Digital Development

Working Paper Series

The Digital Development (formerly Development Informatics) working paper series discusses the broad issues surrounding digital data, information, knowledge, information systems, and information and communication technologies in the process of socio-economic development

Paper No. 94

Exploring Financing for Green-Tech SMEs in East Africa: Current Trends and Risk Appetite

AARTI KRISHNAN

2022

Publisher: ***Centre for Digital Development***
Global Development Institute, SEED
University of Manchester, Arthur Lewis Building, Manchester, M13 9PL, UK
Email: cdd@manchester.ac.uk Web: https://www.cdd.manchester.ac.uk/

View/Download from:
http://www.gdi.manchester.ac.uk/research/publications/di/

Table of Contents

List of Tables

List of Figures

Exploring Financing for Green-Tech SMEs in East Africa: Current Trends and Risk Appetite

Aarti Krishnan
Hallsworth Research Fellow, Alliance Manchester Business School,
University of Manchester, UK

2022

Key Messages

- Green-tech small-medium enterprises (SMEs) are insufficiently studied and lack definitional boundaries. They are classified as two types: born-green, where SMEs use green technologies at the get-go proactively attempting to prevent environmental damage; and retrofitted SMEs which incrementally aim to enhance eco-efficiency and reduce ecological footprints. These can be viewed as a fluid spectrum, rather than as two mutually exclusive categories.
- The key early finance funders (pre-seed/seed/start-up/early growth) appear to be friends and family, venture capital firms, accelerators, philanthropic investments and donors
- Born-green SMEs are predominantly in sustainability/energy sectors and agricultural-tech across East African Community (EAC) countries. Kenya outperforms its counterparts in terms of estimated revenues.
- Rwandan firms seem to outperform other EAC country SMEs in relation to attracting higher funding per firm, however Kenya has attracted the greatest number of investors. Kenya appears to have the most diversified funding and investors' portfolio within the EAC.
- The composition of retrofitted SMEs, apart from agriculture/agtech varies across countries. Kenya and Rwanda outperform counterparts in terms of revenue, despite the Rwandan SMEs being younger.
- Kenyan and Rwandan retrofitted SMEs have the most diversified funding and investors and have raised the highest funding. Uganda and Tanzania have performed very similarly and are still generally at seed/early venture capital stage.
- There seems to be considerable cross-border funding across EAC countries, especially between Kenya and Rwanda.

A. Introduction

With the threat of climate change, biodiversity loss, and waste generation looming large, significant evidence elucidates the need for countries to transition to greener economies (e.g. Okereke et al 2019). This puts significant pressure on governments to promote and implement green regulations, mobilize investments in greening (OECD 2017). There has been progress in investments albeit limited across the world, especially in Africa. For instance, the African Development Bank has announced that European and US donors will provide $20 million in concessional loans to support pay-as-you-go solar companies in sub-Saharan Africa (Forbes, 2022). Countries like Kenya and Uganda have invested over $200 million to support renewable energy (CIF 2022). However, despite these investments, IEA calculates that a minimum investment of $25 billion per year is required for supporting greening activities in Sub-Saharan Africa (IEA 2022). Many countries in East Africa have plans, e.g. Kenya, has a green economy Strategy and Implementation Plan 2016-2030; Uganda has a green growth development strategy, Rwanda has a green growth and resilience strategy, which aims to reduce and mitigate environmental degradation, rather than creating a net positive environmental solution. Various other regional bodies, such as the East African Community (EAC), have specific plans around climate-resilient agriculture, climate change master plans, which are predominantly perspective with very little detail about priority areas to focus on, or how these will be specifically financed (Ozili 2022). Even recently-ratified regional trading agreements such as the African Continental Free Trade Area (AfCFTA), barely mentions the 'environment' in its agreement. Together this suggests that '*green governance deficits'* may exist, whereby public governance (national/regional governments) insufficiently proposes and/or does not develop regimes to regulate greening efforts.

However, over the last two decades, several small-medium enterprises have emerged offering a range of tech and digital services in these countries, with many touted to be able to 'fill' emerging 'green governance deficits' (Krishnan et al 2020). In part this is because of the rapid development and diffusion of information and communication technologies (Zhou et al 2019) and technology and knowledge sharing across borders has facilitated small-medium enterprises (SMEs)[1] to go-green by consistently improving their ability to respond to environmental changes (Song and Wang 2018). SMEs whose key products/services revolve around the innovation/development and/or use of green technologies are often referred to as 'green-tech SMEs'. Research on green-tech SMEs is disparate, with fluid definitional boundaries. *This working paper aims to provide definitions, and a landscape of various categories of green-tech SMEs*.

SMEs represent the biggest part of all registered entities in nearly all activities in the majority of the East African countries, averaging 60% in number or reaching 90% if micro enterprises are also considered (EAC 2022). However, less than 0.25% of SMEs are able to develop and expand into larger firms (ibid). While there are several issues that have been cited including unfavourable regulatory regimes, bureaucracy, lack of capabilities, the EAC finds that the most pertinent issue facing the expansion of green-tech SMEs is the lack of financing (Krishnan et al. 2020). For a start, due to the high risk and uncertain innovation

[1] Defined as less than 100 employees

potential, funders are unwilling to lend (or willing to lend at very high interest rates), reducing credit (and financing) availability (Raga et al. 2021). However, when considering SMEs, it is critical to focus on 'early financing' i.e. finance required such as seed funding, start-up funding or early-growth funding; which occur before SME business models are fine-tuned.

This working paper also seeks to explicate the different types of financing and investors playing a role in early financing for green-tech SMEs, and attempts to highlight whether funding risk appetites exist i.e. similar investors, investing in similar green-tech SMEs across EAC countries, possible facilitating shared knowledge exchange and tech-transfer. Ultimately, this allows better understanding of how such SMEs proliferate.

This working paper is structured as follows. The next section (B) defines and typologizes green-tech SMEs, followed by a breakdown of what early finance is, and the various types of investors involved. Section D briefly highlights the research methods, followed by Section E which discusses the exploratory results of green-tech SMEs and early financing in the EAC, and finally section F outlines the key implications for green industrial policy and future research directions.

B. Typology of Green-Tech SMEs

The definition of green-tech SMEs varies depending on the 'scope' of the technology[2]. According to NRC (2017), a green-tech SMEs is an SME whose business model includes - any product, service or process with a primary purpose of remediating or preventing environmental damage or in terms of eco-efficiency, where SMEs use fewer resources and producing less pollution than products with similar utility. Within this, there are two key types of SMEs:

- those who 'innovate' new green products/services for prevention or eco-efficiency of the environment;
- and those that 'use' green products/services for prevention or eco-efficiency of the environment;

This working paper focuses on the latter category, as the 'use' of green tech is more proliferated in the EAC as opposed to innovations. In the use category, SMEs tend to alter their business models to reduce environmental footprints in their operations (Alonso-Martinez et al 2021).

This implicitly suggests there exists a spectrum of the 'use' of green-tech by SMEs. This can range from those whose proactively prevent degradation of the environment across a range of environmental issues (e.g. GHG emissions, biodiversity, plastics, soil formation, water regulation, deforestation, etc) to those that attempt to merely react to the need to increase eco-efficiency, and reduce or mitigate specific types of environmental externalities that

[2] Here technology is defined as systematised knowledge, often embodied in physical form, as a machine or instrument, used in production or consumption activities, or spelled out in a blueprint or piece of software (Gelb and Krishnan 2018).

arise. Based on this spectrum this paper develops two categories (see Appendix A for a full list of green-tech SME examples):

- *Born green-tech SMEs* which sell green products/services and use green processes to manufacture these products. In this case products can include both final products as well as intermediary products/services. These include SMEs involved in: renewable energy (wind-power, solar-power, biomass, hydropower, biofuels), green chemistry, specialising in recycling, clean web (software, applications and data analytics).

- *Retrofitted green-tech SMEs*: these are more traditional sectors, where 'greening' is embedded into various processes and products to be more eco-efficient or display environmental stewardship. These include green transportation, green buildings, electric motors, eco-friendly lighting, grey-water, and energy efficient appliances

It is critical to note, green-tech SMEs encompass multiple types of industries (e.g., electricity, transportation, building industries, software, consulting) thus the definition of industrial boundaries is fluid unlike those of traditional sectors and it is not easy to define green-tech industry boundaries (Marra et al. 2017). Thus, defining green-tech through this spectrum enables systematization of the green-tech space. Also, important to mention is that born-green and retrofitted green-tech SMEs do not operate in isolation but require significant complementary services and products to function from cloud infrastructure, data centres, e-commerce platforms, drone management, electronics, mechanical design, business information systems, STEM education etc (which this working paper will not focus on, but are key to the growth and expansion of green-tech SMEs).

C. Early Finance for Green-Tech SMEs

C1. What are the types of early financing?

Most green-tech firms are innovative start-ups or SMEs characterized by large intangible assets and technological uncertainty, which makes it difficult to identify their research and development, and pathways to expansion (Riehl et al 2022). Thus, there is a lack of appropriate forms of finance. Much of the investment for green-tech SMEs at the early stage of development (before business models and revenue streams are established) comes from early financing. Typically, early-stage investors are cognizant of the ongoing time required to establish working business models, and often make multiple investments in an SME. In simplistic terms, there are four distinct forms of funding (Menon and Malik 2016, Halt et al. 2017):

- *Pre-seed funding*: earliest stage of funding where entrepreneurs attempt to get operations off the ground, often through family/friends lending and philanthropic investments.

- *Seed capital/seed funding*: is usually the first equity funding stage (where investors seek to take equity in the SME). It often involves scoping the market and product development. Seed funding works through various financial investors, from friends, family, angel investors, venture capital companies, etc. See Table 1 below for details

on investors. The aim of this funding is for the SME to show a track record e.g. establish a user base, show revenue streams, and indicate other key performance indicators that have been achieved.

- *Start-up funding*: this is to allow SMEs to fine-tune business models and products/services. These includes Series A funding, where angel investors, venture capital firms or other private equity investors aim to invest in SMEs with clearly defined strategies and long-term profit-making ability. The move from seed to start-up funding is often difficult, with SMEs having to prove their track record and future potential.

- *Early growth funding*: this includes funding for expansion and development of products. This includes Series B funding, which enables companies to grow their market share. At this stage new waves of less risk-taking venture capital firms and banks invest in the company.

Table 1 provides a brief explanation of the various investors and the various stages of funding they are involved in.

Table 1: Early-Stage Investors and Funding

Investor Type	**Comments**	**Funding**
Friends & Family	At this stage there is very little hard evidence and proof to base a real investment or funding on. They are essentially investing in the idea. It could be in the range of $1,000 to $200,000	Pre-Seed, Seed, Series A
Government Agencies	Government programs providing grants for certain types of projects or subsidies	Pre-Seed, Seed, Series A, B
Peer to Peer Lending	Direct lending of money to individuals or businesses without an official financial institution participating as an intermediary. The institutions that are commonly referred to as financial intermediaries include commercial banks, investment banks, mutual funds, and pension funds	Pre-Seed, Seed, Series A
Accelerators & Incubators	$10,000 to $120,000 in seed money to cultivate ideas and gain traction, while benefiting from additional knowledge and resources from networks of the accelerator and incubator	Seed
Angel Investors or Angel Groups	Primarily seed investments and sometimes beyond. Willing to fund smaller projects with higher risk	Pre-Seed, Seed, Series A, B

Venture Capital	Some specialize in early funding rounds- Series A	Seed, Series A, B
Corporate Investors	Enter at any stage. Some fund own start-ups, others diversifying and growing the business	Seed, Series A, B
Commercial and Investment Banks	Equity purchases, loans or hedge fund investments	Series A, B
Philanthropy Investment	Often called impact investing, for programs, missions or community development tasks. These can be non-profit or for profit	Pre-Seed, Seed, Series A
Donor Funding	Blended funding- international organizations (e.g. UN, World Bank), foundations of corporations	Pre-Seed, Seed, Series A

Source: Author's construction from interviews

C2. Early funders cross-border investment appetite

To gain a better understanding of the possible development and expansion processes green-tech SMEs can follow, there is a need to "follow the money"- a catchphrase coined in the 1976 drama, All the President's Men. In essence, this means gaining a deeper understanding of whether early funders invest across EAC borders, and whether they invest in similar green-tech SMEs. This suggests possible pathways to knowledge exchange, tech-transfer and network building across borders, promoting regional integration. Further, understanding the 'directionality' of investment matters i.e. which country and sector did funders invest in first, and where did they follow. For instance, bi/multi-directional funders (who invest in multiple country green-tech SMEs) may have larger risk appetites, and potentially facilitate creation of stronger regional linkages between SMEs, while funder investing only in one country may be less embedded in regional or national development.

D. Data Collection Methods

Data has been collected using application programming interfaces for TechCrunch and Ag-Funder, which are self-reported and crowdsourced data platforms. This was accompanied with data from LinkedIn and web-searches on specific firms. Table 2 illustrates the depth of the dataset. As of May 2022, Kenya had the highest number of tech-related SMEs, followed by Uganda and Tanzania. However, Kenya, Uganda, Tanzania and Rwanda have a very similar share of SMEs that are considered green-tech. Since South Sudan has no green-tech SMEs and Burundi only 1, the rest of this working paper will only focus on Kenya, Uganda, Rwanda and Tanzania. Furthermore, 10 scoping semi-structured interviews were conducted with key actors including: the EAC Secretariat, the National Treasury in Kenya, Ministry of Finance, Planning and Economic Development in Uganda, and angel investors and green-tech SME firms in Kenya, Rwanda and Uganda.

Table 2: Tech-SMEs in East Africa

Country	No. of tech-firms	No. of tech SMEs	No. of green-tech SMEs	% of total SMEs that are green
Kenya	1596	1452	321	22.11
Uganda	499	486	86	17.70
Tanzania	337	317	47	14.83
Rwanda	145	135	19	14.07
South Sudan	30	24	0	0.00
Burundi	5	5	1	20.00

Source: Data collated from Tech Crunch, LinkedIn and web scraping

E. Results: Green-Tech SMEs and Early Financing in EAC

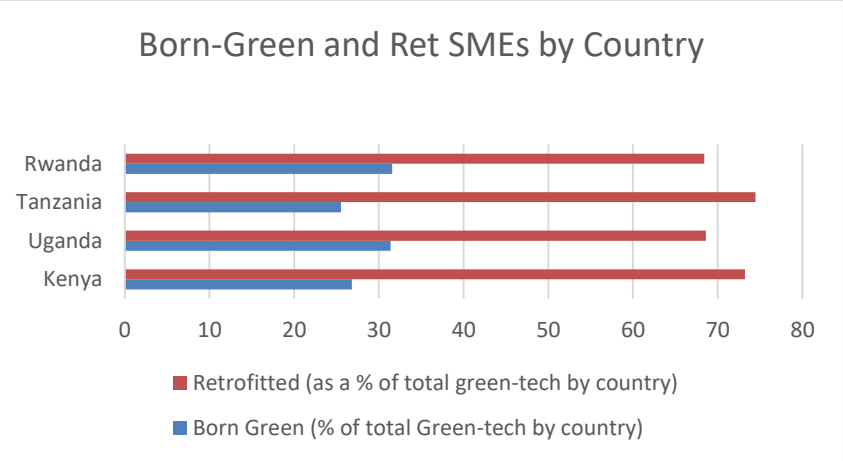
E1. Landscape of green-tech SMEs in EAC

The data below (Table 3 and Figure 1) provides a snapshot of the green-tech SMEs based on the born-green and retrofitted classification. Retrofitted SMEs are much more prevalent than born-green SMEs within the EAC (on an average 30% are born-green versus 70% retrofitted). This is partly due to the novelty and higher risk of born-green sectors, and in part because retrofitting can take place incrementally, without large outlays (interviews).

Table 3: No. of Green-Tech SMEs

Country	*Born-Green SMEs (no.)*	*Retrofitted SMEs (no.)*
Kenya	86	235
Uganda	27	59
Tanzania	12	35
Rwanda	6	13

Figure 1: % of Green-Tech SMEs by Country

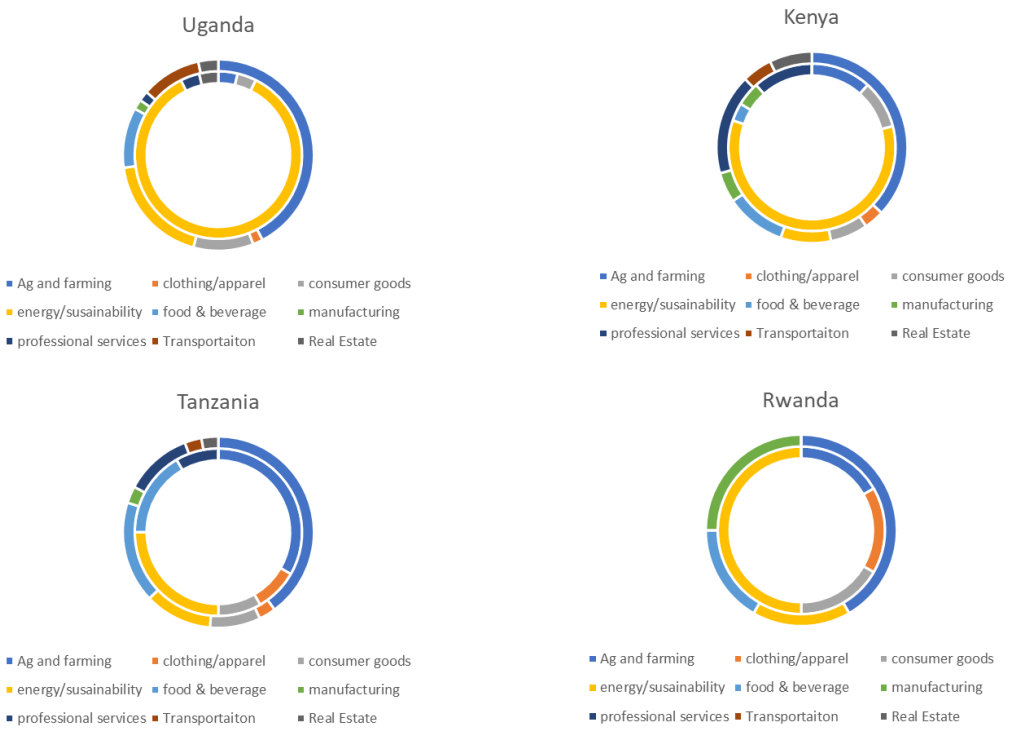


Source: Author's construction

The breakdown of sectors within born-green and retrofitted SMEs are illustrated through a donut chart in Figure 2, where the inner layer represents born-green SMEs and the outer layer retrofitted. Born-green SMEs across Kenya, Uganda and Rwanda appear to be skewed in favour of sustainability/energy sectors. This primarily involves clean energy – solar/wind and recycling/waste management activities. Tanzania seems to be skewed in relation to

agriculture/agtech for both born-green and retrofitted SMEs. Kenya, Uganda and Rwanda seem to follow similar trajectories with a similar proportion of retrofitted SMEs involved in agriculture/agtech. Kenya has several professional services including clean-web, environmental engineering specialists that are a key segment of the retrofitted category. Transportation (e.g. ride/car sharing) and energy management are important retrofitted categories in Uganda; and food/beverages in Tanzania.

Figure 2: Breakdown of Green-Tech SME Categories by Sectors



Source: Author's construction from dataset

Situation of born-green versus retrofitted green-tech SMEs

Born-green SMEs seem to be most profitable in Kenya and are in general slightly larger in size in Kenya than in other East African countries (as shown in Table 4), as they have a higher number of founders per SME. Tanzania and Rwanda have slightly younger SMEs, which are smaller and earn less revenue than Kenya SMEs. Uganda seems to have relatively older firms, but they appear to operate as small enterprises, generating some of the lowest revenues in the EAC.

Table 4: Born-Green SMEs Status

Country	Estimated Revenue Range (USD)/year*	Average Age (years)	Number of Founders	No. of Employees	Co. Type
Kenya	20% <1 mill; 65% 1-10 mill; 15%: 10-30 mill	7.5	1.6	1-10: 45%; 11-50: 45%; 50-200: 10%	95% for profit; 5% non-profit
Uganda	< 1 million	9.1	1	1-10: 74%; 11-50: 26%	96% for profit; 4% non-profit
Tanzania	80% < 1 million, 20% 1-10 Mill	6.2	1.4	1-10: 65%; 11-50: 35%	100% for profit
Rwanda	< 1 million	4.5	1	1-10: 75%; 11-50: 15%; 50-100: 10%	100% for profit

Source: Author's construction from data *less than 50% of the dataset reported estimates

Kenya and Rwanda appear to have a considerable number of medium scale enterprises in the retrofitted category, as indicated by Table 5, and generate over $1 million is estimated revenues as compared to Uganda and Tanzania. Rwanda appears to be a bit of an outlier, with a higher density of founders, along with much shorter average age of SMEs compared to other countries in the EAC

Table 5: Retrofitted SMEs Status

Country	Estimated Revenue Range (USD)/year	Average Age (years)	Number of Founders	No. of Employees	Co. Type
Kenya	29%: < 1 Mill; 46% 1<10 Mill; 25% 10-25 Mill	8.2	1.4	1-10: 38%; 11-50: 44%; 50-200: 18%	91% for profit; 9% non-profit
Uganda	70% < 1 Mill; 30% 1-10 mill	7.4	1.5	1-10: 61%; 11-50: 32%; 50-100: 7%	95% for profit; 5% non-profit
Tanzania	55% < 1 mill; 35% 1-10mill; 15%: 10-20 mill	6.8	1.3	1-10: 35%; 11-50: 55%; 50-100: 10%	100% for profit
Rwanda	15%, < 1 mill; 85% 1-10 mill	4.5	1.9	1-10: 30%; 50% 11-50; 20%: 50-100	100% for profit

Source: Author's construction from data

E2. Early financing for green-tech SMEs in the EAC: born-green SMEs

The data in Table 6 provides details on the funding status, investors and funding types for born-green SMEs. The total average funding varies significantly across countries, with Kenya taking a lion's share, followed by Rwanda and Tanzania. However, when unpacking the SME average funding, the results change drastically, suggesting that Rwandan SMEs have attracted higher funding, followed by Tanzanian and Kenyan SMEs. Uganda has consistently

underperformed compared to other EAC countries. The results are surprising given that Kenya has the highest number of investors and has participated in more funding rounds.

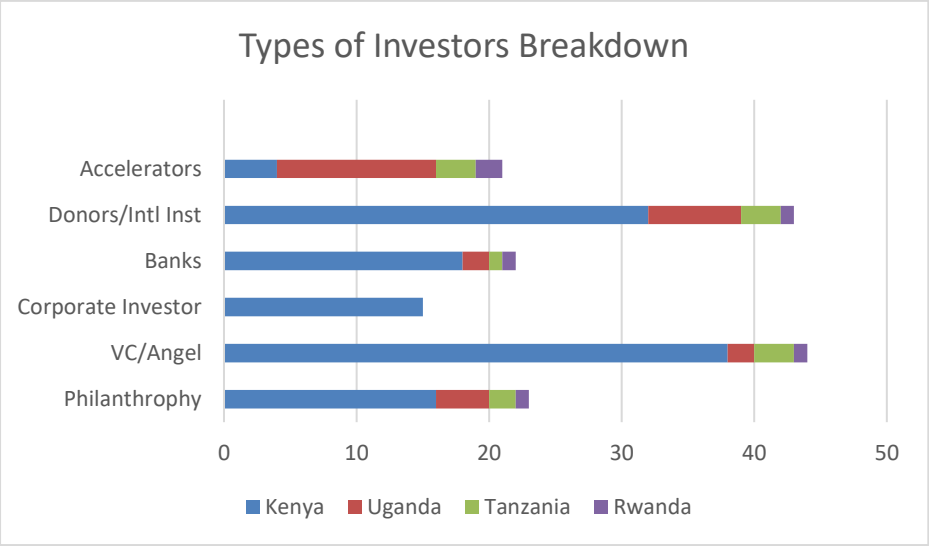
Table 6: Born-Green SMEs Financing Status

Country	Avg total funding amount (USD mill)	Avg funding per green-tech firm (USD '000s)	No. of funding rounds per SME (avg)	Avg no. of investors per SME
Kenya	7.82	24.38	2.3	3
Uganda	0.39	4.58	1.4	1.4
Tanzania	1.97	42.05	1.3	1.2
Rwanda	2.1	110.52	1.25	1.25

Source: Author's construction from data

Figure 3 demonstrates that Kenya has predominantly attracted venture capital and angel investors funders, followed by donor funding. Uganda is supported through accelerators, and has a skewed dependence on donors and philanthropy for its funding. Tanzania and Rwanda seem to have a mix of funders: accelerators, donors, venture capital and philanthropy (impact investing).

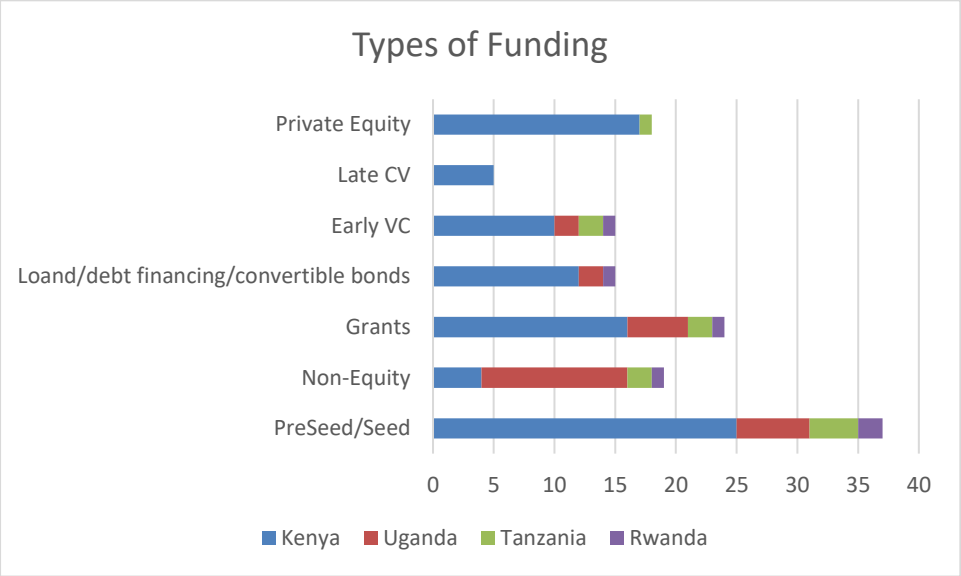
Figure 3: Types of Investors Breakdown for Born-Green SMEs



Source: Author's construction from dataset

Figure 4 indicates that Kenya has the most advanced type of funding, in terms of late venture capital (Series C, D, E) and private equity investments (albeit a very small proportion of Kenya's total funding landscape). Kenya has considerable pre-seed/seed, grants and early-stage private equity funding. Uganda, on the other hand, is dependent on non-equity assistance through accelerators and receives a large chunk of its funding from donors. Rwanda appears to have significant pre-seed/seed funding, as well as private equity funding. Tanzania is predominantly funded through non-equity assistance, followed by grants and seed investments.

Figure 4: Types of Funding for Born-Green SMEs



Source: Author's construction from dataset

E3. Early financing for green-tech SMEs in the EAC: retrofitted SMEs

The data below (Table 7) provides details on the funding status, investors and funding types for retrofitted SMEs. The results of the retrofitted SMEs follow a similar pattern to that of born-green, wherein Kenya and Rwanda tend to have higher average funding per firm, more investors and have participated in a larger number of funding rounds compared to Uganda and Tanzania.

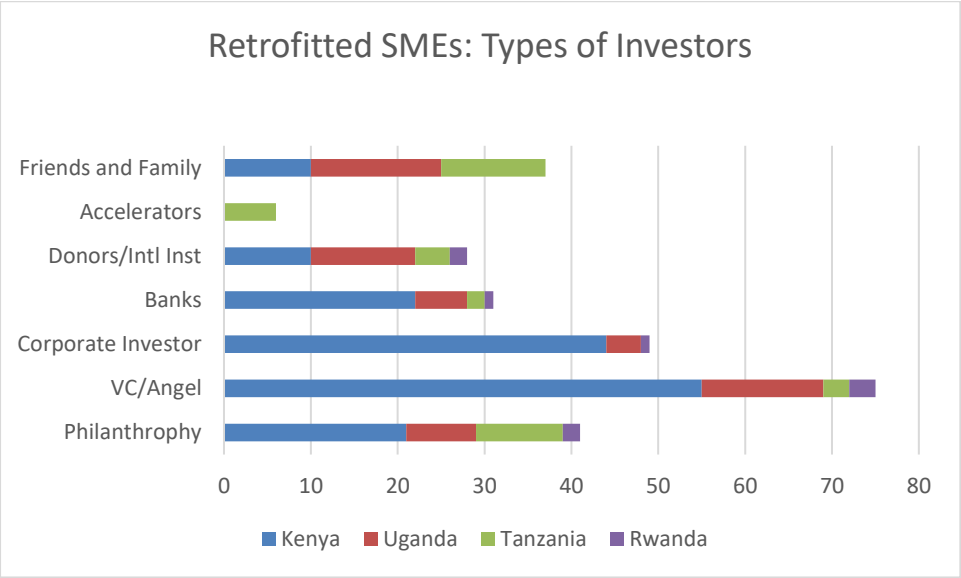
Table 7: Retrofitted SMEs Financing Status

Country	Avg total funding amount (USD mill)*	Avg funding per green-tech firm (USD '000s)	No. of funding rounds (avg)	Avg no. of investors per green-tech SME
Kenya	22.3138	69.5134	2.1	2.3
Uganda	5.065076	58.89623	1.4	1.6
Tanzania	2.622125	55.78989	1.5	1.6
Rwanda	1.632881	85.94111	2.4	2.1

Source: Author's construction from data * less than 50% reported estimates

The results of Figure 5 indicate that Kenya has the most diversified set of investors, predominantly from venture capital/angel investors, and corporate investors. Rwanda and Uganda are predominantly also funded by venture capital and donors. Tanzania is funded through philanthropy and friends & family.

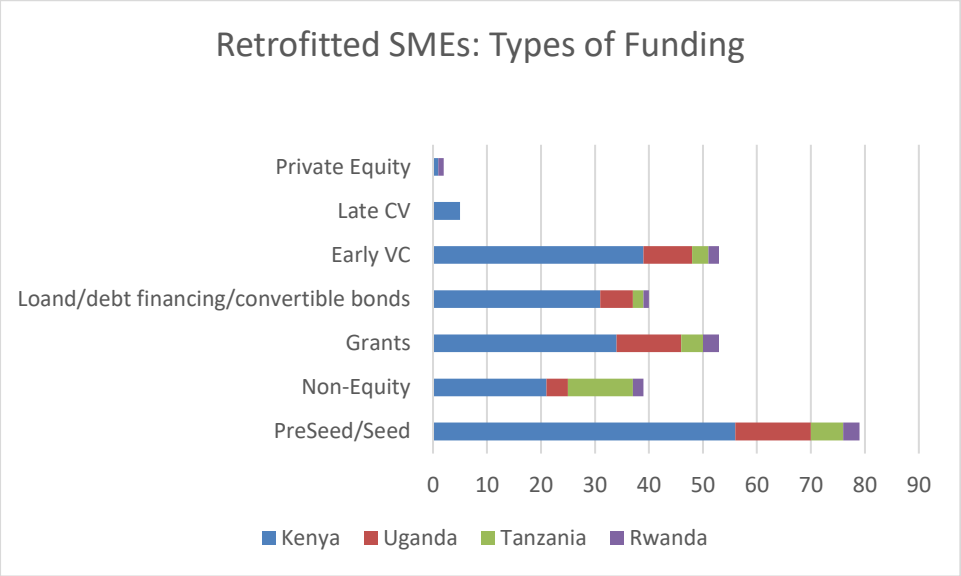
Figure 5: Retrofitted SMEs- Types of Investors



Source: Author's construction from data

Figure 6 echoes the patterns of born-green SMEs, wherein Kenyan SMEs have received funding at seed stage as well as series A-D funding, along with corporate investors and bank loans. SMEs in Rwanda similarly are spread across different forms of funding (except late venture capital). Tanzania and Uganda are both dependent on seed, grants, and accelerator driven support.

Figure 6: Retrofitted SMEs- Types of Funding



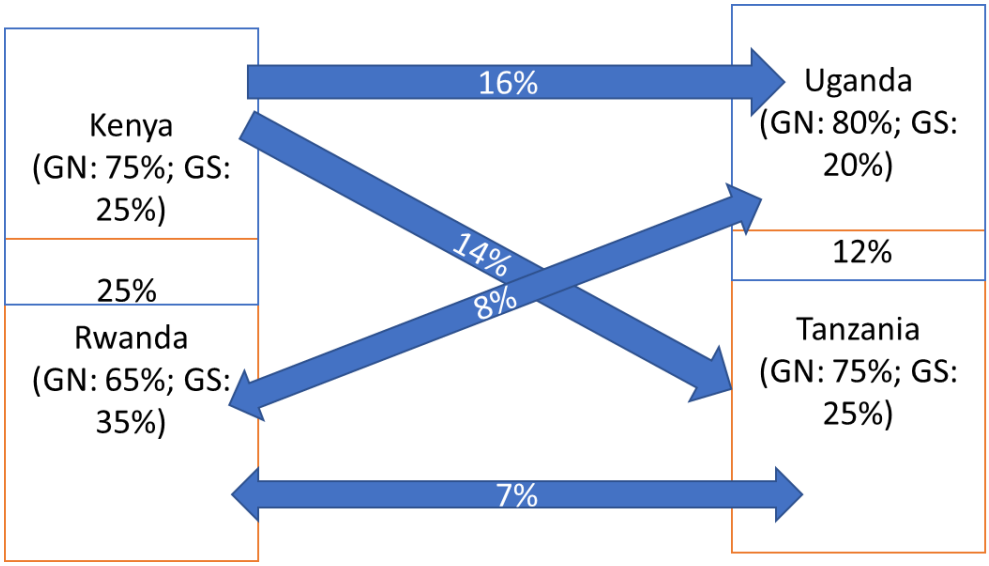
Source: Author's construction from data

E4. EAC cross-border risk appetite of early-stage funders

The evidence suggests that Kenyan and Rwandan green-tech SMEs have been able to attract more funding than those in Tanzania and Uganda. This is despite Tanzanian and Ugandan

green-tech SMEs being in existence for over 7 years. Broadly, the results indicate that funders investing in Kenya and Rwanda also invest in Uganda and Tanzania, suggesting possible knowledge exchange and deeper integration opportunities.

Figure 7: Cross-Border Funding across EAC



Source: Author's construction from dataset (GN= global North, GS= global South)

Overarchingly, the figure above shows that there exist significant overlaps in investors across East Africa. For instance, approximately 25% of the funders invest in both Kenya and Rwanda, albeit at different stages of investment (Kenya has more venture capital seed investments, while Rwanda more philanthropic pre-seed/seed investments). Similarly, there is about a 12% overlap across funders in Uganda and Tanzania. Interestingly, the results also highlight that funders who invest in Kenya also invest in Uganda (16%) and Tanzania (14%), but directionality does not run the other way. That is, funders who invest specifically in Uganda or Tanzania do not necessarily invest in Kenya. The directionality runs both ways in relation to Rwanda, Uganda and Tanzania. The figure illustrates that 7% of the funders invest in both Rwanda and Tanzania, and 8% invest in Rwanda and Uganda. The largest overlap (25%) appears to be between funders in Kenya and Rwanda.

Furthermore, the figure also indicates that most funding in green-tech SMEs appears to be coming from funders in the Global North. For each country, they range between 75-80%, while the global South investment- specifically China, India, Middle East and other African countries- is lower.

Interestingly, the data also suggests that the most likely path to investment is for funders to invest in born-green SMEs in one country and hedge their investment by investing in retrofitted SMEs in other. However, there is less movement across sectors. This could imply that funders have very specific types of risk appetite in terms of the types of SMEs they prefer to invest in, and sector selections.

F. Green Industrial Policy Implications and Future Research Directions

Overall, this study highlights that green governance deficits exist, with the funding structure appearing to be private-led, and driven by the SMEs rather than government support. There is a need to leverage public funds to signal the strength of green-tech SMEs to private investors, so that SMEs can grow from pre-seed stages to achieve early funding and even move on to late funding. This seems to be few and far between in the EAC. For instance, some short to medium term opportunities exist that national governments and the EAC can grasp:

- *Public funding to support and de-risk uncertainties* to show private investors an ability to scale up: a key issue that prevents green-tech SME expansion is the uncertainty of the business opportunity. Creating an ecosystem of support such as infrastructural facilities and training centres can help demonstrate to private investors the potential longer-term opportunities of investment.

- *Dedicated credit lines/increasing credit limits by national banks*: because most SMEs are in the informal sector, and considered high risk, there are no/very expensive credit lines available to them. Furthermore, almost no digital credit footprint exists for SMEs, that can help the bank in making decisions related to risks.

- *Setting up risk-sharing facilities across the EAC* with the EAC Secretariat overseeing the monitoring: this involves creating specialised training zones for supporting green-tech entrepreneurs and creating a pool of capable staff to be able to work in and with these SMEs. Risk-sharing can also involve knowledge sharing and tech-exchange sessions with the EAC matching various complementary SMEs across East Africa. This can occur through creating a data cooperative/trust to share and exchange experiences and knowledge across green-tech SMEs.

- *Create a database to track the health of green-tech SMEs*: through understanding the emerging business models. This can involve finding cases where firms have grown from pre-seed to Series C funding and beyond.

Future research directions

Future research directions are both conceptual and empirical. Conceptually, there is a need to further deep-dive into the scope of green-tech, as this links in closely with several categorizations around environmental goods (e.g. WTO classification) that exist. Second, research needs to move away from generic climate-finance/green-finance related ideas, which often focus on large projects and scales, and turn attention to creating a new nomenclature of early finance in green-tech considering the twin opportunities of ‘green’ and ‘tech/digital’.

Empirically, further research needs to unpack the motivations of why early-stage funders invest in certain green-tech SMEs, and their logics of crossing borders. Do any type of

learning/knowledge exchange spillovers occur when the same funder invests in multiple countries, across different green-tech SMEs? How can these be leveraged to engender SME expansion?

Acknowledgements

This paper builds on research conducted around environmental upgrading in value chains, which was presented at the Catalysing Green Industrialization in Africa workshop, Copenhagen Business School in June 2022. The author would like to thank the ESRC PDF grant (ES/S011692/1), the Hallsworth Fellowship grant and the School of Environment, Education and Development Early Career funding, for funding support. The author would also like to thank Shelmith Kariuki for research assistance support with data collection.

References

Alonso-Martinez, D., De Marchi, V., & Di Maria, E. (2021). The sustainability performances of sustainable business models. *Journal of Cleaner Production*, 323, 129145.

CIF (2022). *Climate Investment Funds*. [online] Available at: https://www.climateinvestmentfunds.org/country/south-africa [Accessed: 25/09/2022]

EAC. (2022). *EAC Industrial Upgrading and Modernisation Programme Overview*. [online] Available at: https://www.eac.int/component/content/article/123-political-federation/204-laying-foundation.html [Accessed: 25/09/2022]

Forbes.(2022*). Africa is on the Path to Digital Transformation of Renewable Energy*. [online] Available at: https://www.forbes.com/sites/markminevich/2022/09/29/africa-is-on-the-path-to-digital-transformation-of-renewable-energy/ [Accessed: 25/09/2022]

IEA (2022). *Africa Energy Outlook 2022*. [online] Available at: https://www.iea.org/reports/africa-energy-outlook-2022/key-findings [Accessed: 25/09/2022]

Halt, G. B., Donch, J. C., Stiles, A. R., & Fesnak, R. (2017). Sources of company funding. In *Intellectual Property and Financing Strategies for Technology Startups* (pp. 11-33). Springer, Cham.

Krishnan, A., Banga, K., & Mendez-Parra, M. (2020). [online] *Disruptive Technologies in Agricultural Value Chains. Insights from East Africa. ODI Working Paper 576*. Available at: https://cdn.odi.org/media/documents/disruptive_agritech_-_5_mar_2020_-_final_draft.pdf [Accessed: 25/09/2022]

Marra, A., Antonelli, P., & Pozzi, C. (2017). Emerging green-tech specializations and clusters–A network analysis on technological innovation at the metropolitan level. *Renewable and Sustainable Energy Reviews*, 67, 1037-1046.

Menon, K. S. V., & Malik, G. (2016). *Funding Options for Startups: A Conceptual Framework and Practical Guide*. Notion Press: Chennai

NRC (2017). Natural Resource Centre Canada- *Clean Technology in Canada's Natural Resource Sectors* [online] Available at: https://www.nrcan.gc.ca/environmental-assessment/public-statements/20089 [Accessed: 25/09/2022]

OECD. (2017). *The Governments' Role in Mobilising Investment and Innovation in Renewable Energy* [online] Available at: https://www.oecd.org/cgfi/forum/The-governments-role-in-mobilising-investment-and-innovation-in-renewable-energy-Insights.pdf [Accessed: 25/09/2022]

Okereke, C., Coke, A., Geebreyesus, M., Ginbo, T., Wakeford, J. J., & Mulugetta, Y. (2019). Governing green industrialisation in Africa: Assessing key parameters for a sustainable socio-technical transition in the context of Ethiopia. *World Development*, 115, 279-290.

Ozili, P. K. (2022). Green finance research around the world: a review of literature. *International Journal of Green Economics*. Available at: SSRN: https://ssrn.com/abstract=4066900

Raga, S., Mendez-Parra, M., & te Velde, D. W. (2021). [online] Overview of trade between Kenya and the European Union (EU). *ODI–FSD Kenya Emerging Analysis Series*. London. Available at:

https://cdn.odi.org/media/documents/Overview_of_trade_between_Kenya_and_the_European_Union_EU.pdf [Accessed: 25/09/2022]

Riehl, K., Kiran, A. S., & Miryala, N. (2022). Capturing greentech-related commercial activities of listed companies. *Global Business Review*, 09721509221085347.

Song, M., & Wang, S. (2018). Market competition, green technology progress and comparative advantages in China. *Management Decision*, *56*(1), 188-203.

Zhou, W., Su, D., Yang, J., Tao, D., & Sohn, D. (2021). When do strategic orientations matter to innovation performance of green-tech ventures? The moderating effects of network positions. *Journal of Cleaner Production*, 279, 123743.

Appendix A: Types of Green-Tech SMEs by Sector

Key sector	Born-Green	Retrofitted
Agriculture and Farming	Agtech	Farming and Agriculture
	Hydroponics	Forestry
		Animal Feed
		Aquaculture
		Horticulture
		Livestock
Clothing and Apparel		Fashion
		Shoes
Consumer Goods	Green Consumer Goods	Beauty, Cosmetics
		Consumer Goods
		FMCG
		Handmade/Recycled
Energy and Natural Resources/Sustainability	Biofuel	Batteries
	Biomass Energy	Other Energy
	Clean Energy	Energy Efficiency
	Electrical Distribution	Energy Management
	Energy Storage	Fossil Fuels
	Renewables- Solar, Wind, Geothermal, Hydro, Tidal	Fuel Cells
	Cleantech	Clean Oil and Gas
	Recycling	Mining Tech
		Timber
		Pollution Control
		Waste Management
		Water Purification
Food and Beverage	Organic Food	Distillery
	3D Printed Food	Food Delivery, Processing
		E-Grocery
Manufacturing		3D Printing
		Paper Manufacturing
		Textiles
		Plastics And Rubber
		Wood Processing
		CAD Systems
Professional Services	Environmental Consulting	Environmental Consulting
	Environmental Engineering	Environmental Engineering
	Clean-Web	Clean-Web
Transportation	Autonomous Vehicles	Sharing Economy (Ride Sharing, Leasing)
		Electric Vehicles
		Ferry Services
		Fleet Management
		Public Transportation
Real Estate	Green Building	Smart Building
		Smart homes
		Timeshares

NOTE: Green-tech SMEs can operate in more than on sector		

Source: Author's construction from review and interviews