

Navigating the urban terrain: enhancing pedestrian safety and comfort in Tashkent's Bo'zsuv canal area

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Abstract:

Pedestrian safety in urban environments is a growing concern globally. This study focuses on Tashkent, Uzbekistan, assessing the factors that contribute to pedestrians' safety and comfort along the Bo'zsuv canal. By examining the existing infrastructure and pedestrian behavior, the research identifies key areas where improvements can significantly enhance pedestrian experiences. The study utilizes surveys to gather data on pedestrian preferences and behaviors, particularly at unsignalized intersections and mid-block crossings. The findings suggest that extended waiting times, a lack of safe crossings, and inadequate crossing durations are the primary challenges faced by pedestrians. Recommendations include the development of underpasses and overpasses and the installation of pedestrian bridges to ensure continuous and safe pathways. The research highlights the need for an integrated approach to urban design that prioritizes pedestrian safety through infrastructural and behavioral interventions. Future work should aim to expand data collection, incorporate advanced predictive modeling, and develop comprehensive policies to further pedestrian safety measures.

Keywords:

pedestrian safety, urban planning, traffic infrastructure, pedestrian behavior, crosswalks, Tashkent, urban design, walkability, road safety, transportation engineering

1. Introduction

In contemporary urban and transport planning, cycling has emerged as a pivotal strategy to address a myriad of urban challenges [1].

Unlike car-dependent infrastructure, which significantly contributes to urban severance and spatial constraints, cycling infrastructure demands substantially less space and mitigates these issues. The economic advantages of cycling are manifold; it not only reduces the cost associated with infrastructure development compared to motorized transportation modes but also lowers healthcare expenditures, boosts work productivity, and provides an accessible transportation option for a broad spectrum of the population [2]. Nevertheless, the development, construction, and maintenance of bicycle facilities represent complex and financially intensive endeavors. The success of these facilities critically depends on the collection and analysis of reliable data to ensure they meet the needs of potential users [10].


Bicycles offer an efficient solution for short urban trips up to 5 kilometers or those with a duration of approximately 20 minutes, outpacing walking and other motorized transport options in terms of speed and convenience [3]. For distances exceeding this range, bicycles can effectively complement other transport modes, such as public transit, facilitating a more integrated and sustainable urban mobility framework. Recognizing the extensive benefits of cycling, numerous countries have initiated a wide array of measures to encourage regular cycling, reflecting a growing commitment to sustainable transportation [2]. Among these urban areas, Tashkent distinguishes itself with a notable increase in daily bicycle usage, showcasing the city's progress towards embracing cycling as a core component of its transportation ecosystem.


This introduction underscores the importance of cycling within the broader agenda of urban sustainability and mobility. By highlighting the specific case of Tashkent and referencing global efforts to enhance cycling infrastructure and adoption, the paper sets the groundwork for an in-depth exploration of how cycling can be integrated into urban transport systems to achieve economic, environmental, and social benefits. Through this lens, the study aims to contribute valuable insights into the strategies and challenges of fostering a bicycle-friendly urban environment, positioning cycling not only as a mode of transport but as a catalyst for urban transformation.

The global push towards cycling-friendly urban environments involves a multifaceted approach, incorporating policy formulation, infrastructure development, and public engagement. Key to this initiative is the design and implementation of dedicated cycling lanes, secure bike parking facilities, and bike-sharing programs. These measures aim to not only ensure the safety and convenience of cyclists but also to make cycling an attractive alternative to motorized transport. In cities where cycling has been successfully integrated into the urban fabric, such as Amsterdam and Copenhagen, comprehensive cycling networks and supportive policies have significantly increased cycling rates, demonstrating the potential for replication in other urban contexts.

However, the path to becoming a bicycle-friendly city is fraught with challenges. One of the primary obstacles is the allocation of urban space, where cycling infrastructure often competes with motorized transportation and pedestrian areas. Achieving a balanced urban mobility mix requires careful planning and, occasionally, the reallocation of road space from cars to bicycles—a move that can provoke resistance from motorists and businesses accustomed to car-centric urban designs. Additionally, the effectiveness of cycling

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infrastructure is contingent upon its integration with other modes of transport, necessitating seamless connections between bike lanes, public transit, and pedestrian pathways to support multi-modal transport options.

The role of technology and data in enhancing cycling infrastructure cannot be understated. Smart mobility solutions, including GPS-enabled bike-sharing schemes and apps that provide real-time information on bike availability, cycling routes, and traffic conditions, are vital in encouraging cycling. Moreover, the collection and analysis of cycling data contribute to informed decision-making, allowing urban planners to identify high-demand areas for bike lanes, optimize bike-sharing station locations, and monitor the impact of cycling on urban mobility and environmental sustainability.

The transition towards more bicycle-friendly cities also hinges on community involvement and behavioral change. Public awareness campaigns, cycling training programs, and events can play a crucial role in shifting perceptions about cycling, addressing safety concerns, and fostering a culture of cycling. Encouragingly, the environmental and health benefits of cycling—reduced carbon emissions, improved air quality, and enhanced physical fitness—are powerful motivators for individuals and policymakers alike to support and invest in cycling infrastructure.

Looking ahead, the integration of cycling into urban transport planning presents a promising avenue for achieving sustainable urban development goals. It offers a pathway to reduce traffic congestion, lower pollution levels, and create more livable, health-oriented urban spaces. As cities like Tashkent continue to evolve and adapt to the needs of their residents, the lessons learned and successes achieved in promoting cycling can serve as valuable blueprints for others seeking to reimagine urban mobility for the better. Pedestrian movement, a fundamental human activity, has shaped interactions with urban landscapes for centuries. Its inherent simplicity belies the complex role it plays in the vitality and accessibility of urban spaces. In both developed and developing countries, the dynamics of pedestrian movement and its integration into urban planning reveal varied approaches to enhancing urban livability and sustainability. While developed nations often emphasize innovative, pedestrian-friendly designs that prioritize safety, aesthetics, and environmental benefits, developing countries face challenges in balancing pedestrian needs with rapid urbanization and limited resources. Despite these differences, the pursuit of improved pedestrian environments remains a common goal, reflecting a universal recognition of walking as not merely a mode of transportation but as an essential component of urban life.

The contribution of specific street landscape features to perceptions of safety and attractiveness in urban environments, however, has not been fully understood. This approach overlooks the nuanced interplay between different design elements and their collective impact on pedestrian experiences.

In response, this article embarks on a detailed examination of how various urban design features influence the perceived safety and attractiveness of pedestrian pathways. By analyzing these elements collectively, our study aims to illuminate the synergies and distinctions that shape pedestrian perceptions. Our findings reveal that the aspects of street landscapes contributing to perceived safety and attractiveness are not only interrelated but also exhibit clear differences in their impact. This nuanced understanding underscores the need for a holistic

approach to urban design, one that considers the multifaceted influences of street characteristics on pedestrian experiences. Through this lens, our research contributes to the broader discourse on creating more engaging, secure, and aesthetically pleasing urban environments for pedestrians across diverse global contexts.

2. Data collection method

Our empirical investigation began with the formulation of a comprehensive survey instrument, designed to capture a wide array of variables relevant to pedestrian safety and comfort. The survey was operationalized via Google Forms due to its accessibility and ease of use for both participants and researchers. Participants were approached at a designated pedestrian crossing along the canal in Tashkent city, chosen for its high pedestrian traffic and significance as an urban thoroughfare.

Participant Sampling. The survey engaged a sample size of 994 pedestrians, a figure robust enough to ensure statistical validity. Sampling was stratified to encompass a variety of pedestrian demographics, though a notable majority were male. The survey was conducted at different times of the day and on varied days of the week to mitigate any time-based biases and to capture the variability in pedestrian flow and behavior.

Data Privacy Considerations. In alignment with ethical research practices, we maintained participant confidentiality. Personal identifiers were not collected, and the survey made clear that participation was voluntary, with respondents free to withdraw at any time without consequence.

Data Collection Variables. The survey instrument was structured to extract data on the following variables:

- **Personal Safety:** Respondents' experiences and perceptions of crash threats.
- **Personal Security:** Feelings concerning the risk of assault or personal harm.
- **Architectural and Environmental Features:** The influence of architectural interest, pathway shade, and the availability of pedestrian amenities on perceived safety and comfort.
- **Social Factors:** The effect of the presence of other pedestrians on individual safety perceptions.
- **Technical Factors:** Observations related to traffic volume, vehicle speed, and driveway frequency.

Data Processing. Upon collection, the data underwent a preliminary screening to ensure completeness and accuracy of responses. Any incomplete or outlier responses that could skew results were carefully evaluated and, if necessary, excluded from the analysis. Data was then coded for anonymity and organized into a database for further statistical analysis.

Quality Assurance. To assure the quality and reliability of our data, several measures were implemented:

- The survey instrument was piloted on a smaller cohort prior to full deployment to validate understanding and relevance of questions.
- The data collection process was monitored for consistency and adherence to the methodological framework.
- Data entry and processing were performed using automated tools to minimize human error.

The processed data forms the foundation for our subsequent analysis, which seeks to illuminate the interplay between urban design features and pedestrian safety perceptions.



3. Methodology

This study is underpinned by a multifaceted analytical framework that considers the varied factors influencing pedestrians' perceptions of safety and comfort within roadway corridors. Recognizing the intricate nature of these factors, which include personal safety concerns (such as the threat of crashes and assault), aesthetic and functional elements (like architectural interest, pathway shade, and pedestrian-scale lighting), social dimensions (presence of other pedestrians), and technical aspects (conditions at intersections), our methodology adopts a holistic approach to model pedestrian behavior. To isolate and examine the roadway environment's influence on pedestrian comfort and safety, excluding intersections, we identified critical factors based on the existing literature [2]. These factors encompass the presence and quality of sidewalks, the separation from vehicular traffic, the existence of physical barriers, traffic volume and composition, the impact of vehicular speed, and the frequency of driveways and access points. The selection of these particular elements was informed by their demonstrated significance in affecting pedestrian behavior and safety perceptions.

Given the broad benefits of integrating pedestrian considerations into urbanism, including ecological, cultural, economic, and social advantages [4], our study also explores how enhancing walkability contributes to the overall livability of cities. We draw on the latest research indicating that walkability is a key component of livability, promoting convenient, sustainable living environments [5]. In this context, we seek to understand how improving pedestrian infrastructure can make cities more accommodating and safer for all inhabitants [6]. Our study encompasses a global perspective, incorporating analyses from cities across Europe,

North America, Australia, Asia, and Africa. This wide scope is designed to capture diverse urban approaches, acknowledging that conditions, practices, and cultural integrations vary significantly worldwide [7]. This global perspective is crucial, as pedestrian-related road fatalities are a significant concern, with more than one-fifth of road deaths involving pedestrians and, in some countries, this proportion rising to two-thirds (WHO, 2013). Factors contributing to these accidents, such as vehicle speed, alcohol consumption, lack of pedestrian infrastructure, and visibility issues, are scrutinized to develop a comprehensive understanding of the risks [8].

An historical overview of pedestrian crossing facilities, based on the works of Hydén (2010) and Ishaque & Noland (2006), traces the evolution from early footpaths and surface markings to modern signal-controlled crossings and traffic calming devices. This historical context sets the stage for understanding current pedestrian infrastructure and safety measures. In Uzbekistan, where pedestrian-involved accidents constitute 10.3% of road transport accidents [9], our study focuses on pedestrian behavior and infrastructure-related factors contributing to accidents. Special attention is given to unsignalized intersections and mid-block crosswalks, which are frequent sites of vehicle-pedestrian conflicts. To gather empirical data, we conducted a survey with 994 pedestrians along a canal in Tashkent city. The survey, administered using Google Forms, captured pedestrian behaviors and perceptions at a designated crossing point. This data collection was executed across varying days and times to ensure a representative sample. While the majority of participants were male, the survey design maintained participant anonymity, respecting their preference for privacy.

Gender

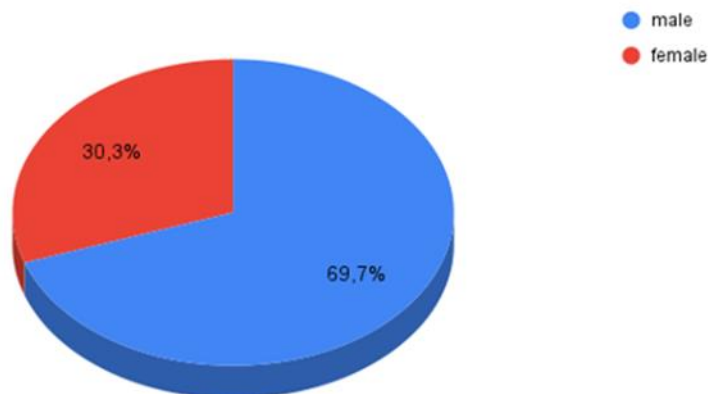


Figure 1. Gender Distribution

The fig. 1 depicts a pie chart showing the distribution of survey respondents by gender. Two categories are displayed: male and female. According to the chart, 69.7% of the respondents are male, and 30.3% are female. This significant

majority of male participants suggests a potential gender disparity among respondents that may need to be considered when interpreting the survey results.



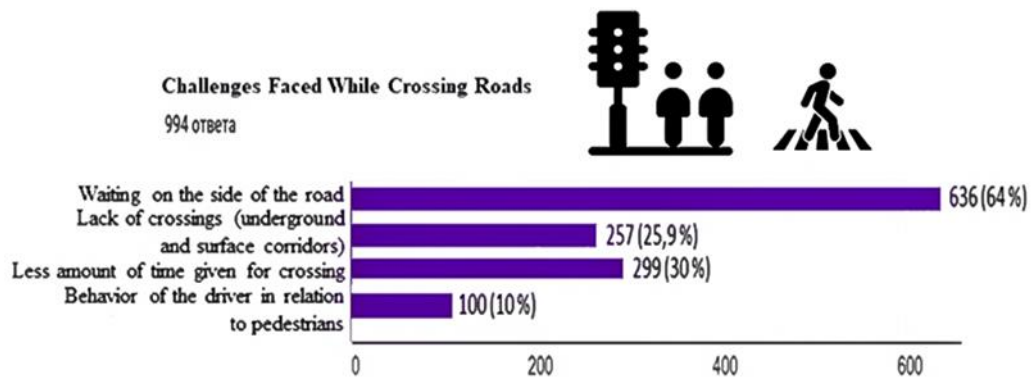


Figure 2. Challenges faced while crossing a road

The fig.2 presents a bar graph illustrating the challenges faced by pedestrians while crossing roads, based on responses from 994 participants. The survey data visualized in the bar graph identifies several key challenges faced by pedestrians when crossing roads:

- **Extended Waiting Times:** A significant number of respondents, representing 64% of the total, reported that they experience long waiting periods on the side of the road before being able to cross safely.
- **Inadequate Safe Crossings:** About 25.9% of the participants indicated a shortage of safe crossing options, including both underground passages and designated surface-level crosswalks, suggesting that the current infrastructure does not adequately cater to pedestrian needs.
- **Insufficient Crossing Time:** 30% of the survey participants pointed out that the time allocated for crossing at designated points is inadequate, which may rush pedestrians and potentially compromise their safety.
- **Driver Conduct:** 10% of the respondents expressed concerns over adverse driver behavior that negatively affects pedestrian safety, indicating issues with driver awareness and compliance with pedestrian right-of-way.

These insights emphasize the necessity for targeted improvements in pedestrian infrastructure and traffic regulations to mitigate these challenges and promote a safer and more pedestrian-friendly environment.

The corresponding number of responses and percentages for each challenge are shown. The majority of respondents (636, which is 64%) identified 'Waiting on the side of the road' as a challenge. The 'Lack of crossings' was noted by 257 respondents (25.9%), and 'Less amount of time given for crossing' was highlighted by 299 participants (30%). The 'Behavior of the driver in relation to pedestrians' was considered a challenge by 100 respondents, accounting for 10% of the feedback.

Key Findings:

- There is a notable gender imbalance in the survey sample, with a dominance of male participants (approximately 70%), which may reflect underlying societal patterns or could indicate a sampling bias that should be addressed in future studies.
- The primary challenge faced by pedestrians is 'Waiting on the side of the road,' indicating possible inefficiencies in traffic light timing or the need for more frequent safe crossing opportunities.
- A significant portion of the participants also highlighted the 'Lack of crossings' and 'Less amount of time given for crossing,' suggesting that infrastructure improvements are needed to provide more and better crossing options for pedestrians.

- Finally, the behavior of drivers is perceived as a concern by a smaller yet noteworthy fraction of the population, pointing towards potential issues in driver education and law enforcement related to pedestrian right of way.

These findings underscore the critical need for urban design and traffic management strategies that prioritize pedestrian needs and safety, taking into account the different experiences and perceptions of all gender groups.

The availability and safety of pedestrian crossings are crucial factors in evaluating the practicality and safety of pedestrian movement, particularly in areas devoid of designated crossings or where such crossings are inconveniently spaced. The prediction of pedestrian crossing behavior is complex, due to their unpredictable movement patterns, which may include sudden directional changes, stops, and starts. Additionally, pedestrians may be obscured by various objects within the urban landscape and can be distracted by interactions with other pedestrians or by the use of mobile devices. These behaviors are influenced by a myriad of factors that may affect their decision-making process when it comes to crossing streets [12]. The issue of pedestrian safety is of paramount importance in urban centers across the globe. Risk-taking behavior on walkways is a major concern for researchers, municipal authorities, and safety organizations dedicated to understanding this behavior and mitigating its negative outcomes. The consequences of unsafe pedestrian practices are severe, ranging from injuries and fatalities to substantial economic costs [16]. Enhancing pedestrian safety requires a multifaceted approach that includes the development of more accessible and safer crossings, the implementation of educational campaigns targeting pedestrian awareness, and the integration of technology to improve the prediction and management of pedestrian movements. Urban planning must prioritize the creation of an environment where pedestrians can navigate safely and efficiently, recognizing the inherent variability and unpredictability of human behavior. This entails not only the physical restructuring of spaces to accommodate and protect pedestrians but also the adoption of policies that encourage safe pedestrian practices and the use of predictive analytics to better design pedestrian-friendly urban landscapes.

4. Result and Discussion

The strategic development of pedestrian infrastructure along Tashkent's Bo'zsu channel is vital for ensuring the safety and convenience of the city's inhabitants. Our study



indicates several key interventions that can significantly improve the pedestrian experience in this area.

- **Underpass Development:** At points where pedestrian paths intersect with vehicular lanes along waterways, creating underpasses can effectively separate pedestrians from road traffic, minimizing the risk of accidents and providing an uninterrupted walking experience. Such underpasses should be well-lit, secure, and aesthetically pleasing to encourage usage (Point 1 on fig.3).
- **Overpass Construction:** In areas where the construction of underpasses is not feasible, pedestrian overpasses can serve as a safe alternative for crossing over busy roadways. These structures should be designed with ramps and staircases to accommodate all users, including those with mobility impairments, ensuring inclusivity (Point 2 on fig.3).

- **Bridge Installations:** To maintain the continuity of pedestrian pathways along the waterway, the installation of pedestrian bridges is recommended. These bridges would not only connect disjointed walkways but also enhance the recreational value of the channel, encouraging walking as a pleasant and healthy activity (Point 3 on fig.3).

These proposed measures respond to a pressing need for safe, continuous, and accessible pedestrian routes in urban areas. By focusing on infrastructure that prioritizes pedestrian movement, Tashkent can address current safety concerns, enhance the livability of the city, and create a more sustainable urban environment. Furthermore, such infrastructure improvements can also serve as a catalyst for social and economic activities along the channel, thereby contributing to the city's vibrancy.



Figure 3. Key interventions to improve pedestrian safety

The fig. 3 depicts a map of a section of Tashkent city with a focus on pedestrian walkways along the Bo'zsuv channel. The map is overlaid with color-coded lines and numbers that correspond to specific areas, where the pedestrian pathways intersect with vehicle lanes and where infrastructure for pedestrian movement is recommended. Red lines represent areas where pedestrian walkways do not exist, green lines indicate where walkways are open for pedestrians, and yellow lines show areas where walkways exist but are closed to pedestrian traffic. There are also three numbered callouts with corresponding photographs and illustrative graphics:

1. The first point suggests a recommendation for an underpass, where pedestrian movement is directed beneath the roadways adjacent to the waterways.
2. The second point recommends an overpass, diverting pedestrian movement above the roadway.
3. The third point recommends the provision of pedestrian bridges over the water to facilitate continuous and safe pedestrian movement along the water channel.

Our recommendations for the pedestrianization of the Bo'zsuv channel area are based on a comprehensive analysis of pedestrian traffic patterns, urban layout, and the current

lack of safe crossing points. The implementation of these recommendations would not only improve pedestrian safety but also promote a healthier, more active lifestyle among the residents of Tashkent.

5. Conclusion

his research, conducted within the urban framework of Tashkent, has elucidated the characteristics that contribute to a perception of safety and comfort for pedestrians navigating the vicinity of the river canal. The findings have offered insights into the varying degrees of influence that specific environmental and infrastructural features exert on pedestrian experiences.

Historically, the development of pedestrian amenities—from basic footpaths to sophisticated zebra crossings and push-button signal-controlled systems—has played a pivotal role in enhancing pedestrian safety. The study's findings draw attention to the significant correlation between the prevalence of pedestrian facilities and the incidence of road accidents involving pedestrians, as observed in Uzbekistan. This correlation underscores the critical need for a deliberate



focus on both infrastructure development and behavioral interventions to mitigate the risks faced by pedestrians.

Through the deployment of surveys, we have gained a nuanced understanding of pedestrian behaviors and their interactions with urban traffic environments. The recommendations put forth, advocating for a seamless and safe pedestrian flow along waterways, emphasize the strategic importance of pedestrian bridges. These bridges are not mere structures but vital components in the urban landscape, ensuring unimpeded movement and reinforcing the safety of pedestrians, particularly in areas where unsignalized intersections and mid-block crosswalks present heightened risks.

Acknowledging the complexities inherent in predicting pedestrian behavior, our study reinforces the imperative for urban areas worldwide to prioritize pedestrian safety. The stakes are high, as the efforts to safeguard pedestrians directly contribute to the reduction of injuries and fatalities. Therefore, urban planners and policymakers must assimilate these findings into their strategic planning to curtail pedestrian vulnerabilities and to foster a safer, more walkable urban environment.

In conclusion, the study advocates for an integrated approach to urban design, one that combines infrastructural enhancements with behavioral insights to reduce pedestrian risks. As cities like Tashkent continue to evolve, the commitment to pedestrian safety must remain at the forefront of urban development initiatives, ensuring that the well-being of pedestrians is held paramount in the pursuit of progress and urban sustainability.

The current study has laid the groundwork for a comprehensive understanding of pedestrian dynamics in urban settings. However, to advance the safety and comfort of pedestrians further, there is a need for ongoing research and development in several key areas:

- **Extended Data Collection:** Future research should aim to gather more extensive data across different seasons, times of the day, and varying weather conditions to capture the full spectrum of pedestrian behavior and preferences.
- **Diverse Participant Sampling:** Ensuring a more balanced gender representation and including participants from various age groups and mobility levels will provide a more inclusive understanding of pedestrian needs.
- **Advanced Predictive Modeling:** Leveraging machine learning and artificial intelligence can offer more sophisticated models to predict pedestrian movements and interactions with vehicular traffic, accounting for the sporadic nature of human behavior.
- **Behavioral Studies:** In-depth behavioral research is required to understand the psychological and social factors influencing pedestrian decisions, particularly at unsignalized crossings and mid-block sections.
- **Infrastructure Experimentation:** Pilot programs for new types of pedestrian infrastructure, such as smart crosswalks and interactive signals, should be explored to evaluate their effectiveness in improving safety and walkability.
- **Policy and Legislation:** There is a need for the development of comprehensive policies that not only prioritize pedestrian infrastructure but also address driver behavior through education and enforcement.
- **Cultural and Social Factors:** Considering cultural and social influences on pedestrian behavior will be crucial for the successful implementation of safety measures tailored to the local context.

- **Economic Analysis:** Future work should also include an economic assessment of pedestrian infrastructure investments, weighing the cost against the potential reduction in accidents and improved quality of urban life.

- **Interdisciplinary Approaches:** Collaborative efforts that bring together urban planners, traffic engineers, behavioral scientists, and public health experts are necessary to address the multifaceted nature of pedestrian safety.

- **International Benchmarks:** Comparative studies with international benchmarks can provide valuable insights and best practices that could be adapted and applied to the local context.

By addressing these areas, future research can build upon the current findings to develop a more holistic strategy for enhancing pedestrian environments. The ultimate goal is to create urban spaces that are not only safe and accessible for all pedestrians but also promote a sustainable and active lifestyle in the urban populace.

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