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Innovation & entrepreneurship for climate action in Africa

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KEY MESSAGES

Climate change poses a significant threat to global livelihoods, with 85% of the global carbon budget already spent, and Africa being disproportionately affected, compared to its emissions. To build resilience, harmonized action from the private sector, young entrepreneurs, and investors are crucial. The African Development Bank supports these efforts.

Technology is driving innovation in climate action, with entrepreneurs harnessing physical and digital technologies to design efficient solutions for their communities in areas like climate-resilient infrastructure, climate insurance, smart agriculture, buildings, cities, and renewable energies. Entrepreneurship support organizations (ESOs) are essential in encouraging and accelerating this trend, and the Lab is committed to supporting them.

1 | BACKGROUND

Action on climate change in Africa

Climate change is a global challenge, particularly affecting Africa¹, which is highly vulnerable to its adverse impacts². The Intergovernmental Panel on Climate Change (IPCC) reports that developing countries are the most

vulnerable to climate change, with millions experiencing food insecurity and reduced water security. Human mortality from floods, droughts, and storms has been 15 times higher in highly vulnerable regions between 2010 and 2020³. Fragile ecosystems, at-risk populations, and limited resources for adaptation and mitigation contribute to the crisis. In Africa, the crisis has a significant human cost, particularly among poor, marginalized, and fragile populations dependent on agriculture. Action on

¹ Butcher, M. 2022. *New Paris-based VC Satgana completes the first close of its €30M fund to back climate tech startups*. Oct. 26. TechCrunch. <https://tcrn.ch/3WTfCXG>

² Intergovernmental Panel on Climate Change (IPCC). 2022. Pörtner, H.-O., et al. (eds.). In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37–118, doi:10.1017/9781009325844.002. . https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_TechnicalSummary.pdf

³ IPCC. 2023. *Synthesis report of the IPCC Sixth Assessment Report (AR6). Summary for policy makers*. Mar. https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf

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climate change adaptation and addressing past events caused by human-related greenhouse gas emissions and global warming is crucial, as it has caused loss and damage to African natural ecosystems⁴.

Climate change requires reducing and stabilizing greenhouse gas levels to prevent extreme temperatures^{5,6}. Africa, which contributes only 5% of global emissions⁷, is focusing on adaptation and loss and damage. The COP27⁸ meeting in Egypt in November 2022 agreed on developing a funding mechanism to address climate disasters in vulnerable countries⁹. This presents significant opportunities for African entrepreneurs and private sector operators, as the timing of COP 27 coincides with a rise in private equity investment in Africa, highlighting the potential for climate action and entrepreneurship in Africa.

2 | INVESTMENT IN AFRICAN INNOVATION AND ENTREPRENEURSHIP

In 2022, Africa attracted a record \$6.5B in venture capital funding¹⁰, despite a global economic downturn. 82% of VC deals were in the technology or tech-enabled sector in H1 2022, with cleantech deals showing a YoY growth of 420%¹¹. These deals were for startups in sectors like sanitation, waste management, and metals recycling. VC investments focused on utilities were the most active sector, followed by financial services in the climate action sector¹². The role of VC investment in 2023 remains uncertain due to looming recessions in Western countries, job cuts in technology companies, and the collapse of Silicon Valley Bank in the USA^{13,14,15}. FDI trends in Africa are waning, with total greenfield announcements remaining low at \$39 billion in 2021¹⁶. However, Africa has great potential to attract international investment in green and blue economies and infrastructure. This economic brief

explores opportunities for African entrepreneurs and innovators in transitioning to a low carbon economy and green growth.

Opportunities for entrepreneurs

Climate action is a significant opportunity for young entrepreneurs, startups, and ESOs in Africa, with venture capitalists seeking new opportunities. From 2016 to 2020, the AfDB has invested \$12.3 billion in climate action, with 43% spent on climate adaptation and 57% on mitigation. The bank plans to invest an additional \$25 billion between 2020 and 2025¹⁷. While PE and VC investments are also a source of opportunity for young African entrepreneurs, significant sources of funding exist in African local capital.

The Innovation and Entrepreneurship Lab of the African Development Bank (AfDB)

The Innovation and Entrepreneurship Lab (The Lab) is part of the Jobs for Youth in Africa Strategy of the AfDB, aiming to reduce youth unemployment and underemployment by supporting youth entrepreneurship. It is part of the Boost Africa initiative, which facilitates access to finance for startups and SMEs. The Lab focuses on creating commercially successful and sustainable youth-led enterprises that create quality jobs and contribute to inclusive human, social, and economic development. It also strengthens the capacities of Entrepreneurship Support Organizations (ESOs) in Africa to support technology-based or technology-enabled startups through improved opportunities for finance, prototyping, networking, and market access. For instance, the Lab is implementing a program in Egypt (funded by the Swiss State Secretariat for Economic Affairs) that trains ESOs to the specificities of the support needed by climate-focused start-ups.

⁴ UNFCCC. 2018. *Loss and damage. Online guide*. May. https://unfccc.int/sites/default/files/resource/Online_guide_on_loss_and_damage-May_2018.pdf

⁵ WWF. 2023. *What's the difference between climate change mitigation and adaptation?* <https://www.worldwildlife.org/stories/what-s-the-difference-between-climate-change-mitigation-and-adaptation>

⁶ NASA. 2022. *Responding to Climate Change*. Dec. 28. <https://climate.nasa.gov/solutions/adaptation-mitigation/>

⁷ Global Center on Adaptation. GCA. 2021. *African presidents and global leaders support bold action on climate change adaptation for Africa*. Apr. 7. <https://gca.org/news/african-presidents-and-global-leaders-support-bold-action-on-climate-change-adaptation-for-africa/>

⁸ UNFCCC. 2018. *Loss and damage. Online guide*. May. https://unfccc.int/sites/default/files/resource/Online_guide_on_loss_and_damage-May_2018.pdf

⁹ UNFCCC. 2022. *COP27 Reaches Breakthrough Agreement on New "Loss and Damage" Fund for Vulnerable Countries*. Nov. 20. <https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries>

¹⁰ Partech. 2023. *2022 Africa tech venture capital report*. <https://partechpartners.com/2022-africa-tech-venture-capital-report/>

¹¹ AVCA. 2022. *Ibid*.

¹² AVCA. 2022. *Ibid*.

¹³ Gebre. 2023. *Record Funding Drive by African Startups Masks Challenges Ahead*. Jan. 6. <https://www.bloomberg.com/news/articles/2023-01-06/record-funding-drive-by-african-startups-masks-challenges-ahead#:~:text=Global%20funds%20such%20as%20Sequoia,over%20the%20past%20few%20years.> c

¹⁴ Hammond, G. & T. Bradshaw. 2023. *'A devastating impact': SVB's collapse leaves start-ups with a funding hole*. Mar. 26. Financial Times. <https://www.ft.com/content/9f8c506f-f01a-448e-ab4b-6c7fcd060422>

¹⁵ Kinder, T. & G. Hammond. 2023. *Silicon Valley VCs tour Middle East in hunt for funding*. Apr. 12. Financial Times. <https://www.ft.com/content/567ca518-b138-4273-bfe6-0712ef31e01d>

¹⁶ UNCTAD. 2022. *Investment flows to Africa reached a record \$83 billion in 2021*. Jun. 9. [https://unctad.org/news/investment-flows-africa-reached-record-83-billion-2021#:~:text=The%20largest%20holders%20of%20foreign,and%20France%20\(%2460%20billion\)](https://unctad.org/news/investment-flows-africa-reached-record-83-billion-2021#:~:text=The%20largest%20holders%20of%20foreign,and%20France%20(%2460%20billion))

¹⁷ AfDB. 2022. *Africa Green Growth Readiness Assessment*. Jan. 28. 130pp. <https://www.afdb.org/en/documents/africa-green-growth-readiness-assessment>

3 | IMPACT OF CLIMATE CHANGE ON AFRICA

The AfDB has identified key climate change risks faced by Africa¹⁸, with the Intergovernmental Panel on Climate Change (IPCC) predicting high to very high impacts on terrestrial, freshwater, and marine ecosystems, particularly terrestrial and marine species¹⁹. Climate change will also significantly affect human systems, with medium impacts on water scarcity, food production, agriculture, health, and wellbeing, as well as cities, settlements, and infrastructure. Key economic sectors are predicted to be highly to very highly impacted²⁰, with the increase of the spread of infectious diseases, heat, malnutrition, and displacement.

Climate related risks in Africa

Summary of climate change risks in Africa: ²¹

- Species extinction and reduction or irreversible loss of ecosystems and their services, including freshwater, land and ocean ecosystems

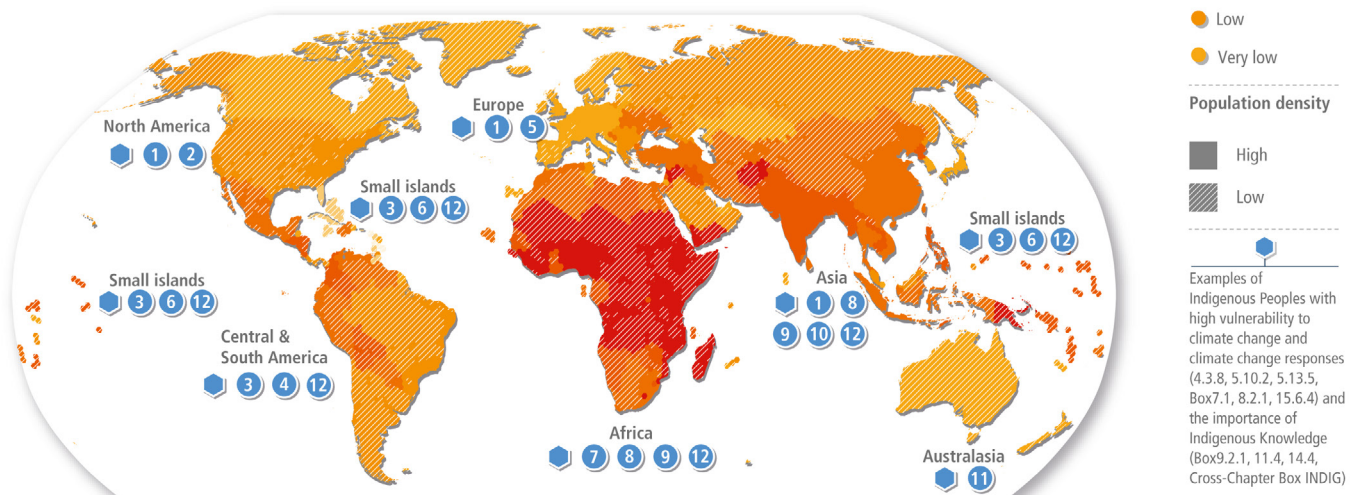
- Risk to food security, risk of malnutrition (micro-nutrient deficiency), and loss of livelihood due to reduced food production from crops, livestock and fisheries
- Risks to marine ecosystem health and to livelihoods in coastal communities
- Increased human mortality and morbidity due to increased heat and infectious diseases (including vector-borne and diarrheal diseases)
- Reduced economic output and growth, and increased inequality and poverty rates
- Increased risk to water and energy security due to drought and heat.

The impact of climate change on human populations in Africa is particularly evident (Figure 1).

FIGURE 1 HUMAN VULNERABILITY TO CLIMATE CHANGE IN AFRICA VS THE WORLD²²

Observed human vulnerability differs between and within countries and strongly determines how climate hazards impact people and society

(a) Map of observed human vulnerability based on two comprehensive global indicator-systems using national data, plus examples of selected local vulnerable populations and Indigenous Peoples



Examples of local vulnerable populations | Examples of some aspects of vulnerability | Chapter references

¹⁸ AfDB. 2021. *Climate and Green Growth Strategic Framework: Projecting Africa’s Voice – Strategy*. Oct. 48pp. <https://www.afdb.org/en/documents/climate-and-green-growth-strategic-framework-projecting-africas-voice-strategy-2021-2030>

¹⁹ Intergovernmental Panel on Climate Change (IPCC). 2022. Pörtner, H.-O., et al.(eds.). In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37–118, doi:10.1017/9781009325844.002. . https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_TechnicalSummary.pdf

²⁰ IPCC. 2022. Ibid.

²¹ IPCC. 2022. Ibid.

²² IPCC. 2022. Ibid.

asters, disasters that displace three times more people than war²³. It is estimated that African countries will have to spend up to five times more on adapting to the climate crisis than on healthcare²⁴. A further challenge in addressing climate impacts is that vulnerable communities in these regions and countries, including in Africa, have no way of knowing that hazardous weather is on the way²⁵.

Addressing adaptation, mitigation and loss and damage.

Climate change adaptation involves “*reducing exposure and vulnerability to climate change*”²⁶, and can be anticipatory, reactive, or transformational. Transformational adaptation changes social-ecological systems to anticipate climate change impacts²⁷, while ecological systems adapt through autonomous adjustments²⁸. Resilience is key, as adaptation seeks to return to a previous state before a disturbance. A resilient system maintains essential function, identity, structure, biodiversity, and capacity for adaptation, learning, and transformation. Climate adaptation focuses on preventing damage from extreme events and returning to a previous state, while loss and damage provides means to repair or rectify past damage. Financing adaptation to climate change is more cost-effective than paying for increasingly frequent and severe crises response, such as loss and damage²⁹.

Building resilience can take many forms³⁰. Resilience involves building systems and structures that are flexible and robust, and that can adapt to change, so that they can not only withstand the change imposed by climate impacts, but they can also return to a previous state, i.e. recover, from climate induced shocks and stresses.

Resilience can take many forms:

- **Physical resilience:** the ability of brick and mortar infrastructure to withstand and recover from the impacts of climate change
- **Social resilience:** this refers to the ability of communities to cope with and address the impacts of climate change by raising awareness, identifying threats and developing strategies accordingly.

- **Economic resilience:** the ability of businesses to adapt to the impacts of climate change and to develop business models and practices that address issues of sustainability. Economic resilience also means the ability of business to partner with the community to develop innovative solutions.
- **Environmental resilience:** this refers to the ability of natural systems to withstand and adapt to environmental changes brought about by climate change.

Priorities for action by the GCA and the AfDB, with support of the African Union and African leaders – the Africa Adaptation Acceleration Program (AAP)

Four priorities for action have been identified to address climate adaptation imperatives in Africa. They are³¹:

1. **The Climate Smart Digital Technologies for Agriculture and Food Security Pillar**, to scale up access to climate-smart adaptation solutions through digital technologies and associated data-driven agricultural and financial services.
2. **The African Infrastructure Resilience Accelerator (AIRA)** aims to scale up investment for climate resilient national, urban, and rural infrastructure in critical sectors including through cost-effective nature-based solutions.
3. **The Empowering Youth for Entrepreneurship and Job Creation in Climate Adaptation and Resilience Pillar** (Youth ADAPT) promotes
 - a. The rapid growth of jobs adaptation for young people, youth enterprise development, and increased finance for youth led MSMEs.
 - b. The program supports creating enabling environments to generate jobs for adaptation, building youth capacity for employability, and increasing adaptation jobs in large-scale investment programs.

²³ UN. 2022. *COP27: \$3.1 billion plan to achieve early warning systems for all by 2027*. Nov. 7. <https://news.un.org/en/story/2022/11/1130277>

²⁴ UNEP. 2022. Ibid.

²⁵ Ibid.

²⁶ IPCC, 2022: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegria, M. Craig, S. Langsdorf, S. Lösche, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844. https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf

²⁷ Ibid.

²⁸ Ibid.

²⁹ Ford, N. 2023. *Helping African communities adapt to climate change*. Jan. 10. https://african.business/2023/01/energy-resources/helping-african-communities-adapt-to-climate-change/?utm_term=Autofeed&utm_medium=Social&utm_source=Twitter#Echobox=1674549481

³⁰ Susan L. Cutter, Lindsey Barnes, Melissa Berry, Christopher Burton, Elijah Evans, Eric Tate, Jennifer Webb. 2008. *A place-based model for understanding community resilience to natural disaster*. *Global Environmental Change*. 18, 598-606. https://www.academia.edu/7740205/A_place_based_model_for_understanding_community_resilience_to_natural_disasters?auto=download

³¹ GCA. 2022. Ibid.

4. The Innovative Financial Initiative for Africa aims

- a. To make substantive headway toward closing the adaptation finance gap and building the capacity of African countries to access adaptation funds.
- b. The initiative supports the design of innovative public and private financial instruments such as resilience bonds and debt-for-resilience swaps, aggregation mechanisms for adaptation investment assets, and monetization of adaptation benefits.

4 | INVESTMENT IN CLIMATE ADAPTATION

Unlike financing climate mitigation, which focuses on reducing GHG emissions, “*adaptation requires a broad array of activities tailored to particular climate risks facing specific locations.*”³² At present, adaptation finance represents less than 10% of climate investments because mitigation activities bring in more immediate and certain financial returns than adaptation initiatives³³. Private sector finance for adaptation is estimated to be about \$1B compared to ~ \$300B for climate mitigation finance. Furthermore, climate adaptation finance is provided *in the form of loans rather than grants*³⁴. Fragile and climate vulnerable countries are “*receiving less finance than other states*”³⁵.

Opportunities for entrepreneurs to address climate adaptation in Africa and to build resilience

While investment in climate adaptation is harder to come by than investment in climate mitigation, the opportunities for action and investment are nominally greater and, in some cases, may be made available under other headings such as urban development and renewal, housing, agriculture and construction activities in general, where an adaptation angle can readily be accommodated.

Extreme weather preparedness

- Developing innovative solutions for extreme weather preparedness such as early warning systems and emergency response technologies.

- Dealing with extreme weather events as well as slow onset events requires earth observation systems modified to act as emergency early warning systems. One such system is based on “multi-hazard early warning systems” (MHEWS). In both cases, the collection, management and use of earth observation data is key, especially in emergencies.

Infrastructure monitoring and resilient infrastructure design

- In order to enhance climate resilience in the power and water sectors in Africa, the following steps have been proposed³⁶:

1. Develop technical guidelines on the integration of climate change in the planning and design of infrastructure in climate-sensitive sectors.
2. Promote an open-data knowledge repository for climate-resilient infrastructure development
3. Establish an Africa climate resilience project preparation facility
4. Launch training programs for climate-resilient infrastructure professionals
5. Set up an observatory on climate-resilient infrastructure development in Africa.

- Monitoring large-scale civil infrastructure³⁷ using sensor and remote sensing technologies such as drones and UAVs and space-based observation platforms to assess risks and detect climate related threats in the built environment that is exposed to climate impacts, etc. This will provide decision makers with the information required to inform planning³⁸.

- Designing innovative solutions to address climate change impacts and develop climate resilient infrastructure in the built environment. These would include the selection of climate resilient building materials and building designs, orienting buildings in such a way that they can influence local microclimate in a favourable way are some examples, etc.³⁹.

³² Larsen, G. et al. 2022. *Adaptation Finance: 11 Key Questions, Answered*. Oct. 25. World Resources Institute. <https://www.wri.org/insights/adaptation-finance-explained#:~:text=Unlike%20mitigation%20finance%2C%20which%20always,methods%20for%20tracking%20adaptation%20finance>.

³³ Larsen, G. 2022. Ibid.

³⁴ Larsen, G. 2022. Ibid.

³⁵ Larsen, G. 2022. Ibid.

³⁶ Cervigni, R., R. Liden, J. E. Neumann, and K. M. Strzpek. 2015. *Enhancing the Climate Resilience of Africa's Infrastructure: The Power and Water Sectors. Overview booklet*. World Bank, Washington, DC. <https://www.worldbank.org/content/dam/Worldbank/Feature%20Story/Africa/Conference%20Edition%20Enhancing%20Africas%20Infrastructure.pdf>

³⁷ World Sensing. 2023. *Monitoring large-scale civil infrastructure for a safer and more resilient world*. <https://www.worldsensing.com/>

³⁸ OECD. 2018. *Climate-resilient Infrastructure. OECD Policy Perspectives*. OECD ENVIRONMENT POLICY PAPER NO. 14. <https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>

³⁹ OECD. 2018. Ibid.

- Infrastructure management adaptation measures are also important, for example, changing the timing of maintenance to account for changing patterns of energy demand and supply.
- Flood protection systems are one example and earth movement sensors used for landslide monitoring⁴⁰ are another.

Climate resilient agriculture

- Adopting **resilient agricultural systems, technologies and practices** that also combine the principles of conservation agriculture: minimal soil disturbance, crop rotation, mulching, erosion control practices, etc. One such system is **agroforestry**.
- Adopting **precision agriculture technologies** that make use of digital technologies and associated data driven services and applications. Sensors and sensor networks (wireless sensor networks), earth observation and measurement platforms and related data analytics tools such as GIS, data analytics and AI applications are examples of technologies and expertise that are required for precision agriculture. Drip irrigation⁴¹ and other technologies can be adapted to the needs and circumstances of all farmers including small scale farmers.
- **Climate smart agricultural technologies** also make use of digital technologies as well as other technologies and practices. Climate smart technologies are farming systems, technologies and practices that aim to build resilience to climate change, reduce GHG emissions from agriculture all the while ensuring food security and livelihoods^{42, 43}.
- **Famine early warning systems** have been available in Africa for over 30 years⁴⁴.
- **Crops adapted to local weather conditions** and invariably warmer climate conditions. Plants that can tolerate drought, pests and disease are better suited.
- **Integrated pest management practices** based on naturally occurring pesticides such as extracts from the neem tree (*Azadirachta indica*) and other plants.

Community engagement

- Informing the public and creating community awareness of the threat and potential impact of climate change on the community.
- Educating the public and government and private sector operators is important to not only increase awareness, but to help people, families and communities to prepare and to assume their responsibilities in addressing climate risks. Motivating community engagement in climate action.
- Linking the public, private sector and civil society in efforts to understand, prepare for and address climate impacts.
- Encouraging policies that raise awareness and motivate and reward climate action. This can include monetary and fiscal incentives for the private sector, the mobilization of public funds, insisting on building resilience in public and private sector procurement notices to streamline and support action to address climate impacts.
- Learning from community practices and combining these with other technologies from different knowledge systems.

Environmental monitoring, conservation and management

- Monitoring environmental change to assess the impact on the environment, on biodiversity and on natural resources upon which the community depends: water, natural resources, extractive activities and industries, etc. The use of telemetry and sensors, aka the IoT, is growing for ecarbon monitoring⁴⁵ and more generally for biodiversity monitoring⁴⁶.
- The international community has come together to address the needs for climate observation. The Global Climate Observing System (GCOS) was established in 1992 to “ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users”⁴⁷.

⁴⁰ Wang, C. et al. 2022. *Real-Time Monitoring System of Landslide Based on LoRa Architecture*. Front. Earth Sci., 06 June 2022. Volume 10. <https://www.frontiersin.org/articles/10.3389/feart.2022.899509/full>

⁴¹ Financial Times. 2023. *Droughts: when deserts make deserts, water tech is needed*. Jun. 11. Opinion Lex. <https://www.ft.com/content/52ae4368-73d9-494a-9c23-a86076459117>

⁴² FAO. 2023. *Climate-smart agriculture*. <https://www.fao.org/climate-smart-agriculture/overview/en/>

⁴³ SAFT. 2022. *How can IoT help us solve our ecological issues? Agritech*. Feb. 10. <https://www.saft.com/energizing-iot/how-can-iot-help-us-solve-our-ecological-issues-agritech>

⁴⁴ Wikipedia. 2023. *Famine Early Warning Systems Network*. https://en.wikipedia.org/wiki/Famine_Early_Warning_Systems_Network (accessed Mar. 28, 2023).

⁴⁵ Wild, T. A. et al. 2023. *A multi-species evaluation of digital wildlife monitoring using the Sigfox IoT network*. Mar. 25. <https://animalbiotelemetry.biomedcentral.com/articles/10.1186/s40317-023-00326-1>

⁴⁶ SAFT. 2022. *How can IoT help us solve our ecological issues? Episode 2 - Biodiversity*. Jun. 30. <https://www.saft.com/energizing-iot/how-can-iot-help-us-solve-our-ecological-issues-episode-2-biodiversity>

⁴⁷ GCOS. 2023. *The GCOS Story*. <https://gcos.wmo.int/en/about/gcos-story>

Africa must adapt to climate change to meet the Paris Agreement⁴⁸ targets and reinvent all sectors of its economy. However, addressing climate change has been challenging due to limited policies and investment. Wealthy countries have not linked impacts to purchasing goods and services⁴⁹, and conventional financing mechanisms are difficult to apply⁵⁰. The AfDB is creating Certified Adaptation Benefits to provide cash flow to developers of adaptation projects and unlock private sector investment to strengthen adaptation⁵¹.

Innovation and entrepreneurship for climate adaptation

Innovation and entrepreneurship in Africa are driven by technology, particularly in climate action. This includes hard tech infrastructure, digital tech, and a combination of both, such as technologies associated with the 4th Industrial Revolution. Other technologies are based on soft tech, such as agricultural practices and traditional knowledge systems. Some require high-end resource mobilization, such as technical skills and access to specialized hardware and software. Others are based on traditional and local coping mechanisms, often referred to as “frugal innovation”. Africa’s adaptation to climate change presents a significant opportunity for African entrepreneurs, who can strengthen climate adaptation efforts in priority areas.

Some of these opportunities are listed in Appendix 1 – Opportunities for entrepreneurs to strengthen climate adaptation efforts in Africa. Table 1 - Opportunities for entrepreneurs to strengthen climate adaptation efforts in Africa – priority areas in red.

5 | LOSS AND DAMAGE

Cop27 achieved a breakthrough agreement to provide “loss and damage” funding for vulnerable countries hit hard by climate disasters⁵². This fund is meant to address the historical impact of climate change based on the principles that the “polluter must pay” for damage caused. Loss and damage “*refers to the negative consequences that arise from the unavoidable risks of climate change, like rising sea levels, prolonged heatwaves, desertification, the acidification of the sea and extreme events, such as bushfires, species extinction and crop failures*”⁵³.

What opportunities for entrepreneurs, SMEs, startups and scaleups as well as ESOs in addressing loss and damage?

Entrepreneurs should focus on sectors like architecture, construction, and engineering for reconstruction. Building resilience in human habitations requires a novel approach, using natural systems to dissipate extreme climate events and utilizing local building materials, or taking advantage of microclimates. Identifying major climate risks to urban, energy, and transport infrastructure and addressing them using innovative approaches will make buildings greener, cleaner, and safer. The objective is to empower vulnerable people and livelihoods to be resilient, prosper and thrive. Disaster recovery from rapid onset events and rehabilitation of human and natural spaces will be necessary.

Opportunities for entrepreneurs will be in the following areas:

Resilient infrastructure

- Some of the technologies and practices used to develop resilient infrastructure under climate adaptation will also apply to loss and damage. Digital tools will be of great assistance in emergency response and in developing resilient infrastructure solutions.

Climate insurance

- Insurance technologies allowing individuals and SMEs, MSME and businesses in general to address loss and damage will also be important. Some of these solutions involve developing products and services such as parametric insurance, weather indexed insurance and micro insurance products and services to help businesses and communities manage the financial risk associated with climate impacts.
- The use of InsurTech, insurance technologies and practices that are adapted to small businesses and individuals will be appropriate and would need to be developed based on appropriate risk assessments.

⁴⁸ Butcher, M. 2022. *New Paris-based VC Satgana completes the first close of its €30M fund to back climate tech startups*. Oct. 26. TechCrunch. <https://tcrn.ch/3WTFcXG>

⁴⁹ Phillips, G. 2020. *Resilience and adaptation to climate change. Part 1 - Financing adaptation and resilience to climate change: why it matters*. Dec. AfDB Blogs. <https://blogs.afdb.org/climate-change-africa/resilience-and-adaptation-climate-change-310>

⁵⁰ Phillips, G. 2020. *Resilience and adaptation to climate change. Part 2 - Financing adaptation and resilience to climate change: why it matters*. Dec. AfDB Blogs. <https://blogs.afdb.org/climate-change-africa/resilience-and-adaptation-climate-change-311>

⁵¹ Ibid.

⁵² UNFCCC. 2022. *COP27 Reaches Breakthrough Agreement on New “Loss and Damage” Fund for Vulnerable Countries*. Nov. 20. <https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries>

⁵³ UNEP. 2022. *What you need to know about the COP27 Loss and Damage Fund*. Nov. 29. <https://www.unep.org/news-and-stories/story/what-you-need-know-about-cop27-loss-and-damage-fund>

Social safety nets

- Providing emergency assistance to affected communities will involve the use of e-payments, mobile phone, mobile money to facilitate cash transfers, food vouchers and employment programs for affected and vulnerable communities.

Disaster response mechanisms

- Developing emergency preparedness systems, search and rescue technologies and disaster recovery services.

Rebuilding and reconstruction of resilient infrastructure and communities

- Assessment and measurement technologies and practices to measure the scope of damage and top plan for realistic responses and estimates of damage and steps and priorities to rebuild and reconstruct with resilience in mind.
- This includes various observation and measurement technologies and tools used in the construction industry to plan rebuilding, including geographic information system (GIS), building information modeling (BIM), computer aided design (CAD) computer aided manufacturing (CAM), etc.

tute costly and GHG emitting sources of power such as imported oil and gas with renewable energy alternatives. Morocco is a key example of this practices, and other countries such as South Africa are also moving in this direction by investing extensively in renewable energy solutions based on solar PV and concentrated solar power technologies. The AfDB is closely involved in providing funding and guarantees to RMCs for this purpose and supports the Alliance for Green Infrastructure in Africa with the expectation of being able to support up to \$10B in green infrastructure investments⁵⁴.

The main sources of GHG emissions in Africa are⁵⁵:

- In 2016, 73% of GHG emissions emanated from this sector in Africa
- 18% comes from agriculture, forestry and land use (AFOLU)
 - 12% from agriculture
- 6 % from industrial processes
- And 3% from waste management activities.

Increases are greatest in the energy sector and in industrial processes. In low-income countries, the largest part of GHG emissions comes from the AFOLU sectors. Generally, over the recent past, AFOLU contributions to emissions in Africa have been decreasing.

6 | CLIMATE MITIGATION

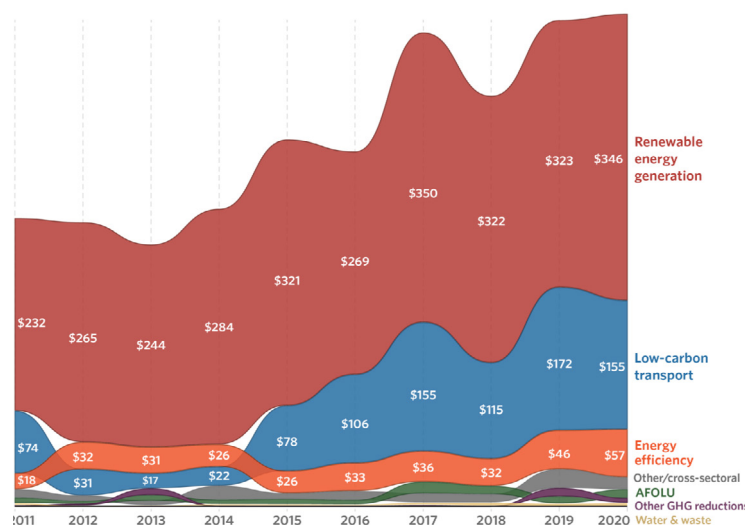
Priorities for address climate mitigation in Africa

In Africa, one of the key factors driving investment in climate mitigation technologies and practices is the imperative for non-oil producing countries to replace and substi-

Investment in climate change mitigation.

The bulk of climate mitigation finance is in renewable energy generation, low carbon transport, energy efficiency solutions, AFOLU, other GHG reductions and water and waste.

FIGURE 2 CLIMATE MITIGATION FINANCE BY SOLUTIONS (USD BILLIONS)



Climate Policy Initiative.2022. Global Landscape of Climate Finance: A Decade of Data. <https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-a-decade-of-data/>

⁵⁴ AfDB. 2022. COP27: African and global partners launch multi-billion alliance for green infrastructure. Nov. 11. <https://www.afdb.org/en/news-and-events/press-releases/cop27-african-and-global-partners-launch-multi-billion-alliance-green-infrastructure-56403>

⁵⁵ AfDB. ?. Drivers of Greenhouse Gas emissions in Africa: Focus on agriculture, forestry and other land use. AfDB Blogs. <https://blogs.afdb.org/climate-change-africa/drivers-greenhouse-gas-emissions-africa-focus-agriculture-forestry-and-other#:~:text=Of%20this%2C%2073%25%20of%20GHG,3%25%20from%20waste%20management%20activities.>

In Africa, PE and VC investment in climate change mitigation is higher than financing for climate change adaptation. According to the AVCA, in 2022, cleantech investments were “the second most active vertical amongst tech related startups that raised venture capital. 56% of the deals in 2022, a record year for VC investment in Africa, were in the climate related renewable energy infrastructure sector with the largest being a \$240 deal in off grid solar energy⁵⁶. Venture capital (VC) investment in climate mitigation is responsible for the bulk of private equity (PE) sourced investment addressing climate action in Africa according to the African Private Equity and Venture Capital Association (AVCA)⁵⁷.

Opportunities for entrepreneurs in climate mitigation

According to the AfDB and the IPCC, the main mitigation options for Africa are⁵⁸:

- Reduction/prevention of emissions by conserving existing carbon pools in soils or vegetation that would otherwise be lost, or by reducing emissions of methane (CH₄) and nitrous oxide (N₂O); (e.g., by conservation of soil and vegetation cover, climate-smart agricultural practices, etc.);
- Sequestration – enhancing the uptake of carbon in terrestrial reservoirs, and thereby removing carbon dioxide (CO₂) from the atmosphere; (e.g., by afforestation and reforestation); and
- Reducing CO₂ emissions by substituting biological products for fossil fuels or energy-intensive products. Demand-side options (e.g., by lifestyle changes, reducing losses and waste of food, changes in human diet, changes in wood consumption), though difficult to implement, may also play a role.

To this can be added:

- Promoting investments in renewable energy and to substitute hydrocarbon burning with renewable energy solutions for electricity production.
 - Specifically, the other sources of emissions that need to be addressed in Africa are: transportation, industrial emissions, buildings and infrastructure in general, waste.
- De-materialization: substituting the use of digital solutions for services provided by public and private sector operators can greatly contribute to reducing emissions in Africa. These solutions include e-commerce and e-government applications
 - Energy efficiency solutions using tech driven smart solutions such as smart grids, smart buildings, smart transportation and logistics systems and smart cities. These systems may apply under specific circumstances in middle- and higher-income countries in Africa.
 - Smart buildings are a well-developed area of research and practice. Tech driven applications such as BIM apps can be used to reduce the carbon footprint of buildings and also be used to plan carbon positive building design.
 - The use of smart tech solutions can also be used to reduce energy consumption of heating ventilation and air conditioning system (HVAC) systems.
 - Designing building that make use of passive energy principles and practices can also contribute to reducing the energy consumption of building.
 - Carbon trading markets
 - According to the International Energy Agency (IEA), carbon markets could generate an estimated \$225-245 billion and more in net financial flows to African countries while preventing significant GHG emissions. 24 African countries have expressed interest in talking part of C markets⁵⁹.
 - Voluntary carbon markets are a suitable and growing source of finance for small holder farmers to invest in mitigating GHG emissions: “*Voluntary carbon markets have grown rapidly in the last two years, reaching approximately \$2 billion in 2021. They are expected to grow 10x by 2030, with increasing demand for “carbon removal” credits generated by agriculture and forestry*”⁶⁰. In Ghana, the AfDB has estimated that the “car-

⁵⁶ African Private Equity and Venture Capital Association (AVCA). 2022. *2022 H1 African venture capital activity report*. Sep. 11 pp. https://www.avca-africa.org/media/3064/02080-avca-vc-mid-year-report-sept22-online_2.pdf

⁵⁷ African Private Equity and Venture Capital Association (AVCA). 2022. *Ibid*.

⁵⁸ AfDB. ?. *Drivers of Greenhouse Gas emissions in Africa: Focus on agriculture, forestry and other land use*. AfDB Blogs. <https://blogs.afdb.org/climate-change-africa/drivers-greenhouse-gas-emissions-africa-focus-agriculture-forestry-and-other#:~:text=Of%20this%2C%2073%25%20of%20GHG,3%25%20from%20waste%20management%20activities>.

⁵⁹ IEA. 2022. *Africa Energy Outlook*. Jun. <https://iea.blob.core.windows.net/assets/6fa5a6c0-ca73-4a7f-a243-fb5e83ecfb94/AfricaEnergyOutlook2022.pdf>

⁶⁰ CASA. 2022. *Carbon finance for smallholder farmers and agribusinesses Analytical briefing on agroforestry solutions*. Technoserve. Dec. <https://www.technoserve.org/wp-content/uploads/2022/12/Carbon-finance-for-smallholder-farmers-and-agribusinesses.pdf>

bon credit at international average carbon market price for Ghana is USD 62.58 billion”⁶¹.

- o The Carbon credit market requires oversight, but still represents a significant opportunity as a source of climate finance⁶². Gabon aims to issue the largest volume of carbon credits under the C trading scheme ever, worth an estimated \$291 million⁶³. Potentially, Gabon could sell credits worth up to \$2.25 billion!

7 | ADDRESSING CLIMATE CHANGE THROUGH INNOVATION AND ENTREPRENEURSHIP

A UNFCCC 2018 report identified the need to strengthen ESOs’ capacity to help founders, startups, entrepreneurs, and SMEs address climate action⁶⁴. While the

AfDB supports climate action initiatives and funds on Africa⁶⁵, there is a need to raise awareness of the opportunities brought by climate change mitigation and adaptation and discuss policies, financing mechanisms, practices, and technologies that entrepreneurs can use to contribute to climate action. The Bank’s Innovation and Entrepreneurship Lab supports initiatives by strengthening the capacity of Enterprise Support Organizations (ESOs) to address climate change challenges and opportunities. In Egypt, the Lab has launched a project with the Swiss State Secretariat for Economic Affairs to help ESOs support entrepreneurs and SMEs identify and tackle Egyptian climate challenges and opportunities. The Lab’s Ennova platform aims to bring together knowledge and resources to assist African entrepreneurs and ESOs in tackling climate change as well. African entrepreneurs face several barriers, including structural barriers, a need for strengthening policy environments⁶⁶, and gaps in knowledge and access to information⁶⁷. This remains a priority for the AfDB and the Innovation and Entrepreneurship Lab.

⁶¹ AfDB. 2022. *Country Focus Report 2022 Ghana. Supporting climate resilience and the just energy transition*. Oct. <https://www.afdb.org/en/documents/country-focus-report-2022-supporting-climate-resilience-and-just-energy-transition-ghana>

⁶² Schwartzkopf, F. 2022. ‘Crazy’ Carbon Offsets Market Prompts Calls for Regulation. Jan. 6. <https://www.bloomberg.com/news/articles/2022-01-06/-crazy-carbon-offsets-market-prompts-calls-for-regulation>

⁶³ Jennifer, L. 2022. *Gabon Aims to Issue the Largest Volume of Carbon Credits Ever (187 Million)*. Carbon Credits. Jul. 1. <https://carboncredits.com/gabon-carbon-credits-biggest-issuance/>

⁶⁴ UNFCCC. 2018. *Energizing entrepreneurs to tackle climate change. Addressing climate change through innovation*. Nov. <http://www.unfccc.int/tclear/tec/brief12.html>

⁶⁵ AfDB. 2023. *Flagship climate initiatives and Funds*. <https://www.afdb.org/en/cop27/flagship-climate-initiatives-and-funds>

⁶⁶ World Bank. 2017. *Ibid*.

⁶⁷ World Bank. 2017. *Igniting Climate Entrepreneurship in Morocco: Findings from the Climate Entrepreneurship and Innovation Ecosystem Diagnostic*. Apr. <https://openknowledge.worldbank.org/entities/publication/e9856fd2-d356-5a86-bb34-6b08bf7145cf>

APPENDIX 1 – OPPORTUNITIES FOR ENTREPRENEURS TO STRENGTHEN CLIMATE ADAPTATION EFFORTS IN AFRICA.

The following is a table of climate risks and related actions and opportunities for innovators and entrepreneurs to contribute to climate adaptation efforts and to strengthen community level climate resilience.

TABLE 1 OPPORTUNITIES FOR ENTREPRENEURS TO STRENGTHEN CLIMATE ADAPTATION EFFORTS IN AFRICA – PRIORITY AREAS IN RED

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
Risk to infrastructure & the built environment	<ul style="list-style-type: none"> Identifying climate risks and hazards Integrating climate risks in the project cycle. Integration of climate change in the planning and design of infrastructure investments Urban planning focused on climate change Improved building designs Improved road and transportation systems. Promote green logistics. Improved building designs Reduce heat building up in human settlements and buildings as well as in livestock buildings, etc. Improved EO (earth observation) and climate data recording & data collection & analysis systems. Early warning systems associated with weather events Local & community radio networks for sharing emergency news and information. Integrated landscape management and experimental innovation for urban green infrastructure Embracing institutional cultures of adaptive policymaking⁶⁸ Strengthen ESOs and entrepreneur networks to adapt to climate risks. Cooling and refrigeration technologies See actions under the risk section below entitled: "Increased risk to water and energy security due to drought and heat" 	<ul style="list-style-type: none"> University of Oxford based National Infrastructure Systems Model (NISMOD) or equivalent UNOPS Capacity Assessment Tool for Infrastructure (CAT-I) & Sustainable Infrastructure Financing Tool (SIFT) or equivalent Transport Association of Canada Infrastructure Health Monitoring Systems (IHM) or equivalent Climate resilient building design & construction using BIM and CAD/CAM Frugal innovation & harnessing local resource base and technologies, innovative practices. Urban environment climate resilience monitoring - Infrastructure Health Monitoring Systems Remote sensing technologies including early warning systems based on Earth observation (EO) tech: GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. Computerized weather and climate models based on EO Improved weather reporting & forecasting systems Appropriate local construction / building practices, materials and technologies. See technologies under section below entitled: Increased risk to water and energy security due to drought and heat. 	<ul style="list-style-type: none"> Mobile network operators (MNOs) WMO, The Global Climate Observing System (GCOS), the Global Earth Observation System of Systems (GEOS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). EU Copernicus program (Copernicus Climate Change Service (C3S)) Satellite data providers : NASA (Landsat, et al.), ESA, SPOT (Fr), etc. Local and community groups, NGOs, etc. including local, rural and urban development organizations Business groups and ESG efforts in investment. VC & other investors Large private sector manufacturers of digital goods and services (FANG group of companies, etc.) 	<ul style="list-style-type: none"> Climate resilient infrastructure design & construction Urban / Infrastructure Health Monitoring Systems EO applications for emergency early warning systems Data aggregators and scientists to manage and interpret data feeds (big data) from earth observation systems) – weather services reporting will be key and a major area of opportunity Universally available & improved meteorological services and related apps. 	<ul style="list-style-type: none"> Local and community level government – rural and urban development planners Weather information systems & weather service providers Local and community groups, NGOs, etc. ESOs and entrepreneurship networks Government entities, local and community groups, CGIAR, WFP, WMO, FAO, UNHCR, DFIs, etc. Data scientists and aggregators Satellite and remote sensing service providers Insurance companies EO service providers Logistics service providers.

⁶⁸ J.P.R. Thorn a b, R. Biancardi Aleu a, A. Wijesinghe c, M. Mdongwe d, R.A. Marchant b, S. Shackleton. 2021. *Mainstreaming nature-based solutions for climate resilient infrastructure in peri-urban sub-Saharan Africa*. in Landscape and Urban Planning, Volume 216, 2021, 104235, ISSN 0169-2046, <https://doi.org/10.1016/j.landurbplan.2021.104235>

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Irreversible loss of ecosystems and their services, including freshwater, land and ocean ecosystems</p>	<ul style="list-style-type: none"> Improved EO (earth observation) and climate data recording & data collection & analysis systems. Early warning systems mostly associated with weather events Land reclamation & regeneration activities Local & community radio networks for sharing emergency news and information. Rainwater collection & aquifer preservation & regeneration Sustainable land & coastal zone + resource management practices: conservation agriculture, low impact & sustainable fisheries, sustainable lifestyles, etc. Emphasize reuse, recycle, remanufacture and repair of goods to limit unsustainable extraction – promoting the circular economy. Strengthen ESOs and entrepreneur networks to address climate action opportunities. 	<ul style="list-style-type: none"> Remote sensing technologies including early warning systems based on Earth observation (EO) tech: GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. Computerized weather and climate models based on EO Improved weather reporting & forecasting systems Biodiversity services including protected areas management Agroforestry for climate adapted crops and sustainable farming systems, etc. Sustainable land / coastal zone management Ecotourism Appropriate local construction / building practices, materials and technologies. Land regeneration and reclamation activities (Agroforestry, conservation agriculture, etc.). 	<ul style="list-style-type: none"> Mobile network operators (MNOs) WMO, The Global Climate Observing System (GCOS), the Global Earth Observation System of Systems (GEOSS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). EU Copernicus program (Copernicus Climate Change Service (C3S)) Satellite data providers : NASA (Landsat, et al.), ESA, SPOT (Fr), etc. Local and community groups, NGOs, etc. including local, rural and urban development organizations Business groups and ESG efforts in investment. VC & other investors Large private sector manufacturers of digital goods and services (FANG group of companies, etc.) 	<ul style="list-style-type: none"> EO applications for emergency early warning systems EO services for sustainable land use management Agroforestry technologies for small – and large-scale landowners Ecotourism operators: local and community groups, NGOs, hospitality sector, etc. Data aggregators and scientists to manage and interpret data feeds (big data) from earth observation systems) – weather services reporting will be key and a major area of opportunity 	<ul style="list-style-type: none"> ESOs and entrepreneurship networks Emergency service providers Farmers and farmers groups/collectives, food producers & supply chains, etc. Agriculture / forestry and use ESOs Government entities, local and community groups, CGIAR, DFIs, etc. Researchers, data scientists and data aggregators Tourism operators Local and community level government – rural and urban development planners Weather information systems & weather service providers Insurance & micro insurance service providers Satellite and remote sensing service providers Insurance companies EO service providers Logistics service providers.

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Risk to food security</p>	<ul style="list-style-type: none"> • Food loss reduction • Alternative food sources, protein sources. • Improved EO (earth observation) and climate data recording & data collection & analysis systems. • Enhanced weather reporting and forecasting to manage risks & reduce losses (disaster risk reduction) • Enhanced pest forecasting & management (disaster risk reduction) • Conservation agriculture, climate smart agriculture, research on new crops species, new ag practices, etc. • Food emergency preparedness / management (disaster risk reduction) • Water services • Improved agricultural / food trading / e-commerce systems / platforms to improve ag / food production & demand • Strengthening ag & food sector supply chains in areas at risk • Improved road and transportation systems. • Strengthen ESOs and entrepreneur networks to address food security issues, especially those that are related to climate change. • Strengthen ESOs and entrepreneur networks to address climate action opportunities. 	<ul style="list-style-type: none"> • Remote sensing technologies including early warning systems based on Earth observation (EO) tech: FEWS, GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. • Computerized weather and climate models based on EO • Frugal innovation & harnessing local resource base and technologies, innovative practices • Improved weather reporting & forecasting systems • Emergency communications including early warning systems (EO) • Agroforestry • Sustainable fisheries • Biotech, gentech, foodtech, etc. • Boreholes and WASH services, including digital WASH services to modernize urban and village level water management systems • InsurTech applications for small holder farmers • E-commerce platforms and agriculture commodity / equipment / food logistics delivery services to strengthen agriculture supply chains. • Improve road transportation in affected areas • Improve capacity of ag and food logistics service providers. 	<ul style="list-style-type: none"> • WMO, The Global Climate Observing System (GCOS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). • CGIAR, WMO, research centres & universities, DFIs, UN, national agricultural research services (NARS). • Local and community groups, NGOS, etc. • Agricultural commodity trading platforms & systems • Ag / food sector private sector operators • VC & other investors 	<ul style="list-style-type: none"> • Agroforestry technologies / practices • Agtech, gentech, etc. for development of new crop / livestock varieties adapted to arid areas, water stress, etc. • EO applications for emergency early warning systems: Famine Early Warning System (FEWS – https://fews.net/), GIS, AI, data analytics, etc. • Automatic weather reporting / stations to enhance weather predictability & facilitate use of crop insurance services • Data aggregators and scientists to manage and interpret data feeds (big data) from earth observation systems) – weather services reporting will be key and a major area of opportunity 	<ul style="list-style-type: none"> • ESOs and entrepreneurship networks • Weather services • Government entities, local and community groups, CGIAR, WFP, WMO, FAO, UNHCR, DFIs, etc. • Data scientists and aggregators • Ministries of agriculture & food safety/production • Extension services and agents • Food production services / restaurants / hospitality sector • Forest products • Satellite and remote sensing service providers • Gentech service providers • Insurance companies • EO service providers • Ag service providers • Logistics service providers.

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Risks to marine ecosystem health and to livelihoods in coastal communities</p>	<ul style="list-style-type: none"> • Improved EO (earth observation) and climate data recording & data collection & analysis systems. • Sustainable coastal zone management practices: sustainable fisheries, sustainable use & tourism, sustainable resource exploitation, etc. • Emergency warning & preparedness systems (weather prediction) • Local & community radio networks for sharing emergency news and information. • Strengthen ESOs and entrepreneur networks to address climate action opportunities. • Strengthen ESOs and entrepreneur networks to address climate action opportunities. 	<ul style="list-style-type: none"> • Biodiversity services • Sustainable fisheries • Sustainable land / coastal zone management • Remote sensing technologies including early warning systems based on Earth observation (EO) tech: GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. • Computerized weather and climate models based on EO • Sustainable tourism. 	<ul style="list-style-type: none"> • WMO, The Global Climate Observing System (GCOS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). • WWF, IUCN, DFIs, UN, national coastal zone management services. • Local and community groups, fisher communities, NGOs, etc. • VC & other investors 	<ul style="list-style-type: none"> • EO services for sustainable coastal zone management • Ecotourism operators: local and community groups, NGOs, hospitality sector, etc. • EO applications for emergency early warning systems: GIS, AI, data analytics, etc. • Data aggregators and scientists to manage and interpret data feeds (big data) from earth observation systems) – weather services reporting will be key and a major area of opportunity. 	<ul style="list-style-type: none"> • ESOs and entrepreneurship networks, including farmers and farmers groups/collectives, etc. • Agriculture / forestry and use ESOs • Government entities, CGIAR, DFIs, etc. • Data scientists and aggregators • Tourism operators • Weather operators and service providers

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Increased human mortality and morbidity due to increased heat and infectious diseases</p>	<ul style="list-style-type: none"> Improved EO (earth observation) and climate data recording & data collection & analysis systems. Include improved epidemiological data collection and analysis systems. Conservation agriculture, research on new crops species, new ag practices, etc. Earth observation Emergency warning & preparedness systems (epidemics, pandemics, etc.) Reduce heat building up in human settlements and buildings as well as in livestock buildings, etc. Cooling and refrigeration technologies Strengthen ESOs and entrepreneur networks to address health related climate impacts and opportunities. Local & community radio networks for sharing emergency news and information. 	<ul style="list-style-type: none"> Biotech, gentech, foodtech, etc. Epidemiological studies Remote sensing technologies including early warning systems based on Earth observation (EO) tech: GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. Computerized weather and climate models based on EO Frugal innovation & harnessing local resource base and technologies, innovative practices 	<ul style="list-style-type: none"> WMO, The Global Climate Observing System (GCOS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). AU, Africa CDC, medical research facilities: clinics & hospitals, universities, WHO, UNICEF, etc. Architecture and construction industry operators Energy generation businesses and operators, including renewable energy enterprises. Public utilities: WASH sector operators, etc. 	<ul style="list-style-type: none"> Historical / traditional & modern heat dissipating & natural cooling construction technologies & practices Smart and zero carbon building technologies and practices – smart buildings Renewable energy for cooling and refrigeration – naturally cooled building using local building materials & practices Smart WASH operations – digitize water service delivery to optimize use of WASH infrastructure and limit leaks and losses and increase water conservation 	<ul style="list-style-type: none"> ESOs and entrepreneurship networks Public and private health service providers Pharmaceutical and medical, health industry actors Emergency service providers Data scientists and aggregators Architects and urban planners focused on locally adapted building cooling technologies and practices Local / municipal government and utilities – water and power WASH operators (water utility) Power generators – electricity utility, etc. Renewable energy service providers.

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Reduced economic output and growth, and increased inequality and poverty rates</p>	<ul style="list-style-type: none"> Improved business data & statistics through business digitization, including improved bankability and access to credit. Improve commercial performance of farmers, farmer groups, etc. by introducing smart agriculture / climate adapted farming systems and seeds, crops, etc. Agricultural insurance schemes to reduce risks and strengthen ag supply chains. Introduction of digital retail services to reduce cost of doing business Strengthen ESOs and entrepreneur networks to address climate action opportunities and build business solutions accordingly. Strengthened extension services for drought adapted crops and farming systems. 	<ul style="list-style-type: none"> Adapted farming & cropping systems & improved linkage between agricultural supply chain and local markets and demand Digitization of SMEs, MSME Digitization of financial service providers and introduction and use of fintech solutions to facilitate access to finance for climate innovators and entrepreneurs E-commerce applications Introduction of digital retail services Trained extension agents. 	<ul style="list-style-type: none"> Local government, local and community groups, NGOs, women's groups, etc. Local Chambers of Commerce and Industry & related business & professional groups Farmer coops/groups/associations CGIAR, WMO, research centres & universities, DFIs, UN, national agricultural research services (NARS). Agriculture extension services Agricultural commodity trading platforms & systems Ag / food sector private sector operators VC & other investors. 	<ul style="list-style-type: none"> Climate aware financial service providers. Use of fintech solutions to facilitate access to credit for climate action & startups, SMEs, etc. Climate smart agricultural crops, farming systems (agroforestry, conservation agriculture, etc.) products and services Digitized food / agriculture supply chains and e-commerce enabled buy and sell platforms for consumers and food merchants, restaurants, etc. InsurTech schemes Eco tourism. 	<ul style="list-style-type: none"> Banks and other financial service providers ESOs and entrepreneurship networks Consumers and consumer groups Agricultural and food market actors Agriculture extension services Insurance companies.

Risk	Actions to adapt	Technologies & practices	Partners	Business case / opportunities	Client(s)
<p>Increased risk to water and energy security due to drought and heat</p>	<ul style="list-style-type: none"> • EO & early warning systems mostly associated with weather events • Rainwater collection & aquifer preservation & regeneration • Vegetation / forest cover & regeneration to preserve watersheds and/or reduce heat impact and evapotranspiration. • Promote use of renewable energy with focus on solar & wind for energy generation and to power water pumps, etc. • Improve efficiency of power utilities and WASH infrastructure & utilities. Digitize WASH infrastructure to conserve water and optimize WASH utility operations. Ditto for power utilities. • Smart water conservation & distribution and pumping technologies. • Strengthen ESOs and entrepreneur networks to address WASH challenges in relation to climate action opportunities. 	<ul style="list-style-type: none"> • Remote sensing technologies including early warning systems based on Earth observation (EO) tech: GIS, UAVs, IoT (sensor networks), AI/data analytics, wireless and fixed broadband, etc. • Improved weather reporting & forecasting systems • Weather forecasting models – including cloud-based services to support data management of weather data sets. • Boreholes and WASH services, including digital WASH services to modernize urban and village level water management systems & preserve water / hydrological and phreatic resources • Use of heat and drought resistant varieties of crops and animals and of sustainable farming systems such as agroforestry • Adoption of precision agriculture and smart agriculture technologies. • Drip irrigation is one adapted precision agriculture technology. • InsurTech applications for at risk populations 	<ul style="list-style-type: none"> • WMO, The Global Climate Observing System (GCOS), UNEP, UNFCCC, CGIAR, WWF, IUCN, DFIs, UN, national meteorological and hydrological services, national agricultural research & land management services (NARS). • EO service providers & space-based observation platforms and satellite data re-sellers. • Local government, local and community groups, NGOS, women's groups, etc. • Farmer coops/groups/associations • Agriculture extension services • CGIAR, FAO & DFIs for improved farm mechanization and irrigation, water pumping & conservation technologies 	<ul style="list-style-type: none"> • Improve efficiency of urban water adduction infrastructure: digitizing the operations of public water infrastructure to generate data for enhanced efficiency in the use of water resources and improved delivery of WASH services. • Water accessibility mapping. • Flood risk assessment & management systems • Irrigation, water collection and canalization infrastructure and technologies, including smart pumps. • Precision agriculture tech. • Smart agriculture tech. 	<ul style="list-style-type: none"> • ESOs and entrepreneurship networks • Local / municipal government and utilities – water • Public and private WASH sector service providers • Data scientists and aggregators • Architects and urban planners focused on improved access to potable / piped water • Power generators – electricity utility, etc. • Renewable energy service providers.

