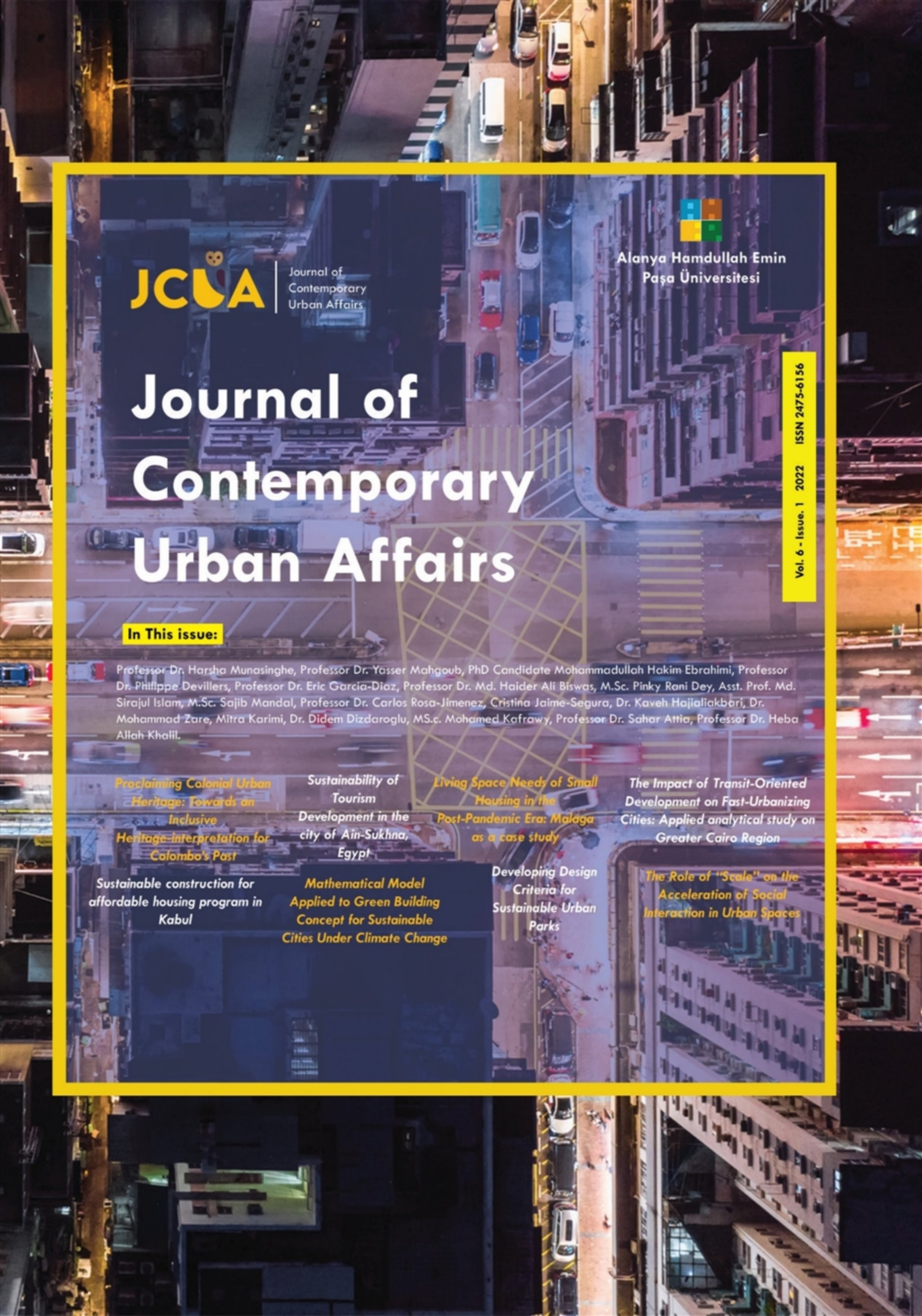

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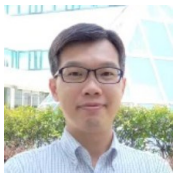

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- Accept the manuscript without further revision
- Accept after revision
- Ask the authors to re-submit
- Reject

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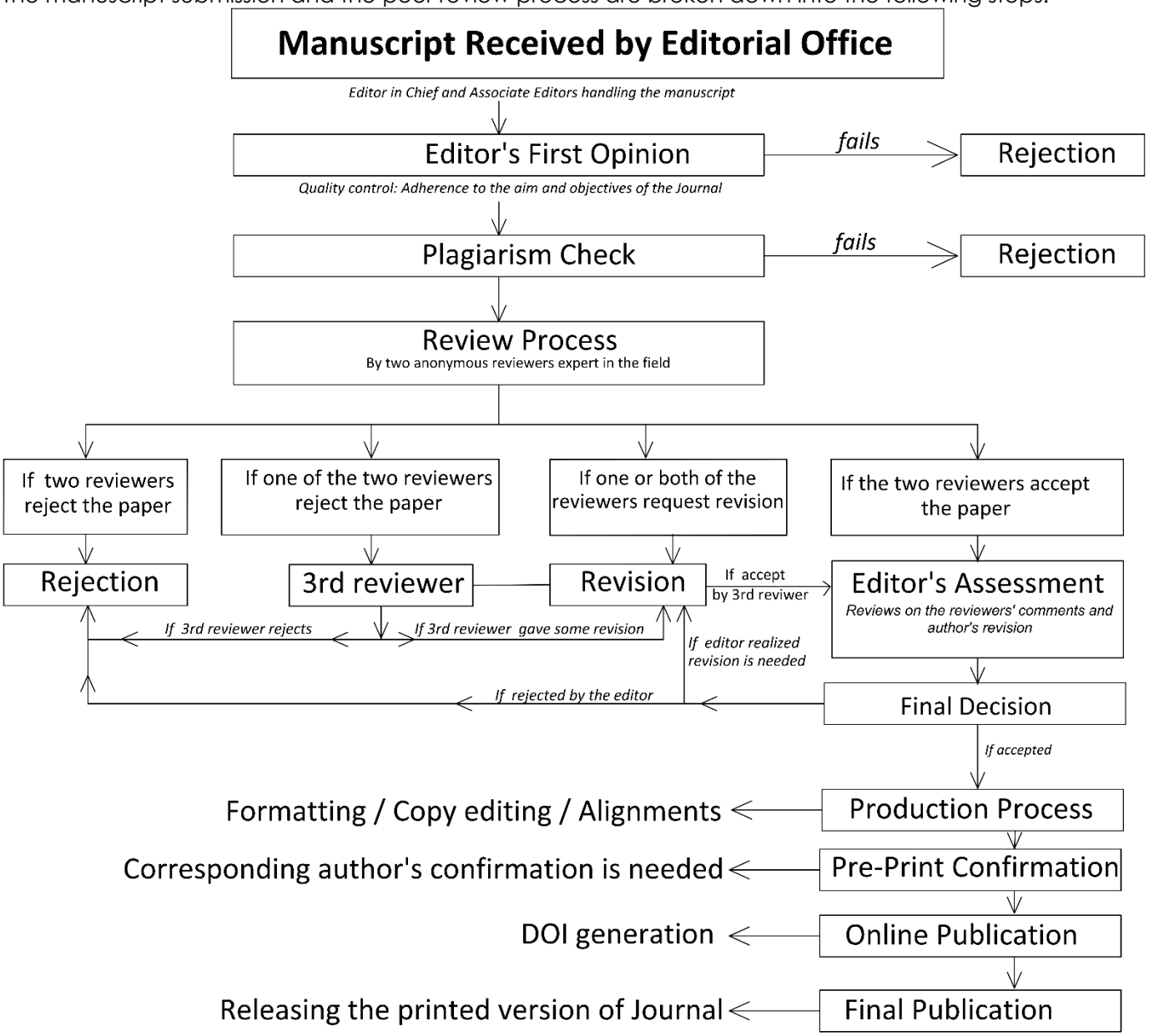

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If authors have used their own previously published work, or work that is currently under review, as the basis for a submitted manuscript, they must cite the previous articles and indicate how their submitted manuscript differs from their previous work. Reuse of the author's own words outside the Methods should be attributed or quoted in the text. Reuse of the author's own figures or substantial amounts of wording may require permission from the copyright holder. The authors are responsible for obtaining this.

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Research Involving Human Subjects

When reporting on research that involves human subjects, human material, human tissues, or human data, authors must declare that the investigations were carried out following the rules of the Declaration of Helsinki of 1975 (**https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/**), revised

in 2013. According to point 23 of this declaration, approval from the local institutional review board (IRB) or other appropriate ethics committee must be obtained before undertaking the research to confirm the study meets national and international guidelines. As a minimum, a statement including the project identification code, date of approval, and name of the ethics committee or institutional review board must be stated in Section 'Institutional Review Board Statement' of the article.

For non-interventional studies (e.g., surveys, questionnaires, social media research), all participants must be fully informed if anonymity is assured, why the research is being conducted, how their data will be used and if there are any risks associated. As with all research involving humans, ethical approval from an appropriate ethics committee must be obtained prior to conducting the study. If ethical approval is not required, authors must either provide an exemption from the ethics committee or are encouraged to cite the local or national legislation that indicates ethics approval is not required for this type of study. Where a study has been granted the exemption, the name of the ethics committee which provided this should be stated in Section 'Institutional Review Board Statement' with a full explanation regarding why ethical approval was not required.

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- Reduction in the number of animals used.
- Refinement of experimental conditions and procedures to minimize the harm to animals.

Authors must include details on housing, husbandry and pain management in their manuscript. If national legislation requires it, studies involving vertebrates or higher invertebrates must only be carried out after obtaining approval from the appropriate ethics committee. As a minimum, the project identification code, date of approval and name of the ethics committee or institutional review board should be stated in Section 'Institutional Review Board Statement'. Research procedures must be carried out in accordance with national and institutional regulations. Statements on animal welfare should confirm that the study complied with all relevant legislation. Clinical studies involving animals and interventions outside of routine care require ethics committee oversight as per the American Veterinary Medical Association. If the study involved client-owned animals, informed client consent must be obtained and certified in the manuscript report of the research. Owners must be fully informed if there are any risks associated with the procedures and that the research will be published. If available, a high standard of veterinary care must be provided. The authors are responsible for the correctness of the statements provided in the manuscript.

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The editor should match the knowledge and expertise of the referees with the manuscripts submitted to the Journal of Contemporary Urban Affairs to be reviewed ensuring that the manuscripts are adequately reviewed by qualified reviewers. The editor should require reviewers to disclose any potential competing

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The editor should provide clear publication guidelines and author guidelines of what is expected of them to the authors and continuously review the guidelines and templates. The editor should review the manuscript submitted in terms of guidelines of the journal, importance of the study, and originality, and if the decision to reject the manuscript is made editor should explain it to the authors in a clear and unbiased way. If the decision is made that the manuscript should be revised by the authors in terms of written language, punctuation, and/or rules in the guidelines (spacing, proper referencing, etc.) the authors should be notified and given time to do the corrections accordingly. The authors should be provided with necessary information about the process of their review (at which stage is the manuscript at etc.) complying with the rules of double-blind review. In the case of an editor change, the new editor should not change a decision taken by the previous editor unless it is an important situation.

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The editor should provide publication policies and guidelines to the editorial board members and explain what is expected of them. The editor should ensure that the editorial board members have the recently updated publication guidelines and policies. The editor should review the editorial board members and include members who can actively contribute to the journal's development. Editorial board members should be informed about their roles and responsibilities such as;

- Supporting the development of the journal
- Accepting to write reviews in their expertise when asked
- Reviewing publication guidelines and improving them consistently
- Taking responsibility in journal's operation

Overall, If the academic editor has ethical concerns about a manuscript sent for review or decision or receives information about a possible ethical breach after publication, they must contact the Editorial Office as soon as possible. Our Editorial Office will then conduct an investigation according to **COPE guidelines**.

To support academic editors, checks are made by Managing Editors and Assistant Editors. However, editors should still report any concerns on any aspect. Checks include

1. Ethics approval and permissions for research involving human subjects, animals or cell lines.
2. Plagiarism, duplicate publication, and that necessary permission from the copyright holder to include already-published figures or images.
3. An international clinical trial registers for pre-register clinical trials or to cite a reference to the registration in the Methods Section.
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When making a final acceptance decision on a manuscript, academic editors should consider the following:

1. Any facts that might be perceived as a possible conflict of interest of the author(s) must be disclosed in the paper before submission.
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3. Data and methods used in the research need to be presented in sufficient detail in the paper so that other researchers can replicate the work.

Accountability

Editors attend four annual meetings through video conferences or virtual communications and advise on journal policy and scope, suggest ideas, new initiatives and programs if necessary to include in the journal. They may review submitted manuscripts, identify topics for special issues or attract new authors and submissions if necessary.

Duties of Advisory Board Members

1. The advisory board typically consists of a group of prominent scholars in the field of architecture and urbanism.
2. In the Journal of Contemporary Urban Affairs, the advisory board members are ambassadors for the journal.
3. Board members attend one or two annual meetings through video conferences or virtual communications and advise on journal policy and scope, suggest ideas, new initiatives and programs if necessary to include in the journal. They may review submitted manuscripts, identify topics for special issues or attract new authors and submissions if necessary.

Conflicts of Interest for the Journal's Editorial Team

For this policy, the editorial team of the Journal of Contemporary Urban Affairs includes the Editor in Chief, Associate Editors, Section Editors, Editorial Advisory Board and International Editorial Board members. All such members of the editorial team are referred to hereafter simply as "Editor". Editors who make final decisions about manuscripts should recuse themselves from editorial decisions if they have conflicts of interest or relationships that pose potential conflicts related to articles under consideration. One challenge for editors is to recognize the potential for conflicts of interest and to take appropriate action when biases are likely. A conflict of interest exists when professional judgment concerning a primary interest (such as patients' welfare or the validity of research) may be influenced by a secondary interest (such as financial gain). Perceptions of conflict of interest are as important as actual conflicts of interest.

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Ethical Guidelines for Authors
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- Authors should accurately present their research findings and include an objective discussion of the significance of their findings.
- Data and methods used in the research need to be presented in sufficient detail in the paper so that other researchers can replicate the work. Raw data must be made publicly available unless there is a compelling reason otherwise (e.g., patient confidentiality).
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All listed authors must have made a significant scientific contribution to the research in the manuscript, approved its claims, and agreed to be an author. It is important to list everyone who made a significant scientific contribution. Author contributions may be described at the end of the submission, optionally using roles defined by CRediT. Submitting authors must provide an ORCID and we encourage all authors to provide one. Changes in authorship must be declared to the journal and agreed to by all authors. Anyone who contributed to the research or manuscript preparation, but is not an author, should be acknowledged with their permission. Submissions by anyone other than one of the authors will not be considered.
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- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Those who contributed to the work but do not qualify for authorship should be listed in the acknowledgements. Any change to the author list during the editorial process or after publication should be approved by all authors, including any who have been removed. We reserve the right to request evidence of authorship, and changes to authorship after acceptance.

Credit Author Statement

In mid-2012 the Wellcome Trust and Harvard University co-hosted a workshop to bring together members of the academic, publishing, and funder communities interested in exploring alternative contributorship and attribution models. Following the workshop (see workshop report), and working initially with a group of mainly biomedical journal editors (and members of the ICMJE a pilot project was established to develop a controlled vocabulary of contributor roles (taxonomy) that could be used to describe the typical range of 'contributions' to scholarly published output for biomedical and science more broadly. The aim was to develop a taxonomy that was both practical and easy to understand while minimizing the potential for misuse. CRediT offers authors the opportunity to share an accurate and detailed description of their diverse contributions to the published work. CRediT (Contributor Roles Taxonomy) is high-level taxonomy, including 14 roles, that can be used to represent the roles typically played by contributors to scientific scholarly output. The roles describe each contributor's specific contribution to the scholarly output.

Role	**Definition**
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims.
Data curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesize study data.
Funding acquisition	Acquisition of the financial support for the project leading to this publication.
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
Methodology	Development or design of methodology; creation of models.
Project administration	Management and coordination responsibility for the research activity planning and execution.

Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
Validation	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.
Writing – original draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
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Recommendations for applying the CRediT taxonomy are:

1. **Multiple roles possible** - Individual contributors can be assigned multiple roles, and a given role can be assigned to multiple contributors;
2. **Degree of contribution optional** - Where multiple individuals serve in the same role, the degree of contribution can optionally be specified as '**lead**', '**equal**', or '**supporting**';
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5. The corresponding author is responsible for ensuring that the descriptions are accurate and agreed by all authors.
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For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used:

CRediT author statement:
Conceptualization: J.F., S.M., R.B, M.W. **Data curation:** S.M., J.F., J.S., J.P.B. **Formal analysis:** M.W., J.F., S.M., R.B. **Funding acquisition:** J.F., S.M., R.B. **Investigation:** S.M., J.S., J.P.B., J.F. **Methodology:** J.F., S.M., R.B., M.W. **Project administration:** S.M., J.F. **Writing—original draft:** S.M., J.F. **Writing—review and editing:** J.F., S.M., R.B., J.S., M.W., J.P.B. All authors have read and agreed to the published version of the manuscript.

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Sources:

1. The presentation of the 14 roles has been adapted from the Consortia Advancing Standards in Research Administration (**CASRAI**) website.
2. https://onlinelibrary.wiley.com/doi/full/10.1002/leap.1210

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- A sentence should not start with But or And (use however or find alternatives).
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- Please capitalize all words in headings including hyphenated words (e.g., Anti-Antagonist), except conjunctions (*and*, *or*, *but*, *nor*, *yet*, *so*, *for*), articles (*a*, *an*, *the*), and all prepositions (including those of five letters or more) (*in*, *to*, *of*, *at*, *by*, *up*, *for*, *off*, *on*, *against*, *between*, *among*, *under*). The first and last words in the title are always capitalized.
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- Write 1980s rather than with an apostrophe (1980's) or just 80s.
- Write don't, can't... in full, i.e., do not, cannot.

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Authors of reports of original research should present an accurate account of the work performed as well as an objective discussion of its significance. Underlying data should be represented accurately in the paper. A paper should contain sufficient detail and references to permit others to replicate the work. Fraudulent or knowingly inaccurate statements constitute unethical behaviour and are unacceptable.

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Authors are asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data (consistent with the ALPSP-STM Statement on Data and Databases), if practicable, and should, in any event, be prepared to retain such data for a reasonable time after publication.

Multiple, Redundant or Concurrent Publication

An author should not, in general, publish manuscripts describing essentially the same research in more than one journal or primary publication. Submitting the same manuscript to more than one journal concurrently constitutes unethical publishing behaviour and is unacceptable.

Acknowledgement of Sources

Proper acknowledgement of the work of others must always be given. Authors should cite publications that have been influential in determining the nature of the reported work.

Disclosure and Conflicts of Interest

All authors should disclose in their manuscript any financial or other substantive conflicts of interest that might be construed to influence the results or interpretation of their manuscript. All sources of financial support for the project should be disclosed.

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The author of the paper should be the person who made the greatest contribution to the creation of the work. All those who contributed to the making of the work should be listed in the paper and as co-authors. If there are other contributors who took part in the preparation of making the same work should be listed or admitted as associates.

Before accepting a final version of the paper for publication is necessary that the author and all co-authors approve the final version.

Funding statement

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The *Journal of Contemporary Urban Affairs* is dedicated to filling the recent gap in the field of urban studies (both in the theory and practice), by examining the emerging social and economic challenges. The journal promotes original academic contributions that are cross-disciplinary to strengthen research under three main areas: *Citizenship Rights and Responsibilities, Territorial dynamics, and Urban Transformations.*

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-develop theoretical and methodological foundations in respect of the social and economic problems of contemporary urbanizations.

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Proclaiming Colonial Urban Heritage: Towards an Inclusive Heritage-interpretation for Colombo's Past

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ABSTRACT

Colombo, Sri Lanka's commercial capital is a forceful creation of European colonialists who occupied the island for over four centuries. Its urban structure displays the social fragmentation sought by the rulers. Colombo elaborates an extraordinary process of city-making, stratified with its Dutch-origin, British-reshaping, and post-colonial adaptation. Proclaiming such a contested past as an inheritance requires an inclusive heritage interpretation. The recent renovation of monumental buildings for potential market values and demolishing minor architecture do not display such a heritage interpretation. This, placing undue attention on a selected social group, is found to be further emptying the compartmentalized city. The exclusion of some sub-societies also cost possible stewardship to urban heritage. Having observed the non-sustainability of current heritage-interpretation practised in Colombo, we searched for alternative means to unify societies in time-space thus sustaining the diversity of urban spaces. Our empirical studies have established the need to integrate the inherent cultural values of the colonial-built urban fabric in heritage interpretation. The results of vibrant heritage-interpretation results have been studied through a literature survey with aims to contribute towards the development of an inclusive heritage interpretation practice to protect Colombo's colonial past sustainably.

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Introduction

Cultural heritage can best be defined as an inheritance of a particular group that proclaims its values. Some may explore the creation of heritage from relics or associations of a reconstituted past or as indicators of an evolved culture, while others may interpret its extensive use as a marketable product. In most cases, tangible remains such as artefacts, built forms or cities are proclaimed as cultural heritage for their potential marketability without paying due attention to the intangible cultural practices that produced those tangible items. Furthermore, most of those proclaimed items are non-intentional heritage but have become protection-worthy for the messages embedded by an evolved value system. Among the most instructive examples

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for such a non-intentional heritage is the Berlin wall. This is why cultural heritage should be considered not as *a* product but *a* process. Hence protecting tangible items as frozen moments without integrating the process that made them a heritage is not useful.

Cultural heritage as an asset of cultural capital and heritage-led economic development is a meaningful way to advance both the conservation and sustainability of urban areas (Munasinghe, 2005; Throsby, 2017). Thus, heritage protection has implications on local and regional economic systems, investment, labour, consumption, infrastructure, services, ecology, social equity, and cultural activities (Nijkamp, 2012). Yet, most policymakers decode this strength of heritage incorrectly and make attempts to protect heritage as a way of boosting tourism.[1] UNESCO's Global Report on Culture for Sustainable Development (2016, p.17) notes, "What we call heritage is found in quality public spaces or in areas marked by the layers of time. Cultural expressions give people the opportunity to identify them collectively, to read the traces of history, to understand the importance of traditions for their daily life, or to enjoy beauty, harmony and artistic endeavour". Tourism-oriented heritage protection pays attention to restored romantic views of the past at the cost of its process of value stratification, and therefore may not be sustainable. In other words, any decision that affects a society should bring its evolved value system to the center of decision making. Since society's values system is best expressed in its way of proclaiming heritage, the close links between culture and sustainability become clear. This is why a particular way of proclaiming heritage could frame sustainable development in the city (Munasinghe, 2005). It is imperative to design protection measures based on the unique identity of a city to make its continuous living. Heritage users interpret its meanings to be used in different fronts and forums. The rebuilding of Warsaw to represent the rebirth of a nation-state is an instructive example for such interpretations.[2] This study reiterates that the particular understanding between culture and milieu should be used as the basis to ensure that heritage interpretation addresses most, if not all, social groups that would use the city.

Colombo's built urban fabric attests to an intricate socio-cultural evolution. Its original creators, the Dutch, who practised a form of mercantile colonialism, expressed different ideas through its urban tissue from its fine-tuners, the British, who practised a form of imperialistic colonialism and rearranged the Dutch-founded city. The British crowned Colombo as the administrative hub to centralize their rule (Brohier, 1985). They dismantled the Dutch ramparts and added grand administrative buildings to display their power while keeping the ruled at a distance. The grand colonnades, arcades or well-maintained turfed lawns that wrapped those buildings fashioned a psychological barrier between the ruler and the ruled. The city has continued to be the power-centric hub even after the colonialists left and new administrative capital has been built. The central precinct of Colombo, the fort has become a place that is visited but not dwelled though it marks a turning point in Sri Lanka's urban history. Both the Dutch and the British patronized local societies to survive in the hostile landscape. These locals took over the inner city after the colonialists left and adapted it for their new urban way of life.

By paying due attention to the urban structure that reflects Colombo's unique process of evolution, its interpretation shall position that processed image within the value system of its inheritors. Yet, the heritage interpreters in Colombo prioritize the potential market values of a few selected buildings or urban precincts and do not intend to promote the protection of its cultural values. They do not interpret Colombo as one liveable city either. As Colombo Page News Desk (2021) reports, their way of protecting outer shells to accommodate artificially grafted extrinsic values has not been sustainable either. Also, the enforced shallow interpretations have destroyed the heritage values of the protected buildings and isolated them within the city.

This paper is a result of observing the tragic consequences of short-sighted heritage

[1]. An architect commissioned by World Heritage Fund as a consultant to the Heritage Protection at Galle Fort in Sri Lanka said, "When tourists come to see the Dutch fort, there should be a Dutch fort. Therefore, we should restore the Galled fort as it was during the Dutch", when he was interviewed by the author. His suggestion was to recreate those past images at the expense of post-Dutch addition.

[2]. Warsaw was annihilated by Nazis as a way of repressing Polish resistance. Hence, its rebuilding was interpreted as a symbol for the inner strength and determination of a nation. https://whc.unesco.org/en/list/30/

interpretation in Colombo and an in-depth study of the paradigm shift in heritage interpretation. Our research first investigated the evolving heritage interpretation practices and then made attempts to fine-tune them to be more inclusive in the context of Colombo as a living city. By confronting the unprecedented challenges in the developing city and especially in renegotiating its contested heritage values, the paper may contribute to the development of a more sustainable approach to heritage protection. Qualitative research methods such as observation, participatory observation and depth-interviews were used to collect primary data after using literature surveys for secondary data collection.

Evolving heritage interpretation practices in Colombo

Undoubtedly, heritage interpretation could play a critical role in regenerating historic urban areas while sustaining a living society and engaging them in protecting the heritage values of those urban areas. The possibilities of trivialising history to inculcate reactionary, superficial or romantic views of the past should be carefully managed through truthful interpretation so that heritage protection would not become an industry that produces authenticated heritage items but provides a solid base for the future of a living city.

Yet, this has not been the case in Colombo, where the policymakers convert colonial buildings into deluxe shopping malls, city hotels and restaurants to attract high-spending tourists and locals. Perera (2021) has reported that the Urban Development Authority (UDA) is currently preparing plans to convert the Colombo fort into a tourism honeypot.[3] At the same time, UDA is demolishing historic minor architecture such as shop-housing of service communities and evicting the low-income communities that occupy those spaces. The reclaimed lands are being reserved for luxury apartment buildings for short-term visitors and elitist sub-societies. This type of money-driven interpretation will not rigorously protect heritage either. Rehabilitation of façades or selected built-envelopes, and then beautifying their surroundings with lawns, ponds, fountains, or flower beds seem to unintentionally distance some societies from their lived urban spaces. The senseless approach of converting historic buildings into museum pieces located in no-man's lands further degrades city life. Aiming at tourism, which is an extremely fragile economic base and the eviction of low-income groups, has brought negative impacts on the city's image. The Colombo fort is already a dead-space during weekends and holidays, and reserving it for tourism will only stop its evolution as a culturally diversified urban precinct. Having documented the consequences of current heritage interpretation, this study aimed at searching for alternative approaches that could strengthen Colombo's liveability while enlarging the awareness of a disowned heritage.

Colombo' attempt to popularize renovated sites as trendy places for young elites to display wasting as a way of celebrating life has brought mixed results. The single-story heritage interpretation that aims at an overrated market value converts buildings, city quarters and streetscapes into open-air museums or museum objects kept on a glittery carpet. The failure to enlarge heritage awareness among living societies has resulted in the physical distortion of heritage buildings though priorities are placed with the protection of tangible remains. The renovated urban spaces are becoming places to visit and not to dwell. There, heritage interpreters have not been able to find techniques or sophisticated means to understand the possible decoding of their meanings. As a result, their interpretation has failed to sustainably protect a heritage or to strengthen continuous living (Munasinghe, 2014).[4] The current interpretation practices hardly engage visitors or educate them of the moral or ethical issues, social justice or sustainability of a protected historic milieu. The message that has been relayed reduces the city into more like a theme park that can be visited for fun, enjoyed and left alone.

[3]. The state Minister for Urban Development says "We identified the Colombo Fort area as a heritage city which can be developed for tourism and hospitality purposes as part of the Government's long-term vision to convert the city to a buzzing tourism city. The Colombo Fort area has many colonial buildings and lands on which hotels can be constructed. This is, however, not an immediate thing but a concept." (cited in Perera, 2021.)

[4]. Refer Munasinghe (2014) for an inquiry of losing the city-identity as a result of tourist-oriented restoration in Colombo. A meal in one of those restaurants cost more than the monthly income of many locals whose minimum wage is around USD 50 per month. https://www.ministryofcrab.com/colombo/the-old-dutch-hospital/(n.d.)

Among the best directions to understand heritage interpretation is given in Tinden's dictum (1957); through interpretation, understanding: through understanding, appreciation: through appreciation, protection. As such, interpretation should be able to frame sustainable protection of heritage. This, focusing on educational aspects of interpretation, could also contribute to the change of attitudes to colonial-built urban fabric as an inheritance of the present-day society, and not just the reminders of an era of suppression. Having conducted empirical research, Uzzel (1998) concludes that interpretation cannot always guarantee this attitude change. Yet, an open-ended interpretation that invites visitors to engage in a constructive dialogue with the interpreted heritage could mark a turning point in enlarging awareness. Unfortunately, Colombo does not see the requirement of facilitating such a dialogue to change perceptions of the colonial past but to inflate the market values of those urban spaces thus inadvertently privatizing the city's public spaces. Their heritage interpretation, hinting that the restored spaces are not for every city dweller, shapes a new form of suppression.

The unyielding interpretations given to the colonial built spaces resemble the explanatory notes displayed in front of the artefacts exhibited in museums, providing raw data of their age or patrons or styles, in short, intrinsic values. It is disturbing to see how such interpretations of lived spaces have failed to comprehend the nexus between knowledge and information. The restored historic buildings may promote tourism and attract high-spending locals, but for a short time. As it has been established, such groups may find another location to spend their money as soon as the excitement of the restored built space is over.[5] Most renters already find it extremely difficult to even pay their rents, and the UDA is in the process of leasing the management of some of those malls to a private conglomeration that would eventually make these spaces more exclusive and expensive.[6] In addition, those well-maintained spaces have become psychologically inaccessible pockets within the city for most locals as they were during the colonial rule. Heritage interpretation in Colombo has been taking steps to reserve the city for a selected group of users.

Heritage interpretation, today, is considered as a powerful tool to imply the dissemination of new knowledge thus facilitating constructive dialogue with a past. Such an interpretation will not only attract investments but also ensure the sustainable development of the city (Nocca, 2017; Slavin, 2011). By incorporating the transformation of various beliefs and ideologies along with the agents of such transformations, interpretation could facilitate an attitude change within a larger context. This could not only promote social cohesion by improving accessibility to and liveability in those spaces but may also garner greater socio-economic benefits for societies by linking historic areas with the city and region, physically and psychologically (Kangas et al., 2017). As UNESCO's Global Report on Culture for Sustainable Development (2016, p.23) notes, "Safeguarding cultural heritage and promoting the diversity of cultural expressions, while fostering values and behaviours that reject violence and build tolerance, are instrumental to the social cohesion of societies, peace-building and the sustainability of cities". Yet, Colombo seems to be fragmenting the society further based on their affordability. Turner (2015) also asserts that strengthening social sustainability is crucial for the continuity of a historic city. The heritage interpretation practiced in Colombo, failing to fall in line with such assertions, reduces social groups with less buying power into a service-provider and not the joint owners of the city. The possible tensions created within the society may not support continuous living in the city or strengthen the city's images as an inheritance.

It is clear that heritage interpretation could change the attitudes of those who live in the city and of those who visit it. Colombo's heritage interpretation practices seem to change attitudes negatively by promoting historic urban space as a place for the rich, and as such, disinheriting a past. Most shops, restaurants, cafes, etc. in the restored buildings are owned by celebrities to lure young adults by making them trendy places. They sell either product of foreign origin or highly-priced local

[5]. Our interviews show that about 55%-65% visitors do not engage in transactions in these luxury shopping malls.

[6]. The leasee of the Colombo Arcade says, "It is our intention to develop this arcade complex into a luxury shopping mall. The highest quality hotels are also included in the plan." (cited in Colombo Page, 2021)

products, yet the involvement of celebrities promote those young adults to consider that hanging out in those malls as a way of showing that they are also members of that high society. This is similar to the new-rich collecting so-called antiques and exhibiting them to show that they had a past. Most of the visitors have no interest in knowing the cultural inheritance or its significance to sociocultural evolution that took place in Colombo but just to consume an exotic space and to boast about that consumption.[7] Their visiting could be a short term affair because they do not develop any attachment to the proclaimed heritage. The failure to articulate theoretical assumptions in interpretations with aims to assemble stewardship for heritage may further fragment the urban society and make more dead urban spaces in Colombo.

As McGuire (1985) says the theory of attitudes comprise cognitive, affective and behavioural elements. Heritage interpreters address the cognitive dimension of interpretation. Thus, heritage interpretation should enhance people's knowledge to understand the status-quo of their city to encourage dwelling. If emotional and behavioural considerations are essential to attitude formation and change, any interpretation that excludes those dimensions is less likely to be effective in making the city liveable. Such behavioural dimensions are not being integrated with heritage interpretation or urban conservation in Colombo. As a result, heritage interpreters have not been able to exploit the potentials of protecting the cultural significance of colonial-built urban fabric as a way of underpinning the liveability and marketability of urban space. The non-inclusive interpretation has failed to continue uses or programmes designated to those protected buildings.

Most crucially, this approach does not acknowledge the cultural significance of colonial rule that is evident in all social groups. The heritage interpretation of the remains of an era of subjugation seems to have been constructed as if there were a dispassionate interest in what is a highly emotional subject. Restoring them to attract high-spending visitors could be as superficial as building visitors to a theme park that hardly diversifies a city culture. The colonialists installed an elitist social group to take over the ruling machine after independence. They were educated and groomed within the value systems of the colonialists. They moved into the urban spaces fashioned by their masters after independence. Today, they are being replaced by a new rich with political clout and wealth. This globally-exposed new social class seems to have developed a value system that is hardly grounded within their own geographical or cultural roots. Heritage interpreters in Colombo seem to be playing for the new rich for their buying power and intention to spend to show off. There is no interest among decision-makers to unify post-independent sub-societies or to calm down the tensions between the city and its surroundings. Since the change of attitudes and emotions evolve along with time, particularly in a global hub like Colombo, it is important to comprehend diversifying actions and various human qualities such as affection, conscience, humanity and comparison of its urban society. The undue attention on short-term place marketing by catering to the new rich has not been sustainable. Colombo requires a heritage interpretation process to strengthen the city's continuity as a living space.

Heritage interpretation in time and place

Cities become popular places of dwelling when the dwellers can identify themselves with the city or orientate themselves within the city. A lived city like Colombo is culturally diverse and as such, is able to present many clues for its dwellers to construct an identity and orientation if the evolved city milieu is interpreted and presented to those dwellers without any prejudices. The heritage interpretation in time and place could facilitate continuous dwelling in the city. On the contrary, a heritage interpretation that does not respond to time and place, ignoring the needs of dwellers, would become meaningless.

Heritage interpretation is a socio-cultural process, and its nexus to time and places is a socio-cultural phenomenon. As Staiff (2017) notes making of meanings cannot escape its distinct socio-cultural dimension, especially when they are attached to heritage places, whose meanings change over time. For example, the appalling living quarters of the

[7]. Most visitors, locals as well as foreigners, said that the restored buildings were "nice" or "interesting". They did not show any commitment to understand the cultural significance of them as an inheritance.

working class could eventually become a trendy living area, or a restaurant that served tasteless fillings during a war or a famine could become the most-sought place for a meal. Conversion of prisons or concentration camps into hotels or cultural centres is a pointer to understand how time changes place meanings and how places accrue values. Hence, heritage interpretation should be open-ended to comprehend such changes in time and place. Lowenthal (1990) notes three levels of analysis to understand historic objects: memories, historical records and artefacts. It is a fact that some declared heritage items move from one level to another while some exist in all three levels at the same time. A war site, for example, may bring unpleasant memories to some while an enjoyable victory to others. Some other groups may even consider those sites as a historical record or an artefact.[8] A colonial-built city is not different from this either, and not all colonial-built places have pleasant memories but excellent lessons for the present and future. Heritage interpretation should inquire about the existing level/s of analysis of heritage places before presenting their meanings to be useful.

Colonial built fabric was not conceived as a monument. Proclaiming it as a heritage in the post-independent era for recording an era of socio-cultural evolution shows its transformation in time and place. The continuous use of such built fabric has accrued new values and new meanings, undoubtedly characterizing the urban landscapes in Colombo. Its flawless urban landscape that composes various spaces to accommodate the evolved needs of today's societies is a result of dismantling the ramparts. Yet, the urban structure and monumental public buildings still display the significance of the fort. The arcades and other such semi-public urban spaces that enveloped its monumental buildings have been successfully adapted by post-colonial societies. Moreover, minor architecture has evolved around some dominating urban structures and in the immediate surrounding of the fort, displaying the making of true cultural diversity. It is important to continuously facilitate different strata of the post-colonial society to ensure the sustainability of city life in Colombo. An interpretation that does not respect time and place seems to be costing possible stewardship, and as such, an unsecured or an unclaimed urban space.

Heritage interpretation shall not be limited to raw data such as what it was, who built it or when it was built, or in other words to intrinsic values such as age, style or builder (Munasinghe, 2018). It should attempt to trigger a dialogue with the present-day society that is expected to decode those interpretations (Staiff, 2017). It is not astute to place priorities with one period over another either. Colombo does not place priorities on a period but certainly on selected buildings to make heritage-protecting a lucrative business. The attempts to make Colombo fort an urban district dedicated to the hospitality industry will be the apex of such short-sighted heritage interpretation. This selective means of interpretation is no different from the obsolete conservation attempts in the past that aimed at addressing a wealthy intellectual minority. The danger of interpretation that disregards the timely meanings of heritage values is reflected by the bankruptcy of renovated buildings and their dead spaces. This inappropriate interpretation is closely followed by alien land use planning that compartmentalizes the city physically and makes it unliveable psychologically (Silberstein & Maser, 2013).

Heritage is invariably subject to multiple and sometimes even controverting interpretations, thus emphasizing their time-place dictum. Living societies come to grips with the meanings within their comfort zones, shaped by their time-place disposition. The most comprehensive heritage interpretation will encourage visitors to inquire about the making of that living space and its continuous dwelling. This is why heritage interpretation that integrates the concept of time-place could support dwelling in those heritage cities. Our way of interpreting a heritage should be an attempt to present the stratification of the past along with the reasons for that particular process of stratification. Once this evolutionary process of the urban landscape is understood as a reflection of a particular socio-cultural evolution, heritage interpreters could easily make historic spaces more liveable and comfortable.

[8]. Uzzel (1998) coined a new term, *hot interpretation* for interpreting the inheritance of a war.

Cities go through an unprecedentedly rapid transformation. City managers are also continuously challenged to keep them attractive to the living societies and newcomers. Undoubtedly, socio-economic changes that were unthinkable at the beginning of this millennium, have taken place, particularly in the cities of the developing world. This is why dwellers should be presented with clues to construct an identity to facilitate the transformation of a fragmented society, deliberated by colonialists. An evolved urban landscape presents an excellent means to support constructing such an identity. Heritage values are required to be interpreted so that the living societies, as well as visitors, are encouraged to investigate the links between the city's past, present and future. This, respecting their timely socio-cultural values, personal memories, or collective representations with place identities could change their attitudes to the inherited past. Enhanced heritage awareness will certainly make local societies realise that they have a role in protecting their inheritance, thus promoting a sense of belongingness within the city. The most demanding role heritage interpretation could play in a post-colonial city is promoting the engagement of its living society and ensuring that the city is protected for its people and not further distancing them from their living city as Lawless (2015) finds in Melaka.

The most damaging mistake possibly caused by interpretation is disconnecting past, present and future, thereby converting historic cities into dead monuments, similar to museum objects with which visitors are hardly engaged. At the same time, such efforts compartmentalize cities and further fragment their societies. Heritage interpretation that fails to connect the historic urban fabric to ongoing processes of living could also trigger intentional or non-intentional destruction. All historic moments are parts of a larger process, and as such all cities, built fabric, monuments, plazas and minor architecture signify the footsteps of continuous socio-cultural evolution. The timely changes of historic built fabric are similar to the patina on certain metal surfaces; patina is the present-day existence of that surface and not a different layer. The existence of a particular component of an urban landscape should be interpreted with much wider ramifications than those that are typically represented. One may search for heritage presentations that could be interpreted differently in time and place, and for an interpretation that brings more enthusiasm to heritage protection. This type of open-ended interpretation in time and place could frame sustainable uses in protected heritage sites.

Colombo's heritage interpretation is planned under the theme of city beautification.[9] Converting the historic urban fabric into amusement parks for high-spending time-travellers, the authorities are planning to build a Colonial Williamsburg in the Colombo fort. Their continuous failure to integrate public, professional or visitors' views seems to have missed shaping more constructive land-use planning in the colonial-built city (Silberstein & Maser, 2013). The policymakers do not use the available extensive range of communication skills or smart technologies to engage social groups in planning sustainable development. A critical aspect of community engagement is that different social groups, as well as individuals, hold different values in their city. It may reveal how to use lands with a heritage value sustainably. As it has been argued, land-use planning shaped by cultural, political and personal experiences and perspectives of living societies is the most sustainable type (Appleton, 2013). Since the city is culturally diverse, land-use planners cannot expect just one view but an array of views, sometimes even conflicting. Also, accommodating such contrasting views should be considered as a core value of a city that is a proclaimed heritage.

Hosagrahar (2016) notes the importance of building awareness, consensus, and capacity of a diverse cross-section of stakeholders for inclusive, empowered and effective participation in managing their urban heritage forms for socio-culturally defined sustainability. An interpretation that pegs down a heritage within time and place will help to facilitate dwelling. Uzzel (1998) has established that the dimensions which serve to define social identity have strong links to place identity. He has used four dimensions for this investigation: distinctiveness, as this emphasizes

[9]. City beautification has been labelled as a 'pet projects' of a powerful politician. As a result, it was not maintained when that particular politician had lost power, allowing their eventual destruction through negligence. UDA, under the guidance of this politician who returned to power, is now implementing more non-sustainable projects.

uniqueness; continuity which emphasizes stable links with the past; self-efficacy, which emphasizes control and competence; and self-esteem, which engenders a sense of pride and self-respect. This emphasizes how people and activities play a major role in creating a city's identity. Therefore, heritage interpretation in time and place would support dwelling in the city. As Zukin (2012) notes a heritage city should support a desirable number and a choice of users or a long-term resident population to avoid their death through gentrification and touristification. This could be possible if a heritage interpretation process unifies possible interpreted meanings within the forte of those who are addressed through such processes.[10] It is important to determine the priorities of those who are addressed through interpretation based on the cultural significance of the heritage that is being protected. The restoration of those historic buildings were not discussed at public forums as UDA has not practiced any mechanism to integrate public or professional views in the decision making process. Its top-down decision making process used for the heritage interpretation would erode the diversity of the city and weaken the connections with city's present-day and future connections.[11]

Heritage interpretation is not immune from contradictions. Its deep connections with the conservation movement and the continuous shaping of the concept of heritage should be paid due attention. The timely evolution of the concept of heritage itself shows that heritage is a process and cannot be protected as frozen moments of the past. What is most fitting is a comprehensive heritage interpretation in time and place, thus recording the existing values along with the protected heritage. Also, heritage interpretation should deal with environmental responsibility in economic development. It is important to note that the failure to assess why heritage should be interpreted within time and place has caused various negative impressions of the past. This is similar to the attempts made to demolish historic buildings in Paris after the French Revolution. The decree issued by the new state, reinterpreting them as a heritage of the French, finally saved what is today considered as a World Heritage. This is an excellent example of the strength of interpreting heritage in time and place, and precedence that Colombo can follow for its colonial heritage.

Interpretation for a wider audience

A considerable amount of research has been undertaken in social psychology to determine the criteria which are central to the social identity process (Breakwell, 2014). It is important to note that heritage interpretation could learn from these how to address a wider audience, including those who live in the city as well as those who visit it. It should be stressed that the dwellers and visitors may develop various attachments to heritage cities, expressing their own social identity. It is important to emphasize that a heritage city is not just an exhibit to reconstruct memories or events but a place where someone can reconcile with his/ her cultural meanings to comfortably dwell. Hence, its interpretation shall focus on strengthening such reconciliation rather than presenting heritage cities as passive warehouses of memories. A city like Pompeii, where timely evolution was terminated, could be presented as a frozen moment of history not only for what it had been but also for how its life was ended. This is not the case of a living city like Colombo, where its living patterns continues thus adding more layers to its urban images. Hence heritage interpretation in living cities should be more informative than *a* symbolic representation of one by-gone era. There are many lessons to learn from the failed attempts to reconstruct past images for tourism that have caused the degradation of city life. It must be noted that once a city has lost its living society, it would not be a city anymore, and therefore heritage interpretation shall make all efforts to encourage dwelling in the city.

The best point of departure for heritage interpretation in a living city is inquiring how societies engage in place-making in relation to those proclaimed historic spaces. It is vital to understand how they orientate themselves within the city and identify themselves with the city. This would help heritage interpreters to find the present-day value system, thus incorporating a larger audience. Such

[10]. Refer Uzzel (1998) for a comprehensive analysis of several unifying heritage interpretation techniques.

[11]. Many foreign visitors, when questioned, noted that the cultural diversity and the living society is a part of the heritage, and the Colombo fort would lose its value if converted into a tourist quarter.

interpretation should also engage working classes and low-income groups in addition to elitist groups and visitors as agents of continuously making that city a heritage. A holistic approach to conservation based on such heritage interpretation that includes a wider community as a part of the inheritance could also frame sustainable development of the city by reiterating a socio-culturally defined carrying capacity (Munasinghe, 2005).

It is important to find a contextual recipe for prioritizing heritage values to make living societies *at home*. This, by informing societies how they could acquire knowledge in framing the future of their city, would shape stewardship to heritage. The traditional approach to heritage interpretation seems to suggest that meaning and significance is self-evident from the object itself. It may be the case for a museum exhibit, but not essential for a historic city with a living society. It is important to find more open-ended interpretations to address a wider community. Colombo needs to move away from this traditional approach to address a more diversified audience. Some of the meanings embedded in the colonial built fabric are contradictory. Their interpretation should address those who have lived there for generations, those who have moved there recently as well as those who visit the city regularly in addition to those who visit the city as a tourist. The current approaches in Colombo seem to be further glossing the meanings of colonial-built urban fabric by covering them with extrinsic touristic value. The locals are being demoted to a passive audience though they are a product of the same evolutionary process that has shaped their city. Such interpretation that addresses a wider society would assert that their city is a cultural product in the making. Heritage interpretation in the city should contribute to the knowledge construction of locals as well as that of visitors to engage both parties in its protection for continuous occupation of urban spaces and making them true cultural diversities. Hence, interpretation of heritage values of colonial-built urban fabric shall make a positive contribution to the continuous engagement of all significant social groups.

Visiting a heritage city is a social experience as all cities are founded as places of congregation. Colombo has evolved along with the changing relationships between rulers and the ruled. Those monumental buildings as well as other modest structures of the colonial era attest to the city's evolution as a public space shared by many social groups. Thus, interpreting a few selected buildings or a declared urban quarter for their potential market values is more like reversing the progress of a city designated as the commercial capital of a country. The dynamic relationships between the interpreted heritage, various visitor groups, and meanings generated through their interaction have been well documented by Uzzel (1998). He states that visitors do not necessarily understand the meanings of heritage places by reading exhibition panels but by interacting with each other and with those who live in that place. On the other hand, as Blud (1990) notes the engagement of visitors, through interpretation, could frame better protection to heritage. Shaping a heritage interpretation that promotes group visits and interaction between visitors and interpreted heritage, in which the living societies are a part, could lead to understanding the evolved heritage values and facilitating sustainable protection. However, this idea of engaging visitors seems to have been misread by heritage interpreters who promote the inclusion of so-called period activities thus converting heritage sites into amusement parks, where the living society is demoted to a mere service provider. Promoting the protection of heritage values should be placed ahead of visitors through correct interpretation yet engaging them as a part and parcel of that interpretation. The most crucial role for the interpreter is to facilitate visitors to discover heritage values and their shaping and then to come to an understanding of the continuity of a past, place and a living society.

Interpretation may focus more on passive public actions as for the behavioural dimension. There should be sufficient room for the public to engage in any action as a consequence of their learning experience through their emotional connections to heritage cities. Heritage interpretation should present choices for diverse social groups to proclaim their inherited past positively to get involved with its protection. As a result, the local societies may not become passive victims of their past or fatalistically remain victims of a processed future. They can actively get involved in designing the future of their cities while integrating tourism and other potential

markets to sustain the socio-economics of their protected inheritance. As such, heritage interpretation could result in re-securing urban spaces for locals and then for visitors (Oevermann & Gantner, 2019). This is imperative in a colonial city, where heritage interpretation could transfer the ownership of the city back to the post-colonial society.

Today, social empowerment through interpretation to frame culturally sustainable development of the historic city has been discussed in many forums. By proclaiming the colonial-built city a heritage through interpretation, it would be possible to promote societies to occupy urban spaces while lobbying for new avenues to make healthy revenue. In other words, a heritage interpretation that promotes such inherent values as cultural significance over such intrinsic values as age or style or such extrinsic values as touristic or market could ensure better protection for the proclaimed heritage and a more sustainable living for local societies.

Conclusion: towards a unifying interpretation

It is clear that Colombo's attention on market value has chosen to only protect grand built forms and city quarters with such buildings. This heritage interpretation aimed at addressing a minority fails to unify sub-societies. Convincing political authorities and the public that colonial heritage should be protected in a country where most cultural heritage sites are indicators of pre-colonial evolution of the country's majority, the Sinhalese-Buddhists, has never been easy. The Antiquities Ordinance 1940 that has been used in Sri Lanka for heritage protection emphasizes the age value of tangible remains. The revisions of the ordinance and other recent legal frameworks have not brought any improvements to widen this age value. The declaration of the ramparts in Galle, a fortified city built by the Dutch, was the first attempt to identify the colonial-built heritage. The implementation of the ordinance that thwarts any development within 400 meters of a declared heritage could protect the entire Galle Fort and its surroundings too. Later, this was extended to list buildings in other cities that are more than 100 years old as protected buildings. However, minor architecture was never listed. This filtering process that renders protection for a few selected buildings also further fractures society.

Heritage-interpretation, instead, should strengthen the liveability of the city by unifying all sub-societies in time, and place. It should also attempt to protect tangible heritage as well as intangible processes. Heritage interpretation, as such, could facilitate the continuous evolution of the city as a place of life by fine-tuning the city's embedded identity. In time and place, heritage interpretation could be more than just descriptive or prescriptive to present alternative scenarios through urban guides and urban briefs to ensure the continuity of the city's image to accommodate its future generations. It is important to fine-tune a basis to develop such heritage interpretations in time and place so that societies could make more informed decisions with regards to the future of their heritage city.

Understanding what is inherently diverse about a heritage city could frame the rationale for its interpretation, and such interpretation could facilitate complete protection to the heritage city. Heritage interpretation aims at various receivers, and therefore, understanding their value system is also essential. The supposed virtue of heritage interpretation lies in its tendency to draw attention to and stress the differences rather than the similarities between people, events and places. For some, colonial-built heritage may be an inheritance that can be proudly proclaimed, while for others it may be a reminder of prejudice and ill-treatment. It is not a secret that such conflicts and various fragmentations are experienced everywhere. This often arises out of ignorance, prejudice, insecurity and a lack of individual pride as well as collective identity and confidence. Heritage interpretation could facilitate healing such past wounds by promoting a new phase of compassion among social groups.

As heritage cities could be interpreted as places devoid of anachronistic and anti-democratic to construct a positive social identity and a sense of place, it is easier to promote place-making in the city. This is not to suggest that interpretation could falsely construct an image that each and every social group has been equal or similar or their role in making the particular city heritage is similar, but it certainly may help to encourage different groups to respect each other, finding their common issues and continuously transforming their living space. It is vital to strike a delicate

balance to ensure an inclusive development strategy for such heritage cities for the benefit of societies and individuals, while at the same time safeguarding its heritage values, cultural diversity, integrity and the identity of present and future communities.

Our contention is to make heritage interpretation more inclusive and open-ended thus leaving the users to interpret them for their social interaction. The heritage protection plans could adopt a policy to include living societies and visitors in their interpretation, leaving the reception of those messages open. Such open-ended interpretation could support a dweller to positively identify and orientate him or her within the city not only as an individual but also as a member of a group. It is this identity and orientation that convert cities into places of life. This can construct positive attributes of the place being perceived to rub off onto the person. It is often suggested in the rhetoric of interpretive philosophy that interpretation contributes to a person's sense of place. The absence of research in interpretation has meant that such an assertion has to be tested. Urban identity theories stress the social value to be gained by people who perceive their city as unique and special. This uniqueness may eventually convert into a sense of pride and a sense of identity. Heritage sites, once inclusively interpreted, will not just enhance a person's sense of pride but more about that person's cultural identity and diversity. This is why heritage interpretation should focus on those intangible components of a lived city. Interpretation is in danger of falling into the same trap: images that move before eyes, without leaving much of an impression on the retina and even less on the brain. Finally, heritage interpretation should be a force for change and should be powerful as those forces which it has been designed to counter.

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Sustainability of Tourism Development in the city of Ain-Sukhna, Egypt

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ABSTRACT

Tourism is a major economic source for Egypt, due to its significant natural and cultural attractions. Yet, rapid development and construction of touristic facilities have a negative impact on the fragile natural and cultural heritage. This paper studies the recent touristic developments of the coastal stretch of Ain-Sukhna on the Red Sea coastal region of Galala Mountain, and their impact on the surrounding natural and cultural attractions. Coral reefs and rich marine life have made this stretch among the prime fishing and scuba diving destinations in the world. The area is also famous for its year-round sunny beaches and the spectacular coastal scenic drive where Galala Mountain reaches the Red Sea. Recently, development has started on the mountains following the construction of Galala Mountain Road. Galala City started with Galala University and several residential, touristic, and commercial facilities. This paper studies the pattern of development in the area during the past 40 years and assesses its impact on natural and cultural resources.

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1. Introduction

Tourism has both positive and negative impacts on the environment and people. Tourism helps to create employment opportunities for a large number of people and increases the economic and sociocultural standards of the community while minimizing the migration to urban areas. It also promotes the conservation of natural features and the commercialization of local products and handicrafts. On the other hand, negative impacts include the increase of land use for construction, water for irrigation, and energy for services; the devastation of natural landscapes with the construction of more infrastructures; the increase in garbage and waste output and need for disposal; changes in ecosystems, including the introduction of non-indigenous animals and plants, and the

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disappearance of habitats; the increase of some illegal activities; the rise in the cost of products and services. Human activities affect the environment physically; individually or collectively, which may impact the long-term viability of tourism and related activities in the region. The environment must be preserved by all relevant parties in the tourist sector. Shaalan (2005) suggests that ambitious plans should consider sustainability as a guiding concept for development. Governments and developers have a critical role in establishing and enforcing rules and practices that safeguard natural heritage and the environment for future generations to enjoy (Shaalan, 2005).

The Ain-Sukhna–Zaafarana strip on the Red Sea Gulf of Suez, east of Cairo, has witnessed rapid development during the past 40 years due to its nature as an attractive mass tourism destination for Egyptians and foreigners. The type, intensity, and characteristics of this development and its impact on natural, built, and human environments are problematic. This rapid development is not sustainable and poses threats to the natural environment and human well-being, health, and safety. Several developments are located on natural rain flood paths, while others are extensively altering the natural environment to accommodate their units, as illustrated in Figure 1. Their economic feasibility is also questionable, as most of the units are used only a few days a year. The absence of planned public beaches and facilities is causing pollution due to the informal usage of the natural beaches. Informal developments are scattered along the coastal road in the form of seafood stands and restaurants.

This rapid development is causing negative impacts on the fragile natural environment and the human environment. For example, in 2016, a flash flood in Ras Gharib manifested the impact on unprotected areas, alerting the national government and the Red Sea local authorities of the hazards of rapid development. The threats and hazards include the pollution of the flora and fauna of the region; degradation of the quality of water, air, and visual characteristics; and natural disasters such as flash floods that can eradicate beaches and cause human fatalities, asset destruction, and investment losses. Negm and El-Sayed (2020) performed a study that concluded that climate change affects rainfall patterns and that Egypt started to experience different rainfall patterns during the early 21st century (Negm & El-Sayed, 2020). Mass tourism, informal use of beaches, and garbage are causing pollution and coral reef deaths. Natural beaches are no longer available with the rapid appropriation of beaches by gated resorts. The social and cultural heritage has disappeared entirely with the absence of local Bedouin tribes. Recently, development has started on the mountains following the construction of Galala Mountain Road. Galala City started with Galala University and several residential, touristic, and commercial facilities.

Figure 1. Alteration of the natural environment by touristic resorts. (Source: Author)

This paper investigates the developments during the past 40 years of the 60-kilometer coastal stretch between Ain-Sukhna (also known as Sukhna) and Zaafarana in the region of Galala Mountain, and their impact on the surrounding natural and cultural attractions. The questions posed are: What is the quality of current tourism development? How sustainable is it? How can we make it more sustainable? The results of this research could be useful for future planning in similar areas. They can increase the awareness of decision-makers about the adverse impact of unplanned development programs. The results should also be useful in improving the sustainability aspects of current facilities in the Ain-Sukhna region.

The paper adopts sustainability as a theoretical framework for the assessment of current development in the region. It asserts that sustainability is a process, not a product, a function not a form. The World Conservation Union (WCU) defines sustainable development as a development process that allows developments to take place without degrading or depleting the resources that make the development feasible. It goes on to define sustainable development as a change process in which resource exploitation, investment direction, technical development orientation, and institutional change are made consistent with future as well as current needs (Keeble, 1987).

Sustainable development entails not only environmental sustainability but also economic

and social sustainability. As well as considering environmental impacts, urban designers need to have regard to social impacts and long-term economic viability. The notion of sustainability is now widely recognized as a critical component of any sort of development evaluation, including tourism. The World Tourism Organization (WTO), the Tourism Council (WTTC), and the Earth Council describe sustainable tourism as satisfying the demands of current visitors and host regions while safeguarding and expanding future opportunities. The concept of sustainable tourism arose with the goal of reducing the negative consequences of tourism operations, and it has since gained widespread acceptance as a desirable and politically suitable approach to tourist development.

Sustainable Tourism Development (STD) concerns economic, social, and environmental tourism development that aims at the continuous improvement of tourists' experience. As indicated by Franzoni (2015), "to measure tourism sustainability requires a knowledge of the complexity of tourism systems and the specifics of any given location. However, most research, although focusing on social, economic or environmental indicators but have not considered how they integrate and relate to each other" (Franzoni, 2015). Adillon (2018) presented a model of sustainable tourism that assists organizations in making informed decisions to control the number of visitors to destinations and attractions to achieve optimum utilization without compromising the future of these destinations (Adillon, 2018).

Red Sea tourism development has received several warning signs from researchers since the 1990s. Hawkins and Roberts (1996) indicated while present levels of recreational usage give the impression of being sustainable, the immense growth anticipated throughout the area will cast doubt on the region's long-term future sustainability. They cautioned that unless the rate of tourism expansion in the northern Red Sea was slowed, there would be extensive coral reef deterioration (Hawkins & Roberts, 1996). Their prediction proved correct with vast areas of reef degradation observed in the northern parts of the Red Sea, especially in the Gulf of Suez and the entrance of the Suez Canal.

Several researchers indicated that rapid development in the region has resulted in pollution and environmental degradation. According to Abdallah (2007), the Ain-Sukhna area lies on the northwestern part of the Gulf of Suez and is characterized by the presence of highly sensitive and fragile natural resources, habitats, a wide coastal plain, an extensive tidal flat, and an important coral reef. The rise of tourism activities, the development of Ain-Sukhna port and resorts, and the ensuing increase in population have all contributed to rapid and rising changes in land-use patterns in this area in recent decades. The area is now suffering from environmental contamination and the loss of various natural resources as a result. Abdallah's research aimed to highlight environmental changes from 1984 to 2002 and investigated their effects on the ecology and environment of the Gulf of Suez's coastal zone. He also found that human activities and development initiatives were primarily responsible for significant land-use changes in the area, such as the building of resorts, highways, ports, industrials, and urban sites. He concluded that the newer scope attracts attention towards the arising hazards concerning bio-system, stability of urban and resort buildings, as well as pollution of petrochemical factories (Abdallah, 2007).

Gohar and Kondolf (2020) conducted a systematic comparison between ecotourism and conventional tourism, based on a group of 37 resorts along Egypt's southern Red Sea coast. All resorts were built on similarly oriented plots between the sea and the Red Sea Mountain Range. They evaluated the resorts based on environmental criteria that included swimming pool surface area, distance from mangrove areas, the proximity of flood plains, the amount of grass space, and methods of access to deep water. They concluded that self-identified ecotourism facilities were not considerably different from the regular ones (Gohar & Kondolf, 2020).

Bratucu et al. (2017) conducted a study on sustainable tourist development strategies in Romania's Carpathian Mountains, in which they confirmed that despite the fact that over-development of mountain tourism may lead to environmental degradation and biodiversity loss, mountains and their landscapes are important resources for the tourism sector (Bratucu, et al., 2017). This is confirmed by Malik and Bhat's study (2015) in the Himalayan area, where tourism has both environmental and socioeconomic repercussions, with mountain

tourism in particular being of concern because it is commonly utilized to promote community development while also destroying the environment (Malik & Bhat, 2015).

2. Sukhna Development

This paper studies the chronological development of the region to understand the conditions in the area and the major changes in the natural environment. As suggested by the research of Abdul Rahman et al. (2020), visual surveys were used to observe the interaction between the natural and urban environment, (Abdul Rahman, Ghani, Teh, & Ibrahim, 2020). Through physical and activity mapping, they made field observations to obtain information on the functional characteristics of the real scenes of the place. They discovered that the interaction between the physical environment and the users' actions greatly affected the quality of place and fabric (Abdul Rahman, Ghani, Teh, & Ibrahim, 2020). This paper analyses several examples of major developments in the region and compares their planning, massing, and pattern of development. Satellite photos obtained from Google Earth were used for this analysis.

Sukhna is an important touristic attraction, mainly for Egyptian citizens. Situated approximately 55 kilometers south of Suez City and 120 kilometers east of Cairo, it is a popular tourism destination due to its proximity to the capital Cairo, year-round sunshine, clear water, beautiful sandy beaches, gentle waves, magnificent mountain scenes, and a spectacular scenic drive where the mountains reach the coastal road. Before recent development, it was known as the ideal location for camping and one-day school trips. It enjoys excellent weather all year round. According to weather reports, the average minimum temperature in winter is 7° while the average maximum temperature in summer is 34°. The average annual rainfall is 17 mm. Wind directions are NW, N, and W, with general speeds ranging between 11 and 20 km/hour. The area is famous for coral reefs, rich marine life, and fishing sites that have made this area one of the best scuba diving locations in the world.

Only 60 kilometers south of Sukhna lies Zaafarana, one of the world's premier diving locations that are famous for underwater photography as well as windsurfing and kitesurfing. Desert safaris into the mountains, canyons, and oases are other adventurous attractions. The area is also close to the Suez Canal and several Christian monasteries, including St. Anthony's Monastery and the Monastery of St. Paul, one of the oldest inhabited monasteries in Egypt. The opening of Galala Mountain Road has made access to the area easier and enjoyable. It reaches an elevation of 1,100 meters above sea level. It hosts many native species of animals and plants.

Figure 2. Map of Sinai, Gulf of Suez, and Sukhna–Zaafarana stretch.

As previously stated, Sukhna is the short name of Ain-Sukhna, which means "Hot Spring" in Arabic. It is the location of a hot sulfuric mineral spring that flows from Gebel Ataqa, the Eastern Desert's northernmost mountain, a few kilometers south of the port, which was known for its healing effects on dermatological and rheumatic diseases. Just behind the hot spring lies an archaeological site of an ancient Egyptian port that was used to import copper and sapphire from Sinai and trade with Pont in Africa. Recent archaeological discoveries indicated that the area hosted ports since the time of King Khufu. Hieroglyphic inscriptions were first discovered here in 1999 by Mahmud Abd El Raziq. Since then, archaeological investigations have been carried out here regularly. Some researchers claim that the crossing of the Red Sea at the exodus from Egypt took place at the northern end of the Gulf of Suez, and identify Ayun Moussa across from Ain-Sukhna as the place of crossing. During the Roman and Arab times, the Red Sea was known as al-Qalzam Sea, after a small village called Clysma or Klysma, that existed around the third century BC and was located near today's Suez City. It was a Roman trading port between the Red Sea and the Mediterranean Sea. The area became the

Muslim Qulzum in the 7th century. The Ottomans developed the city, known as Suez, as a major port for trade with Arabia, Yemen, and India. The port later declined until the opening of the Suez Canal in 1869.

The area became popular again during the 1940s as a vacation location accessible by automobiles. Before the 1967 war, the area was known as a fishing, diving, and camping ground. It was also known for its mineral sulfuric springs. It was usually featured in films (such as *Ibn Hamedo 1957*) as virgin and scenic, with sandy and sunny beaches all year long. It was a usual winter day trip for many school children. Between 1967 and 1977, the area was declared a military restricted zone and was closed for civilian activities. It was part of the battlegrounds of the War of Attrition, especially between 1967 and 1970.

Figure 3. Sukhna as depicted in the 1957 film *Ibn Hamedo*.

After the 1973 war, the reopening of the Suez Canal in 1975, and the signing of the peace treaty in 1977, restricted access to the area was lifted, and fishing, diving, and camping activities resumed. Since the late 1970s, the area has witnessed rapid construction of touristic facilities and resorts that produced a negative impact on the fragile natural and cultural heritage. Between 1977 and 1997, early development and projects started with traditional seafood restaurants, small hotels, and touristic villages. The development started at the northern end and extended southward. The first hotel and resorts to appear were Sukhna Hotel, al-Higaz resort and Portrait hotel.

Figure 4. Early touristic resorts and hotels. (Source: Author)

In 2007 Porto Sukhna was launched as a giant development spreading over 2.5 million square meters extending into the mountain up to 270 meters above sea level. Until recently, it was considered the most ambitious residential development to be constructed on the mountain compared to the adjacent La Siesta resort composed of few villas on the mountain. In addition, it offered the first mountaintop golf course overlooking the Red Sea and a mountaintop seafood restaurant and shopping mall. Porto Sukhna was the first major touristic development in Egypt to be built on the mountain, not the beach, that contained international chain restaurants, cafes, shops, games, and other entertainment amenities. A cable car connected the mountain to the beach for the first time in Egypt. The iconic curved wavey-shaped towers - known as the pyramids - caught the attention of travellers and tourists and increased surrounding land value and attraction to the region. The "Porto-style" changed the traditional idea about coastal development and entertainment in Egypt. This type of development was duplicated in many parts of Egypt from the Red Sea to the Northwest Coast and other parts of the country. The Post-Porto style was characterized by extensive development, leisure attractions, colourful facades, expensive materials, exotic shapes, and international styles encouraged by luxurious gated resorts, such as La Vista and Telal.

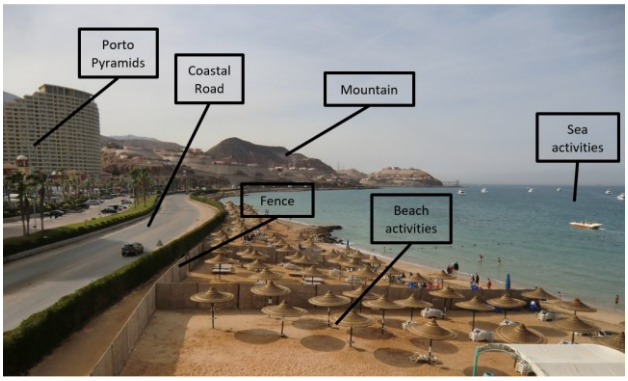

Figure 5. Porto Sukhna beach. (Source: Author)

Figure 6. Post-Porto style (Source: Author).

Recently, development has started on the Galala Mountain Plateau following the construction of Galala Mountain Road. Galala. Galala City contains several developments at different levels from sea level to more than 700 meters above sea level. The Galala Mountain Panoramic Corniche is breathtaking. Galala City is located 700 meters above sea level on the Galala al-Bahariya Mountains between Ain-Sukhna and Zaafarana, covering approximately 19,000 feddans. Galala City is one of several new cities that the government aims to develop in the large Eastern and Western Deserts of Egypt. These new cities aim to attract the population from Cairo and other crowded urban centres by providing investment chances, work opportunities, and better living conditions, especially for the young generation. More than 100 local civil companies have participated in the construction process under the supervision of the Armed Forces Engineering Authority. The project started in January 2014 and provided more than 150,000 job opportunities. The project started with an 82-kilometer mountainous road connecting the Cairo–Sukhna Road and the Zaafarana–Beni Suef Road, integrating the city with major centres in the country. The project creates a new urban community centred around Galala University with housing, services, and employment opportunities for thousands of people. The project accommodates a tourist resort, hotel, and restaurants on the mountaintop enjoying the magnificent scenery. A cable car connects the mountain city with a 1,000-feddan seafront resort containing a hotel, aqua park, yacht marina, and shopping centres. The project is served by water from a desalination plant providing 150,000 cubic meters a day of potable water, and by electricity from a power plant and wind farms. The goal is to create an urban community where Egyptians can enjoy a decent quality of life all year round in this magnificent location.

The Galala City master plan aims to create sustainable, active, mixed-use public transit, new road systems, and public spaces that take into account the existing ecological conditions. The first of the three phases of the city comprise a total of 2,050 acres and includes a variety of activities. Residential districts with the most desirable reasonably priced units, touristic villages, and commercial, cultural, medical, educational, and religious institutions are all included. These institutions are linked to the project's public arena, which houses the convention centre as well as the city's largest mosque. The consultant SITES International office was in charge of the infrastructure that comprised irrigation, sewage treatment plants, massive water tanks, and preparations for solar-powered illumination in public spaces. The city's masterpiece is the breath-taking 6-kilometer mountain plateau corniche walkway, with a drop of 200 meters. In addition to affording fascinating perspectives of the neighbouring residential and tourist settlements, the promenade features vantage points of the Gulf of Suez and neighbouring plateaus, a cycling track, a mix of cafes, restaurants, pedestrian routes, and covered lounging places. As previously mentioned, the mountain city is connected with the seaside Galala Resort by a cable car.

Building materials are acquired from quarries in the Red Sea region, and the landscaping is environmentally friendly. The surrounding ecosystem is protected with minimal changes due to the use of indigenous and semi-indigenous plants, trees, and ground cover palettes, as well as recycled water and an effective water conservation irrigation system.

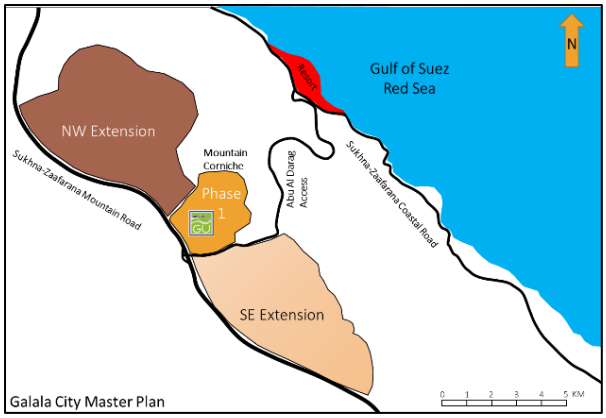

Figure 7. Galala City Master Plan. (Source: Author)

Figure 8. Galala University campus. (Source: Author)

3. Results

This paper investigated the impact of rapid development on the environment in the Sukhna region. It questioned whether this development was sustainable or not. It applied the three aspects of sustainability to analyze the region, namely environment, economy, and equity.

Environmentally, the rapid development affected land, sea, and air quality. The natural environment has been radically modified. The mountains are being terraced for development. The debris of these excavations is thrown to the sides of the mountains and will create hazards during heavy rains due to unpredictable changes in rain flood paths. Seawater is polluted by garbage discarded by big and small boats. This and other beach activities damage the coral and other marine life. Heavy truck traffic is damaging the zigzag coastal roads. Many accidents occur due to reckless driving and narrow road. It is very difficult to widen the road due to the adjacent mountain ridge and the coast.

The built environment touristic resorts are occupying hazardous locations in floodplains along the coast. Many structures are located in the path of flash floods. The architecture of all the buildings does not consider the natural environment in terms of building orientation, openings, materials, or passive cooling systems. Almost all units depend on air conditioners. The landscape design of the residential gated communities applies an English-style landscape of large green lawns and plants that require large amounts of water from irrigation. Whether this water is recycled or not, huge amounts of freshwater are being injected into the ground with unforeseen consequences. The area suffers from irregular construction activities, abandoned buildings and structures of the early development, and informal fish sales kiosks and restaurants scattered along the coastal road.

Economically, investments in Sukhna are affected by environmental hazards. The high levels of investment have a low rate of return and utilization. The high cost of maintenance of luxurious resorts will increase over time. Villas and chalets are used as a weekend house for only a few days every year. The type of architecture and investment is not supported by permanent work opportunities. Recently the establishment of Sukhna Port, Galala University, and heavy industries has encouraged people to live in the area for extended periods. Yet the running cost of this type of housing and touristic facilities is high, due to water shortage and a large number of swimming pools and gardens, and high energy consumption for continuous air-conditioning due to the lack of passive cooling and sun protection. The landscape is consuming too much water and requires continuous maintenance.

The economy of the region depends on the availability of assistance workers to provide services in shops, housekeeping, restaurants, etc. There is no consideration of the needs of these low-income groups. There are no bus terminals or transportation hubs to serve their needs. There are no proper accommodation alternatives for them. There are no public beaches for ordinary people to enjoy. Most beaches are appropriated by gated

communities. In the past, people used to visit this place for day use. Now there is no place for low-income people or non-owners to enjoy the region. No proper housing or accommodation is provided for the limited-income strata of the population.

4. Discussions

This paper proposes a Sustainable Tourism Development Model to study the current problems in the region and propose solutions and approaches to any new development. The model is defined as development that improves the environment, economy, and quality of life of the inhabitants of the region while providing a significant experience for tourists and visitors. The framework covers four dimensions: natural, built, human, and economic.

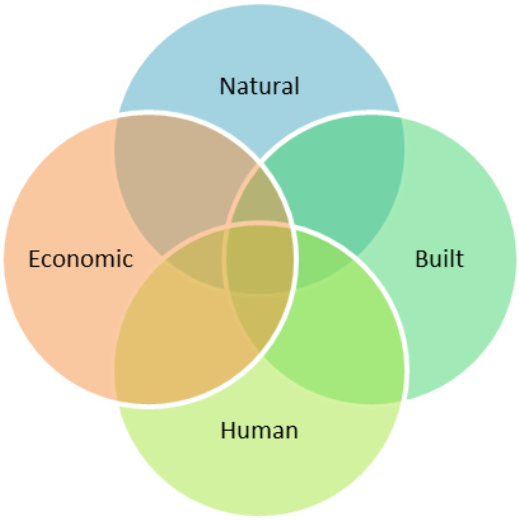

Figure 9. The Sustainable Tourism Development Model.

a). Natural Environment Sustainability

- Protect nature and the coastal area for future generations. Declare parts of the coast as UNESCO Heritage sites.
- Trucks are crowding the coastal road and causing traffic hazards, air pollution, and noise. They should be prohibited from this coastal road during daytime and allowed only during specific nighttime.
- Restore and renovate the original site of the hot spring (Ain-Sukhna). Currently, the Sukhna water spring is surrounded by a fence and is not accessible. The hot spring has great potential to initiate health tourism activities. A health resort and a wellness centre can be established there.
- Study environmental hazards of flash flooding and landslides.

Figure 10. Example of the potential hazard of flash floods.

b). Built Environment Sustainability

- Enforce existing building laws of setback from sea line and buildings.
- Establish guidelines for planning and architectural design to achieve sustainability. Current buildings do not consider the environment; they are mainly commercial consumption and stylistic statements.
- Provide beaches and fishing piers for public use. Resorts constructed on the mountain are claiming the beaches by building fences around them for their exclusive use.
- Apply sustainability and ecotourism strategies to all facilities and attractions.
- Develop building guidelines to use materials, colors, and shapes to give the area a distinctive identity and style.
- Develop sustainable guidelines, to be implemented by current and future developments, that include urban and architecture guidelines, water and electricity conservation, materials and methods of construction, design guidelines, passive energy conservation, application of sustainability assessment, application of Environmental Impact Assessment certification that is renewable every five years.
- Design buildings to withstand the impacts of climate change. Increased number or intensity of weather events increases the requirement for resilient buildings.

Figure 11. Resort buildings footprint examples.

c). Human-Environment Sustainability

- Provide accessibility for different economic and social groups to public beaches and facilities. People who do not have permanent accommodation or who cannot afford to rent should be provided with open beaches and facilities such as changing rooms, toilets, and showers. Those who are interested in fishing should be provided with fishing piers with affordable entry fees. Providing public access to public beaches will achieve equity between all citizens of Egypt from different economic levels.
- High-income tourists' facilities require a workforce (servants, drivers, housekeepers, gardeners, salespersons, etc.) who require means of transportation. Many workers stay temporarily in Sukhna during the weekdays and go to their hometowns during the weekends or monthly vacations. There is no proper transportation hub to serve their needs. The informal bus stops in front of McDonald's are causing traffic jams and safety hazards for pedestrians.
- The location of the informal bus parking area is very dangerous for the users. They have to cross the busy coastal road back and forth. Bridges or speed humps should be provided.

d). Economic Sustainability

- Consider alternative means of investment to replace the very low rates of use. Many owners do not use these assets efficiently, coming only a few days a month or year because of their time restrictions and places of residence. Providing more work opportunities like Galala University, industrial, trading, and oil facilities will increase the use of these assets through renting or use by students and university employees.

5. Conclusions

The study of the development of the Sukhna–Zaafarana stretch reveals several challenges related to the preservation of the nature of the coastal road. The first challenge is to conserve the unique and sensitive natural and cultural resources, notably the coastal zone. The coastal road is being dramatically modified to provide more areas for development along the beach, especially for gated communities and resorts. The nature of the mountains and the coastal road is being eroded rapidly and replaced by planned and constructed roads. Permanent construction of high walls and land infill of sea beaches is destroying marine life and causing coral reef degradation. The area suffers from heavy truck traffic along the coastal road, causing air, land, visual, and noise pollution and deteriorating the original site attractions. We need to fully understand that this type of development near a fragile environment has dangers and hazards, which have been experienced by other countries before. The area is mainly used by local tourists, not international tourists. This is similar to the development in the Northwest Coast of Egypt. The study revealed that the characteristics of the destination's carrying capacity and the resident community quality of life should be kept in mind, along with the visitors' experiences. Similar to the Sinai Peninsula, the Sukhna–Zaafarana stretch suffers from unexpected heavy rainfall and severe weather conditions as major causes of many flash floods (ElAfandi & Morsy, 2020). There should be continuous monitoring of the environmental and urban changes in the region and their mutual impact. An Environment and Development Observatory is being established at Galala University, utilizing its specializations and facilities, especially the Geoinformatics laboratory, to continuously monitor these changes and issue a regular newsletter of the region's status and potential hazards. This area is of paramount importance for the Egyptian economy due to its proximity to Cairo and the New Administrative Capital. Its protection through continuous assessment of environmental changes and hazards would prevent significant loss of lives and assets. In order to prevent or reduce flash flood

tragedies, accurate rainfall forecasting is essential.

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Conflict of interests
The author declares no conflict of interest.

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Original scientific paper

Sustainable Construction for Affordable Housing Program in Kabul

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ABSTRACT

Afghanistan has suffered from four decades of war, causing a massive migration of the rural population to the cities. Kabul was originally designed for 1,5 million people, whereas there are now 5 million in the city. The importation of modern western styles housing for rapid reconstruction reveals apparent cultural conflict and a significant environmental footprint. The new drive for sustainable reconstruction should consider the use of local materials combined with modern technologies. Earthen architecture underlies the embodiment of Afghan architecture. This research aims to revisit traditional Afghan earthen construction with the tools of industrial modernity. The three soils of the Kabul region are first characterized. Sun-dried mud brick and compressive earth block, with and without stabilization have been prepared and tested in the laboratory to develop the most suitable earth construction element which is cost-effective and easily available compared to imported modern products.

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1. Introduction

Earth has been used for thousands of years and predates any other construction material. Even now, a large number of people live in earth made buildings, especially in developing countries. Currently, 30-40 % of the population live in earth made houses and this accounts for 50% in developing countries (Miccoli et al., 2014; Minke, 2009). In Afghanistan, raw soil is the main construction material and most people live in dwellings made with earth (Figure 1b). Every ethnic group uses a particular form and tradition for making shelters.

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Therefore, there is no uniform national architecture in the country, every region has its unique architecture based on the available local materials and techniques. The use of natural and local materials produces a real balance between people and their environment and created a rich form of architecture in the country (Szabo & Barfield, 1991). The main construction materials for houses are sun-dried brick and Cob, locally known as *Pakhsa*, wood and stone lying with clay mortar on a shallow stone foundation. These methods are locally available and traditionally used for centuries because they have passed through generations.

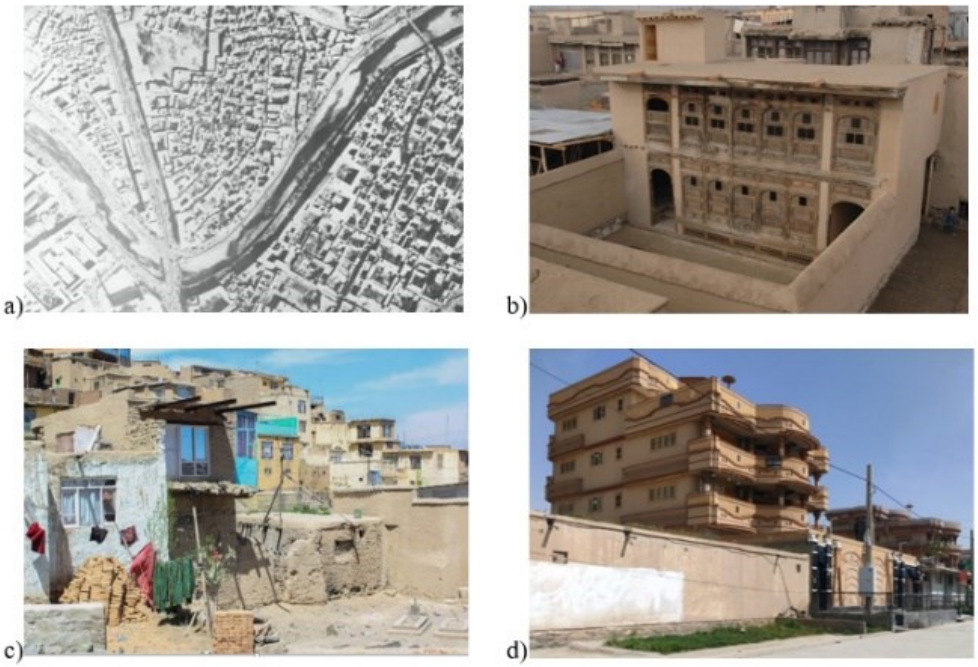

Figure 1. Traditional and modern housing form in Kabul: a) Murad Khani residential neighbourhood of the historic city, b) Traditional inner courtyard mud housing, c) Informal housing, d) New form of modern style urbanisation.

During the four decades of war and instability in Afghanistan, many people moved and are moving to big cities where they can find relatively better security, job opportunity and education for their children. Kabul is one of those cities, where the population has grown very rapidly. Those displaced people need shelter to stay and live. Lack of accessibility to housing in urban areas has caused people to live in cheap informal settlements. The big majority of the urban population (70%) live in slums, which in some areas have resulted in overpopulation, low quality of life and large socioeconomic gaps amongst Afghans. In slum areas, houses are built with sun-dried brick and *Pakhsa* (Figure 1c), however, if they can afford it, people prefer building with a concrete structure with fired bricks. Self-made construction and the lack of experience makes the slum houses vulnerable to environmental hazards and seismic activity. Moreover, for many Afghans, today earth architecture is unpleasant and refers to the image of poverty. The idea that earth architecture is for poor people and low-cost housing (Minke, 2009) still dominates the housing sector in Afghanistan.

This research aims to develop an applicable model for affordable housing using modern earth architecture in Kabul city. The use of local materials and modern methods can help the mass construction of residential housing. The research is designed in two stages: the first step (this paper), includes a selection of soil and a selection of earthen elements. In the second step, an architectural model based on housing units, and their variations will be developed (not discussed in this study). This architectural model will be based on an assembly of inner courtyard house typologies that respect the social and cultural values of Afghan vernacular architecture (Sansen et al., 2021). For the selection of soil, three soils from various areas within Kabul city have been chosen. Then, X-ray diffraction analysis was performed to know the petrography of the three soils. Atterberg limits tests were carried out to understand the suitability of the soils for earth construction and finally, a standard proctor test was performed

to find the percentage of water versus maximum dry density for each of the three soils. For the selection of earthen elements, sun-dried bricks, compressed earth blocks (CEB) and compressed stabilized earth blocks (CSEB) were produced. The compressive strength at 28 days and the thermal properties of those earth elements have been tested and analysed. Finally, based on those analyses, the most suitable earthen element for affordable housing in Kabul city is selected.

2. Traditional and modern housing program in Kabul city

2.1 Traditional housing

The use of local natural materials has produced a real balance between people and their environment. In traditional Afghan architecture, the type of housing that perfectly fits the distinct social and cultural needs is the inner courtyard house (Figure 1b). With different typologies, courtyard houses create a typical urban fabric (Figure 1a) of traditional Afghan cities with high density (Kazimee, 2006). Volumetric features and orientation play a major role in traditional Afghan architecture (Fazeel Hosham & Kubota, 2019). In a morphological study of Murad Khani residential neighbourhood in Kabul old city (Ebrahimi & Devillers, 2022), the northern part, the best preserved of the district, shows that most of the houses are accessible by narrow alleys oriented east/west and in some areas covered with second story habitats, they are served by main streets oriented north/south (Figure 2). A study of traditional housing in Kabul old city has shown that the broadest courtyards are not only associated with the largest houses but are related to the height of the volume on the south side of the house. The ratio of the height on the south side to the north/south width of the courtyard is close to two thirds (Najimi, 2016). This ratio is very close to the height of the sun at noon during the winter solstice (Figure 2). The penetration of the winter sun at the ground level of the courtyard is probably related to the altitude of Kabul which conditions the amounts of snow received during the winter period. This allows keeping a part of the yard without snow. Winters in Kabul are often severe and storms usually come from the north or north-west and are blocked by the massive north wall.

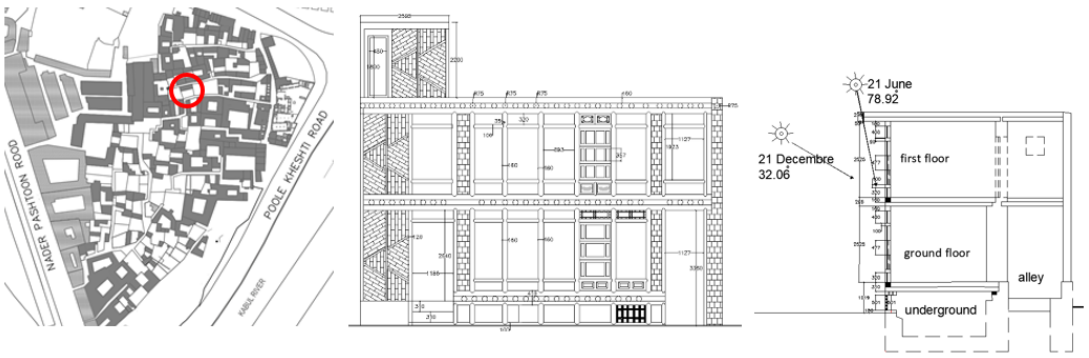

Figure 2. Peacock house, in Murad Khani residential neighbourhood. From left to right, Murad Khani layout, timber frame with mud-brick infill, bioclimatic cross-section.

These characteristics can be found in Peacock House (Figure 2), whose north wall is built from sun-dried brick (70 cm thickness on ground level and 40 cm on the first floor). All other walls of the house with a thickness of about 30 cm are composed of a rough timber frame with mud earth-brick infill and earth-straw plaster (Ebrahimi & Devillers, 2022). The perimeter walls of the courtyard are made with *paksha* and have an average thickness of 40 cm. Afghans still follow the traditional way of life in large extended families. Traditionally, Afghans sleep in shared rooms, parents with their children. This form of housing is consistent with a spatial and social organization, which proposes a harmony between the constructed form and the traditional Afghan culture. Many families practise seasonal nomadism with winter rooms to benefit from sunlight for heating and summer rooms with natural ventilation to look for freshness. Therefore, we can see a passive design in indigenous architecture.

2.2 Modern housing

The development of modern architecture in Kabul city started during the 1930s. The city extended beyond Kabul old city. This urban expansion depended on demographical

change and economic growth. Further, the city grew during the 1950 and 1960s when the Soviet Union and the USA economically help Afghanistan to develop the country (Najimi, 2011). During this time, the government wanted to change the image of Kabul from a backward to a modern urbanised city. In some parts of Kabul old city, existing roads were widened and new roads were driven inside the existing historic neighbourhood (Najimi, 2016).

More recently, the economy has developed rapidly, with money pumped into Afghanistan. In 2001, when the US Army defeated the Taliban regime and seized control of the Afghanistan government, new and modern materials were introduced into the construction industry as a demand by foreign clients, troops and international organisations to build military bases, public structures and housing. Concrete structures, glass facades, various types of thermal insulation and electrical equipment were imported to the country. Moreover, this economic boom in Kabul city has resulted in rapid population growth and greatly raised housing demand. The newly established government's inability to provide housing increased informal settlements in various parts of the city (Figure 1c). The United Nations Human Settlements Programme has said that in Kabul, 70% of the urban populations live in slum areas. Between 2002 and 2012 in Kabul, 85 townships have been built (Nazire et al., 2016). During the last twenty years, the growth of informal settlements together with the townships in the city changed the Kabul view into something unrecognizable. Kouki Mojadidi, an American/Afghan architect, thinks that two factors severely affected the urban fabric of today's Kabul:

- first, change in land value and ownership. The new landowners were disconnected from the traditional architecture of Kabul and constructed buildings with a new foreign vision to get more space and profits by renting and selling them,
- the second aspect was the high hope for a new Afghanistan and the end of the long years of war in the country. Afghans came back from abroad which raised a demand for homes in the suburban area of Kabul.

However, Afghan's construction industry was not able to adapt itself to the new market and as a result construction companies from outside the country have benefitted and migrated to Kabul. Pakistani companies took the most benefits and won a big portion of the new construction opportunities. In addition to the public infrastructure and buildings, they made residential houses with reinforced concrete structures (Figure 1d). Modern houses, without added insulation nor connection to central heating, require more energy compared to traditional houses. As in many other countries (Arenibafo, 2017), with this new form of modern style urbanisation, the cultural value of housing in Kabul city is deteriorating. Therefore, traditional earth architecture should play a role in the rapid urbanisation of Kabul city. Contradicting many developing countries with uncertain and fragmented experiences of social life, Afghans traditional housing pattern as a means of the physical, special and social organisation aligned with the Afghan culture.

3. Soil characterisation

Though the soil is available everywhere, raw soil is not necessarily suitable for construction. Factors such as mineralogy, texture, plasticity and linear shrinkage affect the suitability of soil for construction. Therefore, to find suitable soil for earthen architecture in Kabul, XRD analysis, sieve analysis, Atterberg limits and standard Proctor test have been performed on three soils of Kabul province.

3.1 Soil location, petrography and XRD analysis

In Kabul, there are many places where soil for construction purposes exists. For this study, three sites located in Kabul province were selected (Figure 3):

- Deh-Sabz district to the north of Kabul,
- Arghandi in Paghman district,
- Band-e-Ghazi in Surobi district.

Currently, in Kabul city, the fired bricks came majority from Deh-Sabz and Arghandi districts and it is believed that those districts have good quality soil. Dozens of small companies exist in which fired bricks are traditionally made from sun-dried bricks. Band-e-Ghazi's sandy soil is mostly used for road and pedestrians base course construction. Moreover, a study of Kabul geology shows a good combination of minerals from different ages. A variation of rocks and sedimentation exists (Figure 3). The three studied areas selected for this study,

marked red in figure 3, have the following mineralogy:

- In the Deh-Sabz district, we can find Q3a and Q3loe soils, from the late Pleistocene period. They contain loess, conglomerates and sandstone, shingly and detrital sediments. Gravel and sand are more abundant on the north side of the area close to the mountains,
- In Arghandi, south part of Paghman district, K1gbm and Q3loe soils, from respectively early Cretaceous and late Pleistocene periods. They contain gabbro, monzonite more abundant than diorite and granodiorite. Loess is more abundant than sand and clay,
- In Band-e-Ghazi, south of Sorobi district, N2cgs and P2um soils from Pliocene and Palaeocene periods. They contain conglomerate and sandstone more abundant than siltstone, clay, limestone, marl, gypsum, salt, felsic, mafic, shale and volcanic rocks.

X-ray diffraction analysis was performed on a BRUKER Advance D8 diffractometer in a θ– θ configuration using CuKα radiation (λ = 1.54 Å) for the three soils. The diffractograms were recorded between 2° and 55° with the Lynxeye detector and are showed figure 3. The duration of a recording is 3 hours. The qualitative analysis was carried out with the software X'Pert HighScore Plus 2.2. The diffractograms mainly present calcite and quartz. A separation of the fraction less than 2 µm to highlight the clay part was carried out. The presence of chlorite and muscovite was observed. Moreover, the presence of chlorite in the sample was confirmed by heating treatment. The petrography of the three soils is quite similar.

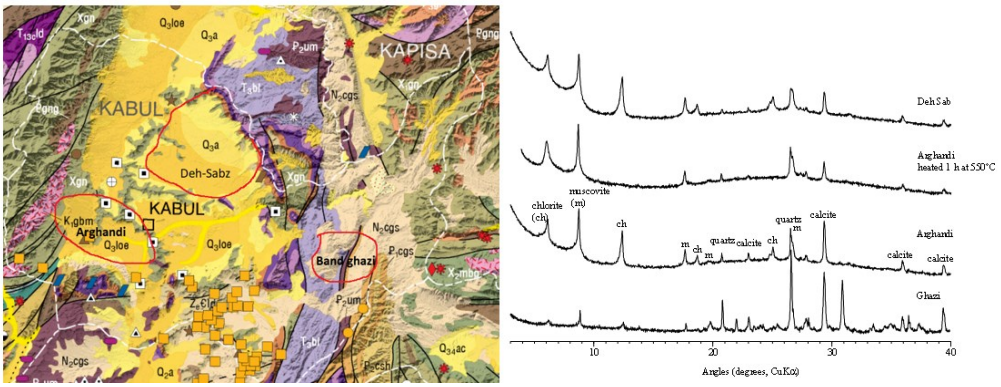

Figure 3. Geological map of Kabul region with the three selected soils locations and X-ray diffraction analysis.

3.2 Soil location, petrography and XRD analysis

To find out the particle size distribution of the soils, wet sieve analyses according to ASTM C136 (2006) was performed. First, one kilogram of oven-dried soil was washed in a 75 µm sieve. The passing fraction of this first step led to access to the quantity of clay (particles less than 2 µm in diameter) and silt (between 2 µm and 75 µm). The results of this first step show that the clay and silt content is high for Deh-Sabz and Arghandi soils at 98,0% and 93,7% respectively (Figure 4). For Band-e-Ghazi soil, this percentage is only 31,2% (Figure 4). Then, the reject fraction on a 75 µm sieve was oven-dried and sieved to find the fraction of sand (between 75 µm and 2 mm) and the fraction of gravel (more than 2 mm). The results of this second step show that sand content is really low for Deh-Sabz and Arghandi soils; 5,1% and 0,4 % respectively (Figure 4). For Band-e-Ghazi soil, this percentage is 29,7% (Figure 4). Gravel content is really low for Deh-Sabz and Arghandi soils, 1,2% and 1,4 % respectively (Figure 4), while for Band-e-Ghazi soil gravel content is high with a percentage of 39,1% and a maximum particle diameter of 19 mm. Finally, Band-e-Ghazi soil appears to be a well-graded soil, while Deh-Sabz and Arghandi soils are uniformly graded fine-grained soils.

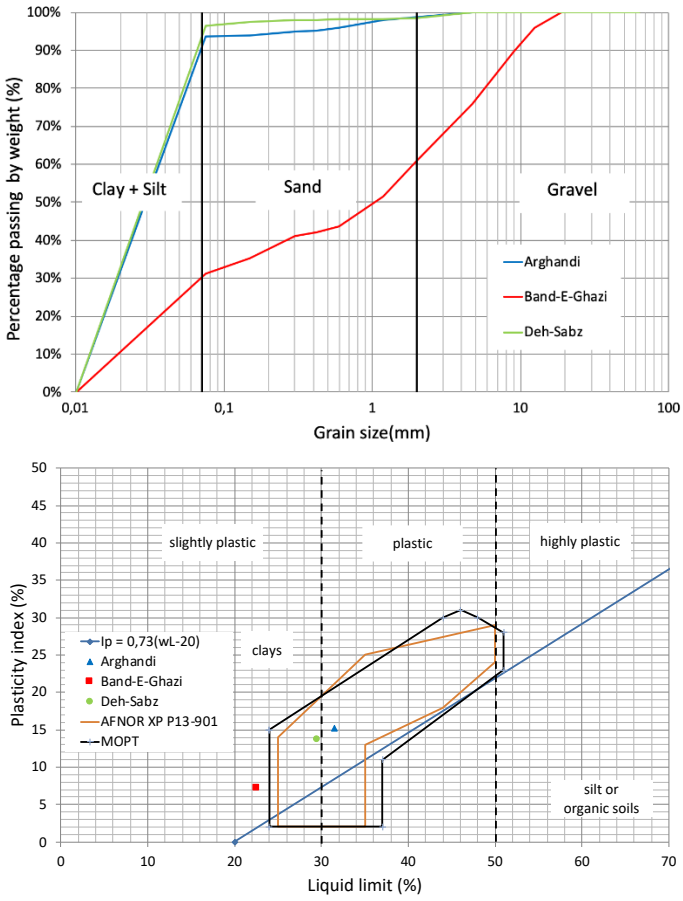

Figure 4. Wet sieve analysis for the three soils and soil suitability analysis based on Atterberg limits.

3.3 Soil suitability analysis

The Atterberg limits are geotechnical parameters intended to identify a soil and characterize its state using its consistency indexes. The Atterberg limits consist of estimating the extent of the range of plasticity and possibly of cohesion of the silty clayey soils. The plasticity index is used to understand the soil through a value indicating the extent to which clay particles are present in a material. The determination of the plasticity index is based on the consistency limits also called Atterberg limits. These are the water content to which material passes from solid to plastic and then from plastic to liquid. The tests have been performed on the soil fraction passing a 425 µm test sieve following ASTM D 4318 (2010). The results are given in figure 4. With a plasticity index between 7.2 and 15.3, all three soils may be qualified as slightly plastic. For Deh-Sabz and Arghandi soils, the liquid limit may be qualified as a medium. For Band-e-Ghazi soil liquid limit may be qualified as weak. AFNOR XP P13-901 (2001) and MOPT (2012) standard codes developed a boundary polygon to find the soil suitability for earth construction (Figure 4). Based on those definitions, test results indicate that Deh-Sabz and Arghandi soils are suitable for earth construction, while Band-e-Ghazi is located very close but outside of the boundary polygon. This is due to the weak liquid limit of Band-e-Ghazi soil. This result does not exclude this soil because previous studies showed that soil outside the polygon may be good for earth construction, like Lattes soil used by the Romans to build their house in the Lattara archaeological site. (Accetta, 2003)

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3.4 Standard proctor test

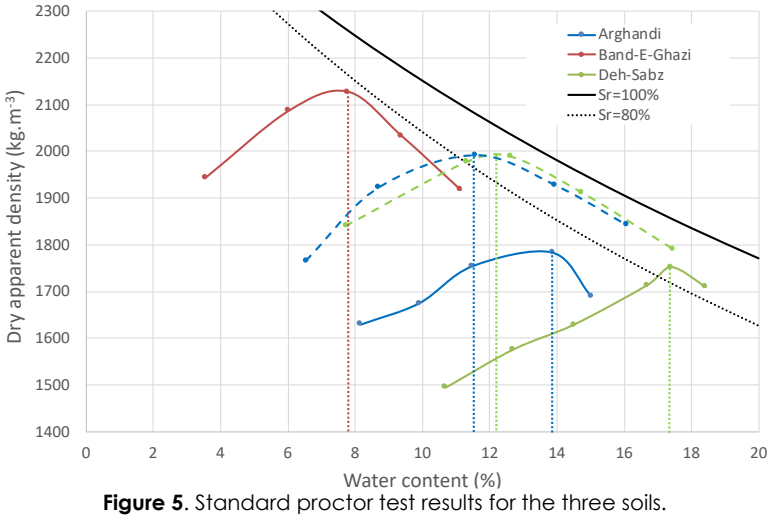

Figure 5. Standard proctor test results for the three soils.

For earth like many others materials, the dry compressive strength is linked to the dry apparent density. For Compressive Earth Blocks, to maximize the compressive strength, the manufacturing water content is usually close to the optimum water content of the soil. A standard proctor test, based on American society for testing and material (2012), was performed for the three soils on the soil fraction passing a 10 mm test sieve. For the manufacturing of the Compressive Stabilized Earth Blocks, Burroughs (2008) argues that good soil for cement stabilization should contain between 21% and 35% of silt and clay. Band-e-Ghazi silt and clay content are located in this range. For Deh-Sabz and Arghandi soils, it is not the case. Therefore, a reconstituted mixture has been prepared with 75% of river sand (less than 2 mm) and 25% of soil. Tests on these two reconstituted soils have also been performed. The results (Figure 5) show that Band-e-ghazi soil has the maximum dry apparent density and minimum optimum water content (8%), while the two other soils have quite similar dry density, but variations in optimum water contents (Arghandi 13% and Deh-Sabz 17%). These results may be explained by the texture and the mineralogy of the soils: the more the particles are fine (clay and silt), the more water will be required to reach the optimum water content. The higher dry density at optimum water content for Band-e-Ghazi soil may be explained by a well-graded size distribution, allowing better compactness of the mixture, in contrast with Deh-Sabz and Arghandi soils. Dashed blue and green lines in figure 5 present results for reconstituted soils. The reconstituted soils have better dry apparent density than the original soils. The reconstitution procedure improves, indeed, the compactness of the mixture. The optimum water content of the reconstituted soils is closed to 12% and weaker than that of the original soils.

4. Confection of earth construction elements

4.1 Mix design and production

Figure 6. Production of earthen elements: from left to right, sun-dried brick, CEB, CEB extruded from the mould.

For the sun-dried bricks, the raw soil has been used and water content determined based on experience (Table. 1). The sun-dried bricks were made using a traditional handmade mould measuring 200mmx100mmx100mm (Figure 6). 24 hours after de-moulding, the bricks were placed in a dry place (top-down) to get dry. Because small particles cause flocs, for Compressive Earth Blocks and Compressive Stabilized Earth blocks, the soil was first sieved through a 10 mm mesh. The cement content represents 10% of the dry granular mixture for Deh-Sabz and Arghandi soils and 9% for Band-e-Ghazi soil (Table.1). The water content has been chosen close to the dry side of the optimum water content determined by the proctor test (Table. 1). The wet mixture is then compacted into blocks measuring 300mmx155mmx100mm using a manual hand-operated constant volume block machine (Figure 6). The study is limited to manual block press because this type of machine is the most used and in Afghanistan, the labour supply is not lacking. The manual block press used develops compaction pressures between 2 and 4 MPa. After compaction, the blocks were immediately removed from the mould (Figure 6) and carefully stacked for curing. Compressive Earth Blocks were air-dried in the laboratory before tests. Compressive Stabilized Earth blocks were moist cured for three weeks. During the first week, water was sprayed on the blocks on a daily basis. During the two following weeks, they were stacked under plastic sheets to keep humidity for cement hydration (Walker, 2004). Finally, in the fourth week, they were air-dried in the laboratory before the test.

Table 1. Mixture proportion for sun-dried brick, CEB and CSEB (for 1 m³).

	Sun-dried bricks			**Compressive Earth Blocks**			**Compressive Stabilized Earth Blocks**		
	Arghandi	Band-e-Ghazi	Deh-Sabz	Arghandi	Band-e-Ghazi	Deh-Sabz	Arghandi	Band-e-Ghazi	Deh-Sabz
Silt and clay (kg)	1590	600	1606	1718	614	1824	445	613	441
Sand (kg)	107	1322	31	116	1352	37	1337	1349	1327
Cement (kg)	0	0	0	0	0	0	198	196	197
Water (kg)	441	317	524	238	157	298	247	186	245
Water content (%)	26.0%	16.5%	32.0%	13.0%	8.0%	16.0%	12.5%	8.6%	12.5%
Total (kg)	2138	2239	2162	2072	2124	2158	2228	2345	2210

4.2 Dry compressive strength

For the compressive strength, a testing procedure developed for fired brick by the British standard institute (1985) was followed. All earth elements were tested after 28 days. Before testing, the samples were weighed and measured to calculate the dry apparent density. They were capped on both sides with 3 mm thin sheets of plywood for better distribution of load (Walker, 2004). The specimens were tested using a semi-automatic ADR-2000 BS concrete cube testing machine with a loading speed of around 2 MPa/min until failure. For Deh-Sabz and Arghandi soils dry apparent density of CSEB is higher than that of CEB which itself is higher than that of sun-dried bricks. For Band-e-Ghazi soil dry apparent density of CEB is higher than that of CSEB which itself is higher than that of sun-dried bricks. There is a good correlation between dry compressive strength and dry density for Deh-Sabz and Arghandi soils (Figure 7). Whatever the earthen element is considered (sun-dried brick, compressive earth block or compressive stabilized earth block), elements made with Deh-Sabz soil have better compressive strength and, elements made with Band-e-Ghazi soil have the weaker compressive strength (Figure 7). This last soil will not be selected. The compressive strength of Deh-Sabz sun-dried bricks is 7% higher than that of Arghandi sun-dried bricks and for Compressive Earth Blocks, the Deh-Sabz compressive strength is 24% higher than that of Arghandi. Whatever the soil is considered, the compressive strength of CSEB is higher than that of CEB which itself is higher than that of sun-dried bricks. All the compressive strengths measured are higher than 2 MPa, which constitutes a good criterion for earth construction (Burroughs, 2008).

CEB compressive strength is higher than that of sun-dried brick which demonstrates the interest

in using the modern method for earth construction in Afghanistan (81% for Argandhi, 109% for Deh-Sabz and 67% for Band-e-Ghazi). These values are much higher than that found in the literature, for example, Nshimiyimana et al. (2020) obtained 1,1 MPa for CEB made with kaolinite-rich earthen material (plasticity index 20, liquid limit 50) available in the vicinity of Ouagadougou, Burkina Faso. These good results may be explained by the fineness of the soils used, leading to an increase in the capillary force intensity (Ouellet-Plamondon & Habert, 2016). These results show that stabilization of raw earth can be achieved by mechanical compaction using relatively low pressure.

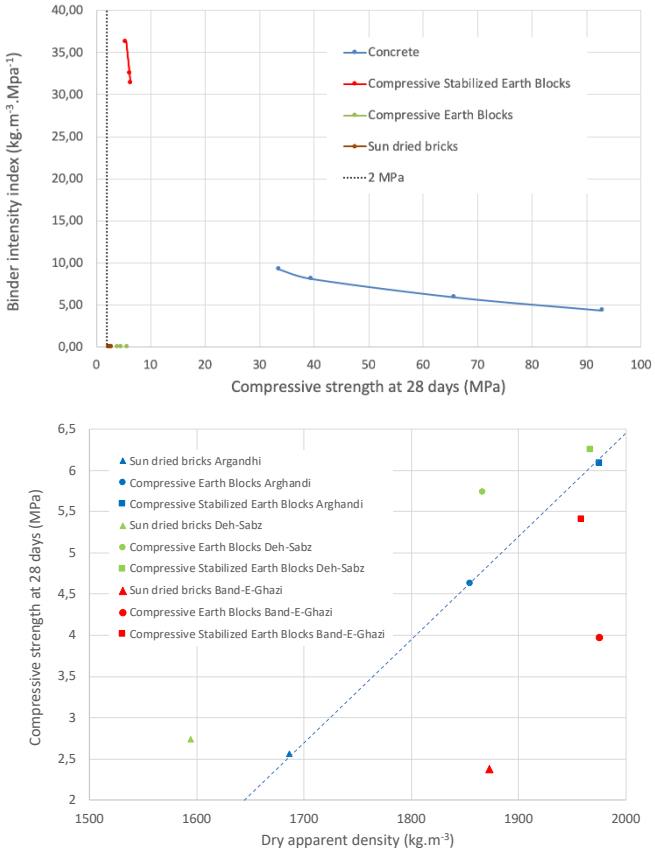

Figure 7. Compressive strength versus dry density and binder intensity index versus compressive strength.

4.3 Binder intensity index

To better understand the efficiency of soil stabilization and its environmental impact in relation to the compressive strength it gains in mechanical performance, the binder intensity index b_i was analysed (Figure 7). This index introduced by Damineli et al. (2010) expresses the total consumption in the binder in obtaining material of compressive strength s: $b_i = c/s$. Therefore, for the question «how much cement do I need to gain a 1 MPa compressive strength? » the answer is the b_i index. The points in figure 7 represent the value for binder intensity index for sun-dried brick, CEB, CSEB and different concrete. In this graph, the good values for the index are small values. This figure shows that the most efficient way to use cement is in high-performance concrete where compressive strength is higher than 60 MPa. The red curve in figure 7, corresponding to CSEB results, shows that the stabilization of the earth with cement is an inefficient way to use cement. The binder index of sun-dried bricks and CEB is equal to zero since they only used raw soil and water for fabrication. The finding of this analysis suggests that stabilization of raw soil with Portland cement is not advisable. It consumes a large volume of the binder while it provides weak compressive strength. Compressive Stabilized Earth Blocks are not a good alternative for sustainable affordable housing in Kabul.

4.4 Thermal properties

Kabul has a semi-arid climate with cold winters and warm summers. Earth made houses with a high thermal mass structure are efficient in creating a comfortable indoor environment

during both seasons. However, there is a need for energy during all seasons in Kabul city, but there is more energy demand during winter compared to summer. For this reason, the thermal properties of the elements made from the three soils were analysed.

Unfortunately, like other properties of earthen elements, the thermal properties of bricks and blocks are not studied in Afghanistan. All the experiments in this research were performed in a machine at Herat University, the only one in Afghanistan (ISOMET Model 2104, heat transfer analyser). It is a portable measuring instrument with surface and needle probes for direct measurement of thermo-physical properties of a wide range of isotropic materials. The surface probe needs a minimum of 60 mm diameter flat surface, minimum thickness requirement is 10-15 mm. Dry samples, aged for three months, of sun-dried brick, CEB and CSEB were tested. The results of these measures are given in figure 8. Dashed green and blue lines are the mean thermal conductivity for Deh-Sabz and Arghandi elements.

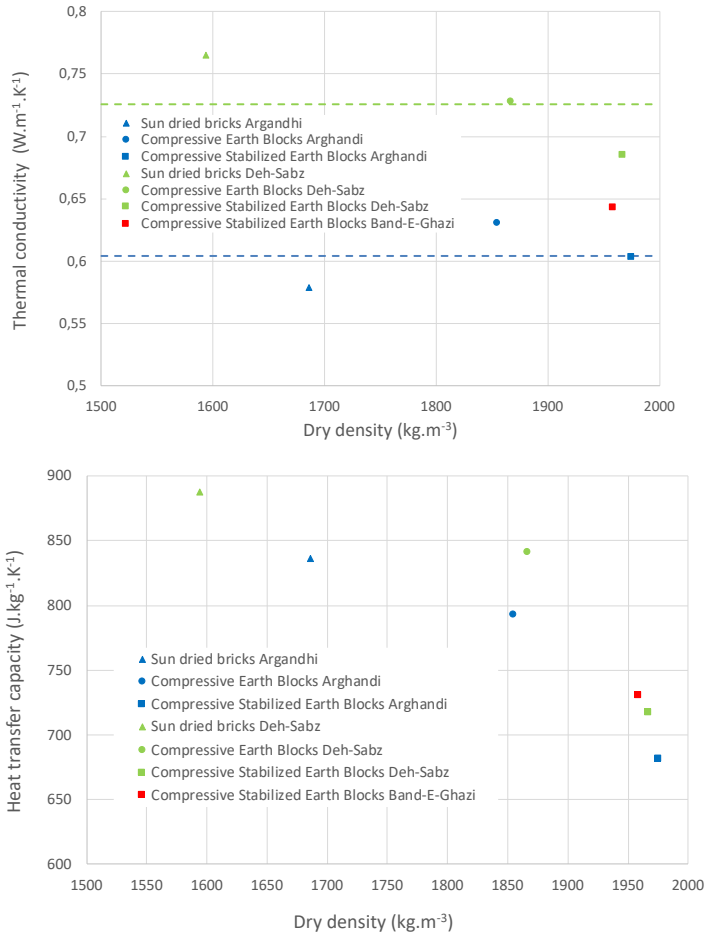

Figure 8. Thermal conductivity and heat transfer capacity versus dry density.

Although dry density increases, the addition of cement caused a small reduction of the thermal conductivity for Deh-Sabz and Arghandi elements (Figure 8). Arghandi earthen elements have the lowest thermal conductivity and Deh-Sabz earthen elements have the highest thermal conductivity, especially for sun-dried brick. The mean thermal conductivity of the Deh-Sabz earthen element is 20% higher than that of the Argandhi earthen elements and twenty times higher than the thermal conductivity of glass wool insulation. The difference in mineral composition of the two soils generates a distinction in thermal conductivity. For sun-dried bricks with different mud to sand ratios (100/0, 95/5, 80,20), Singh et al. (2019) have obtained thermal conductivity ranging from 0,61 to 0,92 $W.m^{-1}.K^{-1}$. These values are in accordance with those obtained in this study. For adobe employed in Peruvian rural areas, Abanto et al. (2017) obtained values of thermal conductivity ranging from 0,26 to 0,33 $W.m^{-1}.K^{-1}$ with bulk density ranging from 1617 kg/m^3 to

1718 kg/m^3. These low values, with values of bulk density identical to this study, may be explained by the use of short strips of wheat and barley dry straw in an amount equivalent to one-fifth of the mud volume. Indeed, straw with a kind of tubular structure can hugely increase the porosity of the composite materials. Therefore, there will be a need for insulation in Kabul affordable housing design. A prefabricated panel from a mixture of clay and wheat straw should be developed and applied for insulation purposes.

Soil has good volume heat capacity and the ability to damp and delay thermal conduction and external temperature flow to the interior (Houben & Guillaud, 2014). Figure 8 shows that there is a good correlation between the three soils specific heat transfer capacity and dry apparent density. As the dry density increases the specific heat transfer capacity decreases. This decrease is more significant when cement is used for stabilization. The bulk density has a significant effect on the specific heat transfer capacity of earthen elements. Increasing bulk density results in a reduction in porosity, thereby increasing the specific heat transfer capacity values. This can be explained by considering a two-phase composite consisting of solids and air where the air has a relatively low specific heat transfer capacity compared to soil and cement materials (Zhang et al., 2017). Whatever the earthen element is considered (sun-dried brick, compressive earth block or compressive stabilized earth block), elements made with Deh-Sabz soil have an average specific heat transfer capacity 6% higher than that of elements made with Arghandi soil. Nshimiyimana et al. (2020) obtained a value of heat transfer capacity of 899 J.K^{-1}.kg^{-1} for CEB with a dry density of 1801 kg/m^3.

5. Conclusion

The sustainable design for affordable housing in Kabul should necessarily learn from the past to invest in local identity. The importation of western-style housing reveals an apparent cultural conflict and significant environmental issues. Earthen architecture with modern methods provides a reasonable answer to overcome the problem of affordable housing. This study compared three types of earthen elements (sun-dried brick, Compressive Earth Block and Compressive Stabilized Earth Block) made with three different soils of the Kabul region (Arghandi, Band-e-Ghazi and Deh-Sabz). The following results have been obtained:

- Considering environmental issues, the stabilization of earth with Portland cement is not efficient, Compressive Stabilized Earth Blocks are not a good alternative for affordable housing design in Kabul,
- Whatever the soil studied, the dry compressive strength of Compressive Earth Blocks is mostly higher than that of sun-dried bricks while the thermal conductivity of both is quite similar. This significant increase is 81% for Arghandi soil, 67% for Band-e-Ghazi soil and 109% for Deh-Sabz soil. These results show that stabilization of raw earth can be achieved by mechanical compaction using relatively low pressure. The most suitable technic for the production of mud brick in Kabul will be therefore Compressive Earth Block.
- Considering the three soils, the dry compressive strength of Band-e-Ghazi CEB is 31% weaker than that of Deh-Sabz CEB and 14% weaker than that of Arghandi CEB. The soil coming from Band-e-Ghazi will not be selected. To conclude for the two others soils is not easy as for Deh-sabz soil the dry compressive strength is 24% higher than that of Arghandi but the thermal conductivity is 16% higher than that of Arghandi. Thermal conductivity varies principally with a particle size distribution of soil, bulk density and the water content, the greater the bulk density and the higher water content, the greater will be the thermal conductivity. The thermal conductivity is linked to the effective inter-particle thermal contact within the soil. Considering the value of thermal conductivity which does not allow Compressive Earth Blocks to be classified in the family of insulating materials, Deh-Sabz soil may be selected as the most suitable soil for affordable earthen housing in Kabul. Additional tests to determine durability indicators such as water absorption capacity or abrasion resistance will confirm this result.

Traditional Afghan architecture should play a role in the rapid affordable housing demand and reconstruction process of Kabul city. New earthen affordable houses, built with Compressive Earth Blocks and modern methods would help the local masons and artisans to establish local business and provide thousands of new responsive bioclimatic

houses. Since material costs are low, a higher proportion of construction costs can be spent on labour. Earthen architecture offers indeed an excellent employment opportunity, based on traditional and sustainable architecture.

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Conflict of interests

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Mathematical Model Applied to Green Building Concept for Sustainable Cities Under Climate Change

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ABSTRACT

Recently the effect of greenhouse gases (GHGs) is worldwide terrified anxiety to the public and scholars. Even this global problem is one of the great issues that continuously makes worrying the governments and environmentalists, but its solution findings are not out of the image at all. In this study, we have proposed and analysed a mathematical model for the solvable management of GHGs by sowing the seeds of green building dynamic systems. Moreover, in the model, the human community is used to enhance the production power of individuals of green buildings by absorbing the GHGs. The model is analysed by stability analysis at the equilibrium points: trivial and global equilibrium, and also by convincing the stability and instability of the system of equations. The behaviour of the propound model has been developed by numerical simulations which shows the rate of the fruitfulness of GHG components.

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1. Introduction

In recent years, green building has become a powerful tool to fight against global warming. Generally, green building is not only a specific construction method but also a gathering of techniques, technologies and equipment which are applied into construction to make it

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environment friendly. All about green building targets to make a healthy construction by reducing its impact on the environment. A green building has a strong way of recycling, reducing, reusing and renewable resourcing of materials. A green building can reduce water and energy consumption, use eco-friendly building tools, minimize GHG emissions, inspire renewable abstraction, develop the environment with trees and roof gardens, etc. Green buildings help to fight climate change in two ways. Firstly, by performing energy efficiency and secondly, by promoting green communities. If green buildings are established inside any community, it can maximize their impact on a healthy environment undoubtedly.

Buildings, transportation, and industries are three well-recognised energy consumption sectors in worldwide (Mardiana & Riffat, 2013). Both trade and residential buildings are responsible for consuming one-third energy of total energy than transport and industries (Gul & Patidar, 2015; Yau & Hasbi, 2013). In developed countries, only buildings are liable to consume 35% - 40% energy of total energy (Gong & Song, 2015). According to the 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC), the emission of CO_2 by building sectors was 8.6 billion metric tons in 2004 and it was predicted to arise about 15.6 billion metric tons by 2030 (Metz et al., 2007). After reaching in 2010, the level of CO_2 emission was almost grown up to 8.8 billion metric tons for building sectors (Edenhofer et al., 2014). According to the Climate Action Tracker (CAT), globally 27% of energy-related CO_2 are emitted and 30% of energy are used for building operation both in manufacturing and constructing (Lebling et al., 2020). Also, the Sustainable Buildings and Climate Initiative (SBCI) predicts that about 33% of GHG emissions and 40% of energy consumption are done by the worldwide building sectors (Gong & Song, 2015). After examining additionally 650 life cycle evaluations of GHGs it is found that as long as a building lasts it emits a maximum rate of GHGs which are mostly responsible for climate change (Röck et al., 2020). The result of the increasing GHGs record an alarming rate of global warming in the last decades. The temperature of the earth becomes warmer day by day. The average rising in global temperature was only 0.29^{0}C in 1981-1990 but it reached 0.82^{0}C in 2011-2020 (Roston, 2021). It is predicted that global warming can reach an alarming rate by 2050 (Lebling et al., 2020). Due to global warming, the environmental ecosystem is getting very damaged in recent years (Biswas et al., 2016). There are some adverse effects of global warming in the environment such as it rapidly declines the groundwater level (Islam & Biswas, 2020), it decreases the plankton density in marine ecosystems as well as oxygen-producing rate by warming seawater (Mandal et al., 2020), it also becomes a threat for the living beings near coastal areas introducing natural destructive phenomena (Mandal et al., 2021). Furthermore, cities can become 4^{0}C hotter by 2100 than rural areas (Zhao et al., 2021). Day to day the temperature of cities becomes high not only for industrialization and population density but also for unplanned construction. So, it is necessary to take a look at building construction technologies not only to cut GHGs but also to save cities. There exists a lot of techniques to reduce GHG emissions from buildings (Pacala & Socolow, 2004). To minimize the level of GHG emissions, carbon-reducing techniques and renewable energy segments need to develop (Pal, 2017). The expansions of renewable energy strategies like bioenergy potential (Smeets et al., 2007), geothermal energies (Pollack et al., 1993), solar, hydro, ocean, wind hybrid sectors (Rezaie et al., 2011) can boost the energy-saving techniques of building. Generally, the application of renewable energies without using fossil fuels is called zero carbon emission building (Kaygusuz, 2007). Moreover, to lessen the energy consumption the residential apartments can be decorated in a north-south oriented configuration, but if it is not possible then the solar chimney will be a good alternative (Rahbarianyazd & Raswol, 2018). It also needs to keep in mind that, buildings need to be environmentally friendly, technically attractive and possibly cost effective (Rezaie et al., 2011). Adopting the "Smart Cities Plan" with green infrastructure will be a standard solution (Zhao et al., 2021). It is also remarked that cities are mostly influenced by the impact of globalization since cities are the main ruler of any country (Kara, 2019). But sustainable smart city planning is a pleasant and environment-saving policy with high-quality life and economy (Sasanpour, 2017). The green infrastructure can become an effective tool for industrialization without harming the natural elements (Reza et al., 2017). An experimental comparison of sustainable green infrastructure is demonstrated for different environmental products of building regions (Nyári, 2011).

Generally, green infrastructure indicates green buildings, which is a good initiative to make sustainable construction for smart cities (Shawkat et al., 2018). Green building is an ecological indicator against all kinds of toxic emissions (Liu & Lin, 2016). Each part of a green building is made to fight against all kinds of ecological obesity. Green building is quite helpful to reduce 20% of building-related GHGs emissions (Nyári, 2011). Green buildings can reduce about 30%-40% of energy consumption, lessen about 33% of global GHG emissions, reduce 30% of water consumption, reduce 50% of solid waste, provide better indoor air quality, etc (Reddy, 2016). In green buildings, the indoor temperature quality can be improved by the buildings green roof impact (Jaffal et al., 2012). The United States Green Building Council (USGBC) works for all possible countries to make people concern about the sustainability of the earth for fighting against GHG emissions, for example, the logical role of green buildings had statistically analysed almost all over India on behalf of GRIHA (Tathagat & Dod, 2015), China recently adopts green building technologies to reduce carbon emission (Wu et al., 2017), etc. Furthermore, many European and South Indian countries like Manila, India, New York, Mexico, Tokyo, Singapore, Jakarta, Beijing, etc. are adopted carbon footprint technologies for developing urban areas (Sovacool & Brown, 2010). Mathematical modelling is widely used to demonstrate various types of real-life problems to create a good prognosis, determination, arrangements and respiration mechanisms (Mondal et al., 2017). Any kind of interaction or affirmation relationships of species is perfected to explain by mathematical modelling. In mathematical modelling, we use the changing rate of any subject according to time, which is expressed in terms of differential equations. The differential equation shows the natural behaviour of the species to cope up with the environment ecosystem. There are a lot of dynamics of mathematical modelling, for example, the SIS epidemic model, the Logistic model, the Lotka-Volterra predator-prey model, the SEIR disease model, the SIR epidemic model, the optimal control strategic model, etc. Each of the models is used for describing the different-different state of environmental ecology. For example, the SIS model is used to describe the rate of natural births-deaths and disease-related deaths with time (Hethcote & van den Driessche, 1995), the SIR model is used to discuss the spread of epidemiology (Parvin et al., 2020), the Lotka-Volterra model describes the ecological dynamics of the interaction of the species where one is prey and the other one is a predator (Zhu & Yin, 2009), the optimal control strategic model generally discusses the control dynamics of any kinds of an outbreak (Shanta & Biswas, 2020), the Logistic-Model is used to describe the carrying capacity of any species in the environment (Marchetti et al., 1996), etc. The study deals with green building technologies and the emission of GHGs by human communities and their correlations. The study is aimed to discuss the impact of green building by absorbing GHG for human communities. We have proposed a mathematical model which contains a set of non-linear ordinary differential equations to make the GHG components beneficial by integrating them into green building technologies. The model is analytically analysed first and then numerical simulations are performed. At each equilibrium point, the stability analysis has been observed with the state variables positivity test. The analytical result is examined with the help of numerical discussion to approve the model.

2. Material and Methods

We are living in such a present world that is fully organized with developed artistic creation, where civilization means highly performed techniques and technologies in every part of daily necessities. To cope up with this modern era we have forgotten about the limitation of natural eco-balance unfortunately. This results in a curse that, 2020 is addressed as the warmest year on record (Hausfather, 2020). It is a very expected result that the Arctic sea ice line is noticed at a record level low than before (Hausfather, 2020). Can we think for a while about our future era? If the global warming issues can't be kept in control the earth will not remain worth for sustain. It is seriously high time to cut GHGs to save our future world. It is a great remark that the developed countries use their land not as much for forestation but much more for industrialization (Hanley, 2015). The World Resources Institute CAIT Climate Data Explorer has made a statistical overview on global GHG emissions shown in Figure 1. The United States and China are the top GHG emission countries. Figure 1 displays the total amount of GHG emissions for top GHG emitted countries in 1990-2012 (Hanley, 2015).

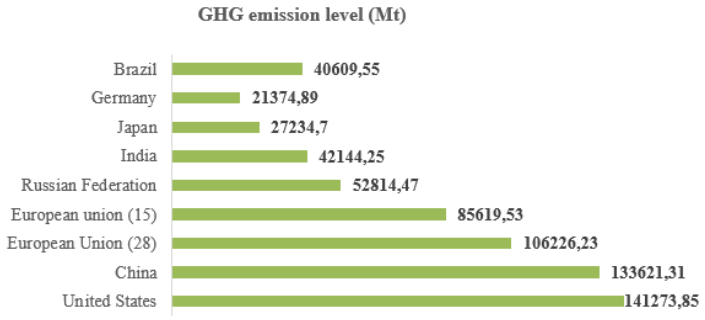

Figure 1. Emissions of GHG by the most GHG emitting countries in 1990-2012.

The last official commencement on climate affairs was carried out by the United Nations (UN) in December 2015 to discuss the global toxic emission which is known as Paris Agreement (Yilmaz, 2021). According to Paris Agreement, all the countries signed to limit global warming "well below" to 2^0c and if possible to 1.5^{0}C (Lebling et al., 2020). To fulfil the target each country needs to reduce at least half of presents emission that is addressed in the Paris Agreement (Broom & Gray, 2020). It is quite hard but it is hardly necessary to save our world literally. But it is a matter of sorrow that, China emitted 14,093 MMt GHGs in 2019 which was 27% of the total GHG emissions and the second-highest GHG emitter was the US which emitted about 11% of the total GHGs (Larsen et al., 2021). The matter of frustration is, in 2020 again the top highest GHG emitter was China. In 2020 China again emitted 14,400 MMt GHGs, which was 1.7% more than the prior year (Grant et al., 2021). Due to excess GHGs emissions, global warming has tied the year 2020 with 2016 around 1.2^{0}C hotter than before (Roper, 2021). For the extreme increase in GHGs the temperature is continuously rising day by day (Roston, 2021). Figure 2 represents the change of decades average temperature from 1951 to 2010 (Roston, 2021).

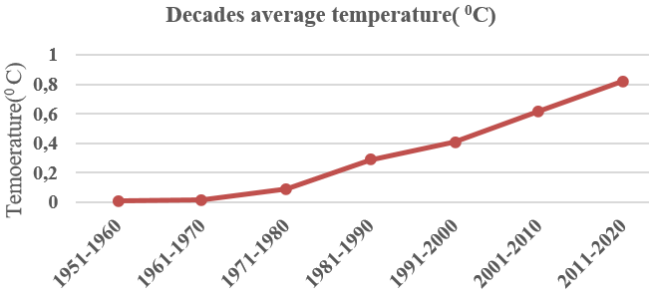

Figure 2. The rising rate of temperature from 1951 to 2020.

A common question is picked up in all the minds of environmentalists about the sustainability of the earth in the future. How GHGs are produced and what are the main reasons? In one word we can say, the human community is the main victim. A huge number of people on many sides are responsible for maximum CO_2 emissions. This large amount of CO_2 contains other heat-trapping gas into the atmosphere and produce GHG components such as CH_4, N_2O, HFCs, PFCs, and SF_6 which causes the increase of atmospheric temperature day by day. We are dreamt to make a bio-technical green building system where all of the GHG components are used to make them fertile. The green building can be any of a residential building, an industry, a factory, a commercial building, an educational institute, a hospital, etc. Suppose any industrial building is designed on the basis of green building technologies. The industrial building stands for refrigerating, air-conditioning, foams, aerosol cans etcetera's production case whose main raw materials are fluorinated gases (HFCs, PFCs, and SF_6). Since the green building holds a lot of plants that help to absorb CO_2 by photosynthesis. Photosynthesis helps to keep the atmospheric temperature in control and also it is a source of food production. On the other hand, methane (CH_4) and nitrous oxide (N_2O) have great use in biomass planting and fertilizer or manure application respectfully. The whole assumption is displayed in Figure 3.

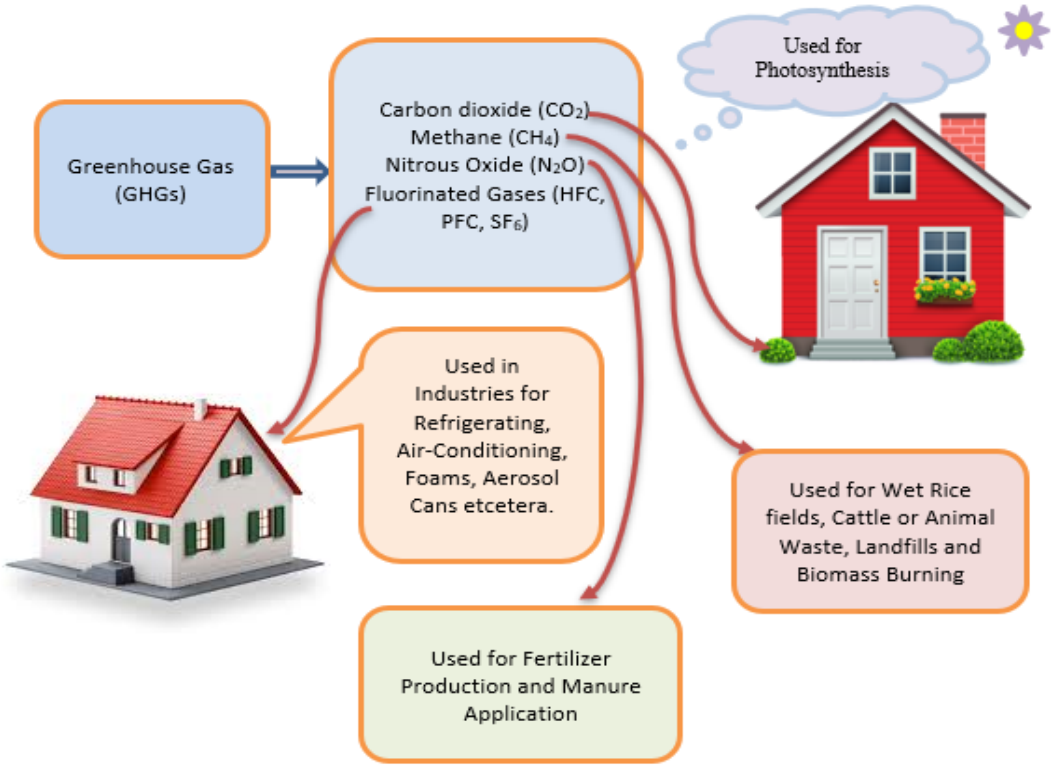

Figure 3. Implementation of GHG components to green building dynamic systems.

In our assumption, the GHG components have been planting into green building systems and made an artistic track like Figure 4 to establish a modelling procedure. We have made the methodological concept according to Figure 4. If there is a large amount of GHGs, green buildings absorb these GHGs and produce numerous numbers of energetic ingredients. The human community will become beneficial by consuming the energetic ingredients and again produce a large number of GHGs. Again, green buildings will absorb GHGs proportionally for reproducing ingredients.

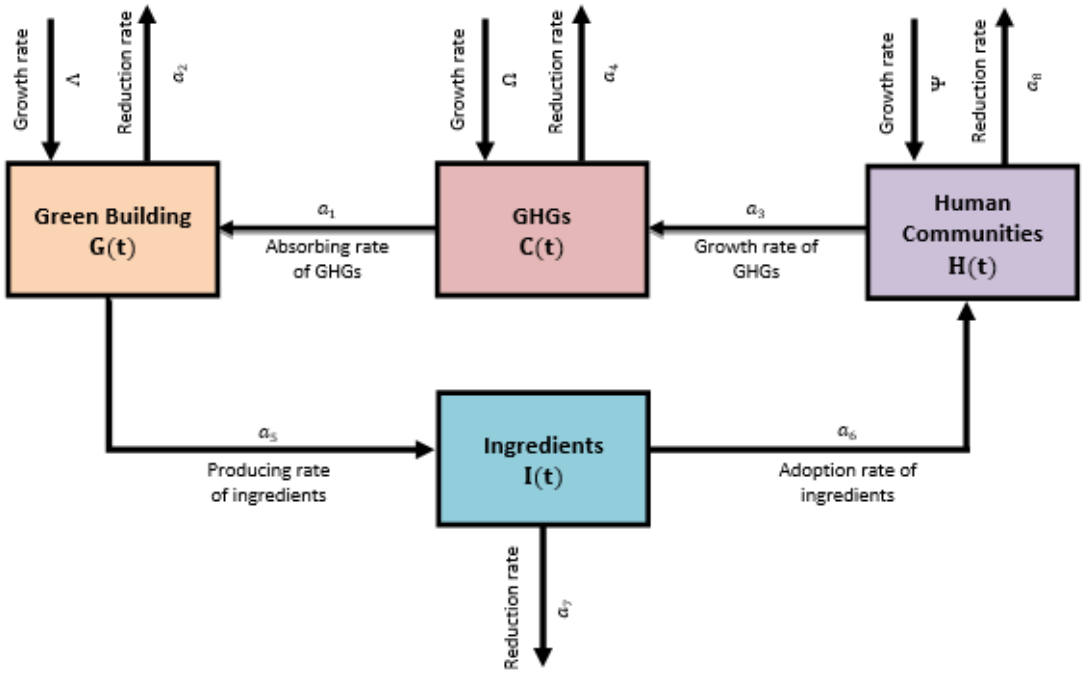

Figure 4. The schematic diagram describing the effect of green buildings on GHGs, ingredients, and human communities.

3. Model Formulation

Mathematical modelling is one of the best weapons to illustrate the lifetime behaviour of any real-life problem. To analyse the impact of global warming because of extreme GHG emissions on sustainable cities, a mathematical model has been formulated by considering four state variables as the number of green buildings, the amount of GHGs, the energetic ingredients producing from green buildings and the human communities of a certain area. Here it is typically mentioned that ingredients are not any kinds of tools it means the environment-friendly effects that are made by green buildings like solar energies, water betterments, temperature assessments, renewable energies, economical managements, food technologies, etc. The proposed model aims to describe how GHG emissions can be controlled by implementing green buildings. Figure 4 describes the interrelation of state variables for the modelling procedure.

To establish the green building model, let us consider the green building variable $G(t)$ where $\frac{dG}{dt}$ defines the rate of change of $G(t)$ at any time t. In the model, $\frac{dC}{dt}$ represent the rate of change of GHGs $C(t)$ at any time t. Also, the green building since produced a number of energetic ingredients $I(t)$ so at any certain time t the rate of change of $I(t)$ is denoted by $\frac{dI}{dt}$. Again let $\frac{dH}{dt}$ identifies the rate of change of the human community $H(t)$ at any certain time t. Here Λ, Ω and Ψ be the quantity of green building $G(t)$, GHGs $C(t)$ and human community $H(t)$ at any certain time t respectively. A mathematical model with four state variables is formulated in the following form according to the schematic diagram described in Figure 4:

$$\frac{dG}{dt} = \Lambda + a_1 GC - a_2 G \tag{1}$$

$$\frac{dC}{dt} = \Omega - a_1 GC + a_3 HC - a_4 C \tag{2}$$

$$\frac{dI}{dt} = a_5 GI - a_6 HI - a_7 I \tag{3}$$

$$\frac{dH}{dt} = \Psi + a_6 HI - a_8 H \tag{4}$$

with the initial conditions, $G(0) = G_0 \geq 0; C(0) = C_0 > 0; I(0) = I_0 \geq 0; H(0) = H_0 \geq 0$.

The parameters that are used in the proposed model with both their description are given in Table 1. If green buildings are interacting with GHGs, it reduces 20% of GHGs by consumption (Wang et al., 2014), so we use a_1 to define the absorption rate of GHGs by green buildings. In the model a_3 and a_6 defines the producing coefficient of GHGs and the absorption coefficient of ingredients by human communities respectively. Also, in the model a_5 is used to indicate the number of ingredients that the green building produces.

Table 1. Descriptions of the model parameters with their corresponding values.

Parameters	Parametric statement
Λ	Amount of green building.
a_1	Absorption rate GHGs by green buildings.
a_2	The reduction rate of green building.
Ω	Amount of GHGs.
a_3	Rate of human originated GHGs.
a_4	The reduction rate of GHGs.
a_5	Production rate of ingredients by green buildings.
a_6	The adoption rate of ingredients by human communities.
a_7	The reduction rate of ingredients.
Ψ	Amount of human community.
a_8	The reduction rate of human communities.

4. Model Illustration Analytical Analysis

The system of non-linear ordinary differential equations (1)-(4) has been analysed in this section to find the stability conditions of the proposed model after performing the positivity analysis.

4.1 Positivity Analysis

Lemma 1: The solution of the state variables $G(t), C(t), I(t)$ and $H(t)$ of the proposed model is positive if $G(t) \geq 0, C(t) \geq 0, I(t) \geq 0$ and $H(t) \geq 0$ (Biswas, Hossain, & Mondal, 2017).

Proof: To prove the considered lemma suppose the equation (1) of the model will be,

$$\frac{dG}{dt} \geq \Lambda + a_1 GC - a_2 G \Rightarrow \frac{dG}{dt} + a_9 G(t) \geq \Lambda \ \ [\text{Let}\,(a_2 - a_1 C) = a_9] \tag{5}$$

$\therefore$ Integrating factor $= e^{\int a_9 dt} = e^{a_9 t}$. After multiplying $e^{a_9 t}$ in both sides of equation (5) we get,

$e^{a_9 t}\frac{dG}{dt} + e^{a_9 t} a_9 G(t) \geq e^{a_9 t}\Lambda$. After integration, we get, $Ge^{a_9 t} \geq e^{a_9 t}\frac{\Lambda}{a_9} + a_{10}$ (6)

where a_{10} is constant.

According to the initial condition, $G(t) = G(0)$ at $t = 0$. So, from equation (6) we get, $a_{10} \geq \left(\frac{\Lambda}{a_9} - G\right)$

By using the value of a_{10} in equation (6) we get,

$Ge^{a_9 t} \geq e^{a_9 t}\frac{\Lambda}{a_9} + \left(\frac{\Lambda}{a_9} - G\right) \Rightarrow G(t) \geq \frac{\Lambda}{a_9}\left(1 + e^{-a_9 t}\right) - e^{-a_9 t} G(t)$. Hence $G(t) \geq 0$ at $t = 0$ and $t \to \infty$.

Similarly, we can also obtain the lemma for others state variables and can mention that $C(t) \geq 0, I(t) \geq 0$ and $H(t) \geq 0$ at $t = 0$ and $t \to \infty$.

Therefore, it is assumed that the state variables $G(t), C(t), I(t)$ and $H(t)$ of the proposed model of non-linear equations (1)-(4) are positive on behalf of Lemma 1.

4.2 Equilibrium Analysis

We will find two types of equilibrium for the propound models such as in section 4.2.1 (the global equilibrium point) and 4.2.2 (the trivial equilibrium point).

4.2.1 Global Equilibrium

The global equilibrium can be held by setting the rate of change of all the variables of the model to zero such as $\frac{dG}{dt} = \frac{dC}{dt} = \frac{dI}{dt} = \frac{dH}{dt} = 0$ and by evaluating equations (1)-(4) such as:

$$\Lambda + a_1 GC - a_2 G = 0 \tag{7}$$

$$\Omega - a_1 GC + a_3 HC - a_4 C = 0 \tag{8}$$

$$a_5 GI - a_6 HI - a_7 I = 0 \tag{9}$$

$$\Psi + a_6 HI - a_8 H = 0 \tag{10}$$

From equation (9) we have, $a_5 G - a_6 H - a_7 = 0 \left[\because I \neq 0\right] \Rightarrow H = \frac{a_5 G - a_7}{a_6}$

(11) Now by using the value of H in equation (8) we get,

$$\Omega - a_1 GC + a_3\left(\frac{a_5 G - a_7}{a_6}\right)C - a_4 C = 0 \Rightarrow C = \frac{\Omega a_6}{(a_3 a_7 + a_4 a_6) - G(a_3 a_5 - a_1 a_6)} \tag{12}$$

Also, by using the value of H in equation (10) we get,

$$\Psi + a_6 I\left(\frac{a_5 G - a_7}{a_6}\right) - a_8\left(\frac{a_5 G - a_7}{a_6}\right) = 0 \Rightarrow I = \frac{a_5 a_8 G - a_7 a_8 - \Psi a_6}{a_6(a_5 G - a_7)} \tag{13}$$

Again, from equation (7) we have,

$$C=\frac{a_2G-\Lambda}{a_1G}\Rightarrow\frac{\Omega a_6}{(a_3a_7+a_4a_6)-G(a_3a_5-a_1a_6)}=\frac{a_2G-\Lambda}{a_1G}$$ [From equation (12)]

$$\therefore G=\frac{(\Lambda a_3a_7+\Lambda a_4a_6)}{\left[(a_2a_3a_7+a_2a_4a_6)+(\Lambda a_3a_5-\Lambda a_1a_6)-a_1\Omega\ a_6\right]}=\alpha \text{ (constant say)} \quad (14)$$

Now using the value of G in equation (11), (12) and (13) we get,

$$C=\frac{\Omega a_6}{(a_3a_7+a_4a_6)-\alpha(a_3a_5-a_1a_6)},\ I=\frac{a_5a_8\alpha-a_7a_8-\Psi a_6}{a_6(a_5\alpha-a_7)} \text{ and } H=\frac{a_5\alpha-a_7}{a_6}.$$

Let the global equilibrium point of the model is $E^*=\left(G^*,C^*,I^*,H^*\right)$ where,

$$G^*=\alpha=\frac{(\Lambda a_3a_7+\Lambda a_4a_6)}{\left[(a_2a_3a_7+a_2a_4a_6)+(\Lambda a_3a_5-\Lambda a_1a_6)-a_1\Omega a_6\right]};C^*=\frac{\Omega a_6}{(a_3a_7+a_4a_6)-\alpha(a_3a_5-a_1a_6)};$$

$$I^*=\frac{a_5a_8\alpha-a_7a_8-\Psi a_6}{a_6(a_5\alpha-a_7)};H^*=\frac{a_5\alpha-a_7}{a_6}.$$

4.2.2 Trivial Equilibrium

For initialization of the mathematical model, we have the trivial equilibrium point at $E_0=(G_0,C_0,I_0,H_0)=(0,0,0,0).$

4.3 Stability Analysis

If we try to establish real-world problems in mathematical analysis, we have to face a lot of complexity for defining them. But the non-linear scheme is the very best way to define the complex behaviour of the natural components in mathematical modelling. In a non-linear scheme, the stability theory helps to address the explicit solutions of the complex mathematical model. To find the stability of the proposed model first evaluate the Jacobean matrix over the system of equations (1)-(4) we get,

$$J_{(G,C,I,H)}=\begin{bmatrix}a_2C-a_2 & a_1G & 0 & 0\\ -a_1C & -a_1G+a_3H-a_4 & 0 & a_3C\\ a_5I & 0 & a_5G-a_6H-a_7 & -a_6I\\ 0 & 0 & a_6H & a_6I-a_8\end{bmatrix}$$

At the global equilibrium point $E^*=\left(G^*,C^*,I^*,H^*\right)$ the Jacobean matrix will be,

$$J_{E^*(G^*,C^*,I^*,H^*)}=\begin{bmatrix}a_1C^*-a_2 & a_1G^* & 0 & 0\\ -a_1C^* & -a_1G^*+a_3H^*-a_4 & 0 & a_3C^*\\ a_5I^* & 0 & a_5G^*-a_6H^*-a_7 & -a_6I^*\\ 0 & 0 & a_6H^* & a_6I^*-a_8\end{bmatrix}$$

which after solving by row-column operations becomes,

$$J_{E^*}=\begin{bmatrix}-a_2 & a_3H^*-a_4 & -a_6H^* & a_3C^*-a_6I^*\\ a_2-a_1C^* & -a_1G^* & -a_6H^* & -a_6I^*\\ a_5I^* & 0 & a_5G^*-a_7-a_6H^* & -a_8-a_6I^*\\ 0 & 0 & 0 & -a_8\end{bmatrix}\begin{bmatrix}r_1'=r_1+r_2\\ r_2'=r_2-r_1\\ r_3'=r_3+r_4\\ c_3'=c_3-a_8H^*\\ c_4'=c_4-a_8I^*\end{bmatrix}$$

from which we get the eigenvalues as, $\lambda_1=-a_2,\ \lambda_2=-a_1G^*,\ \lambda_3=a_5G^*-a_6H^*-a_7$ and $\lambda_4=-a_8$. Since all the eigenvalues are negative except λ_3. Hence, if $\lambda_3\le 0$ then the equilibrium is locally asymptotically stable and also it is.

At the trivial equilibrium $E_0 = (G_0, C_0, I_0, H_0) = (0,0,0,0)$. Now after passing the trivial equilibrium E_0 through the Jacobean matrix of (15) we get,

$$J_{E_0(0,0,0,0)} = \begin{bmatrix} -a_2 & 0 & 0 & 0 \\ 0 & -a_4 & 0 & 0 \\ 0 & 0 & -a_7 & 0 \\ 0 & 0 & 0 & -a_8 \end{bmatrix}$$

Therefore, we have the four eigenvalues as $\lambda_1 = -a_2, \lambda_2 = -a_4, \lambda_3 = -a_7, \lambda_4 = -a_8$. The stability of the equilibrium state is obtained by the eigenvalues λ of the Jacobean matrix. So, the stability of the equilibrium states holds with the conditions depending on λ that is: the steady-state is stable if the eigenvalue $\lambda < 0$ or, the system is unstable if the eigenvalue $\lambda > 0$. Since here all the eigenvalues are less than zero ($\lambda < 0$) so the stability condition is satisfied.

5. Numerical Simulation with Resulting Accessories

Our model targets to hold the accuracy of making the harmful sides of GHGs effective by implementing them into the green building system. The analytical result proofs the stability of the proposed model. Now to make a population favourable presentation, numerical or computer simulation is regarded as the best tool. We have used the MATLAB programming language to perform the numerical simulation of the proposed model. The objective of this simulation is to show the dynamical behaviour of green building dynamics for solving the GHGs emission and make a comprehension study to overlook the human communities proportionally.

The human community is the main tool for emitting unwanted GHGs. If there happens an increase in GHG emissions for different human activities, it directly forces all the biological creatures not to sustain perfectly. But naturally, the human community is an increasing factor. So, with the increasing number of human communities, the amount of GHGs will also rise. Our model targets to put on the increasing GHGs into green building systems to make the GHG component effective. If the discharge of rapid GHGs is happened by human communities, the green buildings take advantage of their technologies against GHGs. Being effective the green building produces several ingredients and also human communities become beneficial by getting the ingredients. After getting energies the human communities again take part in emitting GHGs and green buildings again soak these huge GHGs for energy production. The initial dynamic behaviour of the objects with the rapid GHGs emission is shown in Figure 5. Day by day the GHGs emission is rising for different human-made activities. Now, the performance of green buildings is to absorb these increasing GHGs (a_1) from the atmosphere and make a potential effect on other species as shown in Figure 5.

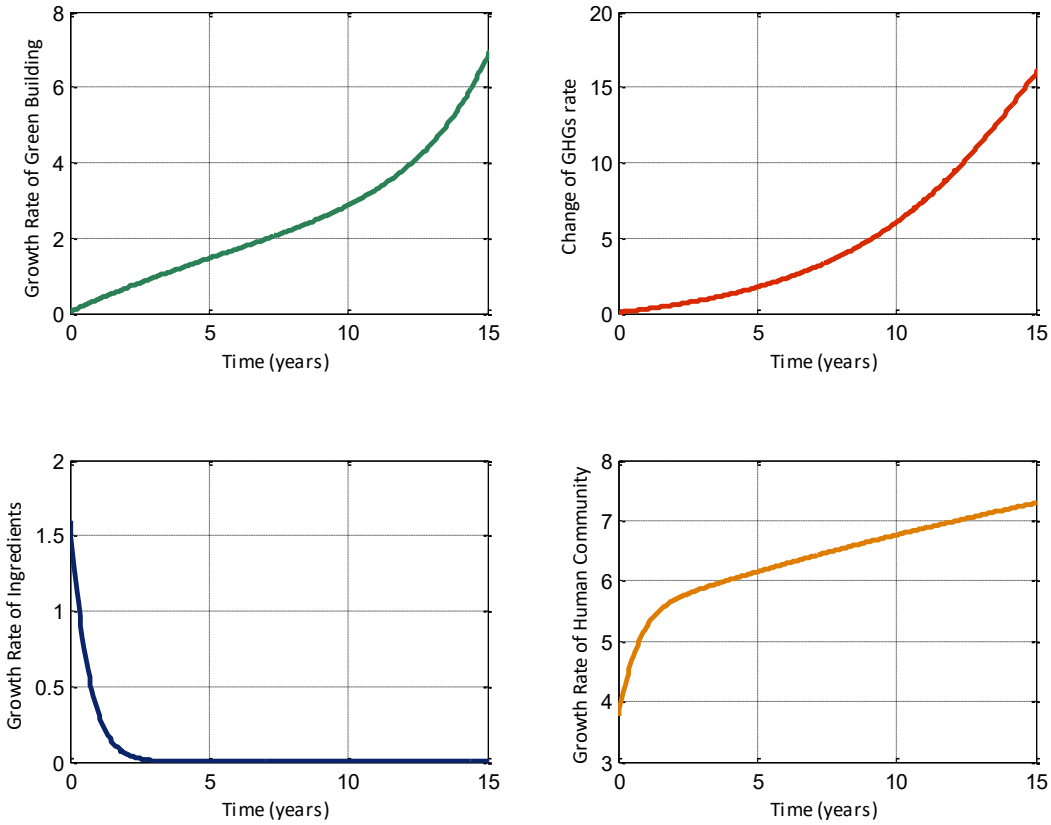

Figure 5. Numerical behaviours of the dynamic variables of the model (1)-(4) over time.

If the harmful GHGs are continuously absorbed by green buildings, the rate of green building is increasing continuously as shown in Figure 6 but the rate of GHGs is undoubtedly decreasing as represented in Figure 7. Due to the high absorption of GHGs, the green building can produce ingredients proportionally which is described in Figure 8. The human communities will be benefitted by getting the ingredients and can convert themselves in rising quantity as presented in Figure 9. The simulation scheme at different rates of GHGs absorption (a_1) by green buildings is shown in Figure 6 and Figure 7 to predict that when green building absorbs less GHGs (a_1) then green building rate is low but GHGs rate is high. But if green building absorbs GHGs at a high rate (a_1) then green building becomes high where GHGs become low usually.

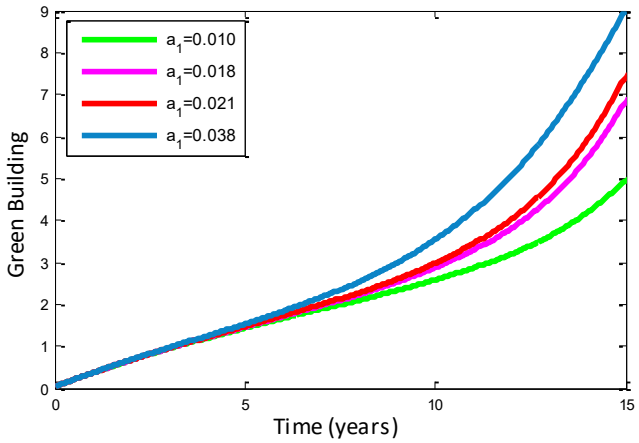

Figure 6. The growth rate of green building for different values of a_1.

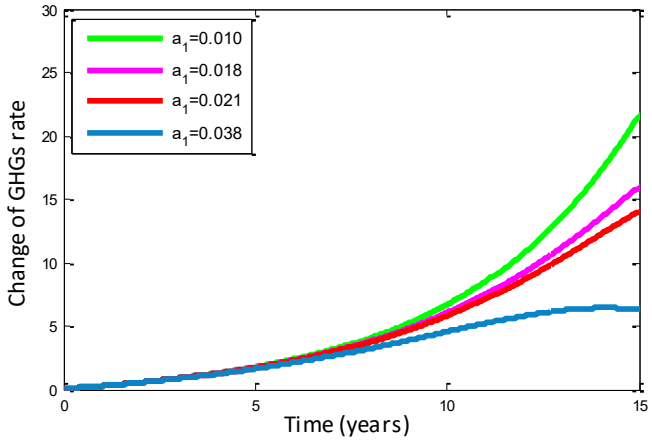

Figure 7. The decreasing rate of GHGs at different values of a_1.

Similar effects also fall on both human communities and ingredients. If green building absorbs low GHGs (a_1), it generally produces fewer ingredients as described in Figure 8 and the contrary happens when green building takes more GHGs. Also, human communities show its rate low for absorbing less GHGs because when low GHGs absorption (a_1) happens then green building also produces few ingredients. Moreover, the increment of human communities happens when green building gives more ingredients to human communities by absorbing more GHGs (a_1) as shown in Figure 9.

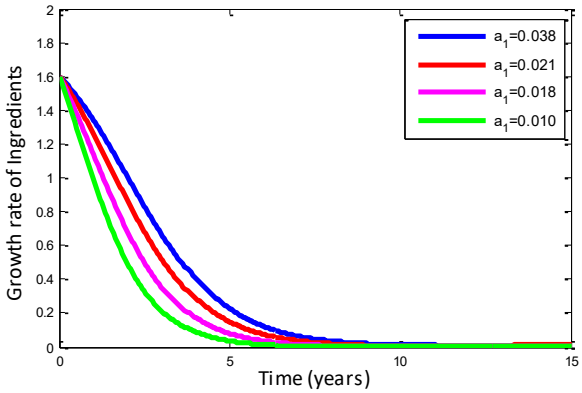

Figure 8. The growth rate of ingredients at different values of a_1.

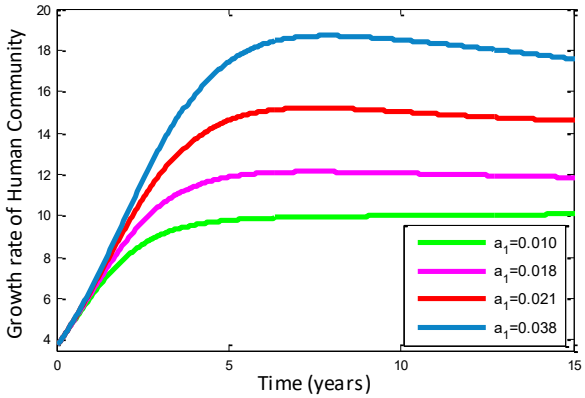

Figure 9. The growth rate of human communities at different values of a_1.

6. Conclusion

To analyse any kind of natural assumption both analytically and numerically, mathematical modelling is a well-recognized tool. To describe the impact of green building on rapid GHG emissions, a non-linear mathematical model has been proposed in this study. The model is developed considering the effects of green buildings on human communities and GHGs absorption. After formulating the mathematical model is verified by the positivity analysis to confirm the existence of the considered state variables. Furthermore, the stability analysis is performed for both global and trivial equilibrium states. To verify and describe the accuracy of the analytical results of this study, numerical simulations are carried on. Overall, the results of this study conclude with the following points:

- Global warming is increasing at an alarming rate due to the extreme emission of GHGs.
- Different human activities especially building technologies are responsible for extreme GHGs emissions. As a result, the earth's climate, as well as atmospheric temperature, are rapidly changing.
- The amount of GHGs is proportionally decreased with the increasing green buildings.
- The production of ingredients and the absorption of GHGs proportionally depend on the number of green buildings.
- Green buildings can enhance the ingredients and human communities by absorbing more GHGs.

If the cyclic process of GHGs absorption is continued by introducing the technology of green buildings, the dream of future sustainable cities will no longer remain in only imagination. The green building is quite enough warrior to fight against the excess concentration of GHGs. Therefore, it is time to protect the world from global warming by controlling extreme emissions of GHGs and adopting green buildings as much as possible.

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Conflict of interests

The authors declare no conflict of interest.

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Original scientific paper

Living Space Needs of Small Housing in the Post-Pandemic Era: Malaga as a case study

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ABSTRACT

The COVID-19 lockdown period has highlighted the ability of housing to accommodate a comprehensive programme typical of the city and its public space. Housing units of under 60 m2 and in blocks of flats are the more vulnerable, as they have a higher percentage of non-community open spaces. That problem was analysed using a methodology based on psychological, urban planning and architectural indicators applied to two coastal cities in the Mediterranean area of southern Spain. The results highlight three aspects in this type of dwelling: the need to consider the orientation of the housing to improve the quality of indoor and outdoor space; the need in public housing policies for a greater number of rooms to facilitate remote working; and finally, the importance of functional terraces overlooking green areas.

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1. Introduction

In Spain, the stay-at-home lockdown during the COVID-19 pandemic highlighted the difficulty of combining remote working and family life. The experience of not only much of the Spanish population but also worldwide was reflected in numerous media assessments of the shortcomings of the housing stock. The stay-at-home lockdown forced people to relegate their whole daily life to their homes. In the words of Fernández Galiano (2020) "the intimate hideaway has become a prison cell". Suddenly, the home has become the centre of all activity, even that which had taken place up until then in the city - which practically emptied -: education, work and leisure. Stay-at-home lockdown revealed the lack of

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terraces, indoor environmental quality and flexible spaces in much of the residential stock built in Spain (Cuerdo-Vilches et al., 2020). Yet the less resilient type of housing to lockdown is, on the one hand, the housing units of under 60 m² and with no views of green areas, as their households are more prone to depression (Amerio et al., 2020) and, on the other hand, those located in community blocks and with aligned façades, given the difficulties to carry out extensions or alterations. This paper stresses three aspects for this type of housing: the need to consider the orientation of the housing to improve the quality of the indoor and outdoor space; the need for public housing policies for a greater number of rooms to facilitate remote working; and, finally, the importance of functional terraces overlooking green areas.

This article is organized into four parts. The first chapter reviews the state of play. The second presents the analysis methodology based on psychological, urban planning and architectural indicators applied to two coastal cities in the Mediterranean area of southern Spain. The third and fourth chapters consider the results and discuss the main contributions of this paper.

2. Background

Until vaccines were developed, the hygienist movement considered the city and housing as a necessary way to prevent disease. Keeping houses clean, locating them in airy and sunny places, going outdoors and breathing pure mountain air in a suitable climate was recommended. These were the tenets of the hygienism advocated by Le Corbusier and the Modern Movement, which influenced the design of hospitals where those four principles were applied, such as the Paimio Sanatorium, designed by Alvar Aalto in Finland between 1929 and 1933. In a review of the literature on the needs arising from the pandemic and its lockdown, the returning to the hygienic principles of the Modern Movement can be organised into indoor space conditions and outdoor space conditions.

2.1. Indoor Space Conditions

During a lockdown, there needs to be a flexible approach to living space (Bettaieb & Alsabban, 2020; Cuerdo-Vilches et al., 2020; Nanda et al., 2021) for work, schooling, leisure and exercise, which requires each user to have at least a private room (Nanda et al., 2021). As regards work, even though the idea of remote working dates back to the end of the 1960s (Van Meel, 2011), its implementation was rare in Spain (del Águila Obra et al., 2002). According to Mitchell (1999), remote working brought the home and the workplace back together, after the industrial revolution had separated it as the result of functional and spatial specialisation. Yet in turn, this would mean, on the one hand, an increase in demand for space for remote working at home with similar qualities to those of conventional offices (Ng, 2010); and, on the other hand, adequate access to information and telecommunication technologies (Ahmadi et al., 2000; Broderick, 1991; Cuerdo-Vilches et al., 2020) in an appropriate, safe and healthy work environment (Harmon-Vaughan, 1995; Hobbs & Armstrong, 1998; Kaufman-Scarborough, 2006; Kim, 2017).

As regards space, current housing is not designed for working from home and alterations would be needed (Gurstein, 2001; Magee, 2000). With the COVID-19 lockdown, many workers were forced into a work-from-home (WFH) using any available space at their home (bedrooms, living rooms, kitchen or terraces), such as pop-up offices (Nanda et al., 2021). A minimum of 60 m² surface area per housing unit (Amerio et al., 2020) and the importance of housing overlooking green areas (Amerio et al., 2020; Mirza & Byrd, 2018) also have to be added in that regard. With respect to the indoor quality indicators, natural lighting and thermal and acoustic insulation (Cuerdo-Vilches et al., 2020) are included, along with using windows to ensure well-aired homes (Porrit & Campbell, 2020).

2.2. Outdoor Conditions on Terraces and Balconies

Terraces and balconies are some of the great contributions of the hygienist movement. There is a difference between both terms: if the width is the same or smaller than the average human size, it is a balcony, while if it is larger, it can be considered a terrace as it is more comfortable (Gupta, 2019). Both elements are closely tied to a medical and hygienist role, as they are used for patients to convalesce, and they were incorporated by the Modern Movement in its architectural designs (Campbell, 2005). Thus, Le Corbusier put forward the solarium or covered garden terrace as one of the five pillars of the architecture of the Modern

Movement (Le-Corbusier, 1986), as manifested in the *Ville Savoye* (1929). It was later transferred in the tower block, evolving from a large double-height space open to the façade, in the first designs of the *L'Esprit-Nouveau* pavilion to the *brise-soleil* balconies and the use of the community roof of *L'Unité d'Habitation*.

Yet after World War II, medical advances in the development of vaccines - e.g., cholera (1884) or tuberculosis (1927) - began to mean that they're being healthy spaces began to lose importance. The speculative pressure of housing prices in the city or the development of environmental comfort technology thanks to air conditioning and mechanical ventilation reduced the size of the terraces and turned them into balconies. On the other hand, the terrace grew in importance in mass tourism architecture (Fernández Fuster, 1991:255): dimensionally (accounting for a third of the total surface area of tourist apartments), spatially (transition space between the outdoors and indoors) and symbolically (enjoying leisure as a social achievement). A paradigmatic example is, certainly, the pyramid terraced blocks of La Grande Motte (Languedoc-Rousillon, France) designed by Jean Balladur.

At present, there is a whole line of architecture specialised in terrace design (Jodidio & Kim, 2016; San Martín, 2007). Apart from its hygienic values, we can find two main lines of study: its environmental value and its link to public space. In terms of comfort, the terrace is the best space to be at dusk and dawn (Gupta, 2019); along with historically improving the energy performance of vernacular architecture (Foged, 2019). While its relationship with the public space depends on its positioning in the building and its link with the street space. Thus, the roof of the building, as it is the furthest plan from the relationship with the city, has links to the idea of a hidden city (Herranz, 2016). As regards the façade and during the pandemic, Grigoriadou (2020) analysed the urban balcony as a spontaneous public space where numerous social activities and social practices took place, including Gardening, leisure, recreation (Bettaieb & Alsabban, 2020) or exercise (Cuerdo-Vilches et al., 2020). In fact, during the lockdown period of the pandemic, it was the most sought-after space by home users (Cuerdo-Vilches et al., 2020). However, specific dimensions, at least 6 m^2 per apartment with sliding doors (Bettaieb & Alsabban, 2020), are required for it to function correctly.

3. Methodology and Study Case

A mixed-method, based on quantitative (objective indicators) and qualitative (subjective indicators) approaches, was used to analyse stay-at-home lockdown during COVID-19. The objective indicators include:

(a) Planimetric survey and calculation of the closed/open surface area:

- Detailed drawing of the furnishing
- Detailed drawing of the possible routes in the house (mobility)

(b) Urban data:

- Urban location: type of neighbourhood, the height of the housing
- Orientation of the main façade
- Views and connection to the public space

The subjective indicators include an online questionnaire that was completed after the stay-at-home lockdown period. It was sent to the occupants who had been previously informed that the study would be conducted. They were asked to assess the positive and negative characteristics of their homes (layout and fittings), the activities they did at home and the changes they would make to them. The profile of the users was very similar: The majority were young couples without children, although a family with an older child was also included, but never with small children.

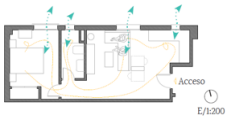
The four case studies (Figure 1) are flats in multi-family residential blocks along the Mediterranean coast of southern Spain. Three of them in Malaga - as an example of a non-tourist urban environment case study -, and one in Velez-Malaga, as a case study in a tourist environment. In Malaga, the first urban fringe (Case A), the urban edge (Case B) and the old town (Case C) were chosen. While a tourist neighbourhood (Case D) was selected in Velez-Malaga.

Figure 1. Location of the Case Studies along the Mediterranean coast of southern Spain. (Developed by Authors).

4. Results

As regards WFM, in housing units of under 60 m^2 with maximum resident occupancy, they were forced to use the living room as a pop-up office (Table 1). However, in homes over 60 m^2, or where there were the same or higher number of residents, the bedrooms were used as pop-up offices, in the same way as before the pandemic. In the case of housing units with only 1 bedroom for 2 users who worked, the living-dining room had to be shared, which limited its use for video conferences, leisure activities (watching television) or meals. It can be concluded that small flats are more appropriate for remote workers who live alone, or where only one of them is working from home. The same situation occurs in the case of the 2-bed housing, which is more appropriate for 2 residents. As regards exercise, the lack of an appropriately sized terrace (A, B, C) meant the dining room or a bedroom had to be converted into a gymnasium. However, in Case of D, if they did have a large enough terrace, the users also used the dining room to exercise, as it was larger.

Table 1. Objective indicators.

Study case	**A**	**C**	**D**	**B**
				
Neighbourhood Height	Haza del Campillo B+4	Molinillo B+5	Torre del Mar B+6	Los Viveros B+2
Orientation	North	North	Northeast	East
S_i (m2) Indoor surface area	40	48	67	70
Number of rooms (N)	1	2	2	3
S_o (m2) Outdoor surface area	-	8	15	2.7
Number of balconies Number of terraces	- -	- 2	1 -	- 1
Number of residents (R)	2	3	2	2
S_i/R (m2)	20	16	33	35
N/R	0.50	0.66	1.00	1.50
S_o/R	0.00	2.66	7.50	1.35
Resident age	26 – 27	49 – 51 – 23	34 – 27	24 – 27
Number of residents in WFM	2	1	0	1
Pop-up office	Living room	Living room	-	Bedroom
Number of residents exercising	2	1	2	1
Exercise space	Living room	Bedroom	Terrace / Bedroom	Living room

As regards the indoor environmental conditions, the results in table 2 indicate a greater need for natural light and less thermal comfort for the case of north-facing buildings (A, C, D), while there was a greater sense of light in the dual-aspect Case B; furthermore, the users were aware of very little noise due to the lack of mobility during the pandemic. As far as the outdoor environmental conditions were concerned, the owners' answers also stressed the need to have a terrace of a functional size, larger than the 6 m^2 proposed by Bettaieb & Alsabban (2020), and of a shape that makes it easier for activities, according to the standards of Gupta (2019). It is almost a psychological need to avoid the feeling of confinement. The existing balconies are very limited as they are used for hanging out washing or even as storage. In Case C, there are terraces large enough for furniture for the space to be used; however, as those terraces are nearly exclusively north facing and have no sunlight, space was not very pleasant and ended up not being used. In this regard, the terrace in Case D is sufficiently large to comfortably hold furniture and was used. Furthermore, even though it is also north-facing, it has views over the sea, which makes it a pleasant spot.

Table 2. Subjective indicators.

QUESTIONS		A	C	D	B
Positive characteristics of current home	Indoor	All rooms with openings outside	The large and well-lit main bedroom	Good surface and distribution	A great deal of light
	Outdoor	-	Has terrace	Enjoyable outdoor space	-
Negative characteristics of current home	Indoor	Small home: all activities in one single room	The temperature is not very comfortable, particularly in the kitchen	Lack of light. Bathrooms do not have windows	Temperature not very comfortable year-round
	Outdoor	No outdoor space	-	-	-
What aspects would you change of your home to make lockdown more bearable?	Indoor	Would add another room or extend the existing one, to create another workspace (currently, both work in the same space and it is very inconvenient). A larger kitchen	More natural light, to avoid feeling locked in	Bathrooms with natural ventilation. Combine the kitchen and living room to have one larger room	-
	Outdoor	Include an outdoor space to avoid feeling locked in	Larger outdoor space on the terrace or on the roof of the building, large enough to exercise	Better distribution of the outdoor space for better use	More outdoor space, to be able to get fresh air or exercise outside

4. Discussion and Conclusion

The results of this study (Table 3) coincide with current papers considering the problem of lockdown during the pandemic. Specifically, the comparison of housing units under 60 m^2 with those exceeding this standard not only confirms the results of Amerio et al. (2020) but also complements them in three aspects, which are detailed below. The first is the inclusion of orientation as a factor influencing environmental conditions. In our study, housing units facing north are a negative factor in the perception of thermal conditions and lighting. An aspect that is not reflected in the study by Cuerdo-Vilches et al. (2020), and which also goes beyond the consideration regarding an appropriate sizing of the window proposed by Bettaieb & Alsabban (2020). As regards the built housing stock, the orientation of a housing unit is a variable that cannot be modified, which makes this indicator a negative factor to be considered in the resilience of the housing during lockdown periods, to avoid such a type of housing.

The second is remote working, the case studies of small housing show that the housing extensions suggested by Gurstein (2001) and Magee (2000) to incorporate this function are

not possible. Therefore, WFH is possible in appropriate conditions where there is a room converted into an office for each user working in the housing unit, i.e., those that originally were oversized in relation to the number of people living there, and when a room had already been converted into an office before the pandemic (Cases D and B). The results are, therefore, in keeping with Nanda et al. (2021) who opted for a relationship between the number of rooms and the number of residents over 1. This is even greater than the need for a balcony for the flats, which is only considered a demand on the rise. However, in contrast with Bettaieb & Alsabban (2020), Cuerdo-Vilches et al. (2020) and Nanda et al. (2021), we do not consider high levels of space flexibility to be necessary, as most of the case studies had the same or a greater number of rooms than the users.

The third is concerning the terraces and balconies. Our results also coincide with Cuerdo-Vilches et al., (2020) and Bettaieb & Alsabban (2020) in that they are the most sought-after spaces and, along with the dining room, the spaces most used for exercise. However, unlike the above authors, this study also stresses the need for an appropriate orientation and quality views. Continuous balconies are the ones that work best and an exercise circuit can be set up if they provide a continuous flow with the home. In this regard, tourist housing offered a better response to the COVID-19 lockdown, as they usually have a large surface area of terraces-solariums design, better landscape visuals, and communal areas with swimming pools and/or landscaped areas. Land availability even means that extensions of the building can be envisaged (Case D).

If we analyse some examples of contemporary architecture, we find two examples that may be relevant. The first is the project to transform *Bois-le-Prêtre* tower (2005-2011) by Druot, Lacaton & Vassal, where a winter garden was attached to the existing façade connected to most of the rooms (Tostões & Silva, 2020). It is a glazed transition space between the main part of the house and the balcony that can be used by the users as an office or exercise area during stay-at-home lockdowns. However, this type of solution is only possible in blocks of flats hath have free areas for growth. The second example is the design of the Huerta Tower, by the MVRDV Studio, as part of the Sociopolis project (Valencia, Spain), where each housing unit has a large cantilever terrace. A design that the architecture team had already tested at the WoZoCo (Amsterdam, Netherlands).

Table 3. Conclusion and assessment of indicators.

	A	C	D	B
INDOOR SPACE				
Dimension S_i > 60 m²	-	-	+	+
Room for remote working	-	-	+	+
Orientation	North	North	Northeast	East-northeast
Sufficient natural lighting	-	-	-	+
Thermal insulation	+	-	+	-
Noise insulation	+	+	+	+
Views	Inner court	Street	Street Green area	Inner court Street
OUTDOOR SPACE				
Typology	-	Balcony	Terrace	Balcony
Surface > 6 m2	-	-	+	-
Assessment	-	Inadequate	Enough	Inadequate
Use	-	clothes horse	Sport	clothes horse
Activity level	-	Low	High	Low

According to the obtained results, there is an obvious need for the social housing standard to be reviewed by the Administration and other legislators (Cuerdo-Vilches et al., 2020; Madeddu & Clifford, 2021): an adequate orientation for the sun is required (banning just north-facing), the number of rooms adjusted to the number of persons (1 room per person) (Nanda et al., 2021) and terraces included (not just balconies) over 6 m² in size and suitable to facilitate activities (Bettaieb & Alsabban, 2020) and avoiding north facing. Guidelines that should be included in refurbishing policies and for new housing developments.

Given that the limitations of this study are focused on childless couples or with an adult offspring, future research should analyse the case of large families with small children, along

with assessing the impact of lockdown on different types of architecture. It would also be relevant to go further into the role of tourist housing as a positive habitat for lockdown and the doors that those designs open for the remote working city.

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Conflict of interests
The authors declare no conflict of interest.

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Original scientific paper

The Role of "Scale" on the Acceleration of Social Interaction in Urban Spaces

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ABSTRACT

Rehabilitation projects are interventions that can lead to the transformation of the socio-spatial structure of obsolescent neighborhoods. The main intention of such projects is the creation and/or improvement of social interactions after physical and functional interventions. Urban Renewal Organization of Tehran (UROT) is tasked with identification of target obsolescent neighborhoods, preparation of neighborhood development plans and implementation of rehabilitation projects to improve the quality of space and stimulate social interactions. In this paper, three urban spaces in different scales ("micro" for neighborhoods, "meso" for local and "macro" for trans-local scales), designed and implemented by UROT, were selected as a case study. By designing and filling a questionnaire and after analyzing research findings, the effect of the scale of the urban project on different activities was evaluated based on the Gehl model. Overall, in the expanded model based on the scale of space, an inverse ratio between the scale of space and both optional selective and social activities has been revealed.

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1. Introduction

Obsolescent neighborhoods are considered as a part of urban structure in which poverty, deprivation, and failure of urban planning-management schemes have led to problems such as deteriorated buildings, service shortages and functional-physical ineffectiveness amongst others. These problems, in a chain process, intensify the obsolescence of local space and reduce the livability in neighborhood. One of the significant problems of Tehran's Obsolescent neighborhoods is the lack of public spaces for social activities and interaction, which in turn

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weakens the relationship between local community members and their neighborhood. Public spaces are essential elements of the quality of life for cities and urban districts and provide public infrastructures and facilities for them (Duivenvoorden et al., 2021). Urban public spaces are areas where urban residents can engage in their daily life activities and participate in social interactions. In an urban public space, people can involve in various activities, communicate with each other, and share experiences (Ji & Ding, 2021).

The quality of life in urban spaces is the consequence of the relationship between the user and the space (Das, 2008). Urban spaces will function properly if they can operate as attractive places for social interaction. Since UROT regards urban public spaces as a platform for establishing social interactions, it employs the capacity of the Neighborhood Development Offices' (NDOs)[1] in the renewal process to that end. Accordingly, UROT has identified specific locations for the creation of public spaces. Hence, to find out about the causes of both strengths and weaknesses of urban spaces, it is necessary to examine these public spaces and evaluate their social effectiveness. In this article, three urban spaces have been considered and investigated as the case study. The selection was based on the case studies' distinct physical, functional and operational attributes in neighborhood, local, and trans-local scales.

The quality of space includes its social environment, civic traditions, cultural facilities, and recreational opportunities. Moreover, public space can be described as well-functioning if it contains physical qualities and semantic features and also encourages social interactions. This place presents as a brand for users and visitors (Reilly & Renski, 2008). Enhancing social interactions and a sense of community by providing comfortable, attractive and active streets, open spaces and parks which embed social networks, urban interactions, personal revitalization and other activities that create social bonds between individuals and groups are notable points in neighborhood development (Dunenberg et al., 2016).

Physical public space embodies struggles between different ideologies, discourses, political decisions and routine activities taking place at personal, interpersonal, local, national, supranational, and global scales (Sadri, 2017). Pertaining to this, the principal aim of this paper is to investigate the importance of the functional scale of urban space in the quality of the relationship between users and space and also its effect on users' satisfaction.

2. Social interaction in urban spaces

Urban public spaces as natural or built environments include streets, squares, public paths (in commercial areas and residential neighborhoods), open spaces, parks, and public-private spaces easily accessible for most people at certain hours of the day (Rafieian & Asgari, 2000). Oldenburg considers "Third Places" next to homes and workplaces that host voluntary gatherings of individuals as a special form of public space (Oldenburg, 1989). Urban public spaces, as much as they are a way forward in the development of social justice, could be a factor for deepening social inequalities if not carefully planned and designed (Rafieian & Asgari, 2000). One of the approaches considered to revive the social life in obsolescent neighborhoods in recent years is the enhancement of their public spaces. Recent studies provide new evidence on the relationship between urban vitality and social cohesion in terms of: first, the role of the built environment in urban vitality; second, the role of the built environment in social cohesion; and third, the links between urban vitality and social cohesion (Mouratidis & Poortinga, 2020). According to Lang, patterns of social interaction have particular importance in urban public spaces. A study of more than one thousand urban public spaces in different parts of the world indicates that four basic factors have leading roles in measuring the quality of urban public spaces; namely accessibility and interconnectedness, comfort and quality of landscape, usage and activities, and sociability (Ghaed Rahmati et al., 2018).

3. Different levels of social interaction

In numerous publications, the urban spaces have been evaluated based on diverse models and various socio-spatial indicators. Gehl (2011), considering activity as the most

[1] NDOs are local departments in obsolescent neighborhoods which are established by UROT to facilitate the renewal process. For more information about NDOs, look at (Hajialiakbari, 2020).

critical factor of efficacy in urban space, defines social activity as a situation in which two people are simultaneously in one specific place, although the purpose of being with each other might vary. The meeting is somehow represented as a seed for inclusive forms of social activity (Hussein, 2018). Social activities are all activities that depend on the presence of "others" in public spaces. They can include greetings, discussions between people and routine activities of all kinds, as well as passive contacts like watching and hearing others (Zerouati & Bellal, 2020). Recognizing the relationships that community members have with their homes, surrounding spaces and neighborhood is becoming increasingly important as designers and city governments seek responsive and equitable design practices and management strategies (Klein et al., 2021).

These activities take place only when exterior conditions like weather and quality of place are suitable. This relationship is particularly crucial in physical planning because most of the pleasant recreational activities to pursue outdoors are found precisely in this category of activities. These activities are especially reliant on exterior physical conditions (Gehl, 2011) and can be classified into three categories:

A) **Necessary functional activities**: These activities occur under any circumstances and regardless of physical qualities because people are forced to do them. Some examples are crossing the streets, going to school and workplace, etc.;
B) **Optional selective activities**: These activities are sensitive to the quality of space and occur only if there is an attractive and inviting place;
C) **Social activities**: Activities that occur only when people are present in the space, such as watching, listening, meeting others, and active or inactive participation in the environment. Based on this group of activities, the concept of vitality can be delineated. A vital public space is a place that the presence of a significant number of people with diverse conditions (age, gender, etc.) engaging in mainly selective or social activities can be seen in wide periods of time.

According to Gehl's Model (Figure 1), different levels of activities may occur in public spaces, which can be regarded as an indicator of success in meeting users' needs. Based on this model, the existence of necessary and optional activities in urban spaces contributes to an increase in social activities, although the level of each category of activities is related to the scale of space. This paper expands Gehl's model based on the functional scale of urban spaces (in three case studies). Based on the aforementioned model, some criteria for functions of the spaces have been selected (Figure 2) and then, a questionnaire was designed to evaluate the quality of spaces for the aim of this paper.

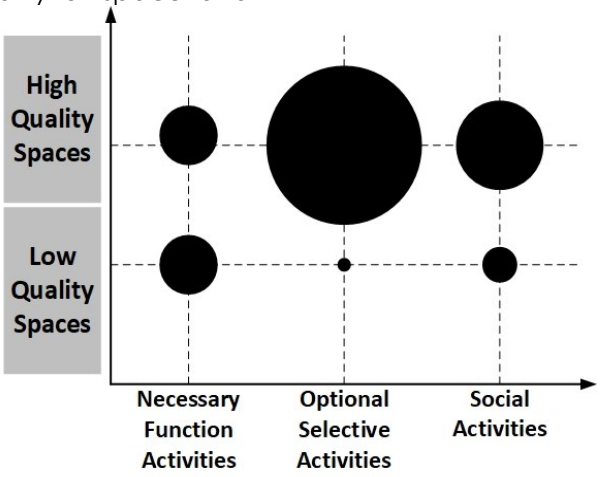

Figure 1. The impact of space quality on different activities (Gehl, 2011) .

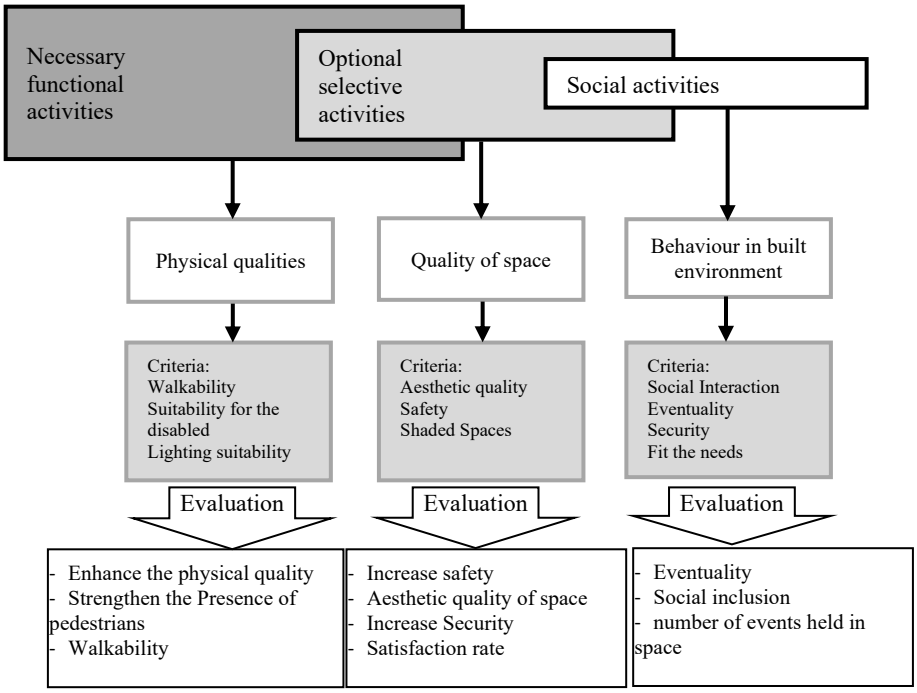

Figure 2. Conceptual model of the study.

4. Different scales of social interaction in case studies

Urban spaces prompt different behavioral reactions in users based on their functional scale. The presence of people in neighborhood-scale urban spaces which have pre-existing social relations in addition to familiarity with the spatial structure of the environment will be different from the urban spaces where users are from other neighborhoods.

The urban space projects that have been defined by UROT are mainly focused on obsolescent neighborhoods. According to the recognition of the neighborhoods' structure and diagnosis of their key weaknesses, UROT has undertaken physical interventions in public areas. These projects are based on the neighborhoods' social structure and service per capita status. Hence, several rehabilitation projects have been put into operation of which, three projects with different scales (neighborhood, local, and trans-local) have been selected for the aim of this paper. In the following part, the case studies' characteristics, methods of intervention and the satisfaction level of residents are presented.

4.1 Simin Neighborhood Centre (micro-scale)

"Simin neighborhood Centre" has been selected to compensate for the lack of public space, provide a playground for children, increase the possibility of public participation in neighborhood, create a sense of belonging and organize an abandoned land in "Anbar-Naft neighborhood" in District 11 of Tehran. The project had an area of 400 square meters. Despite the appropriate potential, it has been abandoned; because the residents believed that while installing furniture, facilities, and equipment, an unsafe place would be created (Figure 3). However, based on the initial studies and negotiation with local community members, UROT decided to plan a safe and secure space that suits families and residents. To appraise the local community's needs and become acquainted with the intervention area, relevant information and opinions of citizens, officials and experts were elicited through questionnaires and face-to-face interviews; the results of which were considered as the main element in the design process.

Figure 3. Pre-intervention status of Simin neighborhood centre.

Figure 4. Simin neighborhood, proposed plan (Down), after implementation (Top).

A field study of the problems in the intervention area indicated that the major issues were low levels of security (25%), lack of green spaces and inappropriate use of the space as a parking lot (27%); and environmental pollution (40%). Due to the poverty of the residents and inappropriate physical quality of the Anbar-Naft neighborhood, many primitive residents have left neighborhood, and current residents showed low levels of sense of belonging. These circumstances led to a lack of social integrity. In the status quo, the use of behavioral patterns in the space are related to the parameters of time and place; it means the least activity was observed before the afternoon, and after 4 pm, most behavioral patterns occurred in the form of a group sitting and children playing. In this small and micro-scale space, an attempt was made to make the best use of the space according to the needs of residents. For this reason, the intervention focused on re-organization of the space, improvement of the green spaces and creation of several places for neighbours to gather and children to play (Figure 4).

4.2 Shirin-Dokht local space (meso-scale)

Shirin-Dokht intervention area covers 2700 square meters in the "Minabi neighborhood" in District 15 of Tehran. The area is the result of buying and merging 36 parcels in an obsolescent neighborhood by UROT in the previous decade which had been abandoned for many years (Figure 5). According to the interviews and surveys, residents classified their social problems into three groups: low levels of security, migration of primitive residents, and occurrence of disturbing activities within the residential neighborhood. They referred to the numerous indefensible spaces in the neighborhood as the basis for the presence of addicted persons and the main reason for unsafety. Also, the lack of sewage collection network, visual disorder and stench caused by garbage was a source of dissatisfaction among residents.

Figure 5. Shirin-Dokht local space, pre-intervention status (Down), intervention area site plan (Top).

In Shirin-Dokht case, local public space played a unique role in increasing the quality of the environment and improving the living standards of inhabitants. This role was performed by creating a spatial opening versus the dense context of the Minabi neighborhood and also by providing some of the necessary local service amenities of the neighborhood (Figure 6). According to a survey of citizens, solving security problems, creating an attractive and inclusive space for different age groups, providing a place for holding rituals and other gatherings, offering some of the neighborhood's recreational and cultural facilities and making a place for were requested. Therefore, elimination of non-observable corners, construction of playgrounds, provision of appropriate lighting, prevention of vehicles from entering the space, creation of visual diversity by using various colors, and construction of a building to organize vocational training and entrepreneurship courses were considered in the planning process.

Figure 6. Proposed plan (Down), after implementation (Top).

4.3 Amir-Kabir Plaza (macro-scale)

Amir-Kabir Plaza, with an area of 8500 square meters, is located in the "Shokoofe neighborhood" in District 14 of Tehran. The site was supposed to be a commercial complex. However, because of to the high density of population and buildings in the neighborhood and lack of any open spaces, additional studies were conducted and fundamental changes were made in the intervention plan. Hence, by allocating the area to an urban space, the prerequisite for the presence of citizens was provided. Moreover, part of the area was determined for the provision of necessary sport and cultural amenities (Figure 7).

Figure 7. Planning area, before the intervention.

In the Amir-Kabir Plaza project, a gross area of 1400 square meters was allocated to the construction of four buildings for cultural, sport, and recreational activities. In addition, 7,000 square meters open space was provided for diverse groups of users, in which various social events can be held (Figure 8).

Figure 8. After implementation (Top), proposed plan (Down).

5. Findings

Analysis of the interviews and questionnaires shows that the time and duration of citizens' presence in urban spaces varies and is dependent on the functional scale of the projects. For instance, in neighborhood-scale projects users tend to stay longer in space (80%) in comparison with trans-local spaces (69%). Furthermore, results indicate that the length of users' presence in the space is directly influenced by the type of activities in the space. For example, children spend more time in a space where the playing equipment is available.

One of the criteria evaluated in this paper is the level of satisfaction of users from spaces in different scales. Researchers rate the satisfaction in three scales by the criteria such as satisfaction from the quality of implementation, ease of walking, security of space especially for the presence of women and children, the capability for hosting public and participatory events, visual quality of the landscape and attention to the needs of users. These indicators were assessed through a questionnaire completed by 30 users in each project (90 in total).

Table 1. Evaluation of social interaction criteria in Simin, Shirin-Dokht, and Amir-Kabir cases.

Criteria	Simin Neighborhood					Shirin-Dokht Local Space					Amirkabir Plaza				
	Very High	High	Mean	Low	Very Low	Very High	High	Mean	Low	Very Low	Very High	High	Mean	Low	Very Low
Satisfaction rate	40%	50%	0%	5%	5%	4%	42%	12%	13%	29%	19%	28%	22%	9%	22%
Increase the quality of the environment	25%	60%	10%	0%	5%	13%	33%	33%	17%	4%	16%	25%	31%	16%	13%
Strengthen the presence of pedestrians	30%	50%	10%	10%	0%	13%	46%	8%	25%	8%	31%	38%	19%	9%	3%
Increase safety	25%	50%	10%	15%	0%	8%	46%	13%	25%	8%	41%	34%	13%	9%	3%
Social inclusion	55%	40%	5%	0%	0%	38%	29%	29%	4%	0%	41%	34%	22%	3%	0%
Eventuality	35%	35%	15%	5%	10%	25%	29%	17%	8%	21%	9%	28%	16%	31%	16%
Improve the visual quality of the environment	65%	35%	0%	0%	0%	33%	46%	4%	4%	13%	63%	19%	16%	3%	0%
walkability	25%	60%	10%	5%	0%	0%	0%	21%	58%	21%	6%	25%	22%	31%	16%
Increase environmental security	15%	50%	25%	5%	5%	8%	9%	25%	4%	54%	3%	28%	19%	31%	19%
Fits the needs of users	5%	30%	10%	45%	10%	21%	25%	16%	13%	25%	3%	16%	44%	22%	15%

The results show that the effectiveness of the intervention is related to the scale of projects. On neighborhood scale, the sense of belonging is more noticeable, which can be attributed to the past familiarity with the environment. On the neighborhood scale, the presence of women and children is considerably higher than in other projects, which shows a sense of security in the space. This result can also be concluded from analysis of the "increasing security" criterion. The evaluation of the "satisfaction rate" criterion also shows that despite more facilities in Shirin-Dokht and Amir-Kabir spaces, the satisfaction level in Simin is significantly higher than the others, which indicates the stronger connection between users and space.

Also, in evaluating the improvement of the visual qualities of the environment, the highest level of satisfaction is observed in the Simin project, which can be attributed to a stronger connection between users and the environment and more familiarity with neighborhood-scale space in comparison with projects on larger scales.

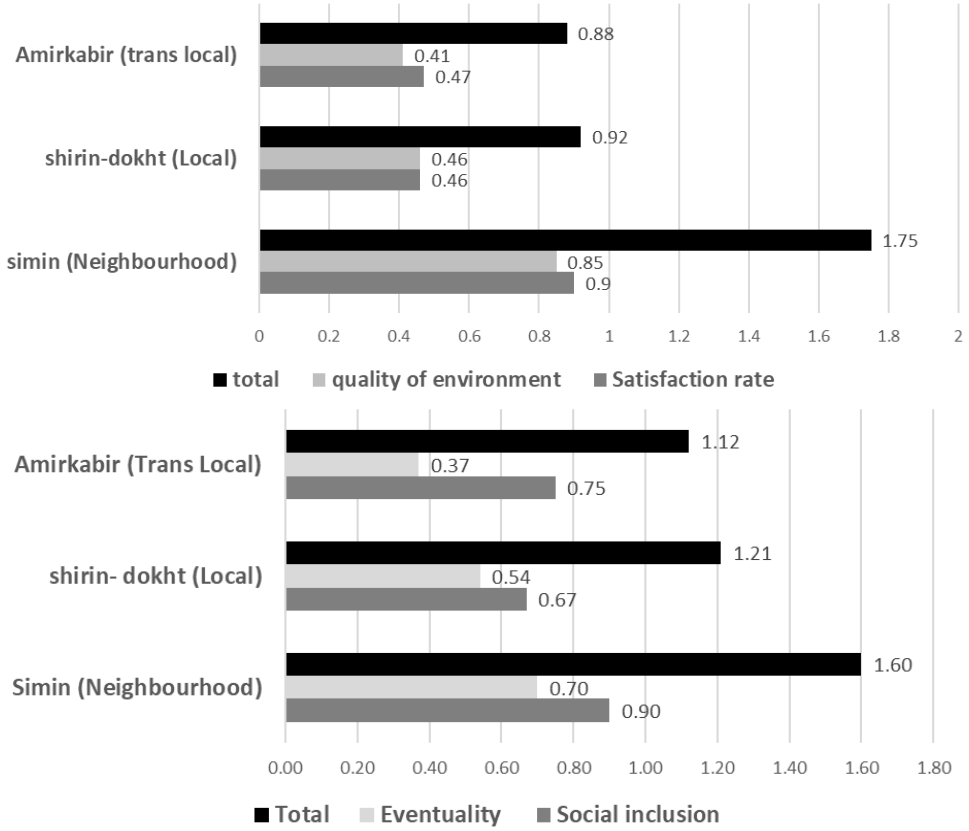

Figure 9. Tendency toward optional selective activities (Top) and tendency toward social activity in different urban spaces (Down) in different scales (Authors).

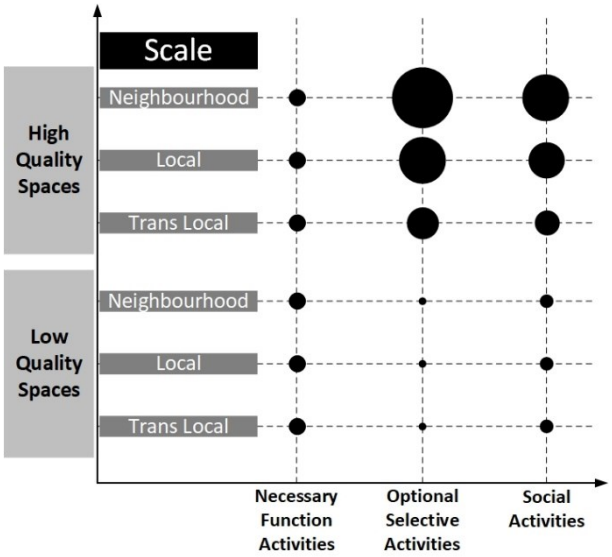

Figure 10. the impact of space quality on activities based on scales (Authors)

36% of users are not optimistic about the adaptation of the function of urban space with their needs at a trans-local scale; but there is 90% satisfaction rate in the neighborhood-scale project which is starkly in contrast with 47% and 46% satisfaction in trans-local and local-scale projects, respectively. The duration of users' presence at different hours of the day varies depending on the functional scale of each project. Results indicate that the time of users' presence in the space showed a direct relation with the functional scale of the space. Ultimately, the type of activities in space is also related to users' presence population.

6. Conclusion

In this paper, Gehl's model was expanded for urban spaces with different functional scales and the effects of scale on the efficacy of urban spaces was analyzed to be used as a tool in the prediction of the results of interventions. A review of the data that was obtained from the questionnaires and interviews indicated that there is an inverse relationship between the sense of belonging to the place and the project's functional scale. In addition, in the cases where there was a previous experience of the space by the users before the intervention, a stronger relationship between the new space and the users was recorded.

According to evaluated criteria on case studies and concerning the Gehl's model, two sorts of tendencies were observed: First, tendency toward optional selective activities, and second, tendency toward social activities. Subsequently, the relationship between functional scale of public spaces and tendency to different activities was evaluated. According to the results of questionnaires, "satisfaction rate" and "quality of the environment" were selected as the key criteria for evaluating optional selective activities in different scales, whereas "eventuality" and "social inclusion" were selected for the evaluation of social activities (figure 9). As the results show, the tendency to use space for both optional selected activities and social activities has a reverse ratio with the functional scale of space.

According to table 1 and the relationship between the promotions of space quality in neighborhood scale, improvement of the quality of space has a significant effect on optional selective and social activities. For instance, some criteria like "social inclusion" and "eventuality" which are directly related to social activities have shown significant growth in the Simin neighborhood, but have reduced in Shirin-Dokht and Amir-Kabir spaces. In this framework, the Gehl model was expanded base on the scale (figure 10). In the expanded model based on the scale of space, an inverse ratio between the scale of space and both optional selective and social activities is shown, in which reduction in the scale of space leads to an increase in the amount of optional and social activities.

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Conflict of interests

The authors declare no conflict of interest.

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Developing Design Criteria for Sustainable Urban Parks

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ABSTRACT

This study investigates how urban parks can contribute to helping cities become more sustainable through developing a set of criteria for the sustainable design of urban parks. Today, there is no example around the world where all the proposed sustainable design criteria are applied together in a specific urban park. In this context, this study aims to make a novel contribution by systematically reviewing the literature on the sustainable design of urban parks. In the light of research findings, this study contributes to the implementation of a comprehensive sustainable park design practice in our cities in the future. These design criteria may further serve as performance indicators to offer information and know-how to local authorities, practitioners, communities, and other actors in this field to help them assess their success levels and progress over time.

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1. Introduction

Globalization and the ever-growing population have been a threat to resource sustainability since the 1950s, as these two factors have introduced drastic changes in the structure of ecosystems and their services. Wasting renewable resources, causing climate change, and producing pollution now more than ever, humans have gone way beyond the Earth's carrying capacity. United Nations Sustainable Development Goals Report (2020) suggests that higher than 39 million people have now been affected by climate change, facing the consequences like disrupted livelihoods, economic losses, and even death. The report indicates that one-fifth of the Earth's surface area (over 2 billion hectares) is now degraded lands. The acidification in oceans is expected to increase up to 100-150% by the

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end of this century, and accordingly, half of the entire marine life will be affected. The annual deforestation rate was estimated to be 10 million hectares between the years 2015 and 2020. Over the last three decades, the risk of extinction for species has deteriorated by approximately 10%. The alarming decrease of the world's forest areas continues at an unprecedented rate, and several species face the threat of extinction.

The COVID-19 outbreak imposed several negative impacts on the progress of Sustainable Development Goals (SDGs). The estimates indicate that the pandemic exacerbated poverty and hunger due to labour losses and food shortages during the worldwide lockdowns (Sachs et al., 2020). The pandemic has shown the importance of urban planning in improving public health and reducing the public's vulnerability to other threats like natural disasters. Preventing infection and arresting the spread of the virus necessitate taking urgent actions to improve access to water, sanitation, and hygiene services. Long-term mobility plans should be put into effect for improving access to public transport systems well-integrated with walking and cycling networks. Demand for open public areas increases even further with cities on lockdown. As the outbreak progresses, urban administrations are required to put new policies and strategies into practice to manage and alleviate the heightened risk of COVID-19 transmission and reconstruct resilient and sustainable cities in a post-COVID-19 environment.

Urban green spaces have begun gaining renewed attention during the COVID-19 pandemic. As has been confirmed by several studies so far, the COVID-19 pandemic has urged people to reconsider the significance of urban green spaces (Rice and Pan, 2020; Hockings et al., 2020; Ugolini et al., 2020; Samuelsson et al., 2020). According to the study carried out by Derks et al. (2020), the number of visits made to forests during the lockdowns in Germany has seen an incredible increase. A study conducted by Geng et al. (2021) has focused on analysing the effects produced by the epidemic and the policies made by governments to manage the outbreak in terms of park visits on global, national, and regional scales. Results of this study indicated that the number of visits made to parks had gone up since February 16, 2020, compared to the number of visits paid to parks before the outbreak. The increase in park visits correlates with the constraints imposed on social events, gatherings, social mobility, the closing of workplaces, and indoor places where recreational activities are carried out. A study conducted by Grima et al. (2020) has focused on evaluating the significance of urban and peri-urban forests, woodlands, and various other natural locations for urbanites and suburbanites of Burlington, Vermont, USA. These areas were substantial for the people for a great variety of recreational activities, including exercising, bonding with nature, finding tranquillity and quiet, walking dogs, spending time with children, and bird watching. Accordingly, this takes us to the critical point; the significance of urban parks for maintaining a healthy urban environment is on the rise for people of all ages.

Urban parks, offering several environmental, economic, and social advantages, serve various purposes in the city. They are a valuable resource in designing sustainable cities. This research aims to investigate how urban parks can contribute to helping cities become more sustainable. The aim of this research is supported by the following research objectives: (1) defining a sustainable city and its design principles; (2) outlining the role of urban parks as part of the green infrastructure of the city, and; (3) establishing a set of criteria for the sustainable design of urban parks. For this purpose, a systematic literature review has been performed in this study. As illustrated in Figure 1, the steps for conducting a systematic literature review consist of: (1) formulating the research aim and objectives; (2) searching databases for literature; (3) evaluating the selected relevant studies; (4) analysing and synthesising the findings, and; (5) writing the research results. This paper consists of four sections: The background and introduction to the study are provided in Section 1. The research methodology is introduced in Section 2. Moreover, the concept of sustainability and sustainable development, along with the design of a sustainable city, is disclosed in this section. Section 3 outlines the sustainable design criteria of urban parks in addition to the environmental, social, and economic benefits thereof. In conclusion, a summary and some concluding statements are provided in Section 4.

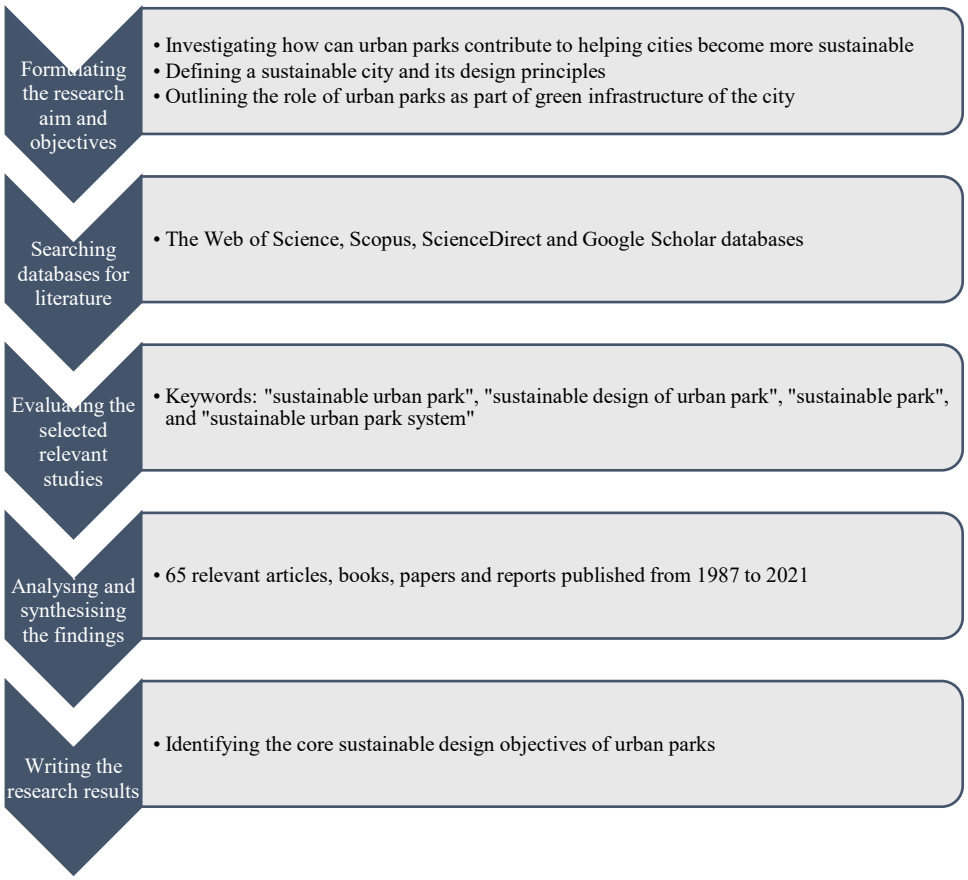

Figure 1. Methodology of the Research.

2. Materials and Methods

In this study, a systematic literature review was carried out to identify and develop sustainable design criteria for urban parks. The literature on sustainable urban parks was reviewed extensively during the development process of the design criteria based on international literature review and analysis of "grey" literature. The Web of Science, Scopus, ScienceDirect, and Google Scholar databases were utilized for searching published and peer-reviewed literature. Keywords like "sustainable urban park", "sustainable design of urban park", "sustainable park", and "sustainable urban park system" were used for the searches conducted in the literature. Sixty-five relevant articles, books, papers, and reports published from 1987 to 2021 were selected using these keywords. Additionally, to devise the search criteria, ten core sustainable design objectives of urban parks were defined, which are: (1) providing the green infrastructure; (2) creating a place for people of all ages; (3) building connected park systems within walking distance, (4) implementing water and energy conservation practices; (5) waste management; (6) promoting access to fresh, healthy, and low-cost food; (7) supporting and preserving biodiversity, (8) environmental education and stewardship through hands-on activities; (9) ensuring the long-term maintenance and management of the park, and; (10) supporting disaster resilience.

2.1 The Concept of Sustainability and Sustainable Development

Sustainability, as a concept, emerged in the early 1970s as an answer to concerns growing about the impact of urban development on resource use. In the book "The Ecology of Commerce: A Declaration of Sustainability" (1993, p.139), Paul Hawken expresses sustainability as a manifesto to overcome

destructive human actions: "*Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make compensations if you do*". In 1972, The United Nations Stockholm Conference on the Human Environment, having issued a declaration to emphasize concerns about environmental protection on an international scale, sparked a debate on the concept of sustainability. The United Nations, to develop a global agenda on resource conservation, formed the World Commission on Environment and Development in 1983. The commission issued a Brundtland report, and the term 'sustainable development' was first introduced in the report Our Common Future (WCED, 1987, p.43): "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The United Nations Conference on Environment and Development also went as Rio Earth Summit, which was organized in 1992. Agenda 21, having been set forth as a result of the Rio Conference, provided an action scheme for sustainable development. The World Summit on Sustainable Development was organized in Johannesburg in 2002 to evaluate the ground covered since the Rio Conference witnessed several discussions on the global difficulties encountered in connection with the preservation of natural resources, poverty eradication, sustainable consumption, and development of a productive and healthy life.

Since then, there has been a considerable amount of research conducted to identify sustainable development. Girardet (2004, p.6) modified the Brundtland Commission definition of sustainable development: "*A city that enables all its citizens to meet their own needs and to improve their well-being, without degrading the natural planet or the lives of other people, now or in the future*". A more comprehensive definition is developed by Roosa (2010, p.44): "*Sustainable development is the ability of physical development and environmental impacts to endure long term habitation on the planet Earth by human and other indigenous species while providing: (1) an opportunity for environmentally safe, ecologically appropriate physical development; (2) efficient use of natural resources; (3) a framework which allows improvement of the human condition and equal opportunity for current and future generations, and; (4) manageable urban growth*". Moreover, there are many descriptions of sustainable development exist in the literature (Wheeler and Beatley, 2004; Baker and Eckerberg, 2008; Clini et al., 2008; Ukaga et al., 2010; Weinstein and Turner, 2012; Sachs, 2015; Breuer et al., 2019; Dalby et al., 2019; Idowu et al., 2020).

The 2030 Agenda for Sustainable Development issued in 2015 introduced 17 goals and 169 targets to achieve worldwide sustainable development by 2030 (United Nations, 2015). From eliminating poverty and hunger to improving education and health, and reducing inequality, and combating climate change, 17 Sustainable Development Goals comprise a large spectrum of issues. The aim of Goal 11: "*Sustainable Cities and Communities*" among these Sustainable Development Goals is to make cities and human settlements more inclusive, secure, resilient, and sustainable. Goal 11 consists of 10 targets: (1) providing everyone access to sufficient, secure, and accessible housing and essential services; (2) providing everyone gain access to secure, accessible, affordable and sustainable transportation systems; (3) enhancing comprehensive and sustainable urban development and capacity for participative and integrated planning; (4) fortifying efforts for protecting and safeguarding cultural and natural heritage; (5) providing resilience against natural disasters; (6) minimizing urbanization's impact on the environment; (7) offering universal access to secure, comprehensive, and accessible public green spaces; (8) promoting constructive economic, social, and environmental bonds between rural, peri-urban and urban areas; (9) pursuing and carrying out integrated policies and plans for inclusion, the efficacy of resources, alleviation of climate change, and; (10) providing financial and technical support for the purpose of constructing sustainable and resilient buildings.

2.2 Designing a Sustainable City

Over the past few years, several cities have started pilot projects to implement sustainable practices and policies such as BedZED (Beddington Zero Energy Development), London; Bo01, Malmö; Christie Walk Eco-Village Project, Adelaide; Hammarby Sjöstad, Stockholm; Model City (MoMa), Mannheim;

ZAC De Bonne, Grenoble; Vauban, Freiburg, and Lombok, Utrecht. Furthermore, many rating tools have been introduced, such as SITES (Sustainable Sites Initiative), LEED (Leadership in Energy and Environmental Design), STAR (Sustainability Tools for Assessment and Rating System), BREEAM (Building Research Establishment Environmental Assessment Method), CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), Green Globes and Green Star to address environmental issues on various geographical scales and track progress towards SDGs. From the examples given above, numerous different sets of principles have been developed to guide the sustainable design of a city. According to ICLEI Local Governments for Sustainability (2021), a sustainable city is defined as: "*building a city with an ecologically, socially and economically healthy as well as resilient habitat for existing populations, without bargaining the ability of future generations to experience the same*". Even though the sustainable city has been identified with different criteria and prominences by many scholars (Jenks and Dempsey, 2005; Newman and Jennings, 2008; Blanco & Mazmanian, 2015; Gardner et al., 2016; Bishop, 2017; Cohen, 2018; Wang et al., 2019), its primary goal is to promote and facilitate the long-term well-being of people and the planet, through effective use of natural resources and management of wastes while enhancing liveability through economic prosperity and social well-being within a city (Newman, 1999).

Designing sustainable cities comprises four extensive policy areas, including ecological integrity, social well-being, economic welfare, and good governance (United Nations, 2013). In this context, ecological integrity implies safeguarding biological diversity and conserving fundamental processes of ecology and systems of life support. Social well-being indicates enhancing the welfare of citizens through social impartiality, namely, providing complete access to utilities, including education, healthcare services, transportation, housing, and recreational activities. Economic welfare involves effectively distributing resources, goods, and services to provide for the needs of people living in the present and potential communities. Good governance implies consolidating democratic institutions at every level to ensure transparency and responsibility in terms of governance and inclusionary participation in making decisions (Dizdaroglu, 2017). It is possible to outline the strategies for designing sustainable cities under the main titles as given below:

Sustainable urban design aims to ensure that natural processes that support life stay intact and keep working along with initiatives aspiring after enhancing individual life quality and public welfare.

Sustainable transportation refers to the capability of meeting society's needs for mobility with minimal damage to both the environment and to the mobility needs of the next generations.

Sustainable use and supervision of natural resources aim to minimize the overall waste generation by employing waste prevention initiatives, ensuring improved resource efficiency, and promoting the shift to more sustainable patterns in production and consumption.

A socially inclusive community is one in which all members of the community are accepted, their differences are acknowledged, and their fundamental needs are fulfilled so that they can live in dignity.

A sustainable economy can offer the best opportunities for general well-being by utilizing the least number of resources and causing the least possible harm to the environment.

Educating for sustainable development is a strategy that intends to prepare and improve students, schools, and societies under the ideals and inspiration serving as an impetus to conduct people to behave in favour of sustainability in their personal lives and communities, and on a global scale, both now and in the future.

3. Developing Design Criteria for Sustainable Urban Parks

In the struggle against climate change and degradation of the environment, the concept of green infrastructure comes into importance as a crucial solution. Urban parks, an essential component of green infrastructure and predominantly covered by vegetation are identified as both public and private open areas encouraging active or passive recreational and sports activities or indirectly creating a positive impact on the urban environment accessible by citizens (Baycan-Levent et al., 2003). Urban parks make

significant contributions to sustainable city designs by providing a range of environmental, social, and economic benefits. In terms of environmental benefits, urban parks offer cooler ambient temperatures compared to surrounding areas. Since pollutant emissions are generally associated with ambient temperatures (e.g., evaporation of volatile organic compounds), cooler ambient temperatures may help reducing pollutant emissions. Urban parks that offer conditions similar to forests are capable of improving carbon storage in time as the net amount of carbon can build up in the soil together with carbon reserved in trees. Additionally, urban parks make contributions to the management of stormwater with an emphasis on increased rates of water runoff in green urban spaces relative to other uses of urban lands. Urban parks have a significant influence on reducing noise. They have the capability of reducing environmental health risks stemming from urban life (Brown and Grant, 2005; Pauleit et al., 2005; Brown et al., 2015; Yan et al., 2018; Aram et al., 2019). Furthermore, urban parks are crucial for maintaining biodiversity in cities. As reported by several researchers, urban parks may serve as especially valuable hotspots for maintaining biodiversity in the urban landscape as they feature high habitat diversity levels as much as microhabitat heterogeneity (Öckinger et al., 2009; Carbo-Ramirez and Zuria, 2011; Tonietto et al., 2011; Oishi, 2012; Ksiazek et al., 2014; Parris et al., 2018; Filazzola et al., 2019; Wenzel et al., 2020; Turo, 2021).

When it comes to social benefits, urban parks create a positive effect on both physical and mental health as they encourage and increase physical activity, reduce stress, anxiety, depression in addition to improving self-respect, cognitive functions, and social behaviours of positive nature (Kaplan, 2001; Cohen at al., 2007; Akbar et al., 2010; Lee at al., 2011; Ward Thompson et al., 2012; Sandifer et al., 2015; Wood et al., 2017; Birch et al., 2020). Rather than being seen as an environment for recreation and relaxation, urban parks are considered an integral aspect of the development of a community. An urban park environment shared by various social and ethnic backgrounds may offer the citizens the opportunity to bond and communicate (Chiesura, 2004; Maas et al., 2009; Peters et al., 2010; Arnberger and Eder, 2012; Moulay et al., 2017). Moreover, urban parks serve as an education platform. Education on the environment advances citizens' knowledge and enhances their perception as much as their behaviour for creating a resilient environment and community. Urban parks are excellent for first-hand learning experiences. Next generations, having acquired knowledge and skills with the implementation of environmental conservation practices, will be encouraged and inspired as a result of helping children bond with nature through nature-based approaches (Varela-Candamio et al., 2018). With regards to economic benefits, urban parks render a city more attractive and make it a popular destination for tourists, thereby creating employment and generating revenue. Additionally, urban parks not only increase the value of real estate properties in close proximity but also improve tax revenues (Troy and Grove, 2008; Hoshino and Kuriyama, 2010; Bark et al., 2011).

The sustainable design of urban parks is one of the most successful approaches in addressing the environmental problems of urban spaces. According to Hermy (2011), sustainable urban park design, which in practice should require adapting to local conditions, utilizing natural processes, the continuation of park monitoring, and knowledge on the management of recreation, is the long-term maintenance of diverse ecosystems to ensure that they keep fulfilling their various roles in the future. Accordingly, the definition of a sustainable urban park should correspond to a place in which natural resources are preserved, wildlife habitat is further improved, and built such that it does not affect the ecosystem while serving people's leisure needs. In view of this definition, it may be concluded that a sustainable urban park promotes sustainable planning and management practices in the creation of a self-resilient landscape that utilizes the least amount of energy and that can respond to ever-changing circumstances. Urban parks have an important place in the minimization of adverse effects on the environment by; (1) providing green alternatives in transportation reducing carbon footprint; (2) enhancing the quality of air by means of increasing tree canopy; (3) decreasing power demand and landfill waste; (4) providing the green structure necessary for reducing stormwater runoff and flooding; (5) taking up natural resource management practices, thereby protecting

watersheds, and; (6) promoting sustainability through public engagement and education activities. Several strategies may be followed for planning a sustainable urban park (Figure 2):

- *Providing the green infrastructure:* Urban parks play an essential part in the improvement of a city's capability of adapting to extreme weather conditions alongside the impacts of climate change. Green infrastructure, necessary for resiliency to climate change, is provided by urban parks. The integration of the green structure into urban parks can create a variety of benefits, including lower surface temperatures, well-managed stormwater runoff, better air quality, new habitats for the local native fauna, and improved environmental health. Planting rain gardens accommodating native or adapted species, building bioswales, bioretention ponds, constructed wetlands, installing rainwater cisterns, and employing water permeable pavers are great examples of green infrastructure practices for urban park environments.
- *Creating a place for people of all ages:* Urban parks play an essential role in establishing a sense of community and social belonging. Bringing life to green spaces requires year-round utilization and events oriented toward individuals of all genders, cultures, and skills. Urban parks that are diverse, socially inclusive, accessible to everybody, and welcoming to all people of all ages and interests require an annual schedule consisting of various events and activities. Promoting physical activities for individuals of all ages and abilities, offering a wide variety of facilities (e.g., water fountains, clean, hygienic, and secure restrooms, informative signs), and designing comfortable sitting areas will result in a park that is capable of catering for everyone.
- *Building connected park systems within walking distance:* A well-designed system of urban parks provide citizens with secure, convenient, and efficient ways to get to and enjoy the parks. There is a variety of solutions that can be implemented to improve a park's connectivity and accessibility, such as creating a properly designed network of interconnected streets capable of accommodating walking pedestrians as well as cyclists, adopting strategies calming the traffic, providing a range of entry points to the park, and upgrading the park's entrances.
- *Implementing water and energy conservation practices:* Urban parks make significant contributions to water conservation. These contributions include but are not limited to; (1) providing support to the utilization of greywater and rainwater harvesting systems; (2) establishing smart irrigation systems (3); selecting water-wise plants; (4) utilizing water-permeable landscape materials; and (5) introducing green roofs and water features that are eco-friendly. Urban parks also contribute to energy conservation by means of; (1) promoting the utilization of renewable energy in the construction of urban lighting and furniture, (2) establishing sitting areas to enhance thermal comfort, and; (3) utilizing light-coloured solar-reflective roofing and paving materials.
- *Waste management:* Urban parks may also function as centres for recycling, allowing for composting of the solid waste created in the park. In addition, urban parks can further save energy and decrease the emission of greenhouse gasses by producing urban furniture, pavements, and walls from recycled materials.
- *Promoting access to fresh, healthy, and low-cost food:* Urban agriculture may be incorporated into urban park systems within the scope of the local and sustainable food production by utilizing community gardens with the aim of enhancing the nourishment and well-being of humans while also fostering social networks, education, and comprehension with regards to food.
- *Supporting and preserving biodiversity:* Urban Park systems accommodate the wildlife and flora by serving as a habitat. Performing the respective landscaping activities in consideration of the native plants provides a range of advantages. Native flora needs less upkeep as they are already adapted to the conditions of the local environment, are disease and insect-resistant and attract pollen carriers and accommodate wildlife. The emission of urban lights may be diminished during the night with the aim of preserving wildlife's migratory and breeding habits. To promote environmental interactions within an urban park, habitat steppingstones may be

created for the wildlife. Variation of the flora for food and shelter, birth baths, fountains and pools, nesting boxes, rocks, brush, and log piles, as well as bee walls and insect hotels are all among the recommended interventions for the habitat. Putting policies and regulations for preserving biodiversity offers security on various levels for safeguarding endangered and under threat species.

- *Environmental education and stewardship through hands-on activities:* Urban parks are the perfect locations for improving the residents' bond with nature and advancing their knowledge, comprehension, and appreciation of nature. Education on the environment advances citizens' knowledge and enhances their perception as much as their behaviour for creating a resilient environment and community. For instance, education on environment and guidance programs may include; (1) urban park activity programs like walks in nature and exercising programs outdoors; (2) voluntary works allow citizens to participate in routine activities and maintenance like cleaning, mowing grass, and planting; (3) educational school trips, after school activities, outdoor events on a seasonal basis for both the youth and children, and; (4) therapeutic landscapes and healing gardens for individuals who are challenged emotionally, physically, and mentally.
- *Ensuring the long-term maintenance and management of the park:* Management of an urban park is not limited to maintenance performed on a periodic basis. The first step to be taken in this regard is to adopt an integral and comprehensive point of view with respect to the definition of an urban park and the duties that the park staff should perform. This involves taking a strategic look at the available assets, deciding on the way these assets can be linked to the community and the way of finding new opportunities that may potentially promote engagement. One point to emphasize in this regard is that an area's residents and other stakeholders should be encouraged to participate and get involved both in the process and after making important decisions and introducing major changes. Efficient management of urban parks requires creating sustainable, inclusive community stewardship through forming partnerships between urban parks and local boards of trade, societies, local businesses, community centers, and other social institutions. Furthermore, non-profit groups that consist of people who are sincerely concerned about urban parks may campaign for introducing changes, plan fundraisers and special activities and events.
- *Supporting disaster resilience:* Urban parks should be designed to serve a variety of functions in consideration of emergencies to provide places for gathering, provisional shelters, food, water, waste management, radio broadcasting, and power. In addition to acting as self-contained centres, urban parks should also serve as part of a vast network that incorporates alternative connections and essential facilities like hospitals and emergency services.

Figure 2. Ten Core Sustainable Design Objectives of Urban Parks.

4. Conclusion

Extending the scope of the role assumed by urban parks as a component of the city's green infrastructure with the aim of overcoming difficulties in urban areas stemming from anthropogenic factors, sustainable urban parks have been a growing trend in recent decades. Sustainable urban park designs have been adopted and put into practice by many local governments. For instance, the New York City Department of Parks and Recreation published a 'Plan for Sustainable Practices within New York City Parks' with the aim of alleviating the city's impact on the environment by means of; (1) adopting sustainable practices in all the stages of urban park development; (2) establishing collection areas for recycling in order to provide assistance with effective waste management; (3) improving composting efficiency for leaves in urban parks; (4) creating sustainable landscape design; (5) creating a communicative bond between the employees of urban parks and citizens with education and outreach programs on education, and; (6) establishing indicators for sustainability with the aim of evaluating progress and focusing on strengths and areas require improvement. The City of Sacramento Department of Parks and Recreation initiated a 'Sustainability Plan' that focuses on nine specific areas, namely, climate protection, air quality, material resources, urban design, land use, green building & transportation, public health & nutrition, parks, open space & habitat conservation, energy conservation, water resources & flood protection and public involvement & personal responsibility along with goals and targets associated with the foregoing. The Pennsylvania Department of Conservation and Natural Resources published 'Creating Sustainable Community Parks and Landscapes Guidebook' to describe the way of maintaining urban parks in a sustainable manner and offer step-by-step instructions with the aim of assisting park employees to achieve programmed results. A number of other examples in this regard include 'Developing Sustainable Park Systems in Oregon' by the Oregon Parks and Recreation Department, 'Sustainability Plan: A City within a Park' by the Westerville Parks and Recreation Department, 'Sustainable Parks Initiatives' by the Minneapolis Park and Recreation Board, 'Sustainability Plan' by the Washington State Parks, etc.

The COVID-19 outbreak that has still yet to be beaten around the world has prompted

countries to introduce drastic measures for social distancing with the aim of arresting the spread of COVID-19. However, these measures and the pressure of social distancing caused loneliness, anxiety, and depression to increase, especially for the people who inhabit heavily populated urban areas with few accessible open areas. Several epidemiologic studies evaluated the effects of the COVID-19 pandemic on mental health and found out that frequent visits to urban parks during the pandemic are related to decreased levels of depression, stress, and anxiety (Heo et al., 2021). It is obvious that spending time in urban parks helps to deal with the negative physical and psychological health effects caused by natural disasters and pandemics. The ongoing COVID-19 outbreak has brought to light the vitalness of built-up green spaces as a core component of life quality in the design phase of sustainable cities.

Adopting and implementing sustainable practices in the design process of urban parks offer an important opportunity for overcoming a variety of environmental issues, including the preservation of nature, biodiversity, and wildlife, alleviation of the impacts of climate change, development of community life, and the reduction of the excessive usage of natural resources. Today, there is no example around the world where all the proposed sustainable design criteria are applied together in a specific urban park. In this context, this study aims to make a novel contribution by systematically reviewing the literature on the sustainable design of urban parks. In the light of research findings, this study contributes to the implementation of a comprehensive sustainable park design practice in our cities in the future. Design criteria proposed in this study may form a basis for converting urban parks into sustainable green spaces by promoting potential improvements for plans of future development. These design criteria may further serve as performance indicators to offer information and know-how to local authorities, practitioners, communities, and other actors in this field to help them assess their success levels and progress over time.

Overall, rapid urbanization imposed significant burdens on public infrastructures like public transport systems and utility facilities. Rapid urbanization also created an ecosystem that is immensely stressed and strained. The continuing mutual action between climate change and rapid urbanization also introduces further complications into the situation. It poses a key threat to the global natural environment, economic prosperity, social security, and well-being of humans. Urban settlements are the areas where the impacts imposed by humans on the climate are the most extensive, persevering, and focused due to carrying the weight of heavily clustered population and economic properties. Consequently, it is widely accepted that proper planning of green areas in urban settlements is vital to ensuring a sustainable future. Integration of sustainability practices into the design process of urban parks is now far more important than ever before to make sure that our cities are more resilient to climate, assuring a better and healthier future for our communities.

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Conflict of interests

The author declares no conflict of interest.

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The Impact of Transit-Oriented Development on Fast-Urbanizing Cities: Applied analytical study on Greater Cairo Region

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ABSTRACT

Transportation has always been the backbone of development. Transit-oriented development (TOD) has been theorized, piloted and expanded increasingly in the past few decades. In this regard, this paper investigates the relationship between urban development, the transportation process, and the required implementation guidelines within fast-urbanizing cities, such as Cairo. After reviewing different related sustainable development theories, the study investigates pioneering case studies that have applied TOD and provided adequate implementation frameworks. The authors then extract and compare a set of required policies. The current Egyptian development paradigm is then discussed in relation to these enabling policies, focusing on Greater Cairo Region, Egypt. The authors debate previous development plans, progress, and newly proposed ones, focusing on the transportation process as the means for development. The study concludes with a set of required guidelines to ensure the integration of transportation with land-use planning, thus ensuring a more prosperous and inclusive urban development.

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1. Introduction

In order to improve the intense and complex relationship between urban planning and transportation networks, several urban development theories have been established in the last decades (Kaufmann, 2011; Mishra, 2019). Smart Growth, New Urbanism and TOD are different examples of these theories, where their methods tried to introduce a clear successful model of this relationship. However, in many cities of the Global South, the relation between urban planning, specifically land use planning and transportation planning is lacking (Yang et al., 2021). In addition to the isolation

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of planning across transport modes (Mahendra, 2018). Hence, the objective of the study is to provide a specific framework explaining how to apply TOD techniques in Greater Cairo Region (GCR), including clear policies and realistic guidelines ensuring that the mentioned framework will be applicable and available for implementation. A major emphasized point is that the exported framework shall be developed through reviewing global case studies, which successfully apply the TOD principles.

2. Methodology

To address the paper's objective, the paper used triple-fold analysis. First, the study devised an inductive method to analyse different theories related to sustainable urban development and transportation. Then, the study conducted a comparative analysis to compare the attributes of the chosen theories determining the main differences. Second, the paper reviewed international pioneer case studies which successfully applied TOD principles as the chosen theoretical framework. The paper selected three case studies with different contexts, including developed and developing countries. Through the analysis of the three cases, the study extracted the relevant policies that were implemented. This review allowed the study to export a clarified strategy for how the TOD applications can/shall be implemented in any new country. Third, the paper critically analysed transportation in GCR relying on published reports and studies. After reviewing the current public transportation situation in GCR and previous suggestions for public transportation, the paper analysed these suggestions in comparison to the principles of TOD. The paper then used a deductive method to provide a specific framework explaining how to apply TOD techniques in GCR. Finally, the authors conducted a pilot study to apply TOD principles in two cities within GCR. Consequently, relevant conclusions and recommendations were developed proposing a strategy to apply TOD principles in the Greater Cairo Metropolitan Area as one of the available solutions that address multiple issues such as pollution, overcrowding, traffic accidents, the lack of transit services, natural resources destruction, greenhouse gas emissions, energy crisis, and visual intrusion, with the possibility to apply TOD worldwide (Figure 1).

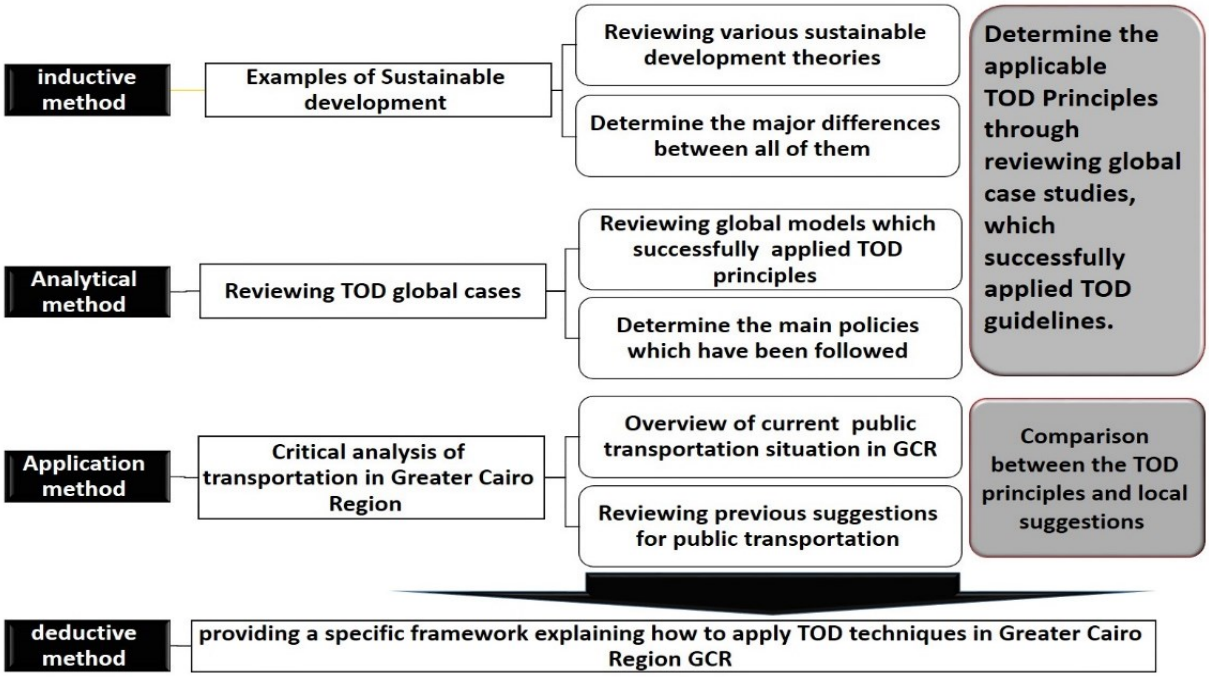

Figure 1. Methodology of the study (Developed by the Authors).

3. Examples for sustainable development theories

The emergence and development of various types of urban planning movements, after 1980, are all attempts to provide a physical model for the realization of a sustainable city. These theories have many similarities and differences, but common principles exceed differences. The most important theories that relate to sustainable urban planning are Compact city (Newman & Kenworthy, 1989), Smart Growth (Stoel, 1999), New Urbanism (Hasic, 2000), Transit-oriented Development (Boarnet & Crane, 2001), Decentralized Concentration (Breheny, 1996; Holden, 2004; Høyer & Holden, 2003), Sustainable Urbanism (Farr, 2011), and Urban Renaissance (Downs, 2005).

3.1. Smart Growth

Several community authorities, institutions, and government agencies have provided different definitions for smart growth, but each one has done that through its perspective and primary references. As a result, no unified definition for smart growth was reached, but rather a group of missions and goals. However, most of them have agreed on the major guidelines and basics of natural resources preservation. Healthy environment, wildlife conservation, green space, open space, clean air, farmland and clean water, all of these elements were the most important and common aspects of the smart growth concept (Ye et al., 2005). Smart Growth can be seen as a group of policies, which may be implemented in several diverse ways. In rural areas, it provides mixed-use, pedestrian villages with different types of housing units around a retail centre. In a huge community, the mentioned type of sustainable development can be intensive, represented by urban neighbourhoods with a large towers that have been established around main transit stations. In both types, there are different neighbourhood concepts, however; their common theme is compactness (Litman, 2015).

3.2. New Urbanism

New Urbanism first appeared in European countries under a different title "Urban Villages", but afterwards the new planning direction was able to find a place in the Congress of European Urbanism (CEU). Prince Charles introduced it in the beginning in England (Stefan, 2005). The first definition of new urbanism contained diversity, pedestrian scale, public space and structure. It is a planning movement, which advocates design based on traditional urban form strategies to restrict suburban sprawl and inner-city decline, and to construct and re-construct neighbourhoods, towns, and cities (Iravani & Rao, 2020). In other words, New Urbanism is a comprehensive definition that concentrates on the traditional neighbourhood development, or "neo-traditional" town planning. It also presents an interactive model, as all its principles and components (as shown in Figure 2), which were prepared previously in Smart Growth, have been reintroduced with more specific standards that were tools to turn the smart growth from a theory into a physical model (Iravani & Rao, 2020).

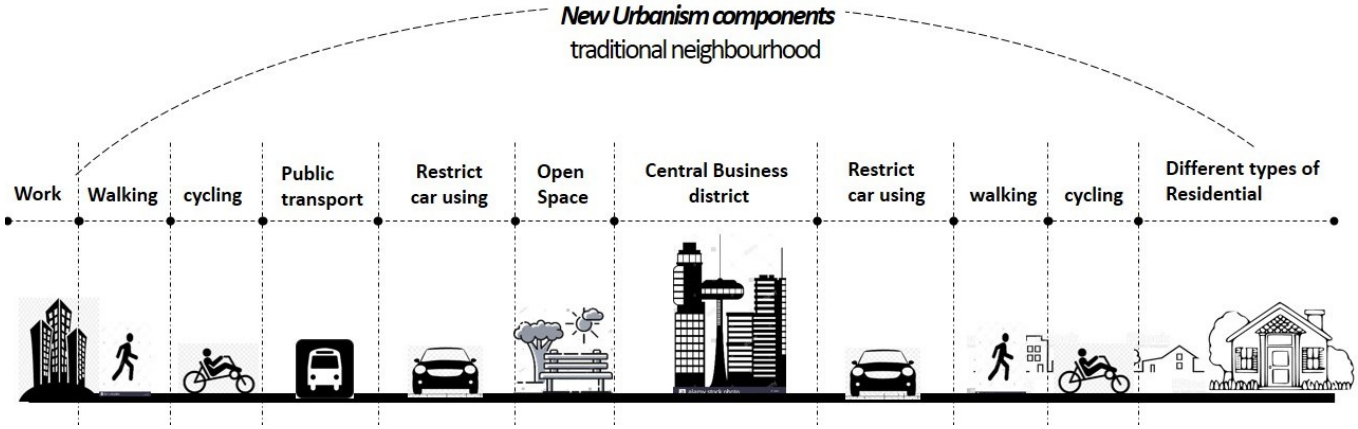

Figure 2. Daily trips in new urbanism – source the Authors.

3.3. Transit-Oriented Development

The mixed-use development area around mass-transit facilities has been defined as a "Transit-oriented Development" or TOD. This movement also drew attention to some urban contents which were matching with those of

Smart Growth or New Urbanism. However, the additional point in TOD is the planning or replanning of the spaces near stations into development hubs, thus, highlighting the urgency for this type of development (De Vos et al., 2014; Transit Cooperative Research Program, 2002). TOD principles often depend on promoting transit-use through planning pedestrian, mixed-use core and a less intensely developed secondary area, with a mass-transit stop, Centre or Station. TOD is a planning approach that promotes the area around transit stations for people to live and work, in the hope of decreasing their dependence on driving (Youzhen & Longlong, 2012) (Figure 3).
Table 1 presents a comparison between these 3 theories regarding the main commonalities and differences.

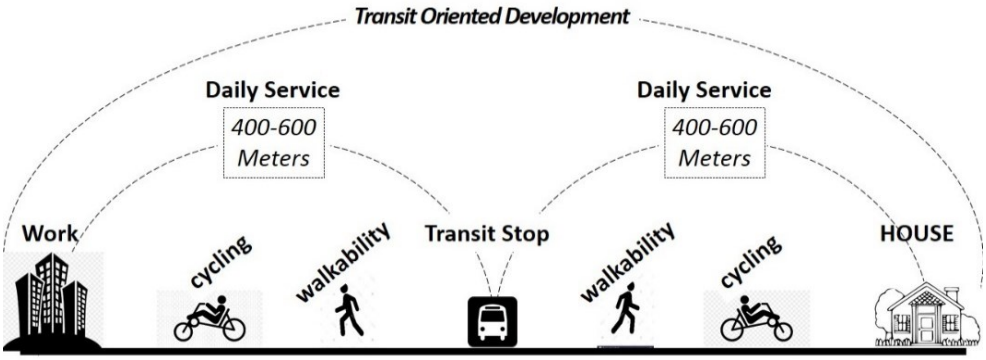

Figure 3. Designation for TOD area around Transit Stop – The Authors based on (Dock & Swenson, 2003).

Table 1. comparison between sustainable development theories (The Authors based on various sources as detailed below).

Major Elements	Smart Growth	New Urbanism	TOD
Main difference	It started as a theoretical idea without specific standards or applied project. (Porter, 2002).	It transformed theoretical ideas into a realistic project, according to specific standards.(Stefan, 2005)	It focuses on the development around new public transportation station (Kelbaugh, 1989)
Pedestrian-friendly	Supporter but no specific strategies or design tools (MacLeod, 2013) (Ye et al., 2005)	The distance between most uses and any other destination shall not be more than 10-minute by walking (Stefan, 2005)	The best area for pedestrian design is the distance people walk from home to a transit stop, which shall be not more than 400- 600 meters (Dock & Swenson, 2003).
Open Space	Supporter but no specific strategies or design tools (MacLeod, 2013).	It adds a clear framework to protect open space(MacLeod, 2013)	The transit hub is taken as the centre to provide open space, (Youzhen & Longlong, 2012).
Mixed land use development	It is an important element but still focuses on the general framework (MacLeod, 2013), (Ye et al., 2005),.	Mixed-use development is designed to be within the distance between work and home (Nyström & Fudge, 1999).	The land near the transit hubs has been used as a centre point for mixed land use development (Youzhen & Longlong, 2012).
Smart Transportation	Supporter but no specific strategies or design tools (Ye et al., 2005)	The connection of all urban communities by high-qualified rails is one of the urgent targets in this sustainable development type. Also encouraging greater use of public transportation (Stefan, 2005)	All types of public transportation, whether intended to connect the railway network or the quality of service, are the focus of this type of development. (Dock & Swenson, 2003).

3.4. Models of Transit-Oriented development

Similar challenges were faced in the studied models. However, the various approaches for providing guidelines and a mix of policy tools have been brought up to the forefront as a result of the analysis of global TOD best practices. The three cities across the world that have been chosen, are in different countries and each one of them has its unique circumstances and challenges. For example, the paper discusses the city of Curitiba, Brazil, a developing country, unlike the other two models, Vienna in Austria, and Los Angeles in the USA. To further elaborate the case study selection process, one of the main criteria was

that sustainable transportation was strongly enforced in all of them.

A major point is that there isn't a "One Size Fits All" approach for TOD. By reviewing the sustainable transportation principles in several European countries, it became remarkably clear that TOD appeared under different names and with minor changes in applications (Pojani & Stead, 2016). For Example, one of the sustainable transport requirements is achieving mixed-use development and medium-to-high densities; all of these are the main objectives in the TOD. Moreover, there is no way for applying sustainable urban transport principles without following TOD measures. In the end, they are all moving on the same track, and are two sides of the same coin (United Nations, 2010, 2016), The main applications of TOD have been studied in many previous global cases, and many documents were carefully inspected alongside the most important policies. The result is summarized for the main aspects that represent the backbone of TOD applications, as per the following points shown in Table 2.

Figure 4. The distinctive TOD ideas in each of the case studies – Source (IPPUC, 2000) (GJEL, 2015).

Table 2. Sustainable transport and TOD policies.

Implemented tactics	Vienna	Curitiba	Los Angeles
Integration between all public transport types	Integration between S-Bahn and U-Bahnfigur4 (Sammer, 2015, May 8-15) (Knoflacher, 2015, May 5).	RIT (Rede Integrada de Transporte) or the Bus Rapid Transport System BRT idea represented a comprehensive integration system (IPPUC, 2000)	Integration between Los Angeles's light rail and rapid bus corridors. (CTOD, 2010)
Integration between land use and transport planning	Extending of combined mixed-use around Vienna's Main Train Station (Sammer, 2015, May 8-15) (Madreiter, 2015, May 11),	Integration between land use and transport planning was one of the main goals for the master plan (IPPUC, 2000)	Prioritize new development for achieving coordinated land use and transport planning (CTOD, 2010),.
Improving walking and cycling conditions	Some streets became shared with a 20 km/h speed, pedestrians and cyclists also having the same right as motorists (Vassilakou, 2015, May 9) (Maresch, 2015, May 13)	Structure corridors that promoted walking and cycling, the municipality also gave people better opportunities to ride bicycles inside the city (IPPUC, 2000)	Using small blocks and avoiding mobility barriers provided local options for accessibility by walking or biking. (CTOD, 2010)
Discouraging the increasing growth of private motorized	Raising gasoline prices, taxes on owed cars, and an increase in the prices of driving licenses (IEA, 2015).	Restrictions for dependence on private car regulations were very weak (Klink & Denaldi, 2011)	Restrictions for dependence on private car regulations were weak compared to Western Europe (Buehler et al., 2017).
Promoting an affordable and accessible public transportation	Expansion of the U-Bahn and S-Bahn systems beside improving all types of public transport since 1990 (Bohrn & Buehler, 2015)	Expansion of ternary road system and bi-articulated buses beside another system to cover most of the city. (Figure 4) (IPPUC, 2000)	Expansion of rail projects and provide a travel time advantage for each of carpools and vanpools (Figure 4) (CTOD, 2010)
Parking management	The parking management federal regulations were set to	Parking regulations were weak, but the high level of	The planning Commission urged the City Council to use

Implemented tactics	Vienna	Curitiba	Los Angeles
	avoid car choice as a method for movement (Herry, 2015, May 12) (Sammer, 2015, May 8-15) (Riedel, 2014)	crime and car theft made owning/using a car a bad choice (Klink & Denaldi, 2011)	parking maximums, pooled parking and automated stacked parking as a basis for new city ordinances (CTOD, 2010)
Discounting Fare policy.	Several policies for discount transit tickets including all residents and workers categories (Ossberger, 2015, May 8)	Unifying a ticket price as one fare will be enough to use on transit systems (IPPUC, 2000)	Discounting Fare policy expanded to include most types of residents and electronic payment (LADOT, 2015)

As per the previously discussed policies, transit-oriented development or sustainable transport not only concentrates on public transportation but also takes into consideration the relationship between transit systems and all other elements that should be integrated with them. Each one of the mentioned seven axes represents an important stage in the TOD system, so in the following part, the study will compare the current proposed general strategy for Greater Cairo Region with the previously discussed policies.

4. Application of TOD strategy in GCR

4.1. Overview

In the Greater Cairo Region, 68% of all daily trips are done by public transportation. Out of all public transport trips, 52% are done by shared minibuses (known as microbuses), 25% by public buses and just 17% by metro, (Figure 5). Although this study was conducted almost 20 years ago, still the share of informal transportation modes is accurate, if not increased. The current situation in Greater Cairo Region has become very complicated with no apparent simple solution. Isolated solutions did not bring any actual success, because there is a need to establish a comprehensive system, rearranging all relevant measures into one coherent strategy with all contingency measures. The GCR is still suffering from many issues such as serious traffic congestion, poor passenger transport system, high accident rate, air and noise pollution, institutional weaknesses and fragmentation and inadequate financial arrangements (World Bank, 2006).

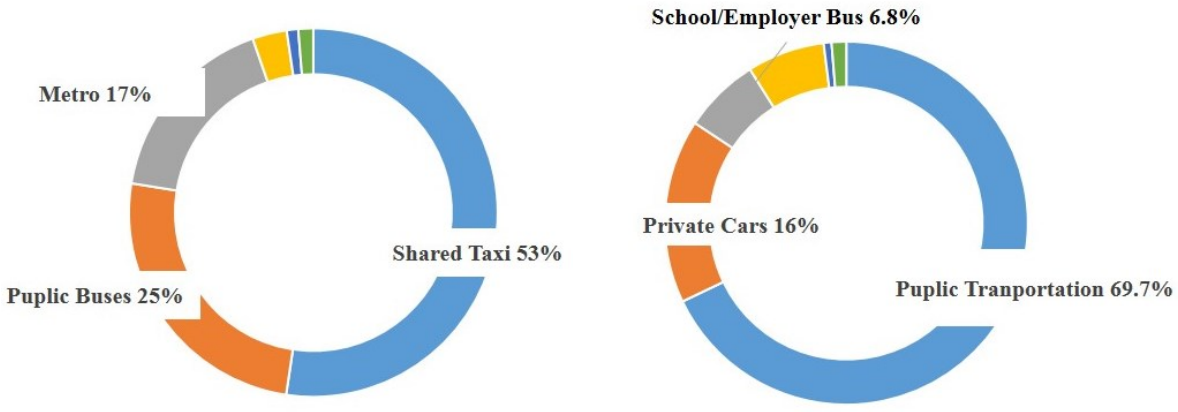

Figure 5. Trip generation pattern- source (JICA, 2002).

More people living in Cairo are choosing the private car as a perfect mode to travel, which resulted in a major change, in recent years, in the used means for total daily trips. Private motorized vehicles usage is increasing every day as a percentage of the total numbers of Greater Cairo daily trips. The proportion of public buses trips has also decreased, because a large number of users have left this option and started switching to informal taxis and minibuses as an effective and affordable new option. This was a logical result of the fact that there was no development or improvement in public buses daily services. Moreover, the percentage of public buses users lost more than twenty percent, from its original forty percent in only ten years despite economy fares. Likewise, most of the tram services have

gone out of operation gradually as investments and periodic maintenance did not balance with the service value. As a result, the second logical step was increasing the demand for the metro system; but still, the largest part of the daily trips demand was for taxis and shared microbuses as the percentage of these types increased by more than 50% of all public transport trips (JICA, 2002).

4.2. Analysis of previous studies

Among the most recent studies that have been introduced in the last decades are the "Urban Planning Restructure for Greater Cairo Region" in 2014, and "Greater Cairo: a proposed urban transport strategy" in 2006. A critical issue here was that the focus of the first study was on urban planning while the second focused more on the transportation master plan. The objective of the second study was to add a comprehensive strategy for the urban transport system in GCR, which was more in synchronization with the objectives of TOD. A specific general plan for clarifying and determining the actual measures and investment priorities has been introduced as one of many other solutions, which would be the basis of a formal transport strategy. Following that, there were seven strategic areas of intervention of a mix of policy actions and priority investments. In the next section of the paper, the comparison between the mentioned proposed seven strategies and seven TOD policies, exported from the previously analysed global models, shall be discussed, thus, proposing a method for how the government can apply TOD in Cairo.

i. **Developing and sustaining urban transportation institutions:** As per the previous discussion, the current transportation situation in Greater Cairo is extremely complex. In addition, the official institution created to manage public transportation is not ready to deal with this kind of mega-city like GCR. All employees who have been appointed to manage the aforementioned subject have not been trained or upgraded to be more qualified and able to succeed in their mission. So, the first strategy focused on providing official institutions with relevant roles that match their employees, policies, and general plans (World Bank, 2006).
   Although this point is very critical and global models have already been made, yet it doesn't come as one of the policies for TOD. This is a result of an underlying logic that qualified institutions would apply sustainable principles.

ii. **Review decision-making stage, as the choice for appreciating investments alternatives, should be more matching and balancing with the financial transport sector plan:** By reviewing the governmental direction of transport in subway lines and the maximum potential capacity of an existing roadway in the last twenty years, it became remarkably clear that there was no balance between transportation demands and services and investments. Hence, it is extremely necessary in this strategy to emphasize effective decision making, and prioritization of investment based on objective criteria (World Bank, 2006).
   This strategy not only matches but also confirms the fifth previously mentioned policy as both promote an effective, affordable, physically accessible, and environmentally sound public transport and communication system.

iii. **Determining the public transport fare to comply with operating costs and without pressure on the poor stratum of the community:** In general, the fare policy needs more in-depth study, as the current tariff of all tickets is low and does not match the actual service provided to all passengers. On the other hand, the low cost represents an attractive public transport tool for all people. Hence, the structure of the fare policy must be redesigned, where the ticket discounts are directed towards those who need them, while all other users shall pay the regular tariff without any subsidization (World Bank, 2006) .
   The authors believe that this point shall complement the previous strategy, as there is no way to improve public transportation without introducing a clear financing system. However, this will be applied with a balance between maintaining affordability on the one hand for all poor and low-income commuters and on the other hand fair prices for commuters with medium and high incomes. Hence, the seventh TOD policy has been introduced as a specific solution for this issue.

iv. **Develop the public transport services to meet the needs of the passenger:** because of the general inadequacy of public transport revenues, the number of investments by the government to improve the service was also inappropriate. In addition, the attempt to provide an affordable and efficient transit service was not always satisfactory to the passengers. Hence, the emergence of the private sector and the introduction of public transport service alternatives that match the passenger's needs was a logical result. Therefore, the fourth strategy here gave special importance to restructuring the public transport system to improve its organization.
By reviewing the previous four strategies mentioned above and comparing them to the sustainable transportation requirements, it shall be made remarkably clear that these strategies can be combined as one policy, which shall be the same in Table 2 under the name "promoting public transport and communication system". However, GCR Strategies shall have more added details on how reinforcement and improvement can be applied.

v. **Modernized effective traffic management system:** All the objectives, that were expounded in this strategy focus on special measures, that would help in addressing the traffic congestion by decreasing the traffic flow in comparison with road capacity. However, these measures act as tools rather than policies, such as using signalized intersections, redesigning for pedestrians around the intersection, applying solid parking management rules, and considering on-street bus operation as a priority to name just a few. *This strategy shall be applied side by side with the fourth sustainable transport or TOD policy, since the major objective shall be addressing the traffic congestion with emphasis on discouraging the increase in growth of private motorized traffic as well as congestion reduction.*

vi. **Application of proactive travel demand management techniques:** Although the car use restrictions and parking demand management became policies that have been applied in several international cities, both are still missing rules in GCR. Hence, instead, some measures shall be applied to help decrease car dependency such as prohibiting car parking in certain areas, increasing parking chargers, tolling selected roads and cordon pricing to permit entry into designated high-density areas. Focusing on proposing integrated applications, that explain how the proactive travel demand management techniques can be applied, shall be the main point in the sixth strategy. *There is no major difference between this strategy and the main axis that has been discussed in the sixth policy of the TOD, as the restriction of car usage without doubt shall reflect on the demand of parking lots and development of parking lots management.*

vii. **Provide an independent institution to strictly apply traffic policies:** Once again, this strategy emphasizes the fact that implementing traffic and demand management is deemed to fail if it is done as a separate measure because success initially depends on strong and rigorous applications. Therefore, the implementation of this policy needs clarification and comprehension. The seventh strategy shall provide a set of policies to be concluded as an integrated strategy, including a different organizational structure and a change in the perception of the users that represent two policies of the said layer. Thus, resulting in less police involvement in traffic. *Treating this strategy as an individual item, not related to the above policy, that in turn focuses more on the restriction of car dependence or parking management, would be a major error. The fifth, sixth and seventh strategies shall be gathered in one group under the name "traffic management unit". This proposal came as a result based on the comparison between these strategies with others in TOD policies.*
In spite of the fact that the study succeeded in introducing applicable models and exporting logical methodology to improve the public transportation system, yet what is still missing is the consideration that both urban planning and public transport will move in different directions. This contradicts TOD that deals with all of them as one entity and considers the integration between land use planning and public transportation network an urgent policy to achieve success for both.

4.3. A pilot study to apply TOD in different parts of GCR

4.3.1. 6th of October City, GCR

One of the most important issues in new Egyptian cities is the reliance on the informal sector as the main mode of travel. For example, the specially modified, privately operated, pick-up van, where two longitudinal seats have been added in the back part under a metallic cover to accommodate passengers. Despite the 6th of October is a new city on the western outskirts of GCR, this mode became a part of the mass transport system in the city for the past three decades. Although it is dissatisfactory for the residents, they have no other public transport alternatives. As a result, the search for another mode of transportation is a critical issue for them (UNDP, 2013).

Although there are many master plans that have been submitted for the 6th of October City, transportation has not been focused on as a major axis of development. The transportation process, in general, has always been treated as only the type of movement or commuting and not as an integrated system with the land use master plan. The missing part is how to achieve integration of land use and transportation plan. This problem was clearly articulated upon reviewing all recommendations of previous studies. The following figure shows the latest proposal to link the 6th of October city with the New Administrative Capital. However, this transit suggestion is not yet coordinated with the land use master plan (Figure 6).

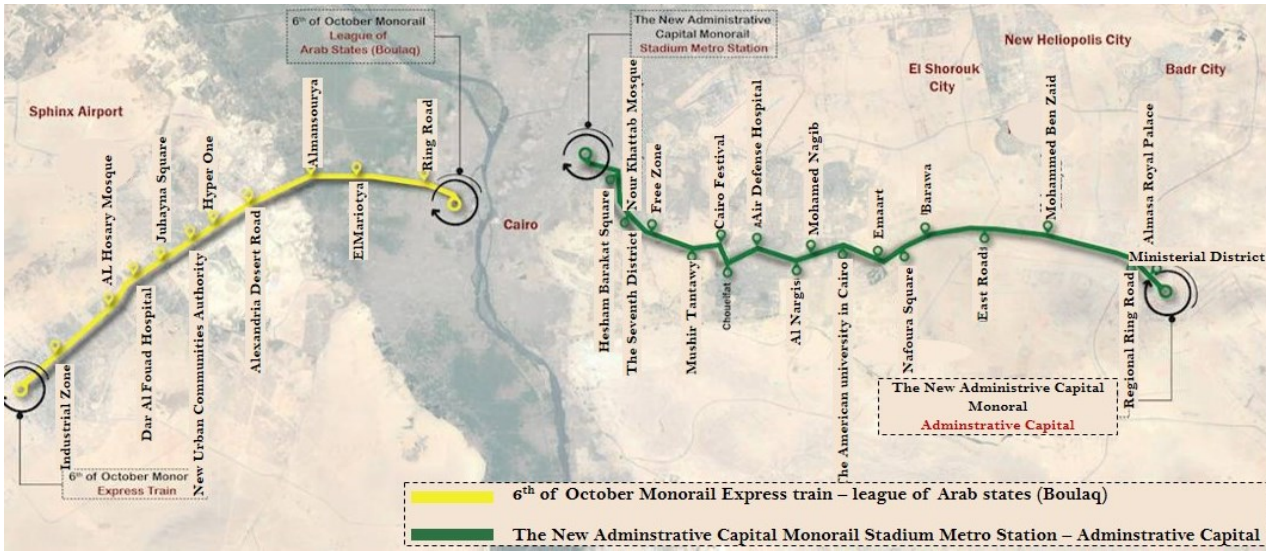

Figure 6. The monorail will run 70 trainsets on two lines east and west of Cairo at a speed of 80km/h (Hill International)- source (Global Construction Review, 2020).

4.3.2. Giza city, GCR

Everyday Giza city experiences a large number of incoming and outgoing daily trips, which renders the city one of the most important parts in the Greater Cairo Region. This justifies the presence of the second most important station in the region. Additionally, the location of the El-Giza train station is considered vital because of the existence of both the metro and train lines. However, the critical issue is that the station does not match TOD standards. The following figure shows how the TOD defined catchment area (a 500 m radius circle surrounding the station) has been compromised due to some mobility barriers (Figure 7).

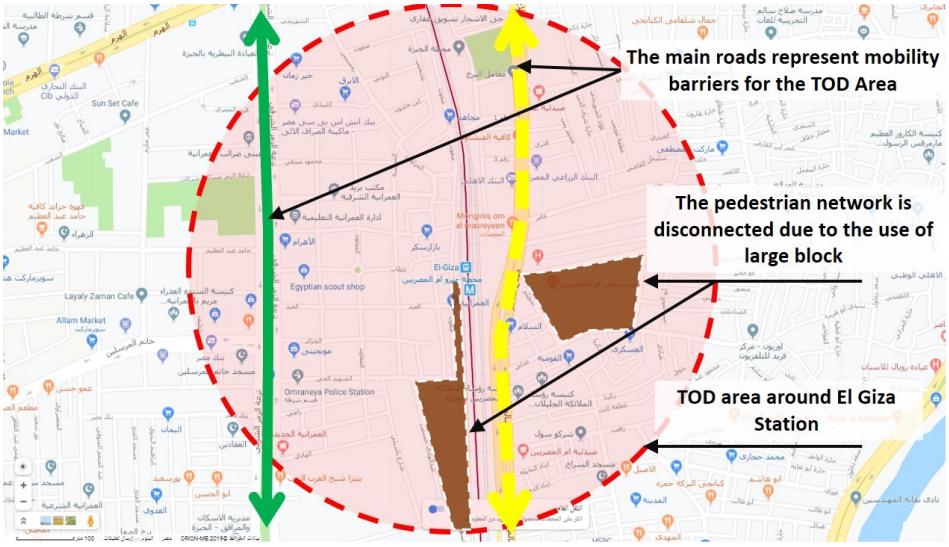

Figure 7. analysis of TOD area for El-Giza metro Station – Source the authors.

5. Discussion

The case study analysis of transportation policies in GCR and comparing them to TOD principles have revealed several gaps together with possible potential interventions. Even though many studies have been prepared for Greater Cairo as an attempt to find a solution to the complex traffic congestion problem, all of them focused either only on transportation or on land use planning, but none combined them both under the TOD umbrella. As explained earlier this is not unique to the Egyptian case. This extends to the recently prepared studies for GCR which included good suggestions for planning or transportation, with some of them already implemented. Still, these suggestions need improvement, coordination and integration to be more compatible with the TOD system.

From a management and operation perspective, GCR has several official authorities responsible for all types of public transportation which, overall, might be a positive point. However, that was the main contributor to losing many of GCR's public transportation potentials, as each of them acted individually with a total lack of coordination or integration policies. Hence, providing one qualified institution will be the first step in the right way. A similar issue has been identified by Louafi for Algiers (Louafi, 2019). Additionally, although most daily trips in the GCR are done by public transport, the majority of these trips are done using informal transportation mode, hence outside the jurisdiction or control of public officials and beyond the reach of planning tools.

The detailed analysis of the existing GCR strategy identified some further gaps other than supporting an integrated transport policy and coordinating land use and transport planning. A combination of other modes of transport, including walking, cycling and private vehicles is still lacking. Additionally, adequate policies should start by defining a transportation-planning network not focussing only on providing transportation, but extending to ensure accessibility, affordability, efficiency, safety, and quality. Focusing on public transportation, most of the previous proposed public transportation routes were defined without related urban planning studies contrary to the ideals of TOD. Consequently, the right methodology would be to conduct the urban planning and public transportation network studies simultaneously. Furthermore, the detailed planning for each station location should be done through more accurate studies, where all services and land uses would be distributed in a balanced way. Accordingly, the Los Angeles case can be of use, where a set of design criteria was introduced for how to choose the appropriate station location to be most effective in a TOD system. Meanwhile, a quick comparison between some of the local stations in GCR especially El-Giza station, and the studied international cases, makes it clear that the station disregarded many TOD related benefits because of the lack of the mentioned standards (Figure 7). By reviewing the proposed new metro lines in the 6th of October city and El-Munib area, there will be one exchange station in October and another in El-Munib. It will be very easy to choose a perfect

location applying TOD criteria in the 6th of October city as the city still has many vacant lands. Contrastingly, El-Munib has a very high residential density and several mobility barriers. Hence, preparing two scenarios for how TOD criteria should be applied in new cities and the existing area is vital and requires urgent further studies.

6. Conclusion

To summarise, this paper argued that to present a clear framework or comprehensive strategy that can deal with the massive and complex problems, faced in GCR, it is essential to integrate urban and transportation planning. To understand and determine which type of sustainable development will be most effective and applicable, the paper findings highlighted the adequacy of TOD as most applicable to GCR from among other theories. Within a megacity such as GCR, transport planning is key to achieve several SDGs, specifically ensuring an inclusive and sustainable city (SDG11). Adopting TOD as the backbone of transport planning is vital to achieve such a goal and improve mobility for all. The city as many cities of the Global South is continuously expanding by both engulfing newly urbanised areas and new urban expansions. Furthermore, many of these new urban areas are serviced through the informal system which needs to be acknowledged and integrated. Hence, the paper concludes by arguing that comprehensive planning with adequate policies is needed to ensure compatibility of formal/informal systems and improve mobility around the city taking affordability, accessibility, efficiency, safety and quality into consideration. The identified gaps in the current transportation planning in GCR serve as lessons learnt, for other cities of the Global South to avoid. The analysis of the global best practices has shown a variety of possible interventions that take into consideration the local circumstances, resources, and needs advocating that there is no "one size fits all". Thus, the suggested interventions and recommendations extracted from the global best practices and a local case could help other cities in their endeavour for better mobility for all. Future studies could fruitfully explore this issue further by developing scenarios for applying TOD principles in different locations, whether within existing compact cities or in new developments.

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Conflict of interests

The authors declare no conflict of interest.

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