etc. As a reference to (Scheer's, 2015) article, it is not clear if green infrastructure is simply bringing natural assets into the urban form setting or that rather the urban spaces have to conform with green infrastructure irrespective of complexity of human activities in the urban spaces that require different infrastructure logics, and configuration.

Digitisation and urban villagisation through green infrastructure

Turning to digitisation and the concept of urban villages (Peter Headicar: Barton et al., 2015:221), writes;

"the concept of the 'urban village' has been advanced which is less formally structured but is characterised by relatively high densities, a mix of uses and high standards of urban design – features which were taken up in official planning policy guidance in the mid- 1990s (Department of the Environment 1997)…….. Such places offer variety and vitality in contrast to the 'barren' quality which characterises low density suburbs. At a larger scale the growth of service employment means that, compared with the days of manufacturing industry generating pollution and heavy goods traffic, businesses no longer need to be segregated into (relatively remote) sectors or zones of a city".

The central place theory has not totally been erased by green infrastructure in the world of computing innovation that might be moving CPT towards fuzzy geometry. This too looks at geographical scales that are largely ever narrowing through "virtual" infrastructures. Whereas they are not seriously mentioned, in the green infrastructure, mini and off grids abled by some technologies are changing the urban infrastructure and form but not the basic principles of infrastructure configuration. These infrastructures it is clamed and are referred to as carbon free infrastructure hence in some ways they are green infrastructure too. Mini and off grids virtual infrastructure operate at varying scales. Understanding how they do emerge and are integrated into urban morphology (see Headicar, 2015:221), is important to understand green infrastructure generally and where infrastructure is not limited to given variables like water, landscapes, forests or ecological assemblages (see Firehock, 2015). Solar and wind grids might transform the built environment and create some forms of nested redundancy associated infrastructures. This is because those resource will eliminate some variables, the environmental and socio-economic costs. However, the question is why solar and wind grids have not been scaled-up so far, if it is true the socio-economic benefits outways other variables.

Hence (Batty and Longley, 1994:35) organic development that invalidates centrality but turns informality, its idiosyncrasies and its picturesque properties enabling urban village exploitation of dramatic natural features might not be so dramatic exactly as in ecological farming that reduces environmental cost but raise economic cost for food provisions. This is critically important to understand how physical or spatial planning will plan the said green infrastructure.

The green evolution trajectory is what is important to this article based on emerging technologies. The study of city form, Batty and Longley, (1994:42) writes about, will represent the spatial pattern of elements composing the city in terms of its networks, buildings, spaces, defined through their geometry mainly, but not exclusively, in two rather than three dimensions. Why should planners be concerned with geometry? Cities will need reliable and dependable energy system, transport networks, food distribution etc., which with green infrastructure are understudied and undermentioned. Once again, wind, and solar technologies are not systematic but emerges here and there, in an inductive process fitting them to unsustainable urban spaces.

A reflection upon this article and dilemmas associated with green infrastructure

Firehock, (2015) efforts to structure a multi-scale approach to planning is commendable but falls short of separating human from nature habitats. This is a dilemma that offers faulty epistemological but also ontological green infrastructure grounds. In the era of green infrastructure planning, there are other processes i.e., land use, human activities, utility placement, and urban flows that need to be fully grasped to have a convincing theory, strategy, structure, and planning framework. Compact human settlements have an allay of standards based on those parameters inadvertently driven by human need.
Frogs in wetlands, have certain specific niches in such habitats that qualifies them to live in such environment and therefore it is within the human abilities to protect those environments. How do such habitats then can be translate into human habitats? Nature habitats have been studied by paleo-ecologists, conservation, and restoration biologists. On the other hand, anthropologists, archaeologists and indeed sociologists have studied ancient human settlements for decades.

Attempting possible solutions

This article does not dwell much on knowledge output and development in Scheer, (*2015*) and Brenner and Schmid, (2015) architecture and sciences of geographical epistemologies respectively, but rather in applied sciences of using nature to develop new urban green infrastructure and forms. Wolfram and Frantzeskaki, (2016) offers four noticeable fields as pathways: (a) transforming urban metabolisms and political ecologies; (b) configuring urban innovation systems for green economies; (c) building adaptive urban communities and ecosystems; and (d) empowering urban grassroots niches and social innovation. Point a is applied in a sense that the infrastructure that enables urban flows are changed through point b and d where there is a possibility of having a reasonable clear agenda to plan and develop green infrastructure. Urban spaces are constitutive of critical structures that have specific logics: housing, transport networks, energy needs, water provisions, sewerage system, trading centres etc. These focal points are interconnected via corridors (see Marcus, 1999) exactly in a similar way as corridors for small insects or big mammals in a tropical forest from where they live to habitats where they feed. If the idea is to mimic myriad habitat niches in Firehock, (2015:6) to engineer urban green infrastructure then the methodology, processes and systems must be clearer and defined. Habitats, scales, and niches (activities) have an implicit relation and technicalities. Urban spaces per definition are compact human settlements different from nature habitats which can be defined in terms of free rage by scale. Human needs and want in the industrial era expanded beyond the village boundaries to the town, region, territory, then continent and global level. What were the underlying reasons current urban infrastructure development and how are they linked to engineering, architecture and planning green infrastructure which therefore drastically reduce the geographical scales? Green infrastructure planning should face a fact of human nature, by mainstreaming processes that translates Green Infrastructure into existing corridors in human settlements without disadvantaging other things in natural habitats thus planners working across different departments, notably; biologists, archaeologist, conservationists, highways, drainage and building conservation as written by Corbett et el., (2019:649). Cities is a multitude of social activities, innovations and economic processes beyond foraging, constrained and shaped by the geometry of nature and those that are man-made Batty and Longley, (1994: 1).

Spatial geography, hence spatial planning is a study of scales whether formal or informal. It is not accidental but rather a fact of nature and the way nature is. An ocean shoreline can't be a tropical forest or an aquifer in a desert given its natural assets and categories. Given to human ingenuity, innovations are impressions of human abilities as the hidden hand of nature.

Wherever there is an urban centre, that was once a wildness of which paleoecology is engraved in archaeological and anthropological artefacts. The work process since it involves habitats both human and in nature should look at both histories, paleoecology and urban growth histories. Emergence of cities are at times associated with a place and its functions: a port, mining, education city, urban forest etc. Nature habitats as well, are associated to their natural geographies: a desert, tropical, temperate region and area.

The idea of green infrastructure is fundamentally to bring nature into urban environments. This is the work of restoration biologists, and ecologists who have better understanding of the functions of the different species in nature habitats and niches. Certainly, spatial planners will have to work across these fields and with other professionals.

There is a yearning to "re-villagise" the urban spaces and reduce urban scales as urban villages Headicar: Barton et al., (2015:221), this work is not solely for planners but more of innovation in a multiplicity of the present urban infrastructure. However, this will not be done with the same knowledge forms that created it in the first place, but systematic research intended to change the present urban infrastructure and order. It is *frustrating* therefore not to read much about urban infrastructure nature engineering but rather narratives of desire to urban change mainly limited to governance and the market.

Conclusion

Green Infrastructure can as well be derived from nature conservation as well as from digitisation of urban infrastructure into mini and off grid services. This is an area that require more research than it has been done. Spatial planners will have to either embrace conservation biology, paleoecology or understand mini grid system process and systems engineering to properly situate green infrastructure planning into the profession.

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