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Timber and Forestry Engineering

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Call for Papers

The Institution of Engineers of Kenya (IEK) publishes Engineering in Kenya magazine, whose target audience includes engineering professionals, practitioners, policymakers, researchers, educators and other stakeholders distributed to its target readers free of charge through hard and soft copies. IEK invites you to contribute articles for our next and future editions. Articles should reach the Editor not later than **20th June, 2026** for our next issue, whose theme is **Women in Engineeing** and related sub-themes, across all engineering disciplines. An article can range from engineering projects to processes, machinery, management, innovation, news and academic research.

The articles must be well researched and written to appeal to our high-end readers in Kenya and beyond.

The IEK Editorial Board reserves the right to edit and publish all articles submitted, in line with the standing editorial policy. All articles should be in Word document format, 500-700 words, font type Times New Roman and font size 12.

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Send your article to: **editor@iekenya.org**

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Message From the Editor

Eng. Prof. Alex Muumbo

In recent years, the global engineering community has increasingly turned its attention toward sustainable materials and environmentally responsible infrastructure. Among the resources attracting renewed interest is timber - one of humanity's oldest construction materials, yet one whose modern potential is only beginning to be fully realized. In this issue of Engineering in Kenya Magazine, we explore the theme "Timber and Forestry Engineering," highlighting the vital role that engineers can play in shaping the future of this strategic sector.

Kenya today stands at a pivotal moment in the development of its forestry and timber industries. The country faces a growing demand for wood products driven by rapid urbanization, expansion in the construction sector, and the rising need for sustainable materials. At the same time, there exists a significant gap between domestic timber supply and national demand. This challenge, however, should not merely be viewed as a constraint - it is, more importantly, an opportunity for engineering innovation.

Historically, forestry in Kenya has often been perceived primarily as an environmental or agricultural concern. Yet modern forestry is increasingly an engineering enterprise. From plantation design and mechanized harvesting to industrial processing and advanced wood manufacturing, engineering expertise is now central to unlocking the full value of the forestry value chain. Mechanical engineers, civil engineers, environmental engineers, and materials scientists all have critical roles to play in transforming how timber resources are cultivated, processed, and utilized.

One area of immense promise lies in the development and application of engineered wood products. Technologies such as laminated veneer lumber, glue-laminated timber, and cross-laminated timber are revolutionizing construction worldwide. These materials provide high strength-to-weight ratios, structural reliability, and significantly lower embodied carbon compared to conventional construction materials such as steel and concrete. As Kenya advances its agenda on sustainable development and green building, timber-based structural systems could become an important component in delivering affordable, climate-friendly housing and infrastructure.

Equally important is the modernization of Kenya's timber processing industry. Much of the existing processing infrastructure still relies on outdated sawmilling and inefficient resource utilization. Engineering-driven improvements in sawmilling technologies, timber drying, preservation methods, and automated wood processing can dramatically improve recovery rates, product quality, and overall industry productivity. At the same time, innovations in biomass utilization can convert wood waste into valuable energy resources, contributing to both energy security and circular manufacturing.

Kenya's ambitious national tree-growing initiatives further reinforce the importance of engineering in the forestry sector. The government's long-term commitment to significantly expand tree cover across the country will require sophisticated systems for forest inventory, monitoring, and management. Technologies such as geographic information systems (GIS), remote sensing, drones, and digital mapping tools are increasingly indispensable in tracking forest health, optimizing plantation productivity, and ensuring sustainable harvesting practices. These tools transform forestry into a data-driven discipline where engineering and environmental stewardship work hand in hand.

Beyond traditional timber uses, the forestry sector is also emerging as a cornerstone of the bioeconomy. Wood is no longer simply a raw material for construction or furniture; it is increasingly a feedstock for advanced materials and renewable energy systems. From cellulose-based biopolymers to wood-plastic composites and biomass energy pellets, the intersection of forestry and materials engineering opens exciting possibilities for innovation. In this context, timber becomes part of a broader strategy to transition toward low-carbon industrial systems.

Another dimension of growing importance is the role of forests in addressing climate change. Sustainable forestry contributes significantly to carbon sequestration, ecosystem restoration, and climate resilience. Engineers are increasingly involved in designing systems that measure forest carbon stocks, support carbon credit markets, and integrate forestry into national climate mitigation strategies. In doing so, forestry engineering becomes not only an economic activity but also an essential pillar of environmental sustainability.

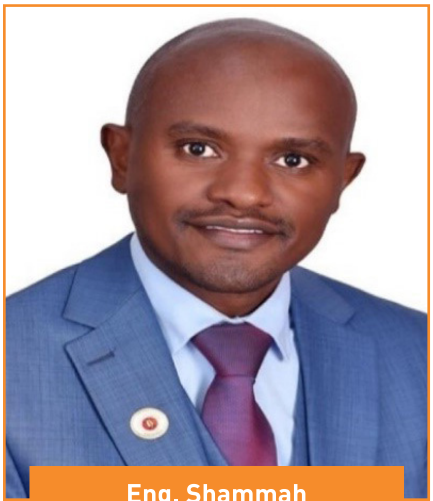
Looking ahead, the prospects for timber and forestry engineering in Kenya are both promising and transformative. By strengthening industrial plantations, modernizing timber processing technologies, and promoting value-added manufacturing, Kenya has the potential to build a vibrant wood-based industry that supports economic growth while safeguarding natural ecosystems.

For the engineering profession, this sector offers fertile ground for innovation, research, and interdisciplinary collaboration. Universities, research institutions, and industry stakeholders must work together to develop the skills, technologies, and policies that will enable Kenya to harness the full potential of its forestry resources.

Ultimately, timber and forestry engineering remind us that the future of engineering lies not only in steel and concrete, but also in materials and systems that work in harmony with nature. As engineers, we are called upon to design solutions that are not only efficient and durable but also sustainable and restorative.

This issue invites our readers to reflect on how engineering expertise can contribute to building a resilient forestry sector—one that supports livelihoods, strengthens industry, and advances Kenya's journey toward a greener and more sustainable future.

Message From the President



Eng. Shammah Kiteme,CE, FIEK, PMP

President, Institution of Engineers of Kenya

This issue of Engineering in Kenya Magazine focuses on Timber and Forest Engineering. For centuries, almost from the start of human civilization human beings have always interacted with trees one way or the other. We all emerged from bushmen and hunter gatherers until we settled in river valleys and started cultivation. This led to agriculture and domestication of animals. Agriculture for food production led to surplus production and barter trade to purchase what we did not have by exchanging with what we have. This way economies grew and we ended up with the complicated global economies that we have today.

Timber and our association with forests have not changed for centuries. We still use the forest for wood which we use for energy like cooking. We also burn charcoal from trees and so use the charcoal for cooking and other purposes. Our primordial instincts make us enjoy forests for walks and it is often very refreshing to have a walk in the winding forest tracks. This revives our primitive association with nature and explains the refreshing experience it conduces. Lovers of nature crave getting lost in forests and connecting with nature.

It is for this reason therefore as ancient as our association with forests is, history is dotted with appreciation of wood. During stone age, timber was used as a construction material. Archeology has shown that during bronze and copper ages wood was also used as a construction material. It has been discovered that timber was used as levers and sledges during the construction of the pyramids of Giza in Egypt.

For many years, timber was used for ship building. This has been known to be the case in Egypt and many other countries in Middle East and far beyond. Shipbuilding using timber can be proven for many centuries. To date we have small boats made of wood. There is evidence of extensive use of timber through out the Roman empire and the Chinese used timber to build temples. In the mediaeval times, many buildings were constructed using timber and therefore carpentry as a trade emerged. Woodworkers were sought after. As it is even in modern construction, timber is used for framing, floors, trusses and walling. Timber is also used for furniture and all manner of fittings. It is almost impossible to miss timber in most of modern buildings. This will be in form of furniture or parts of construction of buildings. From the cradle to the grave timber is a reliable construction material. From the castle to the ghetto, from the palace and statehouse to the slum timber is used extensively.

As a structural material timber provides various advantages including being a strong and durable material. Timber is comparatively a strong material and suitable for load bearing in many instances. It has therefore been used as a beam for bridges. A column for many building structures and a truss and rafters for many roofs. Timber is also light and easy to use. The use of saws and drills make timber easy to work with and form into many shapes and formations. In its natural look, timber is an appealing finish in buildings. When furnished, the furnishing accentuates the natural look and improves aesthetics. Timber parquet is for instance one of the premier floor finishes. When used in cladding and decking, the appealing nature of timber can also be appreciated.

Timber can also be used in a variety of climates. This is because in warm areas it can reduce the heat from outside and in cold areas it can keep rooms warm. Timber is generally a good insulator and this gives it a very good thermoinsulation properties. Timber has both internal and external uses making it a very versatile material with wide applications in the built environment. In addition, due to the fact that trees can be harvested and, in their place, new ones replanted timber is a renewable construction material unlike many other construction materials.

Forest Engineering is concerned with conserving forest ecosystems. Technical knowledge and understanding ecological systems can be applied to conserve forest resources for the sustainable utilization in providing timber for its various uses. A well conserved forest is also a resource for recreation and conservation of nature.

Sustainability of forest resources is necessary for making them available for the current generation without compromising future generations use of the resources. For this to be maintained a delicate balance between human needs and ecological integrity should be maintained.

Engineering by its very nature involves significant interference in nature especially when it comes to horizontal infrastructure like roads, railways, airports etc. engineers should therefore be actively involved in environmental stewardship. Environmental stewardship should focus itself in addressing soil erosion, hydrology and land reclamation. Engineering by its nature involves application of knowledge of forces of nature and applying science in addressing challenges that human beings face. A forest engineer will develop timber harvest plans, construct forest roads, oversee reforestation and land rehabilitation.

The contribution of Forest Engineers in mitigating climate change involves efforts that increase carbon sequestration and reduction of deforestation.

Forest Engineers are required in our conservation efforts as Kenya continues its efforts to plant 15 billion trees. So far, over 1.2 billion trees have been planted and efforts to restore key water towers including Kaptagat Forest, Mau Forest, Oloolua Forest among others is ongoing. IEK continues to contribute to these efforts by the National Government and supporting the Oloolua Forest restoration efforts. The council has approved a tree planting day at the forest and this will be part of the Corporate Social Responsibility contribution of IEK in ensuring sustainable utilization of our forests.

It is now my pleasure to invite our readers to interact with the content of this 26th issue of Engineering in Kenya Magazine. The magazine continues to inform, educate and entertain.

Message From the Honorary Secretary

Eng. Jacton Mwembe, PE,MIEK

It is with great pleasure that I present to our esteemed members and readers this latest edition of Engineering in Kenya Magazine, with the theme focus on Forest and Timber Engineering, an area of growing importance within the engineering profession, particularly in the context of sustainability, climate resilience, and industrial development. This edition brings together a rich collection of articles that explore the intersection of engineering innovation, environmental stewardship, and the economic potential of forest resources.

Forest and timber engineering continues to evolve as a multidisciplinary field, integrating principles from civil, mechanical, environmental, and materials engineering to address contemporary challenges. The content featured in this publication reflects this diversity, offering both technical depth and practical relevance. The articles herein demonstrate how advancements in timber processing technologies and sustainable forest management practices are enabling engineering solutions that support the responsible utilization of forest resources.

A key highlight of this edition is the exploration of engineered wood products such as cross laminated timber (CLT), glued laminated timber (glulam), and laminated veneer lumber (LVL). These materials are increasingly being adopted globally as viable alternatives to conventional construction materials like steel and concrete. For instance, CLT has enabled the construction of mid and high rise timber buildings, offering reduced carbon footprints, faster construction timelines, and enhanced structural performance. Such innovations are particularly relevant for Kenya and the broader African region, where there is a growing demand for affordable and sustainable housing solutions.

We also explore into modern timber processing techniques, including computer numerical control (CNC) machining, kiln drying optimization, and waste minimization strategies. These technologies are essential in improving product quality, reducing material losses, and enhancing the competitiveness of the timber industry. In Kenyan, a significant portion of timber processing is still carried out using traditional methods, the adoption of such technologies presents an opportunity for value addition and industrial growth.

Sustainable forest management. With increasing pressure on forest resources due to population growth, urbanization, and illegal logging, there is a critical need for engineering driven solutions that support conservation and regeneration efforts. We have featured insights from Chief Conservator of Forests, Mr. Alex Lemarkoko from the Kenya Forest Service (KFS). The KFS board oversees strategic initiatives like the 30% tree cover target by 2032. Amongst other mandates of KFS includes; precision forestry, remote sensing, and geographic information systems (GIS) for forest monitoring and planning. These tools enable more accurate assessment of forest cover, health, and productivity, thereby supporting evidence based decision-making.

Role of Biomass Energy and Waste to Value Systems in the forestry sector. Timber residues such as sawdust, offcuts, and bark can be converted into energy through processes like gasification and palletization. This not only reduces waste but also contributes to renewable energy generation, aligning with Kenya's commitment to sustainable energy development. Engineers play a vital role in designing and optimizing these systems to ensure efficiency, safety, and environmental compliance.

The issue of climate change remains paramount and Forests act as critical carbon sinks, and sustainable timber use can significantly reduce greenhouse gas emissions. The publication discusses how life cycle assessment (LCA) tools can be used to evaluate the environmental impact of timber products compared to alternative materials. Furthermore, it highlights the potential of afforestation and reforestation initiatives, supported by engineering interventions such as irrigation systems, soil stabilization techniques, and climate adaptive species selection.

The IEK invites all the stalk holders in the timber and forest engineering sector to address critical emerging issues such as standardization and regulatory frameworks for engineered timber products, particularly in developing countries where such standards are still evolving. Without clear guidelines, the widespread adoption of innovative timber solutions may face challenges related to safety, quality assurance, and market acceptance.

Another pressing concern is the skills gap within the sector. As technologies advance, there is a growing demand for engineers and technicians who are proficient in modern timber engineering practices. The publication emphasizes the importance of capacity building, training, and curriculum development to equip the next generation of professionals with the necessary skills.

The integration of digital technologies such as Building Information Modelling (BIM), automation, and artificial intelligence is also highlighted as a transformative trend. These tools enable better design, visualization, and management of timber structures, improving efficiency and reducing errors throughout the project lifecycle. For example, BIM can be used to simulate timber construction processes, optimize material usage, and enhance collaboration among project stakeholders.

The policy and economic dimensions of the forestry sector. Issues such as land use planning, investment incentives, and public private partnerships are critical in creating an enabling environment for the growth of forest based industries. Engineers, in collaboration with policymakers and industry players, have a key role to play in shaping these frameworks to ensure sustainable and inclusive development.

I am particularly proud of the efforts taken by the IEK Editorial Board that in curating this comprehensive and insightful publication. It reflects the commitment of IEK to advancing knowledge, promoting innovation, and supporting the professional development of our members.

I therefore warmly invite all members, practitioners, researchers, and stakeholders to engage with the content presented in this edition. Whether you are involved in design, construction, research, or policy, there is valuable knowledge to be gained that can inform your work and inspire new ideas. It is my hope that this publication will not only enhance understanding of forest and timber engineering but also stimulate meaningful dialogue and collaboration within the engineering community.

As we navigate the challenges of the 21st century, including climate change, resource scarcity, and rapid urbanization, the role of sustainable engineering solutions cannot be overstated. Forest and timber engineering offers a pathway towards a more resilient and environmentally responsible future, and it is through such knowledge-sharing platforms that we can collectively drive progress.

Thank you, and I wish you an engaging and enlightening reading experience.

How Ardhi Na Mbao is Redefining Construction In Kenya.

Lillian Beauttah
C.E.O / Co-founder,
Ardhi Na Mbao
(Construction Manager, BSc. Civil Engineering, Master in Advanced Ecological Buildings & Biocities)

The inspiration behind Ardhi Na Mbao began with an experience far from Kenya. Lillian Beauttah and her co-founder, Zani Gichuki, spent eleven months in Spain undertaking a master's program in Advanced Ecological Buildings and Biocities. During this period, they lived in a forest environment while gaining hands-on knowledge on timber sourcing, timber processing, mass timber design, fabrication, and assembly.

Through this experience, it became evident that there was need to bring this knowledge back home. At the time, , no combined mass timber, design, build, and manufacturing firms existed in Kenya. Mass timber, also known as engineered timber, is a wood product fabricated from timber that has been laminated together to form larger sections and longer spans. The natural step, therefore, was to start their own. Alongside timber, earth also became a core material in their work, particularly rammed earth, a technique that uses compacted stabilized earth in situ as a load bearing material. This decision was influenced by Zani's prior experience working with it in Rwanda.

Beyond its origin, the team's leadership combines expertise in engineering, particularly civil and structural engineering, enabling the contribution to the development and testing of standards for sustainable construction, many of which are currently lacking in Kenya.In addition, their training in ecological and sustainable construction equipped them with knowledge on sustainable sourcing and material traceability, which are critical in ensuring a truly sustainable material palette.

These principles guide their material selection. For instance, the company prioritizes materials that either emit less carbon during manufacturing or act as carbon storage. Timber, especially mass timber, is a good example. Trees absorb carbon dioxide throughout their lifetime, and when used in construction, that carbon remains stored within the structure rather than being released back into the atmosphere.

One of the indigenous species Ardhi Na Mbao is currently working with is Melia volkensii. a hardwood suited to dryland areas. Considering that approximately 80% of Kenya is classified as arid or semi-arid, this species presents a significant opportunity as a locally adapted timber source.

However, Lillian emphasized several challenges:

Indigenous species like *Melia volkensii* have not yet undergone sufficient structural grading and testing. In contrast, commonly used species such as pine and cypress have already been tested, and their structural properties are well understood.

Even if testing were completed, sourcing remains a challenge. Indigenous species are not yet grown commercially using appropriate silvicultural techniques. Commercial forestry practices are necessary to ensure consistent timber quality, including minimizing defects such as knots, which are critical in structural applications.

There is currently a lack of established plantations for these species. This means that if the market demand were to increase rapidly, supply would be insufficient.

To address these challenges, she stressed on the need for large-scale commercial cultivation first being established, followed by proper grading and testing.

"At present, we are still in the testing phase. We are comparing *Melia volkensii* with more commonly used species such as pine, cypress, and eventually eucalyptus. The goal is to determine whether indigenous species can match or complement the performance of these established materials. This work is being done in collaboration with the Kenya Forestry Research Institute (KEFRI), who are supporting testing using samples sourced from local farmers already growing Melia," she noted.

In parallel, the company is exploring alternative structural configurations. Rammed earth functions as a load-bearing system and can replace conventional concrete columns within a structure. In such cases, timber can be used for the roofing system. A rammed earth system can comfortably support structures of up to two storeys. While there are examples of taller structures, two storeys is a reliable benchmark in practice.

The other approach involves using timber both as timber frame or mass timber as the primary structural framing system, with earth used as an infill material. In this case, earth is applied either as compressed earth blocks or as plaster.

Basically, there are two main systems used:

System A: Rammed earth as the load-bearing structure, with timber used for roofing.

System B: Timber as the structural frame, with earth used as infill (blocks or plaster).

We are comparing *Melia volkensii* with more commonly used species such as pine, cypress, and eventually eucalyptus. The goal is to determine whether indigenous species can match or complement the performance of these established materials.

These combinations allow for flexible, climate-responsive, and low-carbon construction solutions.

Despite the potential of these materials, one of the challenges faced in establishing mass timber manufacturing is access to appropriate equipment.

The C.E.O. of Ardhi Na Mbao stated, "We are currently in the process of working towards ISO certification. A key barrier along this journey has been the high cost of machinery. Interestingly, much of this equipment could be fabricated locally. However, due to limitations in the local manufacturing sector, it is currently more expensive to produce such machinery locally than to import it. This highlights a need to upskill and strengthen the local manufacturing industry so that it can support emerging sectors like mass timber manufacturing. If local fabrication were more competitive, it would significantly reduce the cost of entry for manufacturers. At present, a substantial portion of our budget has gone into importing equipment, something that could potentially be avoided with stronger local capacity."

Looking ahead, Lillian stressed that several policy and industry changes could help accelerate the adoption of engineered timber in Kenya. To begin with, the National Construction Authority (NCA) should adopt standards for glue-laminated timber (GLT). Currently, the existing framework mainly addresses cross-laminated timber (CLT), which is used for slabs and load-bearing walls. She added that GLT is essential for structural elements such as beams and columns. Incorporating GLT into building code would enable manufacturers to produce a full range of structural components.

She further emphasized the following;

Government policies such as temporary VAT exemptions for mass timber manufacturers could help the industry grow, especially at the early stages.

Local design codes need to be updated to formally recognize Glue Laminated Timber (GLT), a version of mass timber as a structural material. Additionally, capacity building at the county government level is important so that officials can effectively review and approve timber-based designs.

There is a need to standardize timber sizes across local sawmills. Currently, inconsistencies make it difficult for manufacturers to source uniform materials. It would also be beneficial if timber could be supplied in specific, pre-cut dimensions rather than only in running lengths.

Finally, the government could support adoption by implementing pilot or showcase projects using mass timber. This would help address common concerns such as fire resistance, durability, and termite susceptibility.

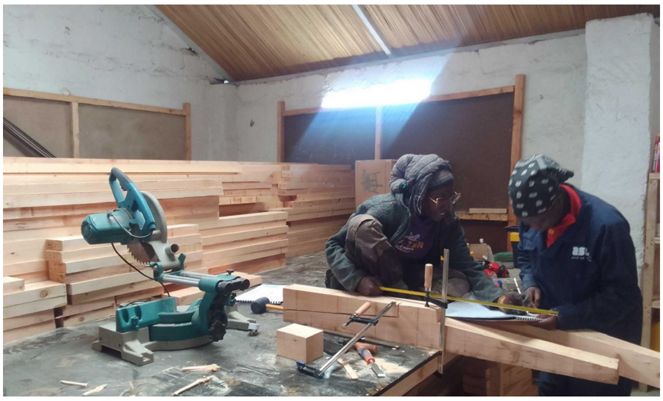
Ultimately, beyond policy, , shifting perception is just as important. Lillian highlighted that in other regions like Europe, timber construction is already well established. However, in Kenya, the issue is less about capability and more about perception. She emphasized that the need to shift this perception would be by demonstrating successful local projects. Within Africa, countries such as South Africa and Tanzania have already begun adopting mass timber construction. Given that Kenya has sufficient timber resources, especially following the lifting of the logging moratorium, there is definitely strong potential for similar progress.

PICTORIALS

Ardhi Na Mbao workshop during pre-fabrication works for the upcoming Tiny Luxury Accommodation project

Ardhi Na Mbao workshop during pre-fabrication works for the upcoming Tiny Luxury Accommodation project

Mass Timber samples in form of Glue-Laminated Timber Sample (Left) and Cross Laminated Timber (Right) at Ardhi Na Mbao's showcase at the 2024 KGBS Annual Conference held at the Radisson Blue Hotel.



Project Supervising Carpenter Seline Monica (Left) and Beth Muthoni (Right) working on pre-fabrication work for Ardhi Na Mbao's upcoming Tiny Luxury Collection project.

Rammed Earth Sample wall by Ardhi Na Mbao for the Maasai Mara Conservation Centre project.

Reimagining Kenya's Timber Sector: Innovation, Traceability, and the Shift to Engineered Wood

Mr. Alex Lemarkoko, EBS, 'ndc' (K)

Chief Conservator of Forests, Kenya Forest Service

Moving from raw timber to smarter, value-added wood products

Engineered wood products are gaining increasing global recognition, particularly in Kenya, where there is a concerted effort to transition from raw timber to value-added solutions such as plywood, medium-density fibreboard (MDF), laminated timber, and cross-laminated timber. The Kenya Forest Service (KFS) is instrumental in facilitating this transition through a variety of strategic initiatives.

KFS has instituted policies that promote downstream processing, requiring timber sector investors to diversify their operations through comprehensive value-addition plans for products that include furniture and construction materials. In addition, KFS advocates for the procurement of advanced sawmilling and wood-processing equipment that reduces wood wastage, thereby promoting the use of modern machinery conducive to engineered products.

The forestry training curricula at Kenya Forestry College (KFC) are currently being revised to include contemporary processing skills, in collaboration with the Kenya Forestry Research Institute (KEFRI), in order to stimulate innovation within the sector. In alignment with national strategies for industrial transformation, KFS supports the shift from low-value timber applications to high-value products while enhancing the development of domestic wood markets.

Bringing transparency into the timber supply chain

The recent establishment of the Timber Tracker System (TTS) by the Kenya Forest Service signifies a noteworthy transition from conventional manual, paper-based controls to a comprehensive, data-driven traceability system. This technological advancement significantly enhances traceability and accountability within the timber value chain through several mechanisms. It facilitates real-time tracking, allowing for up-to-date monitoring of timber movements.

The system ensures a verified chain of custody, providing clear documentation and authentication of each stage in the timber's journey. Additionally, the TTS empowers regulatory compliance through reliable data analysis, thereby reinforcing data-backed enforcement. Transparency in all timber-related transactions is also promoted, fostering openness and trust within the industry. These improvements mark a substantial progression for the timber sector, highlighting the significance of sustainability and responsible resource management.

Adopting improved timber grading and construction standards

Kenya is making significant progress in adopting enhanced timber grading and construction standards. The Kenya Forest Service (KFS) and collaboration with stakeholders, including industry participants and international organizations, are pivotal in these reforms. Recent initiatives aim to standardize timber grading systems to ensure quality control and improve construction safety.

The Chief Conservator of Forests Mr. Alex Lemarkoko plants a tree during the 9th edition of the Kaptagat Intergrated Conservation Programme (KICP) at Simotwo boys high school in Keiyo South, Elgeyo Marakwet County.

However, several challenges persist. There is a lack of knowledge and training among local builders and contractors regarding the new standards, and enforcement is inconsistent, leading to quality variations across regions. Additionally, small-scale timber producers and end-users require greater awareness of these standards. Issues related to the sustainable sourcing of timber further jeopardize the integrity of the supply chain.

Connecting sustainable forestry to low-carbon infrastructure

Kenya Forest Service (KFS) aligns forestry practices with the engineering needs of low-carbon infrastructure by integrating sustainable forest management principles with the design and construction of infrastructure projects. This involves selecting tree species that are not only fast-growing and resilient but also provide the necessary materials for low-carbon construction, such as cross-laminated timber or engineered wood products (EWP). Additionally, KFS emphasizes the importance of maintaining biodiversity and ecosystem health, which can enhance the carbon sequestration potential of forested areas while providing structural benefits for infrastructure. By collaborating with engineers and other stakeholders, KFS ensures that forestry practices support the structural integrity and sustainability of low-carbon projects, ultimately contributing to broader climate goals.

Moreover, KFS may incorporate factors such as site selection, reforestation, and sustainable harvesting techniques that minimize environmental impact while meeting the material needs of low-carbon infrastructure. This multifaceted approach ensures that both forestry and engineering objectives are met in a complementary way, leading to more resilient and sustainable development outcomes.

What will it take to fully unlock the sector's potential?

To realize the potential of Kenya's forestry and timber sector, it is crucial to prioritize engineering innovations and reforms. Implementing advanced sustainable forest management techniques is essential for balancing conservation with economic development. The adoption of precision forestry technology will facilitate efficient monitoring. Additionally, developing integrated agroforestry systems can enhance biodiversity, improve soil health, and optimize land use for timber and food production. Investment in modern timber processing technologies, such as automated sawmills, is necessary to increase efficiency and product quality.

Furthermore, focusing on non-toxic wood preservation methods will extend timber lifespan with minimal environmental impact. Utilizing blockchain technology will enhance traceability in the timber supply chain, fostering responsible sourcing and consumer trust. Promoting research to identify fast-growing, resilient timber species will also be beneficial. Finally, implementing engineering solutions that improve forest resilience to climate change and providing training in modern forestry practices will support local communities and encourage sustainable resource management. Advocating for coherent policies that protect land rights and incentivize private sector investment is vital for long-term sector growth.

"To realize the potential of Kenya's forestry and timber sector, it is crucial to prioritize engineering innovations and reforms.

His Excellency The President Dr. William Ruto during the tree planting exercise at the 9th edition of the Kaptagat Intergrated Conservation Programme (KICP) at Simotwo boys high school in Keiyo South, Elgeyo Marakwet County. On the right is the PS State Department for Forestry Mr. Gitonga Mugambi, CS for Environment Ms. Deborah Baraza, Principal Secretary for Climate Change and Dr. Ouma Oluga, PS for Medical Services while on the left is the Chief Conservator of Forests Mr. Alex Lemarkoko and KFS Commandant Mr. Mohammed A. Mohammed.

Student Research and Innovation in Timber Engineering at the University of Nairobi

Eng. Prof. Siphila Mumenya
The Dean
Faculty of Engineering, University of Nairobi

In this article, Eng. Prof. Mumenya presents insights focusing on the contributions of the Timber and Strength of Materials Laboratory to timber research, engineering education, and industry engagement at the Department of Civil and Construction Engineering.

Inside the Timber and Strength of Materials Laboratory

Timber and Strength of materials Laboratory are one of the Laboratories at the Department of Civil and Construction Engineering at the Faculty of Engineering, University of Nairobi. The Laboratory basically handles the determination of the strength of timber and various types of metals as construction materials.

The Timber Laboratory supports research by staff, graduate students at both Phd, and Masters levels, as well as undergraduates teaching. Students are able to carry out their research through testing of various species of wood available locally, and where necessary, imported wood species. The Timber laboratory also supports consultancy services which are rendered to the public.

The types of timber and wood materials tested in the laboratory are hardwoods, for example: Blue gum, Mahogany, Cedar, Melia and Mangrove as well as softwoods, namely, Cypress and Pine.

Undergraduate Studies on Timber

At the department of Civil and Construction Engineering, Timber is taught at years two and three of the undergraduate programme. During the first semester of the second year, the topic is under the Materials Science, where Physical and chemical structure of engineering materials is studied. The laboratory enhances the student's understanding of the structure of wood, classification of wood, properties, seasoning, and its preservation. Multi-phase composites, and characterization of plywood is also experimented at the Timber laboratory.

During the first semester of the third year of undergraduate study, students are exposed to timber as a structural material. Specifically, its nature and properties are taught through intensive laboratory sessions. The experiments which are undertaken in the timber laboratory at this level are: Behaviour of timber under axial loading, flexural loading, shear and combined loading. Also studied at this level is the behaviour of timber joints and connections under load.

Timber Tests

Among the Standard tests undertaken at the laboratory are Moisture Content (MC) and Specific Gravity (SG). Timber testing also includes characterization of the wood, and the following are the major tests that are undertaken in the laboratory to confirm and affirm their strength:

i. Tensile test
ii. Compression test
iii. Shear test

iv. Bending test

v. Indentation test

vi. Grading tests

Community Service

There are Student industrial visits, Wood seminars, and workshops which are arranged at departmental level to contribute to student learning, capacity building and professional development.

Various Collaboration Agreements have been signed between the University and the Government entities in the forest sector. Some international bodies, wood industry stakeholders, Climate change Champions, and African Universities have also signed the collaboration agreement with the department of Civil and Construction Engineering to bring the wood industry in general to the next level in a few years to come.

Research Capacity

In the year 2024, the Timber laboratory was fully equipped with digital machines courtesy of the World Bank through the Ministry of Roads and Infrastructure. These digital machines have enabled research and learning easier and more efficient.

The current fifth year (finalist) students are testing Melia species of timber from lower eastern region of Kenya as a potential cheaper alternative to other hardwoods.

Kenyan timber research and sustainable forestry have a bright future because of the need to strike a balance between environmental conservation and climate goals and the country's growing wood need. Furthermore, Kenya's long-term plans to promote timber as a low-carbon building material, increase tree cover, and expand commercial forestry positions the industry as a key pillar of green economic growth and employment generation.

Consultancy Services

The Laboratory is open for consultancy services to the public and the entire East African region and beyond so that the timber research is expanded and may go commercial in future to create more innovations in the timber sector.

Recently, the department tested Japonica tree from Ngong (Nairobi) and the results are in the final stages of analysis.

"The current fifth year (finalist) students are testing Melia species of timber from lower eastern region of Kenya as a potential cheaper alternative to other hardwoods.

Equipment Profile

Vertical Band Saw: This is digital universal saw used for contour or normal cutting of wood, bamboo and smaller diameter pieces of metals.

Electric Drying Oven: The Electric Drying Oven is used to dry the wood specimens at specific temperature.

Sliding Panel Saw and Planer & Thicknesser Woodworking Machine: The sliding panel saw has a crosscut table to provide a wide and stable platform for supporting full size panels during crosscutting operations. The flip stops are used for quick measurements for the crosscutting.

a. The planer & thicknesser woodworking machine with red colour at the back is designed as combined planer and thicknesser used for processing of wood and materials on its base within workpiece width of 310mm.

Electronic Tensometer: This is a motor driven universal testing machine with a digital screen for display purposes. The machine is capable to perform the following tests compression, tensile, shear and bending tests just by changing the respective attachments.

Brinell Hardness Tester: Brinell Hardness Tester is used to measure the resistance capacity of a material against indentation of the other harder material.

Unitronic Machine: This is a small universal machine with digital display and data saving slots. This machine is used to test Tensile and compression properties of materials.

The National Building Code 2024: Timber within the Kenyan Regulatory Framework

By Anvar Joseph Alot

Policy, Research and Partnerships Manager, IEK

The true value of timber lies not just in its natural properties, but in how it is engineered, treated, and regulated. *The National Building Code, 2024* provides a comprehensive framework that elevates timber from a "traditional" material to a regulated structural system. From a historical perspective timber has been viewed as a material for temporary structures or interior finishes but modern construction is increasingly adopting engineered wood products for structural use. From an engineering perspective, "timber" is now clearly defined within a regulatory framework that ensures safety, performance and sustainability in the built environment. In the evolving landscape, not merely as a traditional material, but as a high-performance, sustainable and code-compliant solution.

Kenyan Legal Status and Operationalization of the National Building Code, 2024

The National Building Code, 2024 derives its legal authority from the National Construction Authority Act, 2011, which provides the statutory framework for regulating construction standards and practices in Kenya. As such, the Code is not merely a guideline, but a legally enforceable instrument within the national construction regulatory regime.

The Code was formally gazetted in March 2024, marking its official publication and entry into the legal framework. This was followed by its national launch on 17th July 2024, signaling the commencement of stakeholder awareness and industry preparedness. During the launch, 17th July 2024, the Principal Secretary for the State Department for Public Works, Mr. Joel Arumonyang, emphasized that the Code is a critical regulatory tool for safeguarding public safety, guiding orderly development and strengthening sustainability in the construction sector. He noted that through the Building Code, government seeks to ensure effective control of construction activities while promoting safer, more resilient, and environmentally responsible built environments across Kenya.

In accordance with its provisions, the Code was designed with a one-year transition period, allowing industry players sufficient time to align practices, build capacity, and ensure compliance. Consequently, the National Building Code, 2024 became fully operational in March 2025, at which point its provisions became mandatory and enforceable across all applicable construction activities.

Designing with Timber: Inside the Building Code

The Building Code is explicit on the use of timber and removes ambiguity. Timber is no longer used based on "rule of thumb" or informal practice, it is now a fully regulated construction material. Timber use in construction demands strict compliance with the National Building Code, 2024, including proper structural design in accordance with KS EN 1995 (Eurocode 5), use of graded and certified timber as per KS 771 (Specification for softwood timber grades for structural use), adequate treatment against biological degradation in line with KS 1002 and KS 1003, adherence to prescribed detailing and installation practices and integration within fire-safe and code-compliant building systems.

From a construction review perspective, timber is not confined to a single section of the Code, it is systematically embedded across structural design, fire safety, materials and site practice. This multi-part integration demonstrates that the National Building Code, 2024 treats timber as a fully standardized, engineered and regulated construction material, comparable in rigor to steel and concrete.

Early provisions under **Paragraph 29 and 30 of the Code** introduce timber from a risk management perspective, classifying it as a combustible material and regulating its storage accordingly. By addressing timber at the site level, through requirements on enclosure and separation distances, the Code signals that safety considerations begin long before installation. This early emphasis reinforces a lifecycle approach to construction, where material handling is as critical as structural performance.

Under Part VI: Structural Design, the Code provides that the design of a building's structural system shall be carried out in accordance with recognized standards, including KS EN 1995 (Design of Timber Structures). It further requires that all materials used in any structural element, or component thereof, must comply with the relevant Kenya Standards, thereby ensuring structural integrity, safety and uniform quality in timber construction.

Within **Part VIII and IX (Floors and Walls), particularly Sections 99 to 105**, the Code transitions from risk control to structural application. Timber is defined here as a load-bearing material governed by engineering principles, with explicit references to Eurocode 5 (KS EN 1995) and Kenyan grading standards (KS 771). The inclusion of prescriptive requirements for floor systems, alongside mandatory termite treatment under KS 1002 and KS 1003, demonstrates a balance between performance-based design and context-specific durability concerns. For engineers, this section establishes timber as a predictable and designable structural system rather than a material of approximation.

The most detailed treatment of timber appears in **Part XIII (Roofs), Sections 237 to 241,** where the Code integrates both traditional practice and modern engineering rigor. Roofing, being the most common application of timber in Kenya, is regulated through clear requirements on seasoning, defect control, structural proportions, and connection detailing. The provisions on truss bracing, slenderness limits and anchorage against uplift forces reflect a deep understanding of failure mechanisms in timber structures. Here, the Code effectively bridges craftsmanship and calculation, ensuring that timber roof systems meet both practical and analytical standards. In roof construction, the design of timber members must comply with KS EN 1995 (Design of timber structures), ensuring structural integrity and safety. For softwood timber, the applicable grades used in structural applications are specifically governed by KS 771 (Specification for softwood timber grades for structural use), providing clear guidance on quality standards and performance requirements.

Fire performance is addressed comprehensively in **Part XXI,** where timber is classified as combustible but not prohibited. Instead, the Code adopts a performance-based fire engineering approach, requiring compliance with fire resistance ratings and referencing KS EN 1995-1-2 for structural fire design. Limitations on building height and specific requirements for elements such as timber doors further reinforce a controlled and risk-informed use of timber. This section aligns with international best practice, recognizing that timber can perform reliably in fire when properly designed.

- Timber structural systems must achieve defined fire resistance ratings
- As expressly provided under Part XXI—Fire Safety and Fire Installations, Timber construction designed in accordance with KS EN 1995-1-2 and applicable fire resistance requirements is restricted to a maximum of two storeys, particularly for buildings within specified occupancy classifications, namely G1 (light industrial buildings with moderate fire risk), H3 (multi-dwelling residential buildings such as apartments with higher occupant density and shared escape routes), and H4 (single dwelling residential units with lower occupancy and simpler evacuation conditions).
- Fire-resistant assemblies (e.g., plasterboard ceilings, treated surfaces) can enhance timber performance

Additional cross-cutting provisions, such as Paragraph 102 (roof-to-wall fixing) and clearance requirements near chimneys, highlight the Code's attention to the interaction between timber and other building systems. These clauses emphasize that timber performance is not isolated but depends on integration within the broader structural and safety framework of a building.

The Engineer's Role: From Material Selection to Compliance

Within the framework of the Kenya National Building Code, 2024 (Legal Notice No. 47 of 2024), the role of the engineer extends beyond material selection to encompass full lifecycle responsibility for safety, compliance, and sustainability. As practitioners, our mandate is not merely to specify timber, but to ensure that its application meets the highest standards of performance, durability and regulatory alignment, both locally and in reference to evolving international best practice.

This includes:

- Ensuring proper grading, certification, and traceability of timber products
- Designing in full compliance with KS EN 1995 (Eurocode 5) and KS EN 1995-1-2 (structural fire design)
- Aligning fire performance with Eurocode fire design principles (EN 1991-1-2 and EN 13501 classification systems)
- Providing adequate protection against biological, environmental, and durability risks
- Integrating timber into fire-safe building systems, in accordance with Part XXI—Fire Safety and Fire Installations

Photo 1: Pine Timber (25 mm Rough Sawn) - Classified as softwood structural timber. Moderate strength-to-weight ratio, easily graded into structural classes (e.g., C16 (low strength), C24 (high strength) under Eurocode 5), Common in roof trusses, framing, formwork and light structural works — Photo Courtesy of Advanced Builders Ltd

Photo 2: Eucalyptus Timber (20 mm Planed All Sided Sanded) Classified as dense hardwood timber. Higher density, higher compressive and bending strength, Suitable for heavy-duty structural applications (beams, poles, bridges, flooring supports); Photo Courtesy of Advanced Builders Ltd

Importantly, international design frameworks emphasize that timber structures must satisfy fundamental requirements of mechanical resistance, serviceability and robustness. As highlighted in Design of Timber Structures – Volume 1 (Swedish Wood, 2022), these principles are central to ensuring structural reliability and safeguarding human life throughout the building lifecycle. This reinforces the engineer's responsibility in balancing safety, efficiency and innovation in material application.

Similarly, global research and practice show that engineered timber products enable efficient prefabrication, reduced construction waste and faster project delivery, further strengthening their role in sustainable infrastructure development. These advantages have led to widespread adoption in Europe and North America, supported by standards such as Eurocode 5 and the International Building Code (IBC), which now permit mass timber construction in mid- and high-rise buildings.

However, within the Kenyan context, implementation challenges remain. Although Muthike and Githiomi (2017), in their study titled "Review of the Wood Industry in Kenya: Technology Development, Challenges and Opportunities," identified structural weaknesses such as inefficient processing technologies, weak value addition systems, inadequate technical capacity and fragmented supply chains, recent sector evidence indicates that these challenges persist in largely the same form today, albeit within a more pressured demand environment. Contemporary analyses continue to highlight issues such as inconsistent quality assurance across timber supply chains, limited enforcement capacity, weak traceability systems and varying levels of technical awareness among stakeholders, all of which directly affect compliance with modern construction standards and the effective uptake of engineered timber systems. While the Code provides a robust framework, its effectiveness depends on the competence, diligence and leadership of engineers in ensuring compliance and advancing best practice.

At a strategic level, the Kenya National Building Code, 2024 signals a shift toward performance-based regulation. Ultimately, the responsibility lies with the engineering profession to lead this transition. By integrating regulatory requirements with international research and standards, Kenyan engineers are uniquely positioned to bridge the gap between policy and practice. In doing so, they not only ensure safe and compliant structures but also contribute meaningfully to sustainability, innovation and the long-term resilience of the built environment.

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Timber Engineering Research at Moi University

Eng. Prof. Augustine Makokha
Dean, School of Engineering, Moi University

Q1. How is Moi University contributing to the advancement of timber engineering and material testing in Kenya?

First, we recognize that the use of timber, especially in construction, has a low carbon footprint, making it environmentally sustainable compared to the hard/grey engineered concrete structures. At Moi University, we contribute to timber engineering through a strong integration of training, and research. For example, our laboratories conduct testing on timber-concrete composites (TCC) for improved structural performance. Additionally, the university has subscribed to computer software programs based on the Finite Element Methods (FEM) that are extensively used in materials laboratory for structural analysis including analysis of timber connections, long-term behaviour, and creep under various loading conditions. Further, the master's program in structural engineering offers advanced design courses in fields that include timber engineering and materials testing.

With regard to collaborations, the School of Engineering is partnering with the Norwegian University of Life Sciences under the NORPART (Norwegian Partnership for Global Academic Corporation) program to develop innovative non-destructive testing methods for timber.

Q2. What key research areas in timber engineering and material testing are currently being explored within the university?

Our research in timber engineering is multidisciplinary with the following as key focus areas:

i. Mechanical testing/characterization of commonly used locally available timber with particular interest on eucalyptus. This is envisaged to build into the development of Kenyan nationally determined parameters (NDPs) for timber, and scale down on the use of United Kingdom NDPs.

ii. Structural health monitoring of engineered timber using soft sensors and machine learning techniques.

iii. Sustainable building methods with focus on modular housing techniques for sustainable construction, assembly, deconstruction and reuse, towards supporting the needs of affordable housing in situations like refugee camps, military sites or disaster relief efforts.

iv. Moisture dynamics and durability of timber to understand how moisture affects strength and lifespan, especially in tropical climates.

v. Hybrid construction systems that combine timber with steel or concrete to optimize performance and sustainability.

Q3. In what ways has the engineering curriculum adapted to incorporate timber engineering, material science, and sustainability concepts?

Our engineering curriculum is reviewed every after six years to align with current industry trends. The undergraduate Civil Engineering and Mechanical Engineering curriculums have dedicated courses in engineering materials science, building materials, and composite materials, which are embedded with sustainability concepts. The Civil Engineering curriculum incorporates structural design that includes design of high-rise timber structures, which moves away from the usual light-frame construction. This encourages the use of engineered wood products. We also have interdisciplinary units in the curriculum that integrate life cycle assessment (LCA) and environmental impact analysis. Lastly, during the third semester of the second year of study (workshop practice session), students undertake capstone projects involving the design of low-carbon buildings using steel and timber as the primary structural material.

Q4. Are there ongoing efforts to upgrade or modernize testing facilities to accommodate emerging materials such as engineered timber?

Moi University recognizes that the evolution of construction materials, including engineered timber, requires modern testing infrastructure. The university has initiated efforts to upgrade and modernize its material testing facilities to align with emerging industry needs and global quality standards. The university has secured funding of KES 980 Million through the French Development Agency (AFD) to procure and install modern engineering training and research equipment. The key materials research and testing equipment expected include advanced universal testing machines with enhanced load capacities and digital data acquisition systems capable of capturing detailed stress-strain behavior of materials such as laminated timber, bamboo composites, and hybrid structural elements, and the ultrasonic testing equipment and moisture content analyzers that will enable more accurate characterization of timber-based materials under varying environmental conditions. The modernization of our laboratories will also involve training for academic and technical staff on the new technologies.

These efforts reflect the University's commitment to supporting innovation, enhancing research capabilities, and preparing graduates to engage effectively with emerging technologies in the industry.

Q5. How can universities contribute to the development and improvement of standards and codes for timber construction in Kenya?

Universities play a critical role in bridging research and policy. Universities can contribute to improvement of standards and codes of timber construction by:

i. Generating scientific data and evidence through research and pilot tests that informs design provisions for timber constructions. For instance, research findings on fire resistance and load-bearing capacity would directly inform revisions to timber design codes to ensure conformity.

ii. Participating in national standardization technical committees, particularly those linked to development of construction standards and codes.

iii. Providing expert consultation to government agencies and construction industry regulators.

Q6. Looking ahead, what role do you see universities playing in shaping the future of sustainable construction materials, particularly timber, in Kenya?

Universities will be central to the transition toward sustainable construction in Kenya. Timber presents a unique opportunity to reduce carbon emissions through green construction. Looking forward, universities will shape the future of sustainable construction materials in the following ways:

i. Driving innovation in low-carbon materials and green engineering with timber as one of the key materials and facilitating knowledge transfer with industry.

ii. Providing materials testing and consultancy services to foster sustainable development

iii. Supporting training and upskilling programs on emerging technologies in sustainable construction and research partnerships with industry.

A student using the Compression Testing Machine (CTM) at the Materials lab

Student using the XRD Spectrometer at the Materials Lab

Alternative Building Technologies and Low-Cost Housing Delivery: Enabling Sustainable Human Habitats, A Case Study of the City Of Cape Town in South Africa.

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ABSTRACT

Alternative Building Technologies (ABTs) play a crucial role in enabling the attainment of sustainable human habitats. The Paper provides an in-depth presentation of Alternative Building Technologies (ABTs) and their multiplier effects on sustainable human habitats including climate change adaptation and mitigation, waste management and disaster management in the City of Cape Town. Environmental sustainability and effective green building initiatives as core elements of sustainable human habitats are hampered by rapid population growth, climate change, and urbanisation in the City of Cape Town. The symbiotic relationship between green building initiatives, waste management and recycling approaches in low-cost housing delivery process is presented in this Paper, with intent of illustrating inextricable link between Alternative Building Technologies (ABTs) in the design, construction and consumption of low-cost housing subsidies to environmental sustainability. Semi-structured interviews with purposively selected participants were used to collect data. The Paper used qualitative data approach. Key findings indicated that the City of Cape Town uses the green building initiatives, eco-friendly building material such as sandbags, waste management and good stakeholder management in the construction of low-cost housing projects as a means of enabling sustainable human habitats. Findings further indicated the reluctancy of housing beneficiaries to the utilisation of ABTs in the construction of low-cost housing subsidies. Recommendations for future research include capacity building studies for low-cost housing beneficiaries on ABTs, climate change and green building initiatives.

Key words: Alternative Building Technologies, Green Building, Low-cost Housing and Environmental Sustainability

1. Introduction

Alternative Building Technologies (ABTs) is not a new concept in the delivery of low-cost housing. Studies conducted by (Davis, 1993), (Rogers, 1962), (Elkington, 1997), (Holling, 1973), and (Nelson, 1993) provide an in-depth understanding of Alternative Building Technologies in the built environment and how it enables energy efficiency, environmental sustainability, promotes climate change adaptation and mitigation, and enhances good governance. Few studies have been conducted on the symbiotic relationship between alternative building technologies on women empowerment, green building and its effects on sustainable human habitat. The Paper provides the multidisciplinary techniques used by the City of Cape Town and Western Cape Department of Human Settlements to promote community buy-in within the identification, acquisition and use of alternative building technology in the housing construction process.

The paper presents the significance of incorporating the needs of vulnerable groups in housing design and construction processes as a means of enabling sustainable human habitat through alternative building technologies and inclusive housing solutions. The utilisation of alternative building technologies in low-cost housing process through the lens of sustainable development agenda plays a pivotal role in ensuring the ownership of development approaches beyond the construction of the low-cost housing process. The information sharing sessions on the benefits of alternative building technologies earmarked for housing beneficiaries especially women and children in the Freedom Park housing project played a pivotal role in promoting the environmental sustainability of the project and ensured healthy communities. The use of alternative building technologies such as sandbags and timber in the construction of Freedom Park housing project became a catalyst of enabling the achievement of sustainable human habitats in housing delivery process.

In essence; environmental sustainability, climate change adaptation and mitigation initiatives, waste management approaches, energy efficiencies and indoor thermal conditions were interwoven into the Freedom Park housing design and construction processes not only as a means to achieve sustainable development in line with Sustainable Development Goals but as a means of promoting a holistic multidisciplinary and collaborative approach in low-cost housing delivery process. Moreover, the alternative building technologies and sustainable human habitats are inextricably linked and form key elements for the realization of sustainable human settlements in line with Sustainable Development Goals (SDGs).

Literature review revealed that alternative building technologies play a significant role in promoting climate change adaptation and mitigation in housing delivery processes. Moreover, the incorporation of alternative building technologies in the planning, design and implementation of housing projects contributes to inclusive housing solutions, economic resilience pertinent to low maintenance costs of the housing units. Studies conducted by various scholars such as (Davis, 1993), (Rogers, 1962), (Elkington, 1997), (Holling, 1973), and (Nelson, 1993) indicate the multiplier effects of alternative building technologies on good governance, resilient communities, and environmental sustainability.

Research methodology used for data collection and analysis illustrated the significance of beneficiary involvement in the design, planning and implementation of alternative building technologies in low-cost housing process. The challenges pertinent to social acceptance of innovative building materials used in the Freedom Park housing project were addressed through intensive stakeholder engagements. Findings further indicated a parsimonious approach by the South African government in the promotion of alternative technologies such as sandbags and timber in low-cost housing development. Donor funding and participation of international agencies played crucial role in providing financial support, facilitating and enabling women participation in the construction of environmentally friendly and sustainable housing units using sandbags and timber.

Literature Review

Alternative Building Technologies (ABTs) in the provision of low-cost housing have been identified as a major contributing factor towards enabling the realization of environmental, economic, and social sustainability. Studies conducted by (Elkington, 1997), and (Holling, 1973) illustrate the importance of community involvement in the initiatives aimed at promoting the utilisation of innovative building technologies in service delivery programmes and projects. The significance of balancing sustainability and resilience in the development of human habitats in particular the provision of low-cost housing through alternative building technologies have been identified as crucial in ensuring integrated and sustainable human settlements.

The focus of study is on alternative building technologies and their effects on the provision of low-cost housing. The role played by women in the provision of low-cost housing in the Freedom Park housing project indicates the significance of gender mainstreaming and integration in promoting resilient and sustinable communities. Studies done by (Davis, 1993), (Rogers, 1962), and (Nelson, 1993) indicate the importance of promoting social acceptance through capacity building approaches to ensure ownership of innovation in the use of alternative building technologies in the delivery of low-cost housing.

Alternative Building Technologies and Sustainable Human Habitats

In this study, the concept of Sustainable Human Habitat is defined as the utilization of alternative building technologies in housing development in a manner that not only promotes sustainability in terms of environmental, economic and societal but enables stability in terms of spatial resilience and spatial transformation. As a result, the use of alternative building technologies in low-cost housing projects creates a conducive environment for the implementation of climate change adaptation and mitigation in line with the tenets of Sustainable Development Goals. In the case of Freedom Park housing project, alternative building technologies were not only crucial for housing construction process, but they enabled sustainability and resilience in energy efficiency, good indoor thermal conditions, which has a positive effect on healthy living conditions. The balance of innovative building techniques, socio-economic development, climate change adaptation and mitigation, energy efficiency and multisectoral approach in the provision of low-cost housing in Freedom Park housing project indicates the importance of alternative building technologies in creating sustainable communities.

Alternative Building Technology and Theoretical Approaches

The use of Alternative Building Technology (ABT) in the construction of housing subsidies in Freedom Park illustrated an effective and coordinated approach of the Technology Acceptance Model (TAM), Resilience Theory, Socio-Technical Systems (STS) Theory and Innovation Systems Theory (IST) in the project life cycle. The perceptions and acceptance of alternative building technologies by the housing beneficiaries were important elements for the sustainability of the project. Davis (1993) cited in Billianes and Enevoldsen (2022) mentions that the acceptance of using alternative building technology by diverse stakeholders involved in the housing construction processes can be regarded as an enabler for innovative building solutions.

Alternative Building Technology and Innovation Systems Theory

Alternative building technologies are inextruicably linked to innovative building standards. In a South African context, the use of alternative building technologies is guided by the building standards developed by the National Home Builders Registration Council (NHBRC). The building standards formulated by NHBRC are used to ensure that low-cost housing construction process complies with the national building regulations in line with the National Housing Consumer Protection Measures Act, aims at promoting construction of credible and dignified low-cost housing. The key arguments by the NHBRC regarding the utilisation of innovative building technologies in the construction of low-cost housing is aimed at enabling not only affordability, but sustainability and energy efficiency. The Table presented below, illustrates the core elements of innovative building technologies guiding the construction of low-cost housing as per the NHBRC guidelines.

Figure 1: Benefits of Innovation Building Technologies

Group No.	Group Type	Parameters
1	Economic Factors	Improved upfront cost Improved market value Improved profitability in the long term through life cycle costing or cost benefit analysis of the total building
2	Construction Factors	Improved rate of construction and reduced labour cost Ease of construction Lower maintenance
3	Environmental Factors	Improved energy efficiency Improved embodied energy Less wastege
4	Social Factors	Social acceptability Architectural innovation

Note:

- These guidlines are used over and above the required structural compliance requirements
- Point No. 4 is included but does not form part of the scope of NHBRC's perfomace criteria

Source: National Home Builders Registration Council (2022) Innovative Building Technologies

The abovementioned benefits of innovative building technologies as identified by the NHBRC for low-cost housing construction were fully incorporated into the housing design and construction process of the Freedom Park housing development in Cape Town, South Africa. The incorporation of the innovative building technologies was conducted through the utilisation of sandbag technology in the housing construction process, which proved to enable lower maintenance of the constructed housing unit, improved social acceptance by the housing beneficiaries which participated in the construction of the houses. Moreover, the Freedom Park housing project illustrated the acceptance of the innovative building with ease of construction or usabilty of the building materials by the housing beneficiaries who participated in the constuction process.

The use of alternative building technology in Freedom Park housing project indicated that alternative building technologies in low-cost housing process do not only enable the introduction of innovative building materials, however, they bridge a gap between innovative building technologies, affordability and reduce building costs. Weckowska et al. (2025) and Adetooto et al. 2024) put it succinctly that innovative building technologies can be regarded as agents of sustainable transition in the low-cost housing construction process due to their ability to promote socio-technical transition and sustainable transition .

Technology Acceptance Model (TAM) and Theory of Reason Action

Technology Acceptance Model (TAM) and Theory of Reason Action are evident in the Freedom Park housing project because the implementation of alternative building technologies enabled the multiplier effects in terms of implementing the principles of the spatial transformation, spatial resilience of City's Spatial Development Framework, City of Cape Town's Disaster Management Plan and NHBRC's Innovative Building Techniques. The diagram presented below illustrates the interdependence between alternative building technologies and theory of reason action through existing policy and legislative frameworks.

Figure 2: Sustainable Human Habitats through Alternative Building Technologies

Alternative Building Technology and Inclusive Housing Solutions

The inclusive approach of multidisciplinary stakeholders involved in the housing construction process promoted collaborative planning and coordination in the acceptance of alternative building materials. The participation of female housing beneficiaries in the planning, design and construction processes played a crucial role in the adoption of the sandbag approach as opposed to the brick and mortar for the construction of their respective houses. The involvement of women housing beneficiaries in the construction of their housing using the alternative building materials illustrates the importance of infusing the theory of social acceptance in housing delivery process.

Moreover, the socio-economic perspective of alternative building technology (ABT) and Technical Acceptance Model (TAM) used in the Freedom Park housing project promoted the inclusionary housing design where the role of female contractors was enhanced. Studies such as Enevoldsen (2016), Al-Okaily et al (2020), Koenig-Lewis et al (2015), and Chou and Gusti Ayu Novi (2014) indicate the importance of inclusive approach in the project planning phases when dealing with alternative building technology and promoting acceptance of new building technologies. The use of alternative building technology in the Freedom Park Housing Project indicated the importance of iterative approach in the acceptance and adoption of alternative building technology and methodologies.

Alternative Building Technology and Capacity Building Approaches

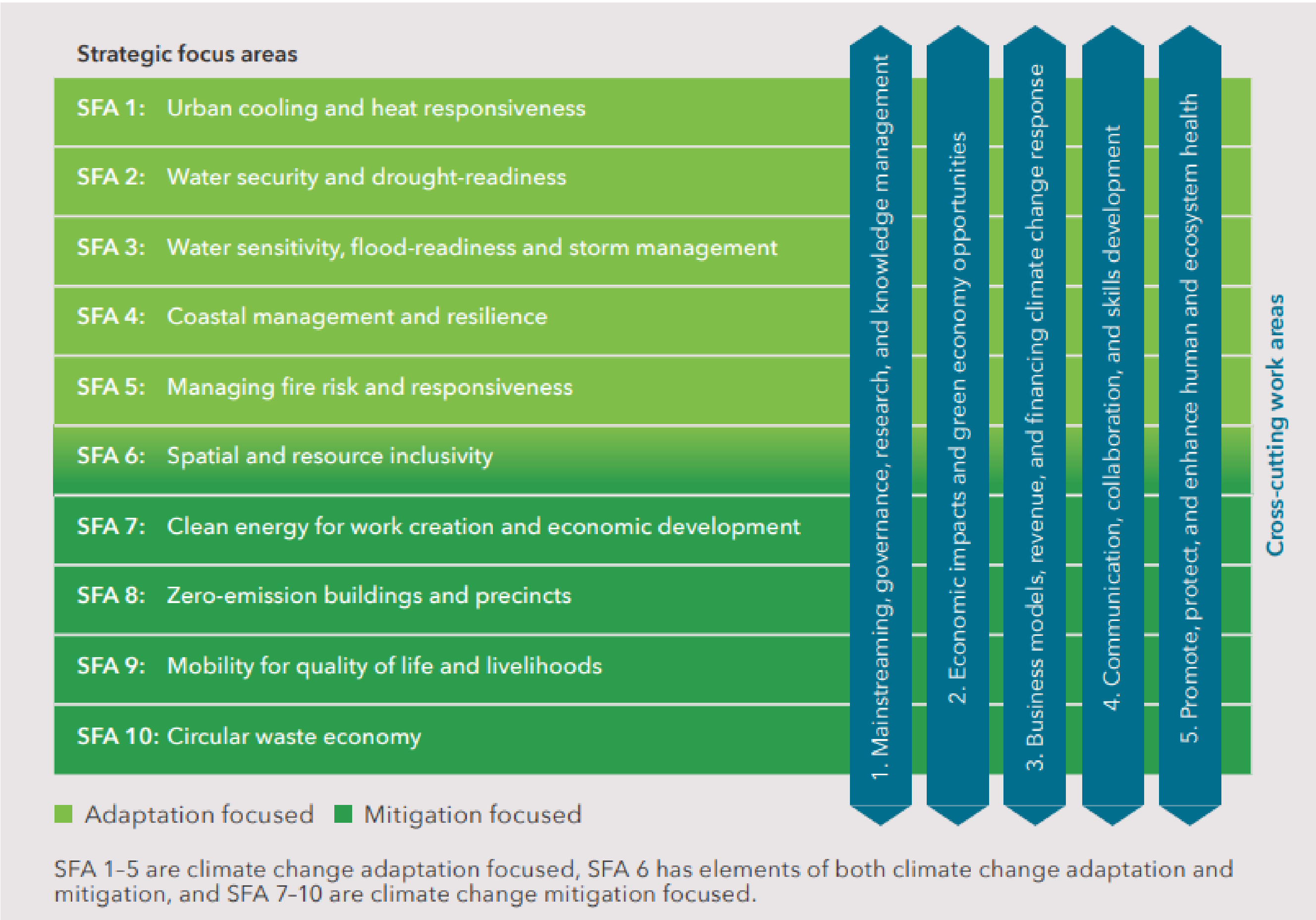
Marikyan and Papagiannidis argue that capacity buiding approaches to empower beneficiaries of the project are significant in enabling the acceptance and utilisation of new building technologies in the project (2025:2). The collaborative and capacity building approaches used to empower housing beneficiaries in the Freedom Park Housing Project illustrate the interdependencies between capacity building approaches and active participation in housing development. Housing beneficiarires were informed of the housing design, represented in all the project stakeholder engagements as a menas of not only promoting beneficiary development but ensuring capacitated housing beneficiaries as end user of the housing project. Housing beneficiaries became the active agents in the design, planning, construction and occupation of the housing units. Thus linking Innovation Systems Theory (IST) and Theory of Reason Action (TRA).

Alternative Building Technology and Climate Change Adaptation and Mitigation

The use of sandbags as part of alternative building technology in Freedom Park housing project aligned with the tenets of the City of Cape Town's Climate Change Adaptation and Mitigation. One of the Strategic Focus Areas for the City of Cape Town is to ensure zero emissions and promote spatial and resource inclusivity, which are evident at the Freedom Park housing project. Studies conducted by Abbass et al. (2022), Hauashdh et al. (2024), Awoyera et al. (2024) indicate that the construction process of low-cost housing units plays a paramount role in the achievement of climate change adaptation and mitigation, sustainable development, energy efficiency and environmental sustainability.

The core objectives of the City of Cape Town's Climate Change Adaptation and Mitigation Strategy is presented as follows:

Figure 3: Strategic Focus Areas of City of Cape Town's Climate Change and Adaptation Strategy



Methods/Methodology

Qualitative research methodology was used in the Study. Semi-structured interviews were conducted with the officials working for the City of Cape Town, and housing beneficiaries. Moreover, interviews were conducted with the intent of determining the use of alternative building technologies in the construction of low-cost housing and the effects in enabling the realization of sustainable human habitat.

Results

The results of findings from the study are presented in line with thematic areas with intent of presenting the extent to which alternative building technologies enable sustainable human habitat through the provision of low-cost housing.

Implementation of capacity building programmes for housing beneficiaries on Alternative Building Technologies

The City of Cape Town, in partnership with the Western Cape Department of Human Settlements and private sector, conducted the capacity building programs with the housing beneficiaries of the Freedom Park. The capacity building programmes empowered the housing beneficiaries with understanding and benefits of using innovative building technologies in the housing construction process. Capacity building programmes used in the Freedom Park housing project are in line with the Western Cape Department of Human Settlements' housing consumer education programmes. The capacity building programmes used in the Freedom Park housing project equipped the housing beneficiaries with the maintenance approaches for their dwelling units. Studies conducted by (Wesonga et al., 2023), (Juckette, 2022) and (Merino et al, 2012) indicate that capacity building approaches need to be focused and tailor-made to address societal challenges in a manner that promotes sustainability of service delivery interventions.

Capacity building programmes for the housing beneficiaries can be regarded as an important contributing factor to the achievement of environmentally friendly housing solutions. The study argues that knowledge transferred to housing beneficiaries on the maintenance of their housing units will not be limited to the housing unit as a structure but will create a collaborative approach for sustainable human settlements interwoven on environmental sustainability, climate change adaptation and mitigation and energy efficiency. Capacity building for energy efficient housing development is also regarded as a key element in the City of Cape Town's Community Engagements Programme as part of the City's public participation process.

Alternative Building Technologies on Beneficiary Capacity Building and Sustainable Human Habitat Matrix

Figure 4: Alternative Building Technologies and Sustainable Human Habitat

The abovementioned diagram indicates the interdependence of alternative building technologies, climate change adaptation and mitigation and capacity building programmes in the planning, design and implementation of low-cost housing units in Freedom Park. The diagram illustrates that sustainable human habitat cannot be realized in an absence of a well-coordinated approach where housing beneficiaries are active agents in the housing delivery chain of their environmentally friendly housing units.

Alternative Building Technologies and Sustainable Human Habitats

The collected data indicated that Alternative Building Technologies have multiplier effects in enabling sustainable human habitat through the promotion of environmentally friendly housing units, and empowerment of housing beneficiaries with socio-technical and economic benefits of sandbags and timber. However, they play a significant role in enabling the achievement of climate change adaptation and mitigation. The use of sandbags and timber contributed to promoting thermal conditions. Studies conducted by Hashemi, et al. (2015), Udawattha and Hlawatura, (2017) argue that alternative building technologies address energy consumption and contribute towards reducing the effects of global warming due to environmental friends indoor thermal friendly conditions.

Life Cycle Costing (LCC) analyses suggest that the utilization of sandbags in Freedom Park low-cost housing project further contributes to economically viable communities because of the low-maintenance costs required for the housing unit. Studies conducted by (Adetooto, 2024) and (Saint, 2023) indicate that sandbags as one of alternative building technologies that contributes positively on energy efficiency, indoor thermal conditions and reducing carbon emissions This plays a crucial role in regulating temperature within the housing unit.

Energy Efficiency in the Freedom Park Housing Project

The use of alternative building technologies in the form of timber and sandbags in the Freedom Park housing project indicated positive effect on energy efficiency in the housing units, which plays a major role in reducing carbon emissions. The attainment of energy efficiency in the Freedom Park housing project not only impact significantly on environmental sustainability and green building materials but it enables socio-economic resilient communities due to economic benefits of the alternative building technologies to their affordability levels.

Women participation in the design, planning and construction of the housing units

The construction of Freedom Park housing project consisting of 100 units was done by women. This illustrates the infusion of gender mainstreaming and integration in the implementation of alternative building technologies in the delivery systems and process guiding housing development. Furthermore, the participation of women in the design, planning and construction of Freedom Park housing project indicates the importance of inclusive housing solutions in low-cost housing delivery instruments to cater for the needs of vulnerable groups. In essence, Freedom Park housing project indicated the significance of incorporating inclusionary housing approaches as a means of promoting a holistic approach to sustainable livelihoods in an environmentally and gender-equitable manner.

Discussions

The findings indicated that alternative building technologies do not only promote environmental sustainability, but they have multiplier effects on spatial resilience, energy efficiency, climate change adaptation and mitigation in line with the principles entailed in the City of Cape Town's Spatial Development Framework (SDF). Successful implementation of alternative building technologies in the provision of low-cost housing requires inclusive housing approach of beneficiaries in the design, planning, and implementation processes. Alternative building technologies in the provision of low-cost housing enable the realization of socio-economic resilience due to the affordability of energy and sustainability of building materials used, which enable low maintenance costs. Capacity building initiatives are pivotal in the delivery of alternative building technologies in low-cost housing projects to optimize participation and commitment of housing beneficiaries in all the stages of housing construction.

Conclusion

Alternative Building Technologies (ABTs) play a significant role in enabling the realization of environmental sustainability in the provision of low-cost housing. The incorporation of green building initiatives in the design, planning and construction of low-cost housing promotes energy efficiency in a manner that has a multiplier effect on building socio-economic resilience communities due to the affordability of energy costs and low maintenance costs.

The construction of low-cost houses through innovative building techniques as per the NHBRC: Innovative Building Techniques augments the development principles enshrined in the municipal Spatial Development Framework through spatial resilience, spatial transformation and good governance. In essence, alternative building technologies (ABTs) used in the Freedom Park housing project play a pivotal role in creating and maintaining a symbiotic relationship between stability and resilience through capacity building and social acceptance approaches.

Participation of women in the construction of low-cost housing using the alternative building technologies promotes inclusive housing solutions in a manner that enables the incorporation gender mainstreaming and integration in housing delivery processes. Moreover, the alternative building technologies used in the Freedom Park housing project enabled the attainment of safer and healthier communities using energy efficiency, good indoor thermal conditions and reduction of carbon emissions. The achievement of sustainable human habitats through alternative building technologies in low-cost housing construction is inextricably linked to climate change adaptation and mitigation initiatives comprising of beneficiary involvement and socio-economic development.

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Engineering the Catchment: How Forestry Systems Influence Water Treatment Performance in Kenya

Bertha Naliaka, Water Engineer

Bertha Naliaka is a Civil Engineer specialized in Water Engineering with over 15 years' experience in utility regulation, infrastructure development and WASH programming.

Forestry systems matter a lot for water supply, but people often miss that. This article looks at how forest condition affects sediment, water clearness, and the cost of treating water in Kenya. Think of forests as part of the water infrastructure. If utilities include forestry engineering in Water Safety Planning (WSP), they can cut operating costs, get better water quality, and be more resilient to climate changes.

At a surface water treatment plant in western Kenya, staff deal with fluctuations in raw water quality. When it rains, turbidity rises and they have to use more alum to keep water safe. The fix happens at the plant, but the real problem starts upstream in worn-out forest catchments. Water infrastructure doesn't start at the intake. It starts with the landscape. Forests, when managed well, are the first line of protection for water systems.

Forests as Hydrological Infrastructure

Forests control key hydrological processes like interception, infiltration, evapotranspiration and soil stabilization. These things cut surface runoff, smooth peak flow and limit how much sediment reaches rivers and lakes. In healthy forests, rain soaks in and comes out slowly. That keeps base flow steady and water quality more stable. From an engineering view, forests are natural pretreatment. When they break down, erosion and sediment yield go up and raw water becomes more variable[2;5].

Impact on Water Treatment Performance

The link between forest health and water treatment is plain and measurable. More sediment raises turbidity. That pushes up coagulant needs, sludge volumes and operating costs.

Table: Indicative Comparison of Catchment Conditions

Parameter	Protected Catchment	Degraded Catchment
Turbidity (NTU)	10–30	150–300
Alum Dose (mg/L)	20–40	80–120

Higher turbidity clogs filter faster and means more backwashing. That uses more energy and wears out equipment sooner. Bad forest management shifts treatment costs from the catchment to the utility[4;8].

Forestry Engineering and Catchment Management

Forestry engineering offers practical fixes to stabilize catchments and cut sediment into water sources. Key measures include:

i. Riparian buffer design to filter sediments and stabilize riverbanks

ii. Controlled harvesting and silviculture to reduce soil disturbance

iii. Forest road design and drainage to block erosion routes

iv. Catchment zoning and land-use planning to protect sensitive sources

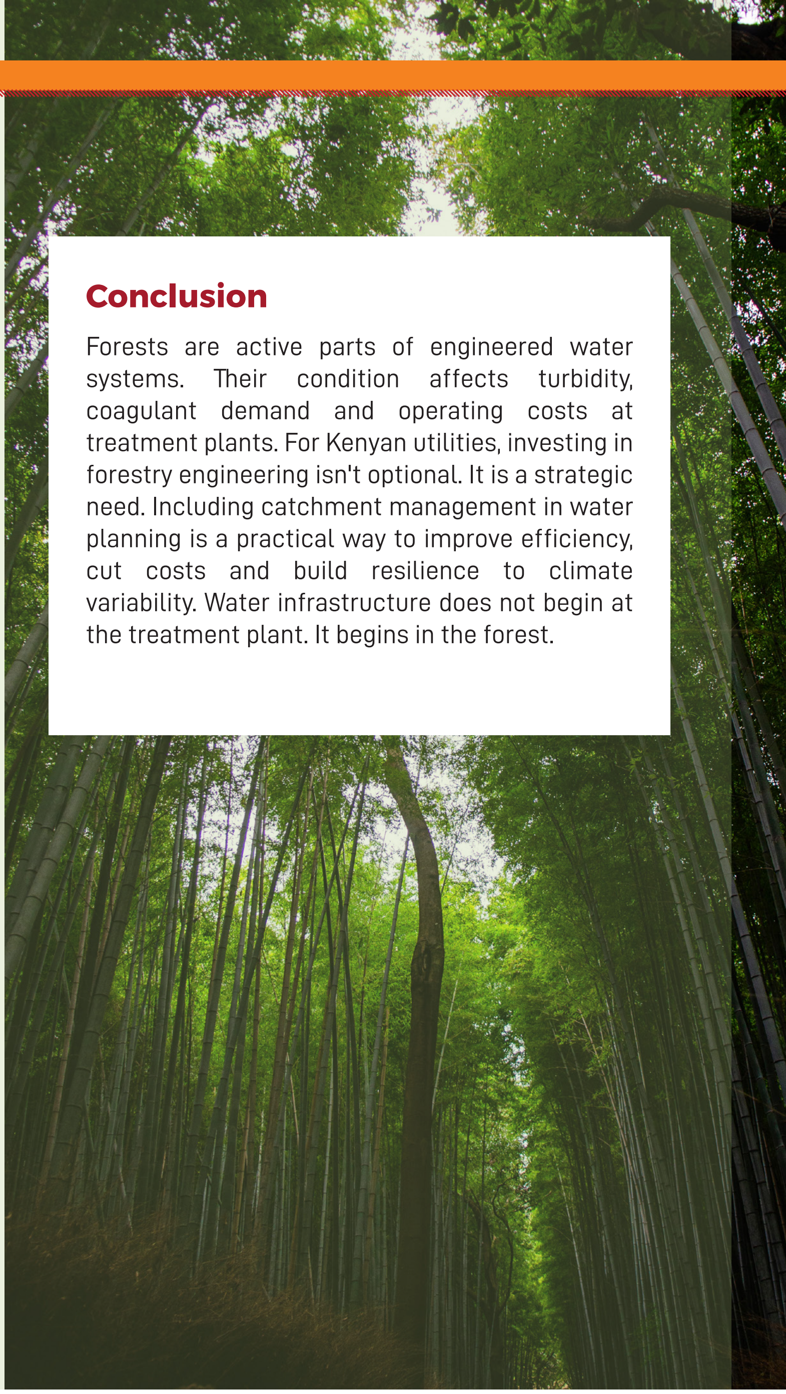
These are not just environmental actions. They are engineered controls that change treatment inputs and system performance[7].

Integration into Water Safety Planning

Kenya's Water Safety Planning framework, guided by WASREB and aligned with WHO guidance, focuses on managing risks across the whole water chain. But in practice most attention goes to treatment and distribution and catchment risk gets little attention. Bringing forestry engineering into WSP means mapping land-use change in catchments. It means adding catchment risks to hazard assessments. It means stronger collaboration between utilities, forestry agencies and communities. And it means using tools like Payments for Ecosystem Services (PES) to reward sustainable forest care. This shifts utilities from reacting at the plant to reducing risk upstream[3].

Policy and Governance Context

Kenya's Water Act (2016) and the Forest Conservation and Management framework both call for integrated resource management. The problem is the link between forestry work upstream and utility performance downstream is weak. Stronger cross-sector coordination is needed so upstream forestry actions actually lead to better water quality, more efficient treatment and lower costs[6].



Conclusion

Forests are active parts of engineered water systems. Their condition affects turbidity, coagulant demand and operating costs at treatment plants. For Kenyan utilities, investing in forestry engineering isn't optional. It is a strategic need. Including catchment management in water planning is a practical way to improve efficiency, cut costs and build resilience to climate variability. Water infrastructure does not begin at the treatment plant. It begins in the forest.

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1. IEK Joins Kenya Chamber of Mines in urging the Government to Invest in Mining to spur Economic Growth.

Kenya's mining sector is set for renewed focus as engineers, policymakers, industry players, and academia gathered in for the 1 ever IEK Mining Conference held at Golden Tulip Hotel in Westlands, Nairobi. The President of IEK, Eng. Shammah Kiteme and the Chief Executive Officer of Kenya Chamber of Mines Mr. Brian Simiyu highlighted the need to move beyond general knowledge of Kenya's mineral wealth toward what was described as the "proven stage", where

investor-grade geological data and systematic information are available.

While the country is rich in minerals, industry experts noted that investors require structured, detailed, and verifiable information before committing resources to largescale projects. This underscores the importance of engineering led research, resource mapping, and technical planning to attract both domestic and international investment. Speaking to the press during the Mining Conference, they further emphasized that mining is capital intensive and carries significant operational risks. Without proper support and oversight, miners are often exposed to hazards that could lead to project failures.

The importance of developing robust governance frameworks, strengthening technical expertise, and promoting public–private partnerships to de-risk the sector and make it more appealing to investors was also stressed. IEK and the Kenya Chamber of Mines jointly called on the government to prioritize investment in mining infrastructure, geological surveys, and policy reforms.

By doing so, Kenya can not only increase revenue from the sector but also create employment opportunities for engineers, technicians, and other skilled professionals, while ensuring sustainable and safe mining practices. The conference concluded with a consensus that engineering knowledge is critical to transforming Kenya's mining sector from potential into measurable economic growth. With coordinated action between government, professional bodies, and industry, Kenya's mineral wealth could become a strategic driver of the nation's industrialization and long-term prosperity.

2. PS Teresia Mbaika Opens IEK Aviation Sector–Based Conference 2026.

The Institution of Engineers of Kenya (IEK) held an Aviation Sector–Based Conference at Golden Tulip Hotel in westlands, Nairobi, with Ms. Teresia Mbaika, Principal Secretary for the State Department for Aviation and Aerospace Development, gracing the event as the Chief Guest.

In her keynote address, Ms. Mbaika commended IEK for convening a timely forum that brought together engineers, regulators, and industry stakeholders to engage on issues critical to the growth and sustainability of Kenya's aviation sector. Speaking under the theme "Future-ready aviation , Engineering, infrastructure, safety and regulation in Kenya," the Principal Secretary emphasized the central role of engineering in aviation and aerospace development.

She highlighted how engineers underpin airport infrastructure, air navigation systems, aircraft maintenance, safety oversight, and regulatory compliance, noting that professional integrity and technical competence remain essential in ensuring a safe and competitive aviation environment.

Ms. Mbaika also outlined the mandate of the State Department of Aviation and Aerospace Development, sharing insights on its role in aviation policy administration, airport and air traffic infrastructure development, safety and security oversight, accident investigation, and the promotion of civil aviation growth. She further spoke on emerging focus areas including infrastructure modernization, alignment with international aviation standards, sustainable aviation fuels, unmanned aircraft systems, and the upgrading of communication, navigation, and surveillance systems.

In closing, the Principal Secretary reaffirmed her support for continued engagement between IEK and professionals in the aviation sector, encouraging evidence-based dialogue, research, and technical input to shape resilient and future-ready aviation systems.

3. Highlights from World Engineering Day 2026

The Institution of Engineers of Kenya (IEK) held the World Engineering Day at the University of Nairobi under the theme, "Smart engineering for sustainable future through innovation and digitalization." The forum brought together engineers, government leaders, private sector players, and academia where in depth discussions were held on the current state of Kenya's engineering industry. The Chief Guest, Eng. Joseph Mbugua, Principal Secretary, State Department for Roads, representing Eng. Davis Chirchir, E.G.H., Cabinet Secretary, Ministry of Roads and Transport, reaffirmed the Ministry's commitment to environmental sustainability and the integration of circular economy principles in infrastructure development. He emphasized that the journey toward a greener and more resilient future requires the collective efforts of government, industry, professionals, and communities. Eng. Mbugua further highlighted that the road sector is making significant investments in smart engineering solutions, including the development of a digital superhighway through the installation of fibre optic networks along major road corridors. To date, a total of 630 kilometres of fibre optic infrastructure has been deployed, providing high-speed internet connectivity that is enhancing trade, promoting regional integration, and unlocking new economic opportunities across the country. In his remarks that were delivered by Eng. Harrison Keter, Eng. Shammah Kiteme, CE, FIEK, President IEK, highlighted the critical role engineers play in driving Kenya's infrastructure modernization, energy security, industrial growth, climate adaptation, and digital transformation. Reflecting on the theme, "Smart Engineering for a Sustainable Future Through Innovation and Digitalization," he emphasized that smart engineering goes beyond technology to include thoughtful planning, sustainability, professionalism, and innovation. He noted key milestones achieved through modern construction technologies, strengthened regulatory frameworks led by the Engineers Board of Kenya (EBK), and enhanced skills development in emerging fields such as renewable energy and climate-resilient design. He also cited collaborative efforts such as the Site Inspection Handbook developed by the IEK Council in collaboration with Engineers Board of Kenya and National Construction Authority to improve quality assurance and accountability in infrastructure projects.

While celebrating these achievements, he addressed the pressing challenge of engineer unemployment, referencing the IEK "10,000 Engineers March" and subsequent engagement with government, including a directive from H.E. William Samoei Ruto to address the issue.

Eng. Margaret Ogai, CE, Registrar/CEO of Engineers Board of Kenya (EBK) emphasized the Board's mandate in regulating engineering practice, upholding professional standards and fostering capacity development to ensure quality and ethical compliance across the sector.

Eng. Harrison Keter, IEK 1 Vice President highlighted the critical role of engineers in driving innovation, embracing emerging technologies and delivering resilient infrastructure solutions that respond to the evolving needs of communities while advancing national development priorities. Eng. Prof. Siphila Wanjiku, Dean, Faculty of Engineering - UoN, delivered remarks on behalf of Prof. Margaret Hutchinson who is the Vice- Chancellor of the University of Nairobi. In her address, she spoke on the importance of collaboration between academia and industry to create SMART engineering solutions. Eng. Jane Mutulili, the President of Association of Consulting Engineers of Kenya emphasized the role of Consulting Engineers in driving sustainable infrastructure and innovative projects. As part of the World Engineering Day 2026 celebrations at UoN, a high-level panel convened to examine the role of innovation, artificial intelligence and technology in driving sustainable national development. Key points highlighted during the session included the transformative potential of AI in infrastructure and urban development, the importance of cross-sector collaboration and leveraging engineering expertise to address national challenges.

Caption: Joseph Mbugua, Principal Secretary, State Department for Roads planting a tree during the World Engineering Day 2026

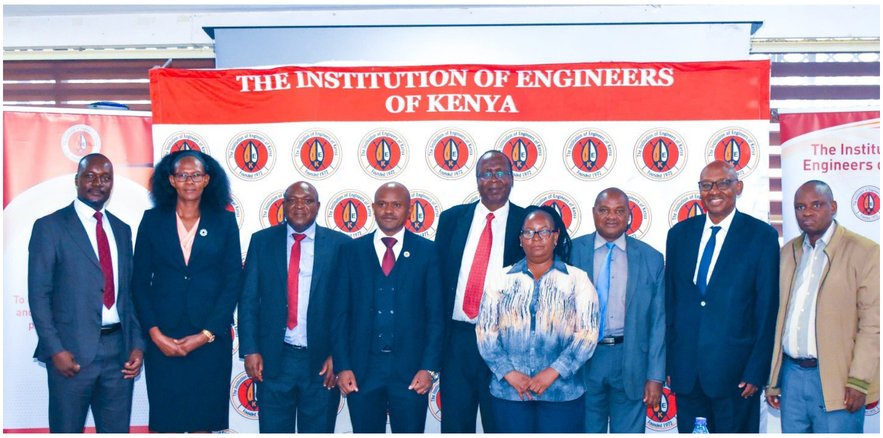
4. Agriculture Sector Based Conference highlights engineering as a sustainable tool for climate resilience in agriculture.

The Agriculture Sector-Based Conference brought into sharp focus the transformative power of engineering in shaping a resilient Agriculture Sector Based Conference highlights engineering as a sustainable tool for climate resilience in agriculture. and commercially viable agricultural sector in Kenya. Convened by the Institution of Engineers of Kenya, the forum highlighted a deliberate shift toward sector specific engagements designed to unlock the potential of industries that are critical to economic growth yet often underrepresented.

Setting the tone, IEK President Eng. Shammah Kiteme explained that the institution's strategy is rooted in intentionality ensuring that each sector receives focused attention and practical solutions. He noted that this approach is already yielding results, following earlier conferences in mining and aviation, and now extending into agriculture, a sector central to livelihoods and national development.

Eng. Laban Kipkorir Kiplagat, Agricultural Engineering Secretary, State Department for Agriculture, representing Dr. Kipronoh Ronoh Paul, Principal Secretary, State Department for Agriculture, Ministry of Agriculture and Livestock Development, emphasized that the integration of engineering innovations is no longer optional but essential. He highlighted how mechanization, smart technologies, and data-driven systems can transform productivity while addressing the mounting challenges of climate change. He called for stronger collaboration across sectors to accelerate the adoption of these solutions.

Prof. Jackson Kwanza, the Deputy Vice-Chancellor, Research, Production and Extension at JKUAT, representing Prof. Victoria Wambui Ngumi, Vice Chancellor, Jomo Kenyatta University of Agriculture and Technology (JKUAT) illustrated how modern engineering tools are already making an impact. From solar-powered irrigation systems to precision soil monitoring technologies, he demonstrated how innovation is enabling farmers to adapt to unpredictable weather patterns while improving efficiency and sustainability.



Mr. Benjamin Tito, Director Regional Coordination Directorate, Agriculture and Food Authority (AFA), underscored the importance of standards and coordination in strengthening agricultural markets. He emphasized that improved processing technologies, coupled with effective regulation, can significantly reduce post-harvest losses and enhance the global competitiveness of Kenyan produce.

Dr. Rachael Kisilu, Director Agricultural Mechanization Research Institute, Katumani, Kenya Agricultural and Livestock Research Organization (KALRO) highlighted the organization's role in advancing technologies, innovations, and management practices that support sustainable agriculture. She pointed to ongoing efforts in value addition, agro-processing, and market linkages as key drivers of agribusiness growth and improved farmer incomes.

Eng. Prof. Lawrence Gumbe, Chairperson, Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE), delivered a strong message on the need for industrialization and mechanization. He emphasized that engineering must be at the core of agricultural transformation if Kenya and Africa are to achieve economic progress and long-term sustainability.

A high-level panel discussion brought these insights together, exploring how engineering can drive climate-resilient agriculture and economic transformation. Moderated by Eng. Jacton Mwembe, IEK Honorary Secretary, the session highlighted the urgency of adopting smart engineering solutions across agricultural value chains, reducing losses, and ensuring knowledge transfer to the next generation.

The presence of IEK leadership, including Eng. Jeniffer Korir, Honorary Treasurer, and Eng. John Nyaguti, Council Member, reinforced the institution's commitment to driving meaningful dialogue and action. At the end a unifying theme emerged, engineering is not just a support function in agriculture it is the engine of transformation. Through innovation, partnerships, and sustained investment, Kenya's agricultural sector is on a path toward greater resilience, productivity, and global competitiveness

A Lean Approach to Analysis of Major Sources of Waste in Building Construction Sites: Evidence from Nairobi City County, Kenya

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ABSTRACT

Waste generation remains a persistent challenge in construction sectors globally, with Nairobi City County facing material, time, and process inefficiencies. This study investigates the key sources of construction waste on building sites in Nairobi, guided by the principles of Lean Construction. Using a mixed-methods approach, the research incorporates survey data (n = 132), site observations, and stakeholder interviews. Findings reveal that inventory waste (58%), labour inefficiencies (53%), and waiting time (41%) are the most significant contributors to waste. These insights highlight the need for systemic reform in procurement, scheduling, and workforce utilization to reduce waste and enhance construction site performance in Kenya's urban context.

Key words: Construction waste, Nairobi, inventory waste, labour inefficiency, lean construction, site management

1. Introduction

Construction waste is a multifaceted challenge in both developed and developing economies. Globally, the sector contributes over 25% of total solid waste (Kibert, 2016), while in Kenya, estimates place construction-related waste at 23–35% of total building materials (Muigai et al., 2018). Waste on construction sites not only leads to cost overruns and time delays but also undermines environmental sustainability and productivity. Nairobi City County, as Kenya's construction hub, is a high-priority region for addressing these inefficiencies.

Construction waste impacts all stages of the construction process and its performance in cost, quality, productivity and sustainability through resulting inefficiencies directly or indirectly. As summarized by the table below, the eight types of waste are evident in all the stages of construction, however, the construction stage can be affected by all these types of waste and therefore it is important to note that characteristics that evident these types of waste within a building site. Lean construction wastes have significant negative impacts on building site processes, affecting cost, quality, productivity, and sustainability. High costs arise from defects, delays, and overproduction, while quality suffers due to material waste and rework. Productivity declines when workers deal with inefficiencies, and sustainability is compromised through excessive resource use and waste generation.

Lean Construction (LC) provides a promising framework to improve efficiency and minimize waste. Derived from the Toyota Production System, LC emphasizes value creation and the elimination of non-value-adding activities (Koskela, 1992; Sacks et al., 2020). This paper analyses the predominant sources of waste in Nairobi's construction sites and offers insight into the operational, material, and labour-related drivers behind it. Identifying the types of waste is crucial for formulating targeted interventions and adopting effective project management strategies. It also explores how LC tools can address Nairobi's key sources of construction waste.

2. Theoretical Background

Construction waste goes beyond physical material loss. Guided by Lean Construction Theory (Koskela, 1992), which was adapted from Lean Production theory (Ohno, 1988), the study conceptualizes construction waste beyond physical material to include process inefficiencies and time delays. This broader perspective is essential in understanding systemic inefficiencies present on Kenyan construction sites. According to Garcés & Peña (2023), Waste in construction is defined as anything that does not add value to the activities required to complete a production unit. This definition shows that waste encompasses a wide range and all forms of inefficiencies, while value is considered the significance or benefit derived from project activities (Ridal et al., 2024). For the purposes of this study, this lean-oriented perspective of waste in construction was adopted. Lean Construction Institute (LCI) reinforces this view by classifying waste into eight types: inventory, overproduction, over-processing, rework and defects, motion, waiting, transport, and underutilized talent (LCI, 2021).

These waste sources can be described and defined as follows:

Overproduction: this refers to the manufacture or procurement of materials, components, or resources beyond what is required for the current project needs. This includes using more material than necessary, employing oversized equipment, or performing redundant tasks. Overproduction leads to excessive inventory, increased storage costs, and resource wastage (Jarkas & Bitar, 2019).

Waiting Time: This is defined as delays experienced during construction due to idle labour, equipment, or materials. These delays often stem from poor planning, lack of timely approvals, or misaligned scheduling. Waiting time contributes no value to the customer and represents a direct loss of productivity (Aziz & Hafez, 2020; Bajjou et al., 2017). Dupin (2014) found that waiting accounted for approximately 29% of time spent on construction sites, making it one of the most significant forms of waste.

Transportation Waste: This occurs when tools, materials, or equipment are moved inefficiently or unnecessarily within or between job sites or within a construction site. This can result from inefficient site organization leading to increased transportation. This not only delays project activities but also increases the risk of damage and adds to labour and fuel costs (Marhani et al., 2019).

Motion Waste: this involves unnecessary movement or actions by workers during construction processes, often due to poor site layout, inadequate organization, or a lack of ergonomic planning. Such inefficiencies reduce productivity and increase fatigue among workers (Sacks et al., 2020). Inefficient site organization can also lead to increased motion waste. Poorly arranged storage areas or equipment zones increase the time and energy spent retrieving materials (Marhani et al., 2019).

Defects and Rework: Defects result from construction errors, non-conformance to specifications, or design flaws, leading to rework and correction. These activities consume additional time, labour, and materials, thereby increasing project costs and causing delays (Zhang et al., 2021). Poor design coordination, unclear specifications, and frequent design changes are also major contributors this waste source (Ajayi et al., 2019). Inadequate planning also leads to mismatches in scheduling, resource allocation, and site logistics.

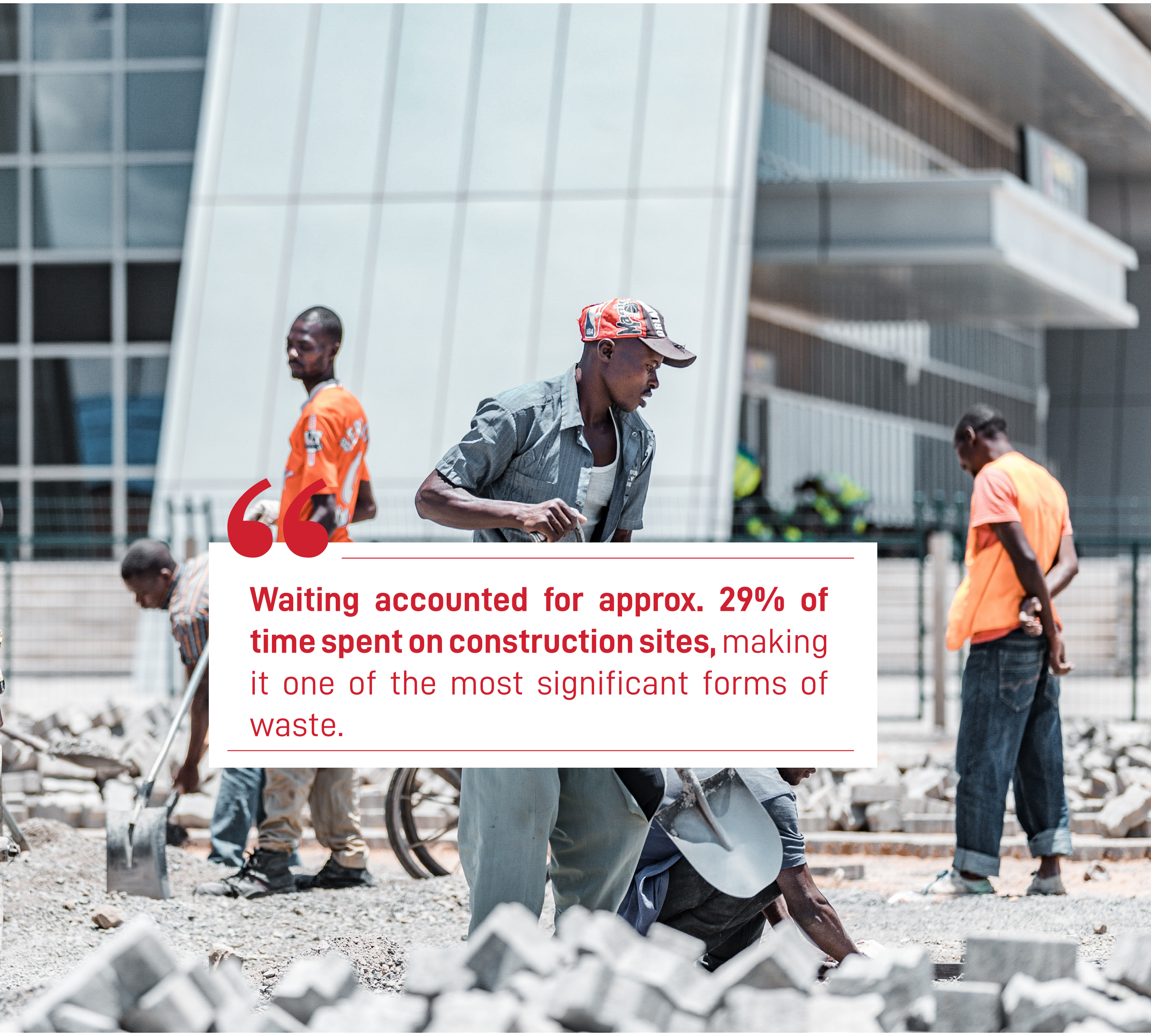
(Excess) Inventory Waste: This arises when surplus materials are procured or stored unnecessarily. This ties up capital, occupies storage space, and can lead to material degradation or obsolescence if not used timely (González et al., 2021). Over-ordering of materials or improper material handling can often result in excess inventory and damaged items, contributing to inventory waste and even overproduction (Yuan, 2020).

Underutilized Talent: this refers to the failure to engage or empower workers to their full potential in construction projects. Poor communication, limited delegation, or underinvestment in skills development may result in missed opportunities for innovation and productivity improvement. Unskilled labour, lack of training, and poor supervision also contributes to the underutilization of human capital (Sacks et al., 2020).

Over-Processing: this involves conducting unnecessary steps or using more advanced methods or materials than required. Delays caused by miscommunication or bureaucratic processes can also result in over-processing. An example is traditional Request for Information (RFI) systems that involve multiple layers of approval before a simple query is resolved, leading to delays and inefficiencies (Hosseini et al., 2019).

In a highly competitive industry, construction firms are forced to reduce their operational margins and optimize resources to deliver projects within predefined parameters, such as time, cost, quality and scope with minimal or no losses. Identifying and eliminating waste is therefore central to improving productivity and maintaining competitiveness within the construction industry. Unlike traditional construction models—which view production as a linear input-output process—lean construction conceptualizes it as a system involving material transformation, continuous resource flow, and value generation. This broader perspective enables the identification of various sources of waste that hinder project efficiency and client satisfaction (Garcés & Peña, 2023). In these developing nations, the most common types include; Inventory waste (excess materials), Labour inefficiencies (idleness, misallocation), and Waiting time (delays due to sequencing or poor communication). These inefficiencies result in cost overruns, schedule delays, and rework (Aziz & Hafez, 2019).

Lean Construction deploys tools to eliminate waste, such as: 5S for site organization and visual control; Just-in-Time (JIT) to reduce inventory waste; Last Planner System (LPS) to improve scheduling and reduce waiting; Value Stream Mapping (VSM) to identify non-value adding activities. Studies in South Africa, Egypt, and Uganda confirm that these lean tools, when tailored to local context, significantly reduce waste and improve coordination (Aigbavboa & Thwala, 2019; Alinaitwe et al., 2019).



Waiting accounted for approx. 29% of time spent on construction sites, making it one of the most significant forms of waste.

3. Methodology

The study was carried out through case study research design and causal research design. Case study research design involves analysis of real world to understand and evaluate past problems and solutions. A mixed-methods approach, combining quantitative and qualitative research methods was used to provide a comprehensive understanding of the impact of lean construction on waste reduction. Data collection involved key stakeholders such as project managers, site supervisors, site architects, quantity surveyors and site engineers from construction companies, providing a comprehensive view of the implementation and impact of lean construction from various perspectives within the construction process. The data collection materials for this study included mainly primary sources of data as outlined:

- *Structured questionnaire* distributed to 132 participants (contractors, site engineers, Project managers, site supervisors) from NCA-registered firms.
- *Observation checklist* on 10 building sites assessing visible waste types.
- *Semi-structured interviews* with 8 industry professionals for contextual understanding.

Quantitative data was analyzed using descriptive statistics (such as mean and Standard deviation), frequency tables, and cross-tabulations. Whereas Qualitative data were thematically coded. To ensure content validity, the questionnaire was reviewed by academic supervisors and industry experts. It was pre-tested on contractors not included in the final sample through a pilot study. Feedback from the pilot was used to revise ambiguous items and improve clarity. The reliability of the questionnaire was tested using Cronbach's Alpha. A threshold value of 0.7 was used to determine internal consistency, in line with standard research practices. Additionally, the observation checklists were used to ensure consistency and objectivity of the data collected, hence validating survey data.

4. Results

Table 4.1:Significance of Waste Types (Survey Results)

Waste Type	Frequency (%)	Ranking
Reworks and Defects	60%	1st
Inventory Waste	58%	2nd
Labour Inefficiencies	53%	3rd
Waiting Time	41%	4th
Motion Waste	35%	5th
Transportation	28%	6th
Over-processing Waste	25%	7th
Overproduction	23%	8th

Source: Study, 2025

These figures align with global findings on common construction inefficiencies but highlight inventory and labour waste as particularly acute in the Kenyan context. Although 70% of respondents were aware of Lean Construction, only 36% reported any form of implementation. Among those: 5S was used for improving site layout and reducing motion waste; JIT helped reduce storage problems and overstocking; LPS improved scheduling and labor utilization. However, lean tools were rarely applied in a structured, integrated way.

Observation checklists from Site visits confirmed that: Materials were often stored in disorganized locations, increasing inventory and motion waste, Skilled workers were frequently idle due to delays in approvals, poor planning and scheduling of activities or lack of equipment, and that Site layout and planning were often suboptimal, contributing to time loss.

Interview respondents, moreover, highlighted procurement delays, poor planning, over-ordering of materials, and unskilled labour as key contributors to waste. Notably, several contractors admitted to ordering 10–15% extra materials as a risk buffer, which often resulted in unused stock and spoilage. Project managers and site engineers noted that most projects they worked on resulted in time overruns due to reworks and defects as a result of poor planning and delays from approvals and procurement.

"Although 70% of respondents were aware of Lean Construction, only 36% reported any form of implementation

5. Discussion

The dominance of inventory waste in Nairobi's construction sector signals systemic issues in procurement planning and materials management. Labour inefficiencies and waiting time are tied to poor scheduling and lack of coordination. These issues mirror findings in similar developing contexts like Nigeria and South Africa (Aigbavboa & Thwala, 2019).

Process-related waste such as motion and over-processing is also rooted in weak site layout and disjointed workflows. Despite moderate awareness of lean construction principles, implementation of site organization strategies such as 5S and Just-in-Time is still lacking.

Table 5.1: Aligning Lean tools with waste sources

Waste Type	Lean Tool	Mitigation Mechanism
Reworks	Value Stream Mapping	Helps eliminate Non-value adding activities
Inventory Waste	Just-in-Time (JIT)	Supplies ordered per immediate need
Labour Inefficiency	Last Planner System	Promotes realistic planning and accountability
Waiting Time	Pull Scheduling	Improves sequencing and readiness
Motion Waste	5S	Optimized site layout and workflow

Source: Study, 2025

The study confirms that lean tools, when properly implemented, directly address the identified waste categories. Yet, fragmented project delivery systems, Lack of formal training in lean tools, cultural resistance and Minimal digital integration such as BIM; impede broader adoption. These align with regional findings that cultural and structural readiness is as crucial as technical capability (Olanrewaju & Abdul-Aziz, 2020).

6. Conclusion and Policy Implications

This study reveals that reworks and defects, inventory waste, labour inefficiencies, and waiting time are the dominant sources of waste on Nairobi building sites. To mitigate these issues, the following measures are proposed:

1. Introduce material tracking systems to optimize procurement and minimize surplus.
2. Invest in site planning and layout using lean tools such as 5S and visual management.
3. Enhance training for site workers and supervisors to reduce delays caused by underutilized labour.
4. Integrate lean practices into national building codes and NCA regulatory frameworks.
5. Initiate pilot lean projects on government infrastructure
6. Train contractors and site managers via CPD programs
7. Promote public-private partnerships for digital lean tools

Addressing these root causes will be instrumental in promoting cost-efficient, sustainable construction practices in urban Kenya.

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Opportunities in Bamboo Engineering and Alternative Fiber Technologies

By Ivy Chelangat

As the global demand for sustainable solutions continues to grow, the construction and manufacturing industries are increasingly exploring alternative materials that reduce environmental impact while maintaining performance. In Kenya, bamboo engineering and alternative fiber technologies present a practical and scalable opportunity to address key challenges such as affordable housing, environmental conservation, and sustainable industrial development.

Bamboo, once considered a traditional material, is now being transformed through modern engineering into high-performance construction products. Engineered bamboo materials such as laminated bamboo lumber are increasingly being used in structural applications including beams, flooring, and panels. One of bamboo's greatest advantages is its rapid growth cycle it matures within three to five years compared to over twenty years for most hardwood species. This makes it a highly renewable resource. In addition, bamboo absorbs significant amounts of carbon dioxide during its growth, making it an environmentally beneficial alternative to conventional materials like steel and concrete, which are associated with high carbon emissions.

In the Kenyan context, bamboo offers a major opportunity in addressing the growing demand for affordable housing. With increasing urbanization and population growth, the cost of construction materials remains a key challenge. Bamboo provides a locally available and cost-effective solution that can be used in both rural and urban developments. Furthermore, bamboo cultivation and processing can create employment opportunities, supporting rural livelihoods and promoting sustainable land use practices, particularly in regions around Mount Kenya where bamboo farming initiatives are gaining attention.

Figure 1: Example Of Bamboo Used in Construction Applications in Kenya

While bamboo remains a leading sustainable material, it is not the only solution. Alternative fiber technologies are also opening new opportunities in engineering and manufacturing. Natural fibers such as hemp, flax, and agricultural residues are being used to develop lightweight and eco-friendly composite materials. These materials are increasingly applied in construction panels, furniture production, automotive components, and biodegradable packaging. In Kenya, where agricultural waste is abundant, these technologies present an opportunity to convert waste into valuable products, reducing environmental pollution while supporting a circular economy.

The integration of bamboo with other natural fibres further expands engineering possibilities. Hybrid composite materials can combine the strength of bamboo with the flexibility of other fibers, resulting in durable and adaptable solutions suitable for modern construction and manufacturing needs. These innovations are particularly important as industries seek materials that balance performance with sustainability.

Comparative properties of construction materials

Property	Bamboo	Steel	Concrete
Maturity/ Availability	3-5 years	Non-renewable	Non-renewable
Strength to weight ratio	High	Very high	Moderate
Carbon emission	Low	High	High
Cost(Relative)	Low- Moderate	High	Moderate

Despite these opportunities, several challenges remain. Bamboo and natural fibers require proper treatment to improve durability and resistance to moisture and pests. In addition, there is limited awareness and technical expertise among engineers and developers regarding their use. The absence of widely adopted standards and regulations also slows down their integration into mainstream construction. However, frameworks such as Kenya's National Building Code (2024) provide a foundation for incorporating sustainable materials into the construction sector, highlighting the need for further policy alignment and implementation.

To fully realize the potential of bamboo engineering and alternative fiber technologies, there is a need for increased investment in research, training, and infrastructure. Collaboration between government, academia, and industry stakeholders will be essential in developing standards, improving material processing techniques, and promoting awareness among professionals.

In conclusion, bamboo engineering and alternative fiber technologies represent a significant opportunity for sustainable development in Kenya. They offer environmentally friendly, economically viable, and locally accessible alternatives to conventional materials. As the demand for sustainable infrastructure continues to rise, Kenya has a unique opportunity to lead in the adoption of these innovative materials. Strategic investment, supportive policies, and increased awareness will be key to transforming these opportunities into practical, large-scale solutions for the future.

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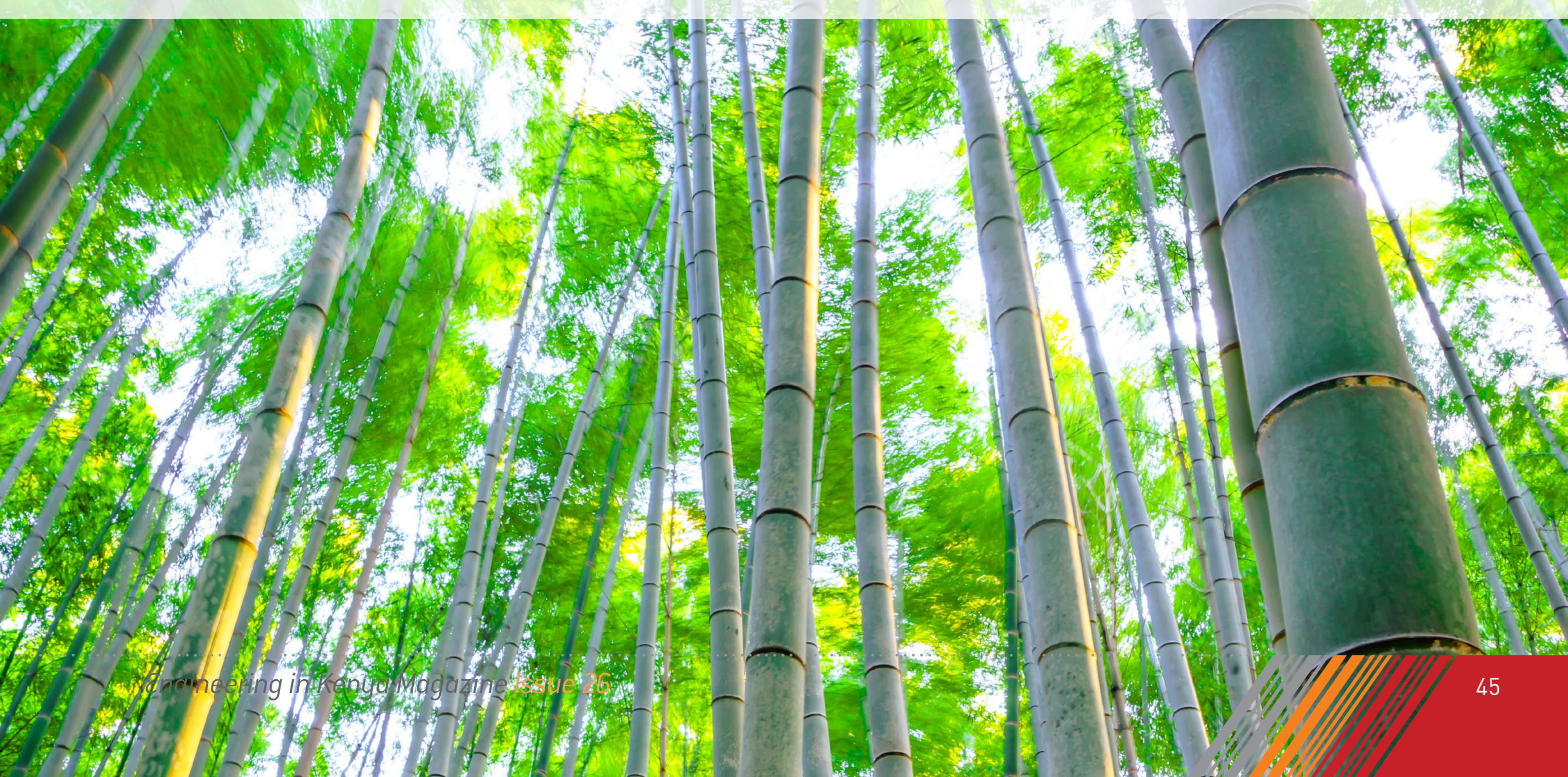

Use Of Structural Timber for Climate Change Mitigation

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Introduction

When trees grow, they transform carbon in the air into wood, removing it from the atmosphere and storing it. Whereas the growth of timber absorbs CO_2 from the atmosphere, the manufacture of cement and steel produces CO_2 to the atmosphere largely due to their energy-intensive manufacturing processes. The building industry is one of the largest contributors to global CO_2 emissions due to the use of these materials among others. The use of timber (that is sustainably sourced, with replanting) as a structural material in place of concrete and steel significantly reduces the embodied carbon of a building; it's a sustainable alternative that can help mitigate climate change by reducing CO_2 emissions. Research and adoption of low-carbon techniques for producing concrete and steel is critical to address climate change in the building sector.

National Buildings & Construction Decarbonization Roadmap

The Kenya National Buildings & Construction Decarbonization Roadmap (2026–2040) was launched by the State Department for Public Works on 26th February 2026 at Serena Hotel, Nairobi. The roadmap outlines a long-term green building strategy to transition the country towards reduction of greenhouse gas emission in the building sector in line with the Paris Agreement. The Paris Agreement is a legally binding international treaty on climate change. The efficient use of timber as a structural material will go a long way in realization of this transition. The future of construction is Green, and the use of Eco-friendly materials will not be optional but mandatory.

Sustainable Forest Management

If timber is not sourced from sustainable, responsibly managed forests, any benefit derived from its use would be offset by the increased deforestation and habitat loss. One way towards 'sustainable development' of timber is through the procedure of independent, credible audit and certification e.g. Forest Stewardship Council (FSC). FSC is a global forest certification system established to ensure that timber is supplied from well-managed sustainable forests; in which controlled harvesting, natural regeneration and re-forestation programmes ensure a sustainable resource. The country has developed a FSC Interim National Standard as basis for implementing responsible forest management applicable to all forest operations. However, none of our forests has achieved the forest management certification under the FSC system. To guide the protection, conservation and management of forests and forest resources in the Country, a Forest Conservation and Management Act (Cap. 385) has also been enacted.

Promoting the Efficient Use of Structural Timber for Climate Change Mitigation.

The Engineer should have a positive outlook and be biased in selecting timber (against concrete and steel) as the first-choice structural material in his/her design. He or She should ensure that timber is used effectively and efficiently,contributing towards "sustainable forest management" for climate change mitigation.

Challenges and Limitations in Timber use

For the use of structural timber, the Engineer specifies the timber species, size, grade (GS or SS) and the moisture content among others. However, well-seasoned and graded timber is not readily available in the Kenyan market, and the Contractors normally buy any timber available in the timber yards, thus rendering the structural design irrelevant.

> "The grade of timber is the most important and most ignored amongst the quality control measures on site when it comes to the use of timber as a structural material in construction.

During construction, it is common practice for Engineers to insist on test on materials such as concrete to check whether the contractor is adhering to the specifications. However, this is not common when it comes to timber. The best way to check the quality of timber is to employ the services of a timber grader (but not testing) who will be able to confirm whether the timber being used at a particular site meets the grade specifications. The Kenya Forest Research Institute (KEFRI) trains timber graders who can offer such services on site, at sawmills and timber yards. As for the specified moisture content, a hand-held moisture meter can be used on site. Effective quality control of timber reduces risks of structural failures, extends the lifespan (durability) of the timber structure and thus maximizes the carbon-sequestering potential.

Heavily loaded and large span structural members (e.g., columns and beams in multistorey buildings, stadiums, etc.) will require large sized timber members that are not available in the local market, consequently, Kenyan Structural Engineers shy away from such designs. The limitations in maximum cross-sectional dimensions and lengths of solid sawn timbers can be overcome by using engineered wood products like cross-laminated timbers (CLT) and Glue-Laminated Timber (GLT or Glulam). Therefore, there is a huge opportunity to rejuvenate Kenya's forest products sector by diversifying into the manufacture of these engineered timber products (CLT and GLT) among others.

Timber Recycling practices

Construction in timber offers an immediate reduction in atmospheric CO_2 levels. However, the stored Carbon is susceptible to re-release to the atmosphere through decomposition or combustion especially at the end of the building lifespan. To extend its carbon-storing potential, timber should be recycled or reused. When a timber structure reaches the end of its usefulness, the individual components should be dismantled carefully and either reused in a new construction project or broken down and transformed into other useful timber products. Carbon continues to be stored in timber and timber products as long as they are used and maintained.

Bamboo Engineering: A Sustainable Frontier for Kenya's Built Environment

By Eng. Dr. A. A Owayo (S. Lecturer, Moi University)

ABSTRACT

As the global construction industry pivots toward sustainability, bamboo has emerged as a high-potential alternative material capable of addressing environmental, economic, and structural challenges. In Kenya, where rapid urbanization, deforestation, and climate change pressures converge, bamboo engineering offers a viable pathway for resilient and low-carbon infrastructure. This article reviews properties of bamboo, its applications in structural engineering, current limitations, and opportunities for mainstream adoption within Kenya's construction sector.

1. Introduction

The construction industry remains a major contributor to global carbon emissions(IEA, 2019; UNEP, 2023) due to its reliance on energy-intensive materials such as concrete and steel (Choudhury et al., 2023). Many studies (Danish et al., 2020; Sarkodie et al., 2020; Eweade et al., 2023; Otim et al., 2025; Kimutai et al., 2025) have examined the source of carbon emissions. These investigations have demonstrated the importance of trade openness, industrialization, and economic growth. In Kenya, increasing urbanization, housing demand, and environmental degradation highlight the urgent need for sustainable alternatives (Powanga and Kwakwa, 2024). Recently, there has been an increased focus on the study of the applicability of bamboo in construction (Krötsch, 2013; Yadav and Mathur, 2021; Lee et al., 2022; Habibi et al., 2023; Cui et al., 2023). Bamboo, often referred to as "green steel," presents a viable solution due to its rapid renewability, strength, and local availability. The term "green steel" is used comparatively to highlight the renewability of bamboo for potential structural applications. Although bamboo has traditionally been used in rural settings, its potential in modern engineering remains underutilized. Although research on the mechanical strength of bamboo is promising (Ramaswamy et al., 1983; Javadian et al., 2020; Gao et al., 2022),aspects such as biodegradability, sustainability (particularly its acceptance for widespread use in construction), and the availability of an adopted local codified design approach are yet to be fully addressed. However, with proper design, treatment, and standardization, bamboo can play a significant role in Kenya's sustainable construction agenda. This article is limited only to the structural applications of bamboo.

2. Engineering Properties of Bamboo

Bamboo (or its composites) possesses excellent mechanical properties that make it suitable for structural applications (Ratna Prasad and Mohana Rao, 2011). In certain composite forms, and at optimal fibre orientation, bamboo can exhibit high tensile performance comparable to mild steel in tension. Studies by (Yao an) and (Gao et al., 2022) report tensile strengths of up to 630 MPa for bamboo fibre-reinforced mortar laminates and stiffness values of up to 17 GPa for bundles of bamboo fibres. Bamboo also exhibits good compressive and flexural strength, enabling it to resist bending and dynamic loads such as wind. However, bamboo is anisotropic (Javadian et al., 2019), meaning its strength is greatest along the longitudinal direction and weaker across the cross-section. This characteristic requires careful consideration in design, especially in jointing and load transfer.

Untreated bamboo is vulnerable to moisture, fungi, and insect attack. Nevertheless, treatment methods such as boron preservation and smoke curing can significantly enhance its durability and lifespan.

3. Applications in Construction

Bamboo has diverse engineering applications, particularly in low- to medium-scale construction. It is suitable for use in structural frames, trusses, and footbridges, especially in rural and peri-urban areas. In addition, bamboo structures are aesthetically pleasing and blend naturally with forest environments. Figure 1 illustrates typical bamboo structures.

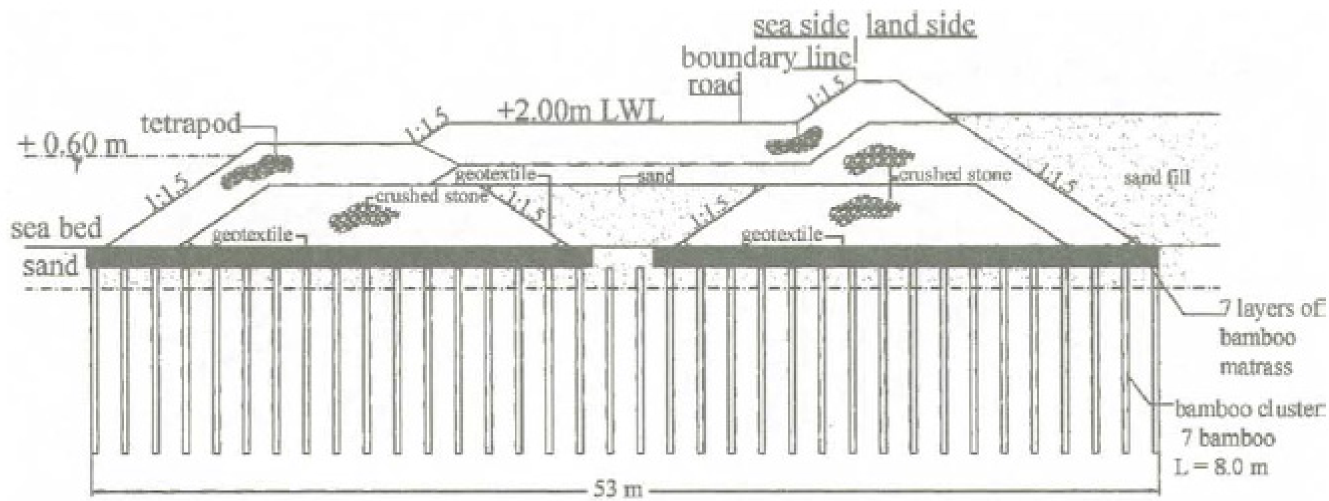
(a) Bamboo frame and roof (Krötsch, 2013)

(b) Bamboo truss (Sonar and Siddhaye, 2009)

Figure 1: Typical structures made of Bamboo

Engineered bamboo products, such as laminated bamboo lumber, are increasingly being used in modern construction. Bamboo has also been explored as a reinforcement material in concrete, particularly for low-cost housing, although challenges related to bonding and water absorption remain. In addition, as shown in Figure 2, bamboo can be used to improve the bearing capacity of soft soils, thereby reducing their susceptibility to earthquake-induced failure. (Mozumder et al., 2025) reported that bamboo fibres enhance the shear strength of soft soils by increasing both cohesion and the internal friction angle. Bamboo micropiles as in Figure 2 b, also improve the soil's lateral confinement through group action, hence increased resistance to dynamic loads. In addition to the applications mentioned above, bamboo also offers environmental and economic benefits, as discussed in Section 4 below.

(a) Bamboo soil reinforcement (Gidon and Sahoo, 2020)



(b) Bamboo micropiles (Rahardjo, 2005)

Figure 2: Potential use of bamboo for soil improvement

4. Environmental and Economic Benefits

Bamboo offers significant environmental advantages. It is a fast-growing material, maturing within 3–5 years, and has a high carbon sequestration capacity (Selvan et al., 2024). Its use in construction helps reduce embodied carbon while promoting sustainable forestry practices.

Economically, bamboo is cost-effective due to its local availability and ease of handling. It reduces transportation and material costs, making it particularly attractive for affordable housing and community infrastructure projects. In Kenya, bamboo is readily available in Nairobi, Mombasa, the Central part, and the Western regions.

5. Challenges to Adoption

Despite its advantages, bamboo engineering faces several challenges in Kenya. ISO 22156 and ISO 22157 (International Organization for Standardization, 2019; International Organization for Standardization, 2021) provide guidelines for bamboo structures. Bamboo, however, is a plant whose structural strength is strongly influenced by environmental conditions; thus, for adaptability, National Annexes are crucial. Moreover, these codes are still under active development, informed by the latest research results, and thus are not exhaustive as per current knowledge. Additionally, connection design remains a technical challenge due to bamboo's hollow structure and susceptibility to splitting. Perception barrier is also another challenge, as bamboo is often associated with temporary or low-quality structures. Addressing this requires demonstration projects and increased awareness within the engineering community.

6. Opportunities for Kenya

Kenya is well-positioned to benefit from bamboo engineering through strong policy support, research, and capacity building. Integrating bamboo into building codes and promoting innovation in engineered bamboo products can accelerate its adoption.

This potential is reinforced by national frameworks such as the Kenya Forestry Policy (MEWNR, 2014) and the Kenya Bamboo Policy (MoEF, 2022), which classifies bamboo as a forest resource and supports its sustainable commercialization. However, beyond its environmental benefits, bamboo requires proper forestry management to ensure long-term viability. Sustainable practices include selective harvesting of mature culms, allowing natural regeneration, and integrating bamboo into agroforestry systems. Such approaches ensure that its use in construction aligns with sustainable forest management and climate resilience goals.

Universities and research institutions can further support this transition through material testing, structural analysis, and the development of design standards, while training engineers and artisans in bamboo construction techniques will be essential to ensure quality and safety.

7. Conclusion

Bamboo engineering presents a sustainable, affordable, and practical solution for Kenya's construction sector. Its strength, renewability, and environmental benefits make it a strong candidate for modern engineering applications.

However, widespread adoption will require the development of standards, improved connection technologies, and a shift in perception. By embracing bamboo as a legitimate engineering material, Kenya can advance toward a more sustainable and resilient built environment.

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Dr. Eng. Alphonce Ayado Owayo is a distinguished civil engineer, academic, and researcher with over 15 years of cumulative experience in geotechnical and structural engineering. He currently serves as a Senior Lecturer in the Department of Civil and Structural Engineering at Moi University, having previously held a similar position at the Technical University of Kenya. Dr. Owayo holds a Ph.D. and MSc in Civil Engineering from the National Taiwan University of Science and Technology, as well as a BSc in Civil Engineering from the University of Nairobi. He is a registered Consulting Engineer with the Engineers Board of Kenya and has made significant contributions to research, teaching, and professional practice, including leading major engineering projects. His research interests encompass artificial intelligence applications, numerical methods in structural and geotechnical engineering, sustainable cities, advanced foundation systems, and sustainable construction materials, with a strong emphasis on resilience and innovation in civil infrastructure. Dr. Owayo has published in peer-reviewed journals, mentored numerous graduate engineers, and actively contributes to the advancement of sustainable and smart engineering solutions aligned with global sustainability goals. His vision is to advance engineering knowledge that bridges technology, sustainability, and societal impact across Africa and beyond.

Advancing Wood Processing in Kenya: Modern Treatment Technologies and Digital Sawmilling for Durable and Efficient Timber Production

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Introduction

Kenya's timber industry is at a critical turning point. With rapid urbanization, population growth, and expanding infrastructure projects, the demand for high-quality construction materials continues to rise. Current national timber demand stands at an estimated 45 to 50 million cubic metres annually against a supply of just 30 to 35 million cubic metres. This persistent deficit of 10 to 15 million cubic metres leads to an increased reliance on costly imports.

This gap highlights a fundamental challenge within the sector: the deficit is not solely a function of inadequate forest resources; it is largely driven by inefficiencies in wood processing technologies and systems. To address this, Kenya must shift from traditional, resource-intensive practices toward modern, engineering-driven solutions. In particular, advancements in digital sawmilling and timber treatment technologies present a significant opportunity to enhance durability, improve recovery rates, and promote the sustainable utilization of our forest resources.

Challenges in Traditional Wood Processing

The timber processing landscape in Kenya is largely dominated by small and medium scale saw millers, many of whom rely on outdated machinery, such as thick-blade circular saws, and manual operations. These conventional systems produce notoriously low recovery rates typically between 18% and 30%, averaging around 25% to 28% resulting in substantial material waste in the form of sawdust and offcuts.

According to the Food and Agriculture Organization (FAO), if national recovery rates were to exceed the 30% threshold, Kenya's overall domestic timber output would increase substantially, closing a significant portion of the supply deficit without the need to harvest additional acreage. In addition to inefficiency, inconsistent cutting methods lead to variable product quality, limiting the use of locally processed timber in structural and high-value applications.

Modern Sawmilling Technologies and Real-World Impact

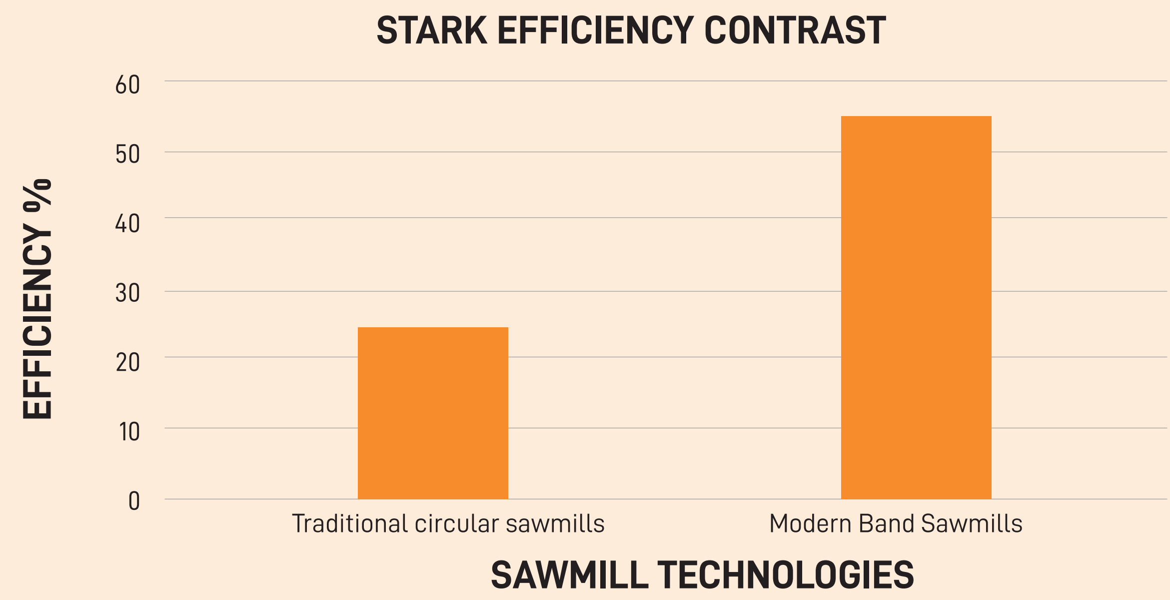
Digital and modern sawmilling technologies are transforming primary processing by integrating automation, precision engineering, and thinner kerf blades. Advanced systems allow for detailed analysis of each log, enabling optimal cutting patterns that maximize yield and minimize waste.

Globally, countries like Vietnam have successfully overhauled their forestry sectors by subsidizing similar upgrades, transforming from raw-log exporters to high-value processed timber hubs. In Kenya, the Flyover Timber Hub in Nyandarua County serves as the primary example of this shift toward value addition. Large-scale operations like Flyover Sawmill have demonstrated that moving beyond raw timber into processed products like tongue and groove (T&G) and door frames is essential for survival in a resource-constrained market.

Ruth Muraya, an industry leader at Flyover Master Sawmill, highlights the impact of this transition: "We used to lose nearly three-quarters of our logs to sawdust and offcuts with the old circular saws. By investing in state of the art value addition machines and precision milling, we have been able to significantly reduce the waste. This efficiency is what allows us to sustain a workforce of 200 people and turn local timber into high-value materials that meet the standards of the modern building market."

Visual 1: Sawmill Timber Recovery Rates in Kenya

The chart below illustrates the stark efficiency contrast between traditional machinery and modern digital/band sawmilling technologies.



Source: Synthesized from Food and Agriculture Organization (FAO) and Kenya Forestry Research Institute (KEFRI) data.

Modern Timber Treatment Technologies

While efficient milling increases supply, modern treatment technologies ensure the longevity of that supply. One of the key limitations of locally available fast-growing timber species such as eucalyptus, pine, and cypress is their susceptibility to biological degradation. Without proper treatment, timber is prone to termite attacks, fungal decay, and weathering.

Modern wood preservation technologies, particularly pressure impregnation systems, enable deep penetration of chemical preservatives into wood fibers. For specialized applications such as utility poles, treated timber boasts a lifespan of over 20 years, compared to less than 5 years for untreated equivalents.

In parallel, there is a growing emphasis on environmentally friendly preservatives. Boron-based treatments and copper-organic compounds offer effective protection with a reduced ecological footprint. These innovations align perfectly with Kenya's push toward sustainable construction and environmentally responsible material use.

Visual 2: Estimated Service Life of Kenyan Softwoods (Pine/Eucalyptus)

APPLICATION ENVIRONMENT	UNTREATED LIFESPAN	TREATED LIFESPAN (PRESSURE IMPREGNATION)	CONCRETE
Indoor Structural (Dry)	5 - 10 Years	30+ Years	Non-renewable
Outdoor / Exposed (Fencing/Cladding)	2 - 5 Years	15 - 25 Years	Moderate
Ground Contact (Utility Poles/Posts)	< 3 Years	20 - 40 Years	High
Cost(Relative)	Low- Moderate	High	Moderate

Data synthesis based on KEFRI and KFS preservation benchmarks.

Barriers to Adoption and Emerging Opportunities

Despite the clear benefits, the adoption of modern wood processing technologies in Kenya faces four distinct challenges:

1. **Capital Costs:** High initial investment costs for machinery like laser-guided band saws are prohibitive for small-scale operators.
2. **Import Duties:** Tariffs on advanced forestry and milling machinery remain high, discouraging capitalization.
3. **Skills Shortages:** Operating and maintaining computer-controlled milling and pressure-treatment systems requires specialized technical training currently lacking in many rural hubs.
4. **Fragmented Value Chains:** Weak linkages between forest growers, processors, and end-markets dilute profit margins, making it harder for processors to secure financing for upgrades.

Nevertheless, opportunities for transformation are substantial. Research institutions such as the Kenya Forestry Research Institute (KEFRI) are actively developing localized wood utilization guidelines. Furthermore, increased interest in public-private partnerships presents a pathway for establishing shared-use processing hubs, allowing smaller operators to access modern equipment without bearing the full capital burden.

Conclusion

Advancing wood processing in Kenya requires a deliberate shift toward modern, technology driven approaches. With the gazettement of the National Building Code 2024 (NBC 2024), which mandates strict quality and durability standards for structural materials, the transition to treated, precision-milled timber is no longer just an industry option; it is a regulatory necessity.

Engineers and policymakers have a pivotal role in this transformation: designing efficient systems, optimizing resource utilization, and creating tax incentives for machinery upgrades. By integrating advanced timber treatment methods with digital sawmilling systems, Kenya can close its 15 million cubic metre supply deficit, reduce its dependence on imported timber, and build a resilient, high-value forestry sector.

Ultimately, the future of Kenya's timber industry will depend not on how many trees are cut, but on how efficiently and intelligently each tree is utilized.

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IEK Membership Report

The IEK membership committee meets every month to consider applications for membership of the various classes received at the secretariat. The IEK council at its, 545th, 546th and 547th council accepted the following members under various membership categories as shown below;

MEMBERSHIP CLASS	NUMBER ACCEPTED- 545th COUNCIL	NUMBER ACCEPTED- 546th COUNCIL	NUMBER ACCEPTED- 547th COUNCIL	TOTAL
FELLOW	2	-	1	3
CORPORATE	1	-	2	3
GRADUATE	62	47	79	188
GRADUATE ENGINEERING TECHNOLOGIST	2	2	8	12
GRADUATE ENGINEERING TECHNICIAN	6	10	5	21
STUDENT	5	17	15	37
TOTAL	**78**	**76**	**110**	**264**

During the period, we had 3 members who transferred from the class Corporate to Fellow member 3 from Graduate to Corporate member. In addition, we had 188 graduates, 12 graduate engineering technologists, 21 graduate engineering technicians and 37 students were accepted as members.

Gender Data

Class	Male	Female	Percentage (Male)	Percentage (Female)
Fellow	3		100%	0%
Corporate	3		100%	0%
Graduate	145	43	77%	23%
Graduate Engineering Technologist	11	1	92%	8%
Graduate Engineering Technician	20	1	95%	5%
Student	28	9	76%	18%
TOTAL	**210**	**54**	**80%**	**20%**

Summary

Gender	No.	Percentage
Male	210	80%
Female	54	20%
	264	100%

547th APPROVAL

FELLOW

S/N	Name	Member No
1	Ariel Mutegi Mbae	F.3209

CORPORATE

S/N	Name	Member No
1	Ezekiel Kipkoech Koskei	M.4008
2	James Mwangi Waruhiu	M.13138

545th APPROVAL

FELLOW

S/N	Name	Member No
1	Dominic Wambugu Mwaniki	F.4583
2	Francis Kibara Mwangi	F.3519

CORPORATE

S/N	Name	Member No
1	Kennedy Bonyo Otieno	M.3522

The council invites Engineers and affiliate firms to apply for membership in the various membership classes, kindly follow the link members.iekenya.org to register or scan the QR Code below to apply for membership;

Student Voices

Rolex Okoth Omondi ,
The Technical University of Kenya
Mechanical engineering
Year of Study: 4th year

Sustainable forestry requires a balanced approach that meets the growing demand for timber while preserving ecosystems and biodiversity. Engineering plays a vital role in achieving this balance through the design and implementation of efficient, environmentally conscious systems in forest management and wood processing.

One key solution is the application of precision forestry technologies such as remote sensing, Geographic Information Systems (GIS), and drone-based monitoring. These tools enable accurate assessment of forest health, resource mapping, and guided selective harvesting, supporting data-driven decisions that minimize unnecessary deforestation and promote natural regeneration.

In addition, engineered harvesting methods such as reduced-impact logging (RIL) are essential in limiting soil disturbance, protecting non-target trees, and maintaining habitat integrity. Within timber processing, optimization of sawmilling operations and the adoption of modern wood utilization technologies help reduce waste while maximizing yield from harvested logs.

Engineers also contribute significantly to reforestation and afforestation efforts by designing efficient irrigation systems, soil conservation structures, and mechanized planting techniques. Incorporating environmental impact assessments into engineering projects further ensures compliance with sustainability standards.

Ultimately, integrating engineering innovation with environmental stewardship enables forestry systems that support economic development while conserving biodiversity for future generations.

Sustainable forest management forms the cornerstone of effective climate action in Kenya. Forest engineers apply innovative techniques to enhance carbon sequestration while supporting economic growth in the sector. Recent developments have created unprecedented opportunities in this field. The introduction of the Climate Change Carbon Markets Regulations in 2024 together with the launch of the Kenya National Carbon Registry in early 2025 has established a transparent framework for generating and trading credits. These tools allow precise tracking of mitigation outcomes from well managed forests preventing double counting and ensuring integrity.

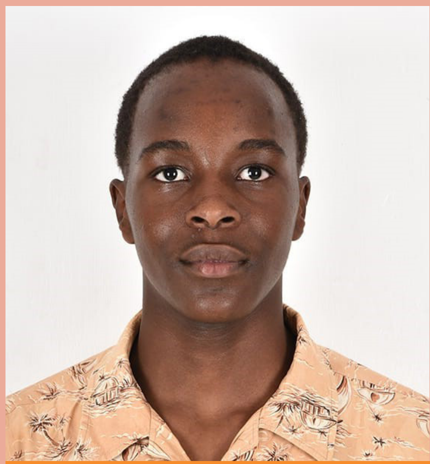
Through REDD plus initiatives such as the Kasigau Corridor project engineers design systems that reduce deforestation rates and restore degraded areas. Satellite based monitoring combined with field verification delivers reliable data for credit issuance. This not only unlocks finance for conservation but also delivers direct benefits to local communities via mandatory sharing mechanisms. Kenya has already issued more than fifty-nine million metric tons of credits positioning the country as a leader in Africa. Emerging trends include nesting guidelines that enable small scale projects to integrate with national programs and digitized registries that streamline participation. By embracing these advancements forest engineers can drive sustainable practices that balance timber needs with biodiversity protection. The result is a resilient forestry sector that contributes meaningfully to national development and global climate goals.

Ian Mutugi Njue, 23yrs
Bsc. Electrical and Electronics Engineering
Kenyatta University
Civil Engineering
Current Year of Study 5thyear

Kenya's industrial wood sector has a problem. It is short of wood by 10 to 15 million meters every year. This shortage costs the country a deficit of about Sh534 billion. To fix this problem the National Commercial Forestry Strategy from 2025 to 2035 marks a decisive shift toward high-recovery digital sawmilling and advanced treatment technologies.

The old way of cutting wood by hand is ineffective. It only uses 23.3% of the wood in a log. In contrast, modern digital systems utilize 3D laser scanners and AI to maximize recovery and precision. By integrating solutions like Wood Mizer's Smart Log Processing, industrial hubs such as Tatu City and Thika Industrial Smart City are providing the fiscal incentives necessary for companies like Tatu Woodworks to scale these high efficiency operations.

Making wood longer is also very important. There is a way to make wood last longer through Vacuum Pressure Impregnation (VPI), preservatives like Copper Azole are forced deep into wood cells to repel destructive Macrotermes termites. Some new treatments are also being used to make wood stronger. These treatments use microwaves to help the wood absorb chemicals. This makes the wood longer. Kenya's timber industry is working with experts from KEFRI and Kenya Forestry College in Londiani to make these changes. They want to make the timber industry in Kenya strong and good for the environment. They want it to help the country's economy grow. Kenya's industrial wood sector and the National Commercial Forestry Strategy are key to making this happen.



Nelson Mwaila
Kenyatta University
Petroleum Engineering

Christine Shabaya, 24
The Technical University of Kenya
Bachelors of Technology in Civil Engineering

Forestry Engineering and Climate Action: Unlocking Carbon Markets

Unlocking carbon markets ensures a rigorous engineering approach to the **Measurement, Reporting, and Verification (MRV)**. Forestry engineering offers the technical backbone through remote sensing and spatial modeling to quantify capturing and storing atmospheric carbon dioxide to mitigate or defer global warming with high confidence. Engineers can maximize the carbon sink capacity of Kenyan plantations by using sustainable forest management (SFM) protocols for example reduced-impact logging and optimized rotation cycles. These data-driven pathways turn standing forests into verifiable assets, allowing Kenya to trade carbon credits globally.

This integration of geomatics and the engineering and biological science of controlling the establishment, growth, composition, health, and quality of forests to meet specific diverse needs and values. Ensures that climate action is a mathematically validated engineering outcome and not just a policy

. These pathways use **Geographic Information Systems (GIS)** to transform standing forests into verifiable, liquid assets, allowing Kenya to participate in the compliance and voluntary carbon trade markets. Soil carbon stabilization and the use of **LiDAR-derived canopy height models**, provide the empirical evidence required to prevent "greenwashing" and ensure "additionality." This integration of geomatics and structural forestry ensures that climate action is not merely a policy goal, but a mathematically validated engineering outcome. By treating biomass as a measurable structural resource, Kenya can leverage its natural capital to fund large-scale restoration efforts while contributing to the global net-zero transition through high-integrity carbon credits that meet international standards like the **Gold Standard.**