

Framework for the preservation of ephemeral natural channels through greenswales: Learnings from the case of Chandigarh

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Abstract

Ephemeral natural channels in cities are reclaimed to provide land for housings and other functions. This is because of limited knowledge about the crucial role played by natural channels in stormwater management. For long, the cities have been dependent upon grey infrastructure to drain out stormwater away from the city. Therefore, it requires a paradigm shift to see the natural channels as a tool for stormwater management. There is a pressing need for the preservation of natural channels because incidences of pluvial flooding are increasing. The inability of existing grey infrastructure to take up the additional stormwater load has forced the planners to think of sustainable alternatives. In this study, the case of accidental preservation of an ephemeral natural channel in Chandigarh city is discussed and analyzed. The symbiotic relationship between Leisure valley (a green belt) and N-choe (a natural channel) offers many learnings in the preservation of natural channels. From careful observations and brainstorming, contributory factors that paved the way for the preservation of the natural channel, the concept of greenswales is evolved. A framework is developed for the sustainable planning of greenswales. It will guide the city planners and managers to have an alternative approach to preserve the natural channels sustainably and use them as a tool for pluvial flood management. This study's significant finding is that ephemeral natural channels in a city can be safeguarded through the judicious superimposition of green spaces over them.

1. Introduction

Today cities are more vulnerable to pluvial flooding than ever (Miller & Hutchins, 2017). Pluvial flooding is when the surface runoff in the area exceeds the stormwater drainage system capacity (Hammond, Chen, Djordjević, Butler, & Mark, 2015). Two major causes are high impermeability and increasing rainfall intensity in urban areas. High impermeability is an intrinsic characteristic of cities that prohibits stormwater infiltration and consequently generates more surface runoff, which is five times more runoff than in a forest of the same size (EPA, 2010b; Khaladkar, Mahajan, & Kulkarni, 2009). On the other hand, increasing rainfall intensity is the external factor majorly governed by climate change (IPCC, 2014). These two factors combined are the cause of increased stormwater generation in urban areas. Most cities are struggling to manage this additional load of stormwater and hence pluvial floods. The last century has witnessed a complete dependence on grey infrastructure for stormwater management, most of which today are either dilapidated or undersized to take up the entire stormwater load (Huong & Pathirana, 2013; Miller & Hutchins, 2017; Zhou, 2014). Thus cities need to retrofit and expand the capacity of drainage systems to prevent pluvial flood situations. However, the expansion of monofunctional grey infrastructure is cost-intensive and is not sustainable (Pitman, Daniels, & Ely, 2015; U.S. Environmental Protection Agency, 2014; Zhou, 2014). Many studies on sustainable stormwater management have suggested that nature-based solutions can supplement the grey infrastructure to take up the additional stormwater load (Chan et al., 2018; Suppakittpaisarn, Larsen, & Sullivan, 2019; The World Bank, 2019).

Dependence upon natural channels for stormwater management also follows the premise of nature-based solutions (Chan et al., 2018; Du et al., 2019; World Health Organization, 2017). The natural

channels play a crucial role in flood abatement (Ray, Pandey, Pandey, Dimri, & Kishore, 2019; Tingsanchali, 2012). They have a vast network that drains the stormwater from the land surface to the rivers and ultimately to the seas and oceans after any precipitation event (Hadley, 1968). Any blockage in the course of channels makes this natural drainage system defunct, which leads to flooding situations. The blockage of channels majorly occurs either by landfilling or encroachment or dumping of garbage and debris (Satterthwaite, Huq, Pelling, Reid, & Lankao, 2007). Ephemeral natural channels that have seasonal streams are highly vulnerable to encroachment and neglect in their non-functional months. They get filled up and become non-existent to provide more land for construction. Some drainage channels get reduced to foul-smelling drains with decreased stormwater carrying capacity because of garbage and debris dumping. This practice of channel blockage is a common occurrence in urban areas where land shortage and waste management are both pressing issues (Satterthwaite et al., 2007). The need to preserve and restore natural channels in urban areas has emerged as a growing concern over the years to mitigate and manage the pluvial floods (EPA, 2010a; Mujibor Rahman, M Akteruzzaman, H Khan, Jobber, & Rahman, 2009).

This study aims to develop a framework for the preservation of natural channels in the cities. When most cities struggle to preserve the natural channels from depletion and encroachment (Mujibor Rahman et al., 2009), an ephemeral channel, namely N-choe, flowing through the city of Chandigarh has retained its function over the years without succumbing to the pressure of urbanization. In this study, N-choe's development over the years is understood and analyzed to identify the factors that have ensured its preservation. These factors are developed further into a generalized framework that can be applied to the preservation of other natural channels.

The paper is structured in six sections to elaborate on the study process. Following this introduction section, Sect. 2 outlines the method employed in this study. Section 3 starts with briefly introducing the city of Chandigarh and develops into the description of the N-choe and the Leisure valley. The Leisure valley is a green belt overlapping the seasonal N-choe. Section 4 has a detailed analysis of the conception and symbiotic evolution of the N-choe and Leisure valley to find out how the development of Leisure valley has resulted in the preservation of the former. Section 5 is the result of the analysis in the form of a framework. Section 6 contains conclusions drawn from the analysis and discusses the scope and limitations of this work. This study's primary outcome is the knowledge that the judicious overlapping of public green spaces over the ephemeral channels helps preserve the latter. This knowledge has been developed into the concept of greenswales.

2. Methods

The method of this research is qualitative, descriptive, and analytic. The facts and data related to N-choe and Leisure valley are majorly obtained from the official website of the Chandigarh Administration and Chandigarh Development Plan 2031 (Chandigarh Administration, n.d.; Chandigarh Development Authority, n.d.). Firstly, the need for overlapping Leisure valley over N-choe is understood from the history of Chandigarh. Secondly, the planning and design aspects of Leisure valley are recognized, which have

contributed towards the preservation of N-choe and maintenance of its function over the years. Factors that have made Leisure valley a well-accepted public place are also understood through the interview of locals. Finally, a framework is developed based on the lessons learned from the case study.

3. Study Area: Chandigarh

The city of Chandigarh (30.74°N, 76.79°E) lies in the foothills of the Shivalik mountain range of the Himalayas in the north of India (Fig. 1). It is a union territory and a shared capital of the two adjacent states: Punjab and Haryana. The city has an area of approximately 114 km², a population of more than 1 million, and is at an elevation of around 321m from the mean sea level. There are a total of 55 sectors in the city laid in a gridiron pattern. It was built in the 1950s and is planned by the French architect Le Corbusier. Chandigarh is globally known for its visionary planning and the contribution of Le Corbusier (Jonathan Glancey, 2015).

The city topography is majorly plane with the view of Shivalik hills in the north. The city has four seasonal streams, namely N-choe, Sukhna choe, Patiala Ki Rao, and Choe Nala. N-choe originates in sector three of Chandigarh, meanders through various sectors of the city, and exits from the city at sector fifty-one (Fig. 2). From there, it enters the adjacent Mohali city in Haryana state and finally descends into the Ghaggar river. Patiala Ki Rao and Sukhna choe originate in the Shivalik hills and flow through the western and eastern sides of the city, respectively. Choe Nala originates in sector 29 in Chandigarh city.

Landscaping is one of the significant planning assets of the city of Chandigarh. An 8 km long green belt, namely Leisure valley, dominates the green landscaped areas due to its size and influence. The presence of Leisure valley has contributed significantly to enhancing the quality of life of its residents (Chaudhry & Tewari, 2010). It is a continuous stretch of public green spaces that runs from sector one in the north-east end of the city to sector fifty-three at the south-west end of the city (Chandigarh Administration, n.d.). It passes through eight sectors and comprises majorly ten gardens (Fig. 2) and other small themed gardens. These green spaces include parks and gardens. The organic sprawl of Leisure valley is in stark contrast with the rigid gridiron plan of Chandigarh. This linear and continuous layout of the Leisure valley is attributed to its strategic placement over the natural channel N-choe. Leisure valley provides social, economic, and health benefits like all green spaces. It helps in reducing noise pollution and enhances the aesthetics of the public realm. It maintains air quality and is also known as the lungs of the city. Parks and gardens in the Leisure valley have a huge footfall. People from neighboring sectors frequently visit here for walks, jogging, picnics, exercises, relaxation, and other leisure activities. From interviews of locals, it is found that the sectors within the close vicinity of Leisure valley are perceived to have a better quality of life and hence have higher land value. It is to be noted that in many Indian cities, lands right next to natural channels have lower land rates. This is due to the excessive garbage dumping that has reduced those channels to foul-smelling drains. Contrarily, Leisure valley has become a significant part of the city's identity. It is a major tourist attraction in the city of Chandigarh. The Rose garden situated here is the most extensive Rose garden in Asia, with more than 1600 rose varieties. The Leisure valley has a lot

of potential to be developed as a green infrastructure along with its current role. However, the policies so far have been formulated only to enhance its role as an active and user-friendly public place.

N-choe running beneath the Leisure valley is silently contributing immensely towards the stormwater management of the city. Many artificial stormwater channels have their outfall at N-choe. It conveys surface runoff during the rainy seasons and also gets partly submerged in stormwater, which slowly seeps in.

4. Analysis: Understanding The Preservation Of N-choe

The preservation of N-choe is purely coincidental. In Chandigarh's documented history, there is no mention of the need to preserve N-choe or to use it as a stormwater management system. It is because i) the city was designed with well-laid grey infrastructure to manage the stormwater, ii) pluvial flooding was not a recognized issue in the last century when the city was built, and iii) dependence upon nature-based solutions for stormwater management is a recent trend. A critical requirement in the planning of Chandigarh city was to provide an uninterrupted view of Shivalik hills even from the farther end of the city (Chandigarh Development Authority, n.d.). To suffice this purpose, there was a need for a long corridor from the Northern to the Southern end. The eroded N-choe running through the city provided the opportunity to realize this vision. It was decided to develop this channel as the long corridor without any visual hindrance though there were equal chances of designing a humanmade corridor as the city is built from scratch. Generally, in neo developments, ephemeral channels are destroyed to reclaim construction land. The destruction of ephemeral channels is shown in Fig. 3, which shows the Janta Nagar colony's case in the Kharar area in the suburbs of Chandigarh city. From the time series analysis of the google earth images, the gradual destruction of a natural ephemeral channel can be seen over the years. Under the pressure of urbanization, the channel has entirely diminished in around ten years, which was otherwise a natural way of draining the area's stormwater. Therefore, though unintentionally, the choice of N-choe for establishing the visual connection with Shivalik hills has paved the way for its preservation till today.

Many planning and design decisions made for the corridor have contributed towards the preservation of N-choe. Careful observations and brainstorming have led to the identification of those contributory factors, which are discussed and analyzed below:

4.1 Factors directly contributing to the preservation of N-choe

1. Green spaces as landuse assignment: A judicious landuse assignment was needed to prevent any future construction over N-choe that could hinder the visual connection. The desired corridor could be in the form of plazas or a broad shopping street, or any other space. The factor that further sealed the preservation of N-choe was the decision to develop the corridor as green spaces. They have retained the natural topography and have prevented the need for leveling of surfaces. This preserved the concave cross section of the channel Green spaces are allowed to get submerged during rains. These undulations

on the ground make for natural detention ponds. Thus with the choice of green spaces superimposition, the function of N-choe is preserved with minimal alterations.

2. Bridges and culverts: The Leisure valley's city-long stretch has ensured the preservation of the complete length of N-choe in the city. Leisure valley is a series of green spaces having distinct boundaries because various bridges and roads cut it across to maintain vehicular and pedestrian traffic. However, culverts and bridges have maintained continuity in streamflow underneath (Fig. 4).

3. Organic layout of the Leisure valley: The long sprawling stretch of green spaces on N-choe is organically following the course of the channel. The organic layout has helped maintain the natural meandering path of the channel without any need to straighten the edges forcefully.

The above three factors are directly contributing to the preservation of N-choe by maintaining its function, permeability, flow-continuity, and path.

4.2 Factors indirectly contributing to the preservation of N-choe

In many cities, public green spaces are also under the threat of encroachment and change in landuse (Li et al., 2019). The Leisure valley is a well-accepted public place with high and evenly spread out footfall and a sense of place attachment. These two factors have contributed immensely to Leisure valley's sustenance, which in return has safeguarded the preservation of N-choe.

Footfall

A public space must have a high and evenly spread-out footfall for its overall health and regular maintenance. There is a threat of overuse in public places at some hotspots while the other parts may remain unused. The underused areas face negligence, get subjected to rampant encroachment, and fall prey to malpractices like drug abuse and garbage dumping. High and evenly spread out footfall is the key to surveillance by the public (Shehayeb, 2008), which helps keep in check any misuse of the space by the negative elements of the society.

Sense of place-attachment

When a place is a part of people's day-to-day lifestyle, then they spend more time there and develop a feeling of attachment with the place (Hashemnezhad, Heidari, & Hoseini, 2013). Place attachment is a psychological approach in bringing about positive behavioral change in people. Najafi and Kamal (2012) suggest that people who feel emotionally attached to a place are more involved in preserving the area and do not take undue advantage (Najafi & Kamal, 2012). There is active reporting of any issue related to ill-maintenance or negligence and diligent pressure on the authorities for immediate redressal of complaints. Thus the sense of place attachment plays a significant role in safeguarding a public space.

The factors that have contributed towards cultivating the sense of place-attachment and have encouraged the high and uniform footfall in Leisure valley are:

4. Equity: Equity can generate high footfall by being receptive to all. The entire stretch of Leisure valley is open to the public. It is frequented by people of all ages, genders, races, and socioeconomic statuses. Therefore, footfall here is very high. The places with controlled or limited access are more vulnerable to damage, encroachment, and vandalism by the non-users.

5. Variety:

a) Variety in design: Leisure valley has different characteristics in different sectors. This variety has been achieved mainly by planting varying fauna, reflecting in the names of gardens. Rose garden, Bougainvillea garden, the garden of Palms, the garden of conifers, the Hibiscus garden, and the garden of fragrances have distinctive characteristics and ambiance. The variety prevents monotony and encourages the users to explore the entire length of the green belt. As a result, the footfall distribution is over the whole stretch.

b) Variety in function: The parks and gardens in the valley are also associated with different functions. Rajendra park and fitness trails are majorly associated with fitness activities, jogging, horse riding, and yoga. Rose garden, Bougainvillea garden, and Hibiscus garden are also used for fitness activities by the neighboring people but are known for their aesthetics and are majorly associated with recreational and leisure activities. In Smriti upvan in sector one has a more sentimental value attached to it. People can plant a tree here in the memory of the departed souls. This functional variety attracts people with different interests and hence adds to high footfall.

6. Multi-point access: The Leisure valley is accessible from all the sectors and has multiple access points. Multiple entries and exit points allow the users to use the green space as a walkway with the choice of entering and exiting at any point. This ease of access contributes to the enhanced footfall. It ensures the usage of all parts of the green belt.

7. Activities: The proximity to the residential area has made the Leisure valley home to many day to day activities like exercise, play, and relaxation. People also visit these gardens for social interactions, picnics, and festivities. Festivals are held in the Leisure valley that includes the Leisure valley carnival in February every year; the annual Rose Festival in February/ March when the roses bloom to their full glory. These daily, seasonal, and annual activities attract a variety of crowd. These have also made Leisure valley a significant part of citizen's lives, and hence there is a deep sense of place-attachment to this place among its users.

8. Adaptability: The valley is evolving and thriving over the years as per people and time demands. The flexibility in the concept and planning of the Leisure valley has allowed it to grow, modify, change, and adapt. A dedicated space for green spaces in the land-use plan was demarcated during the conceptualization period of the 1950s. However, the design and growth of the Leisure valley is a

continuous process. In 1976, Bougainvillea garden was established in sector three, and Smriti upvan in sector one was developed in 1998. In the implementation of Chandigarh Master Plan – 2031, the cycle tracks will make their way in the Leisure valley to have sustainable transportation means in the city (Chandigarh Development Authority, n.d.). Thus adaptability has let the Leisure valley stay relevant in changing times and build an emotional connection with all generations.

4.3 Summary: Value addition through function assignment

The factors discussed in subsections 4.1 and 4.2 are summarized in the flowchart (Fig. 5), which shows the linkages between various characteristics of Leisure valley and their benefits that have ultimately led to N-choe's preservation. From the above discussion, it can be inferred that the primary factor that worked towards the preservation of N-choe over the years is the assignment of an additional function to it. The seasonality of N-choe has been supplemented with the year-long utility of green spaces that are laid over it. This function assignment has added tangible value to the otherwise eroded channel. The aesthetics and function are the aspects that have reduced the chances of its encroachment because it is not seen as wasteland. More importantly, the assigned function has not interfered with the purpose, permeability, flow continuity, and path of the channel.

5. Results

5.1 Concept of greenswales

The primary outcome from Leisure valley's case is the understanding that the ephemeral natural channels in a city can be preserved if greenspaces are developed over them judiciously. On this basis, the concept of greenswales is evolved. A greenswale can be defined as the stretch of green spaces laid over an ephemeral natural channel, having stormwater detention and conveyance as primary functions during precipitation. The term green spaces emphasize the type of landuse without any limitation to vegetation choice. The greens may vary from lawns to urban forests depending upon local needs.

Concept of greenswales:
Green spaces + Ephemeral channels = Greenswales

The terminology greenswale finds its origin in the term bioswale. Bioswale or vegetated swale is a linear form of bioretention used to partially treat water quality, attenuate flooding potential and convey stormwater away from critical infrastructure (Mcpherson, 2017). Bioswales are designed as gently sloping depressions planted with dense vegetation or grass, and they treat stormwater runoff from rooftops, streets, and parking lots (Purvis et al., 2018). The need for introducing the new term greenswale lies in the fact that bioswales are plantations over artificial drains, whereas greenswales are green spaces over natural ephemeral channels. Planners have the choice to place bioswales anywhere depending upon need, whereas greenswales can only be above the natural channels. In principle, bioswales mimic the natural hydrology, and on the other hand, greenswales attempt to preserve the pre-development hydrology of the area.

The greenswales have dual benefits of green spaces and natural channels; together, they can aid better in stormwater management and pluvial flood mitigation. The natural channels follow the topography contours, and the water from the catchment can easily flow to the greenswale with little or no intervention. All stormwater drainage systems are designed to fall into streams and rivers ultimately. The ephemeral natural channels being part of a vast natural drainage system are already connected to intermittent and perennial channels. This connection with higher-order channels eliminates the need for designing an outfall. Also, the channels have concave-shaped cross-section. This facilitates water detention during heavy rainfall. Many cities resort to the development of floodable public places that get submerged in water during heavy rains but retain their function in the dry seasons eg. Water square in Rotterdam (Hampshire & Sipes, 2019), and Yanweizhou wetland in China (Loggia, Puleo, & Freni, 2020). Floodability is a good strategy to mitigate pluvial floods and enhance the resilience of the area (Loggia et al., 2020). Thus in the planning of neo-townships, if there is a provision of greenswales, then a lot of load from grey infrastructure can be reduced, and flood resilience can be built.

Added layer of green spaces makes the greenswales better than ephemeral channels. Along with the environmental, social, and health benefits of green spaces; they also provide various hydrological advantages. The imperviousness in urban areas does not let the stormwater seep into the ground. Therefore, the pollutants get accumulated on the catchment surface in the dry weather and, in the wet weather, the stormwater runoff carries pollutants to the streams, which harm the aquatic ecosystem, and affect the quality of drinking water supply (EPA, 2010b; Gavrić, Leonhardt, Marsalek, & Viklander, 2019). Green covers filter the surface runoff and reduce water pollution (Purvis et al., 2018). In urban catchments, stormwater gets directed to streets, gutters, and channels that convey the water rapidly downstream (Usda, 1986). Obstruction from vegetation decreases overland flow speed and prevents flooding in downstream areas (McDaniel & O'Donnell, 2019; Usda, 1986). Vegetation also intercepts rainfall, reducing net precipitation (Xiao, Mcpherson, Ustin, Grismer, & Simpson, 2000). Transpiration in plants reduces soil moisture, thereby increases subsurface water storage capacity (Bartens et al., 2008).

5.1 Framework for designing the greenswales

A framework (Fig. 6) is developed based on an analysis of the contributory factors in the preservation of N-choe. The foremost goal of the framework is to develop greenswales to preserve the natural ephemeral channels. When the green spaces are laid over an ephemeral channel, the three major characteristics of the natural channel should be retained. i) The permeability of the channel; ii) the continuity in stormwater flow, and iii) the path of the channel. The green spaces superimposition should allow minimal alteration to the channel's natural course and should not create hindrance to the streamflow. Engineered and semi-engineered solutions should ensure the smooth flow of water. Judicious design and material choices should aid in the preservation of permeability as much as possible.

The green spaces should be planned and designed to cultivate a sense of place attachment among its users and encourage high and uniform footfall. These can be achieved through the following design and planning considerations:

- **Equity:** The green spaces should be all-inclusive and prevent monoculture. There may be some administrative controls, but that should not exclude or discourage any user group.
- **Variety in design and function:** Monotonous spaces offer lesser exploration opportunities to the users. Therefore, the planning of green spaces should incorporate a variety in design to break the monotony. The place should also be made multi-functional by combining parks, play areas, fitness trails, gardens, eateries, outdoor gyms, pets' parks, cycle tracks, etc., at different sites.
- **Multi-point access:** The long stretch of green spaces should have easy and approachable access by providing multiple entry-exit points.
- **Activities:** The green belt should facilitate daily, seasonal and annual activities for the citizens. This may include picnics, festivals, sports events, marathons, concerts, and the likes.
- **Adaptability:** The design and planning of green spaces should be such that it adapts with time according to the local needs and environmental demands.

6. Conclusion

Greenswales have the potential to preserve natural channels in a city. The case of Chandigarh is an excellent example of this approach and offers many learnings. The framework developed in this research will guide the city planners to have an alternative approach to preserve the natural channels sustainably and use them as a tool for pluvial flood management. This method of safeguarding natural channels will also provide the opportunity to have more green spaces in a city. The greenswales also have the potential to be developed into green walkways and cycle paths. While creating green spaces, the principles of sustainable urban design should be taken into consideration.

The greenswales offer multiple benefits to humans and the environment. It is a sustainable way of preserving channels instead of concreting, which has many disadvantages. Concrete lined channels have no permeability, and they convey the entire stormwater out of the city. The concrete lining also increases the speed and volume of stormwater discharge, which poses a threat of downhill flooding. Therefore, the approach suggested in this paper is one of the sustainable ways for flood mitigation and groundwater recharge.

This study has followed the qualitative approach and paves the way for quantitative research in the future. The catchment size of N-choe and the volume of stormwater it carries can be studied in future research to have a detailed understanding of the importance of the preservation of the channel in an urban setting. The focus of this paper is only on the role of Leisure valley as a savior of the natural channel. Therefore, the valley is not analyzed on the basis of its performance as a public place. N- Choe, and Leisure valley share a symbiotic relationship where N-choe also has a major contribution to the sustenance of Leisure valley through natural irrigation. However, that aspect is not explored in this study. This paper explores the nature-based alternatives for stormwater management and pluvial flood mitigation, which will steer the city's growth trajectory towards a more sustainable and resilient future.

Declarations

Ethics approval and consent to participate

Not Applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on request.

Competing interests

Not applicable

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Authors' contributions

Ankita Sood developed the idea, and developed the results as well as wrote the final manuscript. Dr. Arindam Biswas supervised the study. Both authors discussed the results and contributed to the final manuscript.

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Figures



Figure 1

Location of Chandigarh city in the map of India. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

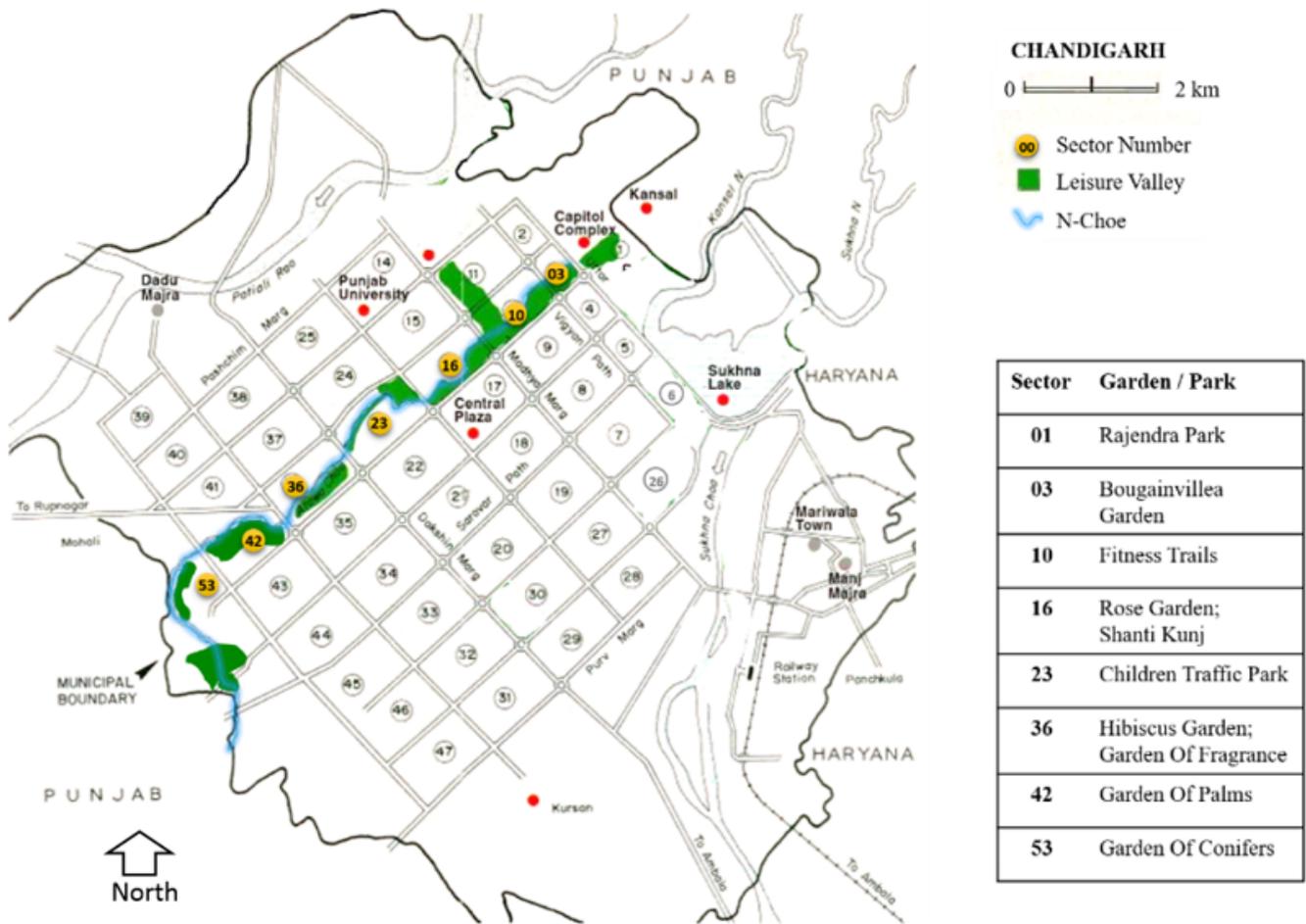


Figure 2

Location of N-choe and Leisure valley in the city of Chandigarh (Developed from Tourism map of Chandigarh). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

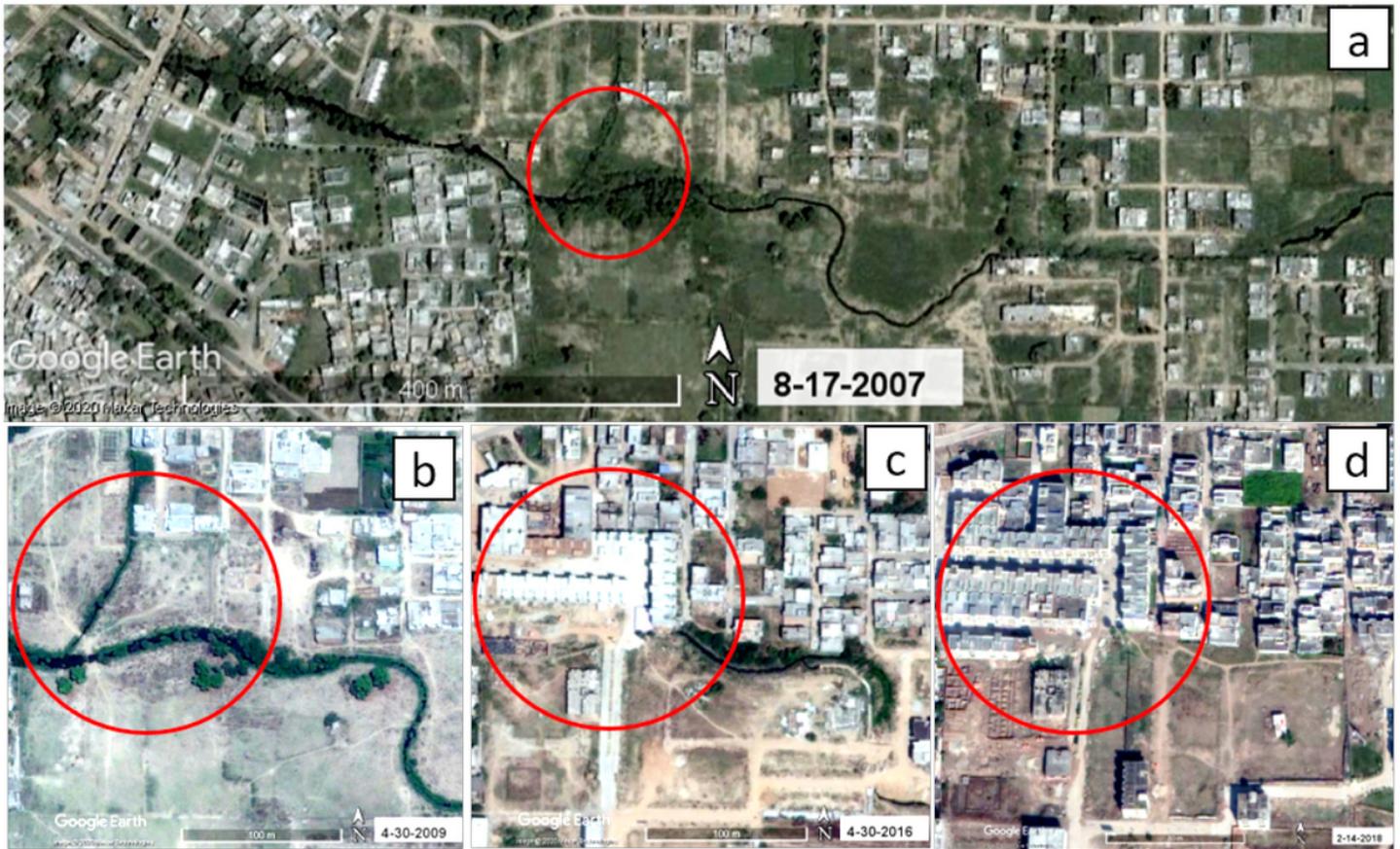


Figure 3

Destruction of the natural channel over the years. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

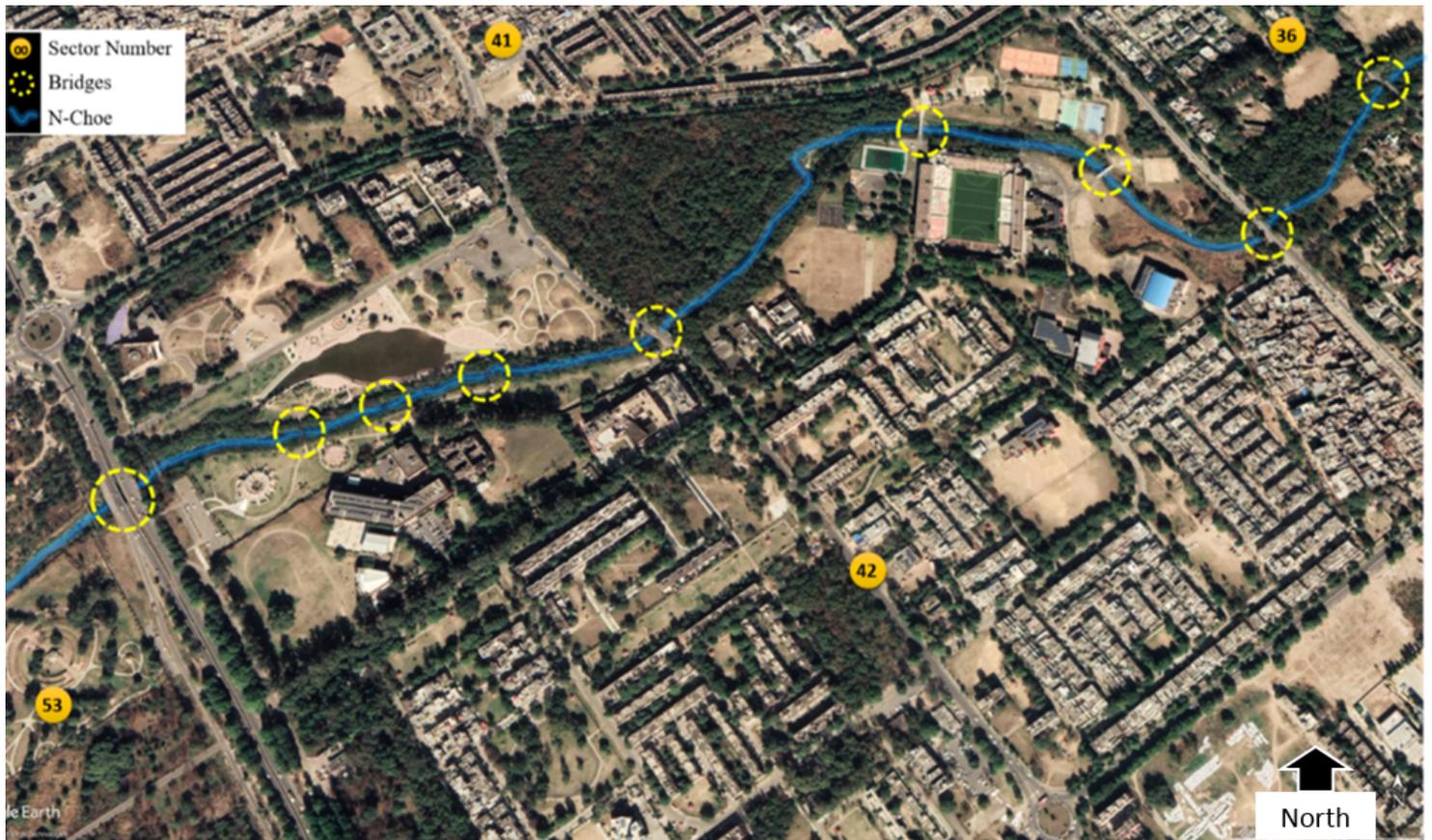


Figure 4

The vehicular and pedestrian traffic flow is maintained through bridges without disturbing the streamflow in N-choe (Developed over the google earth imagery). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

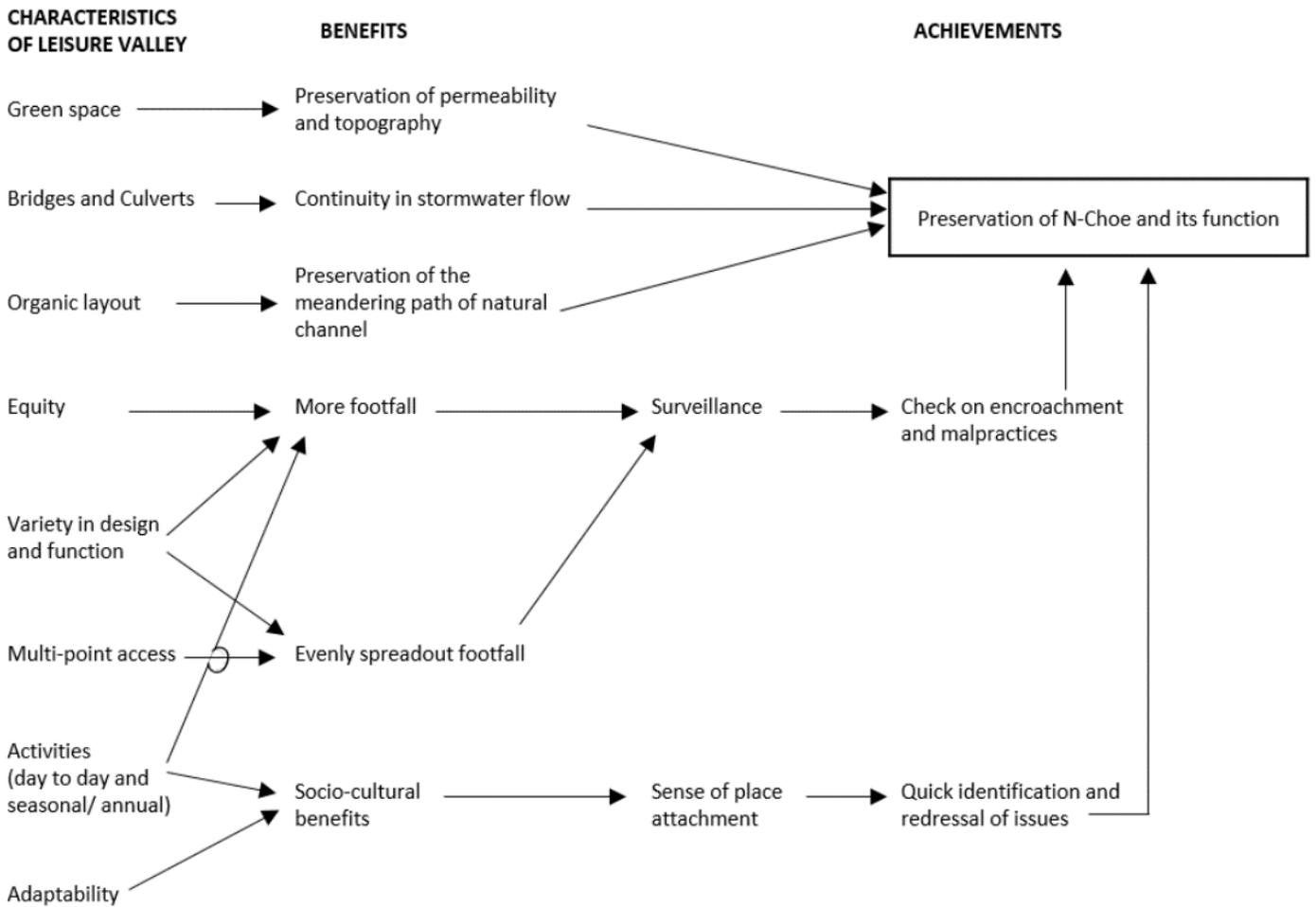


Figure 5

Summary of the factors that contribute to the preservation of N-choe in Chandigarh

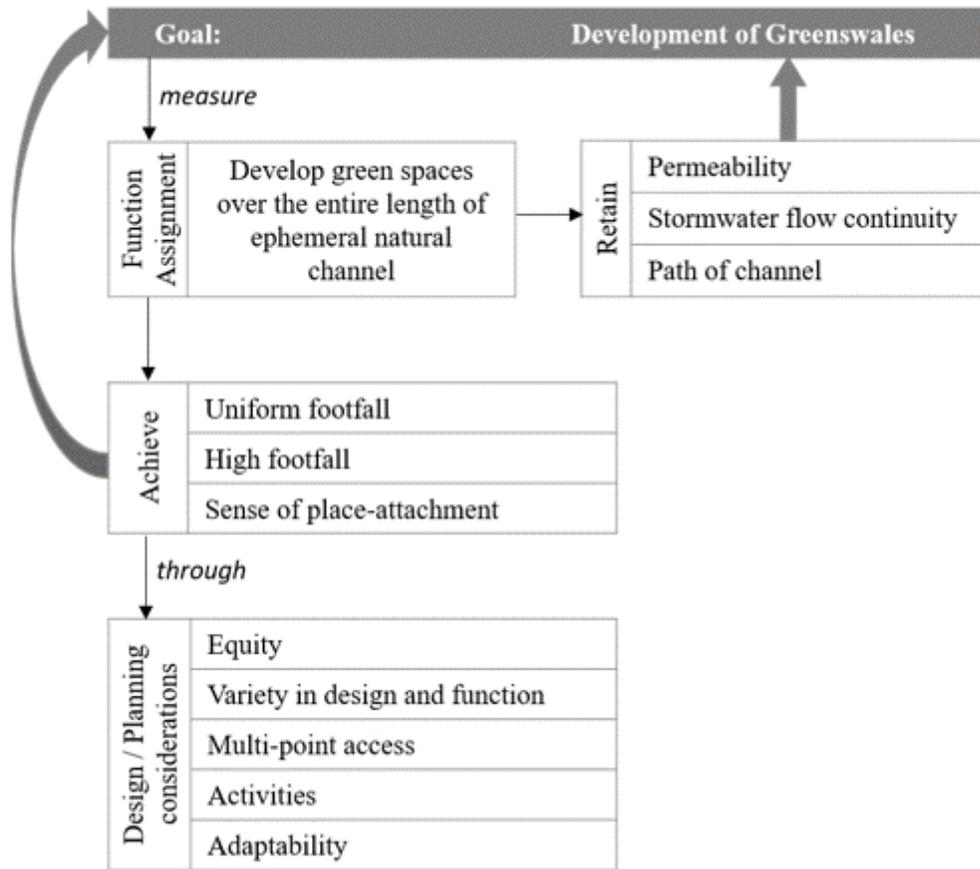


Figure 6

Framework for the sustainable development of greenswales in urban areas