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RESEARCH ARTICLE

Some Thoughts on Urban Renewal and Natural Disasters

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ABSTRACT

This study aims to shed some thoughts relating to the housing and earthquake issue in Istanbul, Türkiye. The study will examine decision-makers' and housing policy designers' approaches, tools, and strategies toward disaster risk in order to highlight and discuss the questions regarding disaster risk in megacities. The dynamics and nature of urban transformation and urban renewal with regard to disaster risk can be advantageous or not, depending on the interpretation and implementation of the relevant regulatory framework. The intention of the policies could be a good guide to follow throughout. The text is structured in three parts: (1) the urban renewal activities that have taken place for almost two decades, (2) the density issue generated by intense construction activities, and (3) the disaster policies and legal framework that requires revision into a workable plan. The three-part discussion will be made by primarily referencing the Zeytinburnu sub-municipal region in Istanbul and other regions secondarily as needed.

Keywords: Housing policy, urban renewal, disaster policies

1. On Urban Renewal

In many developing countries, urban renewal and rehabilitation projects have been used as a means of regulating the urban transformation phenomenon. With the enactment of urban renewal, researchers and professionals involved in the design of large-scale urban transformation projects have changed the nature of urban society: These cities are both developing while at the same time competing with other international cities to become a global city. Societal values have also changed. Accordingly, cultural industries and information technologies are replacing factories and industry.

Unlike the major actors in gentrification such as the elite, administrators, and professionals, urban transformation activities in the Zeytinburnu municipality of Istanbul have been initiated by local authorities and supported by various public and private agencies and sponsors (i.e., revenue-share firms) (Alkışer et al., 2009). As the first gecekondu [squatter] town in Istanbul, Zeytinburnu is expected to present an exemplary transformation for Türkiye, with similar implementations planned in 10 other Istanbul municipalities. Just like in Zeytinburnu, Galata and Haydarpasa are both areas by the sea with cultural landmarks that are planned for being renovated into large-scale port projects. However, Zeytinburnu was picked first among them because it was thought to be one of the riskiest parts of the urban fabric with its irregular settlement pattern characterized by dilapidated housing and very little greenery. The area over time was over built and overpopulated. This is no surprise, as it was the first squatter housing area in Istanbul and later expanded to become a squatter town within the city of Istanbul. The final transformation processes have aimed at changing the area into a contemporary settlement. Its proximity to the sea has been used as an advantage for filling it up with global spaces (e.g., hotels, commercial areas).

The idea was to create planned sustainable urban designs for Zeytinburnu in particular and for Istanbul in general. Urban renewal and resident removal should not be applied only to *gecekondu* [squatter] housing spaces; dilapidated housing elsewhere in the city and houses built on at-risk soils are also candidates for removal from the urban fabric. Each spatial intervention has undesirable sociocultural consequences, as spatial transformation into a rehabilitated residential area or any other type of zoning also breaks that community's cultural networks and economic structures in urban renewal areas.

About 15% of houses are expected to be demolished according to the Zeytinburnu Pilot Project Report. Meanwhile, the residents lacked information about the pilot transformation project that is intended to be implemented on their site. A recently formed association in Cirpici, a Zeytinburnu *mahalle* [neighborhood], pointed out the fact that the citizens are uncertain, have doubts about the urban renewal activities planned for their mahalles, and don't trust the officials. Because they were not properly

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informed about the renewal plans for their housing, they either want to sell their houses and leave their neighborhoods or react against it through protests. After all, the changes implemented in the area have affected their lives directly, as well as their use of urban space.

Capacity, quality, and participation could be a good guide to follow for appraising existing urban transformation projects. Accordingly, the evaluation of transformation projects has indicated that the national housing policy and local strategies need to be re-considered in order to generate more flexible alternatives and to meet diverse and complex urban issues. This puts the principles of socioeconomic and spatial sustainability into the focus of urban transformation project evaluations before they become generalized (Alkışer et al., 2009).

The case of Zeytinburnu is on the national and international agenda, whereby the urban transformation aims to improve its social, economic, and spatial quality. Therefore, the components of a sustainable urban transformation can be identified as follows: The social components (i.e., improved quality of the social infrastructure, social interaction, and educational level), the economic components (i.e., improved quality of existing economic activities and their types), and the physical components (i.e., increasing cultural and natural areas, rehabilitating the housing stock, and generating green areas and life corridors).

As proposed, the Zeytinburnu Transformation Project is characterized as follows:

- Will occur in phases,
- Involves a neighborhood-based urban renewal,
- Prioritizes risky buildings for demolition,
- Increases low-density areas by decreasing high-density areas,
- Residents are not relocated during the urban renewal process but during the on-site urban renewal,
- Increases newly built areas (which will almost double the urban real estate values).

Disaster volunteer groups have been formed in four *mahalles* of Zeytinburnu on the European side of Istanbul and in Uskudar on the Anatolian side. When selecting exit routes, the criteria involve accessibility to gathering areas, as well as to the transportation network. Buildings blocking exit routes are subjected to demolition. Risky buildings are also to be demolished, as well as buildings on risky grounds. The gathering areas include schools, mosques, sports facilities, and parks. Public spaces are mostly considered as they can hold many people in the case of an emergency or disaster. These areas can also serve as field hospitals before residents move to temporary shelters. These areas can also serve as emergency accommodation areas in order to meet any urgent housing needs for disaster victims. Furthermore, community residents have been educated on how to prepare for disaster mitigation (Istanbul Greater Municipality & Zeytinburnu Urban Transformation Atelier, 2003; Istanbul Kentsel Donusum Kanunu Tasarı Taslagi, 2006).

Three time periods (stages) are involved for planning mitigation measures and facing the challenge of an earthquake:

1. Pre-disaster period.
2. During the disaster.
3. Post-disaster period.

The first stage is the main preparation stage for future disasters and is comprised of planning settlements, their layouts, and the height and structures of buildings and deciding on whether to rehabilitate rundown houses and on the proper layout for future infrastructure. A resilient city is one that has renovated and repaired its old housing stock within the required time periods, preserved its historical buildings, and planned new housing on developable land.

In short, location decisions for housing settlements, land development plans, and land use zoning are among the major preparatory work of the first stage. Furthermore, plans for organizing formal and informal networks before a disaster occurs and for how tasks are shared and identifying the responsibilities among the public, private, and community sectors for emergency cases are crucial components of this pre-disaster stage. Only then, can human resources be coordinated and lives saved. Skipping this stage is very dangerous for the city and threatens lives.

The second stage involves providing temporary shelter on reserved lands for disaster victims. Providing *temporary housing* to earthquake victims is an important goal immediately following a disaster. Such accommodations require taking action and preparation before the disaster takes place. This is the duty of the national government at the political level, as individuals on their own is not enough. The third and last stage involves providing the *permanent housing* required for those whose houses have become uninhabitable after a disaster. In extraordinary cases, however, the short-term accommodations can last for a long time, and moving into new and more resilient house may be seriously delayed. These long-term residences may become an issue, as often is the case in the world when any short-term accommodations last longer than expected. Each stage has different responsibilities on the parts of the government, the people, and non-governmental organizations (NGOs).

Prior to the earthquakes in the early stages of Zeytinburnu's development, the Zeytinburnu Community proved its ability to improve its houses and its settlement gradually and informally in the 1950 and 1960; they obtained rights to infrastructure and access to urban amenities. The major strength of the community was its grassroots and volunteer associations. During this period, the first transportation network had been locally created to connect the settlement to the city center. By the end of the 1980s, most houses were on the path to receiving titles and deeds. However, in the first two decades of the new millennium, the legalized housing stock totally shifted into new housing for new residents, with some urban land for housing having been replaced with commercial buildings.

The former squatter town of Zeytinburnu has a population of 247,669 in 16,030 buildings over 13 *mahalles* on 1,200 hectares of land. The reports from the Zeytinburnu Pilot Project indicate 2,295 high risk buildings, 15,019 of which are housing, 2,893 are commercial, and 791 are industrial. The urban transformation is estimated to affect 72,388 individuals. The area has been intensely built up and lacks the greenery for the parks and playgrounds that are also to be used as gathering areas during a disaster. The demolition and rebuilding activities are expected to be completed within 3 years (www.ibb.gov.tr). The Quarter-Renewing Action Program depends on a rebuilding approach to help with the physical and social development of the settlement.

The residents in Zeytinburnu were offered to select one of two alternatives: (1) stay within the settlement by paying extra for the new housing, or (2) move to a new but not near place where mass housing is being built by the Mass Housing Authority. (www.ibb.gov.tr). The total cost of the entire project is $950 million USD, and the Mayor started planning the Zeytinburnu Transformation Project in 2004. He formed a Disaster Preparedness Group for the big Marmara earthquake that is expected to occur. After the 1999 Izmit Earthquake in Türkiye, an Earthquake Master Plan was made, and the existing building stock was found require careful reassessment. In 2010, Istanbul was selected by the European Cultural Union as the Cultural Capital of Europe along its path to join the European Union. In coordination with the Earthquake Master Plan for Istanbul, Zeytinburnu was chosen as a pilot project zone for earthquake resistance due to its deteriorated building stock and limited urban public spaces.

The earlier pilot project for Zeytinburnu's urban transformation had been based on a principle that not more than 20%of the dwellings would be demolished to open up the space required for the life routes/corridors, gathering places, and green belts. However, the series of urban transformation processes in the area proved the fact that by now, the whole area has been gentrified. The commercial and tourism sector has ruled to build high class dwellings (mostly multi-story apartment houses) for the higher income urban classes. The evicted dwellers could stay there if they consented to buying one of the new flats. Gentrification and over-population became the major issues there, as the local people were forced to leave. This way, another Urban renewal had taken its toll, because the location of Zeytinburnu had been such a part of the center of the city, and land values were so high. With the 2012 Law on Disaster, gentrification and post-Fordism have seen the removal of factories and the surrounding informal housing out of town; on these valuable lands have been built prestigious offices, expensive leather shops, touristic hotels, and expensive housing, with the local settlers having been moved to the southwest of Istanbul.

Major changes in building regulations and development plans took place after the 2000s. The earlier assumption and promise of removing 20% of the dwellings in the pilot urban renewal process had not been held, with more houses having been demolished. Most residents had to leave their homes and mahalles because they could not afford the new housing. The whole area was treated as if life had not existed there before. The existing social as well as physical culture had been damaged in order to obtain more profit for Istanbul during the era of globalization. The question remains, had the mostly flat lands of Zeytinburnu really been at risk? If that were the case, why had multi-story buildings (i.e., the notorious 9X16 building) been built during the final Urban Transformation construction there?

Squatter housing in a large city has been associated with disaster over the last two decades. Wherever this type of housing is located is considered an at-risk earthquake zone. This has been the approach of the government officials and bureaucrats. With this changing perspective and perception, urban transformation processes and implementation have aimed at demolishing squatter housing areas in the city. This has had much to do with the sharply changing perception toward *gecekondu* dwellers, from that of useful citizens contributing to industrialization into illegal occupiers of precious valuable central urban land made worthless with its substandard urban housing. Yet they are the very same people. They have proven themselves capable of developing and rehabilitating affordable housing and becoming good urban citizens. Furthermore, social housing was not constructed to compensate migrants with affordable housing. The construction sector is considered to be pumping the economic sector.

Formal and legal urban housing is built according to master development plans and in accordance with building regulations. Squatter housing by definition is considered to be informal and situated on uncontrolled urban land. The main arguments for selecting the squatter housing areas for urban renewal is that they are located in areas at risk of disaster. Razing *gecekondus* should not be the solution for achieving the renewal of the housing stock. In Türkiye and particularly in Istanbul, urban renewal and transformation were conceived as urban development occurring on cleared land. Such an approach has caused unanticipated side effects that can be avoided by reconceptualizing urban renewal in another way. Europe has successful cases of urban renewal, which indicate that other means exist for renewing urban housing stock (Mathey, 2015), the major ones being rehabilitating buildings by strengthening individual urban blocks and redesigning streets by providing new community facilities, public areas, and greenery.

In fact, rehabilitation in areas requiring resilience is already a better strategy because:

1. The construction density in the mahalles will remain the same, leaving room for gathering spaces and future expansion,
2. Relocating people becomes unnecessary, which will prevent poverty areas from forming elsewhere in other parts of the city due to the dislocated residents,
3. Sociocultural networks within the neighborhoods will be protected and remain unbroken with in situ rehabilitation. This also means place attachment will continue in the locale, and
4. Maintaining the sociospatial balance in urban neighborhoods will raise citizen's quality of life and well-being.

2. On Over Density

Housing is a major issue in Türkiye. For urban settlements in particular, the housing issue is more pressing in megacities. These cities face excessive construction activity, which in turn will intensify and overpopulate urban settlements. The topography of built environments is shifting drastically from low-rise to high-rise and skyscrapers through vertical growth. This situation is true not only for the major cities of European countries, but also for the megacity of Istanbul. These cities that compete with one another for moving into the first ranks on the globalization list are building high-tech, prestigious high-rise buildings with luxurious construction materials and differentiated building facades, with the belief that this will pave the way to getting many international firms to invest in the native country and improve their economical wealth. However, if not planned and supported through careful and locally sensitive housing and disaster policies, such a growth goal cannot be sustainable in the long run. Globalization theory, which was initially expected to provide jobs and affordable housing for developing economies in the 1980s, has failed in the new millennium.

Building activity may be a useful tool for overcoming economic crises in the short-run, but when this activity is abrupt and causes radically unplanned or grand scale changes in the spatial character of a historical and layered city such as Istanbul, the results can be highly disastrous. Over density is an undesirable result from the perspective of a city pampered by the appetite of contractors and developers who build unchecked by governmental power structure and may have too high a cost when the country, and especially its largest cities, are located in disaster-prone areas. Not only would historical multi-layered cities such as Istanbul lose their architectural heritage from the undesirable side-effects of globalization, but lower-middle income dwellers would also suffer from high rents and lack of decent homes in the city. The most recent disaster experienced in this century so far took place in the southeastern Anatolia and dramatically taught planners that the so-called "residences" built for the high-income elite national and international investors have become subject to demolition by natural disasters and killed most of their residents in Antakya. The wreckage was unable to be cleared away to help save many lives because of road closures due to being divided by the fault line. Vehicles were unable to bring help for the first two to three of the most critical days following the earthquake.

The earliest attempts at reorganizing Istanbul through an urban transformation workshop was founded on site, with Zeytinburnu being selected as the pilot area for urban transformation studies. The redesign principles involved opening up gathering areas, escape routes or corridors, and green areas or belts. The required space for this was to be acquired by the limited proportion of demolished houses. As the disaster-prone areas were defined mainly as squatter settlements, these became the houses to be deliberately demolished, as by definition they are located in areas not planned for urban development (overly steep areas prone to erosion, swampy land, creek beds, land prone to liquification); houses lacking construction materials of appropriate strength and contemporary techniques were also identified by law as unfit for urban development (Gokmen-Pulat et al., 2005).

Residential density promotes greater density and more built spaces to bring forth more profit, with the construction of new housing as its instrument. On the other hand, planning for lower density housing ironically brings quality housing spaces, more greenery, and more public space for the comfort of residents and more social activities in the city.

Zeytinburnu has gone through several urban transformations: the very first one was the change from agricultural land, as it used to be on the periphery of Istanbul, into an industrial zone. This marked Türkiye's landmark shift to planned industrial development in 1947. The area had belonged to the public as a Waqf [Foundation], and Treasury, and Zeytinburnu had for many years contributed to the national economy through the food and textile factories and leather workshops after the 1950s. The occupants who worked in these factories built their houses on public land in order to be close to their workplaces. In the absence of affordable formal housing, this was a good solution for minimizing transportation and house rental/ownership costs. With the continued in-flow of migration flow, these houses (*gecekondus*) increased in the area. According to Thorns (2002), the first transformation had already taken place because rural areas were being separated from urban areas. The rate of urbanization increased with the industrialization of major urban areas. This reversed trends that had been going on since the establishment of the Turkish Republic, going from being an agricultural to an industrializing nation.

Through the rapid spillover and expansion of squatter homes in neighborhoods, congested areas were formed. Nevertheless, these houses are only 4-5 floors high and made of reinforced concrete, while the newly built houses during the urban renewal on the new Millenium are many stories taller, 20 stories or more. This means more people and denser construction on the same piece of land and that crowding is taking place without have made the necessary infrastructural improvements. This is an example of unplanned and imbalanced urban growth.

Urban transformation in these earlier stages was focused on rehabilitation, supported by both by the builder-occupants as well as the local government through the Squatter Housing Law of 1966, which grandfather-claused and rehabilitated most squatter housing. The amendments to this fundamental law that followed continued this trend and accepted the existence of *gecekondus* in the city for many years. Thus, the informal housing stock had both grown and aged within neighborhoods during the last half of the 20th century in Istanbul. This started to increase the construction density and rapid transformation of Zeytinburnu, resulting in legalization and rehabilitation. Overcrowding in the renewal zones of the 21st century has been caused by the aging housing structures that later became occupied by the lower- and lowest income groups in informal urban areas. Occupants could not repair their houses, and over time the families grew and new tenants came and demanded more housing space. The existing houses were extended horizontally (by adding rooms) and vertically (by adding floors), thus increasing the density of the same plot of land. These neighborhoods became crowded, and such buildings have been in need of modernization.

Density means "quantity" in view of the major decision makers. Policy designers are the national decision makers who aim to provide accommodations for the maximum number of people. From contractors' perspective, dense construction means more housing units on the same site and more profit (e.g., rent) per square meter of built area on a site. All of this means more total floor area usage and indexing per site. In other words, a contractor would not take the risk of constructing by demolishing an old building unless a commercial gain is foreseen. The total constructable/usable area index is determined based on location in the urban zone, and its policies and laws.

Densification or overspill of renewed areas is an expected result of the usual implementation of urban transformation. In most cases, however, over-densification has occurred in Istanbul. In Kağıthane municipality, a large scale mass-housing project that had been built on a green area was totally changed by changing its zoning from a green space into housing estates. This will lower residents' air quality and cultural, leisure, and athletic space requirements. The environmental quality of the neighborhood and other existing houses will also be lowered as a result. These over-densities are achieved at the expense of residents' needs for and constitutional rights to qualitative open spaces, public spaces, parks, playgrounds, and emergency gathering areas, as well as equal access to urban facilities, ramps and other required support systems for handicapped citizens and residents, both in their home environments and in the city overall. Having these will enable a sustainable socio-spatial urban growth. Otherwise, the city will grow in an uncontrollable fashion under the pressure of housing market forces, with urban life quality deteriorating as a result.

Global spaces are generated on local spaces where existing social networks are replaced by global and international ones. This shift is caused by urban transformation. Dense mass-housing has replaced low-rise social housing in Tozkoparan, Istanbul. Furthermore, the urban texture will serve middle-class residents. The green areas have been concretized. The trees have been torn out and replaced by tall buildings, much taller than the 4-5 story former social housing with lots of green spaces and parks. Relocating residents as a result of urban development is not sustainable in the sense of disaster resilience, because these residents go to even poorer areas of the city to survive and start their new lives from zero.

So far, the experience has shown that the government has not provided or guaranteed any favorable conditions such as providing new housing for those evicted from their houses in urban renewal and transformation areas. Squatter housing had been planned for demolishing when they first appeared in the early 1950-1960s, when they were comparatively fewer in number in major urban areas and their surroundings. Yet, not enough alternative affordable housing (i.e., social housing and core housing) had been built to matching the number of families in need. After 70 years, squatter housing have increased to contribute more than half of the population of the major urban areas in Türkiye, as well as in other developing countries, with all previous development and housing plans having failed.

3. On Disaster Law

The Disaster Law was first applied to Zeytinburnu. It was called the *Emergency Action Plan* and appeared in Istanbul immediately after the 1999 Izmir earthquake. This plan was carried out by the Zeytinburnu Urban Transformation Atelier under Istanbul Greater Metropolitan Municipality. Accordingly, Zeytinburnu was selected as a pilot project area to be prepared for the next big earthquake awaiting Istanbul in the future. It had been the largest squatter settlement in Istanbul. Based on the criteria of fast population growth, intense construction activity and densification of buildings had occurred, causing the crowding of neighborhoods on the same street. The area was assumed to not be a well-rehabilitated squatter settlement. The urban transformation processes started there because in the decision-makers' and policy-designers' eyes, the area was considered to be quit at-risk. The goal was three-fold:

(1) generate life corridors for all the mahalles' residents to escape from the area in an emergency (disaster) situation, (2) create gathering spaces for mahalle residents to come together safely, and (3) generate a green-belt so that the zone can have parks and green space to meet the need for open spaces.

The most recent disaster law, originally called the Urban Transformation of Disaster-Prone Zones, was a major guide for re-orienting the mega-cities of Türkiye and their communities. The urban transformation aimed for a more sustainable growth that kept earthquakes in mind and for the safety and security of the families with the claim of having children live and raised in healthy environments with equal access to urban amenities. To carry out this aim, different scales (i.e., building scale, urban block scale, and urban settlement scale) were considered as a whole. The Law was a response to the major earthquake in the last year of the 20^{th} century and changed all regulations and building materials, as well as the quality of concrete and type of construction iron (ribbed iron rods replacing smooth iron rods). The new regulations set the highest standards for building materials using existing technology.

A resilient city means a sustainable city. For a city to be resilient, safety and security needs should be met. Safety includes and means such things as sturdy buildings, durable permanent houses, strong and new infrastructure, well-designed and resilient public spaces. Security means a harmonious society; multi-cultural and multi-ethnic communities; walkability; and equal access to urban amenities. Safety and security go hand in hand, but for this topic, the current article is more interested in the safety aspect for its emphasis on space. Although erosion, landslides, floods, and hurricanes are significant threats, earthquakes are the greatest disaster threat for Istanbul. On the small scale with houses as buildings, their (1) design, (2) construction materials, and (3) construction/structural system are seen to play a dominant role in providing resistance. These involve the design of buildings and urban areas and the location of urban settlements with respect to the natural environment (e.g., the sea, mountains, plains, proximity to other urban areas). Such reasoning falls within the expertise of the architect, urban planner, and civil engineer, while the other stakeholders in this are contractors and developers in the housing markets. Housing policies must provide and guide the planning and design of resilient buildings and cities; the Disaster Law issued in 2012 had the role of supporting the execution of plans, with residents needing to be well aware of (1) the risks of the house they are living and (2) awareness of the laws, following and updating things based on site-knowledge.

The Disaster Law dictates the criteria for urban transformation. Firstly, squatter housing and informal settlements are theoretically located on unfavorable weak grounds. The assumption here is that all squatter housing and settlements are earthquake risks. Secondly, redevelopment of central areas is feasible. Accordingly, the focus is not on strengthening the load-bearing structures of existing buildings but on their demolition and the construction of new housing. Thirdly, the spatial quality for families and households must be increased, but families that were evicted from their informal housing are moved elsewhere. A higher social class sits on top of the new housing on valuable urban land. For decision-makers, primary assets involve learning from past experiences and other international experiences on how to design disaster resistant urban settlements; integrating housing and education with disaster in mind; using locally adaptable technology and planning its finance locally; improving existing housing structures; and creating new home designs that are less risky in cities. The local people, bureaucrats, stakeholders in the housing market, officials, and decision makers must work together to challenge how existing urban housing stock is strengthened and resilient new cities constructed. For a knowledgeable earthquake-resistant design, the public, private, and the popular sectors must pool all resources. In this way, a sustainable urban renewal becomes possible with their participation.

Not only is knowledgeability required from the designer but also from government officials. Furthermore, each locality and *mahalle* is unique. Therefore, field-based feedback on local knowledge could be very helpful for policy design. The priorities must change, and policy designers must start with people's health when providing affordable accommodations and housing. The priority that has been given to high-rise elite housing for generating global spaces in local geographies must be re-oriented toward generating locales for the local people. Here, locale refers to the vernacular local geography, land structure, strength of the soil, development potential for housing, and community capacity to form formal and informal networks for emergency conditions. If strengthening and reinforcing a building is more feasible than rebuilding from the ground up, then reinforcing should be the chosen alternative to implement. However, the Disaster Law prefers Urban Transformation to be a redevelopment because demolishing and building anew on cleared land are easier. This alternative also mitigates such problems as ownership on shared-title lands and provides extra rent for commercially oriented contractors and developers.

Large-scale housing estates could be looked into for how human they are. More people means more strangers and less likelihood to develop neighborly relationships. Maybe the time has come to return to small-scale housing units that are managed formally by the occupants. The existing housing stock, if updated and upgraded continuously, can be preserved sustainably. Maybe the simplicity of homes where the ordinary people live has mostly been forgotten. In modern times, this style can be reconsidered and adapted to contemporary living conditions. In accordance with complex designs and symbolic housing (as a building), these forms challenge the natural horizontal forces (e.g., earthquakes, hurricanes) with extra-long cantilevers and may be possible through the use of advanced technology. However, their cost may be a critical issue. House forms with global appeal and flashy facades for the elite are mostly for the international investors who dwell in these areas. Simple-looking, locally adaptable, and accessible housing spaces might require small-scale *mahalles* where the dwellers become neighbors to each other and benefit from the *mahalle* solidarity and community identity these building are situated in. Perhaps this means the revival of the more traditional and rather vernacular housing spaces and settlements. Furthermore, reserve areas should be planned and preserved for building permanent housing to replace disaster victims' heavily damaged or demolished dwellings.

Reserve areas need to be planned ahead of time before a disaster occurs. Their location crucially must be nearby existing earthquake areas yet removed from the fault lines. Otherwise, migration to faraway distances would have dramatic consequences on victims' health. People's place attachment and social bonds with their neighbors need to be preserved in the new place or settlement. Designing appropriate spaces requires scrutinization and on-going research. Such research would be better if it were interdisciplinary and multi-disciplinary. This would involve NGOs and grassroots organizations on the informal side, experts on the professional side (i.e., engineers, architects, urban planners), and stakeholders in the housing market as the pressure groups, with the formal groups being local and central agencies, government institutions, and decision makers. Regarding the legal framework, laws must be consistent and sensitive to the community and its settlements. The existing cultural fabric must be revitalized; settlement spaces must be reduced to the *mahalle* scale, and houses must be simplified in terms of plan and form, with more social space left to the common usage of the *mahalle*'s residents. In the reserve areas, new communities could be created through the original community core of the resituated *mahalle*. With regard to post-earthquake housing, the parameter of design flexibility is crucial, particularly for permanent housing. This is even important for temporary housing, especially if and when the temporary house turns into permanent housing with the delayed delivery of completed permanent new houses. Different types of housing are needed during the different stages of disaster.

Top-down or centrally decided urban transformation started appearing on the agenda before the Disaster Law was issued in 2012. The legal infrastructure had not existed in the 1st period (prior to the year 2005) until 2000. During the 2nd period (2005-2010), the legal frameworks for local administration and urban transformation implementation had been set, with authority shifted from the central to local administration. In the 3rd period (2010-present), urban transformation implementations have sped up, and laws have given central authority all the rights to enact urban transformation. The Ministry of Environment and Urbanism has been in charge, and the municipalities have gained power over implementation rights (Dulgeroglu-Yuksel et al.,2014).

Law No. 6306: On Urban Transformation was issued in 2012. The Disaster Law involves the Transformation of the Areas under the Risk and aims to improve, remove, and renovate buildings on at-risk lands. The Ministry, municipalities, and the people decide on where these transformations are to be applied. At the time, 10 cities and 24 districts had been selected in Türkiye for urban transformation, with 6.5 million at-risk buildings set to be demolished and re-built within 20 years. This goal has not yet been reached. With this Law of Disaster, geologically unsuitable grounds, areas that have experienced previous disasters, decaying buildings, and buildings on unplanned areas without sufficient facilities or technical infrastructure became candidates for urban transformation.

However, the Law has also set the conditions for how urban transformations are to be implemented:

1. Demolition of houses is to be implemented with the agreement of the owner(s),
2. Tenants/occupiers will be subsidized,
3. Loans will be provided for building reinforcement
4. Squatter homes can be demolished only if residents are assigned suitable houses.

The first condition has been met most of the time, however, the second condition has not been considered, the third condition has been minimally applied, and the fourth condition has been mostly neglected, as residents of squatter homes have only been given some demolition compensation fee for being evicted from their houses (*gecekondus*).

The major point of the Law directs decision-making and control mechanisms as follows:

(1) The Ministry of Climate, Environment and Planning at the central level, with (2) municipalities at the local level. However, because the Law does not equip local authorities with the necessary knowledge tools for implementing the regulations on urban transformation, the municipalities have found their own ways of implementing it in their zones by groping in the dark. Without a holistic plan for the overall implementation of urban transformation processes, conflicts have occurred between local and central authorities, between home owners and authorities, and between residents and commercially oriented urban stakeholders.

Most of the time, technical information is not shared with residents, and resident participation is not sought for discussing the advantages and disadvantages of urban transformation, how it will be carried out, or which lands are hazardous or not. Various studies have shown that approximately 33% of residents in urban transformation zones have no idea about whether their buildings are at risk or not. This is because authorities have not provided residents with the necessary tools. What urban transformation means to residents is strengthening buildings (mainly homes), restructuring and renovating them to have better quality in the housing environment. Almost half the population has no information about urban transformation.

Urban transformation activities have doubled prices on the housing market, as more demand has come from investors. Residents' hesitancy in approaching the Law might be explained by their fear of experiencing large-scale urban transformations through such institution as TOKİ (Mass Housing Authority) and its revenue share firms. They may also fear that the population will increase, as occurred in the Kağıthane neighborhoods, and that traffic and parking issues will worsen, with environmental pollution eventually occurring and location problems arising. Through urban transformation, the law wants to stop unplanned construction activity in the three major cities of Türkiye (i.e., Istanbul, Ankara, İzmir) to achieve healthy housing stock with good standards and safe living conditions for urban citizens. What has been interpreted as urban renewal is demolition and rehabilitation. Urban renewal provides design principles that aim to allow everyone to live in decent quality housing as afforded by the Constitution (Yıldız et al., 2016). However, the razing of houses and relocation of residents have been the major strategy preferred for implementing this.

Conclusion

Mindsets must change, and a shift from the post-disaster stage into pre-disaster stage interventions and preparations is essential. Only then will people be able to prepare for disasters and take precautions before the next big earthquake happens. This change in mentality will enable planning and orderliness throughout the whole dramatic process from start to finish. The three-section structure of the text cover over-density, urban renewal, and disaster law in an attempt to connect them all together. Ideally, an urban renewal that adheres to its design principles and disaster law would be good and beneficial for urban settlements. Yet when implemented inappropriately on site or applied generally as an urban development, the renewal processes fail to contribute to quality housing and city spaces. Nor do houses transform to meet the qualifications set for resisting earthquakes. One major issue this article has dealt with is overpopulation following intense construction activity in the city. The design clue or implication for designers is a lower building density results in better lives for the residents. The gap between the implementation goals and those of the disaster law is that the former is rent-oriented while the latter is life quality-oriented.

Housing policies in particular must focus on the three stages of generating disaster-resistant housing in cities:

1. Pre-disaster stage: prevention strategies, strengthening houses, renovating houses partially or in full.
2. During the disaster stage: providing emergency shelter and accommodations, vacant rooms at hotels, using secondary homes/holiday homes with owners' consent; having tents and containers; having covered sports halls, schools, and public spaces.
3. Post-disaster stage: completing permanent housing for victims; constructing houses in reserve areas under Law No: 6306. (e.g., TOKİ houses).

Types of Housing Plans: Usually, one or two types of highly restrictive house plans are produced for disaster victims. However, disaster victims are as diversified as any other group of citizens. They differ in terms of family demographics, economic capacities, and psychological resistance for facing the experienced trauma.

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RESEARCH ARTICLE

Multi-Objective Analysis of Housing Transformation in Istanbul

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ABSTRACT
The rapid growth of Istanbul has resulted in many housing problems in the periphery due to the development of squatter housing and the decline of districts in the historical center for various reasons. This paper presents a generalized evaluation model on housing transformation projects to examine the most productive use of land based on several objectives. The analysis takes multiple alternatives into consideration for each housing transformation project. The problem is solved separately according to each alternative by taking into consideration weighted objectives, thus revealing the most efficient alternative land use model with the maximum efficiency from among the calculated alternative activities by adding the effects of the targets. The findings obtained within the scope of the study should guide the development of more efficient decisions regarding housing transformation projects. The article proposes further extensions of the model to include the interactions among housing transformation projects and the use of new planning techniques.

Keywords: Urban transformation, land use model, urban planning, Istanbul

Introduction

The rapid growth of Istanbul's population has caused the development of squatter homes in poor urban living conditions on the periphery of the city and the decline of central historical districts as a result of their populations moving to recently developed modern housing projects (Dokmeci et al., 1996) and the city's multicenter development (Dokmeci & Berkoz, 1994). This situation has created the need to transform both of these housing areas. In fact, many successful housing transformation projects have occurred in the historical urban center of Istanbul (Ozus & Dokmeci, 2005; Dokmeci & Ciraci, 1999; Ergun, 2004; Dokmeci et al., 2007; Kolcu & Dokmeci, 2013). Recently, an excellent paper by Kilinc and Turk (2022) investigated 17,369 local housing transformation projects throughout all of Istanbul. As these projects need to be evaluated, the present paper proposes a multi-objective analysis decision model by taking into consideration alternative solutions on housing transformation projects with respect to different objectives.

Multi-objective analyses of urban land-use projects started in the 1960s. One of the earliest studies on this subject was done by Dokmeci et al. (1993). This article presented a land use model for determining the most efficient use of land in line with two main objectives: (1) maximizing returns and (2) minimizing weighted distances between different types of land use units. The article showed the most efficient alternative land use model with the maximum efficiency from among the calculated alternative activities by adding the effects of the targets. Later on, Marquez and Maneepala (1996) conducted another paper on multi-objective analyses. Their article presented an objective model for planning urban lands integrated with public services. The model also facilitated scenarios for land planning and distribution of technical infrastructure areas, such as electricity, sewerage, and gas.

In addition, Hanink and Cromley (1998) presented a paper regarding the insufficiency of market value. Moreover, Feng and Lin (1999) developed the sketch layout model (SLM), which consists of a tool, multi-objective programming, and a genetic algorithm, to facilitate city planners' development of alternative scenarios. Ligmann-Zielinska et al. (2008) presented a comprehensive model on this subject, with their paper presenting a new spatial multi-objective optimization model using a constant based on the level of neighborhood development density, something that was lacking in previous models. The multi-objective optimization model minimizes conflicting targets such as creating open spaces in residential areas, determining zoning rights in vacant plots, and transportation costs. Discussing the planning decisions and their results by developing different perspectives has enabled the development of more accurate land use decisions (Turk & Celik, 2013). Their article aimed to analyze the effects of different

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perspectives on optimum land use decisions analytically and empirically using the generalized land use model Hannink and Cromley (1998) had developed, which integrates a geographic information system (GIS) with multi-criteria decision-making techniques. Xu and Yan’s (2021) study developed an integrated model based on transit-oriented development (TOD) theory that simultaneously optimizes land use and transportation in the new development areas in China. Their study illustrated that the most advanced techniques in land-use planning in the world were only being used in China, which conducts tremendous urbanization and transformation projects.

A review of the literature reveals that multi-objective urban planning analyses are greatly improved by increasing the number of objectives that are taken into consideration, as well as the number of techniques that are used. However, this method has not been used for local housing transformation projects. Thus, the present study illustrates how to apply multi-objective analyses in local housing transformation projects in Istanbul, a very crucial task considering the danger from earthquakes that is expected in the near future.

The paper is organized as follows. The first section explains the development of multi-objective techniques in urban planning. The second section presents developmental information about population and housing growth in Istanbul, as well as the recent local housing transformation projects. The third section explains the multi-objective evaluation of housing transformation projects, and the final section is devoted to the conclusion and suggestions for further research.

Background

Using transformation to improve the issues related to the living quality of housing projects in Istanbul is quite important, due to Istanbul’s long historical background, natural beauty, and status as Türkiye’s socioeconomic and cultural center. In fact, several attempts have been made for this purpose over time.

After the 1950s, the rapid growth of the population, urbanization, modernization, and industrialization in Istanbul caused various housing problems in different parts of the city. On one hand, a third of Istanbul’s urban areas had been covered by squatter housing without the necessary infrastructure and services. On the other hand, historical neighborhoods started to lose their inhabitants to modern housing projects with better living quality along the city’s periphery, such as in Atakoy and Ataşehir. Another reason for the housing decline in the old city center involved the multi-center development of Istanbul following the construction of the Bosporus bridges and the peripheral highways (Dokmeci & Berkoz, 1994).

Several studies have analyzed the transformation of historical areas. One of these studies (Bardo& Dokmeci, 1992) investigated inhabitants’ satisfaction with their neighborhoods in both historical and modern establishments. Their study’s results revealed 95% of residents in modern housing projects to be satisfied with their neighborhoods, while only 75% of the residents were satisfied in the historical neighborhoods. Dokmeci et al. (1996) provided a comprehensive study on this subject. Another study by Dokmeci and Berkoz (2000) revealed that modern housing projects in Kadikoy, Sariyer, and Bakirkoy attracted residents more than the other districts of Istanbul, with squatter areas such as Gaziosmanpasa being the least preferred residential areas.

One of the earliest works on the transformation of historical districts started in Beyoglu, as illustrated by Dokmeci and Ciraci (1990) and Giritlioglu et al. (1993). Dokmeci et al. (2007) presented a study on the restoration of buildings in Beyoglu, which resulted in functional changes and increased land values. Ergun (1994) and Ergun and Dundar (1994) provided comprehensive studies on the transformation of Istanbul. Kolcu and Dokmeci (2013) investigated another analysis of the factors influencing land-use transformation in the historical city center.

In fact, Dokmeci and Erdogan (2021) illustrated how a tremendous need exists for land-use transformation in squatter housing areas, which are under-valued with respect to the rest of the city. Their article examined the distribution of housing prices in Istanbul at the neighborhood scale and compared the increases in housing prices over the last 20 years proportionally. According to the findings from their study, although the number of houses along coastal areas was determined to have increased, the house prices, which are higher than in other parts of the city, remained the same. In addition, high property values were decentralized toward the city periphery. The main reasons for this situation were found to be the formation of new sub-centers in parallel with the development of transportation opportunities, the attractiveness of the suburban lifestyle, and foreign capital investments accompanying the effects of globalization. However, the change in property values were also able to be explained as the increase in inequality between the quality of housing owned by low- and high-income groups. Furthermore, their research findings revealed the urban transformation practices implemented in the squatter housing areas, the revitalization of the dilapidated areas in the city center, and the increase in the number of neighborhoods developed under the control of the plans to have also caused an increase in housing prices at the metropolitan level. 17,369 housing transformation projects were erected between 2009 and 2018 in Istanbul, with Kilinc and Turk (2022) and Tarakci and Turk (2022) having provided comprehensive analyses of these projects from a value capture perspective. Developing evaluation techniques for these projects is important.

Multi-Objective Analysis of Housing Transformation Projects at the Metropolitan Level in Istanbul

Housing transformation projects are based on multi-objectives with respect to their location within the city, socioeconomic and political conditions, aesthetic evaluations (Rezafar & Turk, 2018; 2021), and their own characteristics. Kilinc and Turk (2021, 2022) broadly investigated these housing transformation projects and illustrated their multi-objective characteristics. As a result, the conditions of these projects reveal the need to exist for a decision method based on multi-objectives. Dokmeci et al. (1993) has already used this method for determining efficient land use based on maximization of returns and minimization of transportation costs. The formulation of the model is given below:

$$E_{(a)} = \Sigma_{k=1}^{n} U_k e_{k(a)} \tag{1}$$

where $E_{(a)}$ is the effectiveness of alternative a, U_k is the weight of objective k, $e_{k(a)}$ is the efficiency of alternative a in terms of objective k.

According to this model, for each housing transformation project, several alternatives are taken into consideration. The effectiveness of each alternative is calculated by summing up the weighted efficiencies of each objective with respect to this specific alternative. Finally, the alternative that has the maximum effectiveness is chosen as the best solution to be taken into consideration for the specific housing transformation project. Several other methods are also found that can be applied to arrive at a satisfactory solution for multi-objective programming problems (Nijkamp & Rietveld, 1981).

Conclusion

Istanbul urgently needs to improve the quality of life in the haphazardly developed squatter housing areas and in the historical districts that have declined and to improve the quality of buildings in the face of an increasing earthquake risk. In fact, 17,369 housing transformation projects have occurred in different parts of the city with various deficiencies. Because these projects are based on multi-objectives involving socioeconomics, politics, and aesthetics according to their location and characteristics, the present paper proposes a multi-objective decision model for determining the most efficient housing transformation design. According to this model, several alternatives should be taken into consideration for the benefit of the different social groups subject to public benefits. The effectiveness of each alternative is calculated by summing up the efficiencies with respect to each objective. Finally, the alternative with the highest effectiveness is chosen as the best solution for the housing transformation project under consideration. This decision model eliminates problems that occur such as contradicting objectives and decision makers having different opinions. This model can also be useful in other areas of urban planning, such as transportation, facility planning, urban service systems, and real estate.

Further expansion of the model can be developed by taking into consideration the interactions among housing transformation projects with regard to economic and social aspects using artificial intelligence techniques.

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RESEARCH ARTICLE

The Effectiveness of 5G Technology for Smart Buildings' Energy Management

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ABSTRACT
This study highlights the necessity for developing smart building and cities across the globe in order to conserve natural resources and energy. The aim of the study is to investigate the efficacy of 5G technologies in the architecture and construction industry. The study benefits from an extensive literature review to discuss the advantages and challenges in incorporating 5G in smart buildings. 5G is found to be needed to maximize the use of artificial intelligence (AI) and IoT in architecture in order to be able to efficiently enhance the features of smart buildings by managing energy and waste.

Keywords: Smart buildings, architecture, 5G, energy management

1. Introduction

According to estimates, the construction and maintenance of buildings use between 30%-40% of the total energy produced worldwide and contribute to greenhouse gas emissions in the global environment. Because buildings use a lot of energy and resources, anthropogenic activities associated with buildings are harmful to the environment (Ghansah et al., 2021). For instance, construction makes up 40%, 73%, 20%, 90%, and 56% of the respective energy used in the European Union, Saudi Arabia, the United States, Hong Kong, and Africa (Fazli et al., 2021). Consequently, 36%, 40%, 60%, 33%, and 32% of CO_2 emissions in these same locations can be attributed to building stock. Buildings are responsible for 39% of the world's carbon emissions and 40% of its total energy use (Adams et al., 2019). Providing sufficient and comprehensively constructed infrastructures (e.g., efficient energy management, a reliable water supply, occupant comfort indoors, waste management) for construction sites has become a difficult task for the building industry as a result of skyrocketing population growth, city growth, and globalization.

Significant CO_2 emissions pass into the atmosphere as a result of building construction, operations, and management in Pakistan. The construction industry faces a number of problems and difficulties in reducing CO_2 emissions. Measures to reduce CO_2 emissions in the building sector have been hampered by the use of non-renewable energy sources, subpar building designs, and a lack of sustainability concern in urbanization (Butt et al., 2021). The development and enhancement of new technologies is greatly needed in Pakistan's construction industry by following the footsteps of developed countries that apply new smart technologies in their building construction and design processes.

Architects have introduced the concept of smart buildings in Pakistan for dealing with construction issues and carbon emissions. The concept of smart buildings has already been implemented in various developed countries of the world (e.g., China, Singapore, Sweden, Germany, USA, UK). The idea of smart buildings is used to increase a building's efficiency both inside and out and to help deliver services to users in accordance with their needs for available space (Nazir et al, 2023). A core network connected to the Internet of Things (IoT) serves as the foundation for smart buildings. IoT devices can be sensors that gather and transmit data securely back to the central network and are frequently found in outlying or difficult-to-reach locations. These may be automated systems that regulate temperature, lighting, window shades, and ventilation, or they can link to and improve the adaptability of conference room equipment and office furniture to increase workplace productivity. These might also be tools for security, such as badge scanners, remote cameras, and electronic door locks (Apanaviciene et al., 2020).

Among many of the other latest technologies, 5G technologies have become renowned and significantly useful in developed countries' building construction and management. 5G refers to the fifth generation of mobile networks and is intended to link

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practically everyone and everything, including tools, objects, and gadgets. The 5G network is expected to provide ultra-low latency, robust cybersecurity, high bandwidth data (multi-Gbps speed), greater reliability, and a high number of devices per square kilometer (Park et al., 2021). Additionally, 5G attempts to deliver a far superior and consistent user experience. Compared to 4G LTE or 3G, 5G focuses more on improving mobile broadband experiences for a wider range of use cases. All spectrum types, including shared, unlicensed, and numerous bands, are supported by 5G. 5G can also be utilized for a variety of deployment methods, from hotspots to conventional macro-cells, and also offers brand-new connectivity options such as device-to-device communication and multi-hop routing (Rinaldi et al., 2021).

The present study intends to highlight how a 5G network system can be incorporated in building construction and maintenance and what benefits will be achieved by installing it in smart buildings. This study will also make recommendations for working upon solutions and how to use new technology effectively.

2. Literature Review

Information and communication technologies (ICTs) generally have key importance in advancing sustainability goals through lower energy consumption and emissions. Due to the presence of billions of cloud-connected devices, 5G will be crucial in lowering energy use, influencing new procedures and applications, and improving energy efficiency. With 5G, new features can be created to instantly identify environmental changes, which will help with disaster recovery efforts. 5G aims to minimize energy, resource, and material consumption by facilitating improved automation and digitization across such industries as manufacturing, construction, transportation, and agriculture. High energy efficiency is being achieved as a result of technological developments such as smaller chipsets that reduce power usage and device footprints.

A study (Chew et al., 2020) was conducted in Singapore to assess the efficacy of 5G technologies in building maintenance. According to the study, the incorporation of 5G technology in the construction industry can provide an enabling effect by making the system efficient and reliable. This technology can strengthen smart grid and metering systems, IoT-based monitoring, and AI-enabled analytics and enable smart energy management across a variety of industries. Working remotely, utilizing cutting-edge technologies like augmented reality (AR) and virtual reality (VR), and doing so from home reduces the need for office space, and travel would also become easier with 5G technology. Moreover, 5G will result in just-in-time efficiency in larger processes, with little waste and proactive planning. The intelligent management of people and cargo in transit results in shorter travel times and is also another feature of 5G technology.

In recent years, smart grids, wiser energy consumption, and smart home technologies have all gained popularity. These technologies without question are becoming more prevalent and influential. Smart buildings may considerably increase resident comfort in addition to being essential for enhancing cities and their infrastructure (Sovacool & Del Rio, 2020). This involves being able to enhance comfort levels, service accessibility, quality of life, safety features, and energy efficiency. Numerous definitions are found for the term *smart building*, and the majority of these are centered on the efficient energy usage and the idea of a smart grid. Features in intelligent management systems allow large amounts of data to be stored and analyzed. As a result, using these features in construction and management can greatly enhance energy management and utilization. This happens because electrical equipment on a grid has the capacity to work and adjust to novel situations, which is basically what distinguishes a smart building system from other types of construction and buildings. Services that leverage IoT and Big Data technologies are therefore clever for making extensive use of analytical data and machine learning (Jia et al., 2019).

2.1. Applying 5G Technologies in Smart Buildings

Many developed countries that are looking forward to managing environmental and health issues and making efficient systems in different domains in their countries have started applying 5G- enabled IoT systems in their infrastructure. Huseien and Shah (2021) presented the summary of different countries' usage of 5G in Table 1.

As discussed in the previous sections, the construction industry is a highly dynamic field in which communicating with moving parts (e.g., machinery, personnel) is critical. Wired communications are not an option in this kind of situation, because they cannot respond quickly to changes or facilitate user mobility. Therefore, using wireless communications in this setting is crucial.

Various wireless technologies have been suggested for implementing IoT in the construction industry. Cellular networks, short-range networks, and long-range networks are the three categories into which the suggested wireless technologies fall. However, these technologies are unable to meet every need in this industry.

Table 1. 5G in Developed Countries

Country	Application	Source	Purpose of Use	Reference
Singapore	Residential Structure	IoT	Enhancement and management of energy system for smart grids in residential buildings.	Viswanath et al. (2016)
China	Medical centers and hospitals	IoT	Location of the occupant for hospital department route	Chunjiang (2016)
Malaysia	Medical centers/hospitals	AI	AI used for drug research and discovery.	Mak & Pichika (2019)
USA	Medical centers/hospitals	Machine Learning	The Health Guard facility continuously assesses & compares body functions using associated devices.	Newaz et al (2019)
Italy	Business plazas	IoT	User-oriented building maintenance applications.	D'Elia et al. (2010)
South Korea	Smart Factory	AI	Improve system performance, remove delays in real-time processing, support numerous machines and multiple single protocol products, reduce time and cost, resolve data loss issues, and increase the effectiveness of horizontal data distribution and exchange activities.	Kim & Jeong (2019)
Sweden	Smart Industry	AI	Big data management and predictive maintenance.	Akerman et al. (2018)
Finland	Smart Factory	AI	Enables the division of network functions among commercial entities across various network domains.	Walia et al. (2019)

Three service categories have been defined: ultra reliable low-latency communications (URLLCs), massive machine-type communications (mMTCs), and enhanced mobile broadband (eMBB). New features have also been included, such as network slicing. Massive Multiple-Input Multiple-Output (MIMO), multi-connectivity (MC), and vehicle communications are the three main 5G features that enable it to satisfy the demands of the construction industry.

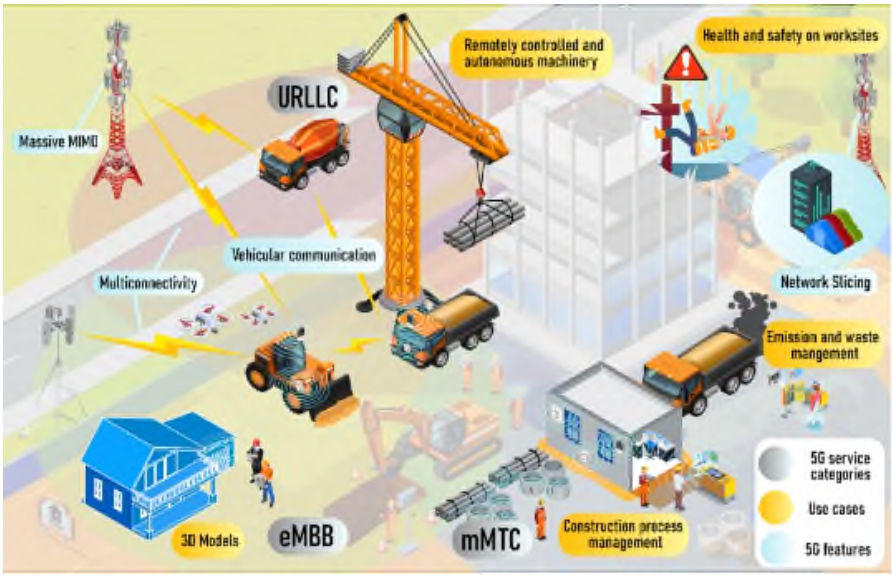

Figure 1. Implementing 5G at a site (Mendoza et al., 2021).

2.2. Categories of 5G Services

Figure 1 is depicting an effective implementation of 5G at a site with all its features that are being explained below.

- eMBB: Enhanced mobile broadband has to do with applications that demand fast data rates over a wide area. These types of services will be useful for applications related to the construction industry that have rigorous throughput requirements, such as the visualization of 3D models using AR and VR services and the observation of work sites using high-quality video cameras.
- mMTCs: Massive machine type communications feature an unusually large number of connected devices that often only require a small amount of traffic. The most significant application of this type of service is in IoT networks. Numerous sensors and other gadgets (e.g., cameras, wearables) can be utilized in the construction sector to monitor job sites.
- URLLCs: Ultra reliable low-latency communications have emerged as a crucial component in critical applications with stringent reliability and latency requirements (e.g., behicle communications, remote monitoring).

2.3. 5G in Architecture and Construction

This subsection presents a high value plan for incorporating 5G in the construction sector. Information sources, communications technologies (5G), data processing, applications, and network administration make up the bulk of this design.

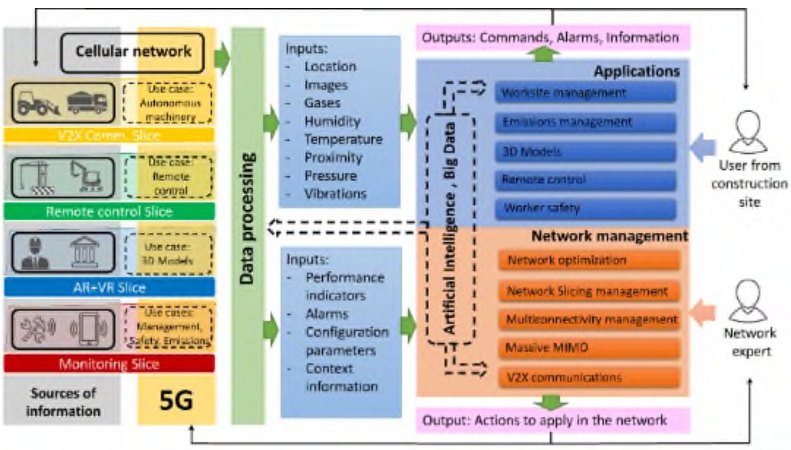

Figure 2. Incorporating 5G into the architectural system (Mendoza et al., 2021).

Figure 2 shows how 5G technology can be used at different stages of smart building construction and maintenance. Previous studies have shown the impact of its application on the efficacy of a new architectural system for obtaining better outcomes in construction and infrastructure. Meanwhile, the present study focuses on future opportunities where a 5G network can be utilized more beneficially to enhance productivity in the construction sector, especially in developing countries such as Pakistan.

3. Methodology

Table 2. Summary of Evaluated Papers

Study Title	**Study Objectives**	**Methodology**	**Study Outcomes**	**Authors**
Evaluating the roadmap of 5G technology implementation for smart building and facilities management in Singapore.	To evaluate the effectiveness, challenges, and benefits of 5G technology used in SFM applications.	Literature review	A framework was developed for teaching and training students to increase their motivation and understanding of 5G networks.	Chew et al. (2020)
Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies.	To critically examine smart home technologies.	Dataset including expert interviews, site visits, and a literature review.	Provided seven policy recommendations for smart home sustainability.	Sovacool & Del Rio (2020)
Adopting Internet of Things for the development of smart buildings: A review of enabling technologies and applications.	This study looks into cutting-edge initiatives and IoT adoptions for the creation of smart buildings in academic and commercial settings.	Literature review	A number of current IoT building apps that help achieve the essential objectives of smart buildings are chosen and presented.	Jia et al. (2019)
Potential Applications of 5G Network Technology for Climate Change Control: A Scoping Review of Singapore	Reexamines the advantages of 5G network technologies for improving Singapore's smart city efficiency and reducing the effects of climate change, resulting in a clean environment conducive to healthy living.	A scoping review	Showed Singapore's clever approach to managing energy, waste, water resources, agriculture, risk factors, and economy to greatly help slow down climate change and meet the country's sustainability objectives.	Huseien & Shah (2021)
5G for Construction: Use Cases and Solutions	Discusses the advantages of utilizing 5G mobile networks in construction.	Literature Review	Established many use cases and associated requirements associated. Noted the primary 5G features that cater to these use cases and suggested a global framework for 5G tech usage in construction.	

The study is based upon an extensive literature review. The summary of all the articles that were reviewed is given in Table 2. For this purpose, the studies that are to be considered in the present study must:

- Have a focus on smart construction and architecture, the latest technologies in the sector of construction, and the use of 5G in construction,
- Have been published between 2019-2023,
- Be in English,
- Be systematic reviews, a literature review, or evaluation study.

The relevant literature was searched with the help of published papers in different reputed journals using reliable databases such as Google scholar, MDPI, Science Direct, and Research Gate. Some of the main keywords used to explore the literature are: smart buildings, AI, 5G network, architecture, and technology.

The study has reviewed and critiqued each paper. A code sheet was created to record important study-related information to help with this process. The study used the reference lists of articles that had been retrieved through the databases and employed the snowball method to find more material. Following the same procedure, databases were searched first by title, then by abstract and conclusion, and then by full text to find the relevant articles.

4. Discussion

A 5G network can make a fully mobile and connected society possible as a complete ecosystem. Additionally, 5G can enable the creation of innovative business models that add value. The amount of traffic and the demand for data transmission over mobile broadband will both dramatically rise in the next years. Mobile broadband will also be employed in more situations. 5G will greatly aid the creation of new services that can be used more extensively and help develop currently available mobile broadband services. 5G represents how a large variety of applications, from those with minimal bandwidth to those with high data throughput and latency requirements, will be able to use 5G (Blanco et al., 2017). The features of smart buildings are being showed in Figure 3.

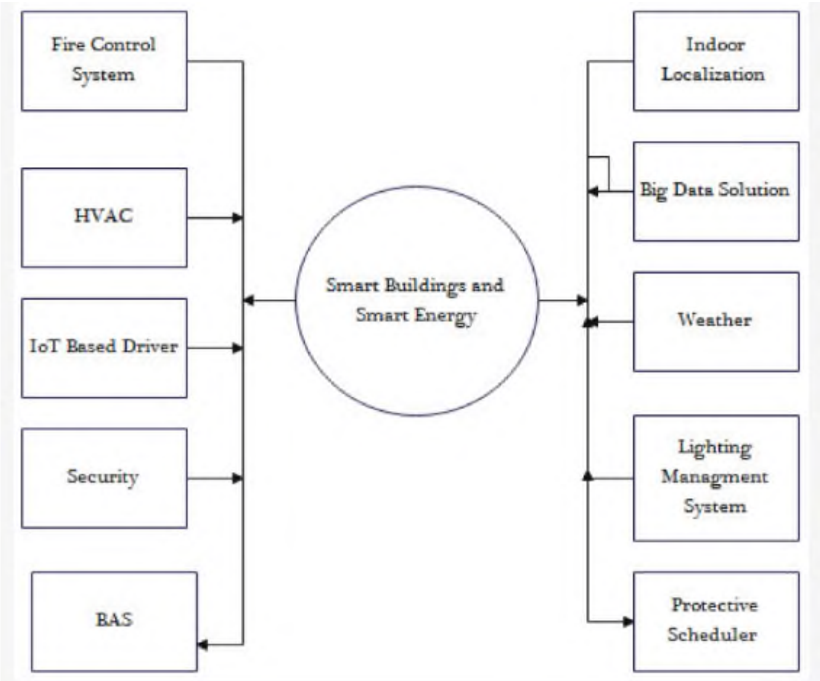

Figure 3. Smart building features (Mazhar et al., 2022).

By combining many various types of urban infrastructures and having them function together, smart and efficient cities aim to create more friendly and creative urban surroundings. In this case, smart buildings are crucial to smart cities and are essential to their viability. Residents of smart cities and buildings can rest easy knowing that IoT technologies and AI are protecting them. Sensor data is used in IoT smart buildings to reduce energy use and improve operational efficiency. Energy use can be controlled by incorporating IoT devices into smart cities and buildings (Ahsan et al., 2021). To save energy in smart buildings, IoT gathers and investigates environmental variables such as air pressure, temperature, and humidity. IoT sensors are used in smart buildings to monitor and control lighting by turning on and off lights as needed. IoT solutions can enhance crisis response and management, which will enhance outcomes in risky situations.

Incorporating 5G technologies into the construction industry is possible with the help of government authorities and other stake holders who aim to construct smart buildings. Information sources, communications technologies (5G), network management, and data processing applications make up the bulk of this design. The various elements of the architectural sector are defined in the following subsections:

- Sources of Information: These sources are connected to the many components of a construction site and have been employed in the use of Construction 4.0. As a result, sensors installed in vehicles, machinery, people, and other objects are potential information sources at a construction site, as well as cameras for worksite surveillance, vehicle communications, and drone remote control; these can be wearable for worker safety or involve AR and VR technology for displaying building information modeling (BIM).
- Communication Technology: This category of services permits the development of preexisting usage cases related to pollution control, waste control and management, and the majority of applications for construction and construction management. 5G technology helps in this category through network slicing.
- Data Processing: This block's primary objective is to produce a set of inputs that have been effectively chosen and utilized for each algorithm specified in the work system. Big data, data analytics, and AI will all be crucial for this.
  - o Cloud, fog, and edge computing are taken into account for processing data. The usage of network resources is referred to as cloud computing. High availability on-demand data processing and storage services are offered via cloud computing. However, cloud computing is limited in its ability to conduct real-time processing tasks because of the separation between nodes for processing and storage and for information gathering plans (information sources). Distributed data processing and storage duties are respectively referred to as fog computing and edge computing. These kinds of methods have the processing and storage nodes located closer to the information sources.
- Application: This area contains all the technologies and applications specified for Construction 4.0's automation, digitization, and process optimization. The inputs in this block are numerous. Applications for worker safety may make advantage of the position of the personnel, high-quality video images, and data on gas concentrations, humidity, or temperature. Applications involving the management of garbage or construction may also use this environmental data. Applications such as remote machine control or AR also use precise location data and high-quality photos. These programs will use the data they get as input to carry out such tasks as automated decision-making, forecasting the potential condition of a construction site, finding and identifying issues, or computing them.
- Network Management: The primary goal of these apps is to maximize 5G's features to achieve the greatest building automation outcomes. These applications can also automatically adjust to changes in the workplace thanks to the use of data analytics and AI technology.

5. Conclusion

The study has intended to review the advantages of incorporating 5G technologies in construction, such as are being used in developed countries like Singapore. This article has examined the use of AI and the potential issues with 5G technology in smart building management and smart energy, as well as their possible fixes as 5G technology becomes more widely utilized in the fields of infrastructure management and smart building. These programs need a range of instructions and inputs, such as configuration parameters, performance indicators, and background data regarding the condition of the workplace, including machinery and equipment quantities, number of workers, and necessary use cases. The execution of these applications can yield a variety of outcomes.

This study may also facilitate developing countries in understanding the benefits and challenges of 5G technology so that their architectural systems can be revised. This article is an educational resource for providing information to stakeholders working in the construction industry.

6. Recommendations

The incorporation of numerous IoT-based smart devices is necessary for smart building management activities as a source of big data production. To achieve real-time performance targets and to integrate with smart building infrastructures, a decentralized cloud storage system must be designed. Future research on the cost-effective design and execution of this storage system will therefore be crucial to increasing the global focus on smart city strategies. Utilizing renewable energy sources is essential for addressing the challenges related to scarcity of non-renewable sources of energy and for ensuring the viability of city functions and operations.

Due to the advancements and broad usage of new technologies, fifth-generation technologies have the potential to improve the functionality of structures, communities, and cities. The rules of usage, including the domain-specific language, must be developed alongside machine learning- and AI-based methodologies in order to employ them in 5G smart city technologies.

Keeping sensitive data in networked environments secure is crucial. Citizens often choose not to use ICT platforms that have any ambiguity in this regard, as such issues reduce the viability and dependability of city operations. Thus, the application of group security techniques in smart cities is a crucial field for future research.

The gaps in the body of knowledge on how ML, DRL, and AI techniques based on 5G technologies can be applied to raise the effectiveness of smart cities can also become a focus for researchers and industry experts.

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RESEARCH ARTICLE

Science and Technology in Architectural Conservation: The Role of Scientific Research on Traditional Building Materials and an Evaluation of Conservation Laboratories

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ABSTRACT

Cultural assets are at risk of decay due to natural processes, poor environmental controls, disasters, human activity, neglect, and even certain conservation treatments. Science and technology are crucial for comprehending historical building materials and their deterioration. Experienced professionals should execute these activities using proper methodologies and appropriate equipment and techniques. The field of conservation science has made significant progress since the first half of the 20th century and continues to advance. Some institutions have now reached their 50th anniversary since their establishment. In the face of these positive developments, these institutes have also encountered challenges. This study aims to make a recent assessment of the importance of conservation laboratories in terms of architectural conservation, as well as the necessity of the global exchange of knowledge and valuable data that have been gained through the efforts of former institutions.

Keywords: Conservation science, instrumental analysis, architectural heritage, conservation laboratory

1. Introduction

Historical building systems typically incorporate a variety of materials with varying properties. In addition to material properties, the long-term performance of a building is also affected by factors such as its location, design, and workmanship. Assessing the properties and level of deterioration of materials is essential for adequately safeguarding historic structures and undertaking effective restoration practices. Collaborative interdisciplinary studies need to be conducted to achieve this purpose. The experts and professionals collaborating in the conservation and restoration field use various factors to determine the appropriate interventions for preserving and restoring artifacts. These factors include the physical and architectural characteristics of the artifact, its current state of preservation, the properties of the materials used in its construction, and the extent of deterioration present in the building or area being investigated. Thus, this field seeks contributions from individuals with diverse expertise to restore and execute projects, to address building-related issues, and to develop solutions. The Venice Charter (ICOMOS, 1964) was the first to recognize the significance of preserving original materials while utilizing modern techniques based on scientific data and long-term experience. The charters adopted in subsequent years have placed an even greater emphasis on pre-conservation investigations, sampling for analysis, and non-destructive testing, as well as an emphasis on carrying out material conservation in accordance with such current standards as the Charter for the Protection and Management of Archaeological Heritage" (ICOMOS,1990), Charter on the Protection and Management of Underwater Cultural Heritage (ICOMOS,1996), and Principles for the Preservation of Historic Timber Structures (ICOMOS,1999). Investigating the characterization and deterioration of historic building materials in restorations is crucial for various reasons, one of these being the need to understand the raw material properties of building materials. In archaeological sites, these investigations may be carried out more for provenance research regarding where the materials originated. As a result of the characterization of materials, conclusions about chronological analysis or some valuable interventions may also be facilitated by evaluating the systems of construction. Another aim of research on building materials is to understand the types, depths, and causes of deterioration. Historic buildings are susceptible to decay due to various factors, including environmental conditions, human impact, and natural disasters. Different building materials deteriorate at varying rates based on geography and climate. Appropriate methods and materials for protecting building surfaces can be determined by identifying the causes of deterioration. Continuing material research during the selection phase is important. Depending on the

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type of surface deterioration, some stone facades or architectural elements may require a superficial application of consolidants or water repellents. Evaluating the effectiveness of the application and its long-term impact on the structure are essential, providing that no adverse effects occur. Performing specialized laboratory tests is also crucial. Ensuring the ability to retreat repair materials is of utmost importance, even if complete reversibility is impossible. One must essentially consider that the repair materials be compatible with the original materials. This is a scientific fact that must be considered in any project involving repairs. Ensuring similarity in physical, mechanical, and mineralogical properties and thermal expansion coefficients between the original material and repair materials during their selection or production are imperative. Having the original material and repair materials match in color, texture, and finish are also essential. All of these issues require comprehensive analyses and experimentations on the materials. Institutions are conducting an ever-increasing amount of material research to ensure optimal effectiveness worldwide. This research can cover a wide range of subjects related to material preservation, such as identifying the nature of deterioration and degradation processes, characterizing materials, suggesting repair materials and techniques, recommending surface consolidants, and identifying the composition of cosmetic repair mortars. Different test programs should be developed based on the specific properties and preservation state of the materials under investigation (Ersen et al., 2010) In order to assess the structural integrity of historic buildings, experiments need to be conducted on both the buildings and the materials used to construct them (Giordano et al, 2022; Barnaure et al., 2020).

Testing and evaluating historic building materials are important, but problems in the experimental field must also be acknowledged. In recent times, instances have occurred where modifying national or international standards was necessary in the field of conservation regarding construction and building materials (Fassina,2015). Alternatively, new protocols have needed to be established for conducting experiments on historical building materials. While efforts are underway to improve testing standards for historic building materials, further studies are clearly needed to investigate some more materials and properties.

2. Laboratories for Architectural Conservation: First Interdisciplinary Efforts and Leading Institutions

In the second half of the 20th century, conservation science became increasingly important, particularly with regard to conservation issues and studies in archaeometry. As archaeometry has progressed, the integration of physics, chemistry, biology, and geology has yielded new insights into historical materials, such as joint studies frequently involving the dating of materials (D'Agostino, 2022). The physicist Lord Cherwell believed that science could make significant contributions to fields like archaeology. He contributed to the development of an x-ray fluorescence spectrometer used to analyze archaeological materials. After conducting his research, he and a group of colleagues came up with the concept of creating the Research Laboratory for Archaeology and the History of Art (RLAHA). The laboratory was eventually established in 1955, and by 1958, Oxford University had begun publishing the Bulletin of the Research Laboratory for Archaeology and the History of Art (Research Laboratory for Archaeology and the History of Art, n.d.). This publication would later become an international journal: Archaeometry. The laboratory has played an important role in archaeological education and has enabled much interdisciplinary and science-led research to be carried out, and continues to do so today with advanced technological facilities.

After World War II, UNESCO became known for its efforts in establishing two non-governmental organizations: the International Council of Museums (ICOM), which concentrates on the problems of museums and galleries, and, more recently, the International Council on Monuments and Sites (ICOMOS), which specializes in the matter of monuments and sites that are of interest to architects, planners, and engineers.

These developments were followed by the establishment of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) in Rome in 1959, and an environment was created through ICCROM for training experts from different countries of the world on the conservation of historical building materials (Plenderleith, 1998). Initially, ICCROM was dedicated to gathering and sharing scientific and technical knowledge related to conservation. A 1959 survey showed an urgent need for specialists in restoration work worldwide. In 1962, the Centre began teaching in collaboration with the University of Rome. By 1966, however, it had taken sole responsibility for the courses. The training was architecturally based, with a strong emphasis on material science and the technology of construction and repair (Goddard, 2020).

In 1965, Harold Plenderleith, ICCROM's director, asked Giorgio Torraca to establish a scientific research laboratory at the Rome Centre. However, Torraca's list of advanced equipment for the laboratory was subjected to intense scrutiny at a meeting of the Rome Centre Council. Although the advanced laboratory was not completed, the facility was repurposed to support ICCROM training (Toracca, 2009). The Scientific Principles of Conservation (SPC) course at ICCROM needed that laboratory. This course covered various materials such as wood, stone, and metals after providing a general understanding of materials science. Mornings consisted of theoretical lectures, while afternoons were reserved for hands-on laboratory training. The SPC course aimed to familiarize conservators, architects, historians, and conservation scientists with the nature of materials and durability issues. The objective was to equip them with the knowledge and skills necessary to handle cultural property with care and to avoid causing damage to it in the future. Working collaboratively, professionals could also develop a common language for interdisciplinary work. The courses in Rome were successful and provided Centre staff with direct contact to leading conservation experts and student colleagues from national institutions (Toracca, 2009). By the 1970s, ICCROM was running many training courses for architectural structures, such as stone conservation in Venice and wood conservation in Norway, as well as programs for museums and interiors (Jokilehto, 2009). In 1982, Jeanne Marie Teutonico joined the Architectural Conservation course as a participant and later returned to ICCROM to work on developing the course's laboratory curriculum. She mentioned having the desire to develop this aspect of the course further so as to provide a more hands-on consideration of building materials and their decay, analysis, and conservation. The course content aimed to increase the practical methods of material deterioration, analysis, and conservation. As a result of these developments, the course duration was extended, and the number of lectures and applications on historical building materials increased. Experts lectured on adobe, mortars, plasters, painted finishes, and their applications. Teutonico's photocopies of laboratory exercises for the participants were then published as A *Laboratory Manual for Architectural Conservators* in 1988 (Teutonico, 2009). ICCROM trainings, which were continuously developed in the late 1980s, can be considered as an important model for its time and one that trained experts in many countries. Getty Conservation Institute (GCI) and ICCROM have collaborated together for various trainings. The first was the three courses at ICCROM devoted to Architectural Records, Inventories, and Information Systems for Conservation (ARIS), which was delivered in 2005, 2007, and 2009. The two institutions collaborated on the International Course on Stone Conservation, which was delivered four times between 2009 and 2015. The 3 month-long courses provided comprehensive learning on the mineralogical and physical characteristics of stone, their decay mechanisms, and the best methods for analysis, maintenance, and preservation. Participants, as well as a global audience, were provided with educational materials and resources (Coddy, 2020). While working in the field of historic monument conservation in France in the 1960s, Jean Taralon alerted his superiors to the need for a scientific body dedicated to the problems of historic monuments. He had long been concerned with the uncontrollable nature of the traditional processes used in the restoration of historic monuments and wanted to see conservation operations better supervised using scientifically validated methods. He pioneered the establishment of the *Laboratoire de Recherche des Monuments Historiques* [Historical Monuments Research Laboratory] (LRMH) in 1970, which is a department of the Ministry of Culture and part of the General Directorate for Heritage. Since its foundation, the laboratory has aimed to preserve historical monuments and objects of cultural heritage classified as *Monuments Historiques* [historical monuments] through its knowledge and expertise in materials and research. Since the laboratory's establishment, it has gained significant experience in intervening with historical buildings, especially during times of disaster. After the Notre Dame fire in 2019, the laboratory team's experts quickly prepared a protocol and documentation, as well as an inventory for reusable materials for starting the restoration (Magnien, 2020; Zimmer, 2020). The *Consiglio Nazionale delle Ricerche* [National Research Council of Italy] (CNR), which started to expand its organization in the late 1960s, has an important background in heritage science research. In 2019, many research laboratories in different cities in Italy merged under The Institute of Heritage Science (ISPC), creating an organization with a large number of researchers and laboratories. Today, the institution has various groups and labs focused on archaeological conservation, heritage materials science, built heritage, and more (L'Istituto di Scienze del Patrimonio Culturale, n.d.). Apart from the aforementioned laboratories, which boast experienced staff and advanced equipment, numerous research facilities are also found affiliated with universities and institutions worldwide. An increasing trend is seen toward utilizing experts from various disciplines and technologies in a collaborative system. (*El Consejo Superior de Investigaciones Científicas* (The Spanish National Research Council), HERKUL,n.d).

3. The Current Situation in Türkiye

State authorities in Türkiye house laboratories that are responsible for conserving heritage building materials. The Istanbul Directorate of Central and Regional Laboratory for Restoration and Conservation was established in 1985 under the Turkish Ministry of Culture and Tourism, Directorate General of Cultural Assets and Museums in Istanbul. Its primary goal is to perform conservation and restoration work on cultural heritage based on scientific principles for movable and immovable items. The history of the laboratory can actually be traced back to the *Kimyahane* in the Istanbul Archaeological Museum (Yarlıgaş, 2021, Ertürk, 2022). In 2012, approval was granted for the establishment of nine regional laboratories across Türkiye in Ankara, Trabzon, Erzurum, Diyarbakır, Gaziantep, Nevşehir, Antalya, İzmir, and Bursa. Over the years, the laboratories have expanded their staff and research facilities. Researchers from different disciplines have gained experience in training programs organized by UNESCO and ICCROM, and some of the trainings have taken place at significant historical sites in Türkiye (Ok, 2019). Following the establishment of the Directorates for the Conservation, Implementation, and Supervision of Cultural Assets (KUDEB) by the Law No. 2863 in 2005, a Restoration and Conservation Laboratory was established within the Istanbul Metropolitan Municipality by KUDEB in 2007. The unit began work under the consultancy of experts, has added staff from different disciplines to its body, and started its active work in and beyond Istanbul. Material characterization and conservation reports have been prepared for many buildings, and the team has also carried out research studies together with their academic advisors. The team created a laboratory handbook to explain test methods for assessing historic building materials and their deterioration mechanisms (KUDEB & Istanbul Metropolitan Municipality [İBB], n.d.). The unit shared the results of their work and other current works on conservation with the public through the publication of *Restorasyon Konservasyon Dergisi*, a journal on restoration conservation publishing a total of 23 issues between 2009-2020 (KUDEB & İBB, Dergiler, n.d.) Following the establishment of the laboratory in Istanbul, several KUDEB units in other cities have also set up their own laboratories.

Universities offering education in architectural conservation often have conservation labs, as the conservation of historical buildings and laboratory research are closely related. The Architectural Conservation Laboratory of the Department of Historic Preservation at the University of Pennsylvania was founded in 1991 as one of these. (Architectural Conservation Laboratory, n.d.) The Historic Preservation program at the University of Texas Austin offers courses that involve laboratory applications in their Architectural Conservation Lab. (Materials Lab ,n.d.)These laboratories not only support education but also provide research assistance for public and private projects. The Heritage and Technology Laboratory at TU Delft was established for the development and assessment of solutions for the conservation of historic buildings. Conservation materials could be subjected to laboratory testing to assess their effectiveness, compatibility, and application techniques. (Heritage and Technology Lab, n.d.)

Turkish universities operate conservation laboratories specifically designed for educational and research purposes. The laboratories of METU, ITU, MSGSU, and IYTU are some examples that can be mentioned. (Material Conservation Lab, Mimari Koruma Laboratuvarı, Merkez Araştırma Laboratuvarı, Malzeme Araştırmaları Merkezi, n.d.)

Apart from these few examples, a low number of architectural conservation training programs are observed to include laboratory studies. This situation may cause difficulties for conservation architects when communicating with other specialists about material research or managing sampling and developing research methodologies. Importantly, archaeologists, architects, and art historians should learn how science can aid in conservation efforts.

4. The Strong Link Between Conservation Laboratories and Scientific Research and the Challenges Encountered in the Process

When analyzing research laboratories concerned with architectural conservation worldwide, commonalities become apparent. Clearly, these institutions were founded due to a lack of scientific and experimental research in the restoration field. This need, seen intensively since the mid-20th century, continues today without diminishing. In addition to maintaining existing institutions, new laboratories must also be established for historical material characterization, diagnosis and detection of deterioration, and identification of repair materials. In this context, conservation laboratories should expect developments in their relationship with restoration projects and applications. The conservation work on historical materials can begin in the field and continue in the conservation laboratories. After conducting research, continuing efforts toward archiving is imperative, as well as publishing findings (Figure 1).

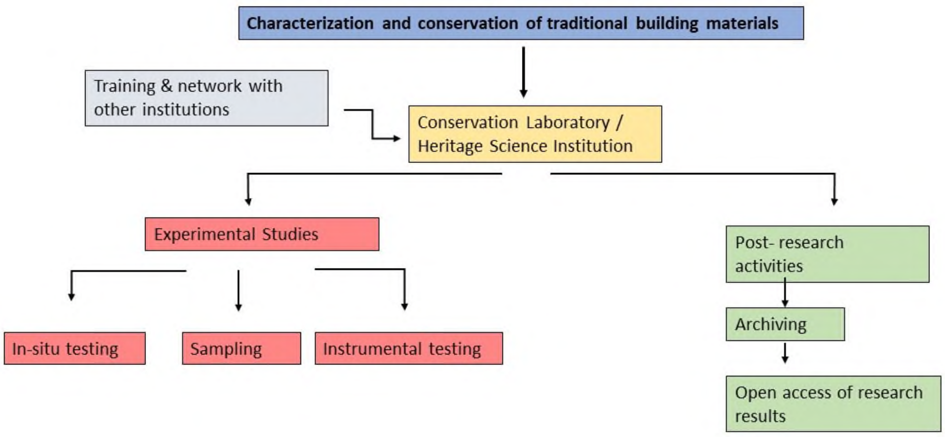

Figure 1. Conservation laboratories and processes refer to the practices involved in preserving and restoring cultural artifacts and historical objects.

At the ICCROM Forum on Conservation Science held in 2013, some key messages were drafted by the participating institutions. These messages conveyed the importance of conservation science and the need for a community of conservation scientists who possess credibility, relevance, influence, and transdisciplinary connections. When engaging in research and development projects, involving all stakeholders (e.g., scientists, conservators, and other heritage experts) who will collaborate to define the issues and objectives is vital. Conservation institutions should conduct research and development to address issues and establish sustainable solutions and guidelines proactively. By collaborating and sharing their resources and expertise, conservation institutions can enhance efficiency, increase access, reduce inequalities, and ultimately achieve better outcomes for a sustainable future. Additionally, conservation institutions should play a leading role in promoting conservation and ensuring access to knowledge at all levels, including knowledge produced by others (Corbeil, 2015).

4.1. Giving Sufficient Time to Material Research

Although material research is essential in architectural conservation, it cannot guarantee successful results in every sense. Describing applicable and tested repair materials and methods based on laboratory analyses is necessary. Simply completing some analyses on materials taken from buildings will not be sufficient for achieving this goal. Having competent people with practical experience in the field of restoration run evaluations will determine what experimental studies contribute to practice. In some cases, having only laboratory research results may not be sufficient; in this regard, some experiments and analyses should be carried out in the field. As these processes tend to consume a lot of time, they must be scheduled meticulously. Viewing materials research as an ongoing process is preferable to seeing it as a task to complete.

4.2. Correct Sampling

The responsibility of architectural conservation laboratories should be valid from the sampling stage to the successful conclusion of the application. The study should start with purposeful, accurate, and non-destructive sampling, followed by an experimental program to understand the problems.

Visual analysis has the potential to accomplish a lot while requiring minimal investment. Having experienced analysts on hand can quickly help clarify problems and identify materials. However, emphasizing that the correct individuals must be employed is important; otherwise, identifications may be incorrect. Visual analysis is a non-destructive technique and should be utilized as much as possible prior to further laboratory or on-site technical investigations. (Hughes et al., 2002) Having architects or archaeologists who have documented the building or site to guide the sampling team during sampling would be more appropriate for ensuring accuracy and relevance.

4.3. Determining the Experimental Methods

The experimental studies should produce high-quality results to guide the restoration project or application. Materials research is a field that evolves with technological advancements (Adriaens, 2004). While some analysis methods and materials have been used for years, keeping up with new materials and research techniques is important. Some excellent research may provide solutions that are inaccessible due to complexity or cost. Currently, powerful technologies such as multispectral imaging and synchrotron radiation studies at national facilities are not widely available. As usage becomes more widespread, sophisticated technologies tend to become more affordable and user-friendly. A good example of this is Raman spectroscopy instrumentation, which used to be confined to research facilities due to its complexity (Corbeil, 2015). Studies can be carried out in the field with some new non-destructive analysis methods. Over the years, a wide range of experimental techniques, including Raman spectroscopy, x-ray fluorescence (XRF) spectroscopy, and Fourier transform infrared (FTIR) spectroscopy, which were initially designed and used for laboratory-based research, have now been modified and made smaller for *in situ* analysis in cultural heritage-related fields. Experimental methods for the characterization of historic materials or structures, environmental effects on materials, and deterioration processes have become familiar, as well as the many studies and publications on the use of these methods (Zhao et al., 2019). Research shows that multiple techniques may complement each other or be more advantageous in certain cases (Carmona-Quiroga et al., 2010). Hence, institutions involved in conservation research evidently require state-of-the-art equipment and skilled personnel. Fulfilling these requirements also apparently necessitates providing sufficient support and budget to this field.

4.4. Training

Laboratories that have been carrying out research on historical materials for many years have considerable experience. This experience encompasses the perspectives of both institutions and specialized staff, including laboratory and field studies. Conducting extensive studies on historical building materials is sometimes necessary for making informed decisions due to their diverse nature and deterioration. When considering that architects are primarily trained in the field of restoration, engineers, researchers, and technical staff from different disciplines working in these institutions can be provided with specific knowledge and awareness on conservation issues through experience and different training in the process. Planning and training new researchers alongside experienced experts is crucial for ensuring a continuity of knowledge and experience.

Past experience shows that continuously training the laboratory team is an issue that needs to be emphasized. Different organizations can come together on a regular basis to follow current developments and exchange information through different trainings on the points where they feel deficient. This is also important for the formation and maintenance of a common language. The fact that the researchers working in the laboratory are familiar with archival research and have an idea about construction techniques or developments in construction technology will enable them to better comprehend the subjects they will evaluate (Toracca, 2009). To have the people who prepare the laboratory reports prepare them in a way that architects, art historians, or conservators can understand will also be important so that the work can be understood correctly.

4.5. Archiving the Samples

The areas where conservation laboratories conduct studies often contain unique materials and construction techniques. Some samples taken from buildings are used for analysis, while others are preserved as valuable documents. The preserved specimens should be displayed and, if possible, properly archived and cataloged and easily accessible for future researchers. The Mora Sample Collection Project serves as an illustration of this. Paolo and Laura Mora, former ICCROM trainers, have preserved samples from their fieldwork that are now stored at ICCROM's Rome headquarters. Today, the Mora sample collection is an extraordinary resource that showcases the complexity and diversity of mural painting as a medium for cultural expression across different civilizations and time periods. The fact that some of the areas where the samples were taken are inaccessible today increases the value of the collection for possible future research (Mora Sample Collection Project, n.d.). ICCROM launched the Heritage Samples Archives Initiative (HSAI) to preserve and promote the use of collections for educational purposes, recognizing similar situations in other institutes worldwide. The aim of the HSAI is to increase awareness about the value and importance of sample archives; establish good practices, policies, procedures, tools, and methodologies for managing sample archives; and create a roadmap for enhancing the accessibility and utility of sample archives by linking them through open digital platforms (Heritage Samples Archives Initiative, n.d.).

The Historic Building Materials Collection (HBMC) of the Architectural Conservation Lab of the University of Pennsylvania has a similar material samples collection from historic buildings and sites around the world. The collection serves as a library of building materials used in construction worldwide, including archaeological sites. The primary function of the collection is to provide direct access to traditional and historic building materials, whether as bulk samples or through advanced sample analysis such as cross-section or thin-section analysis. A searchable online repository for the collection has been created with a digital interface that allows for filtering using date ranges and more. Those who wish to submit a piece to the collection can also apply via the website (Historic Building Materials Collection, n.d.). UPenn's Walker Zanger Reference Stone Collection holds 5,000 natural stones from the 20th and 21st centuries. In 2024, a publicly searchable database will become available.

4.6. Open Access to Results

As mentioned earlier, publications on laboratory techniques and research started in the first years of the establishment of conservation laboratories. Specialized publications on conservation issues have been produced by organizations such as ICCROM and the Getty Research Institute, many of which can be found online. In addition to material samples, the ICCROM archives contain a vast amount of historical correspondence, photographs, and architectural drawings that are available for research purposes. The Digital System Applied to Heritage and its Sciences (SYNAPSE) portal of LRMH can also be used to access resources online or in person. This includes a library of publications related to research and studies on the problems of conservation and restoration of monuments and works of art, an archive of research and reports by laboratory researchers, and a database on research and analyses (Le Laboratoire de Recherche des Monuments Historiques, n.d.).

5. Conclusions

Conservation laboratories evidently play a crucial role in preserving cultural heritage. Given the knowledge that has been gained from the past to the present and the advancements in technology, having administrations demonstrate their support and interest in these institutions is vital. The existence of such institutions, especially in areas with a large number of architectural and cultural heritage such as in Türkiye will facilitate the work of professionals and practitioners working in this field. In addition to equipping institutes with advanced experimental instruments, competent personnel should also be assigned to these institutions. Researchers who have not completed their undergraduate education in cultural heritage may need time to gain competence in this field. Researchers from different disciplines should attend continuing education programs in order to acquire theoretical and ethical knowledge in the field of conservation and to analyze studies on the historical materials they are investigating. In addition to these theoretical studies, they should also master field studies due to some of the material experiments that can be carried out in the field. Joint studies between experienced personnel and new researchers will play a key role in this regard. Having global institutes frequently exchange information will be crucial for honoring cultural heritage without borders. Joint meetings, trainings, and an inter-institutional exchange of researchers can enhance collaboration. The focus on cultural heritage starts from the sampling stage and extends to conservation practices. Sensitivities toward this issue can be explained to public institutions and the public through conservation laboratories, and conservation research clearly should be communicated to a wider audience.

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RESEARCH ARTICLE

Towards an Amalgamated Framework for the Green Retrofitting Process of Healthcare Facilities

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ABSTRACT
Healthcare service providers have focused on the environmental effects of healthcare facilities (HFs) in recent years in order to mitigate the environmental impact of HFs, sustain the well-being of occupants and patients, and delineate the targets of the Sustainability Development Goals (SDGs), the Paris Agreement, and the 2021 United Nations Climate Change Conference (COP26) Special Report on Climate Change and Health. Because the fundamental aims of healthcare are to improve patient health and sustain the daily operations of an HF, green retrofitting practices in HFs form a crucial link between providing environmentally friendly HFs and patient health and well-being. Hence, the main objective of this paper is to propose an amalgamated green retrofitting framework for healthcare facilities by analyzing existing retrofitting methodologies and approaches. Normative refinement and frequency analyses were applied when reviewing the healthcare-specific green retrofitting methodologies and approaches for determining the dimensions and criteria to consider for the framework. Expert feedback also contributed to the framework's improvement and modification based on the methodology's validation step. The finalized conceptual framework is anticipated to facilitate an understanding of the fundamental considerations for green retrofitting HFs and to serve as a guide for healthcare building providers, academicians, and green building professionals.

Keywords: Green retrofit, healthcare facilities, retrofitting methodologies, SDG3, SDG7

1. Introduction

The challenges in providing and sustaining the delivery of required healthcare services have gained momentum due to climate change, its rising influence, and the adverse environmental effects of HFs. HF retrofitting is one of the most problematic types of projects in the construction industry (Mohammadpour et al., 2017). This study aims to investigate the current methodologies for retrofitting HFs with a particular focus on the retrofitting process itself, because retrofitting existing buildings is a sustainability goal that all sustainability-focused agreements aim to meet and the retrofit rate of existing HFs is below desired levels.

When taking climate change, health, and well-being into consideration, the 2030 Agenda, the Sustainability Development Goals (SDGs; United Nations [UN], 2015a), the Paris Agreement (UN, 2015b), and the 2021 United Nations Climate Change Conference (COP26) Special Report on Climate Change and Health (World Health Organization [WHO], 2021) have to be considered as motivators for the efficient and progressive steps all parties must take that are aimed at enhancing the built environment through retrofitting.

The 2030 Agenda for Sustainable Development was adopted by the UN General Assembly by considering the 17 SDGs as an action plan for people, the planet, prosperity, peace, and partnership (UN, 2015a). Implementing the 17 SDGs is an urgent need in order for all countries to end poverty, improve education and health, decrease inequality, and promote economic development (UN, 2021a). Notably, good health and well-being (SDG3); affordable and clean energy (SDG7); industry, innovation, and infrastructure (SDG9); responsible consumption and production (SDG12); and climate action (SDG13' UN, 2021a) are among the 17 SDGs that form a significant link between climate change and HFs. The Paris Agreement is a climate change agreement on how to combat climate change and its impacts and accelerate and intensify the movements and investments necessary to accomplish a sustainable, low-carbon future (UN, 2021b). The Paris Agreement can also likely be highlighted as the primary healthcare-related agreement

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for helping not only reduce and adapt to climate change-related health threats but also achieve the SDGs (WHO, 2018). Notably, HFs should urgently reduce their carbon footprint to deliver a low-carbon future.

Another critical aspect related to climate change, health, and well-being is the COP26 Special Report on Climate Change and Health, which prioritizes issues concerning climate change and critical health situations (WHO, 2021). The report developed 10 recommendations for coping with climate change, restoring biodiversity, and protecting health and well-being (WHO, 2021). Hence, the motivation for this paper is that SDGs, the Paris Agreement, and COP26 recommendations are the main drivers for reducing the environmental impacts of existing HFs for sustaining health.

Hughes (2020) also highlighted digital transformation to be critical for tackling the adverse impacts of climate change. Adopting digital technologies can help realize the desired goals regarding sustainability targets (World Economic Forum, 2023). According to the UN Environment Program (2022), digital transformation can potentially reduce carbon dioxide (CO2) emissions by at least 20%. Schweizer (2023 p.xx) stated, "To accelerate the journey to a net zero future and timely adoption of climate change, we must systematically integrate technology and data at every step of processes." Therefore, an urgent need exists not only to investigate the green retrofitting processes of HFs but also to integrate digital technology tools into these processes.

The detrimental impacts of the underperformance of existing HFs on society and the environment regarding sustainability have necessitated retrofitting actions for improving indoor environmental quality, providing occupant satisfaction, reducing infections, improving patient recovery rates and safety, and providing better service capacity, such as flexible rooms and spaces (Ergin & Tekçe, 2020). The retrofitting process is a general term that may consist of various treatments, including renovation, rehabilitation, restoration, and reconstruction. Therefore, selecting the appropriate strategy and methodology is a tremendous challenge in retrofitting and must be determined individually according to each project's unique conditions.

Green retrofitting existing HFs is a crucial response to mitigating climate change and its impacts and supplements the ability to accomplish all SDGs, the Paris Agreement, and COP26 recommendations by eliminating potential harmful loads regarding CO2 and energy consumption. Green retrofitting applications have a strong link between providing environmentally friendly HFs and patient health and well-being. The pressure to improve patient health and well-being and improve the environmental performance of HFs has led to an increased requirement for methodologies and approaches that enable the green retrofitting of HFs.

Despite the importance of the subject, the existing literature has a relatively limited number of healthcare-specific studies related to green retrofitting methodologies and approaches. Hence, this study works to develop an amalgamated green retrofitting framework for healthcare facilities by investigating the current methodologies and approaches.

2. Green Retrofitting Healthcare Facilities

The construction industry conducts retrofitting works based on advancements, the changing requirements of facilities' occupants, and the age of facilities (Salgın, 2019). Various studies in the existing literature have defined green retrofitting. Green retrofitting existing buildings is recognized as a critical opportunity for mitigating the impacts of global warming, such as greenhouse gas emissions and energy consumption (Ma et al., 2012). Doug Gatlin, who worked in significant positions at the US Green Building Council (USGBC) for many years, explained green retrofitting from USGBC's point of view as:

> *any kind of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use, and improve the comfort and quality of the space in terms of natural light, air quality, and noise – all done in a way that it is financially beneficial to the owner. (as cited in Lockwood, 2009, p. 48)*

When considering global energy, building materials, and water usage, green retrofitting existing buildings substantially affects existing building performance, economic profits, and the health and well-being of the building occupants (Kavani & Pathak, 2014). Green retrofitting supports beneficial results that minimize the massive usage of energy, provide several green retrofitting implementations, enhance society's healthcare, protect the environment, and increase awareness related to retrofitting actions (Mickaityte et al., 2008). Notably, improving society's health and well-being arises as a significant situation in the health industry due to the primary objective of healthcare being to enhance patient health and well-being (Golbazi & Aktas, 2016). Ironically, HFs have been described as an energy-intensive structure that leads to considerable environmental impacts while coincidentally contributing to illnesses and harmful health consequences (WHO & Health Care Without Harm [HCWH], 2009). Generally, HFs run 24 hours a day, seven days a week, and provide proper essential patient care (Morgenstern et al., 2016). Consequently, HFs need to meet not only healthcare but also environmental requirements. According to the literature review, these needs can be identified as healthcare-specific requirements such as stringent control of indoor air quality (IAQ), proper medical equipment for treatments, strict control of diseases, and waste management systems (Kolokotsa et al., 2012), as well as the critical protection of occupants against hospital-acquired infections and occupational illnesses (Leung & Chan, 2006).

Green retrofitting HFs requires critical consideration to support the healthcare-specific necessities and occupant safety requirements (Robinson, 2012). Some essential difficulties occur in the process of green retrofitting HFs, mainly with regard to sustaining HFs' daily management and maintaining patient safety. The need exists for immediate efforts aimed at dealing with the spread of infections and sustaining patient safety during a retrofit in order to prevent dissatisfaction among the occupants and safety difficulties (Mohammadpour, 2014).

With the rising push to green retrofit HFs, significance is had in identifying the critical enablers and drivers of green retrofitting. As noted by Low et al. (2014, p.421), the main drivers that contribute to green retrofitting both new and existing buildings are "government legislation/incentives, corporate social responsibility, rising energy bills, overseas competition/influence, competent team members, marketing/branding motive, local competition, improve the well-being of employees, and return on investments (ROI)." From a regulatory point of view, policies and regulations related to greening have been seen among the predominant drivers for establishing energy efficiency and the technological requirements for promoting green retrofitting (Ma et al., 2012). Notably, Coskun and Selcuk (2022) stated that the processes for building retrofitting and performance assessment could be impacted by inadequate political regulations, economic issues, and user-centered social factors. Thus, consideration for healthcare and healthcare occupant-centered factors while setting regulations for retrofitting is particularly critical for improving retrofitting performance.

In terms of healthcare, Sheth et al. (2010b) underlined and classified the main driving factors for the refurbishment of HFs under their specific categories as users (covering profiles, demographic information, patterns, populations, and needs), construction (covering structural, seismic, energy, technical, and technological changes and improvements in construction), and future drivers (covering new regulations, changing demands, and improved technology).

When considering the green retrofitting of HFs, the methodologies and approaches should focus on healthcare-specific requirements. Several green retrofitting practices can be applied to HFs, and retrofit studies help to create awareness of the current retrofitting practices that are vital for taking fundamental actions. According to existing studies, the primary practices in green retrofitting are mainly based on energy efficiency, improving HVAC system performance, lighting systems, water usage, building envelope improvements, strengthening buildings' seismic performance, and improving the interior design (Ergin, 2020). Implementing these practices in HFs contributes to significant outcomes such as energy savings, providing sensitive control of the indoor environmental quality, preventing the spread of infections, reducing the higher expenses in day-to-day operations and maintenance, payback period adjustments, water savings, seismic improvement, improved occupant comfort and productivity, and reduced patient recovery and hospital stays.

Thus, green retrofitting should be considered an essential move for sustaining and improving the health and well-being of an HFs' users and for meeting sustainability goals regarding building performance. Green retrofitting can also be accomplished by implementing the different retrofitting methodologies and approaches various studies have proposed.

3. Green Retrofitting Methodologies and Approaches

In general, the retrofitting process faces numerous challenges. Hence, from a process management perspective, these difficulties are influenced by each other interactively, and some incur extra costs (Ho et al., 2021). Certain methodologies have been developed to support building retrofit decisions, facilitating the design of the building retrofit process.

To succeed in green retrofitting, the need exists for healthcare providers, project managers, and project stakeholders to have HF retrofitting roadmaps. In terms of guidelines and application strategies, Bertone et al. (2018) conducted a study based on proposing energy and water retrofitting guidelines and underlined five critical steps for a successful retrofitting project (Figure 1).

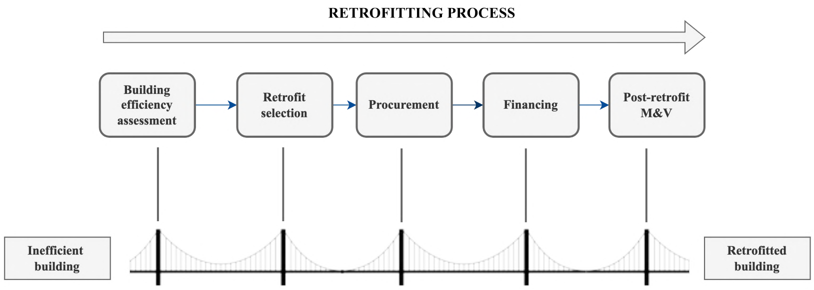


Figure 1. Key components of a building retrofitting project (Bertone et al., 2018).

Ma et al. (2012, p.891) designed a five-phase approach for green building retrofits that covers "project setup and pre-retrofit surveys, energy auditing, and performance assessment, identifying retrofit options, site implementation, commissioning, and validation and verification components" (Figure 2). This approach consists of five phases and is able to retrofit any building type.

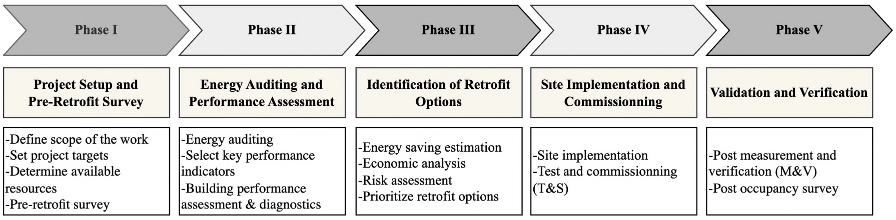


Figure 2. Key phases of building retrofits (Ma et al., 2012).

Moreover, Ma et al. (2012) created a systematic way to define, determine, and execute the possible retrofit measures for existing buildings (Figure 3). Their systematic framework for green retrofitting buildings is mainly based on identifying the key elements of building retrofits and critical elements of retrofit that will lead to the project's success of the project and involve the factors of client resources and anticipations, retrofit technologies, human factors, building characteristics, policies, and regulations, as well as uncertainty factors.

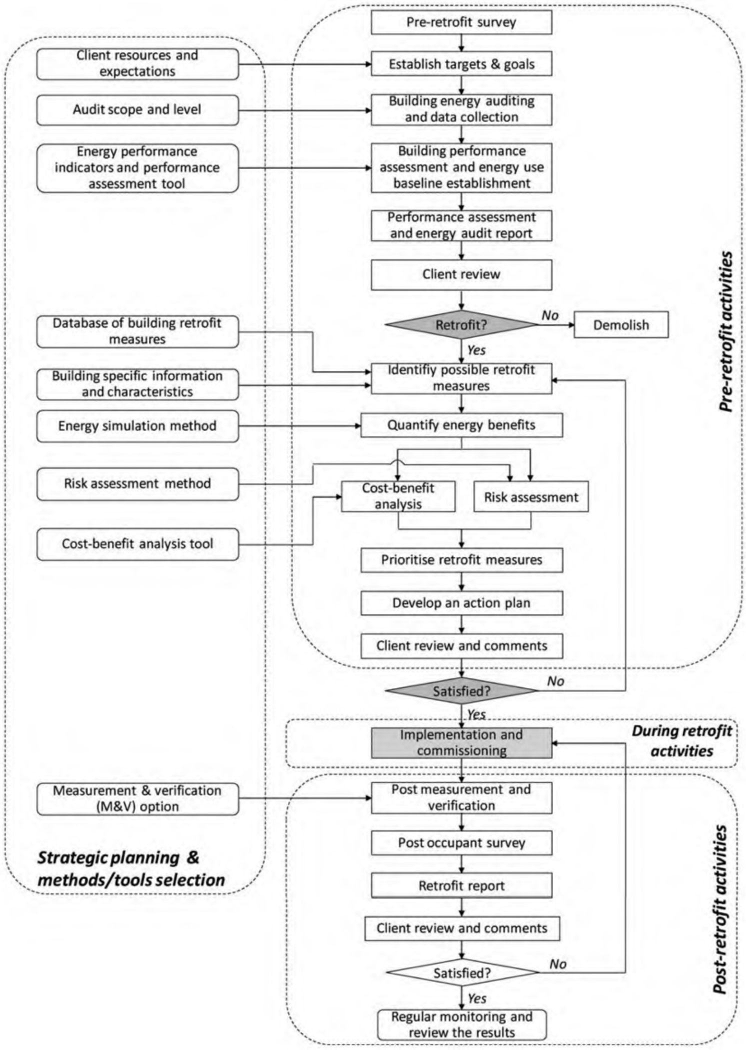


Figure 3. A systematic approach to sustainable building retrofits (Ma et al., 2012).

In addition to the reviewed studies, Luther & Rajagopalan (2014) have identified an energy retrofitting methodology categorized into four stages (Figure 4). The primary consideration of this energy retrofit methodology is to define the energy waste, minimize the need for electricity, and then retrofit to achieve energy efficiency (Luther & Rajagopalan, 2014).

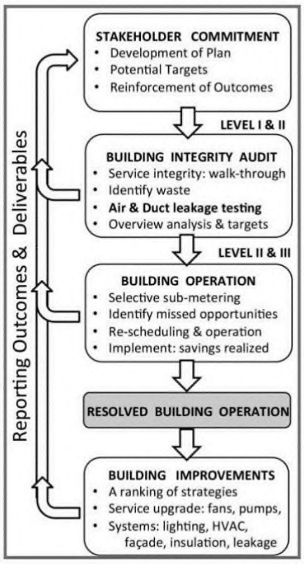


Figure 4. A proposed methodology for energy retrofitting (Luther & Rajagopalan, 2014).

Mickaityte et al. (2008) proposed a refurbishment model from a sustainable viewpoint involving different dimensions such as the technical, cultural, ecological, social, architectural, and economic considerations that substantially impact the general efficiency of a refurbishment implementation (Figure 5). This conceptual model focuses on public health, occupant comfort, aesthetics, decoration, cultural and behavioral norms, public awareness and education, collaboration, and social safety by considering human-based aspects. In addition to the aforementioned dimension, the process of a sustainable building refurbishment should follow the identified steps of "information collection, decision modeling, solution selection, and implementation" (Mickaityte et al., 2008).

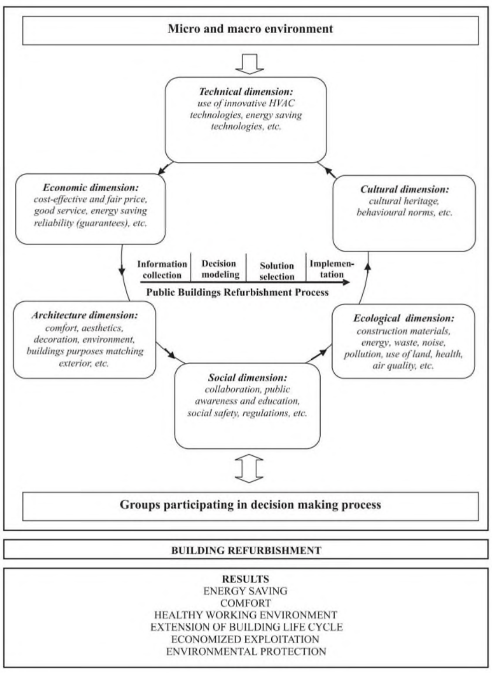


Figure 5. The concept model for sustainable building refurbishment (Mickaityte et al., 2008).

Abidin et al. (2019) conducted a critical study on developing a decision-making tool for energy reduction called the multi-criteria retrofitting energy efficient building (MCREEB). MCREEB consists of retrofitting initiatives, criteria selection, and assessment stages. Decision making with regard to retrofitting is a complex process that can be affected by design issues, building efficiency, and green technologies, as evaluating these critical components contributes to achieving rational and realistic results. Therefore, the development of MCREEB provides a significant path for assessing several factors (Figure 6).

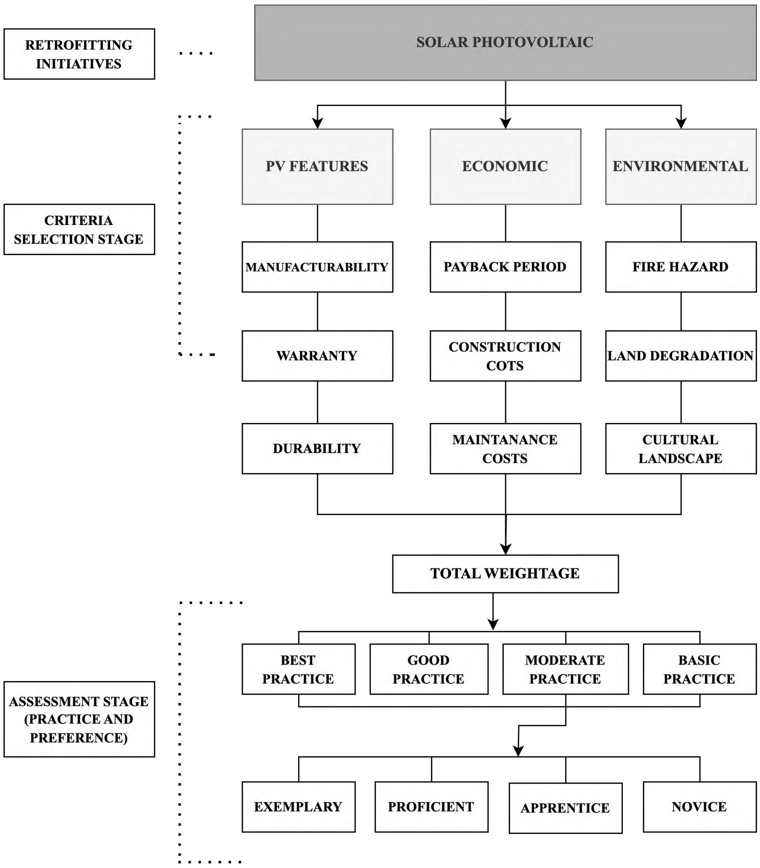


Figure 6. Flow of the decision-making process in retrofitting (Abidin et al., 2019).

Geldenhuys (2017) developed a holistic framework related to implementing green retrofits for existing buildings in South Africa. The study was designed based on the retrofit measures framework Ma et al. (2012) proposed. The proposed framework for the South African context includes five steps: retrofit feasibility, pre-project planning, construction, post-retrofit activities, and operation and maintenance. The significance of the current study is that the first two phases of the developed framework have been implemented in a real-life case study involving a retrofitting project. Figure 7 represents the generic green retrofitting framework for the South African context.

4. Healthcare-Specific Green Retrofitting Methodologies and Approaches

Due to the requirements and considerations specific to healthcare, the need exists to develop retrofitting roadmaps, especially for HFs. Providing and sustaining patient safety is one of healthcare's greatest concerns, which is why Mohammadpour (2014) conducted a retrofitting study based mainly on patient safety and energy efficiency. Mohammadpour (2014) proposed the patient safety and energy efficiency (PATSiE) framework, which includes five efficient phases (Figure 8). This framework has critical considerations regarding HF regulations in the context of a retrofit project, as improving patient health and building efficiency is crucial. Notably, identifying the healthcare retrofitting stakeholders, as well as their roles and responsibilities, strongly influences the ability to achieve the goals of a healthcare retrofitting.

Likewise, Sheth et al. (2010a) developed a framework for refurbishing HFs with an energy focus on other possible construction concerns. The framework covers the three primary refurbishment progressions of pre-refurbishment, refurbishment, and post-refurbishment (Figure 9). To gain better understanding, the framework was designed with three main columns representing the phases, purpose, and tools and processes.

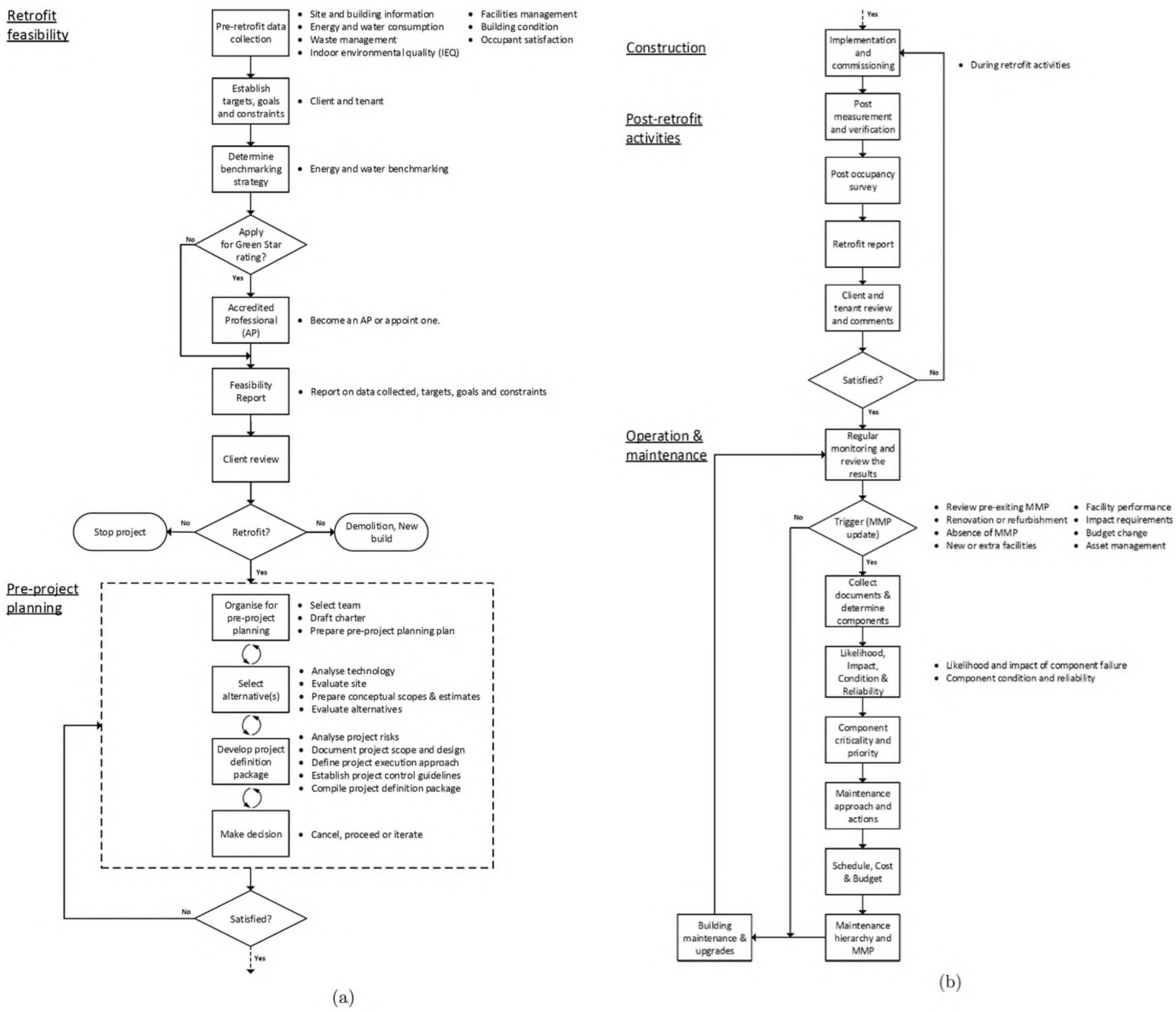


Figure 7. A generic green retrofitting implementation framework for the South African context (Geldenhuys, 2017).

Furthermore, Sheth et al.'s (2010a) framework underlies the significance of taking into account occupant feedback after implementing the refurbishment for improving project performance. It also provides a critical viewpoint of aspects such as the lessons learned during the refurbishment process, as learning from past projects helps prevent making the same mistakes twice.

In addition to developing healthcare-based retrofit frameworks, Sheth (2011) developed a more structured healthcare energy and refurbishment (HEaR) framework. HEaR consists of four phases (i.e., pre-proposal, proposal, proposal execution, and post-proposal execution) that are supported by the project actors, systems, and tools that have a significant role in the refurbishment phases (Figure 10). Notably, identifying the main stakeholders, systems, and tools for the actions to take in an HF refurbishment is crucial for achieving the refurbishment goals. Another critical point for this framework is validation, because receiving feedback leads to the improvement of a retrofit's actions and processes.

The processes in a green retrofitting require decision-making, building energy performance assessment, monitoring, and controlling. Technology offers various digital tools and systems for minimizing changes and potential operational expenses while executing a retrofit and also support effective decision-making. Digital transformations significantly promote having the construction industry become more intelligent and greener (Shen & Wang, 2023). The usage of digital technologies (i.e., digital twins, building information modelling (BIM), Internet of Things [IoT], big data, artificial intelligence [AI], virtual reality [VR], augmented reality [AR], and Blockchain applications) in retrofitting projects and their processes can improve occupant comfort, energy efficiency, and building performance. Sensors, automation, and data analytics are critical for monitoring and controlling different building functions during a green retrofit (Uche Akabogu, 2023). In order to enhance the success of a green retrofit with regard to identifying retrofit objectives, design and planning, data collection from the environment and building, building energy performance assessment, and decisions regarding retrofitting options, these technologies have a significant role by using a proactive approach. Identifying potential problems and benefits and detecting faults before the start of a green retrofit are significant, as

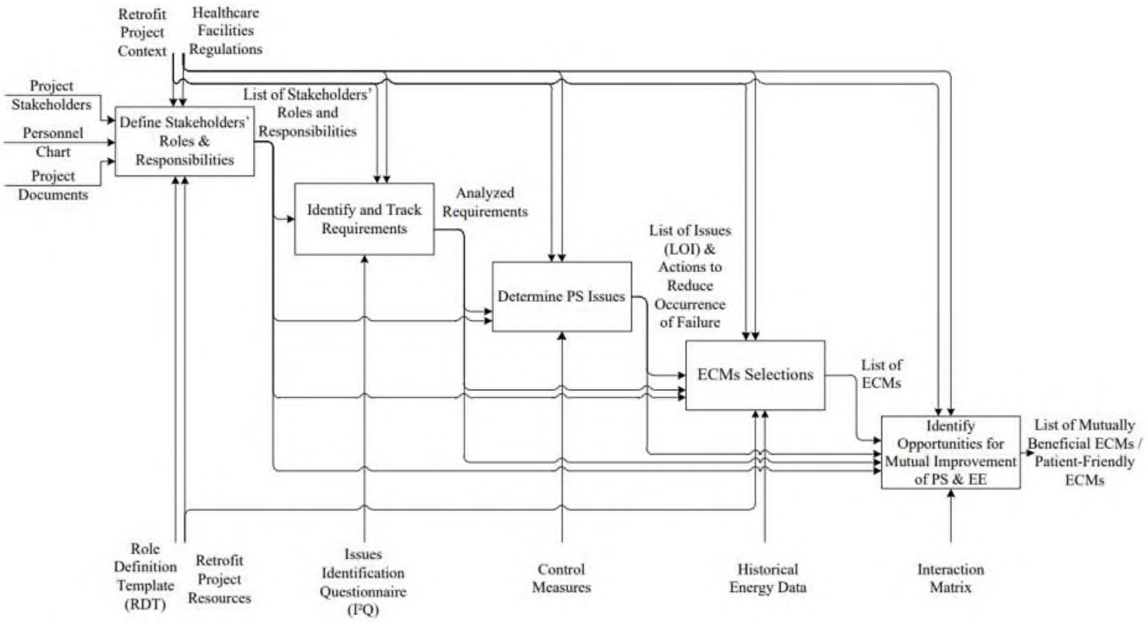


Figure 8. PATSiE framework retrieved from Mohammadpour (2014).

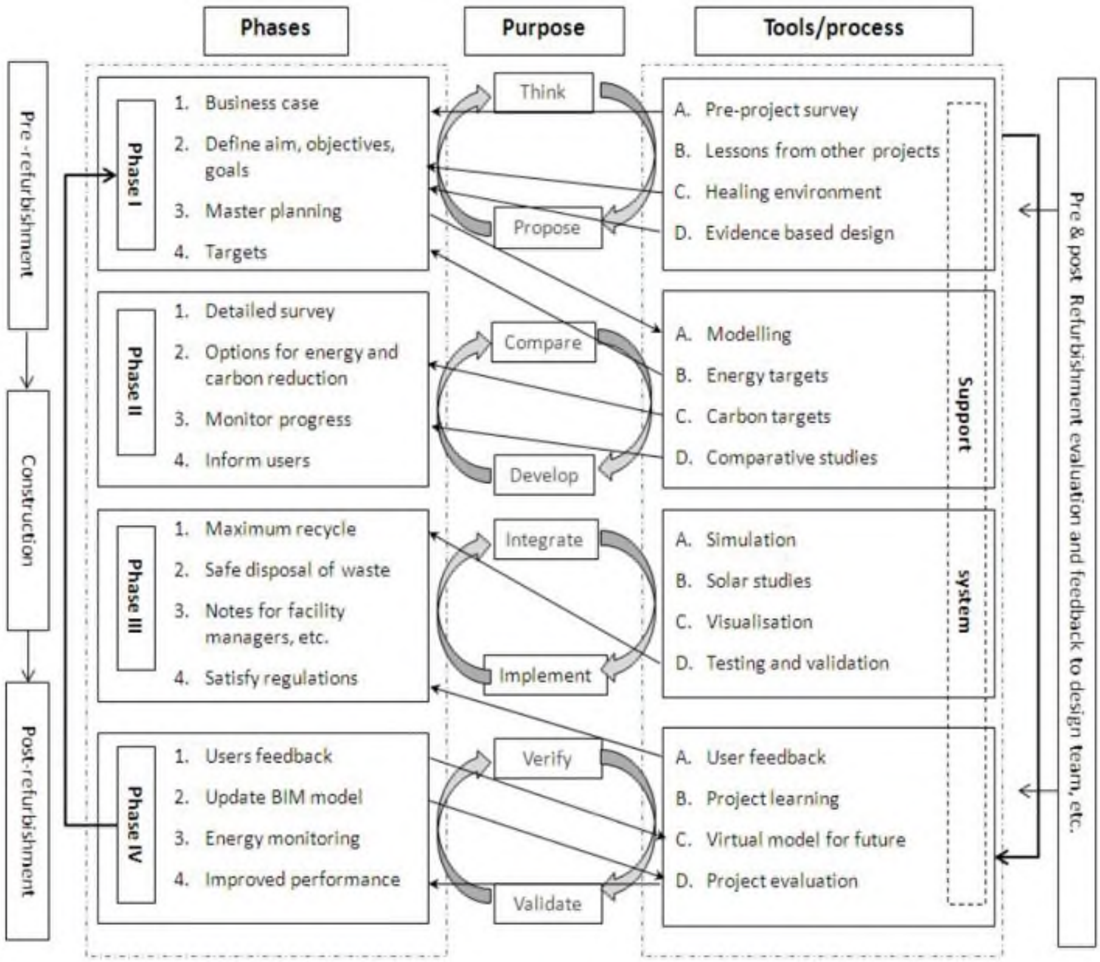


Figure 9. Framework for the refurbishment of HFs (Sheth et al., 2010a).

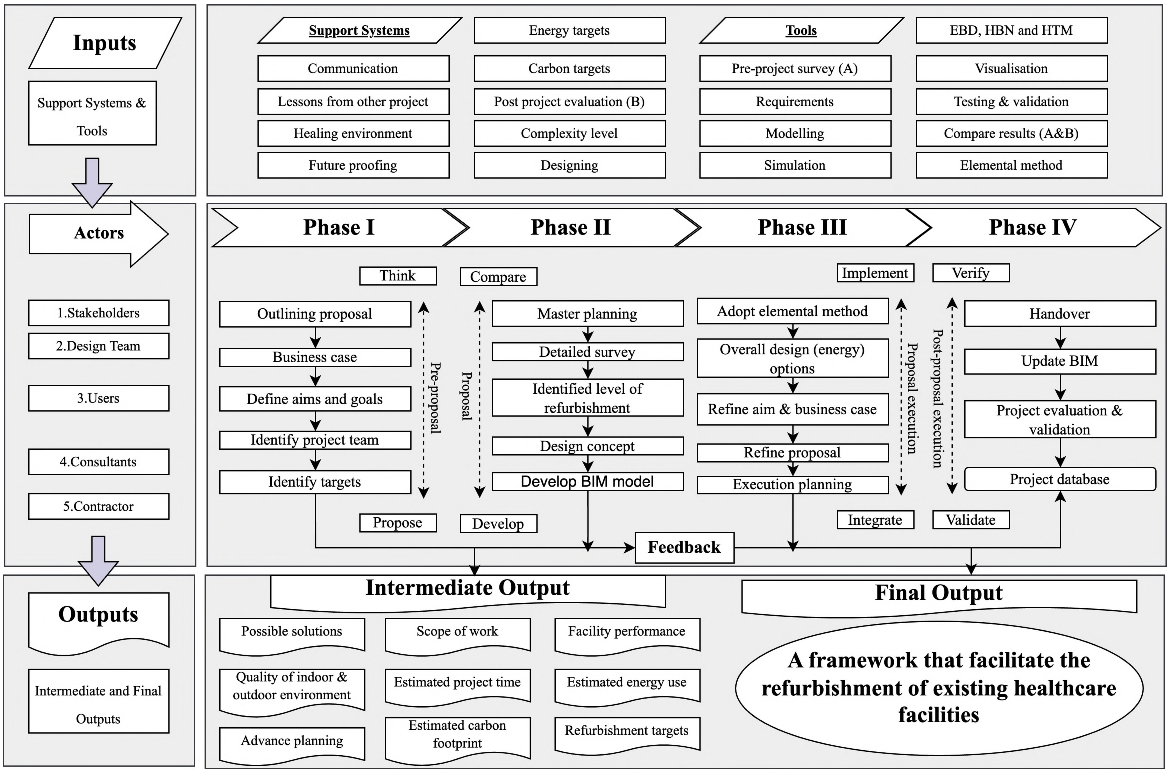


Figure 10. A healthcare energy and refurbishment (HEaR) framework (Sheth, 2011).

green retrofitting has challenges and various uncertainties. Therefore, using embedded digital technologies in any green retrofitting process can help avoid project delays, increase efficiency, reduce operational expenses, and improve decision making.

5. An Amalgamated Green Retrofitting Process Framework for Healthcare Facilities

After investigating the green retrofitting methodologies and approaches specific to healthcare in order to determine the required phases and primary considerations for the framework, normative refinement and frequency analyses were applied as the methodology. The main phases and activities most common in the existing literature have been added to the proposed conceptual framework (Table 1). In addition to common elements, healthcare-specific actions in green retrofitting processes have also been added to the new framework. Existing green retrofitting frameworks also cover the strategic planning and methods, tools, and simulations needed to accomplish the goals of green retrofitting existing HFs (Table 2). Notably, this study proposes adopting digital technologies to drive green retrofitting as being supportive in all framework phases.

Table 1. Frequency Analysis of Phases and Activities of Existing Green Retrofitting Frameworks

Main Phases	References	Total	Activities	References	Frequency
Pre-Retrofitting/ Refurbishment	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4	Set project targets and goals	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014);Geldenhuys (2017)	5
			Develop a master plan	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014)	4
			Client review, feedback, and overview analysis and targets	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014); Geldenhuys (2017)	5
			Pre-Retrofit Survey	Sheth et al. (2010a); Sheth, (2011); Ma et al. (2012)	3
			Define aim and objectives	Sheth et al. (2010a); Ma et al. (2012); Luther & Rajagopalan (2014); Geldenhuys (2017)	4
			Identify project team and stakeholders' roles and responsibilities	Sheth (2011); Mohammadpour (2014); Geldenhuys (2017)	3
			Detailed survey	Sheth et al. (2010a); Sheth, (2011)	2
			Building performance assessment and diagnostics	Ma et al. (2012); Bertone et al. (2018); Geldenhuys (2017)	3
			Retrofit selection	Mickaityte et al. (2008); Bertone et al. (2018)	2
			Building energy auditing and data collection	Ma et al. (2012)	1
			Select key performance indicators	Ma et al. (2012)	1
			Assess building performance and establish the energy use baseline	Ma et al. (2012); Geldenhuys (2017)	2
			Performance assessment and energy audit report	Ma et al. (2012); Geldenhuys (2017)	2
			Identify the level of refurbishment	Sheth, (2011)	1
			Identify possible retrofit measures	Ma et al. (2012)	1
			Quantify energy benefits and estimate energy savings	Ma et al. (2012)	1
			Cost-benefit analysis/Economic analysis	Ma et al. (2012); Geldenhuys (2017)	2
			Risk assessment	Ma et al. (2012); Geldenhuys (2017)	2
			Prioritize retrofit measures and options	Ma et al. (2012)	1
			Develop an action plan/Make an execution plan /Decision modeling	Mickaityte et al. (2008); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4
Retrofitting, Refurbishment, Execution, Construction, and Implementation	Mickaityte et al. (2008); Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	5	Implementation	Mickaityte et al. (2008); Ma et al. (2012)	2
			Testing and commissioning	Ma et al. (2012)	1
			Building operation	Luther & Rajagopalan (2014)	1
			Monitor progress	Sheth et al. (2010a)	1
Post-Retrofitting, Refurbishment, adn Execution	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4	User feedback	Sheth et al. (2010a)	1
			Post measurement and verification (M&V), as well as validation	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4
			Post occupancy survey	Ma et al., (2012); Geldenhuys (2017); Bertone et al. (2018)	3
			Retrofit report	Ma et al. (2012); Geldenhuys (2017)	2
			Client review and comments	Ma et al. (2012)	1
			Regularly monitor (Energy monitoring) and review the results	Ma et al. (2012); Sheth et al. (2010a)	2
			Project evaluation	Sheth et al. (2010a)	1
			Project learning	Sheth et al. (2010a)	1

Table 2. Strategic Planning, Methods, and Tools in Existing Green Retrofitting Frameworks

Strategic Planning and Methods/Tools	References	Total
Lessons from other projects	Sheth et al. (2010a); Sheth (2011)	2
Healing environment	Sheth et al. (2010a); Sheth (2011)	2
Client resources and expectations	Ma et al. (2012)	1
Energy performance indicators and assessment tool	Ma et al. (2012)	1
Database of building retrofit measures	Ma et al. (2012)	1
Building-specific information and characteristics	Ma et al. (2012)	1
Energy simulation method	Ma et al. (2012)	1
Risk assessment method	Ma et al. (2012)	1
Cost-benefit analysis tool	Ma et al. (2012)	1
Measurement and verification	Ma et al. (2012)	1
Criteria selection	Abidin et al. (2019)	1
Communication	Sheth (2011)	1
Energy targets	Sheth (2011)	1
Carbon targets	Sheth (2011)	1
Retrofit project context	Mohammadpour (2014)	1
HF regulations	Mohammadpour (2014)	1
Determine patient safety issues	Mohammadpour (2014)	1
Stakeholder commitment	Luther and Rajagopalan (2014)	1
Group participation in decision making	Mickaityte et al. (2008)	1
Economic, cultural, technical, architectural, social, and ecological dimensions of the micro- and macro-environment	Mickaityte et al. (2008)	1
Pre-project survey	Sheth (2011)	1
Testing and validation	Sheth (2011)	1
Energy conservation measures (ECMs)	Mohammadpour (2014)	1
Infection control	Mohammadpour (2014)	1
Adopt digital technologies	Schweizer (2023)	1

In accordance with the existing methodologies and approaches, this study has designed its proposed framework by referencing Ma et al.'s (2012) retrofit study under three phases: pre-green retrofitting (Sheth et al., 2010a; Ma et al., 2012; Geldenhuys, 2017), green retrofitting (Ma et al., 2012; Geldenhuys, 2017), and post-green retrofitting (Sheth et al., 2010a; Ma et al., 2012; Geldenhuys, 2017; Bertone et al., 2018).

5.1. Pre-Green Retrofitting

In the pre-green retrofitting phase, the pre-retrofit survey is applied to identify the targets, goals (Ma et al., 2012; Sheth et al., 2010a; Sheth, 2011), stakeholders' roles and responsibilities with a focus on context of the retrofit project, the HF's policies and regulations, patient safety issues (Mohammadpour, 2014), and infection control criteria. In addition, the lessons on the targets and goals as learned from past studies (Sheth et al., 2010a) have a vital role while identifying during the pre-green retrofitting phase in achieving success for the HF's green retrofit.

This phase is the most critical, because it also covers building energy performance assessments such as energy performance indicators and performance assessment tools, developing a master plan, developing a green retrofit implementation plan, identifying the possible healthcare-based retrofit measures (Ma et al., 2012), implementing a detailed survey (Sheth et al., 2010a), quantifying energy benefits (Sheth, 2011), and selecting the green retrofitting options (Mickaityte et al., 2008; Bertone et al., 2018).

5.2. Green Retrofitting

The green retrofitting phase is the operational phase for an HF, in which the selected green retrofitting options are implemented (Mickaityte et al., 2008; Ma et al., 2012; Sheth, 2011; Luther & Rajagopalan, 2014; Bertone et al., 2018). One critical point during green retrofitting is that HFs sustain their operations 24/7, so determining a green retrofitting implementation plan is essential for endangering patient safety and satisfaction. Another significant consideration for HF occupants is their behaviors in the building and during the retrofit, as human factors directly impact buildings' energy usage (Coskun & Selcuk, 2022). Therefore, the development implementation plan for green retrofitting of HFs should be designed before implementing selected green retrofitting options.

5.3. Post-Green Retrofitting

In the post-green retrofitting phase, measurement and verification (M&V; Sheth et al., 2010a; Sheth, 2011; Ma et al., 2012; Bertone et al., 2018) are applied to the post-occupancy survey (Ma et al., 2012), and the results of the green retrofitting are monitored and reviewed. The results demonstrate HF performance regarding energy usage, environmental behavior, reduced water usage, and enhanced quality and comfort of the HF with regard to air quality, natural lighting, and noise (Lockwood, 2009).

6. Validating the Framework

Following the amalgamated framework design, a validation study was conducted to ensure the framework is appropriate for the objectives, processes, and context of green retrofitting HFs. Therefore, investigating the validity of the proposed framework has a substantial role in improving this framework. For the validation step, usefulness, practicality, and applicability criteria were determined based on existing studies (Bassioni et al., 2004). The validation step also consists of expert feedback, benefitting from qualitative and quantitative data from selected experts.

6.1. Expert Feedback

Expert feedback was gathered through a validation survey conducted on a varied sample of 15 professionals that included industry practitioners and academic researchers. The respondents to the validation survey were selected using purposive sampling based on being professionals with specialist skills and certificates in green buildings and sustainability in Türkiye. The databases of the Leadership in Energy and Environmental Design [LEED] People Directory (USGBC, 2022) and the Building Research Establishment Environmental Assessment Method [BREEAM] Assessors and APs (BREAM, 2022) were selected to identify the related sample. The validation survey was sent to the experts via e-mail. The validation survey covered open- and close-ended questionnaires to produce qualitative and quantitative input by collecting data from the respondents. A 15-day duration was given for completing the questionnaire, but the response rate was low at the end of the duration. The questionnaire was resent again to the respondents, and an additional 15-day time limit was given for completing it. Fifteen questionnaires were returned within one month of being sent out. The validation study data collected from the experts were analyzed using the statistical software program IBB SPSS Statistics. The program Microsoft Office Excel 2018 was also used to create smooth visual graphs and charts.

The results from the validation were tested at a 95% confidence level. The reliability of the questionnaire responses was measured using Cronbach's alpha (α), according to which the reliability scale was identified. Yaşar (2014) stated the scale to consist of four different levels, with $0.0 \leq \alpha < 0.40$ showing the scale to be unreliable, $0.40 \leq \alpha < 0.60$ to show low reliability, $0.60 \leq \alpha < 0.80$ to show the scale to be quite reliable, and $0.80 \leq \alpha < 1.00$ to show the scale to be highly reliable. The results from the reliability statistics performed by applying Cronbach's alpha test to the validity criteria of the amalgamated green retrofitting process framework for healthcare facilities show the overall reliability value for all validity criteria to be 0.756 (Table 3), which is accordingly considered quite reliable.

Table 3. Cronbach's Alpha Coefficient from the Validation Study

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
0.756	0.790	3

6.2. Qualitative Feedback

Qualitative feedback was mainly based on whatever possible healthcare-specific criteria might be missing, as well as on the performance measurement criteria and tools, healthcare-specific performance measurement tools, and any other comments on the framework related to processes and tools in the development of the framework. According to the results from the qualitative feedback, if any missing considerations or relevant recommendations related to the study were found, the framework was accordingly improved. The framework was adjusted to incorporate the suggested points as visually indicated by different shapes and colors. The following points summarize these findings and the potential enhancements that were made to the framework.

(1) The number of occupants using an HF, as well as their habits and behaviors were determined and added to the proposed framework as a critical consideration in the green retrofitting of HFs, as HFs operate 24 hours a day, seven days a week. During a green retrofitting, non-stop operations should be taken into consideration, because an HF's patients and employees occupy these facilities; also, the number and usage habits and behaviors of these occupants can impact and be impacted by the green retrofitting process.

(2) Patient comfort was identified as a driving factor contributing to green retrofitting and improving HFs' conditions, as patients need conditions more sensitive to their comfort compared to healthy adults. For this reason, needs should be considered such as sensitivity in terms of patient comfort during the green retrofitting process and increasing IAQ at the end of the green retrofitting process.

Enhancing patients' thermal and visual comfort stands out as a crucial healthcare-specific factor that can significantly contribute to the overall success of a green retrofit. Efforts toward improvements that will increase thermal and visual comfort should be considered in green retrofitting, such as increasing indoor environmental quality (IEQ), lighting improvements, HVAC system changes, and development of usable outdoor areas.

(3) The usage of certified environmentally friendly materials, healthcare waste management considerations, water management, and food safety are other supportive actions that can enhance the sustainability of HFs and environmental health.

(4) Seismic resistance of HFs was identified as a significant concern for study, because during green retrofitting of the existing building, the seismic condition of the building should be evaluated, and related activities should be added as needed to the green retrofitting process.

(5) Evaluating the parameters of quality, cost, and time regarding the operations of hospitals and a green retrofit were defined as driving factors for the decision to green retrofit HFs.

(6) Successful implementation of the green retrofitting process can also be assisted by green building certification systems such as LEED and BREEAM. To measure the performance of green retrofitted HFs, categories and criteria for each green building certification system can be taken into consideration. A performance measurement tool can be created by considering the requirements of the certification systems for hospitals and existing buildings. Also, IAQ, accessibility, time, cost, quality, energy performance, and occupant evaluations play an essential role in performance measurement.

(7) Energy performance contracts were also seen as a significant contributor to developing the process of green retrofitting HFs.

(8) Whether a building should be demolished or not is too important to be left to the client alone at the final stage. Therefore, client review and feedback has been revised in the proposed framework to include project stakeholders with an environmental perspective in the decision-making mechanism.

6.3. Quantitative Feedback

A validation questionnaire was designed to rate various validity aspects of the proposed framework to gain quantifiable feedback. The questionnaire was designed to ask the significance of each performance factor in terms of the criteria of usability, practicality, and applicability that were determined for validation using a 5-point Likert scale (1 = Far below standards, 2 = Substandard, 3 = Meets standards, 4 = Exceeds standards, and 5 = Greatly exceeds standards). Feedback was collected from 15 respondents for the validation study. By using a significance level of $p < 0.05$, all answers for the validation were found to be normal. The results from the questionnaire demonstrate the mean values for the validation criteria to range between 3.8-4.2. The mean values for responses with a 5% confidence limit indicate that the proposed amalgamated framework has been assessed as "Exceeds standards" for each validation criterion (Figure 11).

The results from the validation demonstrate that the assessments obtained from the experts positively indicate the proposed framework to be usable, practical, and applicable. The significant missing steps, tools, and considerations were identified and added to the proposed framework in accordance with the qualitative feedback. The omitted considerations have been incorporated and adjusted as elements or processes denoted by asterisks (*) within the finalized framework (Figure 12).

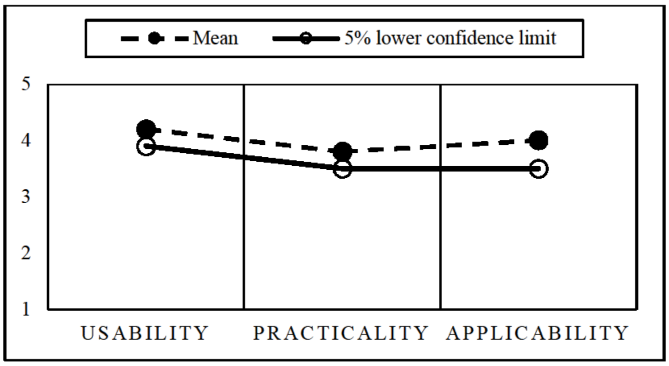
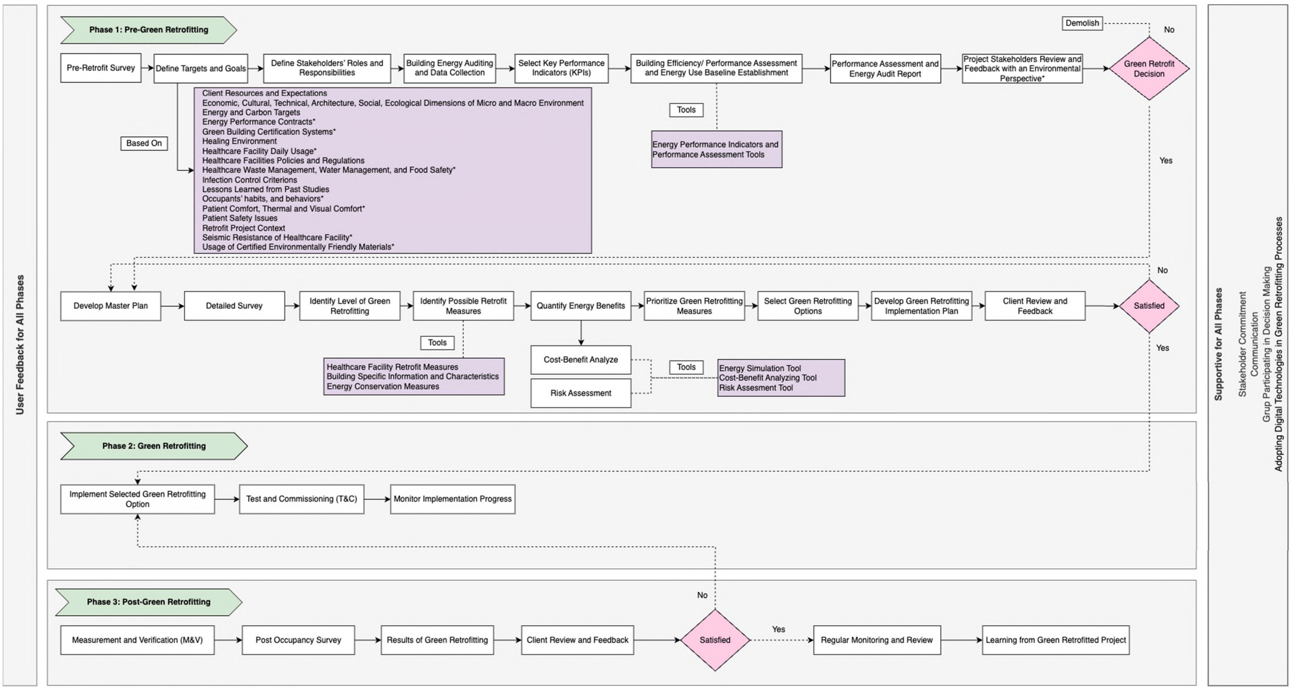


Figure 11. Quantitative feedback regarding the framework for the process of green retrofitting HFs.



*added in accordance with the qualitative feedback.

Figure 12. An amalgamated framework for green retrofitting HFs.

7. Conclusion

Green retrofitting HFs is an urgent and fundamental action for achieving long-term sustainability goals for the healthcare and construction industries. Within the existing literature, a noticeable scarcity exists regarding healthcare-specific studies that have delved into green retrofitting methodologies and approaches. This paper investigates the current green retrofitting methodologies and approaches for existing HFs by conducting a literature review.

The study initially delved into the decision-making processes' retrofitting roadmaps applied across diverse building types. Subsequently, the research focused predominantly on retrofitting methodologies and approaches specifically tailored for healthcare settings. Within the literature, several methodologies have been identified, each concentrating on distinct aspects such as energy efficiency, public health, and ensuring patient safety in retrofitting practices.

Proposing roadmaps to achieve retrofitting goals and implementing the proposed retrofitting roadmaps help at understanding retrofitting processes completely and improving awareness of green retrofitting processes for HFs. Green retrofitting phases from existing studies were described using normative refinement methodology as pre-green retrofitting, green retrofitting, and post-green retrofitting. As a result of the normative refinement process, this study proposes an amalgamated green retrofitting process framework for healthcare facilities in order to enhance the successful outcomes of green retrofitting projects. The proposed framework will improve the understanding of the primary considerations of green retrofitting HFs and will be a practical roadmap for healthcare building providers, academicians, and green building professionals.

Future stages of this research will investigate the implementation of the proposed green retrofitting framework in HFs and the performance measurement of this framework in order to improve the performance of current HF retrofits and make them more sustainable and energy efficient. Moreover, the need exists to investigate key performance indicators for the process of green retrofitting HFs as these indicators provide an objective standard for enhancing the procedural success of the identified HFs' green retrofitting framework. These indicators also have the potential to provide a concrete method for evaluating the identified processes regarding a project's performance.

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RESEARCH ARTICLE

Strengthening of Earthen Material with Some Binding Materials for Traditional and Contemporary Adobe Buildings

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ABSTRACT
This study investigates the effects on adobe soils of adding varying amounts of gypsum, gypsum-lime, and lime to clay soils of different characteristics for replacing traditional adobe. This research focuses on stabilizing soil to enhance adobe's structural integrity, making it a feasible option for modern constructions and renovations. The study investigates four types of clay soils with varying mineralogical compositions to produce adobe with different qualities. Results indicate that the introduction of gypsum contributes to reduced unit volume weight, increased void ratio, decreased thermal conductivity, and enhanced compressive strength. The research assesses the impact of water on adobe, including capillary rise and resistance to sprinkling. Moreover, the study explores the potential of gypsum-adobe to address the increasing demand for affordable and sustainable housing, especially in rural areas, contributing to energy conservation and cost-effectiveness. This study presents the advantages of utilizing adobe produced by this method in rural regions, in comparison to the building materials it may substitute.

Keywords: Adobe, earthen material, strengthening, binding materials, gypsum and lime

1. Introduction

Soil is one of the oldest building materials human beings used when seeking solutions to their shelter needs. The ruins unearthed during archaeological excavations in the Çatalhöyük region of Konya and the Çayönü region of Diyarbakır dated to the Neolithic Age (8000-6000 BC) are the oldest examples of soil being converted into adobe and used in building structures. The findings show that this technology was used uninterruptedly in the following millennia and that mud brick building production continued until recently.

Adobe has been used especially in the central and eastern regions of Anatolia. It evolved and developed over time, was adapted to the requirements of the age, being used as the main building material of the people of the region. While single-story and generally simple single-room buildings without windows were encountered in the early periods, multi-story adobe houses with advanced floorplans and functional solutions, as well as extremely successful detailed solutions equipped to meet all the expectations of the local people have been built in recent times.

By the second half of the 20th century, the spread of industrial building technologies in Anatolia, especially reinforced concrete, led to adobe buildings like all traditional building types no longer being preferred. Thus, mud brick settlements, which had been an important component for the 10 millennia of Anatolia's cultural history, were abandoned one after another and entered a rapid extinction. However, scientific and technical research shows that improved adobe can be used safely as a building material in contemporary buildings and restorations. This research is an experimental study carried out to contribute to studies targeting the contemporary and traditional uses of adobe.

The aim of stabilizing soil with gypsum and using the improved adobe obtained in this way in large areas has been to find a viable and valid solution that does not contradict the real need to improve the structures in rural settlements and bring them to a level worthy of today's people.

Improving rural structures has not been a common issue of Türkiye but rather a complex, multifaceted issue that has become urgent to solve. In this regard, this article believes that a sound solution can be achieved by using the strong interest rural people

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in Türkiye have of owning a home, their deep-rooted knowledge of traditional building methods, and their interest in adopting innovations whose methods and processes have been demonstrated and whose benefits they trust as a motivation and tool to ultimately create an opportunity to use the natural local materials with which they are familiar.

Formal and superficial approaches make problems more complex and difficult to solve. At a time when the need for balanced growth and development at the national level is being recognized and addressed, the need to improve housing and agricultural buildings is evident in rural areas. In addition, the rural population is growing significantly, although its rate is gradually declining. In today's world where the needs of rural people are increasing, the desire to live in a dwelling worthy of present-day people is considered a natural right. To the extent that this can be achieved, cities can be saved from degenerating into villages by urbanizing villages.

Once the above goal and way to achieve it are recognized, understanding the preference for improving adobe, which is despised in many circles, and dealing with mud instead of looking for more interesting and attractive areas becomes easier when observing problems and selecting research topics.

During this time of increased housing needs all over the world, much research has discussed the possibilities for using soil as a building material and other improvement solutions. The results show that soil granulometric structure is an important factor (Schwalen, 1935). Many methods have been attempted at making soil more stable, mainly through the addition of cement and lime (Bell, 1976; Lunt, 1980). However, no research is found regarding the addition of gypsum or its effectiveness. The fact that people in rural areas of Türkiye use a soil-gypsum mixture as plaster and that gypsum deposits are widespread and abundant leads this study to consider trying this mixture as a building material (İmar İskan Bakanlığı, 1964). Research in various regions of Anatolia has revealed evidence that supports this belief regarding the use of soil as a building material.

The importance of building the exterior and interior walls of a house in a rural area in accordance with current requirements and practices is obvious. Walls should be made of a material that has sufficient load-bearing capacity, is of sufficient quality both in terms of the sturdiness of the structure itself and the health of its occupants, fulfills bioclimatic comfort conditions, minimizes the need for heating, is easy to maintain, has a known or easily learned production and application by the local people, does not require technologies foreign to the region, does not require large investments or complex equipment for its production, and can be used in the structure with a minimum consumption of energy regarding the transportation and production of raw materials and finished products.

Comparing Adobe with Other Building Materials

Considering both the use of bricks or concrete briquettes by the public sector in new construction in disaster areas, and the fact that considerable demand exists from the public to use this type of material to improve their houses, the production and transportation of sufficient materials to meet housing needs appears to be an important energy consumption problem. A survey of plans used in disaster areas and of existing houses shows that an average of 150 m^2 of exterior and interior walls are used in a house. A 20 cm thick load-bearing wall requires 30 m^3 of building material. According to several sources, an average of 8 tons of good quality industrial coal or 3.5 tons of fuel[1] is required to fire the bricks needed for such a wall. In addition, it takes an average of 175 liters of fuel to transport 30 m3 of material from the factory to the construction site, plus vehicle costs. If the walls of the same house are built with concrete briquettes, 6 tons of cement are needed for solid briquettes and 3 tons for hollow briquettes.[2] To produce this amount of cement, 1-2 tons of coal will be used, and the cost of cement and aggregate transportation will be about the same as for the bricks. In contrast, gypsum-improved adobe can be produced with much less energy.[3] Constructing 30 cm thick exterior walls and 20-30 cm thick interior walls is appropriate in a building with improved adobe.[4] In this case, the same house will have about 40 m^3 of wall. As will be discussed later, adobe with 10% gypsum content provides good results, assuming that soil with the appropriate granulometric composition is selected. About 4 tons of gypsum are needed for 40 m^3 of adobe, and 0.640 kg of the same coal is used to make it (Papadakis & Venuat, 1970). Having one-third of the 75,000 dwellings to be renovated annually in rural areas under the Fourth Five-Year Plan be built with these types of materials will make a significant contribution to the country's fuel economy. In addition, the use of adobe can greatly reduce the amount of fuel needed to heat these houses, with these values summarized in Table 1.

As stated in the development plan and other official documents, the required number of houses are being built each year in urban and rural areas. The housing shortage grows every year. Many articles on housing address different aspects of the problem. Lack of sufficient and necessary materials and high costs are considered the main causes of the housing deficit. In addition to this

[1] According to the literature and brick manufacturers, 1 kg of bricks requires 500 kcal for drying and firing.
[2] The production of 1 kg of cement consumes 830-1,400 kcal.
[3] For the production of 1 ton of gypsum, 500 kcal is required.
[4] Construction with the proposed adobe will be done on site and the associated values will be determined as a result of further research.

Table 1. The amount of coal needed to heat houses

Material		Coal consumed for the materials for 1 house (tons)	Coal consumed for 25,000 houses (tons)[a]	Thermal conductivity Coefficient kcal/mh°C[d]	Heat loss of 1 house[e]	Annual coal consumption[f] (tons)
Brick[b]	Solid	8.5	213.75	0.68	495	11.5
	Hollow	7.140	178.5	0.52	382	8.9
Concrete Briquette[c]	Solid	2.640	66.0	0.55	400	9.3
	Hollow	1.170	29.25	0.48	365	8.5
Adobe Mixed With Gypsum		0.001	22	0.45	280	6.0

[a] Good quality lignite with a yield of 4500 kcal/kg; [b] Vertical perforated load-bearing block brick; [c] Lightweight concrete load-bearing block; [d] Thermal conductivity coefficient, unit kcal/mh°C, values from DIN 4180; [e] Approximately 12% of the facade of the dwelling is assumed to have windows of the same type and in the same area. Based on 100 m^2 of a cavity-free exterior wall. Cement-lime plaster in brick and briquette and gypsum-soil plaster in adobe are assumed to have the same thickness; [f] The type of coal used in production is assumed to be also used for heating. The annual heat loss value is based on the table in the Ph.D. thesis of Eng. İhsan Gülferi, MSc.

quantitative deficiency, another important point that is almost never addressed is the loss of material and labor due to the repair of damage caused by the inadequate physical quality of the houses being built. Adequate physical quality is easily achieved in adobe buildings, and the need for repair will not be significant. Experiments have shown that the mechanical and physical properties of adobe properly mixed with gypsum are adequate for the structure. Average compressive strength can exceed 40 kgf/cm^2. The low shrinkage and unit weight of the gypsum adobe indicate that a durable gypsum skeleton has formed within the adobe and that the material is more porous than normal adobe. This means that the new material has a lower and yet-unmeasured thermal conductivity. Several tests have shown adobe mixed with gypsum to gain significant strength against water compared to unmixed adobe and to exhibit positive structural behavior. Adobe wall surfaces can be covered with an adequate quality plaster. This plaster should be thick and not easily detached from the wall, and the best examples of how and with what materials such plaster may be made can be found in abundance in old houses. Suffice to say, in the regions of Sivas, Çorum, and Kastamonu and their very harsh climates, the external plaster is made with a mixture of gypsum, lime, and earth. This study believes that the ongoing research on these forms of plaster will have much to teach.

2. Materials and Experiments

Soil

Four types of clay soils with different appearance and mineralogical composition were selected in the vicinity of Istanbul to produce adobe of different quality by adding gypsum and lime to the soil in different proportions. These include:

a. Uskumruköy clay soil
b. Kilyos roadside brown clay soil
c. Topser yellow clay
d. Taşkışla (ITU central building) garden soil

The soil constants for these soils are given in Table 2.

The Uskumruköy clay soil was excluded from the tests due to its high shrinkage and low plasticity, as well as cracking during drying. The remaining soil samples were named according to the way they were treated during the tests. The moisture content of the air-dried soils stored in the laboratory was 3.9%-4%. The proportions of water, gypsum, and lime added to the samples were calculated based on dry soil. The water required to mold the samples was controlled for consistency using a Vicat apparatus. Six samples of 7x7x7 cm^3 each were prepared by adding gypsum to Kilyos brown soil and Topser yellow clay (in raw and corrected form) at rates of 0.00, 0.05, 0.10, 0.15, and 0.20 gypsum-to-dry soil; by adding lime to garden soil (in raw form only) at rates of 0.05 and 0.10 lime-to-dry soil; and by adding lime to garden soil sludge with 10% gypsum at rates of 0.025 and 0.05. The same ratios were prepared for 8 samples of 15x15x12 cm3 with garden soil and achieved positive results. To ensure correlation, 24 pieces of the 0.10 gypsum batch were prepared. The samples were air-dried to a constant weight. The granulometry curves of the mixtures are given in Figure 1.

Table 2. The soil constants for soils

Soil properties		Uskumruköy	Kilyos	Topser	Garden Soil
Liquid limit %		102.0	95.0	50.0	35.5
Plastic limit %		43.6	51.0	23.7	27.5
Plasticity index %		58.4	44.0	22.7	8.0
Shrinkage limit %		20.0	17.0	17.4	15.0
pH		6.7	5.6	5.8	5.9
Unit volume weight g/cm^3		2.82	2.72	2.77	2.75
Color		Dark brown	Brown	Yellow	Khaki
Element %	Gravel	8	-	-	25
	Sand	7	10	15	45
	Silt	50	65	54	27
	Clay	35	25	31	3
Main clay mineral		Montmorillonite		Kaolinite	Kaolinite
Others		Manganese	Bentonite Bauxite	Limonite	Quartzite Plagioclase

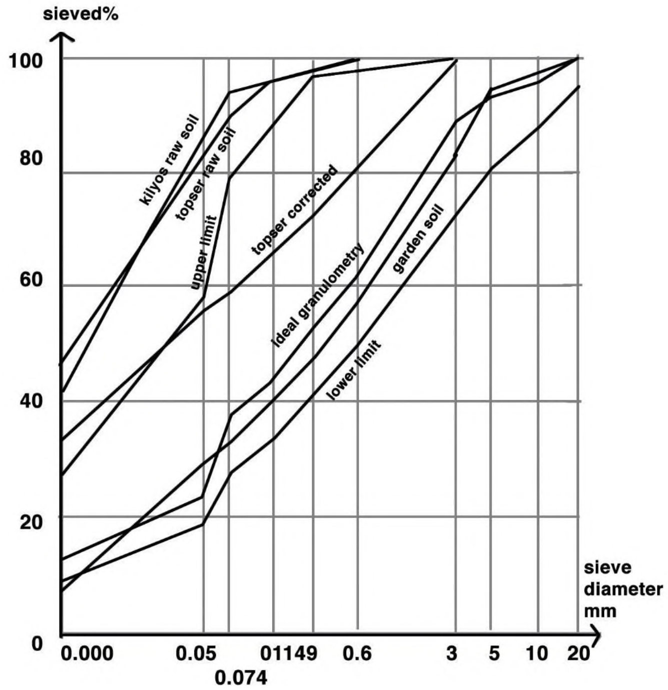

Figure 1. Granulometry curves.

Gypsum

The gypsum added to the adobe is gypsum with a normal consistency of 0.60 water/gypsum, with the unit volume weight and mechanical properties shown in the graph in Figure 2 and the possible addition of a setting retarder.

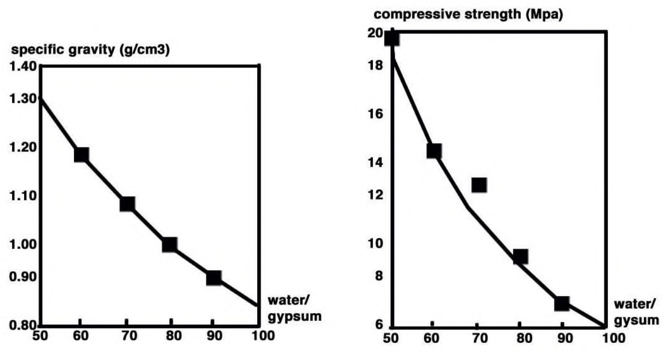

Figure 2. Changes in specific gravity and compressive strength of gypsum based on the water:gypsum ratio.

Lime

Slaked bag lime from the Zeytinburnu Cement and Lime Factory in Istanbul was used.

Tests

Shrinkage

The adobe mud was poured into the molds and dried, their dimensions were measured, and their length changes with respect to the mold dimensions were calculated as a ratio to their initial lengths. The results are shown in Figure 3.

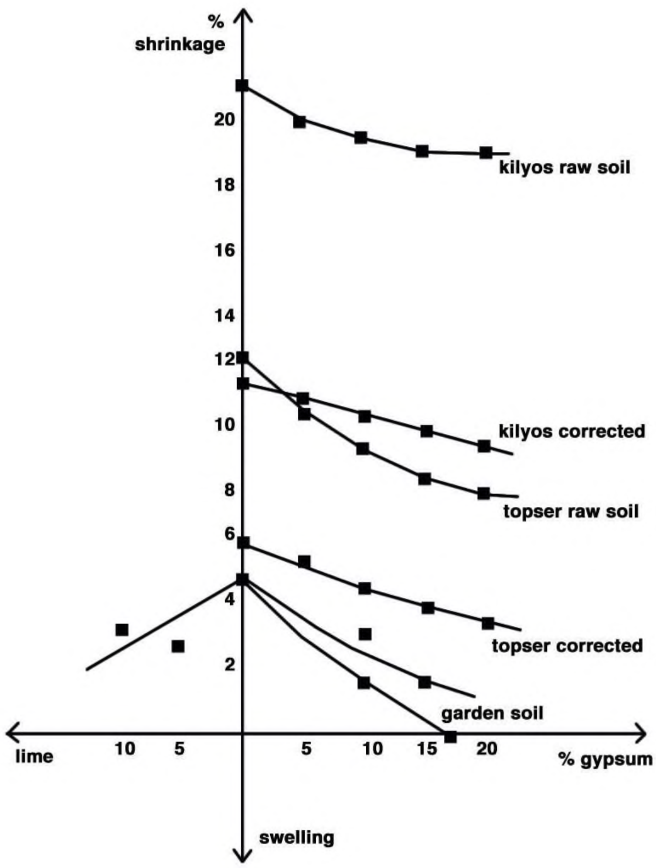

Figure 3. Size change of soil types according to granulometric correction and additive types and ratios.

Compressive strength

One 7x7x7 cm^3 and one 15x15x12 cm^3 sample were kept as a reference and the others were plastered with gypsum on the top and bottom surfaces; their compressive strengths were then measured using a 100 kN universal HPL testing machine. During the tests of the larger samples, deformations were determined with a 1/100 mm dial indicator. The samples were loaded so that the force was 20 kN or 1 MPa per minute. Average compressive strengths for the different soil and gypsum ratios are shown in Figure 4. The results from the large samples and stress-dependent deformation curves are presented in Figure 5.

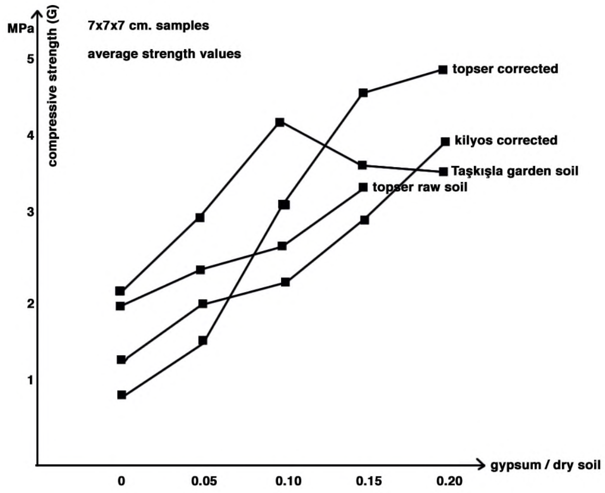

Figure 4. Average compressive strength variation according to concentrated soil and gypsum ratio.

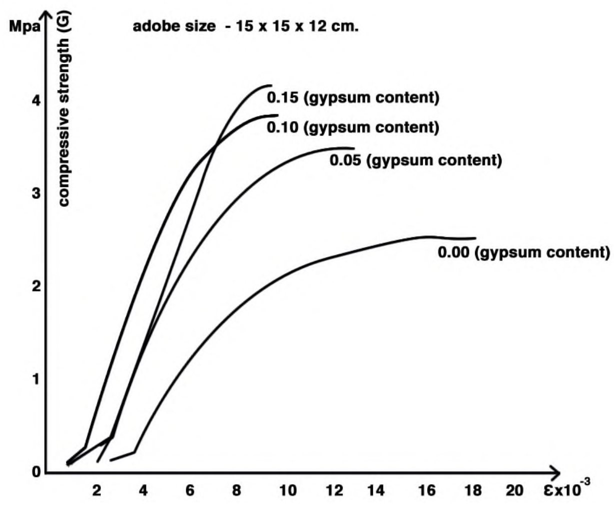

Figure 5. Compressive strength and stress-deformation curves based on gypsum content.

Thermal Expansion

The adobe samples cut in 1x1x4 cm dimensions from the separated test samples were heated from ambient temperature to 500°C in the dilatometer, and the length changes of the samples were recorded. Although slightly different from each other, the samples showed practically the same characteristic size changes based on the gypsum ratio with a very low coefficient of expansion. Thermal strain curve of adobe is shown in Figure 6.

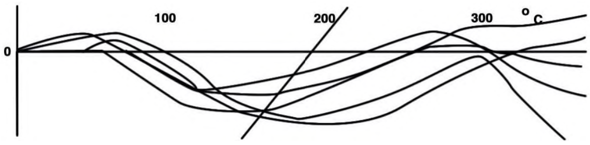

Figure 6. Thermal strain curve of adobe.

Effect of water on adobe

Water rising

The bottoms of the 0.00, 0.10, 0.15, and 0.20 gypsum-to-soil prisms for the 4x4x16 cm^3 samples of garden soil were placed in contact with water to observe how water rises in the adobe over time. The relationship between water absorption and porosity of the samples is shown in Table 3. Water absorption test results are shown in the photographs in Figure 7.

Table 3. The relationship between water absorption and porosity of the samples

gypsum/soil	0,00	0,10	0,15	0,20
porosity	0,39	0,42	0,43	0,44
time to water rising				x 10^2 s
2,4	1,0	1,0	1,0	1,0
36	2,7	3,0	3,3	3,4
165	collapse	6,2	7,0	7,5
792	-	10,5	12,5	13,0

Figure 7. Water absorption test.

Sprinkling effect

A wall was built by placing three of the large mudbricks of garden soil with gypsum on top of each other. This wall was sprayed with water for 10 minutes from a distance of approximately 1 m at a flow rate of 0.26 L/s through a shower head. This treatment was repeated for three consecutive days, and at the end of the test, the effects of water impact on the samples were observed. The results are shown in the photographs in Figure 8.

Figure 8. Sprinkler test results: Starting on the left are shown the samples with 0, 0.10, 0.15, and 0.2 ratios of gypsum added in the front row; the same ratios are shown in the middle row but with 0.05-0.10 lime added, with the rear row showing the 0.00 and 0.10 gypsum adobe with 0.025-0.05 lime.

3. Discussion of Test Results

Because gypsum adobe production is uncommon, this topic is not found in the literature, and thus the results could not be compared with other studies. However, studies are found on adobe reinforced with cement, lime, bitumen, and organic as well as inorganic fibers. Homogeneously mixing the soil with powdered binders is a challenge. When testing the gypsum mixed with soil, the very fluid consistency of the gypsum mixed with plenty of water allowed it to mix easily with the dry soil. Higher strength blocks are obtainable by compressing the dry adobe soil prepared in this way using simple presses (Lunt, 1980; Penton, 1941). The setting effect of the gypsum added to the soil is realized at rates over 0.10. The solidification of the block as the gypsum set made it easier to remove from the mold and transport. As the gypsum set, a gypsum skeleton formed between the clay particles, reducing the shrinkage of the adobe during drying and creating a hollow structure that easily releases water vapor.

The mineralogical and granulometric properties of adobe soil have a great influence on the properties of adobe blocks.

Increasing the percentage of gypsum in the adobe resulted in:

- Decreased unit volume weight
- Increased void ratio
- Reduced thermal conductivity due to the void ratio
- Increased compressive strength
- Increased water rise with capillarity, but increased resistance to sprinkling.

The adobe produced under typical conditions and from soil with good granulometry was found to have a strength of about 2MPa (20 kgf/cm^2). However, this adobe deforms considerably under load. As the proportion of gypsum added to the adobe increases, the strength can reach 4-5 MPa (50 kgf/cm^2). This value can increase to 6-7 MPa when the adobe is formed with simple hand pressing. This strength value is even higher than a mortar brick, which has an average strength of 3.5-4 Mpa (40 kgf/cm^2).

Slaked lime added to the adobe soil and to the 0.10 gypsum adobe mud caused a decrease in strength and an increase in deformation, contrary to what was reported in the literature (Lunt, 1980). However, this mixture is more resistant to the effect of sprinkling than the adobe without the admixture and the adobe with the 0.05 admixture. In all adobe samples, negligible deformation was found in response to temperature changes.

4. Results

Both the ever-increasing cost of energy and the huge housing shortage make the use of soil imperative, as it is a material whose properties can be enhanced and improved. The proposed method is energy-saving, does not require new technology, and does not increase costs. Therefore, it complies with the principles of improvement methods. Using this method will allow houses to be built in rural areas much cheaper than similar houses made of other materials.

Using gypsum adobe removes the need for expensive and complex equipment, investment, and capital to produce materials. Gypsum adobe can be produced with 99% less energy consumption compared to other materials of the same quality (e.g., solid or hollow bricks, concrete briquettes).

By adding gypsum to the soil, the drying time and the drying area of the adobe are reduced, which facilitates molding and allows a robust structure to be. In this way, a strong, breathable, humidity balancing, bioclimatic, comfortable, and fireproof wall material with high strength and low thermal conductivity compared to normal adobe can be obtained.

A robust building can be constructed with gypsum adobe by determining the street level, considering both the possible water rise in the construction area and the maximum height rainwater splashing can reach, placing it on a good foundation, and starting the adobe wall after reliably insulating it against water and moisture. This will eliminate the well-known disadvantages of adobe and make it a sustainable material for use in the construction of adobe houses in rural areas.

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RESEARCH ARTICLE

The Preliminary Step Towards Conceptual Model for the Artificial Intelligence-Neuro-Green Marketing in the Architectural Engineering and Construction Industry

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ABSTRACT
Innovation has fostered and enabled Industry 5.0, Society 5.0, and Marketing 5.0. It has also affected competition and marketing dynamics in all industries, including architectural engineering and construction industry (AEC). Intensified competition in AEC, alongside the accelerated innovations fostering and enabling changes in AEC's supply-and-demand dynamics, highlights the importance of time and how cost-effective, strategic, tactical, and innovative marketing has further influenced AEC's supply-and-demand aspects, which need to be sustainable to reduce its embodied environmental footprint mostly due to the climate crisis humanity is experiencing. Based on an in-depth literature review, this study aims to suggest the preliminary conceptual model's step towards artificial intelligence (AI)-neuro-green marketing in AEC as a potential key for a sustainable built environment. This study emphasizes potential of the AI-neuro-green marketing to foster competition by design (including architectural and interior design), to enhance the effectiveness of neuro-green marketing in fostering sustainable built environment, and to reduce AEC's embodied environmental footprint, outputs, and services. Furthermore, this study emphasizes the potential contribution of the AI-neuro-green marketing in AEC to Construction 5.0 and Society 5.0. This study is expected to contribute to the literature through the concept of AI-neuro-green marketing.

Keywords: Artificial intelligence, green marketing, Marketing 5.0, neuromarketing, neuro-green marketing

1. Introduction

Technological transformation has affected competitiveness in the market (Yau et al., 2021). Industry 4.0 has enabled digitalization in process and management facilities through the integration of operations with information and communications technologies (ICT)(Eriksson et al., 2020; Dalenogare et al., 2018). Competitiveness intensified under market conditions due to the exponential progress of Industry 4.0, has caused radical changes in marketing and the way individuals live and work (Dash et al., 2021; Ghobakhloo, 2020). Building on Industry 4.0, Industry 5.0 supports agility and resilience through ICT (Huang et al., 2022); promotes human centralization, sustainability, and resilience (Carayannis & Morawska-Jancelewicz, 2022; Mourtzis et al., 2022); and aims to achieve the United Nations (UN) Sustainable Development Goals (SDGs) Kasinathan et al., 2022). Industry 5.0 can enable and improve ICT integration not only into production-related process management but also into sustainable management levels and strategies (Dalenogare, 2018). Digital transformation requires acceleration in keeping up with changes in the business world (Ghobakhloo, 2020). Businesses are striving to update and adapt their management strategies to current digitalization management tools to survive under the competitive digital market conditions (Verma et al., 2021). Technological implications (e.g., AI and the Internet of Things [IoT]) that are a part of the digital transformation (Verma et al., 2021) lead companies to seek differentiation in strategic and managerial terms to maintain their market share (Eriksson et al., 2020). The impacts of digitalization, Industry 5.0, and Society 5.0 have enabled a globally sustainable networked system and encouraged organizations in different sectors to invest in AI (Chintalapati & Pandey, 2022; Verma et al., 2021), which has become a critical business strategic tool operating as market intelligence (Chintalapati & Pandey, 2022). AI is transforming the marketing industry by enabling the widespread use of AI in marketing operations (Shaik, 2023; Huang & Rust, 2021). The creation of new-age digitalization-driven marketing, known as Marketing 5.0, is modernizing marketing transforming it into a more data-driven, automated, and intelligent one (Chintalapati & Pandey, 2022; Kumar et al., 2019). AI can have a significant impact on improving and developing marketing

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strategies, including updating business models, revising marketing channels, shifting to customer-centric marketing, and predicting customer behavior (Davenport, 2020).

Advancements in ICT have not only caused a shift in marketing and increase in its complexity (Srivastava & Bag, 2023) but also a cognitive transformation in customers' expectations and decision-making processes (Siddique et al., 2023). While competitiveness is being exponentially increased, companies have prompted to seek new methods to better understand consumer behavior (Alsharif et al., 2021). The architecture, engineering, and construction industry (AEC) cannot isolate itself from the changes in the marketing field and developments. AEC plays an important role in improving quality of life, ensuring economic prosperity, and supporting sustainable development (Ikudayisi et al., 2023). Being a service sector under the classification of professional, scientific, and technical activities according to the UN's International Standard Industrial Classification of All Economic Activities (ISIC, 2022) and the North American Industry Classification System (NAICS, 2022), AEC can provide a project design that contributes to the creation of the built environment and ensures that the performance of the project meet all needs of human beings in accordance with the project purpose (Elshafei et al., 2021). AEC accelerates developments for adapting to Industry 5.0, which emphasizes connection among people, processes, and ICT applications and is based on focal points such as human-centered, sustainability-oriented, and resilience-oriented core values (Ikudayisi et al., 2023).

AEC can provide designs that affect project performance in the built environment to meet human needs. As there is differentiation in segmentation, meeting customer expectations and increasing customer satisfaction are the focus of the design process, analysis of customer data is important in customer segmentations while managing project development in the AEC. Shaik (2023) emphasized that the integration of AI into marketing can increase efficiency. Benchmarking from Shaik (2023), integration of AI into marketing in AEC can provide benefits to AEC companies. Furthermore, Chintalapati and Pandey (2022) suggested that conducting sectoral analysis research on AI in marketing can contribute significantly to the literature. The algorithm-based and data-driven orientation of AI enables analysis of customer behavior through human-imitating technologies and offers customer-focused solutions (Verma et al., 2021). The integration of green marketing and AI into the neuromarketing design process can increase the implementation of digital sustainable marketing strategies in AEC (Alsharif et al., 2021). For example, traditional marketing strategies' inadequacies resulted in neuromarketing as contemporary marketing (Siddique et al., 2023). Additionally, marketing strategies' inability to meet customers' green expectations fostered integration of sustainability into marketing strategies (Tuz & Sertyeşilışık, 2020) resulting in research on green marketing (e.g., Tuz & Sertyeşilışık, 2022). AEC supports and is part of Construction 5.0, which is focused on SDGs and sustainability; and AEC also aims to enhance people-centricity through IT-based solutions (Marinelli, 2023; Yitmen et al., 2023; Ikudayisi et al., 2023). The acceleration of innovation enables changes in AEC's supply and demand, which is indicative of intensifying competition, thus emphasizing the need for collaborative, innovative, sustainable, and people-oriented strategic marketing strategies to gain competitive advantage (Ikudayisi et al., 2023). This study aims to suggest the preliminary conceptual model's step towards AI-neuro-green marketing in the AEC industry as a potential key for sustainable built environment.

2. Contemporary Marketing Constructs in AEC

Marketing is a strategic management tool that can enable help companies gain a competitive advantage and provides short- and long-term benefits (Tuz & Sertyeşilışık, 2021). AEC is a competitive industry where different stakeholders can be involved in different projects that contribute to the creation of a built environment (Tuz & Sertyeşilışık, 2022). Moreover, Industry 5.0, Society 5.0, and Marketing 5.0 foster AEC to become more ICT-oriented, sustainability focused, and human-centric (Kasinathan et al., 2022). From that perspective, this situation increases the importance of marketing, and thus marketing tends to become a more IT-focused strategic management tool that provides competitive advantage.

2.1. Industry 5.0, Society 5.0, and Marketing 5.0's Interactions within AEC

Humanity has experienced different transformations that have affected society, such as the Industrial Revolution (Figure 1). Industry 5.0, which has been accepted and has already taken its place in the global business world (Huang et al., 2022), is built on Industry 4.0 through the integration of human orientation, sustainability, and resiliency (Kasinathan et al., 2022, Huang et al., 2022; Carayannis & Morawska-Jancelewicz, 2022; Mourtzis et al., 2022). Industry 5.0 supports agility and resilience through the use of ICT (Huang et al., 2022) and alignment with SDGs (Kasinathan et al., 2022). AEC is compatible with and supports Construction 5.0, which is oriented towards SDGs to benefit society, and aims to create sustainable and innovative solutions in the construction industry and offers smart solutions (Yitmen et al., 2023). Furthermore, Construction 5.0, which has a human-oriented perspective, aims to increase human-oriented efficiency with IT-based integration of robotization (Marinelli, 2023).

Society 5.0, which can be called as a super smart society (Carayannis & Morawska-Jancelewicz, 2022), envisions the society of the future (Huang et al., 2022) with the assistance of its human-centered position (Kasinathan et al., 2022; Carayannis & Morawska-Jancelewicz, 2022; Mourtzis et al., 2022). As Society 5.0 is a human-centered systematic approach and provides guiding principles for innovative ICT-based solutions, it creates a bridge between the techno-centric and human-centric (Carayannis & Morawska-Jancelewicz, 2022). Social capital is the key asset of Society 5.0 (Carayannis & Morawska-Jancelewicz, 2022), which aims to enhance the life quality based on the triple bottom line (TBL) of sustainability with the aim of creating a lean and super smart society (Huang et al., 2022) under the guidance of science, technology, and innovation ecosystem (Huang et al., 2022). Society 5.0 focuses mainly on social capital, revolutionizing society through sustainability and the integration of ICTs into the human lifestyle and aims to create a lean and super smart society (Carayannis & Morawska-Jancelewicz, 2022), therefore, AEC aims to adopt Society 5.0.

The marketing industry is experiencing a rapid transformation through the impact of Industry 5.0, Society 5.0, and digitalization (Ghobakhloo, 2020). The integration of IoT and AI into marketing has enabled increased connectivity and accessibility to information, forcing existing marketing strategies to become obsolete and exponentially change in Industry 4.0 (Dash et al., 2021). Human-oriented Industry 5.0 has increased the emphasis on sustainability using ICT technologies and enabled marketing to be developed to keep pace with sustainability-oriented digital marketing (Huang et al., 2022). The impact of the Industrial Revolutions (including Industry 5.0) on living and working conditions has required the marketing sector to evolve within itself and adapt to the radical changes that occur (Dash et al., 2021; Ghobakhloo, 2020). Industry 5.0 supports efforts to achieve and improve SDGs (Carayannis & Morawska-Jancelewicz, 2022), while Society 5.0 targets the creation of a future society where it balances economic development with social responsibility (Kasinathan et al., 2022). Industry 5.0 and Society 5.0 have increased the importance of sustainable marketing strategies, drawing attention to sustainability and its TBL (i.e., the social, economic, and environmental) (Kasinathan et al., 2022). Figure 1 highlights the transformation of marketing concept under the influence of industry and society. Accordingly, and in line with the improvements in Industry 4.0, marketing prior to the emergence of the digitalization-oriented Marketing 4.0, marketing had shifted from being product-oriented (Marketing 1.0) to customer-oriented (Marketing 2.0) and then evolved into a customer management-focused approach that creates value for customers (Marketing 3.0) (Sima, 2021; Alanazi, 2022).

Marketing 5.0, which is a result of the integration of marketing 3.0 and 4.0 (Alanazi, 2022), offers simultaneous solutions and aims to improve the customer experience by understanding customer expectations through human imitation technology-oriented methods (e.g., AI) (Sima, 2021). Industry 5.0 and Society 5.0 have supported the delivery of Marketing 5.0, which enhances the integration of ICT applications into marketing strategies (Figure 1). In addition, Marketing 5.0, which provides new-age digitalization-oriented marketing, supports the spread of AI applications in marketing operations (Shaik, 2023; Huang & Rust, 2021). Therefore, contemporary marketing is becoming more data-driven, automated, and intelligent (Chintalapati & Pandey, 2022). As AEC project specific customer preferences such as environmental concerns, sustainability orientation that depend on customer's concerns and expectations are among the key criteria influencing AEC projects (Tuz & Sertyeşilışık, 2022), the AEC project's marketing strategies and marketing mix tools need to meet the expectations of the target segmentation. Adapting AI to marketing strategies, the real-time monitoring of customer expectations and reactions with human-mimicking technology tools (Srivastava & Bag, 2023) can enable AEC to quickly implement changes in customer expectations into the project design and marketing strategies of projects. Marketing 5.0 focuses mainly on human-mimicking technology, creating, communicating, and delivering value to customers by understanding customer expectations, and aims to enhance customer experiences (Sima, 2021). Therefore, AEC aims to adopt Marketing 5.0. This emphasizes AEC as being located at the intersection of Industry 5.0, Society 5.0, and Marketing 5.0. This also shows that AEC arguments overlap with AI (Marinelli, 2023), sustainability (Yitmen et al., 2023), and human centralization (Ikudayisi et al., 2023), which are defined as the common arguments of Industry 5.0, Society 5.0, and Marketing 5.0.

2.2. The Green Marketing, Neuromarketing and AI Marketing Interaction as the Basis for the AI-neuro-green Marketing in the AEC

Progress in ICT has improved the application of tools (e.g., AI) in marketing strategies for Marketing 5.0. Additionally, while Industry 5.0 and Society 5.0 have enhanced sustainability orientation and human centralization, marketing has become customer solution focused (Kasinathan et al., 2022). In this regard, marketing has led to the development of different marketing strategies.

2.2.1. The Green Marketing

Customers' increasing environmental concerns have put pressure on marketing in recent years. The inability of marketing strategies to meet customers' green expectations has led to the integration of sustainability into marketing strategies (Tuz & Sertyeşilışık, 2020). Incorporating the TBL approach into marketing strategies known as green marketing can enhance not only companies' environmental performance but also their social and economic performances, which can create organization values (Tuz & Sertyeşilışık, 2020). Integrating sustainability into marketing strategies enables a green marketing that aims to meet customers'

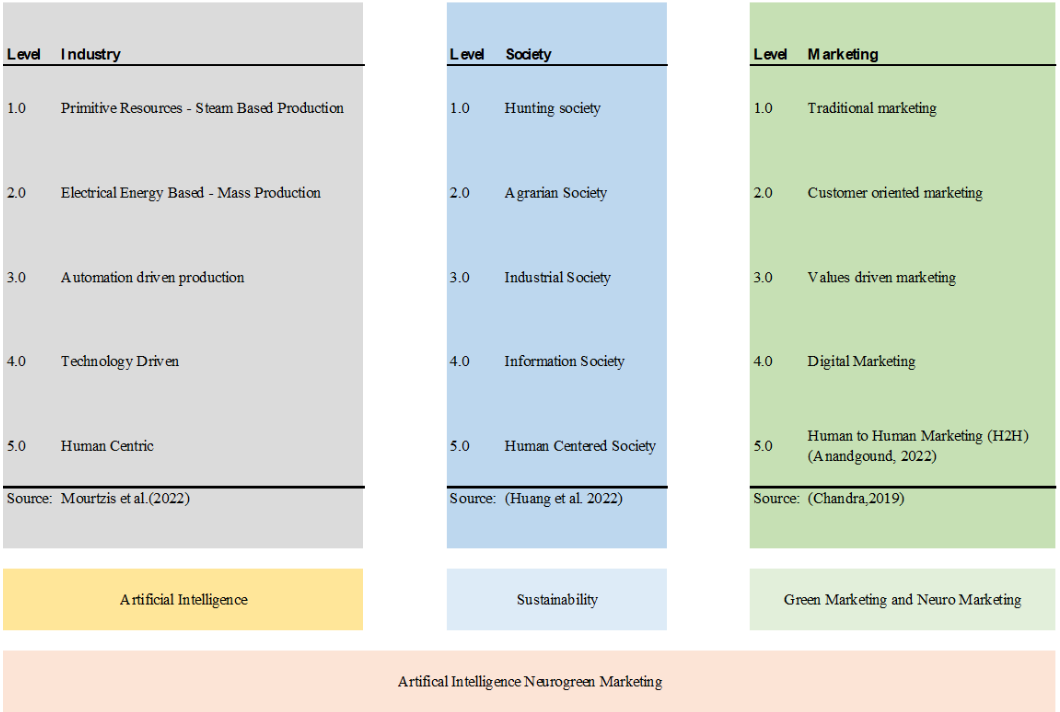

Figure 1. The industry, society, and marketing levels.

green expectations (Tuz & Sertyeşilışık, 2020). In line with the SDGs and the TBL approach, green marketing can provide customization in marketing with a value creation that increases customer satisfaction. Green marketing has a three-dimensional perspective at the intersection of social, economic, and environmental concerns. Green marketing is a strategic management tool (Tuz & Sertyeşilışık, 2022) that is compatible with SDGs and focuses on social expectations in the short run and on customer welfare in the long run (Tuz & Sertyeşilışık, 2021). With its customer satisfaction-oriented approach, green marketing is based on creating, communicating, and delivering value to the end customer (Tuz & Sertyeşilışık, 2020). Green marketing has attracted the attention of academic in recent years. Furthermore, green marketing as a strategic management tool attracts the attention of not only academics from different disciplines but also of professionals who are willing to implement green marketing strategies. Therefore, this attention emphasizes the importance of sustainability, which is the main pillar of Industry 5.0 and Society 5.0, in academic studies and different sectors (Kasinathan et al., 2022).

2.2.2. The Neuromarketing

The inadequacy of traditional marketing strategies has led to a shift towards the discovery of contemporary marketing (Alsharif et al., 2021) known as neuromarketing, which provides a multidisciplinary perspective (Siddique et al., 2023) and which is based on insights gathered from customer behavior (Srivastava & Bag, 2023). Neuromarketing refers to the application of ICT-advanced neuroscientific techniques to the field of marketing that enhance data-driven marketing to better understand consumer behavior (Robaina-Calderín & Martín-Santana, 2021). Neuromarketing has a multidisciplinary perspective at the intersection of marketing, neuroscience, and psychology (Alsharif et al., 2021). Neuromarketing enables the analysis and evaluation of the relationships among the emotion, attention, memory, and decision-making processes that can be classified as consumer behavior (Alsharif et al., 2021). Neuromarketing provides a better understanding of customer behavior to develop value creation strategies for target customers (Siddique et al., 2023). Neuromarketing is a tool-based practice that uses neuroimaging and physiological tools and techniques to record the neural correlates of consumer behaviors related to branding and advertising (Alsharif et al., 2021).

The multidisciplinary perspective of neuromarketing has attracted the attention of different disciplines in academia in the last decade (e.g., Siddique et al. 2023; Robaina-Calderín & Martín-Santana, 2021). In addition, increasing interest leads to an increase in multidisciplinary publications on marketing-oriented neuroscience (Robaina-Calderín & Martín-Santana, 2021). This reveals the impact of Marketing 5.0 on the importance of neuromarketing strategies in determining customer behavior in academic studies (e.g., Srivastava & Bag, 2023; Alsharif et al., 2021). Based on the literature review on the most examined neuromarketing tools and techniques, Alsharif et al. (2021) classified neuromarketing tools into four subgroups (e.g., neuroimaging tools, physiological techniques). Alsharif et al. (2021) indicated that physiological tools provide more sufficient insights regarding customer behavior and underlined the importance of marketing-appropriate neuroimaging tools for advertising and branding to provide information about the neural correlates of emotion and cognitive processes. Alsharif et al. (2021) emphasized the important effects of neuromarketing design that should ensure: (1) the creation of neural correlations with its impact on customer behavior and emotional processing and (2) strengthening the aspects that lead the consumer to enjoy and make decisions. Regarding the changing focuses of neuromarketing research throughout the years, Siddique et al.'s (2023) research on studies between 2006-2021 revealed three following periods, when: in the first period, it was possible to measure customer appreciation (like or dislike); in the second period, the development of technology and developments in neuromarketing measurement tools enabled the understanding of the psychology of the customer and the use of these methods in marketing, mostly in branding and advertising activities;and in the third period, subgroups of consumer behavior (e.g. facial expressions, attitude) were discussed (Siddique et al. 2023). Furthermore, Srivastava and Bag (2023) focused on AI-based facial recognition marketing and neuromarketing that enable segmentation of customers. Srivastava and Bag (2023) classified in five groups (i.e., customer profiling, customer insights, safety and security, data collection through social media, cognitive learning about consumer behaviors). According to Srivastava and Bag (2023) research, customer profiling classification that provides how facial recognition marketing and neuromarketing can provide neuro-information where the customer profiling (directly related to gathering demographics data that provides segmentation) and insights into customer behavior (related to gathering neuro-information and getting an actual response in neuromarketing) are determined as the more significant ones. Srivastava and Bag (2023) recommended for the future research to focus on mimic recognition analysis for precisely segmentation.

2.2.3. AI in Marketing

AI-driven marketing, which provides strategies to increase customer satisfaction through the use of ICT, has attracted the attention of academics and professionals in the last decades (Hermann, 2022; Verma et al., 2021; Davenport et al., 2020). AI acts as: automated (Hermann, 2022; Kumar et al., 2019), algorithm-oriented (Chintalapati & Pandey, 2022; Verma et al., 2021; Eriksson et al., 2020), data-driven (Shaik, 2023; Davenport et al., 2020), continuous learning-focused (Kumar et al., 2019), predictor (Shaik, 2023; Huang & Rust, 2021), decision-making processor (Hermann, 2022; Huang & Rust, 2021; Verma et al., 2021), customizer (Hermann,2022; Davenport et al., 2020; Kumar et al., 2019), intellectual task performer (Verma et al., 2021), interpreter (Chintalapati & Pandey, 2022; Eriksson et al., 2020), cost and time reducer (Shaik, 2023), value creator (Shaik, 2023), and problem solver (Yau et al., 2021; Verma et al., 2021). Therefore, AI can become a strategic powerful management tool that provides multidimensionally consistent and reliable benefits to society and organizations to reshape business strategies in line with digitalization (Hermann, 2022). AI can create various opportunities in marketing as a management tool (Hermann, 2022; Huang & Rust, 2021). Huang and Rust (2021) classified the literature on AI in marketing into four groups as: technical/algorithm-based; psychological - customer-oriented; social impact-living conditions; and management-strategy-oriented. Furthermore, Chintalapati and Pandey (2022) examined the five-year period of the marketing literature (2015-2020) on AI-driven marketing and classified the existing research into five main groups (e.g., integrated digital marketing, contextual marketing). Focusing on the intersection of the effects of AI on marketing and the effects of personalization to support customer satisfaction in marketing management, Kumar et al. (2019) pointed out the difference between personalization and customization from the marketing perspective and emphasized the importance of personalizing marketing channels to provide the customer and organization connection, which has a positive relationship with emotional bonds (e.g., customer behavior, customer engagement, and customer loyalty). Therefore, Kumar et al. (2019) conceptually defined digital curation, which enables the automatic presentation of marketing mix tools aimed at customer expectations and stated that customers encountered with personalized marketing mix tools offered by AI-driven marketing channels can contribute to customer satisfaction, loyalty, and emotions in their behavior, defined as emotional bonds. Furthermore, Kumar et al. (2019) underlined that increasing success in personalization depends on accessing more customer-focused data, creating insights from the data, and strategically applying and evaluating these insights.

Regarding the impact of AI on marketing, Shaik (2023) stated that AI and marketing are an integral whole under today's market conditions and introduced the term artificial intelligence marketing (AIM) as a strategic management tool that increases the customer experience by using technology at the maximum level and by examining the data obtained from the market. Additionally, Shaik (2023) emphasized that the integration of AI into marketing can increase efficiency, improve marketing management, create value for satisfied customers, and enable marketers to create market strategy (e.g., segmentation) and improve marketing by sending messages through digital channels while analyzing customer behavior. Furthermore, Verma et al. (2021) defined AI as an algorithm that improves business processes (e.g., automation), analyzes customer and market behavior by evaluating historical data by providing insight (e.g., market analysis), enables the determination of customer needs with real-time data, and ensures continuity of service. It attracts the attention of old customers and new potential customers by predicting customer insight (customer behavior) (Verma et al., 2021). Additionally, Verma et al. (2021) stated the automation effect of AI as an approach focused on continuous learning and problem solving with any machine that can think like a human. Emphasizing that the process is based on the determination of customer expectations through data collection and analysis, Verma et al. (2021) stated that the data collection phase is the most important element of AI. Shaik (2023) underlined that data is the most ethically important element in AIM management. Furthermore, Huang and Rust (2021) created a cyclical framework of marketing-focused research, strategy, and action. Additionally, regarding analysis of the effects of AI on marketing, Huang and Rust (2021) classified AI into three levels, namely: mechanical, thinking, and feeling. Mechanical AI is based on algorithms and refers to data collection in marketing research, analysis of customer preferences in strategy, and system standardization in action, whereas thinking AI is focused on the decision-making process and emphasizes market analysis in marketing research, how segmentation should be done in strategy, and personalization of the system in action (Huang & Rust, 2021). Furthermore, feeling AI focuses on the emotions of target customers and enables the determination of customer expectations in marketing research, how to communicate with the target audience at the strategic level, and the association of products and/or services with customer satisfaction by using communication methods to meet customer expectations in action (Huang & Rust, 2021).

2.3. The AI-Neuro-Green Marketing

AI, which can be classified as a tactical marketing tool (Erikkson, 2020), is an ICT tool and provides marketing strategies focused on customer satisfaction (Hermann, 2022). AI is an algorithm-based ICT and has a data driven orientation that enables to analyze customer behavior and provides standardized customer-oriented solutions. AI-driven marketing develops strategies on maximizing the use of technology, collection, and analysis of market data to increase customer satisfaction (Shaik, 2023). Adapting innovative, improvement- and solution-oriented AI applications to the marketing sector can enable companies to quickly adapt to changing market conditions and develop customer-oriented solutions (Chintalapati & Pandey, 2022). AI can automate business processes for today's conditions by providing customer and market insight through analysis of historical data (Verma et al., 2021). Furthermore, AI can analyze possible changes in customer expectations by evaluating real-time data and revising the system with a focus on customer satisfaction based on the obtained results (Verma et al., 2021). Therefore, AI can create customer insight on customer behavior that provides attraction of new customers while retaining old customers (Verma et al., 2021). AI can be classified as a tactical marketing tool, and it has significant strategic potential in marketing (Eriksson et al., 2020). AI can provide data to marketing strategies through translation of strategic information to guide managerial activities (Eriksson et al., 2020). Furthermore, neuromarketing can benefit from AI. For example, neuromarketing, which applies advanced neuroscientific techniques focused on AI to better understand customer behavior and develops data-driven and customized marketing into personalized marketing, enables analysis and evaluation of the relationship between customer behavior (e.g., emotions, decision-making processes) (Robaina-Calderín & Martín-Santana, 2021; Alsharif et al., 2021).

Even if there are separate definitions for the concepts of AI marketing, neuromarketing, neuro-green marketing, and green marketing in the literature, there is no definition for AI-neuro-green marketing as a single integrated concept in the literature. AI-neuro-green marketing is defined as an individualized marketing that is data-based, sustainable and technology-oriented, strategized on customer insights, and offers agile, customer-focused solutions that can increase customer satisfaction with its marketing mix tools.

The AEC industry, which can create a built environment with a focus on customer satisfaction, expectations, and design compatible with the TBL approach, can support Society 5.0 and Industry 5.0. Integrating Industry 5.0, Society 5.0, and ICT applications into marketing strategies has enabled the existence of Marketing 5.0 and the rapid spread of AI applications in marketing operations (Kasinathan et al., 2022). Moreover, the integration of Kumar et al.'s (2019) digital curation concept into marketing operations has sought to advance digitalization in marketing in the AEC industry in terms of green marketing, neuromarketing, and AI-neuro-green marketing practices at AEC.

The AI-neuro-green marketing concept in the AEC industry gets its roots from the integration of: (Figures 1, 2, and 3): the mechanical AI, thinking AI, and feeling AI categorization (Huang & Rust; 2021); the individualization, personalization, customization, and standardization from marketing perspectives (Kumar et al., 2019); neuromarketing (e.g., Robaina-Calderin & Martin-Santana, 2021); green marketing (e.g., Tuz & Sertyeşilışık, 2022); data-driven marketing (e.g., Shaik, 2023); neuro-green marketing (e.g., Topcu, 2022; Topcu & Sertyeşilışık, 2021); and AIM (Shaik, 2023). Benchmarking from Huang and Rust's (2021) categorization (i.e., the mechanical AI, thinking AI, and feeling AI), mechanical AI enables automatic data collection in marketing research (Huang & Rust, 2021). As mechanical AI is algorithm-based (Chintalapati & Pandey, 2022), it improves standardization (Kumar et al., 2019) that can be suitable for mass marketing strategies. Thinking AI focuses on customer decision-making (Huang & Rust, 2021). Furthermore, customer orientation can improve strategy in market segmentation and enable customization in marketing (Kumar et al., 2019) through green marketing that can suit niche marketing strategies. Feeling AI enables the determination of customer expectations (Huang & Rust, 2021), through human-imitating technology in market research (Sima, 2021), and personalizes marketing communications through neuromarketing in line with customers' preferences (Alsharif et al., 2021) with marketing mix tools suitable for individual marketing strategies (Kumar et al., 2019). In line with the Marketing 5.0, this study attempts to present the potential marketing strategies for AEC:

- *The mass marketing perspective:* The integration of mechanical AI (Huang & Rust, 2021), also known as automation (Verma et al., 2021), into marketing strategies can increase the data-driven approach through marketing channels, allowing the identification of customer expectations and the creation of databases for different types of projects (Huang & Rust, 2021). Additionally, the integration of mechanical AI can increase digitalization in the AEC industry, which focuses on Industry 5.0, Society 5.0, and Marketing 5.0. Therefore, the industry can become more data-driven, automated, and intelligent in its marketing strategies (Chintalapati & Pandey, 2022). Mechanical AI, which enables automatic data collection in marketing research (Huang & Rust, 2021), is algorithm-based (Chintalapati & Pandey, 2022), and improves standardization (Kumar et al., 2019) that can be suitable for mass marketing strategies.
- *The niche marketing perspective:* Adopting thinking AI in marketing strategies can enable the collection of information about the customer's preferences and orientation (Huang & Rust, 2021). Additionally, ensuring standardization by collecting information about the target market's expectations for different project types can increase sustainability in designs. Therefore, sustainable design criteria for different projects can be achieved through digital data-driven progress. Adopting green marketing strategies as a marketing strategy in the AEC industry can increase the industry's adaptation to Marketing 5.0. In addition, the implementation of green marketing mix tools (GMMT), one of the most important components of green marketing, can increase the sector's adaptation to Marketing 5.0. There has been a lack of green marketing mix and strategies studies focused on AEC. Tuz and Sertyeşilışık (2022) focused on the creation of green marketing strategies and mix tools and identified 16 GMMT for mass marketing in the construction industry. Adapting these GMMT can enable the application of thinking AI to marketing strategies. Therefore, it can increase sustainable marketing strategies on the AEC basis. Focusing on the customer decision-making process (Huang & Rust, 2021), the thinking AI improves market segmentation strategy through focusing on decision-making process. Therefore, customer focus can enable customization in marketing (Kumar et al., 2019) with green marketing suitable for niche marketing strategies (Huang & Rust, 2021).
- *The personalized marketing perspective:* Kumar et al. (2019) emphasized the importance of personalization in marketing. The feeling AI in marketing strategies can enable the creation of marketing strategies for the targeted customer segment (Huang & Rust, 2021). Greater personalization enables more data to be collected through human-mimicking AI applications to determine customer expectations (Srivastava & Bag, 2023). As marketing mix tools vary based on customer expectations, with the effect of personalization, customers can be provided with GMMT that can meet their expectations (Kumar et al., 2019). Customer expectations can be diversified by increasing the application of neuro design in marketing strategies in the light of the information collected from the customer through neuromarketing strategies (Topcu, 2022). There is a lack of studies providing AEC-focused different segments oriented GMMT. Tuz (2021) focused on the creation of green marketing strategies and mix tools and defined GMMT for different socioeconomic classifications for the construction industry. The integration of GMMT and AI into the neuromarketing design process can increase the implementation of digital sustainable marketing strategies in AEC (Alsharif et al., 2021). Integration of Al-neuro-green marketing strategies into marketing management can improve digital strategic decision-making at the strategic, operational, and tactical management levels, while enabling management to focus on sustainably focused digital agile strategies for different target markets (Tuz & Sertyeşilışık, 2021). Feeling AI enables the determination of customer expectations (Huang & Rust, 2021) with human-imitating technology in market research (Sima, 2021) and personalizes marketing communications through neuromarketing in line with customers' preferences with marketing mix tools suitable for personalized marketing strategies (Kumar et al., 2019).
- *The individualized marketing perspective:* AI enables the collection of large amounts of data and analysis of the collected data at the individual level (Kumar et al., 2019). AI-neuro-green marketing can support AEC to create green marketing strategies on real-time tracking data obtained and analyzed from customer expectations and customer reactions at the individual level through technologies (e.g., human-imitating technologies), enabling AEC to demonstrate rapid changes in marketing. Applying neuro-design strategies to AI-neuro-green marketing can enable AEC to get benefit from neuro-green marketing. The neuro-green marketing can support sustainable client-based design criteria for projects to be designed in the creation of a sustainable built environment (Topcu, 2022).

3. Discussion

Figure 3 represents the preliminary step towards the concept of AI-neuro-green marketing in AEC. This concept mainly emerges as a result of the digital integration of mechanical, thinking, and feeling AI types as indicated by Huang and Rust (2021) into marketing perspectives (i.e., standardization, personalization, personalization, and individualization), as highlighted by Kumar et al. (2019) together with: neuromarketing (e.g., Robaina-Caldering & Martin-Santana, 2021), green marketing (e.g. Tuz & Sertyeşilışık, 2022), data-driven marketing (Shaik, 2023), AIM (Shaik, 2023), and neuro-green marketing (Topcu, 2022; Topcu & Sertyeşilışık, 2021). The concept provides the AI-neuro-green marketing concept to the AEC industry digital marketing strategies from the mass- and niche-marketing perspectives: from the mass-marketing perspective, data-driven marketing, green marketing, and neuro-green marketing, whereas from the niche-marketing perspective, neuromarketing in personalized marketing and neuro-green marketing strategies in individual marketing.

AEC	Marketing	Digital Curation	Artificial Intelligence	Client
Built Environment	Management Stage	Deep Learning	High Technology Orientation	Differentiation
Project Type	**Tools & Channels**	**Data Driven** Kumar et al. (2019)	**Data Driven** (Shaik, 2023; Davenport et al., 2020)	**Expectations**
Sustainability	**Green Marketing**	Customization Kumar et al. (2019)	**Industry Classification**	**Environmentaly Friendly Concerns**
Design	**Neuro Marketing**	**Personalization** Kumar et al. (2019)	**Digitalization** Hermann, 2022; Huang & Rust, 2021; Mustak et al., 2021	**Socio-economic classification**
Industry 5.0 & Society 5.0	**Marketing 5.0**	**Industry 5.0**	**Industry 5.0**	**Society 5.0**
		Marketing Mix		

Artificial Intelligence Neurogreen Marketing

Mechanical AI (Huang & Rust, 2021)
Thinking AI (Huang & Rust, 2021)
Feeling AI (Huang & Rust, 2021)

Figure 2. Main aspects of the preliminary conceptual model towards AI-neuro-green marketing.

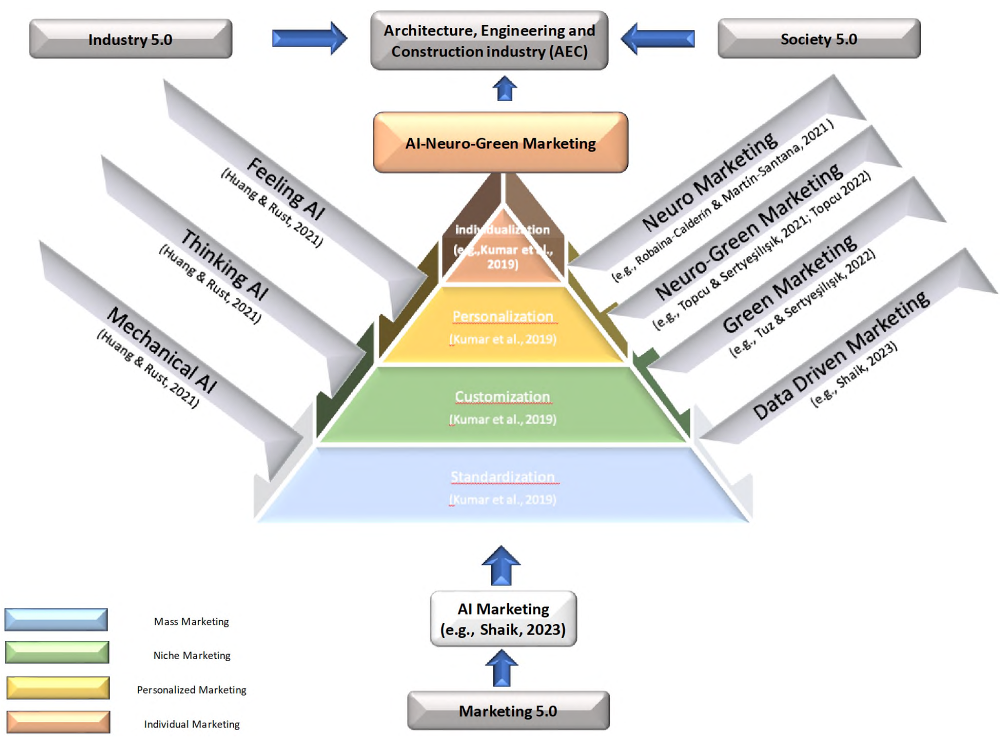

Figure 3. The preliminary concept of AI-neuro-green marketing in AEC.

AI-neuro-green marketing has the potential to enhance the effectiveness of neuro-green marketing in fostering sustainable built environment. Neuro-green marketing has a potential role in supporting the sustainability of the construction material industry (Topcu & Sertyeşilışık, 2021) and of built environment (Topcu, 2022). The potential of the AI-neuro-green marketing to enhance the effectiveness of neuro-green marketing is following the AI integrated marketing's potential advantages as regarding AI's contribution to marketing Shaik (2023) indicated that the integration of AI into marketing can provide many advantages including: increase in efficiency, improvement in marketing management, creation of value for customers. For this reason, benchmarking from Shaik (2023), AI-integrated neuro-green marketing can have potential to be more effective than neuro-green marketing at supporting sustainability in built environment. In this way, the effective use of AI-integrated neuro-green marketing by the AEC industry can have potential to influence its environmental footprint and contribute to reducing the embodied environmental footprint of the AEC industry's outputs and services, both directly and indirectly.

AEC companies effectively using AI-neuro-green marketing can have potential to enhance their competitiveness by value-driven and human-centric design (including architectural and interior design, material design) supported by the input of the better and deeper understanding of their customer segments' expectation and behavior. As companies seek new methods to better understand consumer behavior (Alsharif et al., 2021), AI-neuro-green marketing can have potential to support this process through synergy which can be created as a result of effective integration of the mechanical AI, thinking AI, and feeling AI (Huang & Rust; 2021); the individualization, personalization, customization, and standardization marketing perspectives (Kumar et al., 2019); neuromarketing (e.g., Robaina-Calderin & Martin-Santana, 2021); green marketing (e.g., Tuz & Sertyeşilışık, 2022); data-driven marketing (e.g., Shaik, 2023); neuro-green marketing (e.g., Topcu, 2022); and AIM (Shaik, 2023) aspects into the AI-neuro-green marketing process. As enhanced competitiveness of the companies can support their survival and success in the ever-intensifying competitive market and under the business fluctuation conditions, potential of the effective and successful management of the AI-neuro-green marketing in the AEC industry to directly and indirectly contribute to a company's competitiveness can act as a driver for AI-neuro-green marketing integrated into the strategic management of companies in the AEC industry.

Integrating sustainability and human centralization into marketing strategies can allow AEC to enhance the creation of built environment with the focus on understanding customer's expectation through human-mimicking technologies and designs compatible with the (TBL) approach. In addition, Shaik's (2023) study results may also have benefits for AEC: Improving marketing management, creating value for satisfied customers, enabling marketers to create a segmentation-oriented market strategy.

The AI-neuro-green marketing in the AEC industry has the potential to contribute to Construction 5.0 and Society 5.0 as they have common arguments as: AI (Marinelli, 2023), sustainability (Yitmen et al., 2023), and human centralization (Ikudayisi et al., 2023). Therefore, AI-neuro-green marketing can become an innovative, sustainability-oriented, and strategic marketing tool for companies operating in AEC. It is important for the AEC companies to respect the ethical aspects of the AI-neuro-green marketing mainly due to the ethical aspects related to data acquisition and use. This is in line with Shaik's (2023) emphasis on the data as the most ethically important element in AIM management.

4. Conclusion

This study has aimed to suggest the preliminary conceptual model's step towards the AI-neuro-green marketing as a potential strategic key to a sustainable built environment. AEC cannot isolate itself from the changes and developments resulting from Industry 5.0, Society 5.0, and Marketing 5.0, and it plays an important role in creating sustainable built environment with the contributions it provides. AEC offers design projects to built environment to ensure that project performance meets all human needs in accordance with the project purpose, minimizing environmental degradation and maximizing time and cost effectiveness. AEC is a competitive sector located at the intersection of Industry 5.0, Society 5.0, and Marketing 5.0, directly overlapping with the goals.

This study has provided a suggestion for the preliminary conceptual model's step towards the AI-neuro-green marketing. Figure 3 illustrates the preliminary AI-neuro-green marketing concept for AEC. As seen in Figures 2 and 3, this study highlights mechanical AI-oriented data collection to pave the way of marketing strategies, determination of customer preferences with thinking AI techniques to better customize the marketing mix tools, personalization with the support of feeling AI implementation to get the customers' attention (Huang & Rust, 2021). This study highlights the potential significant effects (e.g., improving digital sustainable orientation in marketing, increasing effectiveness of neuro-green marketing in supporting sustainable built environment, and providing direct or indirect effects in minimizing the environmental footprint of AEC and its outputs) of AI-neuro-green marketing strategies on AEC. Furthermore, this study emphasizes that the effective application of AI-neuro-green marketing as a marketing strategy to companies operating in AEC that can enable companies to enhance their marketing strategies under intensive competition, increase efficiency, improve marketing management, contribute to Industry 5.0, Society 5.0, and Marketing 5.0, and support AEC to keep up with the changes in Industry 5.0, Society 5.0, and Marketing 5.0.

This study highlights the potential of the effective application of AI-neuro-green marketing as a marketing strategy that can support companies to analyze customer expectations and behaviors so that customer satisfaction can be enhanced with the help of designs focused on human-centered value creation supporting their competitive advantage in the AEC through increased customer satisfaction and meeting the expectations of the different target segments. Furthermore, this study highlights the potential of the effective AI-neuro-green marketing to increase marketing effectiveness in creating sustainable built environment.

This study contributes to the marketing literature through putting emphasis on the interaction of AI, green marketing, neuromarketing and marketing in AEC. This study can contribute to the widespread and establishment of sustainable built environment. This study can provide information for professionals and academics to understand AI-neuro-green marketing and its importance in marketing practices. This study underlines the importance of AI-neuro-green marketing, and its marketing mix tools for AEC. Future studies could identify the AI-neuro-green marketing mix tools specific to AEC from the mass- and niche-marketing perspectives. Furthermore, future studies are recommended to focus on AI-neuro-green marketing strategies for different industries.

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DESCRIPTION

Journal of Technology in Architecture Design and Planning (JTADP) is an open-access, peer-reviewed and scholarly journal published biannually in May and November. The journal is the official online-only publication of Istanbul University Faculty of Architecture. JTADP aims to contribute to the knowledge in the fields of architecture, design and planning with a focus on technology dimension. The publication language of the journal is English. Articles submitted to JTADP are subject to a doubleblind peer-review evaluation system. The journal targets national and international audience. Target audience of the journal includes academicians, researchers, professionals, students, and related professional and academic bodies and institutions.

Processing and publication are free of charge with the journal. There is no article processing charges or submission fees for any submitted or accepted articles.

AIM AND SCOPE

Journal of Technology in Architecture Design and Planning (JTADP) aims to contribute to the knowledge in the fields of architecture, design and planning with a focus on technology dimension. It is an open-access, peer-reviewed and scholarly journal published biannually in May and November. In order to expand the boundaries of knowledge in these fields and provide an international forum for the interchange of information and current issues from around the world, JTADP publishes double blind refereed articles on practice and progress regarding the fields; these include research articles, review articles, reviews of projects and case studies. Subjects covered by JTADP include, but are not limited to: Architectural engineering, design engineering, urban engineering.

Technology is defined as a process that covers the transformation and use of basic and applied sciences' data into production within creative processes and the analysis of their social effects. Hence, technology naturally constitutes the essence of architecture, design and planning actions.

The fact that technology takes place as a process in all kinds of design activities emphasizes the organic and inseparable unity of the three aforementioned fields and their sub-titles with technology. Technology, and therefore architecture, design and planning, is a combination of creativity and intelligence with science, art, engineering, economics and social studies in order to increase the quality of human life. The point that should be noted here is that technology is not only related to science and engineering, but also a reflection of fields such as art, sociology, psychology and economics.

Based on the fact that the technology dimension is not adequately addressed in scientific publications in the fields of architecture, design and planning, it has been decided that JTADP will focus on these issues. Moreover, JTADP aims to explore the interface between design, architecture, planning and their practical applications.

EDITORIAL POLICIES AND PEER REVIEW PROCESS

Publication Policy

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Editor-in-Chief does not allow any conflicts of interest between the authors, editors and reviewers. Only he has the full authority to assign a reviewer and is responsible for final decision for publication of the manuscripts in the Journal.

Reviewers must have no conflict of interest with respect to the research, the authors and/or the research funders. Their judgments must be objective.

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Only those manuscripts approved by its every individual author and that were not published before in or sent to another journal, are accepted for evaluation.

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The editor hands over the papers matching the formal rules to at least two national/international referees for double-blind peer review evaluation and gives green light for publication upon modification by the authors in accordance with the referees' claims.

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- Are the interpretations and consclusions justified by the results?
- Is adequate references made to other Works in the field?
- Is the language acceptable?

Reviewers must ensure that all the information related to submitted manuscripts is kept as confidential and must report to the editor if they are aware of copyright infringement and plagiarism on the author's side.

A reviewer who feels unqualified to review the topic of a manuscript or knows that its prompt review will be impossible should notify the editor and excuse himself from the review process.

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