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Greening Building Construction in Africa

Opportunities for Firm Upgrading in the Case of Rwanda

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Declaration of artificial intelligence use

AI-based language tools were used to summarise atlas.ti-coded interview transcripts, shorten the text of some of the sections and check grammar, spelling and style; readers should note that such tools may leave a detectable trace (for example, a digital watermark) in the final text even when used solely for this limited purpose.

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Abbreviations

ASEAN	Association of Southeast Asian Nations
BRD	Development Bank of Rwanda
C&I	commercial and industrial
COP	Conference of the Parties to the United Nations Climate Change Convention
COPCOM	Cooperative for the Promotion of Construction Materials Traders
CPCIC	Cleaner Production and Climate Innovation Centre
CSEB	compressed stabilised earth block
EDCL	Energy Development Corporation Limited
EDGE	Excellence in Design for Greater Efficiencies
EPD	Energy Private Developers
EU	European Union
FDI	foreign direct investment
FIT	feed-in tariff
FONERWA	Rwanda Green Fund
GBMCS	Green Building Minimum Compliance System
GDP	gross domestic product
GoR	Government of Rwanda
IER	Institute of Engineers Rwanda
IFC	International Finance Corporation
INR	Indian rupee
IPRC	integrated polytechnic regional centre
ISSB	interlocking stabilised soil block
KIST	Kigali Institute of Science and Technology
LEED	Leadership in Energy and Environmental Design
LMIC	low- or middle-income country
MINECOFIN	Ministry of Finance and Economic Planning
MINICOM	Ministry of Trade and Industry
MININFRA	Ministry of Infrastructure
MIR	Made in Rwanda
MoE	Ministry of Environment
MSME	micro, small or medium-sized enterprise
NCST	National Council for Science and Technology
NGO	non-governmental organisation
NIRDA	National Industrial Research and Development Agency
NISR	National Institute of Statistics of Rwanda
OSC	One Stop Centre

PAYG	pay-as-you-go
PROSOL	Tunisia’s Solar Water Heater Programme
PSF	Private Sector Federation
PV	photovoltaic
R&D	research and development
REG	Rwanda Energy Group Ltd
REMA	Rwanda Environment Management Authority
RHA	Rwanda Housing Authority
RIA	Rwanda Institute of Architects
RWF	Rwandan franc
RWH	rainwater harvesting
SACCO	savings and credit cooperative organisation
SHS	solar home system
STECOMA	Trade Union of Workers in Construction, Carpentry and Craft Enterprises
SWH	solar water heater
TISTR	Thailand Institute of Scientific and Technological Research
TVET	technical and vocational education and training
UNEP	United Nations Environment Programme
UN-Habitat	United Nations Human Settlements Programme
UNHCR	UN Refugee Agency
USD	US dollar

Executive summary

Rwanda does not lack green building policy instruments. Its main challenge is implementation and turning them into a functioning market. Its relatively advanced policy framework includes a revised Building Code, the Green Building Minimum Compliance System (GBMCS), sustainable public procurement instruments, one of Africa's first green taxonomies and complementary green finance instruments. Yet adoption of green practices in construction remains limited because policy has not consistently translated into market demand, firm capabilities, enforceable requirements or finance accessible to micro, small and medium-sized enterprises (MSMEs).

This report explores the underlying issues based on two complementary firm surveys (with 854 firms across two separate waves), 88 semi-structured interviews and two focus group discussions across a broad set of stakeholders relevant to the Rwandan construction industry between 2023 and 2026. Analyses focus on interlocking stabilised soil blocks (ISSBs), improved adobe/rukarakara, residential solar photovoltaic (PV) systems and solar water heaters (SWHs) as case studies of value chains contributing to green building.

The main findings of the report are as follows:

- **Awareness is not enough: perceived costs, inaccurate information and capability gaps prevent green solutions from becoming routine.** Cost is decisive for clients when choosing building materials, but green alternatives are not systematically more expensive; price premiums often reflect perceptions rather than verified cost differences. Awareness of most green building materials exceeds 80 per cent among survey respondents, yet regular use hovers around 15 per cent; lower awareness is largely confined to ISSBs and solar technologies among masons. In addition, firms that are aware of a green material or technology but do not use it report *higher* skills gaps than firms that are unaware.

  The awareness–action gap has a firm side and a client side: firms are reluctant to use green construction due to a combination of a lack of skills, misperceptions and a lack of client demand, while clients do not ask for green construction due to (perceived) costs, misperceptions of material durability and quality, and a lack of green marketing by firms. Firms therefore need project-linked technical support and green marketing skills, while clients need credible, comparable information on cost, quality and durability as basic awareness campaigns alone will not create a market.

- **Skills and worker retention constraints emerge as firms grow – and are not only technical but also organisational.** Micro and informal firms report the *lowest* skills gaps, while small and formal firms sitting at the small-to-medium growth threshold report the *highest* gaps, particularly in management and soft skills. Firms rightly prioritise green technical training where those gaps are greatest, while this is not the case for unmet needs in terms of management and soft skills. Worker retention is part of the same organisational challenge: firms struggling to retain workers report larger management and soft skills gaps, yet few use retention strategies. Moreover, even though improving health and safety has been shown to be an effective strategy, demand for the relevant training is very low. Solving the retention challenge matters, as our interviewees identify it as a major bottleneck for investing in skills development.

  Meanwhile, past training participation shows no relationship with reported gaps in any domain. What does correlate with lower non-technical gaps is regular peer exchange with other local firms and effective collaboration with technical and vocational education and training (TVET) institutions and universities. Training volume is therefore not a suitable lever; more relevant training – combining trade-specific technical knowledge with support for firms' capabilities in management and soft skills – and fostering exchange within the industry and with education institutions can help firms address the crucial skills constraints to support general firm upgrading and green adoption.

- **The green finance constraint is one of recognition and structural matching of funders with MSMEs, not merely a matter of capital supply.** Green finance is generally available. However, MSMEs in particular struggle to access it, as bank products and requirements do not match their needs, especially regarding collateral rules, risk models and margins. Ireme Invest initially mobilised over USD 200 million, and green buildings made up 71 per cent of the Development Bank of Rwanda (BRD)'s green portfolio at the end of 2025. Yet at the layer closest to MSMEs, local cooperative lenders have no green construction products beyond water tanks and solar systems, cap loans at around RWF 50 million and report a real gap in the ability to assess what counts as green construction. The commercial banks interviewed are only starting to integrate green products into their portfolio and attribute their slow progress entirely to external causes. In addition, local green materials tend to be appraised below their conventional equivalents, so a green building or machinery used for green construction is worth less as collateral and at resale. As a result, green dwellings are not built or machinery is not used, so the material remains unproven and undervalued. Reforming appraisal and valuation standards is cheap and may help to break this dynamic.

- **Different green materials and technologies face different bottlenecks, so firms need targeted support rather than generic MSME programmes.** With 93 per cent of households already living in walls made of bio-based materials, Rwanda's central risk is not failure to adopt something new, but aspirational substitution *upwards* with concrete. The expansion of ISSB technology has stalled: more affordable presses have lowered entry barriers to production, but it remains niche because it lacks a formal code and quality standards, anchor demand, skills and maintenance support, and access to permanent ownership of machinery. Testing and certifying the material, writing it into the Building Code, the GBMCS and curricula, using public procurement and demonstrations to create anchor demand, and expanding longer-term press leasing would create a route to process upgrading. In contrast, improved rukarakara has legal recognition and a standard, but it remains concentrated in low-income housing because formal certification systems exclude informal expertise and stigma limits demand, while limited testing, valuation and finance constrain investment. Certification pathways that recognise established informal producers, coupled with technical and aesthetic improvement, combinations with other materials and public demonstration, can help make it attractive for more profitable market segments. This needs to be coupled with a societal and government mindset shift and targeted demand-side green finance for low-income households.

  Solar presents a different set of constraints. Rising electricity tariffs and unreliable supply are making rooftop solar PV systems economically attractive but the market is prevented from scaling due to high upfront costs without suitable financing, dependence on imported equipment, regulatory uncertainty regarding net metering and the absence of bidirectional meters, and limited maintenance capacity of firms, especially outside Kigali. An updated solar strategy should make rooftop generation viable by installing bidirectional meters, operationalising net metering, implementing connection and surplus credit rules, upgrading the distribution grid, and complementing feed-in tariffs and import exemptions with working capital and after-sales support for firms. SWHs are technically less complex and already have an established market. Finance schemes, quality certification and demonstration projects have helped, but use is still largely limited to hotels and higher-income households in Kigali. Expanding finance schemes with longer repayment periods, repayment through utility bills, better financing for distributors, additional demonstration and stronger building rules could extend uptake to other customers and places.

- **Rwanda has green building rules, but incentives, enforcement and policy signals do not yet align.** Rather than a general regulatory gap, our analysis identifies three specific implementation failures. Firstly, several formal green building incentives exist that have not yet been operationalised in a systematic way, including tax breaks, expedited permitting and fee waivers, leaving firms uncertain about the support available and how to obtain it.

Secondly, the GBMCS applies only to multi-storey, commercial and industrial buildings (Categories 4 and 5), thus excluding most buildings (Categories 1-3) from a planned pathway towards adopting the respective green requirements. Thirdly, building permits are not consistently verified after issue and clients can substitute materials without reporting it. The immediate response should be to fully operationalise all available incentives, making them accessible to firms and customers, extend the GBMCS in realistic and predictable stages beyond only large-scale buildings, and require post-permit verification of approved materials.

In addition, conflicting policy signals may confuse the sector to some extent: in the new 2024 Industrial Policy, construction is no longer a priority sector, thus calling into question the extent to which the planned support instruments such as mentorship schemes and technology transfer offices will be made available to foster green construction. Furthermore, the Made in Rwanda (MIR) Policy promotes local content, while the 2024 Industrial Policy fosters export competitiveness. The question here is which direction green industrial policy for the construction industry will go. Greater clarity will provide an important signal for firms to shift their operations towards green alternatives.

Five levers to support the implementation challenge

Our findings point to five important levers that can generate cross-cutting impacts when applied collectively and sequentially, addressing firm, market and policy barriers simultaneously:

- Reform the green finance framework for MSMEs, firstly by widening existing channels (rather than creating new ones) and then testing a green property tax and land value capture mechanism targeting the high-end market, with revenue recycling into MSME green finance.
- Design supplier development initiatives requiring large businesses that hold public contracts to mentor and partner with MSMEs, thus creating stable value chain linkages that will justify investments in employees and technology.
- Roll out green buildings and renewable energy regulations sequentially, starting from Category 3 buildings, tightening Categories 4-5 in gradual stages, and providing realistic green requirements for Categories 1-2 while ensuring consistency of definitions across all regulatory instruments.
- Leverage public procurement to catalyse early markets for green materials, green skills and local contractors by applying straightforward tender provisions and contract conditions, as well as allocating MSME work packages under major public contracts.
- Demonstrate public commitment to green buildings by applying tested local materials in public buildings and staggered-price demonstration houses across the country, thus generating comparable evidence on cost, comfort, maintenance and durability in addition to visibility through public communication via media and/or local champions.

Relevance beyond Rwanda

Three contributions travel. Firstly, green is not binary: 58 per cent of firms and jobs in Kigali's construction value chain are partially green, so policy aimed at "green firms" misses the majority. Secondly, the skills constraint on green upgrading is also managerial rather than only technical and intensifies as firms formalise and grow – which challenges the technical training default in green industrial policy across low- and middle-income countries (LMICs). Thirdly, upgrading pathways determine which constraint is binding: credentialing for bottom-up materials, ecosystem and anchor demand for hybrid ones, and finance depth and maintenance capacity for top-down imports. Any country facing Rwanda's choice – how to build at speed without locking in concrete – will recognise all three.

1 Introduction and rationale of the study

The buildings and construction industry is a major contributor to global climate change. It accounts for around 37 per cent of global carbon dioxide emissions and 28 per cent of global energy consumption, alongside nearly 50 per cent of global material extraction (UNEP [United Nations Environment Programme], 2026). Its emissions are also expected to continue rising under current trajectories. Recent modelling suggests that, without a significant change in direction, construction alone could consume the remaining carbon budget compatible with the 1.5°C and 2°C climate targets by 2050 (Li et al., 2025). Construction presents two challenges. Firstly, emissions come both from the energy used in buildings and from the materials used to construct them. Materials such as cement, steel and fired bricks generate substantial embodied emissions that are effectively locked in once construction takes place. Secondly, much of the world's future construction will occur in the rapidly urbanising regions of the Global South. The buildings and infrastructure constructed today will therefore shape emissions and resource use for decades to come.

The choices made in Sub-Saharan Africa, the world's fastest-urbanising region, will be critical. The region's urban population is projected to nearly double by 2050, while the region faces a widening housing deficit of tens of millions of units (UN DESA [United Nations Department of Economic and Social Affairs], 2025). Each new wave of construction is therefore a development necessity but also a climate choice with consequences that reach far beyond the boundaries of any single project. This places Sub-Saharan African economies in an unusual position: unlike many industrialised countries, they have not yet made the same scale of investment in carbon-intensive buildings and infrastructure that will require costly retrofitting in the future. This gives African countries an opportunity to avoid locking in high-carbon construction practices and to adopt more sustainable approaches from the outset. Whether this becomes a genuine advantage, however, will depend on the will and capacity of institutions and firms to implement them.

The Government of Rwanda (GoR) has already set ambitious climate and development targets, including achieving high-income and carbon-neutral status by 2050 and reducing greenhouse gas emissions by up to 53 per cent by 2035 relative to business as usual levels (Republic of Rwanda, 2020; MoE [Ministry of Environment], 2023). These commitments build on two decades of action on environmental sustainability. Rwanda has introduced measures ranging from its early ban on single-use plastics to large-scale ecosystem and forest restoration (WEF [World Economic Forum], 2016; GGGI [Global Green Growth Institute], 2023). In 2012, it also established the Rwanda Green Fund (FONERWA), which has become an important channel for public, private and international finance for climate and green investment (UNFCCC [United Nations Framework Convention on Climate Change], 2023). At COP27 in Egypt in 2022, the GoR launched Ireme Invest, a green investment facility to boost private sector access to climate finance (FONERWA, 2026).

Vision 2050, the GoR's long-term strategy, frames these commitments not as constraints on development but as the form development is expected to take, with explicit goals of universal access to affordable and decent housing and the development of smart and green cities for sustainable growth (Republic of Rwanda, 2020). Achieving these objectives will require Rwanda to expand its housing and infrastructure while ensuring that new construction is resource-efficient, climate-resilient and increasingly low-carbon.

The scale of this challenge is significant: Rwanda is landlocked, resource-constrained and one of the most densely populated countries in the world (Imasiku & Ntagwirumugara, 2019). Its population is projected to reach approximately 22.1 million by 2050, compared with around 14.6 million in 2025 (Republic of Rwanda, 2020; UNFPA [United Nations Population Fund], 2026). Meeting this growth will require the construction of at least 150,000 housing units each year through to 2050, while Kigali alone is estimated to require approximately 310,000 additional housing units by 2032 (RHA [Rwanda Housing Authority], n.d.; MININFRA [Ministry of Infrastructure], 2019a). At the same time, Rwanda faces increasing climate risks, including heavy

rainfall, floods, landslides and droughts. The May 2023 floods killed at least 135 people, destroyed 3,000 homes and displaced 5,000 people (MINEMA [Ministry in Charge of Emergency Management], 2024). Located within the East African Rift Valley, Rwanda also faces a moderate risk of seismic activity, requiring earthquake-resistant designs for buildings and infrastructure, as specified in the Rwanda Building Code (RMB [Rwanda Mines, Petroleum and Gas Board], n.d.; Republic of Rwanda, 2019).

The transition must also create economic opportunities. Rwanda has maintained strong economic growth, averaging around 8 per cent annually over the last two decades (NISR [National Institute of Statistics of Rwanda], 2025). In 2025, Rwanda's gross domestic product (GDP) grew by 9.4 per cent (NISR, 2025). However, labour underutilisation, which includes unemployment, time-related underemployment and potential labour force, remained high at 54.2 per cent in 2024, while economic diversification remains below African averages (NISR, 2024b; ACET [African Centre for Economic Transformation], 2023). Three challenges must therefore be addressed simultaneously: building a low-carbon economy without compromising development needs, providing adequate housing for a rapidly growing urban population, and developing the skilled workforce and decent jobs that a young and growing labour force requires.

The construction industry as a strategic entry point

The construction industry sits at the intersection of Rwanda's housing, climate and employment challenges. It is the country's third-largest employer, with employment expected to grow by around 9 per cent annually in the coming years (Mwiza, 2025; Never et al., 2025). It is also central to addressing the housing deficit and will strongly influence Rwanda's future emissions through choices of materials, technologies and skills. For example, greater use of locally sourced materials, resource-efficient technologies and lower-carbon production methods can create jobs, strengthen skills, reduce input costs and increase resilience to import price fluctuations. Energy efficiency and circular production can also improve productivity and create new business opportunities (Nußholz et al., 2020; Darmandieu et al., 2022; Horbach & Rammer, 2019; Sovacool et al., 2023). For Rwanda, making construction greener therefore offers a practical opportunity to advance climate objectives while expanding housing, employment and economic opportunities.

Realising this opportunity will require action across the construction value chain – from the availability and affordability of green materials and technologies to finance, skills, market demand and regulation. This policy report draws on qualitative and quantitative research conducted by the German Institute of Development and Sustainability (IDOS) in collaboration with the University of Rwanda and Equilibria Ltd, a Rwandan consultancy firm, to answer the question of how Rwanda's construction industry can become both greener and more productive. The report considers current dynamics in the construction industry, examines barriers to greening and productivity for micro, small and medium-sized enterprises (MSMEs), and identifies practical policy measures to accelerate the adoption of green construction materials and technologies while supporting wider development and employment objectives. The report also presents three case studies on green building materials and technologies with high potential: interlocking stabilised soil blocks (ISSBs),[1] improved adobe/rukarakara,[2] and residential solar photovoltaic (PV) systems[3] and solar water heaters (SWHs).[4]

1 Locally produced earth blocks stabilised with cement (typically 4-8 per cent) and shaped using a manual or hydraulic press, including the Hydraform variant (used a synonym for ISSBs in Rwanda, referring to the firm that introduced the technology)

2 A locally produced sundried earth block (adobe) made according to improved technical guidelines for mixing, curing and wall protection

3 Rooftop and ground-mounted solar electricity generation, including grid-connected and off-grid configurations

4 Roof-mounted thermal systems for domestic and commercial hot water production

In terms of a conceptual framework geared towards more academic audiences, this report assumes that different sub-sectoral upgrading pathways for firms are possible according to the type of material or technology. This means that a firm producing ISSBs may follow a different upgrading trajectory, in other words may become more productive and achieve greater growth than a solar PV firm, for example. Based on the literature on global value chains, industrial policy, and sectoral and technological innovation systems (Chioatto et al., 2026; Bergek et al., 2008; Humphrey & Schmitz, 2000; Gereffi et al., 2005; Malerba, 2002), we roughly differentiate between two (stylised) pathways:

- A *top-down* pathway: Large lead firms, often international and/or export-oriented ones, are instrumental in both the spread of environmental innovations, particularly product and process innovations, and in firm growth (Humphrey & Schmitz, 2000; Gereffi et al., 2005). From this perspective, the integration of local firms into global value chains is regarded as key for local firms, especially MSMEs, to become more productive, grow and generate jobs.
- A *bottom-up* pathway: This starts from smaller, local firms that innovate and adopt new materials and technologies. These then spread more horizontally at first and eventually move upwards into higher market segments as firms upgrade. From this perspective, the integration of firms into local networks and clusters as well as local or regional markets is key for upgrading and the spread of innovations (Chioatto et al., 2026; Bergek et al., 2008; Malerba, 2002).

Both pathways are influenced by a range of firm-level, market and policy characteristics that may be either general or specific to each of the four materials and technologies we analyse in this report.

As this report targets an audience of policy-makers and practitioners, we refrain from more in-depth academic discussions and analyses of upgrading pathways and the relevance of our findings for these conceptual debates here; academic articles for interested readers will be forthcoming.

2 Current dynamics of Rwanda's construction industry

The construction industry is one of the most dynamic economic sectors in Rwanda, especially in Kigali and major secondary cities such as Huye and Musanze. It accounted for 8.7 per cent of the gross domestic product in 2024 and grew by 11 per cent in 2025 (NISR, 2024a, 2026). In Kigali, the numbers of commercial buildings such as shopping centres and office towers and of mid- to high-end condominium buildings (where individuals own a housing unit but share communal space) are surging. Large government projects such as the new Bugesera Airport are providing an additional market boost that is also being felt in the demand for materials, for example cement. Outside the major cities, the construction industry is of a much smaller scale and is less dynamic, geared towards individual dwellings and repairs.

The speed of developments differs by building types, differentiating the market into segments. The market segment for multi-storey buildings in central urban areas is growing the fastest. These buildings cater to both densification needs and the interests of international investors who expect high rates of return. Many of these buildings have at least some green features. Especially in Kigali, population growth and space restrictions of the hilly city require a shift to vertical construction and densification. Aimed at middle- to upper-income households and commercial users, such projects offer high profits, receive building permits quickly and attract foreign direct investment (FDI). In contrast, green or low-carbon houses for lower-income brackets of the population rarely present a viable business case on their own yet. These projects are usually state- or international donor-funded and thus offer the strong lever of public procurement, but

the dynamic of the market segment depends more on public project cycles. In between these two extremes, a considerable amount of small-scale construction of individual one-storey buildings, renovations and repairs is happening. The dynamics in this market segment are steadier to the extent that clients can access finance. However, projects are small-scale and usually less profitable for firms engaging in it.

The fragmented, skewed firm landscape reflects these market segments and indicates weak value chain linkages. The few large national and international firms active in the market focus on large construction projects with high rates of return, mainly in Kigali. They maintain close relationships with the GoR and win most government contracts. A vast array of micro and small enterprises and of individual *amafundi* (masons) cater to the many small-scale individual dwelling constructions and repairs. The largely missing middle indicates weak value chain linkages, as medium-sized firms often function as an anchor for small suppliers and larger procuring firms. The missing middle poses a challenge for local green and productive firm development because well-functioning enterprise ecosystems support individual firm upgrading in general, and specifically technology and innovation diffusion along value chains (Altenburg & Lütkenhorst, 2015).

The strong role of the government in the construction industry cuts both ways for future green building market development. The GoR is the most dominant economic actor in construction. It is also the largest employer and client. This allows the state to steer the industry in the desired direction, such as the green transition, rather than the industry pushing for it itself. These positive effects are likely to increase with the implementation of the new public procurement policy, which could provide a strong lever for the green building transition. The disadvantage of the strong role of the state is that the private sector depends so much on the government that it tends to enter a state of inertia or reluctance to innovate independently. The relations between the state and large construction firms are not fully transparent. Behuria (2026) argues that political control shapes economic decisions to the disadvantage of domestic firms and technological upgrading in sectors such as agriculture, mining and manufacturing. For the construction industry, we also find that the GoR is waiting for the private sector to upgrade and grow, while the private sector appears to continue to be waiting for signals from the GoR.

Generally speaking, the private sector is not proactive or productive enough yet to reap the full benefits of current market dynamics and a green building transition. This is due to a variety of factors within firms and at market level but may also reflect some general challenges pertaining to the structure and political economy of the innovation system (see Section 4). The generally low levels of productivity and very limited upgrading dynamics of MSMEs hamper participation in other construction market segments irrespective of the degree of “greenness” of the building. For the green building transition to succeed, all building types and market segments and therefore all firm types need to be included in sequential, target group-oriented implementation pathways.

3 Current status of green practices and green jobs in the construction value chain

The construction value chain in Rwanda includes all firms that contribute to planning and design, material sourcing and manufacturing, pre-construction and procurement, actual construction, and operations or maintenance of a building (leading to end-of-life recycling). In the first phase of our research project (2023-2025), we captured the status of green practices and the number of green jobs in Kigali’s construction value chain. Green practices include resource saving (energy, water, materials), transport reduction (fuel emissions, air pollution), reuse and lifecycle considerations, resource-efficient design and client advice on all the topics mentioned. On the

one hand, the extent of green practices varies according to the firm type: on average, planners (architects, civil engineers) and technology installation firms tend to engage more frequently in green practices than material producers and hardware stores or suppliers; construction firms, including masons, hold the middle ground in our sample of 546 firms (2024 firm survey). On the other hand, most firms in our sample fall into the middle range, engaging in some selected green practices. While a small minority of firms have adopted robust sustainability measures, an equally small proportion remain almost entirely disconnected from green practices. The majority of firms (58 per cent) are categorised as "mixed green", indicating that many remain partially or marginally engaged in sustainable initiatives (Never et al., 2025).

A range of green jobs already exist in the construction industry, even if not all jobs are fully green yet (see Figure 1), meaning that firms regularly perform green practices in all key environmental dimensions:[5] 5 per cent are fully green jobs, 58 per cent are mixed green jobs and 37 per cent are mostly non-green jobs in Kigali's construction value chain. Based on regression analyses of our survey data, we found that greening firms is associated with higher employment, higher shares of permanent jobs and better working conditions. We define green jobs in Rwanda's construction industry as roles that advance environmental sustainability or resource efficiency throughout the building lifecycle, from planning and design to demolition or repurposing (green practices). These jobs may involve responsibly sourced and low-impact materials, minimal transportation emissions, and consideration of environmental impacts during a building's use; cost-effective strategies that reduce resource consumption by saving energy and water and/or reusing/recycling materials; and providing guidance to clients on greener choices. Such roles can be found at any point in the value chain – directly on construction sites or indirectly in administrative and supply functions. They vary in green intensity, ranging from certified practices to partial improvements that emerge from bottom-up or informal initiatives. In our definition, "green" is thus not a unidimensional concept and going from non-green to green is not dichotomous: in other words, there are different shades of green in terms of green practices across environmental dimensions. For example, a firm may save water and energy but not yet engage in recycling or transport emission reduction, or it may do all of these but not yet integrate lifecycle thinking.

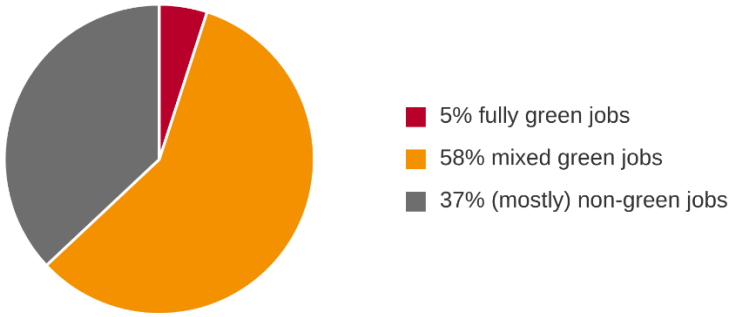
The move from green practices in construction firms to more productive green jobs has several interim steps. More green jobs are one of the results of higher productivity rather than the other way around. To achieve higher productivity, factors such as the firm's labour productivity and machinery/technology per number of employees, sales performance and profit margin, and cost and resource efficiency (lower production and operating expenses) must increase first. Factors external to the firm such as infrastructure and the business environment add to the complexity. As interim steps towards more green jobs, improving the input costs for production and reducing operational expenses by saving resources as well as investing in green marketing to improve sales performance present useful measures that firms can undertake themselves.

5 As defined in Never et al. (2025): water, energy and resource saving; transport emission reductions; planning/building/selling recycled/reused materials; lifecycle considerations (planning and building with dismantling and reuse of parts of the building in mind); client advice on water, energy and resource saving as well as recycling

Figure 1: Green jobs, job growth and job quality in Kigali's construction value chain

Greening rapidly growing cities offers many opportunities. What effect does greening have on employment? How can the potential be reaped?

Current distribution of green jobs



Support pathways from mixed green to fully green jobs

Job growth

Green firms grow faster and offer more permanent jobs than non-green firms*

Job quality

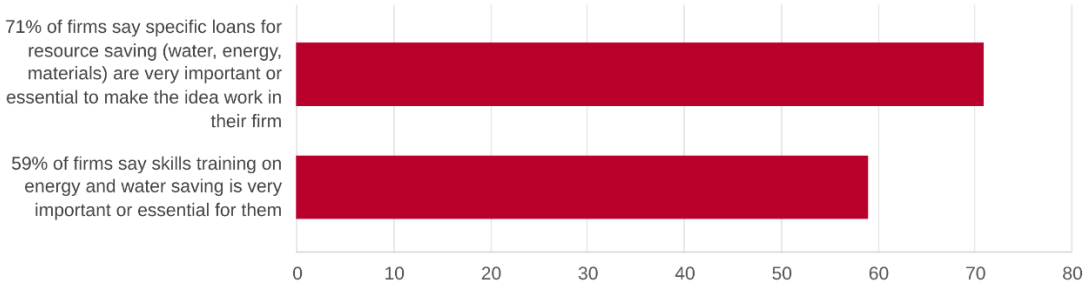
Green firms offer better working conditions e.g. stable employment conditions, especially for women*

** Results statistically significant in our survey*

The circular economy is happening from the bottom up

- 47% of masons/builders in our sample reuse clay bricks
- 25% reuse parts of concrete
- 38% reuse steel frames and pipes

Ways forward



Innovative approaches

About 75% of the firms surveyed see the value of setting up **material banks** to exchange materials, have **test facilities** for quality/durability and **order materials in bulk** together to save costs

Source: Data obtained by authors (Never, Stoecker, Tsinda & Mugisha) in the first phase of the research project (2023-2025)

The main green construction materials and technologies vary in technological complexity, durability and market scaling opportunity, which is reflected in their current position in the Rwandan market. In terms of environmental friendliness, improved rukarakara and ISSBs are most favourable due to their locally sourced content, often directly on the construction site. Volcanic stone is environmentally friendly, but may score higher on transport emissions due to its high weight, depending on the distance of the construction site from its source. Regarding timber, its environmental qualities depend on whether it is sustainably sourced and certified by an independent body – as a renewable material, it is very environmentally friendly and, when treated for construction, is also very stable and durable. Fired bricks are made of local clay in Rwanda (for example, Ruliba bricks) and are hence environmentally friendly, but the firing process generates greenhouse gas emissions. Depending on calculation methods, assumptions about the dwelling and comparative measures, the environmental footprint of each material calculated in scientific publications may differ (see, for example, Hafez et al., 2026; Hammood et al., 2026).

Based on the 2026 firm survey (see Figures A1 and A2 in the Annex), the largest awareness gap among the selected materials is found for ISSBs and is slightly more pronounced among masons/roofers than among architects/engineers. Regular use is virtually absent across both groups. Improved rukarakara is better known but has the highest share of respondents who are aware of the material but do not use it; regular use also remains limited. By contrast, fired bricks are the predominant material, with a large majority of both architects/engineers and masons/roofers reporting very frequent use. Timber is the second most widely used material, again somewhat more frequently used among architects/engineers. Volcanic stone is relatively well known among both groups, but use is generally occasional rather than frequent. The firm survey further shows that awareness and use of solar panels and SWHs are substantially higher among electricians/plumbers than among masons/roofers, consistent with their greater technical specialisation. The difference between the two groups is smaller for rainwater harvesting (RWH) systems: awareness is higher among masons/roofers, while reported use is broadly similar. SWHs are the most widely used of the three technologies among electricians/plumbers, with 60 per cent reporting regular use, but they remain much less familiar and less frequently used among masons/roofers. Solar panels show a broadly similar pattern.

Regional variations within the country are significant for construction material and technology value chains. The availability of local soils and input materials varies considerably. Volcanic rock is widely available and used in Musanze, although blasting makes it expensive as a construction material, while Huye has substantial untapped laterite deposits. This opens up opportunities for value chains based on ISSBs, improved rukarakara or combinations of these with low-carbon cement. Almost everything that green construction depends on is concentrated in Kigali. According to interviewees, certified green building professionals are almost exclusively based here, as are skilled workers more broadly, with peri-urban areas functioning as suppliers of both labour and raw materials to the capital. Green technology providers operate primarily from Kigali, and high-end demand, suppliers and demonstration projects are all clustered here, while firms in other cities still need to build up these capacities.

4 Main findings: how to foster greening and productivity

The key to fostering greening and productivity of local construction firms, especially MSMEs, lies in using the most effective levers to overcome the remaining cross-cutting and specific barriers at firm, market and policy level in a concerted manner. Based on our firm survey, focus group discussions and interviews, we have identified five main levers with the potential to generate cross-cutting positive effects: (1) revision of the green finance system for MSMEs, including generating revenue via green property taxes (land value capture), (2) the introduction of supplier development programmes to strengthen value chain linkages, (3) a sequential phase-in and integration of green building and renewable energy regulations, (4) the implementation of public procurement with the aim of greening MSMEs and (5) green construction confidence and acceptance programmes. In this section, we first summarise the main barriers before discussing the levers to overcome them in more detail. We zoom in on skills and training as a necessary, but not sufficient condition for successful firm upgrading.

For the sake of readability, we refrain from quoting extensively from the interviews and from inserting references to the 88 interview (INT) numbers, the two focus group discussions and/or the firm survey at the end of every sentence. References are given for key statements and controversial opinions to flag the evidence base more explicitly in these cases.

4.1 Remaining barriers to greening and productivity in the construction industry

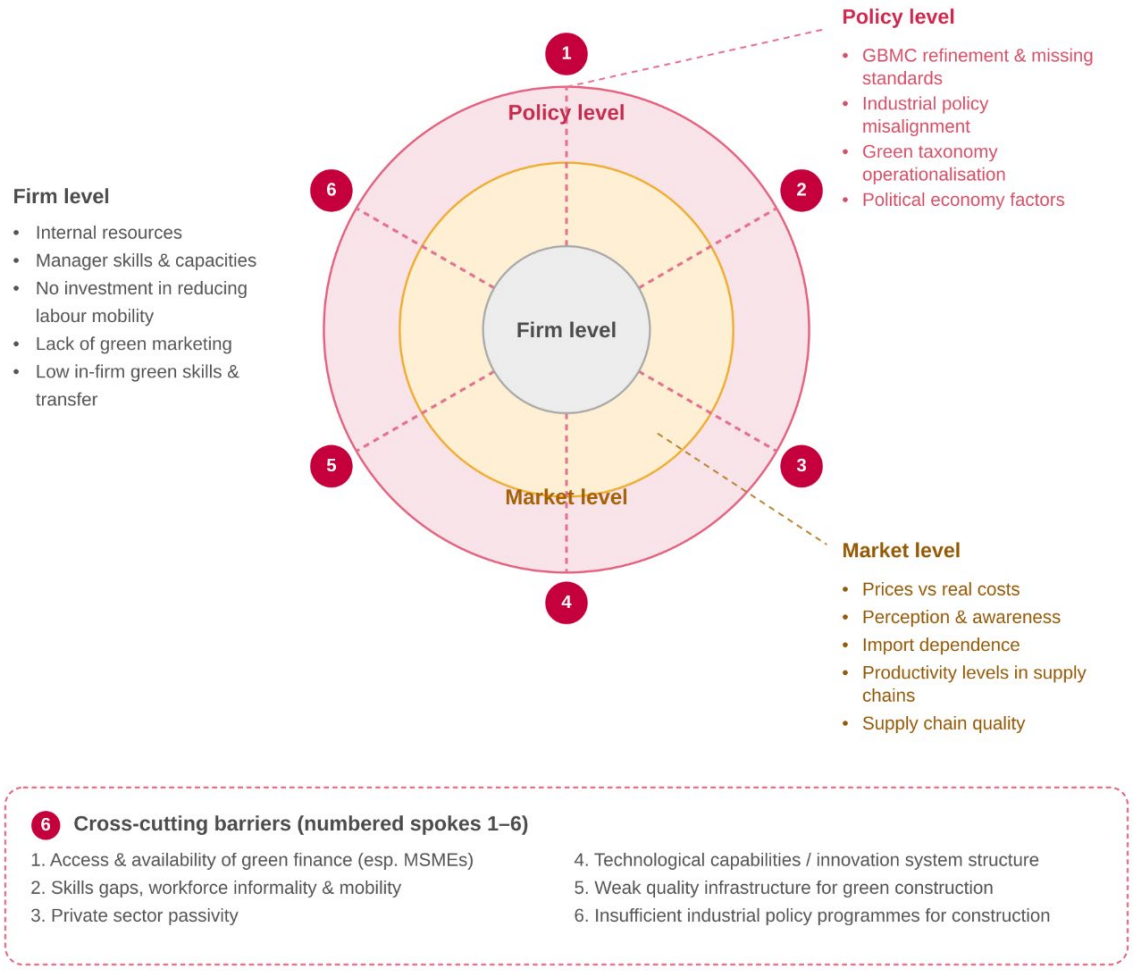
4.1.1 Barriers at the firm, market and policy level

Only some of the remaining firm-, market- and policy-level barriers are specific to construction, especially to green construction. Within **firms**, these barriers are a lack of green marketing by managers, low levels of green skills and technological capabilities, and a lack of their transfer between employees (see Figure 2). A lack of proactive green marketing reflects generally low levels of marketing capability and missing business management skills and possibly overlaps with perceptions of client demand or own concerns about durability or quality of green options (see below).

At the **market** level, the divergence between perceived and real prices for green materials and technologies and the attitude towards and awareness levels of these materials and technologies are specific to the construction industry. Cost is the single most decisive factor in whether clients accept or reject a particular material, technology or design. There was very high agreement among interviewees on this point. Several practitioners argue that the *perceived* cost gap between green and conventional construction is larger than the *real* one (e.g. INT 9, 31, 49). The perception that “green is expensive” is deeply entrenched and is not limited to clients: MSMEs and even some practitioners equate “green” with paying more, regardless of the actual costs involved (e.g. INT 15, 47; focus group discussion 2).

Real green construction costs vary compared with conventional construction, depending on the material or technology involved (see Tables 1 and 2). Whereas some green materials cost more than conventional ones, options such as traditional and improved rukarakara are notably cheaper than concrete blocks or fired bricks. While ISSB bricks are slightly more expensive than fired bricks according to our data collection and calculations, they are in line with concrete blocks and have much better environmental properties.

Figure 2: Barriers to a greener and more productive construction industry in Rwanda



Source: Authors' data from qualitative research (2026)

Some firms report green construction costing 50 or even 100 per cent more than the price of conventional construction (e.g. INT 9, 49), and as Tables 1 and 2 show, technologies such as SWHs can entail higher upfront costs. Yet our rough calculation of lifecycle costs across 10 years indicates that SWHs come with lower long-term costs. Given the wide variation in upfront costs, unit costs and wall costs across materials and technologies, it is hard to generalise about green versus conventional construction costs. On the one hand, when firms present these costs to clients, the standard response is to revert to conventional practices to stay within budget. On the other hand, some firms calculate their price offers to contracting engineers or clients at a higher level when green features are asked for, simply assuming that green construction must be more expensive.

In terms of attitudes and awareness, there is a widespread notion that green materials are weaker, less durable and less reliable than conventional ones (e.g. INT 2, 9, 11). Interviewees report that conventional materials such as cement blocks and fired bricks are generally more trusted and assigned higher value by clients (e.g. INT 1, 2). The reality is more nuanced: some green materials perform less well under specific conditions, but mitigation measures can usually be taken to offset such disadvantages. Moreover, durability is relative. While cement houses are known for long lifespans, traditional earth-based houses built from rukarakara in Rwanda have stood for 50 years and more, and improved versions could perform better still. Durability nonetheless remains a legitimate concern in a country that is increasingly exposed to climate risks and seismic activity. Misconceptions surrounding newer technologies compound the issue.

Some clients still believe that solar systems are unreliable or short-lived, a perception rooted in earlier generations of technology and in low-quality imported products. Furthermore, many MSMEs and clients alike do not know what green construction looks like, what it costs, how it performs or why it is important. Materials such as ISSBs are unfamiliar to many, and passive design options such as natural ventilation and passive cooling remain largely unknown. Even where a material or technology is named, such as “improved rukarakara”, there is often no clear sense of what makes it “improved” (see Section 5.2).

Table 1: Materials costs

Material	Unit price (RWF)	Face size	Bricks per m² of wall	Cost per m² of wall (RWF)	Cost for 180 m² of wall (RWF)
Traditional rukarakara	150	20 × 40 cm	11.61	1,742	313,589
Improved rukarakara	250	20 × 30 cm	15.36	3,840	691,244
Fired bricks	150	21 x 6.3 cm	62.27	9,340	1,681,196
ISSBs	350	29 × 11.5 cm	11.61	10,315	1,856,764
Concrete blocks	900	20 × 40 cm	29.47	10,453	1,881,533

Notes: Unit prices are based on interviews and phone calls with respective firms and suppliers (February to March 2026). Brick dimensions follow RHA standards, Makiga specifications for ISSBs, and Ruliba Clay specifications for fired bricks (Standard Brick 10). For traditional rukarakara, dimensions are indicative, based on supplier information, as units are not standardised and may vary between different producers and batches. Bricks per m² are calculated using a 10-mm horizontal and vertical mortar joint for conventional masonry. ISSBs are assumed to be dry stacked, with a 10-mm mortar bed after every fifth course. Costs represent wall unit purchase costs only; mortar, labour, transport, finishing and wastage are excluded. The final column assumes 180 m² of wall area for a standard 100 m² house.

Source: Authors’ calculations (2026)

Table 2: Technology costs

Technology	Upfront cost (RWF)	Annual electricity cost (RWF)	Overall cost over 10 years (RWF)
Regular water heater (50 L)	350,000	127,313	1,623,125
Solar water heater (50 L)	1,000,000	38,194	1,381,938

Notes: Upfront costs are based on interviews and phone calls with respective firms and suppliers (February to March 2026). Annual electricity costs assume that 50 L of water is heated daily from 20°C to 50°C, requiring 1.74 kWh per day, at an electricity price of 200 RWF/kWh. The SWH is assumed to meet 70 per cent of hot water demand, with electricity used to cover the remaining 30 per cent (based on REG [Rwanda Energy Group] guidance). Overall costs equal upfront costs plus annual electricity costs over 10 years; they exclude maintenance, installation, financing and changes in electricity prices.

Source: Authors’ calculations

An improved phase-in of the Green Building Code System, aligning industrial policy instruments and operationalising the Green Taxonomy could help overcome remaining barriers to green firm upgrading and further refine the current policy package.

Firstly, the (revised) Building Code and the GBMCS are key policy tools for the green building transition. Up to 2026, there were nine formal incentives for green buildings (tax incentives, bonus density, expedited permitting, net metering, grants, loans, fee subsidies, technical assistance and leasing assistance), but the building-specific incentives have not yet been operationalised in a systematic or documented way. Firms consequently bear the full cost of greening with no compensating reward. Without such a reward, building green will remain a matter of compliance rather than commercial motivation. The third listed incentive, “expedited permitting” (i.e. including green construction indicators in the permitting process and giving it preferable treatment), has been directly mentioned as being absent in our interviews.

Interview findings also suggest that clients can change construction materials after receiving the construction permit without having to report this back to the authority (e.g. INT 55, 63). Permits as currently issued are not consistently followed up on site, so what applicants build can differ from what they applied for. This means that introducing preferential treatment for green materials in the permitting process would need to be paired with post-permit verification to translate into actual changes on the ground.

In addition, the GBMCS needs an updated, systematic phase-in process that is communicated to all stakeholders with clear sequencing steps to reduce uncertainty. Interviewees identified this as a gap (e.g. INT 7, 20). This phase-in process also needs to include standards setting that gives enough time for the domestic market to be ready while clearly signalling the time plan for ratcheting up. A market readiness study is only being conducted now rather than before the introduction of the GBMCS. The German energy-efficient building system provides an instructive example of a phase-in managed over decades (Never & Kemp, 2017).

In line with discussions within MININFRA, an extension of the GBMCS to cover residential buildings and the adjustment of thresholds would be advisable. For large buildings, thresholds need to be ratcheted up, as several interviewees describe the compliance threshold as low and easily achievable for the large buildings to which it applies. One of our interviewees reported that the moment the GBMCS was introduced, every one of the firm’s existing buildings already qualified without any change in practice (INT 50).

Secondly, the current misalignment of industrial policies in the construction industry may send confusing signals to the market. This barrier about policy signals mainly concerns the Made in Rwanda (MIR) Policy (2017) and the new Industrial Policy (2024). The new Industrial Policy is oriented towards export competitiveness and integration into global value chains, which is at odds with MIR, a policy explicitly designed around import substitution and local content production (MINICOM [Ministry of Trade and Industry], 2024). The available empirical literature on the impact of MIR is still scarce. However, it does point to a generally positive, but uneven effect of the policy on the construction industry.

Analysing a small sample of 48 construction industry respondents, Sikubwabo (2024) finds that around 71 per cent of these agree or strongly agree that growth-oriented MIR instruments (policy incentives, infrastructure access, raw materials access, government support programmes and policy awareness) improved their market position, with 69 per cent reporting that competitive advantage instruments (export facilitation, quality standards, trade agreements, branding, capacity building) did so. Thus, while MIR pushes more towards local construction materials and building domestic manufacturing, the new Industrial Policy pulls towards global markets and supports export-competitive sectors, leaving the construction industry outside its priorities. Construction constituted a priority sector in the previous industrial policy, but it is no longer a

focus. Further industrial policy instruments to boost value chain development, such as supplier development programmes with mandatory training, are also missing (see Section 4.2.2).

Thirdly, operationalising the Rwanda Green Taxonomy presents a key challenge. Showcased at COP28 in Dubai in December 2023 and then finalised in November 2024 as one of the first green taxonomies in Africa, the taxonomy provides a common framework for identifying activities that qualify as green investments (MINECOFIN [Ministry of Finance and Economic Planning], 2026b; IMF [International Monetary Fund], 2024). It aims to improve transparency, reduce greenwashing and channel finance towards Rwanda's climate and green-growth objectives (MINECOFIN & MoE [Ministry of Environment], 2024b).

Its importance for construction is growing, as taxonomy alignment can determine access to green finance from institutions such as BRD, FONERWA and Ireme Invest. Buildings can demonstrate alignment through established green building certification systems such as EDGE – Excellence in Design for Greater Efficiencies (developed by the International Finance Corporation, IFC) and LEED – Leadership in Energy and Environmental Design (developed by the US Green Building Council) or by achieving at least 80 points in the energy module of the GBMCS, among others (MINECOFIN & MoE, 2024a). Alongside international interoperability, credibility and scalability, the effectiveness of the taxonomy depends on local adaptation and buy-in – that is, how well the taxonomy fits the country context and existing regulations, how easily firms can understand and apply its requirements, and how incentivised they are to comply if compliance is voluntary, as is currently the case in Rwanda (SAIIA, 2024). International experience, particularly in the European Union (EU), shows that high compliance costs, complex requirements and limited technical capacity can discourage MSME participation even where willingness to comply exists (O'Reilly et al., 2023). So far, no studies have been conducted on the impact of the Rwanda Green Taxonomy in general, let alone specifically on MSMEs in the construction industry.

However, findings from our own research suggest that there is no simplified pathway or dedicated MSME-specific guidance in the taxonomy materials yet. BRD should therefore provide such pathways and guidance, drawing, where relevant, on international reference documents such as the Association of Southeast Asian Nations (ASEAN) Taxonomy for Sustainable Finance Supplementary Document, which provides practical guidance for MSMEs and a use case for construction (ASEAN Taxonomy Board, 2024). Moreover, disclosure requirements and compliance costs should be kept proportionate and manageable to avoid discouraging MSME participation; instead, targeted government incentives or funding could be provided to encourage and support MSMEs that comply with the taxonomy. In addition, aligning taxonomy with the Building Code, including the GBMCS, is critical.

The non-green barriers to firm upgrading at firm, market and policy level also exist in other economic sectors in Rwanda. Some even apply to the realities of semi-formal and informal firms in LMICs more broadly. Limited business and management skills, limited technological capabilities, quality and reliability issues in often semi-formal supply chains, weak contractual ties and high worker mobility, a general lack of resources and actor capacity at various levels and the import dependence of a small, land-locked country are all factors that are well known in development economics and economic policy debates (e.g. Biggs et al., 1995; Hampel-Milagrosa et al., 2015; Humphrey & Schmitz, 2000; Mano et al., 2012; Söderbom & Teal, 2004). They require no in-depth discussion here. Labour market constraints such as skills mismatches, insufficient levels of training and challenges concerning decent work criteria still affect most economic sectors in Rwanda, as they do in other countries in Sub-Saharan Africa (Brudevold-Newman & Ubfal, 2024; RDB, 2023; Filmer & Fox, 2014). Policy implementation, effectiveness, monitoring and evaluation also present common challenges, even if Rwanda is doing fairly well overall compared with other countries in the region (World Bank, 2026b).

4.1.2 Cross-cutting barriers

Six cross-cutting barriers that hamper all levels of the construction industry (Figure 2) merit attention.

4.1.2.1 Access to green finance

Access to and availability of green finance for MSMEs presents a major bottleneck. MSMEs face a working capital mismatch: without sufficient equity, firms cannot maintain the stock levels needed to grow, unlike equity-funded or larger firms. Green finance instruments such as Ireme Invest, BRD and FONERWA are formally available, but most MSMEs cannot meet eligibility requirements due to inadequate financial records, weak proposal writing capacity and collateral demands that exclude green equipment (banks require land). Many MSMEs are not aware of the credit and loan options available or, if they are, they do not know how to navigate application and eligibility (e.g. INT 4, 7). The core issue is therefore not a lack of instruments but a structural mismatch between Rwanda's green finance architecture and the realities of the firms it is designed to serve. According to an African Development Bank (2025) report on Rwanda, Ireme Invest was initially capitalised with USD 104 million to support e-mobility, green buildings and circular economy projects, while initiatives such as the Kigali International Financial Centre and Intego Green Investment mobilised more than EUR 300 million in private capital. The clearest sign that this architecture is more aspirational than operational comes from the banks themselves. Of the three institutions interviewed, only BRD runs an operational green construction product (via Ireme Invest, where green buildings made up 71 per cent of the green portfolio at the end of 2025). Both the Bank of Kigali and I&M Bank frame their inaction as externally driven, referring to the lack of clear national green building criteria and costly EDGE certification (USD 20,000-30,000, which the Bank of Kigali does not finance) and to the absence of below-market concessional capital from development finance institutions or FONERWA. Tellingly, neither bank mentioned internal barriers such as margins, collateral rules or risk models in the interviews.

The gap is starker at the savings and credit cooperative organisation (SACCO) level. SACCOs are closest to MSMEs, yet demand for their services already exceeds supply. They remain primarily savings institutions; construction-related accounts mostly collect deposits rather than fund loans. Loans are capped at around RWF 50 million (at least for some SACCOs), far below the requirements of most green construction projects. SACCOs face the same collateral problem as banks, especially in urban areas, but partly offset it through relationship-based lending and cooperative guarantors. So far, SACCOs have no structured green construction products – only water tanks and solar systems – and report a real skills gap in assessing green construction (e.g. INT 68, 73). The financial layer closest to MSMEs is thus structurally unable to channel green finance into construction, while the banks above it wait for outside funding.

Collateral deserves separate attention, since it operates differently at each level. Banks require land titles or formally recognised assets; green equipment is not accepted in the same way as vehicles or real estate are elsewhere. MSMEs without formal land titles or with leasehold arrangements are especially disadvantaged. SACCOs partly compensate through relationship-based lending, but loan ceilings and liquidity limit scale. The absence of intermediate instruments such as partial credit guarantees and risk-sharing facilities and the lack of complementary formal partnerships between SACCOs and banks mean that collateral is treated as a structural fact rather than a solvable design problem.

Furthermore, local green materials tend to be undervalued in land and property appraisals, which makes such projects unbankable, confining green building largely to public developments (e.g. INT 68, 90). A building appraised below its conventional equivalent cannot serve as equal collateral, and developers cannot recover investment through resale. This creates a circular dynamic – materials remain undervalued because they are underused, and underused because

they are undervalued – showing that the bottleneck is due not only to the capital supply but also to how green construction outputs are *recognised* within the financial system. This is linked to the broader definitional issue: without a shared understanding of what "green" means, the system cannot reliably recognise green construction as collateral or as bankable or compliant.

4.1.2.2 Skills gaps, workforce informality and worker mobility

Skills gaps, informality of the workforce and high worker mobility are labour market challenges that affect both supply and demand dynamics in the market. The Rwandan construction industry suffers from both a skills gap and a skills mismatch, meaning that training does not always fit firms' needs or machinery (see Section 4.3). Most masons and unlicensed construction workers are not registered with the Trade Union of Workers in Construction, Carpentry and Craft Enterprises (STECOMA) or any other official certification authority, which prevents them from being hired on formal contracts that require certified personnel and blocks their move up the formal value chain (focus group discussions 1 and 2). This also affects micro and small firms, many of which rely on informal labour arrangements and lack administrative capacity, financial resources or incentives to formalise their workforce. As a result, they struggle to access larger contracts, formal financing, public procurement opportunities and certified green construction projects, which limits both their growth potential and their ability to participate in the sector's green transition. High worker mobility and a lack of company strategies to retain workers restrict firms' investment in training and reduce the chances of stable value chain development.

4.1.2.3 Private sector capacity and coordination

Private sector passivity, insufficient capacities and coordination of key private sector organisations such as the Private Sector Federation (PSF) go hand in hand. Our research points to three reasons for this. Firstly, the private sector is used to the government taking the lead in developing the market and to some extent is reluctant to enter what is perceived as potential government turf (e.g. INT 2, 3, 11, 16, 36). Secondly, interviewees pointed to limited and uncertain demand for green construction outside publicly funded projects, the absence of clear and stable incentives to justify the additional upfront investment, and past policy commitments that did not fully materialise (e.g. INT 2, 8, 36). The result is that firms that could invest defer green investment, postpone capability building and concede potential first-mover advantages to avoid sinking capital into upgrades that the market may not yet reward. Thirdly, PSF and its Construction Chamber are perceived as organisationally weak (e.g. INT 4; focus group discussions 1 and 2). Several major firms have stopped paying membership fees because they do not see any benefits from membership, which undermines the federation's capacity to represent private sector positions in dialogue with the government on green construction.

Smaller, more specialised associations, such as Energy Private Developers (EPD), are perceived as more effective in supporting and representing their members (e.g. INT 48). Their focused mandate allows them to engage more actively with sector-specific barriers; for example, EPD played an important advocacy role in efforts to lift government-imposed caps on the installation capacity of commercial solar energy production.

The construction workers' trade union STECOMA is generally highly regarded by its members and respected by the government. Interviewees reported that membership materially increases their chances of being hired and helps them negotiate salaries (e.g. focus group discussions 1 and 2). At the same time, the union's own institutional capacity is very small; its membership database and outreach capacity are limited, which keeps it from reaching most informal workers in the sector. STECOMA is therefore perceived as a less effective government partner in translating policies and initiatives into sector-wide practice – the issue being the organisation's capacity and reach, not its general standing – than more capable trade associations such as the Rwanda Institute of Architects (RIA) and the Institute of Engineers Rwanda (IER), with the latter benefiting from representing a more formalised and therefore easier-to-reach client base. The

union also cannot fully satisfy members' demands for long-term contracts, savings groups (*ikimina*), health insurance or minimum-wage benchmarking (e.g. focus group discussions 1 and 2). Activities to promote green construction through training and awareness raising have so far been very limited. Both companies and private sector organisations would need to become more proactive to reap the benefits of green construction business models.

4.1.2.4 National innovation system

The national innovation system and the technological capabilities it generates do not yet sufficiently address green construction. In recent decades, the GoR has strategically invested in building up a national innovation system with elements such as supportive policies and programmes by the National Industrial Research and Development Agency (NIRDA), the National Council for Science and Technology (NCST), incubators and centres of excellence. The financial investments in research and development (R&D) by both government and private companies are limited, however, and very few partnerships exist between universities and firms. Regarding construction, a range of interviewees criticised the lack of proactive bridging institutions between state, firms and academic systems. While important steps towards a national innovation system have been taken, the system is not yet fully functioning with substantially increased technological capabilities and effective relationships between firms and the state (Behuria, 2026; Yongabo & Göransson, 2020).

Generally, such effective state–firm relationships need to ensure that firms receive "rents" for learning or other incentives to make them invest in training, skills and technology transfer while not impeding broader private sector development due to government favouritism (Whitfield et al., 2015). Rents for learning are a special type of rent. Rents are defined as above-average profits for firms, which can either arise from market opportunities or be created by policy to achieve a specific political goal such as supporting the renewable energy transition by granting solar subsidies (Schmitz et al., 2013). Rents for learning are tied to a specific timeframe or a requirement to expand exports to foster technological learning among companies (Khan & Sundaram, 2000; Whitfield et al., 2015). As undue rent capture by firms has proven to be a risk in many cases in various countries, careful rent management is required, for example a clear and stable alignment of interests across private and public entities, combined with monitoring, pressure and rent withdrawal in the event of non-compliance (Schmitz et al., 2013).

Regarding green construction, there are hardly any incentives or requirements for large firms to invest in technological capabilities and innovation. To our knowledge, formal innovation partnerships aimed at green construction are largely absent, as distinct from teaching or placement links, which do exist (see Section 4.3). The Centre of Excellence for Bamboo at the NIRDA Research Centre in Huye constitutes a notable investment and effort to foster innovative green construction in Rwanda. Unfortunately, the withdrawal of Belgian development cooperation funding has made its financial future less secure. The overall low priority of green construction in the national innovation system also relates to the existing quality infrastructure and industrial policy priorities.

4.1.2.5 Quality infrastructure

The current quality infrastructure for green construction is still weak. R&D, quality testing and standards infrastructure for green construction remain underdeveloped. Local quality testing capacity is weak, which is closely tied to limited institutional capacity and knowledge gaps on specific materials and technologies, for example at the Kigali City One Stop Centre (OSC). Scientific research, laboratory testing, and applied R&D on locally relevant green materials and construction methods are insufficient, leaving the sector dependent on imported norms and standards that do not always reflect Rwandan conditions (e.g. INT 54, 55). In addition, definitions of what counts as "green" are inconsistent and at times contested across banks, training institutions, policy documents and firms (e.g. INT 4, 16, 20, 22). This creates uncertainty,

complicates the flow of green finance and weakens the basis on which both regulators and clients can verify green standards.

4.1.2.6 Industrial policy programmes

Industrial policy programmes do not support supplier development or foster general links between MSMEs and large firms, and they no longer directly target construction value chains. Rather than covering misaligned industrial policy signals (see above), this barrier concerns the concrete programme instruments. The Industrial Policy of 2024 lists a number of useful and evidence-based approaches designed to foster innovation in the priority sub-sectors, such as mentorship schemes across firms and university-based technology transfer offices. It is unclear to what extent these approaches will be targeted and implemented in the construction industry too. To date, industrial policy programmes have not managed to strengthen links between MSMEs and large firms or support stable value chains and thus enable technological learning and firm upgrading (e.g. INT 3, 47; Behuria, 2026). This may be partly due to the political de-prioritisation of construction as a key economic sector and the push towards more export-oriented sectors and towards the establishment of a service economy. In the 2010s, construction was regarded as a key sector and potential job motor (ILO [International Labour Organization], 2019; Tabaro, 2017). International institutions and donors promoted the mainstream approach of focusing efforts on likely export sectors that can increase competitiveness, while the GoR also saw opportunities in establishing a service economy rather than concentrating on manufacturing. The current Industrial Policy of 2024 now contains a combination of both. Irrespective of the sector, the GoR now seems reluctant to follow the example of the East Asian Tigers and initiate supplier development programmes or require large firms to invest in training and MSME linkages. For the construction value chains, this means that coherent and targeted industrial policy support programmes are now largely missing.

4.2 Main levers

Building on the barriers and potential solutions identified across our research and informed by the existing literature, we identify five main levers that are likely to have a lasting effect on reducing remaining barriers to a greener and more productive firm landscape in Rwanda: (1) a revision of the green finance system for MSMEs, including generating revenue via green property taxes (land value capture), (2) the introduction of supplier development programmes to strengthen value chain linkages, (3) a sequential phase-in and integration of green building and renewable energy regulations, (4) the implementation of public procurement with the aim of greening MSMEs and (5) green construction confidence and acceptance programmes via differently priced green demonstration houses across the country. Furthermore, more specific support measures for various stakeholders are presented in Section 6. Recommendations are based on both interviewee suggestions and literature research.

4.2.1 Revision of the green finance system for MSMEs

To be more effective, the green finance system in Rwanda a) needs to match MSME realities in a more fine-grained way and b) could use a redistributive green property tax that captures land value of the high-end market segment to further support MSMEs. Rwanda should first optimise the utilisation of existing green finance mechanisms before establishing new schemes, especially for MSMEs. Green finance is currently available through various channels, including Ireme Invest, BRD-related instruments, commercial banks, SACCOs and partner-supported programmes. However, a significant proportion of construction MSMEs are not yet making use of these resources.

The underlying reasons for this underutilisation are not yet fully clear. Some firms may encounter challenges related to collateral requirements, elevated interest rates, constrained repayment periods, limited access to information, inadequate application capacity or difficulty in substantiating the environmental credentials of their investments. A focused follow-up study is therefore required to investigate the specific points at which MSMEs disengage from the finance process, spanning from initial awareness and eligibility assessment to application submission, appraisal, collateral provision, approval and the finalisation of loan conditions.

In the interim, existing channels can be made more accessible. This could include streamlined pre-assessment forms, facilitated application processes for firms deemed eligible, extended repayment periods, reduced interest rates where financially viable, and the provision of guarantees where collateral poses the primary impediment. Patient capital (loans with repayment periods of two years or more) has positive effects on MSMEs' performance and job quality in LMICs (Sommer, 2023). Collateral rules ought to be more flexible, permitting the consideration of green equipment, machinery, contracts, purchase orders or receivables as acceptable forms of security, where appropriate. Here, the role of BRD in collaboration with international development banks is key for both pushing and supporting local commercial banks to adjust their systems.

SACCOs could play an important role for green machinery or technology acquisition by smaller firms and informal contractors, given their proximity to local markets. However, they would need guidance, risk-sharing support and capacity building to finance green construction initiatives. Cooperation schemes with cooperatives such as the Cooperative for the Promotion of Construction Materials Traders (COPCOM) that organise bulk orders of materials, tools and machinery could be explored. However, the immediate priority is to enhance the efficacy of existing finance mechanisms for construction MSMEs while simultaneously generating robust evidence regarding the actual barriers encountered by these enterprises.

The introduction of a green property tax and land value capture from the high-end market segment could generate further revenues that could be directly reused for MSME green finance schemes, for example for reducing interest rates or lowering banks' commercial risks. The exact design and potential impacts of such a tax would require follow-up studies. São Paulo provides a successful example of this kind of redistributive tax and land value capture system for vertical buildings, drawing on air rights owned by the public (Bryan et al., 2026). According to our interviewees, some of the large construction firms, including international investors, would accept a (small) tax or alternative requirements to invest in green housing projects or MSME development in return for Category 4 and 5 building permits.[6] The GoR could follow up on this by engaging with the firms to verify the degree of de facto willingness if such a tax were actually introduced. The very high rates of return of high-rise and commercial buildings in Kigali, for example, ensure large, international firms' interests and investments irrespective of rather small (financial) demands by the government. The GoR should therefore consider reviewing its reluctant position on this topic, given the limited means to financially de-risk green MSME loans for commercial banks at this stage. If introduced, revenue recycling into underdeveloped parts of the domestic green construction value chain is highly advisable, as large and international firms then benefit again from better supplier quality and reliability over time.

6 Under Rwanda's building permit classification, which is also used to determine the applicability of the GBMCS, the following categories are applied: Category 1 – temporary, low-risk structures; Category 2 – small, single-storey residential, commercial and administrative buildings; Category 3 – larger, low-rise residential and commercial buildings; Category 4 – higher-rise and other non-industrial/non-hazardous buildings; and Category 5 – high-occupancy public, institutional, industrial and hazardous buildings.

4.2.2 Supplier development programmes to strengthen value chain linkages

The introduction of supplier development programmes, including requirements or incentives for large firms to make value chains more inclusive and stable and to transfer their knowledge, can help overcome the current market segmentation and can increase the quality of domestic supply chains. More stable value chain linkages across different projects may increase worker retention in firms as incentives to invest in well-trained, capable workers.

The arguments for introducing a supplier development programme in Rwanda's construction industry outweigh the challenges attached. Generally speaking, supplier development programmes enable technological learning among MSMEs, creating interactions through which efficient construction practices can be transferred. This is likely to improve the quality of buildings in segments of the building sector served by these MSMEs too. Supplier development programmes spread income from the construction industry more equally and support the increase in general productivity levels. Once a skilled MSME supply chain has emerged, large firms also benefit due to the choice available between several reliable green suppliers. However, in the short term, there is an extra cost for large firms as suppliers are inefficient or untrained in green technologies (Sikombe & Phiri, 2022; Arráiz et al., 2012; Altenburg, 2000). In the Rwandan case, these initial costs are very unlikely to scare large firms away from the market due to the very high rates of return in the upper market segments. The strong fragmentation of the firm ecosystem with a missing middle of firms and the disinterest of large firms in engaging in stable value chain linkages and worker retention add reasons to introduce a green construction supplier development programme in Rwanda. Without state intervention, the current market segmentation and the insufficient number of medium-sized firms are unlikely to change. Yet such medium-sized firms are the anchors for green technology adoption, having their own capital for a green and (potentially) more diverse client base, as our interviewees also argued.

So far, no concerted supplier development programme or requirements for large construction firms to engage with or train MSMEs exist in Rwanda. Only very few longer-term, formal contractual ties exist between STECOMA masons and large firms such as Horizon Construction or NPD Ltd that enable lower-skilled masons to access jobs in these large firms (e.g. INT 87, 88). Since there are no systematic incentives or mandatory quota for MSME inclusion and MSME training in public tenders, large firms are not forced to change their rather exploitative, ad hoc linkage strategy. In the case of Horizon Construction and NPD Ltd contracts with STECOMA, the GoR's ties to these firms play out positively. As we argued above (see Section 4.1.2.4), strategic rent creation for learning is important to enable and speed up firms' technological capability development on green construction. Two reasons substantiate the case for creating green construction rents: greening the market (adoption of green materials and technologies) and overcoming market segmentation. The highest gain in general productivity comes about by lifting general productivity to the current best practice level in the market rather than by pushing the technology frontier (World Bank, 2017). The GoR possibly already creates rents for green construction in public green projects by guaranteeing higher prices than the current market would pay for such a building and by essentially covering the perceived higher price of green materials and technologies compared with the real green construction costs. However, careful rent management is required to avoid undue rent capture with negative effects on the competitiveness of the whole sector (see below). For instance, a construction firm could ask for the perceived higher green price and then build in a not fully green way.

The East Asian Tigers Korea, Singapore and Taiwan have introduced successful supplier development programmes in the automotive, petrochemical, steel and iron, and food retail sectors with different designs that sought to avoid rent capture (Amsden, 1992; Lee, 2003; Wade, 2018). All set clear conditions for rent allocation and combined subcontracting requirements with additional elements such as preferential financing in line with the desired goal (in the Rwandan case: green construction and overcoming market segmentation for higher overall productivity) to give signals to all stakeholders in the sector to change and increase

chances for long-term upgrading. For example, Korea made rent allocation contingent on export and sector target performance, punished non-compliance by asset seizure, set time boundaries of rents and retained competition within sectors (Amsden, 1992; Wade, 2018). Nevertheless, the collapse of the automotive company Daewoo in 1999 counts as an example of rent capture and failed compliance (Lee, 2003). Taiwan, in contrast, relied on upstream state-owned enterprises in its steel and petrochemical sectors and distributed rather small rents among a range of MSMEs without the risk of any firm becoming too big and capturing an undue amount of the rents (Amsden, 1992; Wade, 2018). Countries in other world regions tried to mirror these East Asian examples: an evaluation of the Chilean supplier development programme revealed that MSME turnover, jobs and business survival times all increased, while large businesses managed to boost sales and export capacities (Arráiz et al., 2012). These three Asian countries' success stories cannot be transferred to African countries directly without adjustments, as examples of supplier development programmes in the automotive and construction industries from South Africa, Ethiopia and Zambia have shown (Esaiyas & Kahssay, 2020; das Nair & Landani, 2020; Lee, 2003; UNIDO, 2013; Sikombe, 2021).

To increase the chances of substantial positive effects of a green construction supplier development programme, lessons learned from Ethiopia, South Africa (especially the AfriSam Business Development Centre) and Zambia should be considered. In contrast to the international examples from other sectors, the Rwandan construction industry does not have just one lead firm, such as Toyota in Japan. Therefore, in the Rwandan case, a two-pronged approach makes sense: all of the few large construction enterprises present need to be engaged in a supplier development programme, and adjustments to upgrading pathways for green material and technology need to be considered (see Section 5). For the market segments with many *amafundi* and MSMEs without large lead firms, the other four levers discussed in this section are important.

The following design principles could make sense for a green construction supplier development programme in Rwanda: all large construction firms should be encouraged to take part in the supplier development programme to support Rwanda's goals of greening construction and overcoming market segmentation for a more productive, competitive construction industry; large firms winning government projects should be obliged to take part and compliance should be monitored; public monitoring could be offered on a voluntary basis for firms that voluntarily engage in supplier development in their own project. In addition, the design of public tenders could contain several elements:

- There could be a mandatory requirement for large firms to conduct green construction training with the supplier MSMEs for the project. The organisation and content could be left to the firms themselves, as too detailed requirements may backfire (for example, compliance on paper only or rent capture). The government would need to consider whether it wants to decide how many or which suppliers take part, what they should learn and to what extent it wants to prescribe learning cooperation between lead firms, supplier MSMEs and TVET/education institutions. Generally, closer cooperation between large firms, supplier MSMEs and education institutions makes sense to ensure that firms get what they need (see Section 4.3).

- As in South Africa, large firms could be required to give between 0.2 per cent of the project volume (cidb BUILD fund in South Africa's construction industry) and 2.75 per cent of the annual company turnover over ten years (South Africa's automotive sector) to a green construction fund, which could then be used for green construction finance for MSMEs or green construction projects (cidb, 2023). South Africa successfully works via such funds.

- A careful monitoring and guarantee system is required.

These design decisions need more in-depth analyses and planning than this report can provide.

4.2.3 Sequential phase-in and integration of green building requirements and renewable energy regulations

For Rwanda, a phased expansion of green building requirements and renewable energy integration would make sense, supported by a clear vision, a defined pathway for progressively raising standards and a specific implementation timeline. The parallel establishment of greater testing and monitoring capacities at all relevant levels increases the probability of compliance, and randomised but thorough spot checks could replace full monitoring under conditions of limited resources. For the GBMCS, commencing the phase-in with Category 3 buildings and successively tightening Category 4 and 5 requirements over time would be advisable. Subsequently, the introduction of less onerous stipulations for Category 1 and 2 structures would be useful. Uniform application of requirements across all building categories is not advisable at this stage. Smaller buildings necessitate practical and cost-effective measures, encompassing elements such as natural ventilation, daylighting, water efficiency, rainwater management, fundamental energy efficiency and the judicious use of certified local materials. Successful green building phase-in programmes in countries such as China, India, Germany and the Netherlands benefited from proactive government planning with a vision and a clear roadmap, selecting and designing support options with experts, gradual tightening of regulations in a sequence, explicit policy learning cycles, adequate implementation controls and a comprehensive policy package (Never & Kemp, 2017).

SWHs ought to be mandated in new buildings incorporating water heating systems. Furthermore, solar power systems should be systematically incorporated into the Building Code and energy regulations, particularly for structures where technical and financial feasibility have been established. This integration must be accompanied by a more clearly defined framework for net metering, encompassing generation limits, grid connection protocols, bidirectional metering and provisions for crediting surplus electricity. More specific findings and recommendations for solar energy can be found in Section 6.

The GBMCS should remain the fundamental mandatory instrument. A certification system adapted to Rwanda, such as the local version of EDGE currently being developed (INT 57), could subsequently acknowledge buildings that exceed these minimum requirements. This approach would facilitate the differentiation between regulatory mandates and incentivised best practices, whether through certification or other incentives.

The Building Code, Green Taxonomy, green finance mechanisms, TVET and university curricula, public procurement guidelines, renewable energy regulations and material standards need to adopt harmonised definitions and priorities. Such harmonisation would mitigate fragmented implementation and enhance clarity for firms, professionals and households regarding expected compliance.

4.2.4 Public procurement to drive the greening of MSMEs

The implementation of the 2024 public procurement law can be a strong strategic tool for green construction if it is translated into simple tender clauses, realistic contract conditions and reporting requirements. The interviews suggest that public procurement can help Rwanda build an early market for green construction, but only if used carefully (e.g. INT 20, 28, 70). Its purpose should not be to make firms dependent on government contracts. Instead, it should aim to use selected public projects to create demand for green materials, green skills and local suppliers while simultaneously helping firms gain the experience needed to compete in the wider market. Public procurement can also be used to strategically demonstrate green construction in a range of public buildings such as schools, community centres and administration buildings across the country to increase public awareness and acceptance (see below).

The creation of an early market for green construction on supply and demand sides can be achieved through the existing contractor grading system established by the Rwanda Public Procurement Authority (RPPA). Public tenders can include green requirements that align with the project's size and the contractor's capacity. For large projects, MSMEs can be engaged through clearly defined work packages, such as finishing works, drainage, landscaping, solar installation, maintenance and the supply and use of certified local materials. This provides capable MSMEs with a realistic entry point without asking them to manage works beyond their capacity.

This approach, however, requires careful execution. Dividing large projects into too many small lots can increase costs, delay implementation and complicate coordination. A more practical approach is to retain one main contractor responsible for overall delivery while simultaneously requiring a clear MSME participation plan. This plan should detail which local firms will be involved, what their specific roles are, how quality will be controlled, how timely payments will be ensured and how skills will be transferred.

The Sustainable Public Procurement Policy, approved in October 2024, presents a significant opportunity, but its impact will depend on how it is implemented. The immediate next step should be to translate the policy into simple tender clauses, evaluation criteria, contract conditions, reporting templates and monitoring tools specifically for green construction. These should first be piloted in a few public projects before wider expansion.

4.2.5 Green construction confidence and acceptance programmes

Green construction confidence and acceptance programmes via differently priced green demonstration houses and test centres across the country are key to reaping the full potential of domestic construction value chains. A major issue with local green materials in Rwanda is trust. While materials such as ISSBs and improved rukarakara show potential, many developers, contractors, officials and households remain cautious until clear proof demonstrates their safety, durability, affordability and suitability for formal construction (e.g. INT 1, 8, 15, 37, 57, 59). Perceived costs and real price issues as well as the widespread aspirational norm to become similar to Singapore with its concrete high-rise buildings add to this (e.g. INT 4, 8, 19, 47, 56). Combined, these factors lead to the current low acceptance of green materials.

Demonstration should therefore not be limited to one or two showcase buildings. One model building in Kigali will not be enough to change wider perceptions. A more convincing approach would be to use tested and certified local materials in numerous regularly used public buildings, such as schools, health centres, community facilities, district offices and housing projects for low-income households across various districts. In addition, showcasing and advertising houses in several cities and towns with different green features and thus a staggered price range for different market segments, especially for low-income (buy and rent) and middle-income households, would be useful. Public–private partnerships with investors or interested companies with a viable business model could be an option for financing (see Box 1).

Research, testing and approval should come first. Improved rukarakara should not be treated as ordinary adobe bricks, which are currently mentioned in the Building Code. It requires its own comprehensive assessment of strength, durability, safety, cost, comfort, maintenance and environmental performance. The same applies to ISSBs. Setting up and maintaining a quality infrastructure system for green construction materials, including tests and standards for used, secondary and recycled materials, is highly advisable. On the one hand, explicitly including secondary materials in quality tests and approvals acknowledges and values the informal business setting, integrating informal and semi-formal workers in the field into the official system to a greater extent. On the other hand, testing and establishing quality standards for used and recycled materials will improve an important part of the green building transition that is often

neglected. This ensures quality and durability for clients, which may, in turn, increase acceptance of and demand for green materials.

Demonstration projects should also generate evidence, not just visibility. For example, a school or health centre built with ISSBs could be compared with a similar building constructed with conventional materials. This would show differences in cost, indoor comfort, maintenance needs, durability and environmental performance. Similarly, demonstration buildings for private households could showcase visually attractive, comfortable buildings with different levels of greenness that vary by using and installing different materials and technologies as well as passive design principles. This could help to counter the “green is expensive” and “local materials are not modern” attitudes. Here, working together with behavioural scientists, architects and interested companies that could co-finance such demonstration buildings would be useful. Creating such visual, practical evidence with public and private demonstration buildings that are used by the public would be helpful for districts, developers, contractors and households.

Rwanda Environment Management Authority (REMA)’s Green Model Village approach can also be utilised, but the role of construction materials should be made clearer. Future green model villages or upgrading projects could deliberately include tested local materials, alongside existing green solutions for housing, energy, water, sanitation and livelihoods. These would need to be accompanied by community engagement and communication strategies to increase ownership and acceptance of residents, using them as potential multipliers of positive experiences with green materials.

The aim is not to automatically promote all local materials. Instead, a clear pathway needs to be created: research and test the materials, certify them, use them repeatedly in visible public projects and subsequently reflect them in building standards, permits, training and procurement. This would help ISSBs and improved rukarakara move from informal or low-status use to credible green construction options.

Box 1: Demonstration houses for affordable and attractive green buildings

A national demonstration house programme can help overcome the widespread perception that green construction is either unaffordable or unsuitable for modern housing. Rather than relying on one flagship building in Kigali, Rwanda should develop a network of attractive, lived-in demonstration houses in several cities and towns. These should present different combinations of green materials, technologies and passive design features at staggered price points, tailored especially to low-income households – including rental housing – and middle-income buyers.

The lowest-cost models could demonstrate improved rukarakara, good drainage and damp-proofing, natural ventilation, daylighting and rainwater management. Mid-range houses could combine ISSBs with higher-quality finishes and water efficiency measures. Higher-cost models could add solar water heating and, where technically and financially feasible, solar PV. Each house should make its full costs transparent: construction cost, financing options, expected operating cost savings, maintenance requirements and expected lifetime. This would allow households to compare realistic options rather than assuming that all green features carry a large price premium.

Demonstration houses should be constructed with tested and certified materials and should visibly apply good workmanship, particularly for moisture protection, curing and finishing to avoid further reputational damage to the respective materials. They should also function as learning and evidence sites: local firms, artisans and TVET providers can receive practical training, while programme partners monitor and publish comparative evidence on costs, indoor comfort, maintenance, durability and environmental performance relative to conventional houses. This is most feasible by comparing similar public buildings such as health centres, schools and district offices. Public–private partnerships with developers, suppliers and investors could support financing, while public communication and resident engagement could help turn users/occupants into credible ambassadors for green housing.

Kenya's Appropriate Building Materials and Technology Centres provide a relevant model: decentralised facilities combine ISSB machine access, practical training, quality control, maintenance and links to accredited professionals. Rwanda's SWH pathway offers a second lesson: visible installations in the hospitality sector helped legitimise the technology for residential clients. Public buildings such as health centres, districts offices and schools can serve the same purpose for the relevant building materials, as they cater for a diverse clientele. Nevertheless, the effect is likely to depend on being combined with affordable finance, tax incentives and awareness raising, as was the case for SWHs. Demonstration houses should therefore be embedded in a broader package of quality assurance, skills development, communication and financing support.

4.3 Skills gaps, skills mismatch and worker mobility from a systems perspective

This sub-section examines the skills gaps that may limit firms' ability to adopt and scale green materials and technologies. It compares gaps across foundational, soft, management and technical skills and across three firm types: (1) masons and roofers, (2) electricians and plumbers and (3) engineers and architects. It then examines how skills gaps relate to firm characteristics, green material and technology use, training, worker retention and the local learning ecosystem. The analysis identifies patterns and unmet needs but does not establish cause and effect.

Overall, the findings point to a broad need for non-technical skills, while technical priorities vary substantially by firm type. Masons and roofers report the largest overall skills gaps, while electricians and plumbers report the lowest average gaps across most domains. Once other firm characteristics have been taken into account, differences between firm types are mainly found in foundational, soft and management skills rather than technical skills. At the same time, technical skills remain an important constraint across firm sizes, and the specific technical needs

differ considerably between firm types. Larger, more formal and higher-revenue firms also report particular needs in non-technical skills. Together, these findings suggest that skills support should combine technical training with broader foundational, soft and management capabilities rather than focusing on technical skills alone.

The skills gap indices measure four distinct domains, and differences in technical requirements across firms should be considered when interpreting them. The indices cover foundational skills (numeracy and literacy), soft skills (problem solving, communication, understanding and explaining information, and learning and adapting), management skills (supervision, planning and scheduling, compliance and monitoring) and technical skills. Technical skills cover the material- and technology-specific capabilities needed to build, install and maintain relevant solutions. The technical index is tailored to each firm type: architects and civil engineers were assessed across all focus materials and technologies; masons and roofers on relevant building materials; and electricians and plumbers on relevant technologies, including solar panels, SWHs and RWH systems. Technical gap comparisons should therefore be interpreted relative to each group's technical requirements rather than to proficiency in an identical set of technologies. All indices range from 0 to 100, with higher values indicating larger skills gaps and greater unmet demand.

The main findings of the analysis are as follows:

- **Skills gap profiles differ substantially across firm types, with the most pronounced overall needs among masons and roofers.** Masons and roofers report the highest average gaps across all four domains, particularly in management and technical skills, and show a relatively high concentration of firms with medium-to-high gap levels (see Figures A3-A5 in the Annex). Architects and civil engineers report the lowest foundational skills gaps, but their average technical gap is relatively high. However, this technical gap is predominantly moderate rather than severe: most firms fall into the second-lowest gap category, while relatively few report the highest gap level. Electricians and plumbers report the lowest average gaps in soft, management and technical skills, with their technical gaps considerably lower than those of the other two groups. Their generally lower averages reflect larger shares in the lowest-gap categories, particularly for soft skills. Nevertheless, management skills emerge as their main relative challenge, with a notable share of firms reporting the highest gap level. Taken together, these patterns suggest that the surveyed electricians and plumbers are relatively more proficient in installing and maintaining the technologies relevant to their work – such as solar panels, SWHs and RWH systems – than masons and roofers are in relation to the relevant building materials, while architects and civil engineers fall between these two groups. Technical gap comparisons should be interpreted cautiously, however, as the index covers different materials and technologies depending on the firm type. These are descriptive differences and do not account for other firm characteristics that may vary systematically across groups and influence skills gaps; the following regression analysis therefore assesses these relationships simultaneously.

- **Skills gaps are mainly linked to firm type, size, formality and use of green materials and technologies**. The patterns differ between technical and non-technical skills. The analysis draws on a firm survey conducted from February to March 2026 with 308 firms in the construction industry, selecting firms from Kicukiro and Kamonyi district to gain insights from both more urban and more rural contexts. Due to data coverage, the analysis is based on only 297 firms with information for all four skills gap indices. It uses multivariate regression analysis to examine how skills gaps relate to different firm characteristics while taking the other characteristics into account. The findings show relationships, not cause and effect.

- **Masons and roofers continue to report the highest overall skills gaps after controlling for other firm characteristics, while electricians and plumbers also report higher gaps than architects and engineers** (Table A1 in the Annex, column 1). MSMEs report higher gaps than micro firms, which is consistent with fully formal firms reporting higher gaps than the least formal firms. Thus, size and formality appear to be closely linked, while the results suggest that skills gaps are not the most pressing barrier for the smallest and least formal firms, but that this barrier becomes more severe as firms grow and formalise. Firms using more green materials and technologies report lower skills gaps, suggesting that material and technology use is at least partly driven by skills. Company-owned firms report lower gaps than individually owned firms, while firms with higher revenues report higher gaps. Training experience, firm age, manager education, government clients and district are not clearly related to overall skills gaps.

- **The overall index hides important differences between skill areas.** The higher gaps reported by MSMEs are mainly found in soft and management skills, suggesting that, as firms grow, the demand for these skills outpaces their supply. Medium-sized firms also report higher technical gaps, while small firms do not. Similarly, fully formal firms report higher foundational, soft and management gaps, but not higher technical gaps. Higher-revenue firms mainly report higher foundational, soft and management gaps, especially in soft skills.

- **Differences between firm types are mainly found in non-technical skills once other characteristics have been taken into account.** Compared with architects and civil engineers, both masons/roofers and electricians/plumbers report higher foundational, soft and management gaps. Their technical gaps do not differ strongly, suggesting that the descriptive differences across firm types reported above can be largely explained by differences in firm characteristics. Training experience is not linked to gaps in any skill area, which suggests that firms selecting for training do not differ in their skills gaps and that training access and participation alone may not be sufficient to address the firms' reported skill needs. Company-owned firms report lower soft, management and technical gaps. Firms in Kamonyi report lower management gaps but somewhat higher technical gaps.

- **Size/formality profiles and the move from awareness to use reveal where skills gaps become most acute.** Almost all micro firms are informal, while almost all medium-sized and large firms are formal. Only small firms show considerable variation in formality. A combined measure with four groups – micro, small/informal, small/formal and medium/large – shows that, after controlling for other firm characteristics, only micro firms report lower predicted skills gaps. There is virtually no difference in reported skills gaps between the other three groups.

- **Micro firms report consistently lower gaps across the different skill domains than non-micro firms.** The difference between micro and non-micro firms is particularly large for foundational and management skills. The difference is smaller for technical skills, where micro firms also report relatively high gaps. This suggests that technical skills are a constraint for firms across size and formality groups, while unmet demand for non-technical skills rises as firms grow and formalise.

- **Further cross-tabulation shows that the four size/formality groups are strongly associated with firm type.** Most micro firms are electricians/plumbers, while small/informal firms are mainly masons/roofers. Small/formal and medium/large firms are dominated by architects/engineers. This uneven distribution complicates analysis of the size–formality relationship within firm types. However, the difference in skills gaps between micro and non-

micro firms appears to be particularly large among electricians/plumbers. Soft and management skills drive this difference, indicating that, for this firm type, growth is more closely associated with unmet demand for these skills.

- **Green material and technology use is consistently associated with lower skills gaps, particularly technical gaps.** Firms that use more firm-specific green materials and technologies report lower gaps in all four skill areas. This relationship is strongest for technical skills. This may indicate that firms already using more green materials and technologies are better able to meet related skills needs. However, the analysis cannot show whether green use itself reduces skills gaps.

- **Skills gaps may also constrain the transition from awareness of green solutions to their actual use**. Firms that are aware of relevant materials or technologies but do not use them report higher skills gaps than firms who are unaware or do use them. This pattern is consistent with skills gaps acting as a barrier to translating awareness into use, even though the cross-sectional analysis does not establish causality. Technical, management and soft skills gaps mainly drive this pattern. Descriptively, electricians/plumbers report lower shares of no awareness and non-use, while masons report the highest shares of no awareness and non-use and therefore the lowest use share.

- **Training participation differs strongly by firm type, but participation alone is not associated with lower reported skills gaps.** That said, larger green technical skills gaps are associated with greater demand for future green training. Architects and engineers report the highest training participation rate (64 per cent), compared with 29 per cent of electricians and plumbers and 20 per cent of masons and roofers. However, previous training participation is not associated with differences in any of the skills gap indices. This pattern also does not differ clearly by firm type.

- **The relevance of training appears to be more important than participation alone for some skill areas.** Firms' assessments of training relevance are not linked to the overall skills gap index. However, firms that rate their training as more relevant report lower foundational skills gaps and somewhat lower technical skills gaps. Training relevance is not clearly linked to soft skills or management skills gaps. This points to the potential importance of training relevance and quality rather than participation alone.

- **Demand for future green training increases substantially with reported green technical skills gaps.** The predicted probability of selecting green training rises from 34 per cent among firms with no reported green technical gap, to 44 per cent among firms with a gap score of 50, and 55 per cent among firms with the highest gap score of 100. This represents an increase of around 20 percentage points across the full gap scale. The pattern is consistent with firms that report larger green technical gaps being more likely to prioritise green training in the future. This suggests that firms' stated training demand broadly reflects their reported unmet green technical skills needs. The relationship does not differ clearly by firm type, although it appears to be larger among masons and roofers; estimates for this group remain uncertain. We find similar positive links for compliance skills and machine operation skills, but not for skills for operating digital tools and not for supervision skills.

- **The detailed skills profiles point to broad non-technical needs but more clearly defined technical priorities for each firm type.** The heatmaps in Figures A6-A8 show limited concentration on individual items within the foundational, soft and management domains. This suggests that, where support is needed, it should generally address packages of related core skills rather than isolated training modules.

- **Foundational and soft skill needs differ across firm types, but no single non-technical skill dominates across groups.** Among the foundational skills, architects and engineers report somewhat lower gaps in basic numeracy and physical skills. Masons and roofers report the most pronounced gaps in literacy, especially advanced literacy. Electricians and plumbers also report stronger literacy than numeracy gaps, together with some gaps in understanding-related skills. Within soft skills, coordination has the lowest reported gap across all three firm types. The remaining items are relatively even, although understanding, problem solving and communication stand out somewhat among masons and roofers. Management gaps also show no strong concentration on individual items for any firm type.

- **Technical gaps show clearer differences by firm type.** The clearest technical priorities for architects and engineers are ISSB production, followed by improved rukarakara production and construction with ISSBs. Traditional rukarakara production and construction appear to be less problematic. Among installation-related skills, gaps are lowest for RWH, followed by SWHs and solar panels, while maintenance gaps are somewhat higher for some technologies.

- **For masons and roofers, ISSB production is by far the most pronounced technical gap.** Improved rukarakara production and construction with ISSBs also emerge as priorities. In contrast, traditional rukarakara production and construction appear to be least problematic. This pattern suggests that the main challenge is the transition from familiar traditional materials towards improved rukarakara and ISSB-based methods. Machinery operation and digital tool use are additional technical needs.

- **For electricians and plumbers, machinery, digital tools and selected renewable energy technologies are the main technical gaps**. The most prominent general technical gaps are in machinery operation and the use of digital tools. SWH installation and maintenance are the main shared technological priorities. Among electricians, solar panel maintenance appears to be more challenging than installation. Among plumbers, RWH system installation and maintenance gaps are very similar.

- **Labour retention challenges are linked to broader workforce and organisational skills gaps rather than technical skills gaps.** Worker retention is particularly challenging for skilled trades such as masons, electricians and plumbers, but less so for more professionally qualified staff such as architects and civil engineers. Firms facing greater retention challenges also report larger overall skills gaps after accounting for firm type and other firm characteristics. The association is strongest for management skills, followed by soft and foundational skills. Retention challenges do not show a clear link with technical skills gaps. This pattern suggests that retention pressures are more closely connected to supervision and management capabilities in firms than to trade-specific technical skills, making supervision and management a crucial training priority for improving worker retention. The findings also point to a potentially important role for dedicated human resource functions, which appear to be limited among the surveyed firms.

- **Health and safety improvements are the most highly rated retention strategy among the small firms examined, but related training remains limited.** The majority of small firms have not tried *any* specific strategies to improve retention among masons. Moreover, relatively few firms have participated in training dedicated to health and safety conditions, and demand for such training is low, which indicates a potential window of opportunity to improve retention.

- **Effective collaboration with universities and integrated polytechnic regional centres (IPRCs) is associated with lower non-technical skills gaps.** Firms that rate their collaboration with universities or IPRCs as very effective report lower overall skills gaps, especially in soft and management skills. They also report somewhat lower foundational

skills gaps. Firms that describe this collaboration as only somewhat effective or somewhat ineffective do not report lower gaps than firms without any effective collaboration of this kind. This suggests that the usefulness of collaboration may matter more than collaboration alone.

- **Regular peer learning is also associated with substantially lower non-technical skills gaps.** Firms that regularly share skills with other local firms also report substantially lower overall, foundational, soft and management skills gaps than firms that share only sometimes or not at all. The pattern is particularly strong for soft and management skills. Regular exchange may support practical problem solving, coordination, supervision and business management learning. Neither university/IPRC collaboration nor peer knowledge sharing is clearly linked to technical skills gaps. These findings can be read in two ways: either university collaborations and peer learning are particularly effective in fostering better non-technical skills in firms, or more advanced levels of non-technical skills in firms enable firms to collaborate more effectively with universities and engage in peer learning.

Taken together, the findings point to a differentiated skills support approach that combines technical specialisation with broader organisational capabilities. The evidence does not indicate a single skills constraint across Rwanda's construction firms. Masons and roofers report the largest overall skills gaps and particularly pronounced needs related to management, technical skills and literacy. Electricians and plumbers report lower average gaps but show specific needs in management, machinery, digital tools and selected renewable energy technologies. Architects and engineers report relatively low foundational gaps but specific technical needs, particularly around ISSB production and related construction. Across firm types, larger, more formal and higher-revenue firms report greater needs in foundational, soft and management skills, while worker retention challenges are also mainly associated with these non-technical capabilities. Training participation alone is not associated with lower skills gaps, whereas training relevance and firms' demand for future green training appear to be more closely aligned with specific needs. Finally, effective institutional collaboration and regular peer learning are particularly associated with lower non-technical skills gaps. Overall, the findings support a policy approach that combines firm type-specific technical training with broader organisational, management and soft skills development while recognising that the observed relationships are associative rather than causal.

5 Case studies: green construction materials and technologies

This section examines three complementary and locally relevant case studies: ISSBs, improved rukarakara bricks, and solar PV systems and SWHs. ISSBs and improved rukarakara are alternative materials for wall construction that can draw on local inputs and practices while reducing the environmental impacts associated with conventional building materials such as concrete blocks or fired bricks. Solar PV systems and SWHs address the operational energy use of buildings by harnessing Rwanda's renewable energy potential. Together, these cases cover both the material and technology dimensions of greener construction.

The cases were selected because they are already emerging in Rwanda, offer clear potential for wider application and illustrate the practical challenges that often prevent promising solutions from being adopted at scale. They are not intended as an exhaustive list of green construction options; rather, they provide concrete examples through which to assess local opportunities, barriers to uptake, lessons from international experience and realistic pathways for upgrading and scaling. Furthermore, we assume that these four materials and technologies differ in terms of firm development and innovation (upgrading) pathways (see Section 1). In our view, they follow sub-sector, top-down (from larger to small firms) or bottom-up pathways (horizontally in niches and clusters, then to higher market segments and larger firms) or a hybrid combination of both.

5.1 ISSBs

ISSBs are a type of compressed stabilised earth block (CSEB) comprised of a mixture of soil or sand, water and a stabiliser, usually cement or lime. ISSBs are characterised by their interlocking design – like that of a LEGO block – which significantly reduces or eliminates the need for mortar and plastering during construction (Olatunji et al., 2025). ISSBs can be produced using a manual (hand) press or a hydraulic block-making machine; depending on the machine, the dimension, weight and form (straight, curved, wide, single/double interlock) of blocks vary (UN-Habitat, 2015; Bredenoord et al., 2019). The blocks are then cured in the sun. Globally, ISSBs have been mostly used for one- or two-storey residential homes, water storage tanks and sanitation facilities, though recent developments show their expansion into multi-storey, commercial, community and even luxury buildings by developers, governments and non-governmental organisations (NGOs) around the world (Bredenoord et al., 2019).

Figure 3: The Makiga press, the Hydraform press and ISSBs



Source: © Makiga Engineering Services Ltd (left), authors (centre, right)

5.1.1 Why ISSBs are promising for Rwanda

ISSBs offer numerous benefits over conventional materials. If properly manufactured and constructed, they can achieve relatively high compressive strength: Bredenoord and Kulshreshtha (2023) reported 5-7 MPa in Thailand, Cambodia and Nepal, while the UN Refugee Agency (UNHCR, n.d.) reported 4-10 MPa, depending on stabiliser content. Nkiranuye and Mutijima (2024) found an even higher strength of approximately 12.43 MPa in Kigali, up to four times that of the tested concrete cement blocks. Despite variations across studies, these results indicate that ISSBs are suitable for load-bearing internal and external walls. Their interlocking design also improves workability and can accelerate construction by reducing mortar use and simplifying block laying (UN-Habitat, 2015), although precise block surfaces and temporary support are required during construction (Tan et al., 2025). The performance advantage of ISSBs is paired with a stronger sustainability profile: they rely on locally abundant materials, such as areas with high laterite deposits, reducing dependence on imported inputs that concrete block production often requires. However, Rwanda's soils vary considerably, making site-specific soil assessment necessary (Nkiranuye & Mutijima, 2024). Limestone calcined clay cement (LC^3) can provide an affordable and lower-carbon stabiliser than conventional cement (Muchui Mugambi et al., 2024). In terms of thermal performance, studies find that ISSBs perform similarly to or better than concrete blocks and fired bricks (Tepke et al., 2022; Bredenoord & Kulshreshtha, 2023). For example, Hashemi et al. (2015) reported thermal conductivity of 0.8-1.4 W/m·K for ISSBs compared with 1.0-1.7 W/m·K for concrete blocks, indicating ISSBs' greater resistance to heat transfer. Furthermore, ISSBs' local sourcing, lower mortar and plaster requirements and the avoidance of brick firing can reduce energy use, carbon emissions and construction costs (Surwade & Kamal, 2023). This is particularly relevant in rural Rwanda, where access to cement and other industrial materials is limited, and for low-income households, for whom affordability remains a key consideration (Olatunji et al., 2025).

4Taken together, ISSBs offer cost, performance and environmental advantages over conventional materials and score even higher than adobe blocks in terms of tree protection, material efficiency, technical performance and shelter habitability.

ISSBs make a compelling case for affordable green construction, yet they remain a niche and unevenly adopted green construction material in Rwanda (see Figure A1). A look at history provides initial clues as to the reasons behind this. Historically, ISSB development in Rwanda followed two waves. The first wave – in around 2005 – was institutionally driven: the GoR contracted Hydraform, a South African firm, to teach Rwandans how to produce ISSBs using their hydraulic machines, and the Kigali Institute of Science and Technology (KIST) to oversee the training. However, the partnership ended in 2007 following a disagreement between the parties (AllAfrica, 2007). SKAT Consulting Ltd, a Swiss company specialising in international cooperation, and other partners continued to provide technical advice and training to workers on how to operate and repair ISSB machines, yet the lack of nationwide training and supervision effectively stopped the spread of ISSBs in the country. Nonetheless, to this day, Rwandans often know and refer to ISSBs by the name "Hydraform". A second, more recent wave centres on smaller private initiatives and manual presses, particularly Makiga machines – imported by Makiga Engineering Services Ltd, a Kenyan firm with a Rwandan branch – which are easier to operate, lease, transport and repair due to their smaller size and simplicity (Figure 3). Nevertheless, ISSB construction in Rwanda remains low and mainly concentrated in government-funded or institutional projects rather than the private residential market (INT 87).

5.1.2 Key drivers of and barriers to ISSB adoption

ISSB adoption is driven or hindered by various factors (see Table 3).

Table 3: ISSB adoption factors

Factor	Driver/ Barrier	Explanation
GoR intervention/ development cooperation	Driver	The GoR, supported by development actors, has been the main driving force behind the first wave of ISSB adoption.
	Barrier	Today, in the absence of government procurement programmes or development cooperation housing projects explicitly specifying ISSBs, firms depend on individual clients, who may commission a single house and then disengage.
Absence of regulation	Barrier	Unlike adobe, which now benefits from its inclusion in the Rwanda Building Code as well as a dedicated national standard (RS 484:2022) and Technical Guidelines, ISSB construction currently does not have an equivalent formal regulatory framework. This lack of formal recognition, reliable standards and quality assurance mechanisms was mentioned frequently in our interviews as an important reason for its limited uptake (e.g. INT 86; focus group discussion 1 and 2).
Skills and quality infrastructure gap	Barrier	A workforce skills gap reinforces the situation (Nkiranuye & Mutijima, 2024), which is also supported by our survey evidence finding considerably larger skills gaps for ISSB production and building knowledge than for other materials (see Figure A9). Producing quality blocks requires trained workers who understand correct mixing ratios, machine operation and curing – yet earlier Hydraform machines fell into disuse not from technical failure, but from a weak repair and maintenance ecosystem, showing that lasting adoption needs training beyond basic operation (e.g. INT 45, 55). This is compounded by the fact that few MSMEs currently own the necessary machinery, limiting scale and creating dependency on external equipment and labour for repairs.
Weak green marketing and client perception barriers	Barrier	Based on our survey and interview evidence, ISSBs remain a little-known building material in Rwanda, with only 5 per cent of respondents reporting regular usage (see Figure A1). Many clients and firms are unaware of ISSBs or their benefits, and even those who do know of them often do not view them favourably. Meanwhile, firms that are aware of ISSBs frequently fail to market them effectively. Demonstration projects exist but are scarce in Rwanda.

Source: Authors

5.1.3 Local and international ISSB experience: lessons for adoption and scale-up

Examples from Rwanda and other countries illustrate how ISSBs can be applied in different construction contexts and what conditions shape their wider adoption and scale-up. The Rwandan cases demonstrate the material's application in community construction, housing and skills development, while international experience provides examples of approaches to technology development, testing, standards, training, production and demonstration. Taken together, these cases show both the potential of ISSBs and the technical, institutional and market conditions that influence whether successful applications remain isolated projects or develop into wider uptake.

5.1.3.1 Local experience

Isooko Community Development Center

The Isooko Community Development Center near Masoro village, Rulindo District, designed by the non-profit General Architecture Collaborative, integrated on-site ISSB production into a larger community construction project using other local and sustainable construction materials and technologies. During the project, it trained and employed 390 locals – more than half of them women – to co-design and build the centre, blending indigenous knowledge with traditional and modern construction methods and locally sourced materials. Over half of the materials were sourced on site, and 85 per cent within 100 km, including clay, sand and stone for foundations and walls. Construction used earthquake-resistant, low-mortar techniques such as on-site ISSBs made without petrochemicals. The centre won several international architecture and design awards and stands as a strong and scalable example of earthen construction for community infrastructure (General Architecture Collaborative, 2024).

Genocide survivor housing

In 2014/2015, the non-profit organisation Reach Rwanda participated in a genocide reconciliation programme to build a survivor's family home in Ntarama, Bugesera District, using almost entirely local materials, including on-site excavated soil to produce ISSBs. SAWA Architecture trained the group to mix lime-stabilised earth plaster and operate a Makiga machine to compact the soil into blocks; the group kept the machine afterwards as a source of future income. The project is a strong example of community-led, locally sourced earthen construction paired with skills training and equipment ownership (SAWA Architecture, 2015).

Muhabura Integrated Polytechnic College

At Muhabura Integrated Polytechnic College in Musanze, students learn to produce ISSBs using a Hydraform machine and to build with the material, constructing structures on campus for educational purposes. While outside clients can purchase ISSBs from the college’s production, most are unaware of this option and the college lacks the capacity for large-scale production.

5.1.3.2 International experience

Stabilised soil block technology first emerged in Colombia in the form of the CINVA Ram machine – a machine that produces uniform rectangular compressed soil blocks (UN-Habitat, 2009; Earth Architecture, 2026). In the early 1980s, the Thailand Institute of Scientific and Technological Research (TISTR), together with the Human Settlements Division of the Asian Institute of Technology, further modified this machine, creating the first interlocking stabilised soil block (UN-Habitat, 2009).

Today, countries across the globe, including in Africa, Asia-Pacific, the Americas and Europe, have developed their own CSEB or ISSB standards. In France, the International Centre for Earth Construction (CRAterre)/Grenoble National School of Architecture (ENSAG) champions earthen construction techniques and serves as the centre of excellence for the UNESCO Chair on Earthen Architecture, Constructive Cultures and Sustainable Development (Bredenoord et al., 2019). Moreover, UN-Habitat’s research, publications and pilot projects have championed ISSB production and use across Africa, including in Kenya, Uganda, Sudan, Niger and Nigeria.

Thailand – R&D-driven ISSB development, transfer model and regional expansion

- **Research institute-led development:** Following decades of continuous testing (including under severe flooding, earthquake and tsunami conditions) and redesign (four block

generations since 1982), TISTR improved the block's interlocking function, compressive strength and reinforcement, reduced its weight and lowered its cement content, cutting construction costs by more than 20 per cent compared with conventional materials. This scientific rigor gives ISSB credibility for load-bearing walls, although TISTR recommends that current models remain best suited to one- or two-storey buildings (Bredenoord et al., 2019).

- **Transfer model and local economic integration:** Rather than implementing a one-off training campaign, Thailand built a sustainable training ecosystem: TISTR transfers technology and provides accompanying training to communities, entrepreneurs and micro, small and medium-sized enterprises (MSMEs), which then set up their own block production factories (more than 650 factories have been set up nationwide since 1998) and sell blocks, construction packages and technical assistance directly to households. This has shifted ISSBs from a donor-driven pilot into a self-sustaining local industry, with government housing bodies (National Housing Authority, Community Organization Development Institute) integrating ISSBs into affordable housing programmes, including condominiums and incrementally expandable homes (partly self-build housing). The National Housing Authority also supports low-income households through green housing initiatives, home renovation grants and housing building loans (Bredenoord et al., 2019).

- **Regional spread and adaptation:** At the ASEAN Next 2019 workshop, Thailand actively promoted the model regionally. In Cambodia, a social entrepreneur adapted the technology into "My Dream Home", building affordable two-storey homes 20-40 per cent cheaper than conventional housing; Habitat for Humanity separately used compressed earth bricks for social housing. In Nepal, CSEB/ISSB technology was deployed at scale by Build-up Nepal after the 2015 earthquake, rebuilding 90 villages, cutting costs by 25-40 per cent and CO_2 emissions by 60 per cent, and creating women-led earthen block enterprises – with government approval formalising the technology nationally (Bredenoord et al., 2019).

- **Lessons for Rwanda:** Thailand shows that sustained R&D investment, rigorous testing, and building a self-sustaining local production and training ecosystem are what allows ISSBs to be scaled from a pilot to a national industry. Furthermore, through its regional promotion and collaboration, Thailand has positioned itself as a leader in the affordable green housing industry.

India – demonstration projects and training infrastructure

- **R&D:** India's Auroville Earth Institute (AVEI) is a highly respected centre of expertise in earthen construction that has developed and disseminated CSEB technology, including the Auram press, provides courses and training, and has constructed several three- and four-storey CSEB residential buildings in India; in addition, the Indian Institute of Science in Bangalore has played a major role in R&D and dissemination of CSEB technology (Bredenoord and Kulshreshtha, 2023).

- **National code & training infrastructure:** A national building code for earthen construction (IS 1725) exists but is barely known among architects and builders. However, the Housing and Urban Development Corporation of India set-up of more than 500 building centres across the country has proved highly effective in training 300,000 builders in low-cost CSEB construction techniques and entrepreneurship – an example of how training centres can help spread knowledge and skills (Kulshreshtha et al., 2020).

- **Demonstration projects:** Similar to Rwanda, earthen construction struggles with a low social image in India, with CSEB houses linked to poverty (Kulshreshtha et al., 2020). However, Kulshreshtha et al. (2020) note that interviewees expect this perception to ease once not only low-income households, but also middle- and upper-income households,

entrepreneurs and government bodies visibly build with earth themselves. Successful, well-finished demonstration projects have repeatedly been shown to shift local attitudes in India towards wider acceptance far more effectively than technical arguments or written information ever could. In contrast, failed demonstration projects can set back trust for years (Jagadish, 2009; Kulshreshtha et al., 2020).

- **Lessons for Rwanda:** India's experience shows that technical potential alone does not translate into adoption; rather, standards and regulations must be backed up by accessible training, support for MSMEs, and visible demonstration projects, and vice versa.

5.1.4 Upgrading pathways

ISSBs represents a distinctive hybrid pathway. The raw material is local, but the enabling technology – compression machines imported from South Africa or Kenya – was introduced through regional supply chains and, in some cases, development cooperation programmes. This makes ISSBs' origins neither purely bottom-up (they did not emerge from existing informal knowledge, as improved rukarakara did, or from local MSMEs) nor top-down (adoption was not driven by a large firm alone or a public–private partnership between a large firm and a government mandate); instead, affordable capital equipment lowered the entry barrier for small firms to adopt it from abroad.

Despite the accessibility of the production model for small firms, ISSBs have not achieved significant uptake among larger construction firms or in formal, government-commissioned construction projects. Multiple reinforcing barriers explain this (see Section 5.1.2). Rather, ISSB producers are mainly small, project-based enterprises or cooperatives that are not yet consistently growing into larger firms. ISSB capability alone is thus not a competitive advantage because firms that do not differentiate themselves by investing in quality assurance, finishing techniques or green marketing cannot capture the price premiums needed to reinvest and grow.

A key differentiator within the pathway is between firms that own a Makiga machine – implying a more committed, capitalised investment in ISSB production as a business model – and those that only rent one on a project basis. The former are better positioned to build cumulative expertise, develop quality protocols and market their services to a broader client base. Machine leasing (renting for a longer period) is a promising, underused form of process upgrading – one that requires modest capital (where SACCOs could help) but is currently limited by weak business management capacity among firms.

In short, both material and firms currently appear to be stuck in a hybrid, static condition rather than progressing in either direction. This suggests that the pathway is not self-correcting: ISSBs' strong environmental case will not translate into market growth without deliberate intervention.

Converting the current static hybrid pathway into a dynamic upward one requires activation of an enabling ecosystem alongside the existing bottom-up dynamic, specifically building code and quality standard integration, TVET-based training and certification pathways, anchoring demand through government or development cooperation housing programmes, and a functioning equipment leasing ecosystem. If these are established, ISSBs could evolve from scattered activity by small firms into a coordinated MSME cluster – similarly to the examples of Thailand and India above – capable of subcontracting into larger affordable housing projects, turning today's ceiling into a genuine growth trajectory.

5.2 Improved rukarakara

Improved rukarakara is composed of the same earthen materials as traditional rukarakara, but is subject to strict government regulations governing its production and use. Traditional

rukarakara, known globally as adobe, is an unfired earthen brick consisting of a mixture of clay, gravel, sand and silt, with or without organic materials. The material is commonly understood as the precursor to CSEBs (which include ISSBs), with the main difference being the absence of compression and a stabiliser. While used for construction in Rwanda for centuries, the GoR effectively restricted the use of rukarakara under urban master plan zoning regulations in the 2000s following concerns that poor construction could produce "unsafe, unhygienic and high-maintenance" buildings (Local Building Materials Think Tank, n.d.; Rwanda Today, 2019). In 2019, the GoR reversed its decision after lobbying by traditional builders and cooperatives, which highlighted rukarakara's benefits and deforestation concerns linked to fired-brick kilns. As a consequence, the GoR recognised rukarakara as "an important building material for future housing development" and added it to the Rwanda Building Code, legalising its use under specific conditions (Local Building Materials Think Tank, n.d.).

Following nationwide research and testing by the Local Building Materials Think Tank – RHA, Rwanda Standards Board (RSB), Rwanda Polytechnic, MASS Design Group, EarthEnable and Greenpact Africa – the GoR released two regulatory documents for an "improved" version of rukarakara in 2022: the Adobe Block/Rukarakara Specification RS 484:2022 and the Technical Guidelines for Adobe Block Construction in Rwanda (RSB, 2022; RHA, 2022). Significantly, the specification does not alter the building material's composition but recommends a specific soil ratio while requiring improved rukarakara to conform to standardised dimensions (RSB, 2022). Under the technical guidelines, improved rukarakara may be used in single-storey, basement-free residential buildings up to 200 m² (excluding commercial buildings, churches and mosques), provided that they have a solid foundation of stone, sand or cement; local authorities retain the power to restrict its use in specific zones (RHA, 2022). Builders, in turn, are required to join associations or cooperatives for training on improved rukarakara (RHA, 2022).

5.2.1 Why improved rukarakara is promising for Rwanda

Improved rukarakara offers clear economic, environmental and social advantages over conventional materials. The strongest argument in its favour is its accessibility and cost: the material is locally available, abundant and cheap to produce. A study by MININFRA et al. (2023) found that replacing fired brick infill walls with improved rukarakara as part of a broader material substitution strategy (for example, using earthen floors instead of a concrete slab and CSEBs and triplex instead of fired bricks for partition) could reduce construction costs, excluding foundations, by approximately 15 per cent. Our own market research and interviews suggest savings for wall construction of more than 50 per cent compared to a home built with concrete bricks (e.g. INT 5, 31, 47, 55). Improved rukarakara is easy to produce on site and build with, requiring minimal training given the workforce's existing skills in traditional rukarakara; it also makes importing labour unnecessary. Furthermore, as an earth-based material, it has strong thermal and acoustic properties and performs well on stability and durability when guidelines are followed. Beyond this, production requires little energy and generates low carbon emissions, and the material is easy to recycle. For example, a typical adobe home saves 2.9 tonnes of upfront greenhouse gas emissions compared to fired bricks (MASS, 2022). It also fits naturally into the local ecology and helps preserve traditional building methods and cultural heritage.

Improved rukarakara does not come without challenges – but its limitations can be offset. Due to its heavier weight and lower compressive strength, improved rukarakara is unsuitable for high-rise buildings, which are seeing rising demand as Kigali and secondary and satellite cities urbanise and densify (e.g. INT 2, 29, 31, 40). However, most Rwandans cannot afford high-rise living and culturally tend to prefer stand-alone homes over large complexes. As the 2022 Population and Housing Census shows, around 93 per cent of private households in Rwanda still use wall materials consisting mainly of sun-dried bricks, wood or mud, with or without cement. Most construction will therefore continue at the individual, low-income household level, where improved rukarakara remains a solid choice. Adobe's vulnerability to moisture (Mora-

Ruiz et al., 2025) is also a concern in Rwanda, worsened by the country's tropical climate and growing exposure to heavy rains, floods, landslides and earthquakes. Nonetheless, even traditional rukarakara buildings have been known to stand for 50 years (INT 5, 12, 55), and clear guidelines for the improved version allow engineers to mitigate risks, for example by avoiding hazardous sites and reinforcing retaining walls with concrete, stone masonry, sandbags or honeycomb concrete blocks (Local Building Materials Think Tank, n.d.). Builders can further reduce failure risk by carrying out proper soil testing and drying blocks in the shade rather than in direct sunlight to prevent cracking (Local Building Materials Think Tank, n.d.).

5.2.2 Key drivers of and barriers to improved rukarakara adoption

A number of factors are involved in driving or hindering the adoption of improved rukarakara (see Table 4).

Table 4: Improved rukarakara adoption factors

Factor	Driver/ Barrier	Explanation
Regulation	Driver	The integration of adobe into the Rwanda Building Code and the development of the Specification and Technical Guidelines have been an important driver of its market re-entry. Today, builders can declare improved rukarakara in building permits, including in urban areas, provided that they follow quality protocols.
Profit margin and market segment mismatch	Barrier	Improved rukarakara is mainly used in single-storey, low-income housing, capping achievable sale prices. This holds little appeal for larger firms, which favour higher-margin, multi-storey or middle/upper-income projects and show little interest in moving beyond standard cement-based solutions.
Social image	Barrier	Stigma and social resistance rooted in improved rukarakara's association with poverty, rurality and informality persist (e.g. INT 7, 9, 38, 58). Even in rural areas where traditional rukarakara dominates, users aspire to build with fired bricks or concrete blocks as a sign of social mobility, while urban residents avoid it as a marker of lower status. Confusion over what "improved" rukarakara means reinforces this, as does the association of imported materials with durability, strength, development and modernity versus local materials as inferior. Rarely is improved rukarakara considered an affordable, green building material. Practitioners cope with pragmatic workarounds such as plastering (now mandatory) to visually match conventional walls or using improved rukarakara in interior or hidden walls only.
Weak quality infrastructure	Barrier	Limited testing capacity and structural innovation support constrain confidence in wider or more experimental use.
Financial value	Barrier	Banks and appraisers tend to treat improved rukarakara homes as less valuable than homes built from conventional materials, weakening their use as loan collateral and depressing resale value (INT 61, 77). Moreover, no dedicated loan or green finance products specifically target improved rukarakara, and no matched financing pipeline exists at scale – even though it remains cheaper than concrete blocks or fired bricks.

Source: Authors

5.2.3 Local and international experience of improved rukarakara: lessons for adoption and scale-up

Examples from Rwanda and other countries illustrate how improved earthen construction can be applied, promoted and scaled, while highlighting the technical, institutional and social conditions that shape adoption. The Rwandan cases demonstrate the use of improved rukarakara in affordable housing and planned public housing, while international experience provides examples of how standards, structural reinforcement, demonstration projects, local champions, community engagement and architectural design have influenced the uptake of adobe construction. Taken together, these cases show that technical improvements alone do not determine adoption: perceived benefits, trust, skills, institutional support, and the visibility and quality of built examples also shape whether improved earthen construction moves beyond individual projects.

5.2.3.1 Local experience

Rubona Affordable Housing Estate

Rubona Estate in Rwamagana District, designed and built by the American NGO EarthEnable (locally known as Tuba Heza), is a multi-unit housing example for low- and modest-income households: in 2025, 26 homes with walls of improved rukarakara, stone foundations, timber ring beams and clean earthen flooring were inaugurated in line with the Adobe Specification and Technical Guidelines that EarthEnable co-developed. EarthEnable trained local masons to build the houses, selling them under the rent-to-own finance model and including income-generating greenhouses. EarthEnable is currently constructing additional homes in Rwamagana, Bugesera and Nyamagabe districts and plans to build 100 more homes in 2026. The example shows that private clients accept the material when shown evidence of durability, cost savings and long-term performance (EarthEnable, 2026).

Volcanoes Community Resilience Project

The Volcanoes Community Resilience Project, supported by the GoR and the World Bank, is currently developing a Smart Green Village for communities affected by the expansion of Volcanoes National Park. The planned housing – around 510 units – is required to follow Rwanda's latest building standards, including the Adobe Specification and Technical Guidelines, making it an important example of the new standards being incorporated into large-scale public housing (Republic of Rwanda, 2023). The village is designed to combine improved rukarakara with other local building materials and climate-resilient features (Republic of Rwanda, 2023). However, the project has not yet been completed: the Smart Green Village remains under development, with the most recent updates confirming that the wider project is still being implemented (MoE, 2025; World Bank, n.d.). If successful, the Smart Green Village could show how the new adobe standards could be applied not only to individual houses but to a large, government-supported settlement project and how improved rukarakara can fit in with other sustainable construction practices.

5.2.3.2 International experience

Adobe construction is seeing renewed global interest, particularly in LMICs facing population growth, housing shortages and sustainability pressures (Kulshreshtha et al., 2020). Through research, standards and regulations, physical reinforcement (often through fibres and stabilisers), demonstration projects, and awareness and educational campaigns, countries are pursuing adobe improvements and promotion, offering valuable lessons for Rwanda.

Peru – national standard, structural reinforcement and educational campaigns

- **National standard:** Peru's Norma Técnica E.080 is one of the most developed national adobe building codes globally, regulating unit and wall dimensions, admissible stresses, reinforcement and moisture protection; it also cross-references the seismic design code E.030, which prohibits construction on the poorest soils. It is a useful benchmark for comparing and potentially expanding Rwanda's RS 484:2022 in the future.

- **Structural reinforcement systems:** Four decades of research at Peru's Pontificia Universidad Católica del Perú (PUCP) identified internal cane reinforcement, welded wire mesh with mortar overlay, and polymer geomesh (anchored to the foundation and a ring beam, sealed under mud plaster) as most effective in strengthening adobe construction against seismic events. After the 2007 Pisco earthquake, PUCP and CARE Peru trained more than 800 community members and produced illustrated manuals, resulting in over 1,000 geomesh-reinforced adobe houses built by NGOs. Low-cost variants (repurposed tire straps, polypropylene packing bands) worked well in the most resource-constrained settings.

- **Community trust-building and educational campaigns:** PUCP's Pullo project found that trust, not technical merit, was the real barrier to adoption. Multi-level campaigns (schools, government, NGOs, media) were essential alongside the engineering. The most effective tool was a portable shaking table showing an unreinforced house collapse next to a surviving reinforced one – more persuasive than any written explanation, especially paired with early community leader buy-in and illustrated, plain-language manuals with relatable local characters, especially where literacy was low. Reaching remote areas, transporting equipment and maintaining a local presence remained real constraints (Serrano et al., 2016; Blondet et al., 2017).

- **Lessons for Rwanda:** Strong codes and reinforcement techniques translate into adoption when paired with visible, trust-building demonstration at the community level.

Ethiopia – demonstration projects, local champions and context specificity

- **Demonstration projects and local champions:** From 2009 to 2012, a project led by Halmstad University (Sweden) built four technically strong adobe demonstration buildings in Durame, Kambaata Region, including a temporary roof construction method that solved the region's unpredictable rainy weather. A 2015 follow-up found the buildings still in good condition, and an initial survey showed strong local enthusiasm (93 per cent supported adobe and 90 per cent were willing to train). Yet the buildings were never used as intended and essentially had no lasting impact on regional adoption. The project's core failure can be traced to the withdrawal of the local development organisation that was supposed to "champion" the technology – due to a lack of resources, it never carried out the planned follow-up training and never used the buildings as reference or demonstration objects (Hjort et al., 2016).

- **Context specificity:** Unlike other Ethiopian regions where adobe spread spontaneously, driven by deforestation-caused timber shortages, Durame still had an adequate eucalyptus supply, so adobe's central selling point elsewhere simply did not apply locally. Other benefits (indoor climate, termite resistance) are only perceptible after years of living in a building, making them too slow and invisible to independently drive adoption. Compounding this, working with clay carries low social status in Ethiopia (Hjort et al., 2016).

- **Lessons for Rwanda:** Technical success does not equal adoption success. Rather, diffusion of an "improved" building technology depends on (a) a visible, locally felt advantage over the status quo, (b) a credible local champion (an individual or institution) sustaining trust (not a single donor-funded organisation likely to withdraw) and (c) continued institutional follow-through, not a one-off demonstration project.

Burkina Faso – architectural and aesthetic value and community involvement

- **Architectural and aesthetic value:** The Gando Teachers' Housing, designed by architect Diébédo Francis Kéré and completed in 2004, demonstrates that adobe construction can be technically upgraded while even enhancing its architectural and aesthetic value. Locally used adobe walls were set on cement and granite foundations to prevent moisture damage, protected by generous roof overhangs against wind-driven rain, and finished with a durable bitumen render instead of the traditional loam coating vulnerable to termites. Roofs paired vaulted compressed earth bricks with an in-situ reinforced concrete pour, while crescent-shaped gaps between walls and vaults allowed passive ventilation and daylight.
- **Community involvement and cultural heritage:** The six housing units were arranged in a sweeping arc that echoed traditional Burkinabé compound layouts, reflecting Kéré's design philosophy: rather than treating local materials as a technical compromise, he uses them as the foundation for a simple, yet modern architectural language. Moreover, involving the community in design and construction created a lasting sense of ownership and pride, helping to counter the stigma of earthen materials as "premodern" and providing an easily adaptable example (Kéré Architecture, 2026).
- **Lessons for Rwanda:** Kéré's work suggests that better design and finishing and community involvement – not just technical reinforcement – can reposition improved rukarakara as a source of architectural pride rather than a marker of poverty.

5.2.4 Upgrading pathways

Improved rukarakara's development is unusual among Rwanda's green building materials: it emerged from the bottom up from masons and small firms (with support from development cooperation), building on centuries of traditional rukarakara use, rather than through an (international) lead firm (top-down pathway assumed in the global value chain literature). It was also not initiated by a government programme, foreign investor or research institution. The informal sector's accumulated experience with the material was influential enough that practitioners successfully lobbied the GoR to formally legalise improved rukarakara's use in construction. Moreover, a stable rural market for the traditional (unimproved) version persists alongside it.

Despite its advantages, improved rukarakara has not moved up the pathway for adoption by larger firms. Multiple barriers (see Table 4 above) compound firm-level constraints already common to small Rwandan construction businesses, such as project-to-project operation without capital reserves, weak business and marketing skills, and irregular, low-value contracts with low-income clients, leaving little room for reinvestment or growth. A further, specific constraint is that formal training and certification systems do not recognise improved rukarakara skills, so masons with genuine expertise cannot credibly signal their expertise to clients, NGOs or government programmes that might otherwise offer larger contracts; this functions as a ceiling on growth rather than merely a barrier to entry.

The firm EarthEnable shows that the upgrading pathway is not fully blocked: by developing a visually attractive, affordable earthen flooring product and proactively marketing it to NGOs and development cooperation-funded affordable housing programmes, it demonstrated that combining technical performance with aesthetic improvement and deliberate market positioning can create real demand and a scaling trajectory. However, EarthEnable remains heavily dependent on NGO/international funding, and many low-income households still cannot afford its products or access financing. This demonstrates that demand-side finance remains a binding constraint even when supply-side barriers are addressed.

Five conditions are needed to unlock improved rukarakara's potential:

- A societal and government mindset shift to address stigma
- Technical and aesthetic improvements of the finished product
- Experimentation with material combinations (drawing on international examples) to broaden acceptability in more upscale market segments
- Integration into formal quality infrastructure and TVET systems
- Targeted green finance, particularly via SACCOs, on the demand side

Looking ahead, improved rukarakara's green credentials are strong, but its productivity/scaling potential is constrained unless it moves into mixed-material applications – for example, as infill walls in cement- or steel-frame multi-storey buildings, or flooring/interior surfaces in mid-market housing – which could allow specialised small firms to supply components to larger contractors via subcontracting, an indirect route into the "top-down" pathway. The conclusion is that improved rukarakara is a viable alternative to conventional materials, but there is an institutional and market underdevelopment: the conditions needed to realise the material's potential are achievable but require deliberate policy, standards and investment choices not yet made.

5.3 Solar PV systems & SWHs

A solar PV system is a renewable energy technology that uses PV panels to convert sunlight into electricity, powering homes, businesses and communities. PV systems can be grid-connected, hybrid or off-grid. Grid-connected systems typically comprise a PV array (a collection of rooftop panels), an inverter, a utility meter and a grid connection (Clean Energy Business Council, 2026). In contrast, off-grid systems operate independently and therefore do not require a utility meter or grid connection, instead using a charge controller and (most often) a battery bank to regulate and store electricity generated by the PV array. In Rwanda, off-grid systems can be divided into two main categories: stand-alone systems, including basic/advanced solar home systems (SHSs) that serve individual households or homes, and solar mini-grids, which supply multiple homes or facilities through a local, isolated network (MININFRA, 2016). PV system efficiency depends on the climate, panel type, proper system configuration and installation, and regular maintenance (Clean Energy Business Council, 2026).

Solar thermal systems are similar, yet different to PV systems. A SWH is a solar thermal system that uses thermal collectors (rather than PV panels) to convert sunlight into energy to heat water. Collectors absorb solar radiation and transfer the resulting thermal energy to a heat-transfer fluid, typically water or a water-based mixture of ethylene or propylene glycol (Greco et al., 2020). The heated fluid then transfers heat to water stored in an insulated tank for later use (Greco et al., 2020). For domestic applications, collectors are commonly available as flat-plate or evacuated-tube systems (Greco et al., 2020). Their performance depends on many of the same factors as PV systems. However, while PV systems can provide electricity for a wide range of applications, solar thermal systems are solely designed to provide hot water. SWHs are also simpler to install, as they do not require a battery, inverter, utility meter or grid connection, resulting in lower maintenance requirements and failure risk.

5.3.1 Why solar PV systems and SWHs are promising for Rwanda

Rwanda's energy supply currently remains heavily dependent on conventional, greenhouse gas-emitting sources. Most prominently, biofuels and waste account for 87 per cent of the total energy supply (including domestic and imported sources), while households using traditional cooking stoves consume an average of 1.8 tonnes of firewood annually (FAO [UN Food and

Agriculture Organization], 2022; IEA [International Energy Agency], 2022; REG, n.d.-a). Other key sources include imported oil for transport, coal, methane gas from Lake Kivu, and hydropower, while solar and wind contribute less than 1 per cent of the total energy supply (IEA, 2022). When considering electricity generation alone, Rwanda presents a more sustainable picture: in fiscal year 2024/2025, the country generated 1,568.5 GWh, comprising hydropower (31.35 per cent), domestic methane-based thermal (33.85 per cent), peat-based thermal (9.96 per cent), other thermal (0.37 per cent), solar (1.13 per cent), jointly owned hydropower plants (15.8 per cent) and imports via interconnectors (7.6 per cent) (World Bank, 2026a).

Rwanda's journey to electricity has been remarkable: the country has achieved one of the fastest electricity access expansions in the world, increasing household electrification from just 6 per cent in 2009 to 84.6 per cent in July 2025, while also connecting most productive users, including MSMEs (Republic of Rwanda, 2024b; REG, 2025). Today, Rwanda has a 1,158-km transmission network and a 37,728-km distribution network, with 59.6 per cent of households connected to the national grid and 25 per cent able to access electricity through (mainly solar) off-grid systems (World Bank, 2026a; MININFRA, 2025a; REG, 2025). Nevertheless, with electricity demand projected to grow by at least 8-10 per cent annually through to 2035 and in view of national commitments to universal electricity access, clean cooking and carbon neutrality by 2030, 2035 and 2050, respectively, expanding the renewable energy sector is essential (REG, 2024; Republic of Rwanda, 2020). An estimated USD 3.6 billion is required to meet Rwanda's energy needs up to 2035 (Ngowa, 2025). This presents a significant policy challenge for the country.

Solar energy offers a wide range of advantages over conventional energy sources. Firstly, solar is one of the most abundant and accessible renewable energy resources in the world, supporting applications from small- to large-scale power generation (Damo et al., 2024). With an average solar radiation of approximately 5 kWh/m² per day and five peak sunshine hours per day in Rwanda throughout the year (even during the rainy season), the country's proximity to the equator provides favourable conditions for solar energy generation (EPD, 2026; Hakizimana et al., 2020). In particular, Rwanda's Southern and Eastern provinces have a high solar energy potential, recording an average solar radiation of 5.4 kWh/m² per day (Hakizimana et al., 2020). Secondly, solar systems can reduce electricity costs in the long term and can lower greenhouse gas emissions by replacing diesel with solar systems for electricity and hot water, with far lower air and noise pollution and no direct pressure on forests or soils (Hakizimana et al., 2020). Thirdly, using solar energy can secure energy independence from conventional energy sources and export countries (Clean Energy Business Council, 2026). Lastly, solar systems can contribute to job creation as skilled technicians and engineers are needed to install and maintain them.

Solar energy has limitations, too. Disadvantages include the high upfront cost of PV systems and their intermittent nature, which requires backup energy sources during prolonged periods of low sunlight (INT 23, 24); this can increase system costs (Damo et al., 2024). In addition, increasing volumes of end-of-life solar panel waste, which too often ends up in landfills in Africa, present another challenge (Damo et al., 2024). Regulations to ensure an adequate recycling infrastructure and sufficient environmental policies are the most effective way to prevent this from happening.

In Rwanda, PV adoption remains uneven. The most visible part of the market are commercial and industrial (C&I) off-grid rooftop PV systems. Reference installations include Norrsken Kigali House and I&M Bank Kigali, several Kigali hotels and factories, embassies and UN buildings. The less visible part, but arguably the most institutionally successful, is the off-grid SHS segment. According to MINECOFIN (2026a) data, 46,861 SHSs were supplied and installed by March 2026, exceeding the initial target of 25,000 systems.

SWHs are one of the most commercially mature green construction technologies in Rwanda – albeit with considerable scope for expansion. The GoR introduced SWHs in cooperation with development partners in 2009 and then officially launched a programme in March 2012 piloting the installation of 100 SWH units (Hakizimana et al., 2020). Since then, the hospitality sector has emerged as an important market for SWHs in Rwanda, with residential adoption growing particularly among (high-income) residential buyers in Kigali, while rural household uptake remains limited (INT 48, 69). Similarly, most commercial and institutional buildings in remote areas rely on diesel generators as the main source of electricity (Republic of Rwanda, 2024a). To increase uptake, MININFRA has been promoting SWHs in modern settlements and large facilities, including hotels and accommodation establishments (MININFRA, 2025a). During fiscal year 2024/2025, 830 units were disseminated, bringing the cumulative number installed nationwide to 4,367 (MININFRA, 2025a). These low levels of deployment (and demand) indicate significant scope for market expansion.

5.3.2 Key drivers of and barriers to solar PV and SWH adoption

The factors involved in driving or hindering the adoption of solar PV and SWHs are shown in Table 5.

Table 5: Solar adoption factors

Factor	Driver/ barrier	Explanation
Solar PV systems		
Policy and regulatory environment	Driver	The adoption of off-grid PV systems has primarily been driven by Rwanda's 2016 Rural Electrification Strategy, which established a nationwide SHS programme to provide basic electricity access for households with the lowest income (MININFRA, 2016). Rather than supplying SHSs directly, the GoR supported deployment through credit lines and results-based financing implemented through BRD and Energy Development Corporation Ltd (EDCL), while REG and EDCL monitored progress towards annual electrification targets through performance contracts (*imihigo*) (REG, n.d.-b). EDCL also partnered with over 30 private solar companies to strengthen the supply chain and expand nationwide access, while import tax exemptions for eligible solar energy equipment further accelerated off-grid market growth (REG, n.d.-b; World Bank, 2024). Initiatives including (but not limited to) the Rwanda Renewable Energy Fund and the Energy Access and Quality Improvement Project, backed by the World Bank, helped to improve the affordability of SHSs – for example, through the Window 5 subsidy – and supported their deployment (REG, 2018; World Bank, 2024). The 2019 Minimum Standard Requirements for Solar Home Systems aimed to prevent low-quality products from undermining consumer confidence (MININFRA, 2019b). Historically, grid-connected rooftop PV has received less attention than off-grid SHSs. This is now changing. In May 2026, the GoR signed a Country Partnership Framework with the International Solar Alliance, intended to accelerate the roll-out of rooftop PV in the country (MININFRA, 2026). Higher electricity tariffs for higher-consuming households and commercial users since late 2025 may further increase the economic attractiveness of on-site PV systems (RURA [Rwanda Utilities Regulatory Authority], 2025; KT Press, 2025; INT 69).

Factor	Driver/ barrier	Explanation
	Barrier	Rwanda's regulatory framework for renewable energy, including solar power, is still evolving. For example, under the 2015 National Energy Policy, autonomous generation systems below 50 kW of installed capacity were exempt from licensing requirements, effectively constraining the deployment of larger C&I solar projects (MININFRA, 2015). Following lobbying by solar developers and investors against the constraint, RURA initiated a review of the policy and rules, considering an extension of the 50 kW peak limitation to 250 kW (Ashimwe, 2023; EPD, 2024). Indeed, I&M Bank's installation demonstrates that exceeding 200 kW at Kigali Heights is feasible (Mwiza 2025). Nonetheless, the regulatory framework governing such larger systems remains under development. The new 2025 Energy Policy calls for further solar regulation and integration into the wider electricity system, with the aim of generating 30 MW by 2029/2030 and another 20 MW by 2034/2035 (MININFRA, 2025b). In particular, the policy envisages connecting the energy generated from solar energy to national and isolated mini-grids through direct sale or net metering (MININFRA, 2025b). Prime Minister Justin Nsengiyumva reiterated the goal of introducing net metering in July 2026 (AllAfrica, 2026). However, the relevant regulations remain to be developed, which gives rise to uncertainty.
Grid reliability and electricity prices	Driver	Rather than climate objectives, our research findings suggest that concerns over grid reliability and rising electricity costs are increasingly influencing demand for rooftop PV systems, including in urban areas with established grid connections (INT 23, 59). This is consistent with wider evidence that grid-connected consumers face frequent outages due to old and overloaded transmission and distribution lines, leading to consumer distrust and loss of business for the private sector (Republic of Rwanda, 2024b).
Institutional and market incentives	Barrier	Existing institutional incentives favour electricity sales over distributed self-generation. For example, our research findings suggest that REG has invested heavily in expanding grid access and relies on electricity sales to recover these infrastructure costs, meaning that widespread rooftop PV may reduce utility revenues. Furthermore, grid-connected households are not eligible for SHS subsidies, and net metering and bidirectional meters are not yet deployed, reducing incentives for rooftop PV. On top of that, the continued prevalence of single-phase connections may also constrain the use of rooftop PV for higher-power productive activities, such as agro-processing and small-scale manufacturing, which commonly require three-phase electricity supplies. Nonetheless, REG is currently working on upgrading substantial sections of the distribution network from single- to three-phase supply to accommodate increased C&I demand (REG, 2021).
High upfront costs and finance	Barrier	High upfront investment remains the principal constraint for PV adoption (INT 20, 31, 69). Batteries account for a large share of system costs, while our research findings suggest that commercial bank loans are poorly suited because of high interest rates (14-18 per cent), collateral requirements and lengthy approval (due diligence) processes. While pay-as-you-go (PAYG) finance models already exist, our research findings suggest that despite several years of engagement between solar firms and the banking sector, no dedicated bank products for PV systems have materialised. Firms also report limited access to inventory finance.

Factor	Driver/ barrier	Explanation
Import dependence	Barrier	So far, Rwanda has limited domestic capacity for PV module assembly and manufacturing. As a result, components need to be imported, leaving prices vulnerable to external shocks, exchange rate volatility and long supply chains (World Bank, 2024; INT 48). While global PV prices have fallen, depreciation of the Rwandan franc against the US dollar (from RWF 650 in 2014 to approximately RWF 1,450 in 2026) has offset much of these savings, increasing local system costs.
Trust and consumer confidence	Barrier	Earlier poor-quality installations of PV systems have created a persistent perception that “solar does not work”. Weak communication between installers and customers reinforces this trust deficit.
Skills and maintenance	Barrier	Installation capacity of PV systems has expanded faster than maintenance services, resulting in an acute skills gap in repair. Furthermore, repair expertise is concentrated in Kigali, limiting after-sales service and contributing to system abandonment in rural areas.
SWHs		
Policy and regulatory environment	Driver	The uptake of SWHs has been driven by early grants and REG’s SolaRwanda programme, which provides zero-interest, two-year instalment financing through local distributors. Our research findings suggest that stakeholders identify the reinstatement of the scheme (after its suspension between 2018 and 2023) as the main reason for renewed market growth (INT 48, 69). Rwanda’s solar water heating regulations and standards also provide a regulatory framework (RURA, 2025).
Demonstration and awareness	Driver	A mechanism with a measurable effect has been the Cleaner Production and Climate Innovation Centre (CPCIC) and NIRDA demonstration project, which equipped a set of firms (predominantly in agricultural processing) with solar thermal systems. The demonstration effect was strong and produced an observable peer effect on neighbouring firms. Radio and TV awareness campaigns linked to the loan programme have accelerated uptake by normalising the technology rather than by transferring technical details.
Certification	Driver	Solar Keymark certification has become an important quality benchmark for SWHs, helping suppliers differentiate themselves from earlier low-quality products and increasing consumer confidence (INT 48).
Electricity prices	Driver	Recent increases in electricity costs have added a demand-side push, since electric water heating accounts for a substantial share of energy use among hotels and higher-income households. Rising tariffs make the savings from SWHs more visible and can shorten the (perceived) payback period (INT 48, 69).
High upfront costs and finance	Barrier	Despite the availability of zero-interest financing under SolaRwanda, upfront purchase costs remain a significant barrier for most low- and middle-income households. Given competing energy needs, hot water remains a luxury that few households can – or are willing to – afford.
Import dependence	Barrier	Like PV systems, SWHs are imported, primarily from China, with smaller volumes from India and Europe. However, exchange rate depreciation has increased equipment costs, with a typical 300 L water capacity system now costing around USD 1,200.

Source: Authors

5.3.3 Local and international experience of solar PV and SWHs: lessons for adoption and scale-up

5.3.3.1 Local experience

Rwanda–International Solar Alliance Country Framework Partnership

In May 2026, MININFRA and the International Solar Alliance signed a three-year Country Partnership Framework to accelerate the development of Rwanda's solar projects. The partnership covers utility-scale, rooftop and off-grid solar, with around 40 per cent of the planned capacity expected to come from decentralised systems, including rooftop and agricultural applications. It also supports solar-powered irrigation, agricultural processing, cold storage, clean cooking and e-mobility, alongside improved project preparation, access to blended finance and private-sector investment. A Solar Technology Application Resource Centre at the University of Rwanda will support training for policy-makers, engineers, technicians and entrepreneurs. The partnership provides a strong platform for scaling solar energy, but its impact will depend on whether financing, grid infrastructure, affordability, skills and implementation capacity keep pace with the planned expansion (MININFRA, 2026).

5.3.3.2 International experience

Across the globe, countries have combined financial and market-based instruments to accelerate solar uptake among residential and C&I consumers, including grants and rebates, tax credits and exemptions, feed-in tariffs and premiums, net metering and net billing, R&D incentives, and competitive auctions and tenders (Ramírez et al., 2017; Dransfield et al., 2026; IEA, 2025a, 2025b). These measures are complemented by regulatory provisions governing licensing, permitting, grid connection and technical standards. Moreover, business models such as leasing, monthly payment plans, PAYG and subscription services are increasingly expanding access to solar systems by improving affordability and stimulating market growth (Damo et al., 2024).

Vietnam – feed-in tariffs, tax incentives and metering for PV systems

- **Incentives, metering and bottlenecks:** Vietnam rapidly expanded solar PV systems deployment after introducing feed-in tariffs (FITs) in mid-2017 and net metering in late 2017 (Prime Minister of Vietnam, 2017; Do et al., 2021). The FIT scheme guaranteed solar producers electricity prices of up to USD 93.5 per MWh for 20 years, exceeding the estimated cost of PV generation and creating strong incentives for private investment before tariff rates were reduced again in 2020. FITs were supported by tax incentives (including import tariffs and corporate income tax exemptions for solar developers), land lease exemptions, and an enabling investment framework that encouraged private and foreign investment. Moreover, net metering allowed consumers' surplus electricity generated by a rooftop PV system to be fed into the national grid, which was then settled or credited according to state-level regulations. In 2019, Vietnam replaced net metering with a scheme in which exported rooftop solar power is metered separately and paid at a set tariff, after tax and invoicing uncertainties had delayed Vietnam Electricity (EVN)'s signing of rooftop solar PPAs (Baker McKenzie, 2019; Duane Morris, 2019). Two strong regulatory frameworks – the National Strategy on Renewable Energy Development 2015 and Resolution 55/NQ-TW on the Orientation for National Energy Development 2020 – supported solar expansion. However, the rapid expansion outpaced transmission infrastructure, leading to grid congestion and the curtailment of solar generation in several provinces (Do et al., 2021).
- **Lessons for Rwanda:** Vietnam's experience demonstrates that while attractive FITs can accelerate renewable energy investment, they must be accompanied by timely grid expansion, energy storage and long-term policy certainty to ensure reliable integration of

variable renewable energy. Moreover, policy adaptability, as demonstrated by the move from net to gross metering, is necessary (Do et al., 2021).

India – pathways to overcoming barriers to residential solar uptake

- **National measures:** India's rapid economic growth and expanding population increased energy demand massively (World Bank, 2026a). In 2016, India launched multiple measures, including the World Bank-funded Grid-Connected Rooftop Solar Programme, which improved access to debt finance, reduced financial risks and strengthened industry capacity, significantly accelerating C&I rooftop solar uptake. However, residential adoption remained limited, particularly among low- and middle-income households, and overall uptake fell well short of the government's target. Key barriers included a lack of stable roofs, high upfront costs despite capital subsidies, limited access to collateral-free and low-interest financing, limited awareness of benefits and procedures, and capacity constraints among distribution companies, lenders and installers. State-level differences, including in feed-in tariffs and net metering policies, further hindered adoption. In response to these challenges, India introduced the PM Surya Ghar Muft Bijli Yojana scheme in 2024, targeting ten million rural and urban households by March 2027: the programme provides capital subsidies of INR 30,000 per kW for the first 2 kW and INR 18,000 for the third kW, alongside provisions for collateral-free loans, a streamlined online portal and a national programme implementation agency. On top of that, India is now promoting Made-in-India PV modules to reduce import dependence (World Bank, 2026a).
- **Lessons for Rwanda:** While much smaller in size, the key lesson for Rwanda is that scaling residential solar requires easy access to relevant information, affordable financing, streamlined (digital) procedures, strong private-sector and institutional capacity, and quality standards to ensure sustained residential uptake.

Kenya's M-KOPA PAYG solar business model

- **PAYG financing:** In 2007, Safaricom launched the M-Pesa mobile money platform in Kenya, creating the foundation for innovative energy financing. Building on this platform, M-KOPA Solar introduced a PAYG model in 2011 that enabled low-income, off-grid households to purchase SHSs (for USD 200) through a small upfront payment (USD 35) followed by daily instalments (USD 0.45) for one year via M-Pesa. After the loan was paid off, the SHS was theirs. M-KOPA estimates that customers who replace traditional energy sources with its basic solar kit save approximately USD 750 over the first four years (Rastogi, 2018). By late 2025, M-KOPA had served more than 4.8 million customers in Kenya, with earlier evidence suggesting repayment rates of around 95 per cent, and demonstrated that PAYG financing can expand affordable access to clean energy (M-KOPA, 2025; IFC, 2018). Today, the business model has even gained popularity in urban and peri-urban areas that typically benefit from more advanced technological infrastructure (Damo et al., 2024). Bboxx, a multinational company, has since established a similar PAYG model for SHSs in Rwanda, reaching more than 350,000 households (Bboxx, 2026).
- **Lessons for Rwanda:** The Kenyan experience shows that PAYG models require three enabling conditions: widespread mobile money services, regulations that allow internet-enabled remote service management, and strong last-mile sales and maintenance networks.

Tunisia's PROSOL for SWHs

- **National programme:** In 2005, the Tunisian National Agency for Energy Conservation, together with the state electrical utility, the Tunisian Company of Electricity and Gas (STEG), UNEP and the Italian Ministry for Environment, Land and Sea, initiated the Tunisian Solar

Programme (PROSOL; inno4sd.net, 2019) to jumpstart the SWH market (World Bank, 2016). PROSOL combines five-year concessional loans for households purchasing SWHs with a government capital cost subsidy covering 20 per cent of the SWH costs to offset existing liquefied petroleum gas subsidies (Omri et al., 2015; World Bank, 2016). The solar loans are repaid through the monthly electricity bill, with STEG acting as debt collector and loan guarantor, thereby reducing the risk for commercial banks and encouraging their participation in renewable energy financing (World Bank, 2016). By 2024, PROSOL had facilitated the deployment of around 400,000 SWHs and renewed its financing agreement until 2026 (AMNE, 2024). Beyond increasing solar thermal uptake, the programme also delivered public-sector savings by reducing liquefied petroleum gas consumption and associated fossil fuel subsidy expenditure, estimated at USD 101 million over the lifetime of the systems (World Bank, 2016).

- **Lessons for Rwanda:** PROSOL shows that utility-collected loan repayment addresses the bank credit problem documented in our interviews, and sustained support significantly increased demand while reducing carbon emissions. However, the simultaneous subsidisation of both liquefied petroleum gas and solar water heating was – and is – not recommended in the long term.

5.3.4 Upgrading pathways

Solar PV systems

Solar PV systems have primarily been diffused in Rwanda through a top-down pathway, although demand-side dynamics show some hybrid characteristics. PV equipment is imported, installation requires specialised technical skills, and the market is divided between off-grid and on-grid systems. These features have made diffusion dependent on government programmes, imported technology and established solar firms rather than broad market-driven learning.

Diffusion beyond established firms remains limited because installation and maintenance of PV systems require specialised expertise and the market has historically been confined to off-grid systems and large commercial projects. While some electrical contractors are beginning to offer PV services, skilled installers and maintenance capacity remain concentrated in Kigali, creating challenges for long-term system reliability outside the capital.

Firm upgrading has been strongest among companies combining technical expertise with business capabilities and service-based models such as solar-as-a-service and power purchase agreements. Government support, including import tax exemptions and SHS subsidies, has reduced costs and stimulated market growth. However, the absence of feed-in tariffs, net metering and supportive grid infrastructure continues to constrain expansion of distributed rooftop PV. Overall, PV development depends on the interaction of firm capabilities, market demand driven by electricity costs and grid reliability, and an enabling policy environment.

SWHs

SWHs have also followed a predominantly top-down diffusion pathway, but with a stronger demand pull from the private sector, particularly the hospitality industry. Like PV systems, solar thermal systems are largely imported, but installation is considerably simpler because they do not require electrical integration, making entry easier for local contractors.

Although more firms can install SWHs than PV systems, diffusion remains geographically concentrated in Kigali, and limited working capital restricts distributors' ability to expand. Rather than scaling exclusively in SWHs, most firms upgrade by diversifying into PV systems and

broader clean energy services, as the SWH market is constrained by relatively low demand for hot water and a limited customer base.

Nonetheless, the relative success of SWH diffusion in Rwanda reflects the combination of a relatively simple technology, clear economic returns for commercial users, sustained government support and demonstration effects from the hospitality sector. Continued growth will depend on addressing affordability constraints, expanding finance for distributors and strengthening implementation of building regulations that encourage wider adoption.

6 Summary of key findings and main recommendations

This section summarises the key findings from our research and presents recommendations for stakeholders across Rwanda's green construction ecosystem, including the GoR and its district authorities, financial and education institutions, energy and building material professionals, unions, cooperatives and trade associations, and development cooperation partners.

6.1 Government of Rwanda

Key findings

- The GoR continues to play a key role in providing the necessary stimulus to expand green construction practices. While a strong government can spur demand through public procurement and investment pushes, it also risks private-sector dependence, weaker innovation and rent capture.
- The policy framework is already well developed, but some policies need constant updating and refinements for the future and partly better alignment with each other (e.g. GBMCS, Green Taxonomy, public procurement, energy policy). See detailed recommendations below.
- Upgrading pathways differ between partly green and highly green firms, and between individual materials and technologies, so support measures need to be differentiated accordingly.

Recommendations

- **Align support with distinct upgrading pathways.** For partly green firms, provide practical entry support – such as short, applied training, technical advice, small equipment leasing and procurement preferences for using approved green materials – to help them adopt and reliably integrate green practices. For highly green firms, focus on scaling measures, including larger working capital and investment finance, certification support, supplier development links to major contractors, and access to larger public and private projects. These measures should be tailored to individual materials and technologies. For example, ISSB producers may need equipment leasing, quality control support and anchor demand through public projects; improved rukarakara producers need formal certification, better testing and targeted demonstration projects to overcome quality and market perception barriers; and firms adopting more technically complex technologies, such as SWHs, require specialised installation and maintenance training, standards enforcement and finance that recognises the higher upfront investment.

- **Use these five strategic levers** (see Section 4 for details): (1) reform the green finance system for MSMEs, including generating revenue via green property taxes (land value capture), (2) introduce supplier development programmes to strengthen value chain linkages, (3) sequentially phase in and integrate green building and renewable energy regulations, (4) use public procurement strategically to promote the greening of MSMEs and (5) build public confidence in and acceptance of green construction through green demonstration buildings and projects at different price points across the country, with a particular focus on ISSB.

- **Specifically on setting up supplier development programmes for MSMEs in construction: acquire expertise in supplier development and green industrial policy**, for example technical assistance from a development cooperation partner. The establishment of a dedicated unit within MINICOM is another option. The programme should combine carefully designed incentives and requirements, such as mandatory green training obligations for large firms winning public tenders and voluntary incentives for green practices in private projects. A dedicated green MSME finance mechanism could be funded from contributions to a dedicated fund by firms winning government tenders. The design of the fund and level of the contributions require a feasibility study; South Africa has a 0.2 per cent project levy in construction and a 2.75 per cent contribution of automotive company turnover over ten years to such a fund, representing the bandwidth possible. The programme should also define, where appropriate, the number and type of training activities large firms are expected to provide and ensure that the needs of large firms and MSMEs are matched with relevant education and training providers, including in areas such as business and soft skills. A robust monitoring and review system should prevent non-compliance and rent capture. Quotas or joint venture requirements alone are unlikely to upgrade domestic firms without complementary measures, particularly access to green finance and skills development.

- **Expand the GBMCS sequentially.** Currently, the GBMCS only covers Category 4 and 5 buildings. However, it should initially be expanded to Category 3 buildings, followed by simpler and more cost-effective requirements for Category 1 and 2 buildings. Lower building categories should not be subjected to the same stringent requirements as larger structures. Instead, the focus for these categories should be on pragmatic measures, including ventilation, daylighting, water efficiency, rainwater management, fundamental energy efficiency, SWHs (where hot water provision is applicable) and solar PV readiness (where technically feasible).

- **Integrate ISSBs into the Building Code, the GBMCS and relevant teaching curricula.** Embedding ISSBs into these frameworks and university and TVET curricula, combined with the construction of ISSB-compliant public buildings through public procurement, can provide the market with the critical push needed to accelerate adoption at scale. Moreover, following thorough research and testing, visually attractive, cost-effective, durable and environmentally friendly ISSB construction could become a Rwandan construction brand with clear benefits for the local economy and the environment.

- **Set up a green construction coordination platform** as part of MININFRA's Urbanisation Sector Working Group. The new group could maintain a comprehensive overview of ongoing initiatives, available funding and unaddressed gaps, increase policy coherence (for example, by making suggestions for harmonising definitions and priorities across relevant policies and regulations, including the Building Code, the GBMCS, the Rwanda Green Taxonomy and green certifications such as the Rwandan version of EDGE currently being developed) and reduce duplication of efforts. In addition, the existing thematic sub-group on Capacity Development could take the lead in coordinating education institutions and the private sector to align university and TVET curricula and the industrial placement system more closely with evolving industry and labour market needs.

- **Provide clear policy signals to drive innovation in green construction.** Explicitly use planned innovation support measures of the 2024 Industrial Policy for green construction. Moreover, mandate the revision of green quality infrastructure in line with these signals and measures.

- **Leverage Rwanda's solar energy potential.** Most importantly, establish a renewable energy law to diversify Rwanda's energy mix and provide a clear regulatory framework for autonomous solar generation, signalling long-term government commitment. Simplify licensing and other constraints on solar self-generation while rehabilitating and expanding transmission and distribution networks to accommodate rising electricity flows and improve reliability. Where appropriate, upgrade transmission voltage from 110 kV to 220 kV, as suggested by the World Bank. In collaboration with industry and NIRDA, prioritise grid upgrades for industrial sites with high electricity demand, enabling more reliable electricity supply and supporting industrial growth. Moreover, enable solar self-generators to connect to national and isolated grids, as envisaged in the Energy Policy 2025, and introduce net metering or net billing for grid-connected prosumers. Use standardised feed-in tariffs for smaller residential PV systems and competitive auctions to procure electricity from utility-scale solar projects developed by independent power producers. Offer grants or rebates to accelerate residential solar uptake, in other words extend existing support for off-grid SHSs to grid-connected households. Maintain tax exemptions for renewable energy equipment, including SWHs, solar systems and batteries, rather than phasing them out prematurely. In the longer term, explore national or regional manufacturing of PV and solar water heating equipment but consider how incentives would need shifting. Consult energy sector experts to assess the technical and economic feasibility of these measures and identify additional regulatory and implementation requirements.

6.2 District authorities

Key findings (also relevant for the GoR)

- Awareness and capacities regarding green materials and technologies are generally lower among local government institutions and firms in secondary cities in comparison to Kigali; local differences in soil/resource availability need to be considered for building material choices.

- Permitting and enforcement remain weak. Green materials do not receive clear preferential treatment in approvals, changes in materials may go unreported, and post-permit verification is inconsistent.

- Coordination within the local government institutions (e.g. OSC, district/city councils, etc.) and with local education institutes on questions of green housing and construction value chain support is still fragmented.

Recommendations

- **Introduce digital worker registration.** Given the persistence of informal and daily labour in construction, a digital registration system should improve workforce visibility without excluding workers or increasing barriers for MSMEs seeking public contracts. The system should record basic worker data, including location, skills, training, certification, attendance, payment history and links to insurance or financial services. Registration should be simple, cost-effective and accessible on site through contractors, mobile teams, district offices, training centres or contractor associations. During the transition period, unregistered workers should be supported in registering instead of being excluded from employment. District officials could pilot different systems together with STECOMA, initially on selected

public construction projects rather than imposing sector-wide registration immediately. The GoR should provide oversight, establish data protection regulations and stipulate the integration of the system with permitting, inspections, training and public project management. Day-to-day operations could be managed by a suitable technology provider.

- **Strengthen knowledge and capacity of green materials and technologies among OSC staff** given the currently limited understanding and high staff turnover. Regular, practical training on technical standards, application and sustainability should be provided to ensure that knowledge is retained and consistently applied despite staff changes. Moreover, monitoring of green building permits should be strengthened across *all* building sizes and should include *all* materials, with clear verification procedures at key stages of construction to avoid mistakes (for example, categorising a building incorrectly) and ensure compliance with approved green building requirements.
- **Develop and implement a demonstration housing programme with local stakeholders.** The central government should provide overall direction and financing, including through public procurement, while district authorities should lead the identification of suitable sites and coordinate the construction and use of demonstration houses within communities. Public–private partnerships with potential investors should also be explored to expand the programme. A participatory process and a positive communication strategy are advisable to increase acceptance, positive attitudes and norm change regarding what a modern, attractive Rwandan building should look like.

6.3 Financial institutions

Key findings

- MSMEs struggle to access existing green finance instruments, as they lack the capacity to take loans from commercial banks, while SACCOs are limited in their lending operations.
- Commercial banks are only just starting to expand their green portfolio, making use of green funds provided by the government and international organisations; SACCOs have virtually no dedicated green lending programmes and lack access to earmarked green funds.
- Both commercial banks and SACCOs lack guidance and staff capacity to apply funding guidelines for green funds, for example determining eligibility of customers.
- Knowledge/awareness gaps and misunderstandings still exist on both the customer/firm and bank side.
- Commercial banks see the main bottlenecks outside of their own business processes, pointing to public institutions to provide support and guidance.

Recommendations

- **For BRD: support MSMEs in adopting and complying with the Rwanda Green Taxonomy.** BRD should provide practical, simplified guidance on implementing the taxonomy, with proportionate disclosure and compliance requirements. Targeted government incentives could further encourage MSME participation and compliance.
- **For commercial banks: introduce favourable financing conditions for green investments.** Commercial banks should review and broaden the conditions under which green technology and machinery used to produce green building materials can be accepted as collateral, thereby improving firms' access to credit for such investments. Banks should also expand their range of green financial products, including dedicated green credit lines and

green advisory services that help clients identify suitable technologies and financing options. Finally, banks should strengthen staff capacity through targeted training on green credit products and lending options, enabling loan officers to better assess green investments, advise clients and communicate the available financing opportunities effectively.

- **For SACCOs and STECOMA: strengthen access to green finance and reduce lending risks.** SACCOs should explore partnerships with STECOMA to facilitate bulk orders of green materials and technologies. In addition, risk-sharing mechanisms – such as a green property and land value capture redistribution scheme or partial guarantees for green credit lines – should be explored to reduce the risks faced by commercial banks and SACCOs when financing green investments.

- **For BRD, commercial banks and SACCOs: engage with the government (MINECOFIN) on the set-**up **and management of a green construction MSME fund** if the government decides to set this up as part of a green construction supplier development programme.

6.4 Education institutions

Key findings

- Non-technical skills gaps particularly affect small and growing firms, which especially lack supervision, planning, compliance and communication skills.

- The ability to produce and build with ISSBs is by far the deepest technical skills gap affecting masons in particular, but also architects and civil engineers. The most profound skills gap for electricians and plumbers concerns SWHs, especially in terms of maintenance.

- Firms generally appear to be able to identify unmet needs for green skills by demanding more green training; this is not necessarily the case for digital tools, supervision skills and knowledge on how to improve health and safety conditions.

- Simply participating in training is not enough to overcome the discrepancy between awareness and use, as learned skills remain unused if they are not linked to a concrete construction project.

- Informal on-site learning remains the dominant channel but cannot readily transmit unfamiliar green skills.

Recommendations

- **Explicitly target small and growing firms to develop their non-technical skills**, especially supervision, work planning, compliance, communication and problem solving, as these firms are in a critical phase that demands more of these skills. Making human resource management a crucial aspect of training for growing firms is particularly important to reduce worker fluctuation, which serves as a strong deterrent for small firms to invest in skills development of their workers.

- **Expand dedicated skills training on producing and building with ISSBs**, with a particular focus on small and medium-sized masonry firms, but also expand teaching on ISSBs at universities for architects and civil engineers to strengthen ISSB knowledge along the whole value chain. Link this with support from international development cooperation (see recommendation below). A similar strategy could be followed for improved rukarakara, though with less urgency. With regard to green technologies, the most important skills gap appears to be for SWHs, more so in terms of the capacity to maintain these systems than to

install them, which is also a particular bottleneck for its spread beyond Kigali and other major cities.

- **Improve training relevance** by co-designing modular courses with the different firm types and respective unions/associations to ensure that course content reflects the specific gaps identified for each trade rather than offering one generic green skills package. Link training to the use of demonstration sites, workshop-based practices and real project assignments to tackle the bottleneck among firms that are aware of green materials and technologies but do not yet use them. Provide post-training follow-up, such as trainer visits, refresher sessions and short coaching support to ensure newly developed skills stay up-to-date. International development cooperation can provide support here too.

- **Establish regular peer-learning groups, site visits and problem-solving sessions organised by trade**. IPRCs and TVET providers could convene trade-specific learning groups, site visits and practitioner sessions, including alumni networks, which appear to especially help address non-technical gaps. This should be done in collaboration with unions/associations.

6.5 Energy professionals

Key findings

- Upgrading is happening top-down for both PV and SWHs, while some firms enter horizontally through product diversification or upgrading from simpler to more complex technologies (e.g. expanding their product portfolio from SWHs only to SHSs and/or solar streetlights).

- The market remains comparatively small as affordability limits PV usage and SWHs remain a “luxury” for the majority of the population.

- A combination of green marketing, business management skills (rather than purely technical capability), flexibility in payment methods and an early move into service-based business models, including solar-as-a-service and power purchase agreements, are success factors for the market expansion of firms in the sector.

- Recent price hikes on electricity have stirred both commercial and private demand for solar PV and SWHs. This rise in demand now needs to be harnessed for further market expansion.

Recommendations

- **For the GoR**: see the **recommendations on solar policies** above.

- **For firms: invest in green marketing and new business models** such as solar-as-a service; explore the potential of smart meters (digital meters that improve grid management).

- **For firms: offer payment by instalments** over longer time periods or adjust to flexible payment abilities of clients (e.g. according to season); approach the banking sector to support the offering of such financing options.

- **Consider reuse options and end-of-life management early.** Electric vehicle batteries may have a second life as storage for solar batteries, but they also need adequate recycling. Solar PV modules also require an end-of-life strategy. Waste from SHSs and solar chargers has accumulated substantially in other Sub-Saharan African countries (Huang & Long, 2026;

Kinally et al., 2022; Hansen et al., 2022). Rwanda can avoid this future problem by planning differently from the start (for initial steps, see IRENA, 2026).

6.6 Building materials professionals

Key findings

- Firm upgrading is possible from the bottom up for ISSBs and improved rukarakara, but many firms are stuck at the crucial step from small to medium size; more mid-sized firms, especially among masons, are needed to further scale the use of both building materials.
- Skills gaps are compounded by a mismatch between training provision and the practical needs of firms and equipment in use. High worker mobility also discourages employers from investing in training and retaining skilled workers.
- Negative client perceptions in quality, durability and aesthetics of ISSBs and improved rukarakara create persistent bottlenecks for further expansion of their use.
- Many small practitioners, especially masons, lack formal registration or certification, which excludes them from formal contracts, larger projects, public procurement and certified green construction work.
- Access to finance and equipment remains difficult for small practitioners. Collateral requirements commonly exclude machinery, while SACCOs' lending limits and limited green construction assessment capacity constrain financing for equipment leasing and material production.

Recommendations

- **Engage in green marketing**, making a more compelling case for the use of green building materials such as ISSBs and improved rukarakara by underlining resource and cost efficiency to clients. Help to correct misconceptions about quality, durability and aesthetics, one customer at a time. For the latter, support from government institutions and unions/associations is needed through demonstration projects.
- **Form or join cooperatives** with other masons and ISSB producers to jointly rent Makiga machines, pool production capacity and strengthen eligibility for larger government contracts.
- **Invest in water, energy and resource saving** to free operational capital; participate in training on these topics if available.
- **Invest in developing business management and organisational skills,** especially at the level below the owner or manager, to help solve the worker retention challenges that obstruct the accumulation of skills.

6.7 Unions, cooperatives and trade associations

Key findings

- The support efforts of PSF and its Construction Chamber are perceived as fragmented and engagement with green construction is still limited. Many firms have withdrawn from it, opting instead for more specialised trade associations that represent more narrowly defined topics, such as EPD.

- STECOMA is highly appreciated among its members for its advocacy, knowledge sharing, training and support for recognition of prior learning, but its effectiveness remains restricted due to limited reach to informal workers, lacking organisational capacity and funding.
- RIA and IER are much better organised and can claim a better reach to their respective members, which makes them more effective partners in translating government policies and initiatives.
- Cooperatives such as COPCOM were much more popular in the past, but currently play a minor role.

Recommendations

- **For PSF: strengthen a focused green construction offer for members,** ideally through structured collaboration with specialised associations such as EPD, covering policy dialogue, market information, awareness raising (including demonstrating resource-saving effects), supplier linkages and practical guidance on green standards, public procurement opportunities and finance. Serve as a coordinator that links government initiatives to relevant firms for implementation and lobby the government on refining the policy framework as described above.
- **Consider offering your own regular training sessions**, supported by RHA, rather than waiting for RHA to conduct them.
- **For STECOMA: prioritise outreach and service delivery to informal construction workers,** including mobile membership drives, locally accessible training and support with recognition of prior learning. Strengthen partnerships with the government, training providers and larger contractors to secure sustainable funding, expand organisational capacity and link certified members to more stable work opportunities.
- **For STECOMA, RIA and IER: support members in identifying unmet demand for skills,** especially for digital tools, supervision skills and how to improve health and safety conditions. The latter appears to be a viable retention strategy in the Rwandan context, as our analysis in Section 4 suggests.
- **For RIA and IER: engage in the development of a green quality infrastructure system**, especially in the development of standards for used materials and quality testing.
- **Foster cooperation between cooperatives such as COPCOM and STECOMA** regarding the supply of materials and/or access to machinery needed for production.

6.8 Development cooperation partners

Key findings

- International development cooperation is an important source of early finance, technical assistance and demonstration funding for green construction. However, green building activity remains concentrated in public- and donor-funded projects, with limited spillovers into commercially viable MSME markets.
- Development cooperation support is appreciated at various levels in the system, especially direct technical and business management work with construction firms and workers to support bottom-up value chain development.

- Long-term effects of development cooperation projects remain an issue as market transformation has not really taken off yet. The ISSB initiatives supported by SKAT Consulting Ltd achieved early traction but were not sustained.

Recommendations

- **Consider jointly developing the complete green construction value chain** in a focused way along all stages rather than having several donors being involved in parts of the value chain in an uncoordinated way.
- **Support supplier development programmes** by providing analyses and technical expertise on the design of such programmes and on green industrial policy packages for construction more broadly.
- **Support the set-up and revision of green quality infrastructure (including research, testing and standards)**, especially for ISSBs, improved rukarakara and other used or recycled materials.
- **Support the green finance system to ensure better access for MSMEs** to bulk ordering and material banks at MSME level up to advice on the green finance architecture and coordination of stakeholders. Moreover, conduct a follow-up study to investigate when and why MSMEs drop out of the finance process – for example, because they are unaware of the funding available, fail to meet eligibility criteria, struggle with the application, lack collateral or find the loan terms unsuitable.
- **Support skills development** by strengthening trainer capacity, equipment and demonstration facilities for ISSBs, improved rukarakara and renewable energy technologies, especially SWHs. For the latter, this can help to ease the reliance on skilled labour from abroad.
- **Provide coordination support** for a new Urban Sector Working Group on Green Construction and other dialogue forums to consider measures for greening and enhancing productivity in domestic construction value chains together.
- **Provide financial and technical support** for centralised grid readiness and maintenance for renewable feed-in. Support energy planning and custom-made solutions for a combined centralised and decentralised grid.

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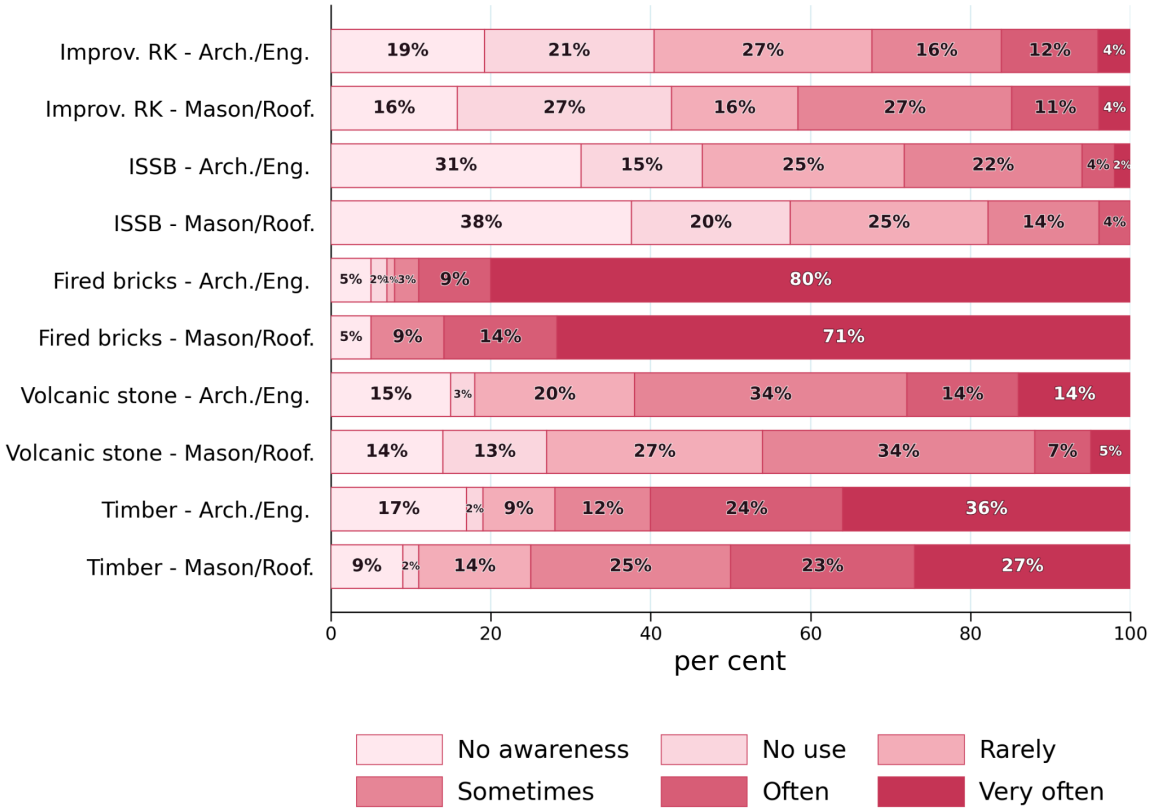
Annex

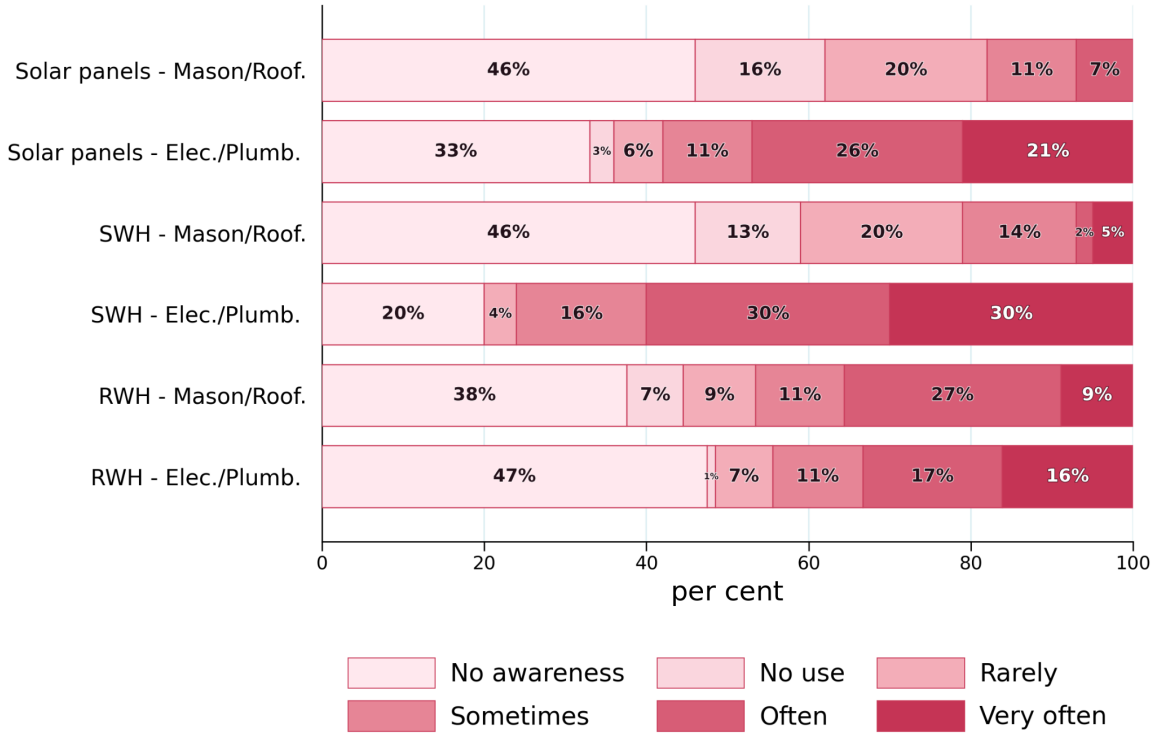
Figure A1: Awareness and usage of selected building materials by firm type



Notes: Each stacked bar shows the share of surveyed architectural/engineering (Arch./Eng.) firms and mason/roofer (Mason/Roof.) firms reporting their awareness and frequency of use of the selected materials. Categories are mutually exclusive: “no use” refers to firms that are aware of the material but do not use it; the remaining categories indicate increasing reported frequency of use.

Source: Authors’ calculation based on firm survey (2026)

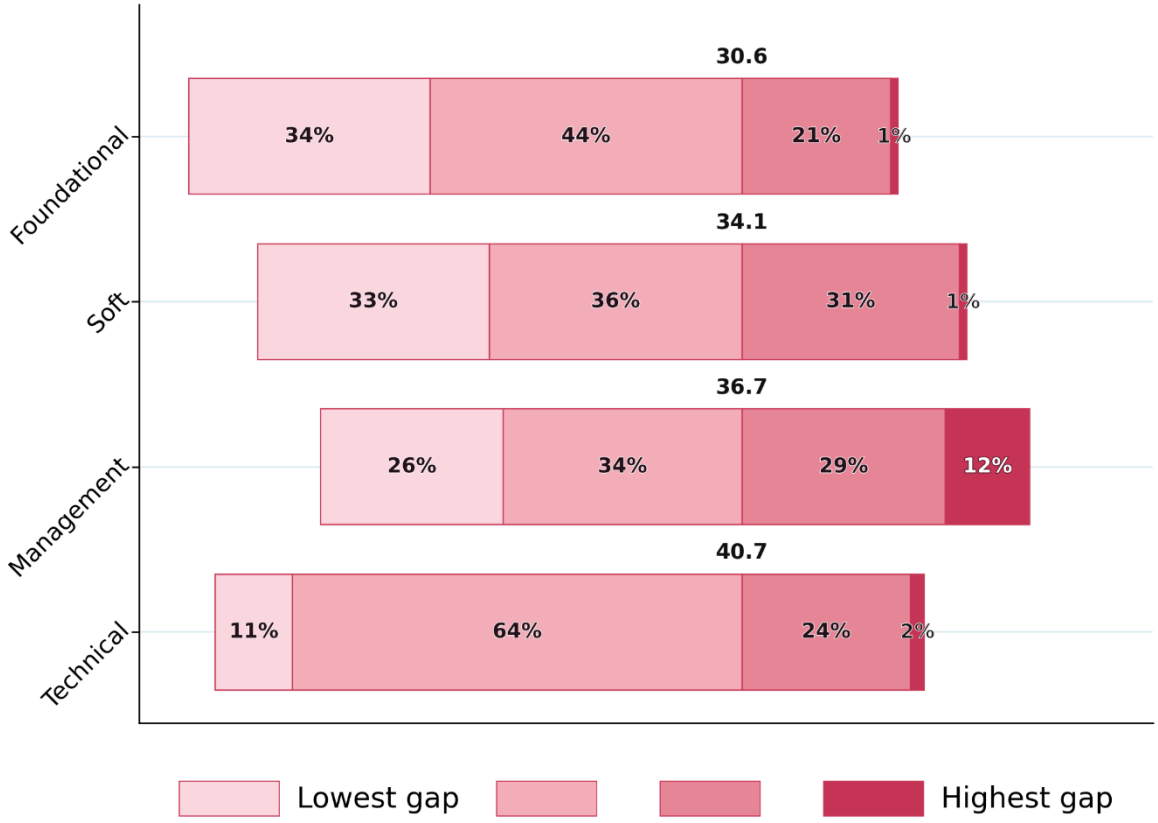
Figure A2: Awareness and usage of selected building technologies by firm type



Notes: Each stacked bar shows the share of surveyed electrician/plumber (Elec./Plumb.) firms and mason/roofer (Mason/Roof.) firms reporting their awareness and frequency of use of the selected technologies. Categories are mutually exclusive: “no use” refers to firms that are aware of the technology but do not use it; the remaining categories indicate increasing reported frequency of use.

Source: Authors’ calculation based on firm survey (2026)

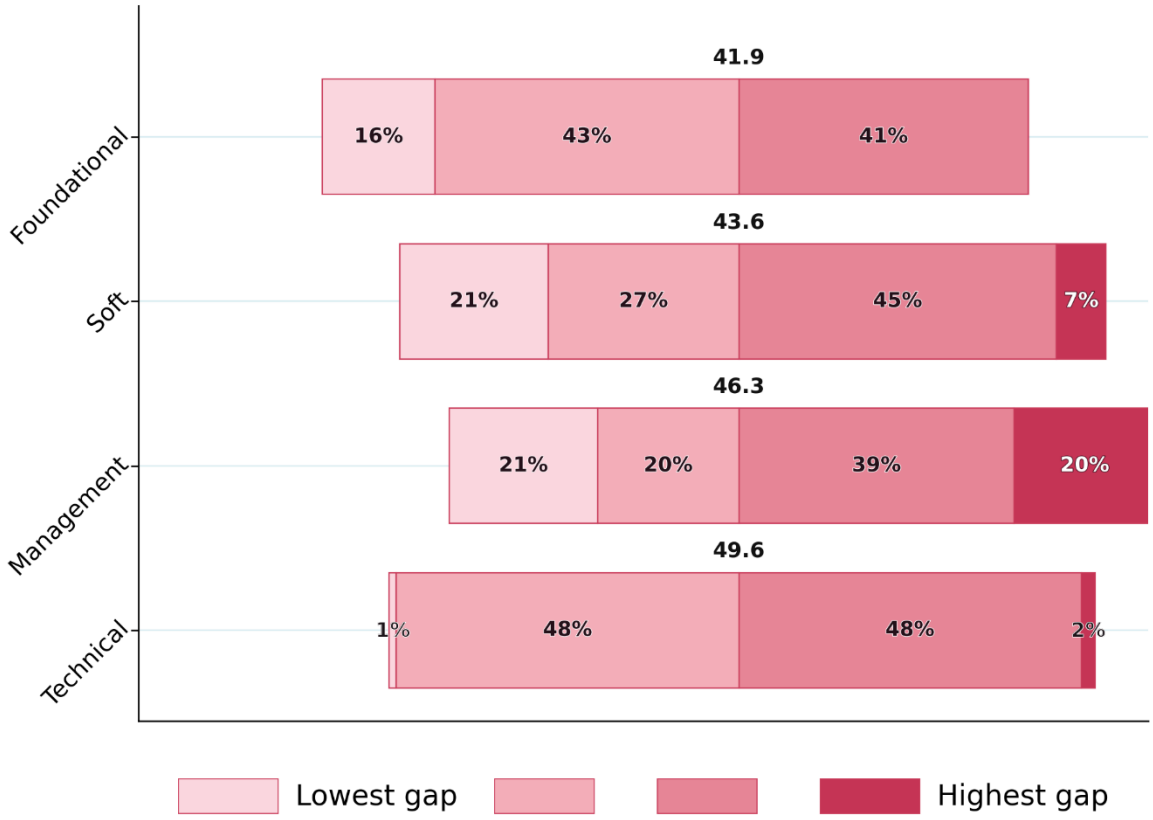
Figure A3: Skills gap indices by skill domain (architects/civil engineers)



Notes: Skills gaps are measured at the firm level on a 0-100 scale, where higher scores indicate larger reported gaps. The four domain indices aggregate survey items covering foundational, soft, management and technical skills. Firms are grouped into four ordered gap categories from lowest to highest based on their respective domain score, and numbers in the bars represent the shares of firms in each category.

Source: Authors' calculation based on firm survey (2026)

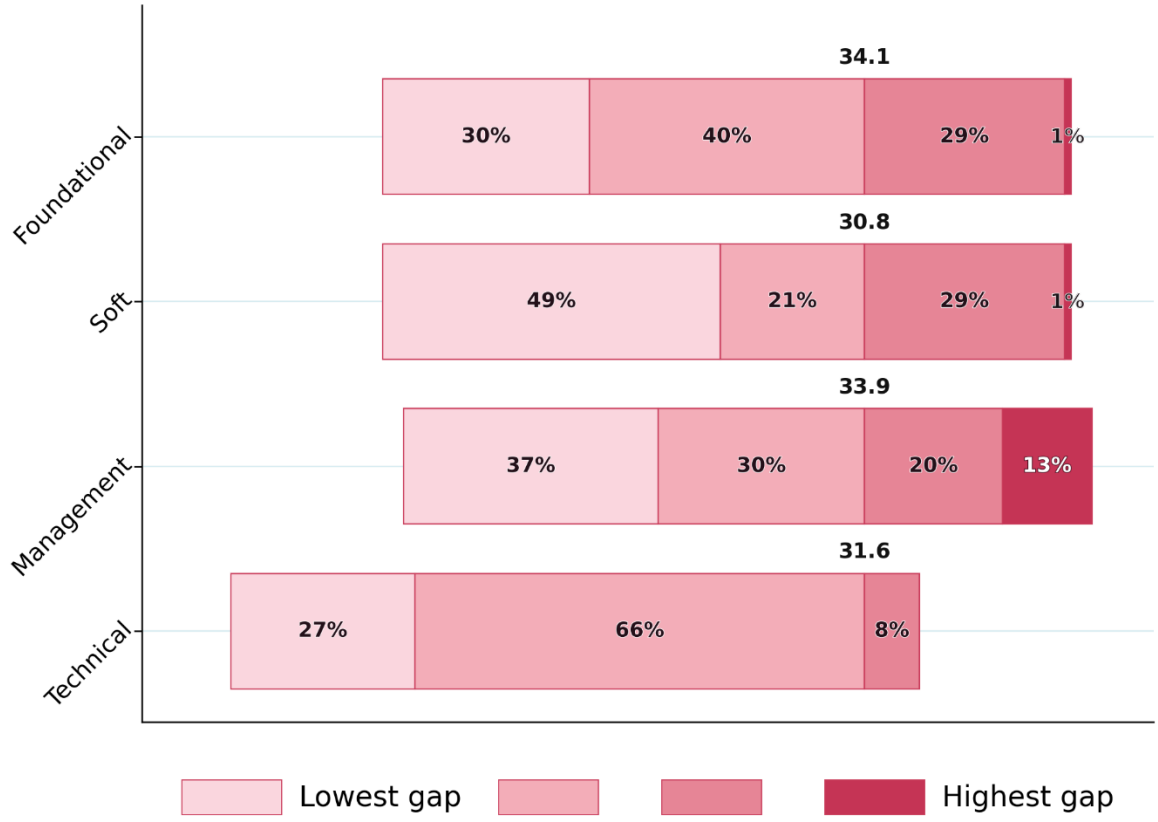
Figure A4: Skills gap indices by skill domain (masons/roofers)



Notes: Skills gaps are measured at the firm level on a 0-100 scale, where higher scores indicate larger reported gaps. The four domain indices aggregate survey items covering foundational, soft, management and technical skills. Firms are grouped into four ordered gap categories from lowest to highest based on their respective domain score, and numbers in the bars represent the shares of firms in each category.

Source: Authors' calculation based on firm survey (2026)

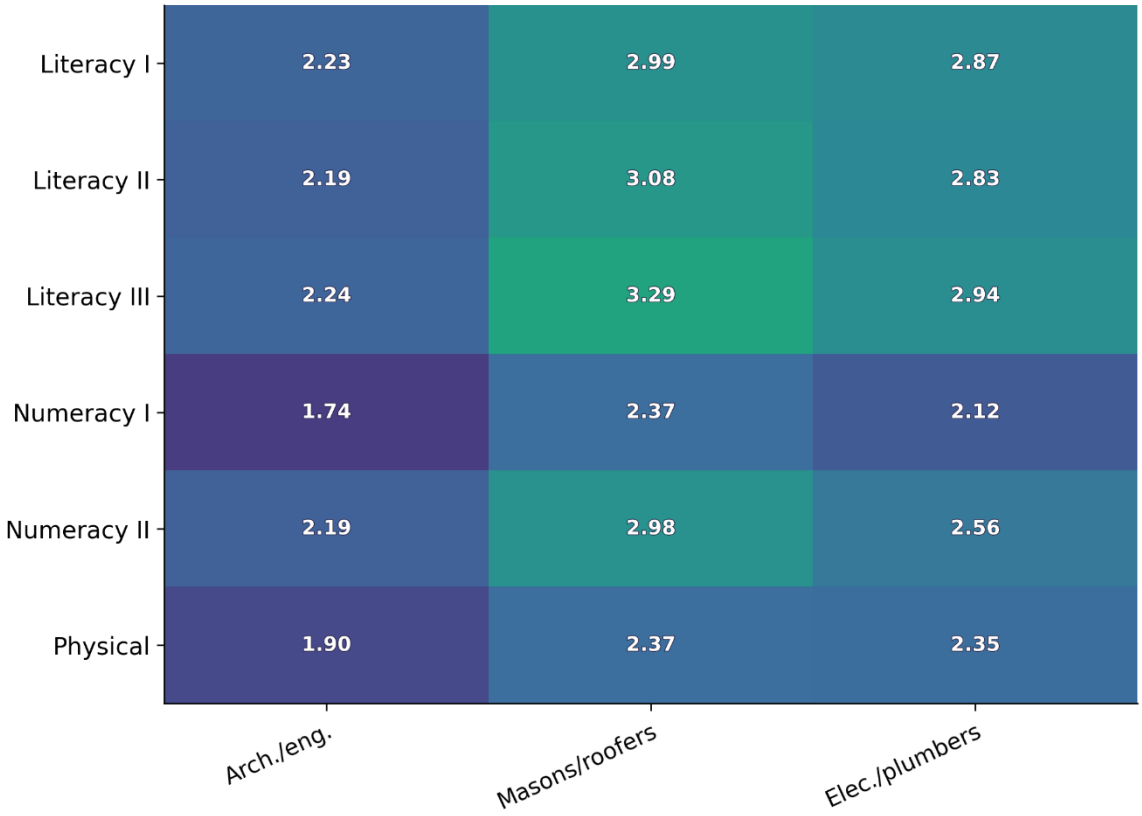
Figure A5: Skills gap indices by skill domain (electricians/plumbers)



Notes: Skills gaps are measured at the firm level on a 0-100 scale, where higher scores indicate larger reported gaps. The four domain indices aggregate survey items covering foundational, soft, management and technical skills. Firms are grouped into four ordered gap categories from lowest to highest based on their respective domain score, and numbers in the bars represent the shares of firms in each category.

Source: Authors' calculation based on firm survey (2026)

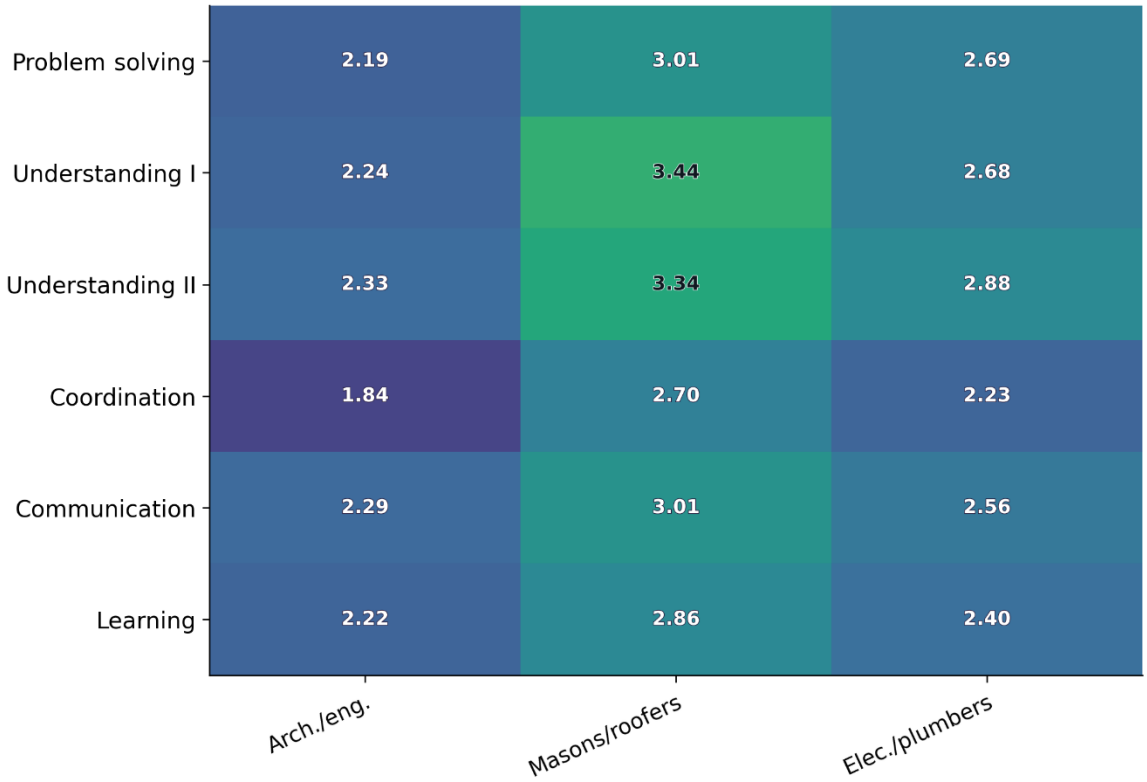
Figure A6: Heatmap of predictive margins of items in the foundational skills gap index by firm type



Notes: Cells show predictive margins from separate regression models for each item included in the foundational skills gap index. Estimates compare the different firm types (architectural/engineering, masons/roofers, electricians/ plumbers) while adjusting for the other firm characteristics included in the model (see regression model in Table A1). Higher values indicate a greater reported skills gap.

Source: Authors' calculation based on firm survey (2026)

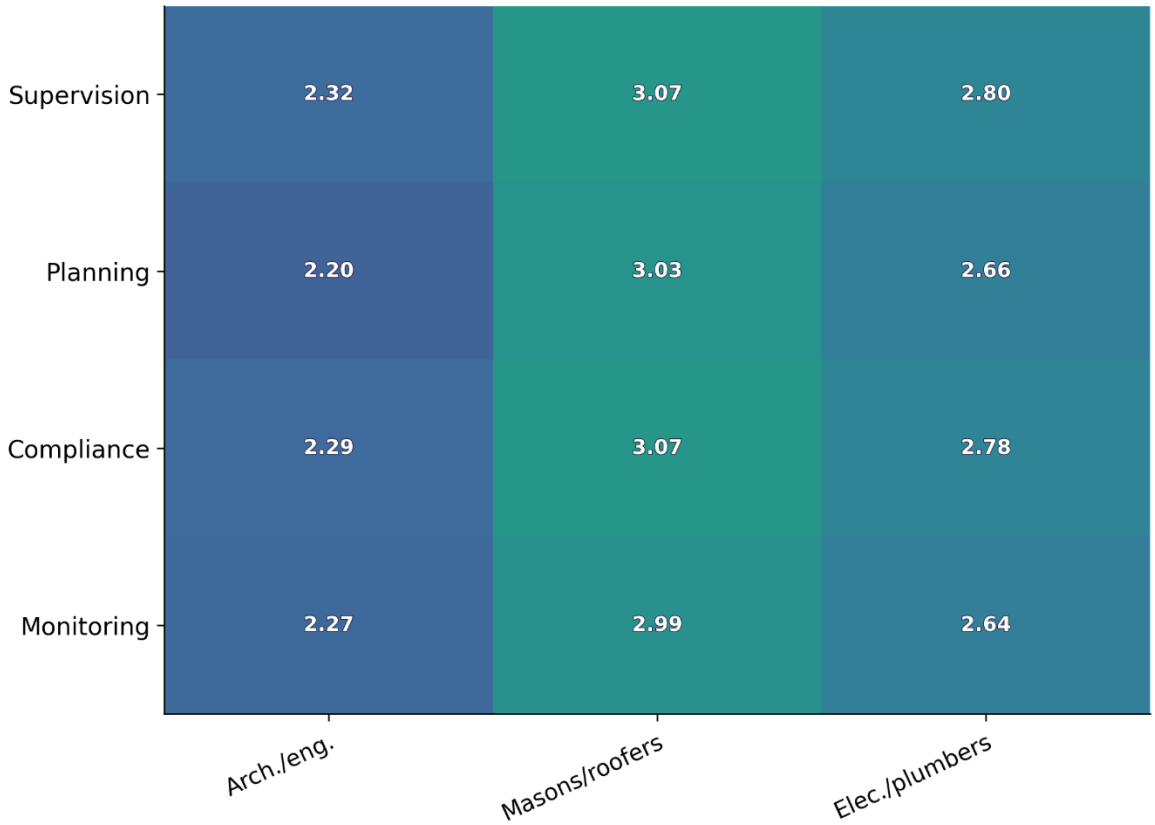
Figure A7: Heatmap of predictive margins of items in the soft skills gap index by firm type



Notes: Cells show predictive margins from separate regression models for each item included in the soft skills gap index. Estimates compare the different firm types (architectural/engineering, masons/roofers, electricians/plumbers) while adjusting for the other firm characteristics included in the model (see regression model in Table A1). Higher values indicate a greater reported skills gap.

Source: Authors' calculation based on firm survey (2026)

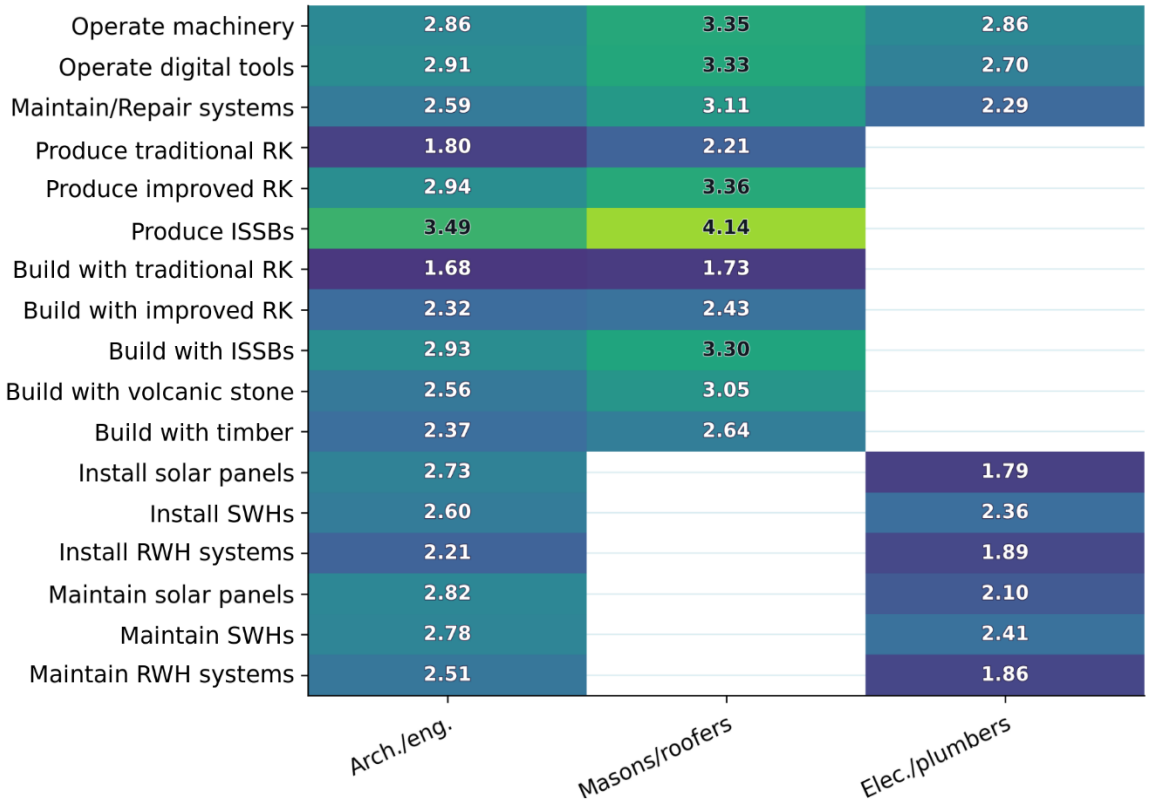
Figure A8: Heatmap of predictive margins of items in the management skills gap index by firm type



Notes: Cells show predictive margins from separate regression models for each item included in the management skills gap index. Estimates compare the different firm types (architectural/engineering, masons/roofers, electricians/plumbers) while adjusting for the other firm characteristics included in the model (see regression model in Table A1). Higher values indicate a greater reported skills gap.

Source: Authors' calculation based on firm survey (2026)

Figure A9: Heatmap of predictive margins of items in the technical skills gap index by firm type



Notes: Cells show predictive margins from separate regression models for each item included in the technical skills gap index. Empty cells indicate that the items concerned are not relevant to the firm type. Estimates compare the different firm types (architectural/engineering, masons/roofers, electricians/plumbers) while adjusting for the other firm characteristics included in the model (see regression model in Table A1). Higher values indicate a greater reported skills gap.

Source: Authors' calculation based on firm survey (2026)

Table A1: Baseline regressions of the skills gap indices and domain sub-indices

	Overall	Foundational	Soft	Management	Technical
(Size: micro=0)					
Small	9.43***	8.65**	11.77***	13.61***	3.71
	(2.94)	(3.57)	(3.77)	(4.33)	(2.44)
Medium	11.99***	10.15**	12.56**	16.56***	8.70***
	(4.05)	(4.74)	(5.24)	(5.87)	(2.88)
Large	0.25	-4.74	0.73	6.61	-1.61
	(9.84)	(9.85)	(11.88)	(12.49)	(7.62)
(Formality: informal=0)					
Formality=1	2.99	4.82	5.20	3.84	-1.90
	(3.25)	(3.89)	(4.23)	(4.72)	(2.57)
Formality=2	2.86	5.46	4.65	1.49	-0.15
	(3.61)	(4.37)	(4.84)	(4.95)	(2.98)
Formality=3	7.59**	8.68**	11.79**	11.53**	-1.62
	(3.77)	(4.36)	(5.05)	(5.30)	(2.72)
Green material/ technology use index	-0.27***	-0.19***	-0.23***	-0.29***	-0.37***
	(0.05)	(0.06)	(0.07)	(0.08)	(0.04)
(Type: Architectural/Engineering=0)					
Masons/Roofers	14.89***	19.45***	21.04***	19.41***	-0.34
	(4.88)	(5.70)	(6.33)	(6.90)	(2.92)
Electricians/Plumbers	8.68**	13.83***	11.68**	13.12**	-3.91
	(3.88)	(4.55)	(5.15)	(5.60)	(2.69)
Ln(firm age)	-2.11	-0.82	-3.31*	-3.86*	-0.45
	(1.44)	(1.77)	(1.92)	(2.09)	(0.94)
Workers' training	2.28	3.31	1.52	2.05	2.23
	(2.11)	(2.45)	(2.79)	(2.95)	(1.44)
(Ownership: individual=0)					
Company ownership	-6.60***	-3.51	-8.70***	-8.90**	-5.29***
	(2.38)	(2.76)	(3.22)	(3.47)	(1.67)
(Manager education: primary=0)					
Secondary/TVET	3.12	0.41	2.39	5.72	3.95
	(5.44)	(7.00)	(6.89)	(8.39)	(2.82)
IPRC	2.42	3.29	2.07	3.07	1.25
	(6.90)	(8.72)	(8.80)	(10.11)	(3.62)
University	-4.20	-7.93	-6.03	-3.11	0.26
	(6.97)	(8.61)	(9.03)	(10.39)	(4.10)
Government clients	0.84	5.13	0.89	-2.04	-0.60
	(3.81)	(4.98)	(4.86)	(5.03)	(2.60)
Revenue	2.67***	3.59***	4.05***	3.41***	-0.37
	(0.83)	(0.96)	(1.10)	(1.21)	(0.54)
(District: Kicukiro=0)					
Kamonyi	-1.52	1.51	-2.52	-8.37**	3.29*
	(3.12)	(3.85)	(4.05)	(4.12)	(1.89)
N	297	297	297	297	297
R-squared	0.262	0.197	0.208	0.224	0.448

Notes: The table shows ordinary least squares (OLS) regressions of the overall skills gap index and its four domain sub-indices. Higher index values indicate larger reported skills gaps. Coefficients show associations conditional on the full set of firm characteristics included in the model; they should not be interpreted as causal effects. Reference categories for categorical variables are shown in bold above each respective estimate. Robust standard errors are reported in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

Source: Authors' calculation based on firm survey (2026)