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Survey Article

Landscape Planning and Public Space Optimization of Grand Canal Cultural Park based on Computer-aided Design

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ABSTRACT

Collaborative As the rate of urbanisation is increasing at a very fast pace, there is a huge demand for Landscape planning with proper public space optimisation. China, a country which has witnessed rapid growth in population and economics, has become a target of urbanisation. The country is known for its aesthetic appeal in the Grand Canal cultural park, which has been a primary factor in the country's development since ancient times. However, landscape planning with efficient utilization of available public space in the region using contemporary computing technologies is the need of the hour. This work focuses on deploying Computer-Aided Design in landscape planning using the Artisan plugin, specifically meant for environment planning. The special tools available in this plugin help landscape planning architects to accurately study the characteristics of the landscape, like terrain, water bodies, planar regions, etc. Also, this work proposed a four-phased model that aids the development process of landscape planning activity by including micro-level factors that directly interact with the environment. In future, this model could be extended to include AR, VR, AI and ML technologies.

Keywords: CAD, Artisan, Grand Canal Cultural Park, Landscape Planning, Space Optimisation, Water Bodies.

INTRODUCTION

The massive population migration in China has created new villages as a part of the country's urbanization. This has subsequently accelerated the socioeconomic development of the country and also changed the countryside [1], [2]. The National Bureau of Statistics of China reveals the dramatic reduction of the rural population by 164.36 million over the previous decade while the urban population has escalated by 14.21% [3]. This urban–rural dichotomy is focused on megacities and even in some medium and small cities. Figure 1 shows the uneven distribution of population in China. This has eventually led to the shrinking of the rural areas. This has led to many problems like poor space utilization, overcrowding, biased access and distribution of natural resources, etc. Figure 2 enumerates some of the vital problems that have been raised due to urbanisation.

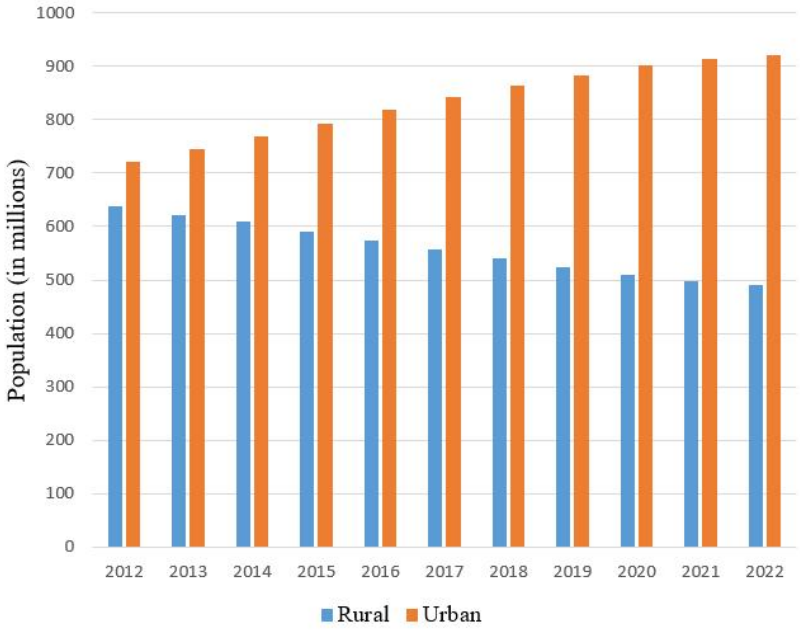

Figure 1. Distribution of Rural and Urban Population in China

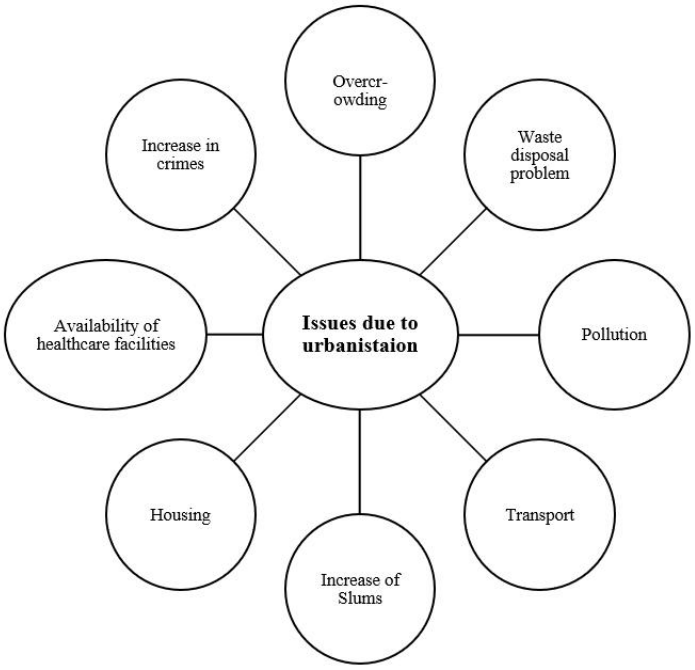

Figure 2. Problems due to Urbanisation

China's rapid urbanization has caused the habitat of the rural and urban areas to undergo dramatic changes [4]. The availability of physical places is quintessential to carrying out social activities like cultural activities, interpersonal communication, information exchange, etc [5]. A vast area of rural spaces has been occupied and converted into private spaces due to urbanization, thereby losing its originality [6]. In terms of creating and imparting countryside appearance to rural public space, there is a constant lack of restoring its character [7]. The emotional identity of the public space is disrupted when a large number of buildings are placed in rural appearance, which is commercialized, but there is a heavy mismatch [8]. Also, there is a tendency to intensely consume the vernacular culture. This prevents the rural people from identifying their own cultures. According to a study, it was found that China currently has only 271 million villages, which was 363 million 10 years ago [9].

It is true that new rural buildings are found advantageous despite the fact that they obliterate hundreds of traditionally rich villages with a high degree of scientific, aesthetic and cultural characteristics. Rapid urbanization causes the rural public spaces to experience trends that cause humanistic care, local characteristics, disintegration of communities, un-familiarization and spatial shrinkage [10], [11], [12]. This creates a contradiction between the availability of rural public spaces and the demands confronted by the residents, which also creates tension among

the people and civic structures [13].

All these factors have transformed the profession of landscape architecture to deal not only with the design and development of land without compromising the measures to conserve nature, climate, soil and plant species [14]. Towns and small cities with open spaces demand landscape design around terraces of buildings and industries to cater to the specific goal of controlling pollution, amusements, hotels, transport lines, riverbanks, etc. They should also closely collaborate with horticulturists, ecologists, service engineers and architects. Landscape architecture has emerged as a miniature of a multitude of professions of various disciplines. The fundamentals of landscape design are components of scale, unity, balance, variety, simplicity, sequence and emphasis. These interconnected elements are applicable to all lines, textures, forms, and colours [15]. Figure 3 shows the various factors influencing landscape design. Landscape planners must investigate the major and minor factors before construction.

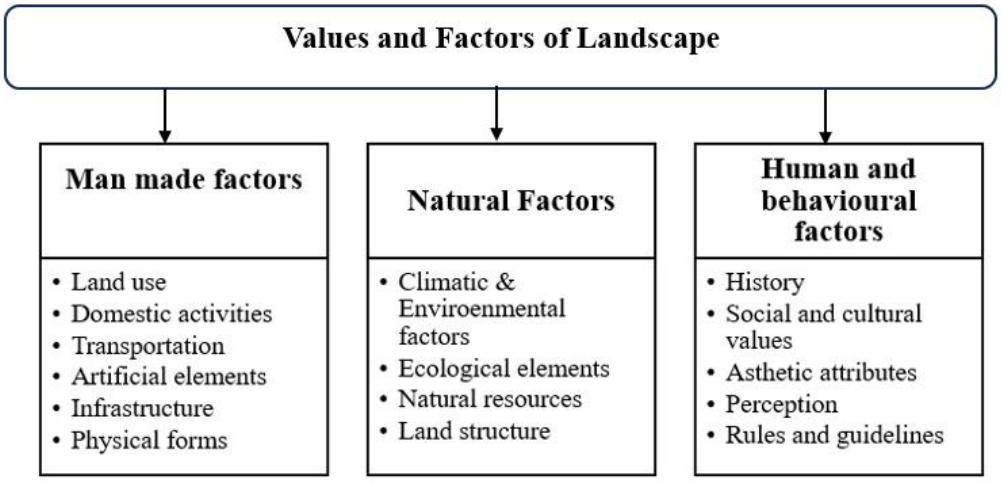

Figure 3. Factors Influencing the Landscape [16]

As a potential solution to these problems, planners have now employed the information to foresee and reveal problems in planning urban as well as rural spaces without spoiling the nature of the land. Leveraging this information as a basis for research and analysis, many new research directions are emanating. This has become a new genre of urban design. When compared with classical graphical design language, this information language is useful and has better scientific objectives. This urban design and landscape planning has to be implemented in the 3D space of the area to be constructed. It must be noted that 2D graphic language cannot meet the complexity of the design; hence, 3D graphic language is used to reveal the mechanism of 3D urban space. Though the technology is very powerful, it does not furnish a complete mapping among the various factors.

Technologies Used

Recent contemporary technologies have changed the notion of landscape architecture. It has completely transformed the design processes, education, business, construction, etc. A Few important technologies in landscape designing and urban town planning are mentioned below:

Artificial Intelligence and Machine Learning

The most attractive, recent technologies that have found applications in almost all fields are Artificial Intelligence(AI) and Machine Learning (ML) [17]. These technologies help the applications to explore the domain of machine-generated images while planning the landscape. This also includes the social, ethical and moral considerations which foster development in landscape designing.

Data and Mapping

Employment of data, along with proper mapping, has eventually increased as the years pass. This is further augmented by the ability of the users to purchase data along with factors like environmental, economic and social conditions, permitting the landscape planning to easily understand the spaces with a potential to understand the place over seasons, time, as well as events. Suitable visual representation through graphs and maps facilitates landscape architects to impart more fine-grained understanding knowledge to their clients.

BIM

This is a powerful technology that is capable of manipulating software specific to floors, ceilings, and walls to create comprehensive landscapes. These tools either exist as plugins or apps that render the ability to impart designs to terrain and other curved elements in a better manner [18]. This tool can be perceived as the next

generation in design as well as the documentation of landscape architects after CAD. Figure 4 shows the environment for Revit.

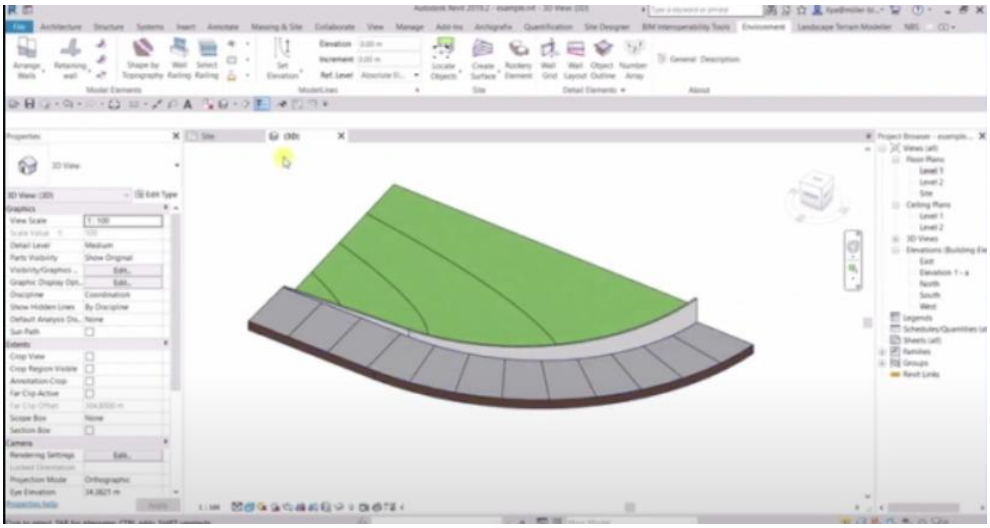

Figure 4. Environment for Simplifying Terrain Modelling

3D printing

The 3D printing technology has witnessed a steep increase in the application of landscape architecture and urban space planning in the recent past. This is primarily deployed for small-scale model making, which is very cost-effective for landscape designing, planning, and urban space optimisation [19]. Most firms outsource prototype 3D printing to small and medium labs as a cost-cutting measure.

3D Scanning/LiDAR

This has the potential to create a 3D model that helps the designers to comprehend the site in a more detailed manner. Apart from this, it also provides evidence of the existing landscape that could be used to study the terrains and to create optimised designs with greater accuracy.

Computer Aided Drawing

Computer-aided drawing (CAD) is the most popular landscape design software that enables architects to explore landscape design. In the highly competitive world, CAD garden designing and planning software forms a pivotal part of the architect's toolbox. This facilitates the teams' collaboration to render more visual insight. This tool is extensively used for designing backyards, commercial gardens, decks, patios, and outer buildings. Figure 5 shows the outlook of the CAD.

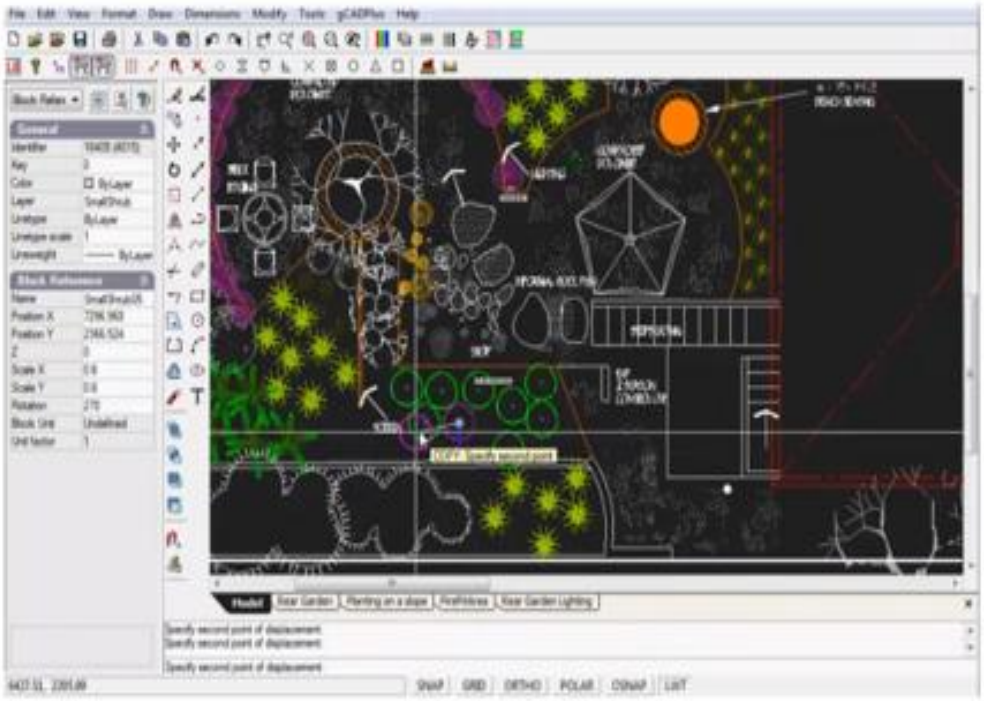

Figure 5. Outlook of the CAD

Some of the prominent features of CAD include:

Easily revisable diagrams

Using quick commands to fasten the process

More specialized landscaping with a wide variety of options to choose from

Fast and seamless workflow that supports a wide variety of files like DWG, DXF, DWT, Sketchup, Image, ACIS SAT, and PDF.

Availability of a vast catalogue of symbols

Facility to streamline the team's commercial landscaping projects.

Ability to cope with industry standards.

This work focuses on the usage of CAN tools for landscape planning and public space optimization of Grand Canal Cultural Park.

Grand Canal and its Cultural Park

The Grand Canal of China spans more than 3,000 km in length and is important evidence of Chinese history [20]. It serves as a primary cultural resource that blends history with modern China. It plays a crucial and significant role in portraying China's legacy and drives its development. The legend of this canal has been remembered in almost all Chinese provinces and extends up to an area of 800,000 sq. km. among 500 million people. This highlights the aesthetic and cultural value of the Canal as a significant cultural heritage site. The Grand Canal is a predominant large-scale system of water transport for people. The canal, besides being admired for its aesthetic properties, is used to promote tourism apart from transportation heavy cargo.

Figure 6. Grand Canal Region

Figure 6 shows the Grand Canal region. In the year 2019, the Grand Canal Cultural Protection, Inheritance and Utilization Plan, along with the Construction Plan for the Great Wall and National Cultural Park, were formed and published. These plans showed that the Grand Canal protected the heritage apart from being a waterway. The salient features include a waterway system, environmental restoration, cultural tourism, and coordination of urban and rural areas. The primary heritage in the National Cultural Park area, along with tangible and intangible assets, represents the significance of the National Cultural Park. The association with cultural as well as heritage conservation and sustainable development must be mapped with social, economic and environmental considerations. The aesthetic value of the National Cultural Park can be further fostered by integrating the core heritage site along with other important features. Notable strategies include archaeological studies, intrinsic protection, investigation of history, culture, cultural industry, community development and cooperation among the cities. Figure 7 shows the Grand Canal Cultural Belt.

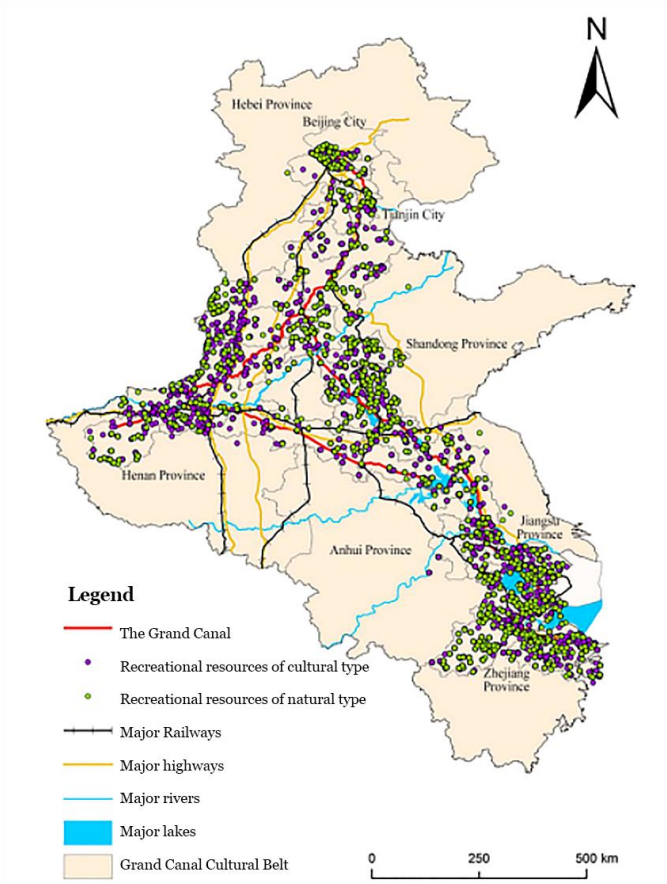

Figure 7. Grand Canal Cultural Belt

The Chinese government is trying hard to preserve the cultural value of the Grand Canal National Cultural Park by initiating landscape planning and optimising space utilization using various technologies. This work explores the usage of CAD in the process of landscape planning and also in the efficient optimisation of the public space in the region of Grand Canal Cultural Park.

The organisation of the work is as follows: section 2 briefs a few prominent works in the domain of deploying technologies in landscape planning. Section 3 explains the proposed method of using CAD in landscape planning, while Section 4 shows the planning and optimisation of the Grand Canal cultural part. Section 5 concludes the articles with a special mention of future scope.

LITERATURE REVIEW

This section highlights Landscape Planning (LP) and public space optimization using contemporary technologies. The deployment of computer virtual and visual technology in LP aids construction in a more scientific and standardized manner. This work covered geological verification till simulated design [21]. The work also studied the layout as well as the mode to optimize the space problems. The technologies were used to search the unknowns to evolve a fresh structure of association relationships in LP [22]. The work used Berlin to investigate the usage of open space with proper contemporary, purposeful and structural qualities. A study on the Jinzhai Country at the macro level analysed the issues of the current status of LP [23]. The study indicated that the overlook corridor control has a more powerful impact on the building height.

A detailed investigation of the plant spatial types, along with their scale characteristics from different perspectives, establishes a comprehensive knowledge of plant-based LP [24]. This work explored the impact of visual aesthetic elements on a scale along with psychological scale to implement the plant elements in LP. The development of AI-based technologies introduced a fresh visual phenomenon based on the cross-border as well as on the multidimensional interactions of visual images in the context of data mining [25]. Also, the same metric information can be correlated among the projection and corresponding scene surface when investigated in 3D.

A comprehensive case study based on the LP and space optimisation of Nanjing, China, facilitated proper planning of the greenspace network [26]. This work aimed to construct LP with a greater degree of flexibility with future urban expansion, acquisition of green fields, modern recreational activities, wildlife and other benefits in mind. A novel spatial optimization model was proposed that facilitated efficient utilization of space by development, compatibility augmented with defensible redevelopment [27]. This uses a density-based design, which imposes a predefined level of neighbourhood development. The locational trends of post-industrial economic activities integrated with new urban governance policies rearrange the LP [28]. The inner city is eclectic clustering focussed on economic activities such as high-level financial services, technology, and knowledge institutions.

A detailed study of the ecosystem service approach, along with appropriate valuation, has definitely modified the policies on conservation, management, and other areas of natural resources [29]. It was acclaimed that investments in the conservation of the ecosystem are seen as a "win-win situation". A framework that prioritized and selected the urban green infrastructure for cooling was proposed that explored the associations among the .urban geometry, temperature control and UGI [30]. The work focussed on quantifying the benefits of the cooling elements in green open spaces, shade trees, and green roofs, as well as in vertical greening systems.

Connected vehicle technologies were closely coupled with LP by considering certain aspects like fleet safety, vehicle design, usage and ownership [31]. The study examined the challenges in extensibility, scalability, privacy and security components. Research on the utilization of 3D CAD, Virtual Reality (VR) and GIS with parametric modelling plants was done [32]. The work created a 3D digital terrain model with real-time fluctuation of the water body. A holistic review of the modelling of domestic landscape grid space drawing as well as design was done [33]. The work focussed on the CAD in LP. A survey on the status quo of the LP and space optimisation based on CAD is done [34]. This work helped to select more suitable computer-supported software. An integrated GIS-based 3D model specific to the district of Cologne-Mülheim was developed [35]. The additional data models were gathered from data sources.

The brief review of the LP and space optimization reveals that many technologies like VR, CAD, AI and ML were used for effective town planning. Most of the works used technologies that consider the influential factors in landscape planning and space optimisation. However, there is limited work that focuses on the Grand Canal cultural park. This work proposes a method for planning landscapes with better space utilization along with an assessment system.

METHODOLOGY

CAD based Landscape planning and public space optimization of Grand Canal Cultural Park

CAD occupies a pivotal position in LP and public space optimization. This has been used in planning developed cities, which are popularly known for their urban planning as well as construction. The visual features are captured using powerful cameras without compromising the wide range of cultural values of the Grand Canal cultural park for optimised urban planning. The primary challenge is in aligning the public space as it demands a harmonious coexistence among various elements like man, nature and other creatures. As the public space signifies justice as well as tolerance level of the society, it becomes a gathering place that fosters the cultural characteristics of the Grand Canal cultural park [36], [37]. It also embraces heterogeneous social life, which signifies the freedom spirit. In the infancy stage of economic development, the urban public space in this region is planned to provide information exchange among the people. By leveraging the CAD, the public landscape designers can overlook the constraints of space and time and then turn the sketch into an effective model. Figure 8 shows the prominent steps in the development process.

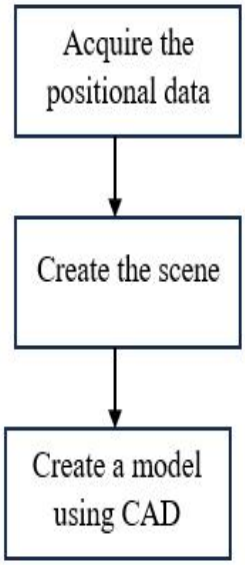

Figure 8. Steps in the Development Process

The elements in Grand Canal Cultural Park are very versatile and encompass water bodies, mountains, bridges, canals, historical monuments, archaeological artefacts, wildlife species and very precious ecosystems [38], [39], [40]. The four main criteria for understanding the terrain of the cultural park are listed below:

This stands as solid evidence of human creativity, which demonstrates the technical competence in hydrology.

This is acknowledged as an imperial monopoly of storage as well as transport of grain, troops, salt and iron, and formed the backbone of the taxation system from time immemorial.

This region is known for its support in the socioeconomic development of the country. The construction of dykes, bridges and weirs using sophisticated materials is appreciated.

This cultural belt fosters ways of life and nourishes the development of rich culture, wildlife, natural reservoirs, scenic beauty and a comprehensive ecosystem.

Hence, the proposed work covers all these criteria in various phases by considering all these elements in CAD-based LP and urban space optimisation. The phases are mentioned in Table 1.

Table 1. Phases in LP and Space Optimisation Using CAD

Phase	Activities
Phase 1	Formulate the objectives, document them, collect site maps and information and interview residents
Phase 2	Site analysis, tourist attraction, facilities survey, local, regional and national laws and

	their compliances, investigating the environmental factors, analysing the GIS visibility, selection of viewpoints
Phase 3	Concept design, landscape design ideas, study on spaces, block plans, references, alternate designs
Phase 4	Design process, workflow, references, photographs, various drawings in CAD, rendering images through visualization technologies, assessments

The above-mentioned phases are an overview of the CAD-based planning process. A realistic design in CAD can happen only after a detailed analysis of the granular elements of the Grand Canal Cultural Park region. The analysis of geography, climate, people's opinions, land usage and understanding of cultural values are also important during the requirements-gathering process. Figure 9 shows the fine-grained analysis of the design process.

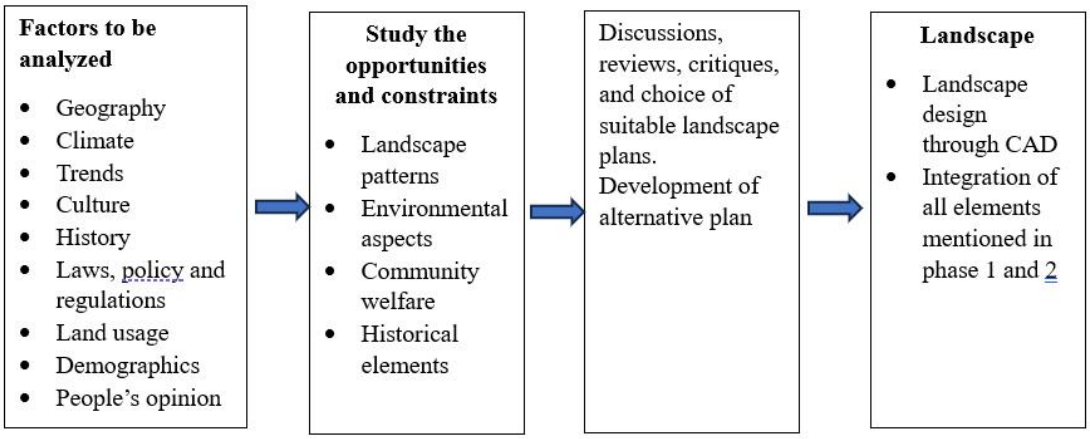

Figure 9. Granular Analysis of the Elements in the Design Process

The CAD-based designs will focus on environmental attention, which enables the coexistence of humans with nature and enriches diversity. The functions and operations of the natural systems should not conflict with human interactivity in this region [41]. The LP should consider the entire environment, along with plants, animals, history and humans, as a part of the ecological system without compromising the people's enjoyment and needs. Social and community innovation facilitates the promotion of fresh, sustainable forms of interaction by promoting tourism facilities [42]. The LP should include co-production, co-events, co-living, etc., by considering features like climate, soil, species, and lifestyle. Incorporating sustainability augmented with future opportunities will nourish the existing natural, cultural and human in the long run. As natural systems evolve and autostabilize themselves, the CAD design should impart a good degree of flexibility.

RESULTS AND DISCUSSION

The proposed work employs CAD-based systems to design landscape and space optimisation in the Grand Canal Cultural Region by considering all the factors listed in the above sections. The landscape design shown in Figure 10 is based on the various factors enumerated in the previous sections. This work was done in AutoCAD Revit, which is a popular BIM platform for landscape planning and space utilization.

(a) (b)

Figure 10. Two Landscape designs are CAD

The procedures followed in this work are:

This does not follow a layered approach, and the elements inserted in the landscape are considered as families. The families, such as water bodies and greeneries, are graphically rendered in 2D images.

The models have been created using parameters like dimensions, weight, materials, appearance, etc.

This work facilitates information scheduling for every object that is rendered.

The artisan plugin is used to create the greeneries, paths, terrain, and other landscaping elements. It has planting symbols, data for planting plans, etc. Figure 11 and Figure 12 are a few working modules of the landscape.

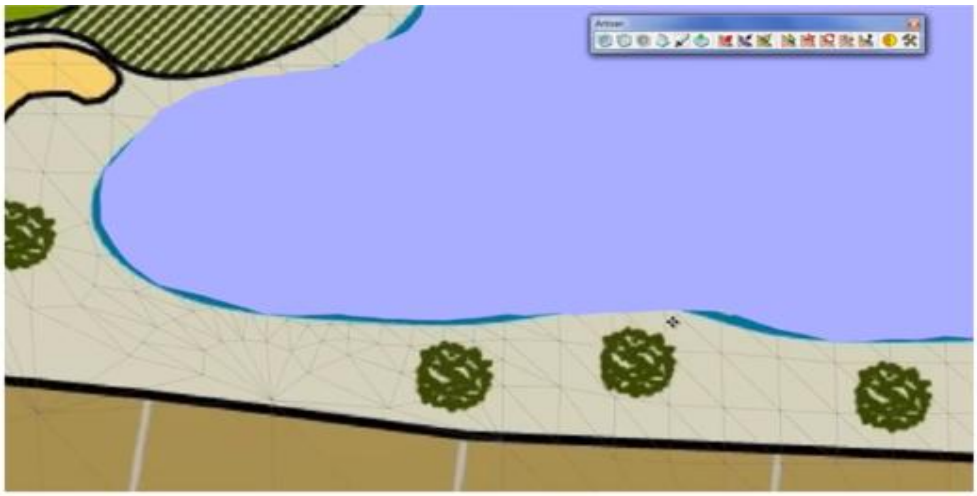

Figure 11. Soft Transmission of Water Bodies

Figure 12. Planar Transformation

This tool eases the Imports and exports without Revit software. This facilitates easy viewing of the models.

The proposed four-phased model is used step by step to create the landscape for Grand Canal National Park. The geographical terrain and features of the Grand Canal National Park are studied, including the climatic factors and compliances. The landscape patterns are analysed before doing the planar transformation. The integration of the rudimentary elements from the initial phases is done in planar transformation. The product of human creation and culture influences the cities, their patterns, street places, and landscapes. This should be rationally arranged based on the characteristics of the environment, which maximizes the function by exploring sustainable principles. The continuity, cultural appeal and aesthetics of the Grand Canal cultural park must also be considered. Thus, the work delineates the factors that have to be considered while planning the landscapes for better space utilization using CAD.

CONCLUSION

Designing and developing landscapes in the Grand Canal cultural belt with efficient space utilization is the need of the hour. The primary challenge in doing this is the heterogeneity and versatility of the landscape, as the cultural park encompasses large water bodies, terrains, mountains, greeneries, farmlands, mines, etc. Hence, this work presents a model that enumerates the factors that have to be considered while focusing on landscape planning, right from the geography of the land to people's opinions in utilizing the landscape. The four-phased model presents various stages in model development and then drills down the design scenario into more granular elements. The model design is done using a CAD tool named Revit, which includes a special plugin, Artisan. The model designing modules are also shown for soft transformation and planar transformation of terrains. Thus, the model proposed in this work is very generic and versatile; hence, it can be deployed in any CAD tool. As a future enhancement, this model could be extended to include contemporary computing technologies like AR, VR and AI.

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