

Geo-Design in Planning for Bicycling

Subjects: Transportation

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Cities have increasingly promoted bicycling as a mode of transport as part of their strategy to develop a more sustainable transportation system. Australia is one of the countries that seeks to promote bicycling in a significant manner. There are two primary barriers faced in this effort. The first is the organizational complexity of planning and of implementing cycling-related projects, which can span across different agencies in government at various levels, from federal to local. Second is the lack of a clear framework for effectively planning a bicycling network using multiple data and tools available to these agencies within a limited budget. The use of a geo-design-based, collaborative, and data-driven framework for planning bicycling networks brings various stakeholders, such as transport planners, urban designers, and academics, into the planning practice, thus overcoming the mentioned barriers. Geo-design is an environmental design framework for complex problems involving the collaboration of different teams and stakeholders, supported by digital computing and communication technologies.

Keywords: geo-design ; bicycling planning ; Penrith ; collaboration ; data-driven approaches ; Agent-Based Modeling (ABM)

1. Introduction

Today, more than half of the world's population lives in urban areas, which is expected to increase to more than 68% by 2050 ^[1]. In Australia, 86% of the population lives in urban areas, with 40% living in Sydney and Melbourne. Transportation planning in today's congested cities is critical as it defines the dynamics of people's movement ^[2]. Bicycling as an alternative mode of transport has gained attention in transportation studies due to increasing congestion and vehicle traffic in cities ^[3]. Bicycling is a physical activity that can promote public health and environmental sustainability, leading to significant economic benefits ^[4]. To achieve these benefits, many countries, including Australia, are planning to increase bicycling to create more sustainable urban transportation ^[5]. Countries have considered infrastructure programs and policies to increase bicycling. Some of the efforts look to provide bicycling infrastructures, such as bicycling tracks ^[6], bicycle racks on public transit systems, and bicycle traffic signals ^{[7][8][9]}, or consider programs like bike share schemes ^[10] or car-free zones ^[11], and policies like city bike systems (in the city of Lublin) ^[12].

To increase the number of bike riders in Australia and, more specifically, in the Greater Sydney Area (GSA), several strategies have been developed. According to the Inner Sydney Regional Bicycle Network report, in the Sydney region, one of Australia's largest cities, the economic cost-benefit ratio of investing in the bicycle infrastructure development is estimated to be 3.88\$, with a net economic benefit of \$500 million a year ^[13]. The Committee for Sydney cycling report stated that Sydney needs more programs and funding to make Sydney a more bicycling-friendly city. To encourage more riders, there is a need for a well-connected and safe bicycling infrastructure ^[14]. More recently, the Movement and Place framework has considered a place-based approach for planning and designing transport networks and includes guidelines and toolkits to support bicycling planning ^[15]. In response to COVID-19, a few strategies were implemented to address the new demand for a better network for bicycling, such as new pop-up cycleways around the city ^{[16][17]}. Despite all efforts, in Australia, the level of bicycling is about 1%. Similarly, according to the Australian Bureau of Statistics (ABS), in the GSA, only 1.1% of trips are made by bicycle ^[18]. This level of modal share for bicycling is lower than in many countries around the world, such as the Netherlands (27%) and Denmark (16%) ^{[19][20][21]}. One of the main reasons for the insignificant number of bike trips is that there is more emphasis on motorized modes of transportation. As a result, vehicle traffic takes more consideration in street designs, and therefore, bicycling is a marginalized mode of transport ^[22]. Furthermore, there are challenges in the collaboration of different agencies in the planning process on a government and local scale. Planning and, more specifically, bicycling planning traditionally occur in a series of long and short-term plans proposed by different governmental agencies. This process has caused problems and issues in the coordination and sequencing of urban projects ^[23]. Therefore, bicycling planning, as part of the city and metropolitan planning, can be considered a significant problem with high complexity and impacts on different systems that change and constantly evolve ^[24]. To

overcome this, there is a need to engage different stakeholders and experts in the decision-making process to explore their views and consider new strategies for improving planning for bicycling [23][25].

Applying the geo-design approach can overcome challenges in coordinating critical urban projects by supporting collaborative and integrative planning. Geo-design is a collaborative planning process that changes the geography with design, by developing and applying a collaborative design process [26]. Geo-design can improve traditional environmental design and planning practices by using modern communication, computing, and collaboration technologies. This approach allows for analysis of the impact of design scenarios by the simulation to integrate theoretical and societal knowledge into the practice of designing alternative futures [27]. With the geo-design framework, barriers to creating single strategic planning by different stakeholders can be broken down using data-driven approaches [23].

2. Geo-Design

Ervin (2012) defines geo-design as an environmental design for complex issues in large areas involving the collaboration of different teams and stakeholders with digital computing and communication technologies. Geo-design depends on feedback on the effects of proposed design scenarios based on simulation, dynamic modelling, and systematic thinking. Geo-design tools are an innovative way to integrate technology and the process of decision-making in planning and design. Applying this method can produce better outcomes for any project, the community, and the environment [28].

Geo-design combines geography with design and provides tools to support decision-making. Geo-design is a holistic approach that has been increasingly applied over the last five years in design, landscaping, transportation, and land-use planning studies [29][30][31]. Nonetheless, to the best of researchers' knowledge, no bicycling studies have applied this approach. For instance, a geo-design approach has been used in designing the fuel station network in the southwestern U.S.; developing an open-sourced platform for facilitating interactive and collaborative development scenarios with spatial data layers and the evaluation of the network performances, named Collablocation [31]. In a similar study, Kazak et al. (2019) [32] used a geo-design framework to engage citizens in planning public transport processes to verify the suitability of the planning support systems, such as CommunityViz, to create public transport facilities scenarios. In more recent research, led by Liu et al. (2020) [33], a geo-design approach was developed for sustainable urban landscaping under the pressure of climate change effects to optimize urban landscape composition in the north of China. One of the main challenges to creating more sustainable futures is traditional barriers to collaborative planning across government agencies. For example, in metropolitan planning, different agencies separately carry out processes. Pettit et al. (2019) [23], proposed a siloed approach through the geo-design framework for city planning to solve coordination problems with collaboration through geo-design workshops exploring alternative future scenarios for 2050.

The geo-design collaboration approach uses the power of digital technologies in computing and communication to enhance the information-based design and receive feedback about the implication of design alternatives. The most used technical tools for this are Geographic Information Systems (GIS), Computer-Aided Design (CAD), and Multi-Criteria Evaluation (MCE), in conjunction with dashboards and spreadsheets [27]. Some software has been developed to conduct geo-design studies, such as Geo-design Hub® (<https://www.geo-designhub.com/> (accessed on 11 August 2022)), which is software to analyze and assign land use. Furthermore, ESRI®'s GeoPlanner® is another commercial software for urban planning. Debnath et al. (2021) comprehensively discussed commonly used tools in geo-design studies. Considering a geo-design approach in the post-COVID-19 world necessitates considering new tools and PSSs that can support face-to-face and virtual collaboration using online platforms and workshops [34]. Accordingly, some studies have adopted the online and hybrid geo-design approaches. For instance, they used tools like GISColab, which is a shared spreadsheet in Excel software [35], or had remote meeting rooms and used digital tools [36], which have been proven to be effective [35][36][37].

Geo-design is a data-driven paradigm that uses geographic and spatial information to improve and structure urban planning processes [26][38]. As previously mentioned, geo-design approaches have not been used in bicycling planning. However, by having data-driven approaches to decision-making, some studies have developed tools and techniques, such as planning support systems (PSS) or decision support systems (DSS) [39]. They have assumed that interventions in bicycling networks necessitate considering what and where to build the infrastructure using PSS or DSS. One example of these tools is the Propensity to Cycle Tool, an online PSS developed by Lovelace et al. (2015) to determine where to build new infrastructure for bicycling [40]. Another example is the NCHRP Project by Kuzmyak et al. (2014), which used to estimate walking and bicycling routes according to different criteria [41]. Attracting more cyclists needs developing methodologies to prioritize the location of bicycling facilities. Larsen et al. (2012) created a GIS-based model as a prioritization index for locating bicycling infrastructure in Montreal, Canada [42]. In addition, there was research on applications for new crowdsourced and open-sourced data in urban planning research and practice [43]. For example,

Lissner et al. (2018) used smartphone-based data to model bicycling traffic volume and used the information in planning and political discussions ^[44]. Using open and crowdsourced data can enable stakeholders to access detailed bicycling data, such as the type of bicycle, the socio-demographics of bicyclists, and route choices ^[45]. Although these studies have provided a tool to support decision-making, it is essential to use them in a collaborative planning environment. Ratanaburi et al. (2021) confirmed that the presence of stakeholders in the process of planning for bicycling is essential to receive positive outcomes ^[46]. Similarly, Macmillan et al. (2014) explored the role of participatory modeling by comparing the impact of realistic policies to increase the number of bicyclists in cities, and they confirmed that the understanding of stakeholders has improved regarding complex bicycling systems ^[47].

This entry proposes that a hybrid geo-design framework is an efficient approach for planning bicycling infrastructure networks, especially in an Australian context, as it enables the participation of different stakeholders and practitioners alongside applying data-driven approaches using open and crowdsourced data, PSSs, and simulation of future scenarios. The current entry uses different tools and platforms to apply the geo-design framework to bicycling planning. Each tool was expected to suit one stage of a geo-design study. The main tool developed for this entry is an Agent-Based Model (ABM) for the simulation of bicyclists' behavior in the built environment as PSS. ABMs are complex systems that use the perspective of individual agents and represent emerging patterns and structures ^{[48][49]}. The specification of the model has been presented in the methodology section, and more details on this model have been placed in a separate study ^[50]. Overall, this entry can improve the current process of bicycling planning in the following ways: (1) improving practitioners discussion regarding planning and design for bicycling; (2) enabling community and stakeholder engagement in the planning process and empower them to evaluate future plans for their community; and (3) enabling the use of data-driven approaches in planning for bicycling and using evidence for decision-making processes in a hybrid mode.

3. A Geo-Design Approach to Bicycling Planning

The findings presented illustrate essential evidence for applying collaborative geo-design workshops in planning bicycling networks. This geo-design process proved to be generally helpful in facilitating the bicycling planning process: (1) design scenarios for the bicycling network were found successful as they can be translated as proposed plans for the case study, (2) a successful and facilitated discussion environment for collaborative planning had been created, (3) the geo-design workshop provides a framework for comprehensive and efficient usage of different tools and datasets.

The geo-design process created room for participatory scenario planning for bicycling networks using different tools and datasets. This process was aimed at creating a co-learning process that enables creative thinking ^[51]. There are various proposed plans for the future of bicycling networks; using impact assessment methods, such as ABM, enables the examination of design scenarios using exemplary indicators, such as the level of satisfaction of bicyclists according to the new proposed infrastructure. At the next stage, these indicators can be translated into the co-cost and co-benefit of design ideas.

One of the main challenges in developing plans for more sustainable cities is breaking down the traditional barriers to collaborative planning in government agencies. Using a geo-design approach can enable the engagement of key government agencies to break down these barriers and allow them to create more integrated plans for cities ^[23]. According to the received feedback, these workshops enabled participants to go through the planning process more efficiently. This process facilitated their communication in group work and allowed them to propose various design ideas and strategies in a small amount of time. This shows that even though the workshop is held for authorities to plan a real bicycling network, geo-design enables effective collaboration. Having a hybrid mode allows participation even from other countries.

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