

**ADVOCATING FOR GREEN BUILDING MINIMUM  
COMPLIANCE SYSTEM IN RWANDA:  
USING BRICKS TO ACHIEVE SUSTAINABILITY**

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**Abstract.** *Development countries in Africa will see 75% increase of its current building stock until 2060 due to the economic development, rapid urbanization and population growth. Rwanda's Third National Communication under the United Nations Framework Convention on Climate Change estimates that the carbon dioxide emissions from buildings will increase by 574% by 2050 in the business as usual scenario. The aim of this paper puts sustainable architecture and green buildings in a context of rapidly urbanizing Rwanda, showing five recently constructed brick buildings that exploit the culture while meeting the sustainability demands of the 21<sup>st</sup> century. Global sustainability agendas are advocating for the use of brick for its durability, quality, with environmental, economic, and social benefits for construction sector. This paper provides insights on the policies, such as the Green Building Minimum Compliance System, advocating for the use of brick as a sustainable construction material. Despite the rapid urbanization in Rwanda, the existing sustainable construction practices help in reducing carbon dioxide emissions, while this paper also documents results on social and economic perspectives for the community from construction sector.*

**Key words:** *green building, sustainable construction, sustainability, brick, green building policy, Rwanda*

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## I. INTRODUCTION

There are no preserved built structures in Rwanda prior to 20<sup>th</sup> century, which is the period prior to the colonization, as Rwandans traditionally used perishable construction materials. After being appointed by Germany as an administrator in Rwanda, Richard Kandt started building the new capital, and his own house, which is the oldest built structure, from 1909, in Rwanda's capital Kigali [1,2]. After World War I, for decades during the Belgian colonization period, Kigali spatially grew from 40 ha in 1916 to 200 ha in 1958 [1]. There are numerous brick buildings from the colonization period that still remain today, including Maternity Clinic CHUK, Kigali Central Prison, Cloister of the Bernardine Sisters in Kigali; Group Scolaire, Our Lady of Wisdom Cathedral, and the post office in Huye [3,4], to name a few.

After its independence from Belgium in 1962, Rwanda continued to work on the infrastructure in Kigali and other today's secondary cities using brick. There are several examples of brick buildings in Rwanda from the period after gaining the independence, such as the 1980s extension of the Huye Campus of the University of Rwanda where brick is used and for buildings and for the pavement of public spaces. Another example includes the Ethnographic Museum in Huye built in the late 1980s.

During the genocide against the Tutsi in 1994, many of the heritage buildings were places in which crimes took place. Also, many of the buildings were destroyed. Only after the reconciliation process started with the new government, urbanization was triggered [5]. The urbanization process was followed by Vision 2020, Vision 2050, Economic Development and Poverty Reduction Strategy (I & II), National Strategy for Transformation (I), National Roadmap for Green Secondary Cities Development, master plans, and other new plans and policies related to green cities and green buildings [6,7].

In 2019, the Rwanda Housing Authority in collaboration with the Building Construction Authority of Singapore, the Global Green Growth Institute, the Rwanda Green Building Organization, and other stakeholders developed the Green Building Minimum Compliance System [8]. Designing a successful green building policy within the complex context of a government agency is difficult as multiple stakeholder perspectives are considered and aligned to meet the common vision and plan of action [9-12]. This system was approved by the Rwanda cabinet in April 2019 through a ministerial order determining the Urban Planning and Building Regulations and is an Annex-3 to the Rwanda Building Code 2019 [13]. Implementing the green building rating systems contribute to buildings' performance in environmental aspects, among others [14-16].

Implementing green buildings offers several environmental, economic, and social benefits to the construction industry, that includes prevention of global warming and climate change, minimizing carbon dioxide emissions and other pollutants, protecting the ecosystem, use of renewable natural resources, improving health, comfort, and well-being, alleviating poverty, improving economic growth, raising rental income, decreasing healthcare costs, and others [17-22]. The green building in Rwanda indicators address the basic green features any building should have, such as appropriate orientations for daylighting, natural ventilation, rainwater harvesting, efficient plumbing fixtures, low-impact refrigerants, greenery protection, paints not harmful to occupants, etc. These features can be applied to new Category 4 and 5 public buildings, such as health facilities, commercial buildings, educational buildings, cultural buildings, and others [8]. The Green Building Minimum Compliance System in Rwanda also promotes the use of bricks as energy-efficient building materials that reduces heat ingress into space by using advanced bonding techniques, such as the row-lock/rat-trap

bond, thereby reducing the need for air conditioning systems and providing thermal comfort for occupants [8,13].

Buildings contribute a quarter of global carbon emissions that arise from energy demand during construction and operation, and hence, considerable effort has gone to reduce energy consumption in buildings as it is responsible for a third of the world's consumption [23-24]. The Third National Communication Report on Climate Change of the Rwanda Ministry of Environment estimates that the carbon dioxide emissions from buildings will approximately increase by 574% by 2050 compared to 2012 levels in a business as usual scenario [13,25], although transition to green buildings comes with specific costs [26-30].

Thus, the Government of Rwanda and other stakeholders are pursuing sustainability in the building and construction sector by recommending the use of energy-efficient practices and sustainably produced local construction materials, such as brick. They also recommend the use of energy-efficient kilns and alternative raw materials for firing instead of firewood, thereby reducing carbon dioxide emissions and protecting the environment [8]. The Updated Nationally Determined Contribution of Republic of Rwanda 2020 identifies efficient brick production as one of the key mitigation pathways in the energy sector [31]. The use of locally-sourced raw materials for building material production, in this case bricks, by reducing dependence on conventional materials such as concrete and steel, potentially relieves pressure on the material supply chain, avoid increased construction costs while reducing transport-related greenhouse gases emissions and provides opportunities for local economic development [32].

The Made in Rwanda policy of 2017 by the Rwanda Ministry of Trade and Industry promotes the development of local construction materials, such as brick, in collaboration with the private sector, to reduce the trade deficit in construction materials [33]. The Assessing Rwanda's Affordable Housing Sector report by the Centre for Affordable Housing Finance in Africa has noted that bricks are part of Rwanda's top 10 building material exports [34]. This can be potentially owed to Rwanda's abundant clay deposits, which are of excellent quality. There is also a massive demand of the country's fast-growing cities for bricks [35].

The Promoting Climate Responsive Construction Material Production and Off-farm Employment in the Great Lakes Region (PROECCO) project of the Swiss Agency for Development and Cooperation (SDC) and implemented by SKAT Consulting Ltd has showcased many innovations ranging from low-carbon brick manufacturing to modern brick construction systems by promoting semi-industrial brick manufacturing, which consumes 20%–30% less energy in the production stage. This method uses biowaste, such as sawdust and coffee husk, for firing bricks. It also makes use of an innovative brick kiln technique that is modified to a local context. This technique can consume up to 75% less energy, thus significantly reducing carbon dioxide emissions compared with traditional brick manufacturing methods [35]. The PROECCO project has demonstrated that the brick walls built using the row-lock/rat-trap bond technique are 30% cheaper than conventional cement block walls and also help in insulation and thermal comfort. This lower cost of construction combined with modular designs results in affordable construction that embraces brick as a key construction material that can potentially meet the growing affordable housing needs in Rwanda [35].

The revised master plans for Kigali and newly developed for six secondary cities emphasize the inclusive nature of the participatory approach of developing polycentric cities with iconic cultural and traditional values. The revised Kigali City Master Plan Zoning Regulations mandate green building requirements by encouraging the use of local

construction materials, including bricks, and provide developers with incentives that permit certain additional gross floor area if a project demonstrates a sustainable building design technology and sustainable construction methods as per the Green Building Minimum Compliance System [36]. In addition, District Development Strategies 2018–2024 recommend cities and other settlements within the district to use brick and other sustainable construction materials.

The Government of Rwanda and stakeholders organized additional outreach events to promote the use of sustainable construction materials, especially brick, including “Urban Walk” [3, 4]. In addition, awareness and capacity building programs on Green Building Minimum Compliance System were organized for government officials, Rwanda Institute of Architects, Institution of Engineers Rwanda, and other professionals, where the usage of bricks and various green building strategies has been stressed [37,38].

## 2. MATERIALS AND METHODS

This chapter describes the research methods for the present study and the approach that was followed to fulfil the research objectives. In researching this paper, a combination of materials and methods was utilized.

1. The authors traced built heritage sites to better understand the cultural and traditional aspects of using bricks in Rwanda in its 20<sup>th</sup> century architecture, this was done through the “Urban Walk” event in Kigali and Huye in 2019. Outcomes of the event served authors to write an introduction of this paper.
2. A document review was utilized to understand the recent developments in the use of bricks globally and in Rwanda, especially with regard to the context of sustainable development and green building policies and practice. Relevant literature reviews of green building development were done using multiple databases like Web of Science and Scopus. While this activity informed research on global practices, it did not provide insights on country specific emerging patterns of the policy formulations and implementations related to green construction materials, especially bricks.
3. Original content and data from Rwanda that were used were prepared by the Government of Rwanda, the Global Green Growth Institute, SKAT Consulting Ltd., ENABEL, and other stakeholders. It supported Introduction of this research.
4. Descriptive case study research design was used. This research benefited from outcomes of following workshops and events:
  - 4.1. Two school years of a semester-long course “Architectural Theory” at the School of Architecture and Built Environment, in which the contemporary architecture in Rwanda was discussed and documented in 2018 and 2019. During this activity, the authors of this research also interviewed architects working for the Mass Design Group and ASA Studio to better understand their sustainable construction practices and the use of bricks in their flagship projects. Interviews were conducted with professional team members who were involved in the construction of each building. It was determined that the consultants who provide design and construction solutions utilizing green design standards would be better suited to assess the use of brick and other green building materials and discuss implementation of green building legislation. The interview questions were asked in person. The interview protocol consists of 10 questions that relate to the interviewee’s personal information and about the green building they

designed or implemented within the studio. These questions were included to assess each respondent's role in the construction industry in Rwanda and, more specifically, it was used by authors to select buildings being studied in the chapter 3 of this paper. Outcomes also served to prepare results of this research.

- 4.2. Workshops organized as part of the various Green Building Minimum Compliance System dissemination programs conducted in 2019, 2020, and 2021, which targeted multiple building industry stakeholders and that authors of this research attended. It helped with understanding the policy in Rwanda and used to further assess buildings selected for this research.
5. In addition, the collected data for this research includes photographs of the buildings in Kigali and other cities from 2018, 2019, and 2020. Site visits were undertaken to obtain a greater understanding of the building and the key features that contributed to its green building aspects, that supported authors in the selection process and write the results for this research. Each case study building was visited by at least two authors.

### 3. RESULTS

As a building material, brick is very durable, user and maintenance friendly. Moreover, brick buildings are energy-efficient [39], highly resistant to compression, fires, and frost and can be reused and recycled. The production processes of bricks are environmentally acceptable, and the life cycle of brick structures is long. Bricks also do not require extensive maintenance [40].

Numerous public policies have been implemented globally and in the region in the last ten years to promote green building in the private sector [41,42] regardless of the implementation drivers [43-46]. The concept of green buildings and its definition is constantly updated as the construction industry develops [47,48]. This paper presents findings on five recently constructed buildings using brick in Rwanda, and they are in both urban and periurban areas. Some of these buildings were constructed before the Government published the Green Building Minimum Compliance System and before initiatives of SKAT Consulting Ltd.

To promote modern brick construction systems as a method of achieving affordable housing solutions and other policies on green construction materials and techniques, the selected and presented buildings show that by using bricks, these buildings fulfill their intended sustainability objectives, serve as inspirations for industry stakeholders to emulate contemporary architecture practices using locally made bricks, and contribute to the overall sustainability of Rwanda. The existing studies predominantly focus on the environmental aspect of green building [49] while this research in addition to the aspect of Rwanda's tropical climate, also discusses social sustainability of brick buildings, usually overlooked by researchers [50]. The green building research had been concentrated on the subject categories of engineering, environmental sciences & ecology, and construction & building technology, while knowledge gaps were detected in the areas of corporate social responsibility [51] that this article discusses. The results discuss buildings with various functions: culture, sport, health, housing, banking, and others.

#### 3.1. I&M Bank Headquarters in Kigali

The new I&M Bank headquarter was built in Kigali, city center (Figure 1), and it was designed by a Kenyan company Planning Systems Services Ltd. Its main and unique character

is that bricks were used as the main construction material, for its facade. The building comprises two towers: a four-floor tower that is exclusive for bank activities and an eight-floor tower with offices for renting purposes. The towers are unified through a curling-like roofing structure. The eastern and western facades have 80% brick and 20% glass, thus optimizing on the window-to-wall ratio and reducing unwanted heat gains through windows. The building is ventilated through cross ventilation because it narrowly faces the axis of the most prevailing wind directions in Kigali: North-East and South-West. The Rwanda Green Building Minimum Compliance System encourages buildings to use sustainable construction materials such as fire-clay bricks, which are made by a local manufacturer. The project has used *Ruliba* (popularly known as *Ruliba* bricks), manufactured locally within Kigali, where coffee husk is the primary material used to burn the bricks in the industrial kiln. These bricks also have a low embodied carbon coefficient of 0.175 kgCO<sub>2</sub>e/kWh, which is lower than that of the bricks manufactured in the United Kingdom or elsewhere. Thus, overall, the use of bricks contributes to the sustainability of the building. Moreover, the use of bricks as a predominant building facade material that acts as a perforated screen wall on the eastern and western facades filters in the daylight also helps in reducing heat ingress into the building. Furthermore, the window installations on the building are concave, thus deflecting the direct heat from the sun on the building. Therefore, the building's brick and window design help light its interior without the need for the excessive use of air conditioning and artificial light systems. The building has a double skin with bricks in its exterior design and a glass facade in its interior design, thus considerably reducing the thermal transmittance (U-value) of the wall assembly. The Rwanda Green Building Minimum Compliance System 2019 encourages the design of an efficient building envelope for reducing energy consumption by following the envelope's measures related to the wall and roof assembly, hence, building presents a good example to construction industry stakeholders on how the sustainability can be achieved.

The roofing design is unique in Kigali. In addition to providing a different skyline to the city, it has environmentally-friendly features. The central portion of the roof is fairly transparent, allowing for natural light to pass into the central portion of the two tower blocks of the building. The roof is also overlaid with solar photovoltaic panels that help generate on-site electricity and reduce the dependence on grid-sourced electricity. The building was completed in 2020.



**Fig. 1** I&M Bank HQ under construction © Ilija Gubić

### 3.2. Umubano Primary School in Kigali

Umubano Primary School is an educational facility that was designed by Mass Design Group to help support the educational programs in the Kabeza neighborhood in Kigali. A Partner In Education, with a mission of boosting education in Africa, got on board with Mass Design [52, 53] and completed the construction work in 2011 [54].

The school is located on a high slope terrain, and its design layout and circulation were directly inspired from the neighborhood, where the movement of people throughout the stepped agricultural land is similar to that on the designed walkways of the school [54]. The school comprises indoor classrooms, outdoor teaching areas, and playing areas for children, which are terraced, based on the surrounding landscape, and are all within five different levels of blocks. In the construction process of the school, local materials were used to minimize the transportation fees and support local markets, which helped in developing the region's economy, as employment opportunities were provided to the local people. The team used bricks and papyrus reeds in the construction, thus avoiding the use of imported materials, which are usually expensive and inappropriate. The design involves the application of natural lighting and ventilation to minimize energy consumption. For example, in each classroom, the walls are perforated to let in air and have vertical windows that transmit light. Also, the doors were made from papyrus reeds, which also allow light and air in the classrooms. The Green Building Minimum Compliance System 2019 encourages projects to maximize the use of passive design features, such as orientation, natural ventilation, and daylighting, to minimize heat gains, thus improving indoor thermal comfort and reducing energy consumption. The roof structure is made of Vierendeel trusses with two levels, resulting in clerestory lighting [54].

### 3.3. Women's Opportunity Center in Kayonza

The nonprofit organization Women for Women International got land to build an opportunity center in Rwanda and wanted a female architect to design it, choosing Sharon Davis. Sharon Davis Design is focusing on the social benefits, sustainability, and aesthetic sides of the design. Her best-known project in Rwanda is the Women's Opportunity Center, which received culture and brick awards. Focusing on collaborative design, sustainability, and public interest projects, the architect began her design by talking to the neighborhood's



**Fig. 2** Women's Opportunity Center © Elizabeth Felicella

women who had misplaced family individuals or had been assaulted amid the 1994 genocide against the Tutsi. She aimed at designing a safe public space for women and girls. Rwandan women ultimately responded to her suggestion of designing the opportunity center to be like a village with a series of low-rise pavilions arranged in a circular pattern and classrooms at the heart of the site [55]. A farmers market, a community space, gardens, and guest lodgings would be arranged along with the outer edges of the circle. Women's Opportunity Center required a holistic perspective for meeting long-term social and economic demands that are related to the local Rwandan culture and available natural resources.

This project on a two-ha piece of land is described to be a series of human scale pavilions that are together to create a safe place and community for over 300 women. The buildings have round shapes, perforated brick walls, and hanging roofs, thus allowing passive cooling and natural ventilation.

### 3.4. Health Center in Rugerero

Health centers are few in the rural communities of Rwanda. However, people need easy access to them. In 2016, ASA studio was appointed to design the first health center in Rugerero, which was expected to serve up to 35,000 people from around the area. The building consists of one level, and it was built using local materials, such as fired bricks, stone foundations, metal roofing, and wood ceilings [56]. People were also involved in the design and construction of the project. Up to 50% of the builders were women who were hired from local communities. The layout was designed to provide easily accessible spaces with a strategic flow, and some basic considerations—such as the separation of the outpatients and inpatients—were applied to avoid contamination. Going deep into the plan, the programs were distributed in two blocks interconnected by a central corridor that is naturally lit using a skylight. Also, ventilation was achieved using the perforations on the walls and green patios. The use of these natural opportunities is the key for ASA studio to reduce power consumption. There is another block with spaces for nurses, isolation, and pregnant women. Between the two main blocks, there is a big central courtyard with natural views to enhance the healing process of patients. Rainwater is collected in an underground water tank and filtered using a water treatment plant. The built area is 3200 sqm on a 6000 sqm plot. Generally, the project is environmentally, economically, and socially sustainable.



**Fig. 3** Health Center and public space in front of the building © ASA studio



### 3.5. Education Center in Nyanza

Rwanda has a vision of being a knowledge-based middle-income country as stated in the policies of Vision 2020, which is now Vision 2050. To achieve this goal, educational facilities are needed to train and educate the people. Different educational projects have been recently built using bricks. The Education Center is located on the road connecting Kigali and Huye (the Nyanza district, a southern province of Rwanda). The project was designed by the German architect Dominikus Stark Architekten and completed in 2010, and it is well known for its economic and architectural sustainability, as it uses local materials and involves the local community. The project comprises a 5500 sqm facility that is mainly composed of an administration office, classrooms, a language laboratory, a library, a kitchen, a dining room, an internet café, and a copy shop. The complex has no outward-facing windows as all the openings are oriented to a central courtyard, around which all the spaces are arranged, except for the internet café and copy shop, which face the outside of the complex and define the main entrance of the facility. The architectural approach aimed at arranging the spaces around the central courtyard to be training classrooms so as to also integrate the existing buildings into the new layout.

The upstream courtyards and brick column rows form the intermediate spaces between the central courtyard and the building, except for the dining hall, which can also act as a multipurpose hall. This hall is completely open to the courtyard by a glazed facade so that the courtyard can be an extension of the hall if needed. However, there is a row of wicker doors for protecting the interior from the hot sun, and the openings are high to allow air to circulate.

The complex was completely built by local builders using local materials, such as clay adobe bricks, steel, papyrus, and wicker. A simple ventilation concept was reached from the combination of these materials through the thermal storage capacity of the brick walls, resulting in a comfortable indoor relaxing climate, as well as natural ventilation from the wicker doors. Dominikus Stark Architekten used over half a million handmade bricks to build the education center's walls, floors, and columns. The choice of the main material was based on the material that is locally available and that can easily be made and installed without complex machines. Due to the manual firing processes that were used, the bricks had irregularities and different colors, giving the walls a different appearance due to their differences in terms of color and texture.



**Fig. 4** Education Center in Nyanza © Florian Holzherr, Dominikus Stark Architekten

Thin papyrus sheets were used for the ceiling panels, and wicker works made from dried eucalyptus branches were used for dining doors and for the main gate of the facility, which were built by local basket makers. The other materials that were used were steel and corrugated metal sheets for the roofs and glasses for the windows, which were the only imported materials that were used in the project. The mono-pitched roof slope at the central courtyard is used to collect rainwater so that it can be used in cleaning activities and in irrigating the kitchen garden. Overall, the educational center built by Dominikus Stark Architekten used local materials and crafts with sophisticated designs to provide for the various needs of the local community.

#### 4. CONCLUSIONS

Brick was very often used in the 20<sup>th</sup> century and currently in Rwanda as a building material. Nowadays, the brick production process is advanced with the use of industrial and semi-industrial kilns. The Government of Rwanda and its partners are supporting traditional brick manufacturers to upgrade their production facilities into semi-industrial facilities to improve the quality and supply of bricks along with reduction of their embodied carbon coefficient. The Government is also encouraging developers and investors to use “Made in Rwanda” construction materials such as brick in the construction of many types of buildings – that this paper is showcasing. Development stakeholders like SKAT Ltd. are working closely with the brick producers to upgrade their facilities, employ sustainable clay extraction methods, improve the working conditions of brick producers, produce low-carbon modern bricks, train masons on the modern brick construction systems such as row-lock bond, and max span slab systems to meet the growing demand for affordable construction in a sustainable manner. Examples of buildings in Rwanda that this paper presents, are examples of how construction sector should engage communities.

The Rwanda Green Building Minimum Compliance System is also supporting the Government in its bid to promote green buildings by adopting sustainable construction practices along with increasing the operational efficiency of buildings to mitigate the emissions from the buildings sector thereby meeting the Nationally Determined Contributions (NDC) targets. The Government with support from partners is encouraging the implementation of Green Building Minimum Compliance System through awareness, outreach and capacity building programs to ensure the environment, economic and social benefits of green buildings trickle down along the construction value-chain. The five buildings discussed in this paper underline the importance of using locally manufactured materials in this case bricks that showcases the contemporary architecture of Rwanda combined with aesthetic designs that are functional yet relevant to the local climate context, and aided with passive designs as means to achieve sustainability. The usage of locally produced bricks also helps in the local economic development that has the potential to not just meet the growing construction material demand but also create decent off-farm employment opportunities for Rwandans as seen during the process of construction of buildings presented in this paper. The buildings demonstrate several green building principles that projects can adopt not just within the country but across the region to meet and potentially exceed the Rwanda Green Building Minimum Compliance System standard, at the same time create time-less contemporary architecture through bricks and ultimately contribute towards the triple bottom line of people, planet and prosperity.

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#### REFERENCES

1. Michieletto M. (2020). The architecture of the city of Kigali. In Sorbo E, Brusegan E (eds). An “analogous city” for Venice. Venezia: Lettera Ventidue and Università di Venezia, 141–7.
2. Gubić, I., Birungi P. (2019). Rwanda kicks off annual Urban October celebrations with urban walk in Huye district. Seoul: Global Green Growth Institute. Retrieved from: <https://gggi.org/rwanda-kicks-off-annual-urban-october-celebrations-with-urban-walk-in-huye-district/> [Accessed 24 July 2021].
3. Gubić, I., Birungi P. (2019). Advocating for green cities and green buildings during the “urban walk” in Kigali. Seoul: Global Green Growth Institute. Retrieved from: <https://gggi.org/advocating-for-green-cities-and-green-buildings-during-the-urban-walk-in-kigali/> [Accessed 24 July 2021].
4. Nduwayezu, G., Manirakiza, V., Mugabe, L., & Malonza, J. M. (2021). Urban Growth and Land Use/Land Cover Changes in the Post-Genocide Period. Kigali, Rwanda. *Environment and Urbanization ASIA*, 12(1), S127–S146. <https://doi.org/10.1177/0975425321997971>.
5. Gubić, I., Baloi O. (2019). Implementing the new urban agenda in Rwanda: Nation-wide public space initiatives. *Urban Planning*, 4, 223–36. [HTTPS://DOI.ORG/10.17645/UP.V4I2.2005](https://doi.org/10.17645/UP.V4I2.2005).
6. Baffoe G, Malonza J, Manirakiza V, Mugabe L. (2020). Understanding the concept of neighbourhood in Kigali city, Rwanda. *Sustainability*, 12, 1555. [HTTPS://DOI.ORG/10.3390/SU12041555](https://doi.org/10.3390/SU12041555).
7. Republic of Rwanda. (2019). Annex 3, Rwanda Green Building Minimum Compliance System. Government of Rwanda: Kigali. Retrieved from: [https://www.rha.gov.rw/fileadmin/user\\_upload/documents/general\\_documents/laws\\_of\\_construction/green\\_building\\_minimum\\_compliance\\_system-official\\_gazette.pdf](https://www.rha.gov.rw/fileadmin/user_upload/documents/general_documents/laws_of_construction/green_building_minimum_compliance_system-official_gazette.pdf) [Accessed 21 August 2021].
8. Anthony F Cupido, F., A, Baetz, W., B., Pujari, A., Chidiac, S. (2010). Evaluating Institutional Green Building Policies: A Mixed-Methods Approach. *Journal of Green Building*, 5 (1): 115–131. <https://doi.org/10.3992/jgb.5.1.115>.
9. Cidell, J., Cope, M., A. (2014). Factors explaining the adoption and impact of LEED-based green building policies at the municipal level. *Journal of Environmental Planning and Management*, 57:12, 1763-1781, <https://doi.org/10.1080/09640568.2013.835714>.
10. Pearce, R., A., DuBose, R., J., Bosch, J., S. (2007); Green Building Policy Options for the Public Sector. *Journal of Green Building* ; 2 (1): 156–174. <https://doi.org/10.3992/jgb.2.1.156>.
11. Sharma, M. (2018). Development of a ‘Green building sustainability model’ for Green buildings in India. *Journal of Cleaner Production*, Volume 190, 538-551. <https://doi.org/10.1016/j.jclepro.2018.04.154>.
12. Arrabothu, D., Birungi P. (2019). Rwanda Cabinet approves Green Building Minimum Compliance System: Global Green Growth Institute. Retrieved from: <https://gggi.org/rwanda-cabinet-approves-green-building-minimum-compliance-system/> [Accessed 23 August 2021].
13. Rouzbeh Shad, R., Khorrami, M., Ghaemi, M. (2017). Developing an Iranian green building assessment tool using decision making methods and geographical information system: Case study in Mashhad city. *Renewable and Sustainable Energy Reviews*, Volume 67, 324-340, <https://doi.org/10.1016/j.rser.2016.09.004>.
14. Khan, M. A., Wang, C. C., & Lee, C. L. (2021). A Framework for Developing Green Building Rating Tools Based on Pakistan’s Local Context. *Buildings*, 11(5), 202. <http://dx.doi.org/10.3390/buildings11050202>.
15. Remizov, A., Tukaziban, A., Yelzhanova, Z., Junussova, T., & Karaca, F. (2021). Adoption of Green Building Assessment Systems to Existing Buildings under Kazakhstani Conditions. *Buildings*, 11(8), 325. <http://dx.doi.org/10.3390/buildings11080325>.
16. Hikmat H. Ali, H., H., Al Nsairat, F., S. (2009). Developing a green building assessment tool for developing countries – Case of Jordan. *Building and Environment*, Volume 44, Issue 5, 1053-1064. <https://doi.org/10.1016/j.buildenv.2008.07.015>.
17. Ahn, H. Y., Pearce, R. A., Wang, Y., Wang, G. (2013). Drivers and barriers of sustainable design and construction: The perception of green building experience. *International Journal of Sustainable Building Technology and Urban Development*, 4 (1), 35-45. <https://doi.org/10.1080/2093761x.2012.759887>.
18. Chan, A. P. C., Darko, A., & Ameyaw, E. E. (2017). Strategies for Promoting Green Building Technologies Adoption in the Construction Industry—An International Study. *Sustainability*, 9(6), 969. <http://dx.doi.org/10.3390/su906096>.

19. Darko, A., Zhang, C., Chan, P., C., A. (2017). Drivers for green building: A review of empirical studies. *Habitat International*, 60, 34-49. <http://dx.doi.org/10.1016/j.habitatint.2016.12.007>.
20. Zhang, Y., Kang, J., & Jin, H. (2018). A Review of Green Building Development in China from the Perspective of Energy Saving. *Energies*, 11(2), 334. <http://dx.doi.org/10.3390/en11020334>.
21. Wang, H., Chiang, P.-C., Cai, Y., Li, C., Wang, X., Chen, T.-L., Wei, S., et al. (2018). Application of Wall and Insulation Materials on Green Building: A Review. *Sustainability*, 10(9), 3331. <http://dx.doi.org/10.3390/su10093331>.
22. Chung-Feng, J., K., Chieh-Hung, L., Ming-Wen, H. (2016). Analysis of intelligent green building policy and developing status in Taiwan, *Energy Policy*, Volume 95, 291-303. <https://doi.org/10.1016/j.enpol.2016.04.046>.
23. Zepeda-Gil, C., & Natarajan, S. (2020). A Review of “Green Building” Regulations, Laws, and Standards in Latin America. *Buildings*, 10(10), 188. <http://dx.doi.org/10.3390/buildings10100188>.
24. Government of Rwanda. (2018). Third National Communication Under the United Nations Framework Convention on Climate Change (U.N.F.C.C.C). Ministry of Environment, Rwanda Environment Management Authority: Kigali. Retrieved from: <http://climateportal.rema.gov.rw/sites/default/files/rwanda%20third%20national%20communication%20to%20the%20unfccc.pdf> [Accessed 24 August 2021].
25. Edwin H.W. Chan, H., W., E., Qian, K., Q., Lam, T., I., P. (2009). The market for green building in developed Asian cities—the perspectives of building designers, *Energy Policy*, Volume 37, Issue 8, 3061-3070. <https://doi.org/10.1016/j.enpol.2009.03.057>.
26. Häkkinen, T., Belloni, K. (2011). Barriers and drivers for sustainable building, *Building Research & Information*, 39:3, 239-255, <https://doi.org/10.1080/09613218.2011.561948>.
27. Albert Ping Chuen Chan C., P., A., Darko, A., Olanipekun, O., A., Ameyaw, E., E. (2018) Critical barriers to green building technologies adoption in developing countries: The case of Ghana, *Journal of Cleaner Production*, Volume 172, 1067-1079, <https://doi.org/10.1016/j.jclepro.2017.10.235>.
28. Fan, K., Chan, E. H. W., & Chau, C. K. (2018). Costs and Benefits of Implementing Green Building Economic Incentives: Case Study of a Gross Floor Area Concession Scheme in Hong Kong. *Sustainability*, 10(8), 2814. <http://dx.doi.org/10.3390/su10082814>.
29. Qian, Q., Chan, E., & Khalid, A. (2015). Challenges in Delivering Green Building Projects: Unearthing the Transaction Costs (TCs). *Sustainability*, 7(4), 3615–3636. <http://dx.doi.org/10.3390/su7043615>.
30. Republic of Rwanda. (2020). Updated nationally determined contribution. Retrieved from: [http://climateportal.rema.gov.rw/sites/default/files/rwanda\\_updated\\_ndc\\_may\\_2020\\_0.pdf](http://climateportal.rema.gov.rw/sites/default/files/rwanda_updated_ndc_may_2020_0.pdf) [Accessed 24 August 2021].
31. Cheong C, Storey D. (2019). GGGI Technical Report No. 4. Meeting Global Housing Needs with Low-Carbon Materials. Retrieved from: <https://gggi.org/site/assets/uploads/2020/10/meeting-global-housing-needs-with-low-carbon-materials.pdf> [Accessed 01 September 2021].
32. Republic of Rwanda. (2017). Ministry of Trade and Industry, Made in Rwanda Policy. Retrieved from: [https://rwandatrade.rw/media/2017%20minicom%20made%20in%20rwanda%20policy%20\(1\).pdf](https://rwandatrade.rw/media/2017%20minicom%20made%20in%20rwanda%20policy%20(1).pdf) [Accessed 24 August 2021].
33. Centre for Affordable Housing Finance in Africa. (2019). Assessing Rwanda’s affordable housing sector. Retrieved from: <https://housingfinanceafrica.org/app/uploads/cahf-rwanda-hevc-and-hcb-final.pdf> [Accessed 24 August 2021].
34. Swiss Resource Centre and Consultancies for Development. (2017). Modern Brick Construction Systems, a catalogue of affordable solutions, Made in Rwanda. Retrieved from: <http://madeingreatlakes.com/wp-content/uploads/2017/07/cat-modern-brick-solutions-draft-third-edition-beta-version2.pdf> [Accessed 24 August 2021].
35. City of Kigali. (2020). Zoning Regulations, Kigali Master Plan 2050. Retrieved from: <https://masterplan2020.kigalicity.gov.rw/portal/sharing/rest/content/items/b9e31b07d8684053b0f3eac8649e1213/data> [Accessed 24 August 2021].
36. Arrabothu, D., Birungi P. (2019). Awareness workshop on the newly approved Rwanda Green Building Minimum Compliance System for architects. Retrieved from: <https://gggi.org/awareness-workshop-on-the-newly-approved-rwanda-green-building-minimum-compliance-system-workshop-for-architects/> [Accessed 24 August 2021].
37. Arrabothu, D., Birungi P. (2020). Engineers from IER trained on Rwanda Green Building Minimum Compliance System and Templates at the Continuous Professional Development Workshop. Retrieved from: <https://gggi.org/engineers-trained-on-the-rwanda-green-building-minimum-compliance-system-and-templates-at-the-continuous-professional-development-workshop/> [Accessed 24 August 2021].
38. Momcilovic-Petronijevic A, Toplicic-Curcic G, Curcic A. (2018). Architecture and ceramic materials, development through time: adobe and brick. *Facta Universitatis: Series Architecture and Civil Engineering*, 16, 387–400. <https://doi.org/10.2298/fuace180521016m>.

39. Joglekara SN, Kharkar RA, Mandavgane SA et al. (2018). Sustainability assessment of brick work for low-cost housing: A comparison between waste based bricks and burnt clay bricks. *Sustainable Cities and Society*, 37, 396–406. <https://doi.org/10.1016/j.scs.2017.11.025>.
40. Li, Y., Yang, L., He, B. & Zhao, D. (2014). Green building in China: Needs great promotion, *Sustainable Cities and Society*, Volume 11, 1-6. [HTTPS://DOI.ORG/10.1016/J.SCS.2013.10.002](https://doi.org/10.1016/j.scs.2013.10.002).
41. Weidong Chen, Liming Li. (2021). Incentive contracts for green building production with asymmetric information. *International Journal of Production Research*, 59:6, 1860-1874. <https://doi.org/10.1080/00207543.2020.1727047>.
42. Windapo, A. (2014). Examination of Green Building Drivers in the South African Construction Industry: Economics versus Ecology. *Sustainability*, 6(9), 6088–6106. <https://doi.org/10.3390/su6096088>.
43. Olubunmi Olanipekun, A., Albert P C Chan, C. P. A., Xia, B. & Adewumi Adedokun, O. (2018). Applying the self-determination theory (SDT) to explain the levels of motivation for adopting green building. *International Journal of Construction Management*, 18:2, 120-131. <https://doi.org/10.1080/15623599.2017.1285484>.
44. Darko, A., Chuen Chan, A., P., Ameyaw, E., E., He, B., Olanipekun, A., O. (2017). Examining issues influencing green building technologies adoption: The United States green building experts' perspectives, *Energy and Buildings*, Volume 144, 320-332. <https://doi.org/10.1016/j.enbuild.2017.03.060>.
45. Darko, A., Chuen Chan, P. A., Gyamfi, S., Olanipekun, O. O. A., He, B., Yu, Y. (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective, *Building and Environment*, Volume 125, 206-215. <https://doi.org/10.1016/j.buildenv.2017.08.053>.
46. Gieseckam, J., Barrett, R., J., Taylor, P. (2016). Construction sector views on low carbon building materials. *Building research & information*, Vol. 44, No. 4, 423–444, <http://dx.doi.org/10.1080/09613218.2016.1086872>.
47. Zhang, Y., Wang, H., Gao, W., Wang, F., Zhou, N., Kammen, D. M., & Ying, X. (2019). A Survey of the Status and Challenges of Green Building Development in Various Countries. *Sustainability*, 11(19), 5385. <http://dx.doi.org/10.3390/su11195385>.
48. Jian Zuo, J., Zhao, Z. (2014). Green building research—current status and future agenda: A review, *Renewable and Sustainable Energy Reviews*, Volume 30, 271-281. [HTTPS://DOI.ORG/10.1016/J.RSER.2013.10.021](https://doi.org/10.1016/j.rser.2013.10.021).
49. Wang, W., Zhang, S., Su, Y., & Deng, X. (2018). Key Factors to Green Building Technologies Adoption in Developing Countries: The Perspective of Chinese Designers. *Sustainability*, 10(11), 4135. <http://dx.doi.org/10.3390/su10114135>.
50. Xianbo Zhao, X., Zuo, J., Wu, G. & Huang, C. (2019). A bibliometric review of green building research 2000–2016. *Architectural Science Review*, 62:1, 74-88. <https://doi.org/10.1080/00038628.2018.1485548>.
51. Kitchin J. (2021). Deriving embodied carbon factors from scratch. Retrieved from: <https://www.istructe.org/sitefiles/handlers/downloadfile.ashx?productid=9957> [Accessed 24 August 2021].
52. MASS Design Group. (2019). Mission. Retrieved from: <https://massdesigngroup.org/about> [Accessed 12 April 2019].
53. Archdaily. (2013). Umubano primary school. Retrieved from: <https://www.archdaily.com/372709/umubano-primary-school-mass-design-group> [Accessed 20 May 2019].
54. Designboom. (2013). MASS Design Group: Umubano primary school, Kigali, Rwanda. Retrieved from: <https://www.designboom.com/architecture/mass-design-group-umubano-primary-school-kigali-rwanda> [Accessed 20 May 2019].
55. Nonko, E. (2016). Sharon Davis designs buildings that look good and do great. Retrieved from: <https://archive.curbed.com/2016/11/15/13600386/sharon-davis-design-architect> [Accessed 24 August 2021].
56. ASA Studio. (2017). Rugerero Health Center. Retrieved from: <https://www.archdaily.com/935298/rugerero-health-center-asa-studio>. [Accessed 24 August 2021].

## **PRILOG PROUČAVANJU IMPLEMENTACIJE ZAKONSKIH OKVIRA U GRADITELJSTVU RUANDE: OPEKOM KA ODRŽIVOSTI**

*Zemlje u razvoju u Africi će povećati svoj sadašnji građevinski fond za 75% do 2060. godine zbog ekonomskog razvoja, brze urbanizacije i porasta broja stanovnika. Prema izveštaju o klimatskim promjenama koje je Ruanda pripremila za Ujedinjene nacije, emisija ugljen-dioksida gradnje povećaće se za 574% do 2050. godine ukoliko se bude gradilo po sadašnjem scenariju. Ovim radom se održiva arhitektura analizira u kontekstu ubrzanе urbanizacije Ruande i novih regulativa u graditeljstvu. Radom se prikazuju pet nedavno izgrađenih objekata od opeke koji svedoče o određenim kulturnim i istorijskim*

*aspektima gradnje u Ruandi, istovremeno ispunjavajući zahteve održivosti u novom milenijumu. Globalni programi održivosti zalažu se za upotrebu opeke radi njene izdržljivosti, kvaliteta, sa ekološkim, ekonomskim i društvenim prednostima za građevinski sektor. Ovaj rad pruža uvid u novije zakonske okvire koje je Ruanda postavila, a koji se zalažu za upotrebu opeke kao održivog građevinskog materijala. Uprkos ubzanoj urbanizaciji u Ruandi, postojeće održive građevinske prakse pomažu u smanjenju emisije ugljen-dioksida dokazujući društvene i ekonomske benefite građevinskog sektora za zajednice.*

Ključne reči: *zelene zgrade, održiva izgradnja, održivost, opeka, regulativa, Ruanda*