

Basic Framework and Implementation of Land-sense Ecological Planning in Urban-Rural Ecotones: Postprint

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Abstract

Traditional urban planning methods have primarily concentrated on urban land use, population scale, and transportation priorities, while devoting insufficient attention to urban environmental quality and environmental welfare. To construct an urban morphology compatible with future residents' quality of life, urban ecological planning must consider more diversified data foundations and accessible technologies, particularly residents' actual perceptions of these plans. Rational and scientific planning necessitates comprehensive analysis of urban ecosystems, encompassing both natural and anthropogenic factors. A novel concept and theory, "Landsenses Ecology," can couple urban planning blueprints with human perception. Landsenses ecological planning should inherently incorporate various human perceptual needs regarding planning, including visual, auditory, gustatory, olfactory, and tactile senses. This paper adheres to the fundamental theories of landsenses ecology, using Xiji Town as an implementation case study, to exploratorily conduct landsenses ecological planning for the rural-urban fringe, thereby elucidating the challenges and importance of integrating residents' sensory information into the ecological planning process.

Full Text

Preamble

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Title: "Landsenses" Ecological Planning for Urban-Rural Ecotones

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Abstract

Traditional urban planning methods focus primarily on urban land use, population size, and transportation priorities, often failing to consider environmental quality and welfare within urban systems. Developing urban forms that improve future quality of life for residents requires incorporation of available data and technologies, especially residents' actual experiences, into urban planning frameworks. Moreover, rational, scientific planning depends on comprehensive analyses of urban ecosystems, including both natural and human factors. A novel concept and theory, "landsenses ecology," can assist urban planners in integrating human experiences into urban-planning frameworks by incorporating information deriving from direct sensory experience, including vision, hearing, taste, smell, and touch, into planning frameworks. Based on the framework of landsenses ecology, and using the town of Xiji as a case study, we constructed a provisional landsenses plan for the urban-rural ecotone, in which we addressed the importance and challenges of incorporating sense-based information into the ecological planning process.

Keywords: ecological planning; Internet of Things; landsenses ecology; sustainable development; urban-rural ecotone

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1. China's Cities Need New Ecological Planning Concepts

China is currently in a special period of ecosystem conservation, which presents both opportunities and challenges for ecological planning and ecosystem management. While guidelines for ecological urban planning emphasize energy, light and thermal environments, waste management, and green space utilization, these principles are difficult to implement in practice. Planners struggle to obtain comprehensive information through existing institutional frameworks, making it challenging to plan intelligently for the future. Information reflecting urban residents' lifestyles, preferences, social equity, and satisfaction is not easily collected, yet this sensory information is precisely what planners need to integrate into the planning process. Urban planners and designers require more diverse data from thriving cities, including experimental data, questionnaire surveys, and psychological information, to study land use planning, construction,

and management for sustainable development. Based on ecological principles, comprehensive analysis of natural processes and risks is essential. Landscape ecology provides a framework for this integration [8].

2. Enriching Ecological Information in Planning Processes

Landscape planning advocates for full consideration of social and environmental factors, leading ecological planning to focus more intensively on human-nature relationships, which requires enhanced data collection and analysis methods [13]. Data formats in urban planning have evolved from early analog data to precise scientific observations. Urban ecological and environmental planning data come in many types and sources, forming diverse datasets. The urban planning field emphasizes “big data” characteristics: Volume (requiring substantial effort to measure each ecological factor), Velocity (demanding multiple observation methods for the same target), and Variety (enabling long-term monitoring and coupled analysis of phenomena from different perspectives) [13]. Traditional landscape ecological planning includes landscape ecological suitability and sensitivity analyses based on landscape ecology methods. Landscape ecological planning builds upon this foundation by integrating humans into the environment itself, focusing more on diversified human-environment interactions with the development of IoT technology, convenient environmental information collection, and increased environmental experience demands. This approach requires more real-time information about the environment and human behavior as a basis for planning and decision-making.

3. Making Full Use of Residents’ Sensory Data

Humans are the most complex components of urban ecosystems, and urban sustainable development goals are extremely broad, creating massive data management requirements with high demands for input and processing speeds. Every day, large numbers of individuals move and work within densely populated urban areas. These dynamic data represent ecosystem status information for numerous urban complexes, reflecting the complexity of components and relationships within urban ecosystems and illustrating the intricate connections between human activities and environmental issues [14]. These data vary greatly in structure, dimension, and granularity—some contain urban life information, others reflect quality of life, and some can analyze and solve environmental problems. Sustainable urban construction requires enriched data types about urban ecosystems. Future urban development will shift from traditional simple human-nature relationships to more human-centered models, particularly emphasizing human emotions, incidental activities, and basic needs. Planning approaches based on collaborative thinking and learning with stakeholder knowledge participation are more conducive to strategic integration. Stakeholders can incorporate their shared perceptual goals into planning, such as distance to green spaces and sense of security. Planners can easily obtain new insights from stakeholders’ sensory data. We should fully utilize urban residents’ sensory data because

these people are the true stakeholders in ecological planning. The Internet of Things provides opportunities to digitally study and analyze urban ecological issues, particularly for complex problems like urban sustainable development [16]. Smartphones and wearable electronic devices can track human behavior and physiological conditions, establishing a foundation for population-oriented sustainability data analysis and planning [15].

4. Making Full Use of Environmental IoT

In digital and smart city construction, urban information infrastructure has accumulated vast amounts of data while providing information services. Urban environmental data are particularly important for planning, including atmospheric conditions, wind, and other environmental elements. Environmental IoT enables collection through online remote monitoring methods, providing technical support for sustainable city planning, construction, and management. With improvements in information technology, collection and processing methods, and observation and sensing devices, modern technology has evolved to support urban planning, simulation, and prediction from multiple sources, for multiple targets, and with multiple functions.

3. Basic Ideas and Implementation of Landsenses Ecological Planning for Urban-Rural Ecotones

Based on landsenses ecology concepts and the above analysis, we exploratorily implemented landsenses ecological planning for Xiji Town, a typical urban-rural ecotone in Tongzhou District, Beijing. Through processes including early-stage multi-source sensory data processing and comprehensive balancing of stakeholder interests, we clarified the basic ideas of landsenses ecological planning for urban-rural ecotones and carried out implementation in Xiji Town.

1. Sensory Data Processing for Urban-Rural Ecotones

Urban-rural ecotones are transitional zones with mixed urban and rural land use characteristics, also known as urban fringe areas. These zones, particularly those near cities with urbanization features, are primarily connected by transportation arteries. Landsenses ecological planning for urban-rural ecotones aims to enhance harmony between humans and nature, requiring planners to fully understand interactions between natural and human systems. Environmental perception information must include traditional planning data, such as water environmental quality, species composition, and population sizes, as well as personal feelings and psychological responses like skin sensations and visual effects. Excellent ecological planning should satisfy the five basic human senses: sight, hearing, taste, smell, and touch. In this study, data derived from human senses are treated as primary source materials.

Table 1 categorizes planning content and methods based on landsenses ecology concepts, including eight sensory types: sense of beauty, hearing, taste, smell, touch, wind, psychological reactions, and sense of direction. Planning categories include landscape pattern optimization, building color planning, plant configuration design, historic building preservation, IoT technology demonstration, water surface cleaning, waste treatment, glass curtain wall and night lighting design, green buffer design, natural soundscape construction (frogs, etc.), farmhouse dining and entertainment, ecosystem service supply design, soil-friendly design, flower fragrance configuration, water accessibility design, on-site experience design, green corridor patterns, and visual axis design. Researchers developed an appropriate scheme to effectively combine these elements.

Constructing an ecological corridor provides both physiological and psychological satisfaction, reducing heat island effects while improving green space accessibility. Building colors and natural soundscapes create feelings of closeness to natural processes and daily life. Green belts around buildings reduce noise pollution while increasing oxygen supply and other ecological functions. Landsense planners must make judgments based on urban residents' living environments, but the key challenge is determining what actions to take where. This study expresses each sensory dataset as thematic map layers for spatial analysis, which helps analyze soundscape patterns. Geographic Information Systems (GIS) can analyze interactions between biophysical environments and human perceptions [17]. Spatial pattern design should create comfortable wind conditions, natural ventilation, and environmental visibility, which are crucial for livable environments. Urban form and architectural design are very important, with specific layers corresponding to landsenses planning shown in the figure.

2. Comprehensive Balancing of Stakeholder Perceptions

In ecological planning, stakeholder participation is fundamental to grasping local knowledge. As a typical urban-rural ecotone, Xiji Town's landsenses ecological planning must consider various stakeholder interests, particularly four aspects: (1) integrated Beijing-Tianjin-Hebei development; (2) protection of historical context alongside industrial innovation; (3) key ecological nodes connecting Beijing-Tianjin-Hebei; and (4) ecological harmony. Another important consideration is balancing inequities between urban and rural residents while comprehensively balancing land resources and environmental benefits. Planning should also account for economic interests of local governments and enterprises in ecological construction. Through full communication with local governments and development enterprises—especially analyzing potential ecological benefit demands and determining their perceptions of planning options—a landsenses ecological planning scheme can be formed that integrates the perceptions of all stakeholders.

3. Ecological Infrastructure Planning Based on Landsenses Ecology

In implementing the Beijing-Tianjin-Hebei integrated development vision, Figure 3 [FIGURE:3] illustrates the landsenses planning information flowchart for Xiji Town. Vulnerability and other indicators are considered in the ecological planning process. Mapping and scenario design tools help planning teams organically integrate stakeholder perspectives with expert knowledge. GIS can incorporate local ecological knowledge and experience. Planning scheme options originate from and conform to public participants' perceptions of beauty, which contain important planning insights. For example, cultural heritage protection must respect original architectural styles to maintain the Grand Canal's World Cultural Heritage status.

River ecological corridors are planned to enhance aesthetic value of urban and rural ecosystems, provide wildlife habitats, and offer recreational spaces for citizens [18]. Water environment functions are improved by planning the Yanfangdian Wetland as a landscape with underground and surface runoff wetlands and ecological ponds. Comprehensive ecological water network construction controls water flow while eliminating odors, ensuring residents' water ecological perceptions and touch-related welfare are not compromised. Green buffers reduce noise pollution from traffic arteries [19], such as establishing curved green belts around residential areas and surrounding villages with forests. Such forest networks effectively protect residential areas and farmland from wind damage in summer and winter. In biodiversity impact assessments, comparative analysis of various factors can create environments where forests, grasslands, and wetlands produce different levels of sounds from mammals, amphibians, and insects [20].

4. Xiji Town: Landsenses Ecological Planning for a Typical Urban-Rural Ecotone

Through comprehensive analysis of current land use types in Xiji Town, this study identifies it as a critical area for future urban-rural ecotones significantly disturbed by urbanization. The planning area has a large proportion of ecological land but suffers from single landscape types and limited ecosystem service varieties. Due to high-grade roads, the landsenses ecological functions of the land use pattern have obvious defects. As a direct beneficiary of the administrative sub-center relocation, Xiji Town faces large-area occupation with low comprehensive ecological benefits, causing global ecological space separation. Plantations dominated by public welfare forests and orchards have single tree species and low biodiversity. Riverbank zones and water networks, as important ecological spaces, are not well utilized, with landsenses ecological service functions nearly lost and high ecological vulnerability.

Based on the above analysis and using the landsenses ecology theoretical framework, this study actively responds to ecological disturbances from Beijing's urban sub-center relocation. The ECO-TOWN concept was developed (E-Ecological: ecological civilization town; C-Collaborative: innovation and

entrepreneurship town; O-Opportunity: Tomorrow of Welfare Node; TOWN). Due to the special status of the North Canal and Chaobai River in the planning area, combined with existing ecosystem conditions, protective forest land and rivers serve as the ecological protection core. The planning scheme forms six major ecological function zones for key protection and construction: (I) Industry and human settlement development zone; (II) Northern modern agriculture and high-end service industry development zone; (III) Southern forest conservation and modern agriculture development zone; (IV) River cultural landscape protection and development zone; (V) Yanfangdian wetland conservation and creative leisure zone; (VI) Chaobai River riparian conservation and leisure agriculture development zone.

4. Conclusion

Among all disciplines, ecology is particularly suitable for linking science, arts, and humanities, and connecting people with land [21]. To protect China's Grand Canal and historic towns, diverse data derived from human perception are crucial in the planning process, as is comprehensive integration of hydrology, environmental economics, and social sciences into ecological planning. More importantly, landsenses ecology methods can help ecological planners understand indigenous peoples and their feelings without reducing design artistry or affecting enterprise economic benefits. Integrating perceptual data into planning requires more effort to produce the information planners truly need [22]. Effective combinations of mapping and scenario planning tools enable planning teams to integrate expert knowledge and stakeholder perceptions into landsenses ecological planning for typical urban-rural ecotone areas.

Implementation is a gradual refinement and step-by-step process. The landsenses ecology concept should run through initial conceptual planning, mid-term regulatory planning, and later detailed planning and implementation schemes. This paper proposes specific implementation solutions for conceptual and regulatory planning of landsenses ecological planning for urban-rural ecotones. In subsequent execution, the landsenses ecology philosophy must be continuously integrated into specific implementation processes.

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Figures

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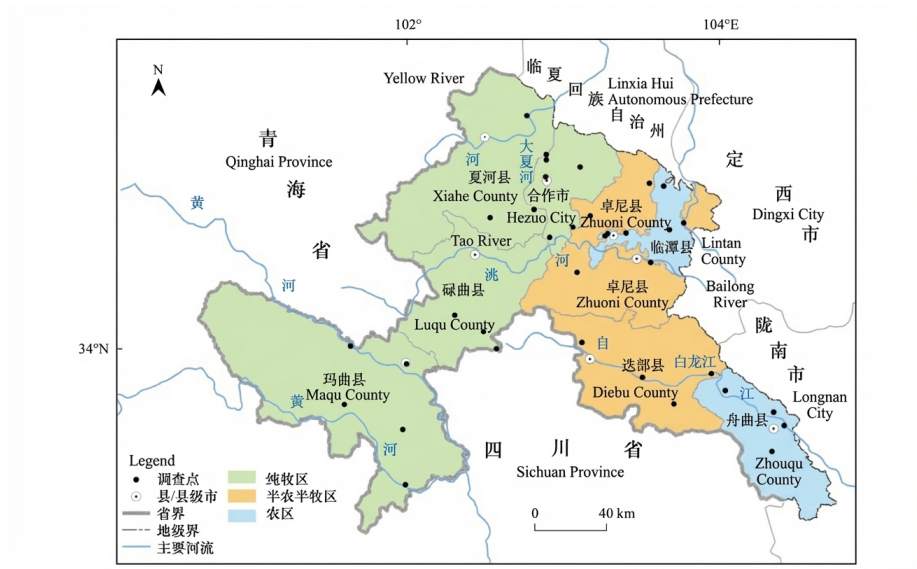


Figure 1: Figure 1