Adaptation **C**ommittee

AC20/TP/7B

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Draft 01.0

Draft Technical paper: Priorities and needs: technologies for adaptation in agriculture, water resources and coastal zones; including experiences in stakeholder engagement and regulatory issues pertaining to the development, transfer and uptake of technologies in those sectors

Recommended action by the Adaptation Committee

The Adaptation Committee (AC), at its 20th meeting, will be invited to consider the work-in-progress draft technical paper on technologies for adaptation, along with possible next steps. It may wish to provide its feedback on the current draft, including guidance on completing the paper, continue engaging with the CTCN and the NAP Task Force when refining and finalizing the paper, and consider whether to include any follow-up activities in its new 2022-2024 flexible workplan.

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1. Introduction

1.1. Background

1. In its revised 2019-2021 workplan,[1] the Adaptation Committee (AC) agreed to prepare, in 2021, a technical paper on the application of technologies for an adaptation priority topic. It further agreed to determine the topic and prepare a scoping note in the second half of 2020; this scoping note was considered at AC18.[2]

2. Following AC18, the AC agreed on the topic of "Priorities and needs: technologies for adaptation in agriculture, water resources and coastal zones; including experiences in stakeholder engagement and regulatory issues pertaining to the development, transfer and uptake of technologies in those sectors" and further agreed to consider an annotated outline at its 19th meeting.[3]

3. At AC19, the AC agreed on the objective, scope and annotated outline of the technical paper, provided additional guidance on the outline, focus areas, and information sources for the paper, and requested the secretariat to seek inputs and feedback from the NAP Taskforce when preparing a first draft for consideration at AC20.

4. This draft, prepared for AC20, is a work-in-progress. When reviewing the paper and providing feedback, the AC may wish to consider that the next iteration will, among other things:

a) Integrate further research materials, including documents from the UNFCCC climate funds and the Koronivia Joint Work on Agriculture, as appropriate;

b) Incorporate quantitative analyses from the national documents reviewed, along with accompanying visuals/graphics;

c) Integrate further case studies, ensuring overall regional balance;

d) Include section(s) on indigenous knowledge and technologies and on gender-sensitive and -responsive approaches;

e) Refine the figures;

f) Complete any other sections now represented by placeholders; and

g) Incorporate insights from relevant upcoming events, including during Africa Climate Week 2021 (26-29 September 2021).

1.2. Technologies for adaptation in agriculture, water resources and coastal zones

5. At the broadest level, technology may be defined as "a piece of equipment, technique, practical knowledge or skills for performing a particular technology" (IPCC, 2000). Adaptation technologies may be more narrowly defined as "the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change."[4] Adaptation technologies are commonly subdivided into three categories: hardware, software, and orgware (Christiansen, Olhoff, and Trærup, 2011). Hardware encompasses tangible "hard" technologies such as infrastructure or equipment, including climate resilient crops. Software, by contrast, refers to knowledge, skills and general capacity that underlies the use of technologies. Finally, orgware includes the institutional arrangements and coordination mechanisms that exist where a given technology will be used and facilitate the use of the technology. These overarching categories cover a wide range of sub-categories that are important features of the adaptation technology landscape, including nature-based solutions and ecosystem-based adaptation, as well as indigenous and traditional knowledge and technologies.

6. Many adaptation technologies have existed and been deployed for many generations, such as building houses on stilts to cope with flooding or irrigating crops to cope with erratic precipitation. At the same time,

[1] https://unfccc.int/sites/default/files/resource/ac_workplan_post_ac17_web.pdf
[2] https://unfccc.int/sites/default/files/resource/ac18_8b_technologies.pdf
[3] https://unfccc.int/sites/default/files/resource/ac19_8b_technologies.pdf
[4] FCCC/SBSTA/2005/8, para 17.

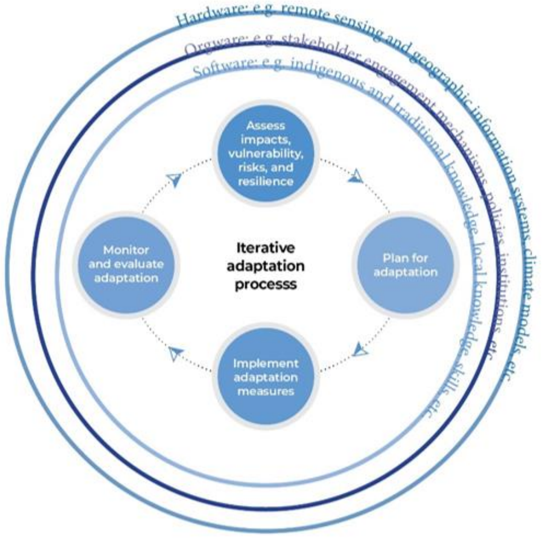
the rapid development of new and innovative technologies provides opportunities to apply new practices and techniques in the service of adaptation, and to improve upon the existing techniques by making them more efficient or environmentally sustainable.

7. Despite this long history and expanding landscape of adaptation technologies, there are still urgent and growing technology-related needs that must be met in order for these technologies to fulfil their potential in reducing vulnerability, bolstering resilience, and enhancing adaptive capacity. In the Paris Agreement, Parties outlined a shared "long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions"[5] and, "noting the importance of technology for the implementation of mitigation and adaptation actions under [the] Agreement and recognizing existing technology deployment and dissemination efforts, [committed to] strengthen cooperative action on technology development and transfer."[6]

8. According to the *Fourth synthesis of technology needs identified by Parties not included in Annex I to the Convention* (hereafter referred to as the *Fourth synthesis of technology needs*), the most commonly prioritized sectors for adaptation technology needs are agriculture (87 per cent of Parties), water resources (79 per cent of Parties) and infrastructure and settlements, including coastal zones (33 per cent of Parties).[7] This testifies to the critical importance of adaptation technologies in these sectors and the enduring needs of countries to access and implement such technologies to build resilience to the worsening impacts of climate change.

9. Across these sectors, and in pursuit of adaptation more generally, hardware, software, and orgware can be applied at all stages of the iterative adaptation process. While there are some technologies that may be most suited to one of the stages – for example, hard technologies such as water efficient irrigation or breakwaters are clearly deployed while implementing adaptation measures – there are also technologies that are useful throughout the process. See Figure 1.

Figure 1. Examples of technology in the iterative adaptation process



Source: Adapted from Adaptation Committee, 2019.

1.3. Objective, scope and structure of the technical paper

10. As a component of the AC's work on providing technical support and guidance to Parties on means of implementation, this paper aims to provide an overview of planning and implementation of adaptation

[5] Article 10, para. 1 of the Paris Agreement.
[6] Article 10, para. 2 of the Paris Agreement.
[7] FCCC/SBI/2020/INF.1, para. 61.

technologies in the areas of agriculture, water resources, and coastal zones. Chapter 2 elucidates some of the priorities and needs for adaptation technologies in the agriculture, water resources, and coastal zones sectors identified as part of the adaptation planning process. Chapter 3 then examines the implementation of adaptation technologies in these sectors and more generally, highlighting issues of stakeholder engagement, innovative approaches, regulatory issues, as well as related good practices, gaps, needs, and challenges. Both chapters draw on the information communicated by Parties in their national adaptation plans (NAPs),[8] adaptation communications (ADCOMs),[9] technology needs assessments (TNAs), and nationally determined contributions (NDCs),[10] as well as documents from the multilateral climate funds under the UNFCCC, along with academic and grey literatures. The concluding chapter offers general reflections on the preceding chapter, as well as potential next steps for consideration by the AC.

2. Planning of adaptation: overview of priorities and needs identified for technologies for adaptation in agriculture, water resources and coastal zones

2.1. Agriculture

11. In 2014, the IPCC concluded that "[a]ll aspects of food security are potentially affected by climate change, including food access, utilization and price stability" (IPCC, 2014). To tackle the challenge of climate change and fulfil the promise of the Paris Agreement while simultaneously eradicating hunger, and achieving the Sustainable Development Goals more broadly, "will require a profound transformation of food and agriculture systems worldwide" (FAO, 2016). Adaptation technologies will inevitably play a vital role in this transformation. In the agriculture sector, common adaptation technologies include seasonal forecasts, which support planning decisions and early warning; water efficient irrigation, which helps farmers cope with drought and variable rainfall patterns; resilient crop varieties, which boost food security by enhancing resistance to water- and heat-stress, salinity, and pests; and farmer-led sustainable agriculture practices, which help ensure farmer ownership, the sustainability of agricultural techniques and their suitability to their context (TEC, 2014a).

12. Most adaptation technologies prioritized by Parties in their TNAs in the agriculture sector relate to sprinkler and drip irrigation (prioritized by 37 per cent of Parties) and biotechnologies, such as those related to crop improvement, new varieties, and drought-resistant, salient-tolerant and short-maturing varieties (together prioritized by over 50 per cent of Parties).[11] Other commonly prioritized technologies related to conservation agriculture and land-use planning, agroforestry, rainwater harvesting, storage techniques for grains and seeds, and integrated soil nutrient management.

13. In their NAPs, most countries (90 per cent) include explicit mention of technologies for agriculture, highlighting their related priorities and needs for facing adverse climate change-related impacts, as well as taking advantage of any resulting opportunities. The level of detail included in NAPs, however, varies, with some plans providing generic statements on the need to develop and implement technologies in the agriculture sector – such as promoting and improving the use of appropriate technologies for crop production for vulnerable farmers – whereas others outline specific technologies and their envisioned use. Types of agricultural technologies mentioned include genetically improved crop varieties that are drought resistant, saline tolerant or otherwise adapted (e.g. short cycle seeds), efficient irrigation technologies, rainwater harvesting, and other technologies that can reduce the water footprint of the agriculture sector, post-harvest crop preservation technologies, technologies for the management and reduction of soil erosion and desertification, technologies to protect crops against floods and heavy rains such as perimeter dikes and breakwaters, and against high winds and sandstorms, such as living hedges or shelterbelts, and technologies to recover agricultural soils degraded by salinization, including bioremediation processes and plant cover management. Agriculture-related measures proposed in NAPs also encompass technologies for information and data gathering and analysis, such as modelling and climate-risk mapping, as well as

[8] See https://www4.unfccc.int/sites/NAPC/News/Pages/national_adaptation_plans.aspx
[9] See https://unfccc.int/topics/adaptation-and-resilience/workstreams/adaptation-communications
[10] See https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx
[11] FCCC/SBI/2020/INF.1, para. 79.

information and communications technologies to improve access to information and technologies in the agriculture sector. Parties further prioritized technologies to bolster the energy efficiency of adaptation measures in the agriculture sector, including solar pumps and wind power.

14. Parties also underscored in their NAPs the need to develop new adaptive technologies in the agriculture sector, including new products, processes, and services, noting that existing technologies were not created considering the impacts of climate change. One specific example is developing soil management technologies that are suited to atoll conditions. Another example is developing and testing technologies for controlled environment agricultural production – such as cold frames and polytunnels with plastic and polycarbonate - which provide benefits such as protecting crops from adverse weather or extending growing seasons. It is anticipated that such new technologies, in addition to bolstering the resilience of crops and agricultural systems, may also generate higher crop yields and reduce the greenhouse gas emissions resulting from agricultural practices. Indeed, prioritizing measures that offer benefits across these areas was highlighted as a marker of an especially successful adaptation strategy.

15. Related to this, research on agricultural technology and innovation, including for soil management, resilient crop variety identification and climate-smart agriculture, featured as part of some Parties' plans for enhancing adaptation in the sector. Specific technologies to assist with research and assessment in the agricultural sector were also cited, including GIS mapping and crop modelling technologies. Some NAPs also included orgware-related needs to enhance the uptake of adaptation technologies in the agriculture sector, such as improving farmers' access to credit for procuring adaptation technologies and equipment or creating a system for using (dis)incentives to support agriculture enterprises that incorporate climate change considerations into their operations. Capacity-building (i.e. software-related) objectives were also included, such as training agricultural technicians in climate-smart agriculture techniques, including the use of drought resistant crops; establishing climate-smart agriculture demonstration sites to showcase different technologies and techniques; creating farmer field school programs to enable peer-learning on climate-smart agricultural practices and technologies; or improving diagnostic facilities to deal with crop and livestock pests and diseases.

16. Similarly, in the adaptation component of their NDCs, many Parties outlined technological measures for adaptation in the agriculture sector. As with other documents, irrigation technologies were frequently highlighted in NDCs, with emphasis once again placed on prioritizing efficient irrigation systems, including micro-irrigation and smart hydroponic systems, as well as supporting the use of renewable energy to power irrigation systems. Biotechnologies for improving the resilience of crops and livestock to climate change were once again common features of agricultural needs and priorities in NDCs, testifying to the important role envisioned for drought-tolerant and otherwise improved crop varieties and climate-resilient livestock species. Practices for soil and water conservation – including mulching, cover cropping, zero tillage, crop rotation, and agroforestry – were also cited as priorities. Plans to promote digital agriculture and technological innovation in the sector were also highlighted. Other technologies prioritized related to, among other things, infrastructure for effective grain and seed storage, weather stations to facilitate tailored climate services for farmers, improving animal breeding technologies through artificial intelligence, and conservation and precision agriculture.

17. Agriculture-related orgware also featured in NDCs, with Parties planning to take actions such as promoting market-based instruments for the adoption of new irrigation technologies, providing agricultural input subsidies and incentives, improving support services for climate resilient crop production, establishing agricultural institutions to research drought resistant varieties, promoting the provision of improved extension services for farmers, and more.

18. In their ADCOMs,[12] Parties once again prioritized irrigation technologies, seed storage, enhanced crop varieties, drainage systems for agricultural lands, nature-based solutions such as cover cropping, and other measures that overlap with those referenced in other national documents and communications. Other measures included enhancing pest infestation warning services, tackling nutrient leaching and soil compaction, and preventing plant and animal heat stress through shade, cooling, and breeding technologies.

[12] In order to avoid overlap, sections throughout this paper summarizing content from ADCOMs focus on information reported in ADCOMs that are not submitted as a component of a NAP or NDC, which are analyzed separately. Of the 17 ADCOMs that have so far been submitted to the UNFCCC secretariat, this includes six ADCOMs.

Parties also prioritized software and orgware for the agriculture sector, including programmes for knowledge development, extension services, and enhancing research and policy to support food security.

19. [Placeholder for analysis of documents from the GCF, GEF, and Adaptation Fund, as recommended during AC 19]

2.2. Water resources

20. According to the IPCC, increasing greenhouse gas concentrations significantly increase the freshwater-related risks of climate change; throughout the 21st century, it is expected that the fraction of the global population affected by major river floods and the fraction experiencing water scarcity will increase (IPCC, 2014). Moreover, it is expected that raw water quality will decrease as a result of climate change, which will also pose risks to drinking water quality as a result of various interacting factors, including increased temperature; increased sediment, nutrient, and pollutant loadings from heavy rainfall; increased pollutant concentration during droughts; and disruption of treatment facilities during floods. There is a wide range of technologies that can help adapt to these changes; common examples include boreholes and tube wells, which help enhance water efficiency and access to safe drinking water by extracting water from subsurface and groundwater levels; rainwater harvesting, which supplements water supply and increases efficiency through rainwater collection from rooftops and other catchments; desalination, which is the process of removing sodium chloride and other dissolved constituents to purify water; and various types of orgware, such as water management fora, which convene stakeholders to discuss options and develop related plans for the water resources sector (TEC, 2014b).

21. Parties place a high priority on applying adaptation technologies in the water resources sector in order to reduce their vulnerability and increase their resilience to these risks. In their TNAs, Parties most commonly prioritized adaptation technologies in the water sector relate to rainwater harvesting (54 percent of Parties) and water storage and catchment (35 per cent of Parties).[13] Parties also prioritized technologies related to small reservoirs and dams, integrated river basin management, desalinization, water supply systems, and watershed management.

22. Ninety per cent of countries referenced adaptation technologies for the water resources sector in their NAPs. Some measures prioritized adapting and ensuring the adequacy of water-related infrastructural technologies, including rain gauge stations, stormwater systems, drainage infrastructure, infiltration galleries, boreholes, dams, reservoirs, canals, aqueducts and modern wells, hand and solar pumps, leak detection and control technologies, and, more generally, developing water infrastructures for vulnerable people. In some cases, it was emphasized that the construction of new water infrastructure, as well as upgrades, repairs, and relocations of existing infrastructure, must be undertaken with a view to withstanding projected climate risks and meeting the future needs of all community members. This focus on infrastructure is apt, given that "the value of water to society is underpinned by hydraulic infrastructure" that store or move water and thereby deliver both economic and social benefits (UN Water and UNESCO, 2021).

23. Information and analytical technologies were also prioritized to support adaptation in the water sector. These include computer models - such as integrated hydrological models and climate forecasting models - weather radars, and sensors, as well as data management platforms. Other prioritized technologies include those that can support water harvesting and water retention, facilitate water reclamation and reuse, treat and safely store household drinking water – including treatment through environmentally sustainable methods like reverse osmosis – reduce consumption, reduce surface evaporation from water bodies, and generally enhance water resource efficiency. Technologies for water desalination, including desalination plants, were also prioritized in NAPs.

24. Still other measures target specific demographics: using appropriate technologies to alleviate drinking water access issues for women in the dry season, or supporting urban areas vulnerable to climate change-related water shortages, through the installation of water-saving sanitary products such as low water consumption toilets, showers and urinals, water saving taps, flow reducers, and other devices. Parties also

[13] FCCC/SBI/2020/INF.1, para. 80.

made general references to promoting and introducing technologies in the water sector, including for water work development and rehabilitation.

25. Some of the water-related technologies and technological measures prioritized in NAPs – as well as other documents – are also intended to contribute to adaptation in the agriculture sector, testifying to the inherent linkages between adaptation in the two sectors including with respect to technologies for adaptation. Agriculture accounts for around 69 per cent of water withdrawals globally as a result of irrigation, as well as water for livestock and aquaculture (UN Water and UNESCO, 2021). The related technologies prioritized in NAPs include, for example, implementing water storage infrastructure to ensure surface water availability for agricultural use in dry seasons and more generally constructing climate resilient water supply and storage infrastructure for crops and livestock production, promoting water conservation technologies and practices (e.g. mulching) in agricultural production systems, promoting rainwater maintenance, improving farm drainage infrastructure, and identifying the most appropriate, modern, and efficient irrigation technologies to improve efficiency and reduce water demand. This latter measure also encompasses improving irrigation systems in a broader sense for sustainable water conservation purposes, through practices such as hydro-zoning – i.e. grouping plants with similar water requirements – and biodiverse planting. Measures prioritizing water-related technologies for adaptation measures in other sectors were also highlighted, including technologies for promoting water reclamation and re-use in the tourism and industry sectors.

26. Parties' NAPs also highlighted orgware-related measures to help facilitate and coordinate the deployment of hardware and software in the water resources sector. Examples include establishing planning committees focused on watershed-based land use, developing integrated watershed management plans, establishing a centre for early warning systems and technology to forecast future climate change impacts on water resources, strengthening institutions that can help boost water resources capacity, and exploring policies such as price caps to ensure the affordability and adoption of prioritized technologies. Efforts to bolster software in the water sector were also prioritized, such as conducting public awareness campaigns on the benefits of low flow technologies and other water conservation systems under current and future climatic conditions.

27. Through the adaptation components of their NDCs, many Parties also articulated a variety of technological priorities, needs, and commitments for the water resources sector. As with NAPs and TNAs, Parties also frequently cited rainwater harvesting and water storage technologies in their NDCs. Desalinization technologies were also prioritized in order to increase the quantity of potable water in vulnerable areas. Another technological measure aiming to boost water quantity is artificially increasing the recharge rate of groundwater aquifers; related measures to improve the distribution of water include inter-basin water transfers. Technologies for monitoring water flow and sediment loads in priority basins were also highlighted. Some Parties also referenced plans to build new water resources infrastructure, including accumulation lakes. Water resources-related orgware was also referenced in NDCs, including, for example, pursuing innovative public-private partnerships for water desalination and irrigation.

28. Finally, in ADCOMs, technological measures water resources prioritized include bolstering the climate resilience of reservoirs against challenges like suspended sediment and floods, ensuring the safety of large-scale dams, maintaining groundwater quality, and optimizing transport capacities during low water periods through deepening navigable channels and removing local obstacles. Orgware-related measures, such as national guidance for freshwater resources management and improving cooperation in transboundary water management were also prioritized.

29. [Placeholder for analysis of documents from the GCF, GEF, and Adaptation Fund, as recommended during AC 19]

2.3. Coastal zones

30. As a result of climate change and associated sea level rise, coastal and low-lying areas are increasingly faced with submergence, coastal flooding, coastal erosion and other adverse impacts (IPCC, 2014). Small island States and some low-lying developing countries are expected to bear the brunt of these impacts, and in some cases will be confronted with damages and adaptation costs amounting to several percentage points of GDP. Technologies to adapt to these changes – and to avert, minimize, and address related loss and damage in coastal zones – include those that support risk assessments, those that advance risk retention,

and those that facilitate recovery and rehabilitation (WIM Executive Committee and TEC, 2020). Included in the risk assessment category are ocean and coastal observation technologies, geospatial technology, numerical simulation models, stakeholder engagement mechanisms, institutions, and more. Meanwhile, the risk retention category encompasses technologies that directly manage risks, such as structural and engineered measures (e.g. seawalls, dykes, sand nourishment, tetrapods, etc.), organizational and financial planning, regulatory and legal measures, contingency planning, nature-based solutions, and more. Finally, the category of recovery and rehabilitation features technologies like mangrove restoration, data collection platforms, resilience-building assessment frameworks, and partnerships and mechanisms to support local communities in the aftermath of disasters.

31. In their TNAs, Parties' most prioritized adaptation technologies in relation to infrastructure and settlements, including coastal zones, were hard and soft measures related to coastal protection.[14] Specifically, these prioritized technologies related to wetland restoration and disaster prevention, such as early warning systems, as well as seawalls, mapping and surveying technologies, and beach reclamation.

32. Parties prioritized similar technologies and measures in their NAPs, including coastal hardware such as detached breakwaters, drainage mechanisms, and other coastal protection barriers to protect communities and infrastructure against sea level rise. In some cases, these barriers were envisioned as nature-based or hybrid solutions or plans to integrate ecosystem-based adaptation considerations into the construction of structures such as seawalls and riverbanks, including mangrove planting, were outlined. Hard measures to improve the condition of beaches were also prioritized in NAPs, including beach nourishment and reclamation, as well as the provision of laboratories and equipment to collect and analyse related data. Plans to establish coastal information systems were also featured. Parties further prioritized measures that could help facilitate the application of hard coastal adaptation technologies, such as researching the role of mangrove forests and coastal dikes/drainage systems to protect against flooding and storm surges, providing open access information and communications networks for relevant sectors and actors, building tools for modelling climate risks in coastal areas and devising solutions, and capacity-building efforts to support the deployment of adaptation activities.

33. The adaptation components of NDCs also listed various technological needs and priorities to adapt coastal zones to the impacts of climate change. Nature-based solutions, and mangroves in particular, were once again commonly cited tools in this respect, with Parties highlighting integrated mangrove ecosystem management, mangrove restoration, and mangrove conservation, as well as supporting measures such as establishing mangrove ecosystem health surveillance, monitoring and analysis tools. Risk assessment measures featured in NDCs include, among other things, establishing accurate sea level rise forecasting systems and updating vulnerability and risk maps for coastal areas. Infrastructural risk retention measures, meanwhile, include offshore breakwaters, groins, seawalls, and revetments, as well as relocating and rebuilding endangered structures, and generally promoting resilient coastal infrastructure. Other risk retention measures include developing port development plans and coastal zone policies, strategies, and management plans, and managing a fund for the recovery of mangroves, coral reefs and other coastal marine ecosystems.

34. Parties' NDCs also highlighted orgware and software related actions, including bolstering communication, education and public awareness on the importance of coastal ecosystem protection for natural disaster impact reduction and establishing institutional structures to strengthen the research, management and monitoring of coastal marine ecosystems and species, and their vulnerability to climate change.

35. In their ADCOMs, Parties once again made reference to risk assessment measures, including climate change-informed assessments of coastal hazards and risks. Risk retention measures prioritized include integrated coastal zone management, strengthening early warning systems, and boosting climate resilient investments in shoreline protection, including built infrastructure. Supporting software and orgware measures include preparing guidance to support local authorities in interpreting related policies and supporting nationwide research on coastal vulnerability and management.

36. [Placeholder for analysis of documents from the GCF, GEF, and Adaptation Fund, as recommended during AC 19]

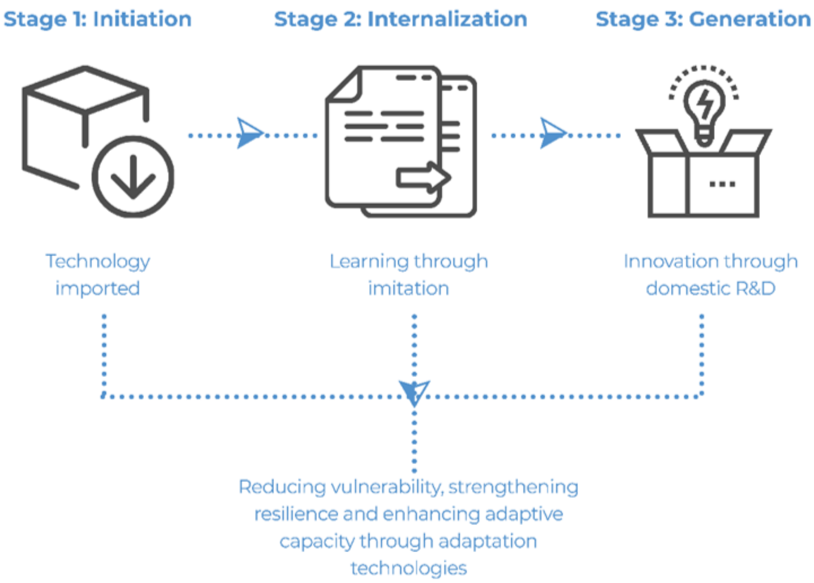
[14] FCCC/SBI/2020/INF.1, para. 81.

2.4. Technology transfer

37. Technology transfer, as defined by the IPCC (2018), is the "exchange of knowledge, hardware and associated software, money and good among stakeholders, which leads to the spread of technology for adaptation or mitigation" and "encompasses both diffusion of technologies and technological cooperation across and within countries." Technology transfer has been recognized as integral to climate action under the UNFCCC since its inception, with the Convention stipulating that developed countries "shall…provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of [Article 4],"[15] which included commitments to "[c]ooperate in preparing for adaptation to the impacts of climate change," and, particularly relevant to this technical paper, to "develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture."[16] As highlighted in paragraph 7 above, Article 10 of the Paris Agreement reiterated the importance of technology transfer to improve climate resilience and implement adaptation actions. The UNFCCC's Technology Mechanism plays an important role in facilitating and accelerating technology transfer to support the implementation of the Convention and the Paris Agreement.

38. For developing countries, the process of technology transfer can involve progressively climbing through three stages (see Figure 2 below). First, an initiation stage during which technology is imported; an internalization stage, during which domestic firms learn through imitation; and, finally, a generation stage, where local firms and institutions undertake their own research and development to innovate (UNCTAD, 2007; Khor, 2012). This process thus "may involve the purchase and acquisition of equipment; the know-how to use, maintain and repair it; the ability to make it through 'emulation' or reverse engineering; to adapt it to local conditions; and eventually to design and manufacture original products" (Khor, 2012).

Figure 2. Stages of technology transfer



Sources: Based on UNCTAD, 2007; Khor, 2012.

39. [Placeholder for further exploration of technology transfer, including needs, priorities and examples highlighted in national documents and other documents. To include discussion of South-South and Triangular Cooperation, drawing *inter alia* on the 2017 TEC Brief on this topic.]

[15] Article 4, para. 3 of the Convention.
[16] Article 4, para. 1(e) of the Convention.

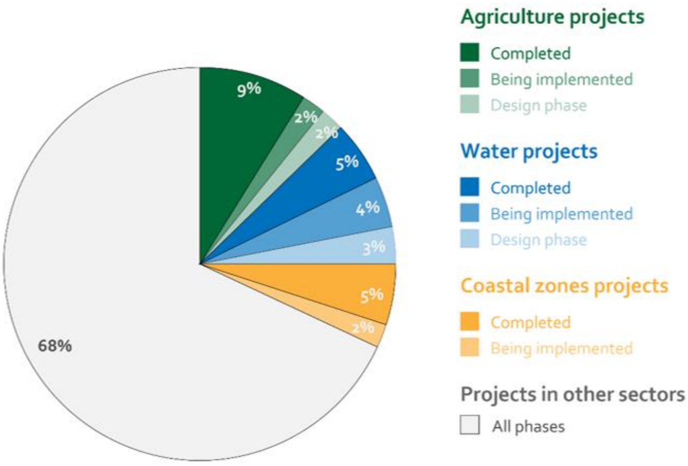
3. Implementation of adaptation measures in agriculture, water resources and coastal zones through enhanced uptake of technologies

40. It is thus clear that countries have widespread enduring needs and associated priorities for adaptation technologies in the water resources and agriculture sectors, as well as in coastal zones, and that these needs and priorities are well documented in their national planning and communications documents. It is also clear that needs must be met, priorities must be acted upon, and technologies must be applied in order to realize the envisioned progress towards building resilience to the impacts of climate change. The extent to which this transition between planning and prioritization to implementation is taking place, however, is more difficult to assess. According to the 2020 UNEP Adaptation Gap Report, close to 400 projects with adaptation as a primary aim have been financed by the UNFCCC climate funds since 2006 and these projects most frequently addressed the agriculture and water sectors (UNEP, 2021). While this represents a degree of progress, the report concluded that "[f]urther scaling up of the levels of implementation is needed to avoid falling behind with managing climate risks, particularly in developing countries."

41. This chapter aims at a general discussion of the implementation of technologies for adaptation in agriculture, water resources, and coastal zones, rather than a comprehensive overview of the state of technology implementation in these sectors. It features sections on stakeholder engagement, regulatory issues, and innovative approaches given the importance of these factors in enabling the development and deployment of adaptation technologies in these sectors and beyond. Finally, each subchapter features a brief discussion of challenges, gaps, needs, and good practices – as well as a general subchapter devoted to these topics – in order to draw attention to some of the barriers that continue to complicate the path towards deployment of adaptation technologies, as well as some of the steps that can help alleviate those barriers.

42. Considering the central role of the Climate Technology Centre and Network (CTCN) in promoting the transfer of environmentally sound technologies for adaptation to meet the needs and priorities of developing countries, the below sections on agriculture, water, and coastal zones begin with a snapshot of CTCN activities aiming at accelerating technology deployment in each of these areas. Figure 3 below provides an overview of how these activities fit into its broader portfolio of technical assistance in the area of adaptation, for which there are currently 133 projects listed on its website.[17]

Figure 3. CTCN technical assistance for adaptation in the Agriculture, Water and Coastal zones sectors (Percentages are of the 133-adaptation focused technical assistance projects listed on the CTCN website)



Source: CTCN, Active technical assistance

[17] See https://www.ctc-n.org/technical-assistance/data?f%5B0%5D=ta_page_objective_facets%3A14912

3.1. Agriculture

43. The CTCN lists 16 technical assistance projects in 15 countries focusing on adaptation in the agriculture sector, of which two are in the design phase, another two are being implemented, and the remaining twelve have been completed.[18] These projects are aligned with several of the priorities and needs for the agriculture described by Parties and summarized in section 2.1 above. For example, the CTCN is supporting Mongolia to enhance the capacity and knowledge of herding communities on climate-resilient livestock farming,[19] and Sri Lanka to address the low level of adaptation technology adoption – including technologies such as soil and moisture conservation practices, cover cropping, and more - by coconut growers.[20] Completed projects have helped, among others, Belize to develop an integrated and comprehensive agroforestry policy,[21] and Benin to establish a sustainable system for collecting and disseminating agro-meteorological information.[22]

44. [Placeholder for projects from the GEF, GCF, Adaptation Fund and other sources of evidence of implementation of agriculture sector adaptation through technology]

45. Despite a long history of adaptation technologies being deployed in agriculture, and their widespread inclusion in adaptation plans and projects, the implementation of adaptation technologies in this sector can nonetheless be reactive and ad hoc in practice. Indeed, as worsening climate change impacts catch producers and firms off guard, adaptation measures used in the sector are sometimes temporary and

Box 1: Reactive adaptation technology deployment in the agriculture sector

Around the world, vineyards facing changing climatic conditions are increasingly turning to temporary and desperate technologies to save their crops. In Napa Valley, in the United States, the region's soil, temperature, and rainfall patterns used to be well suited to growing cabernet, chardonnay, zinfandel, and other varieties of grapes for wine production. Now, extreme heat is causing problems across the valley, from wildfire smoke penetrating the grapes and tainting the taste of grapes – and the resulting wine – to scorching temperatures roasting grapes on the vine. While the smoke taint is difficult to prevent or solve, some growers are turning to spraying sunscreen on their crops to keep them from burning, a strategy that produces mixed results. More expensive options include using shade cloth to cover the crops, or costlier still, to replant vines so that they sit parallel to the sun during the hottest part of the day.

Across the ocean, wine producers in Europe are struggling with late frosts that threaten to damage delicate spring buds. In April 2021, some vineyards in France and Italy surrounded their vines with "bucket-sized candles" to warm the air and protect their crop. This technology proved insufficient in some cases, with some regions losing 90% of their crop – an approximately €2 billion loss – to frost.

In the face of these challenges, there are calls for producers to plant more diverse and resilient grape varieties. Nonetheless, the above examples demonstrate how some agricultural producers are being caught out by the adverse effects of climate change, and are not yet implementing the costlier. but longer-term, adaptation measures that can better safeguard their operations in a changing climate.

Sources: (1) https://www.nytimes.com/2021/07/18/climate/napa-wine-heat-hot-weather.html (2) https://www.economist.com/europe/2021/07/15/climate-change-is-affecting-wine-flavours

[18] See https://www.ctc-n.org/technical-assistance/data?f%5B0%5D=ta_page_objective_facets%3A14912&f%5B1%5D=ta_page_sectors_facets%3A14957
[19] See https://www.ctc-n.org/technical-assistance/projects/enhancing-climate-resilience-and-economic-sustainability-livestock
[20] See https://www.ctc-n.org/technical-assistance/projects/technology-adaptation-program-farmers-minimize-impacts-climate-change
[21] See https://www.ctc-n.org/technical-assistance/projects/development-integrated-and-comprehensive-agroforestry-policy
[22] See https://www.ctc-n.org/technical-assistance/projects/establishment-sustainable-system-collection-and-dissemination-agro

arguably extreme measures that are far removed from the careful planning taking place at the national level. This underscores the need to scale up proactive adaptation technologies. See Box 1 for an example.

3.1.1. Good practices, gaps, needs, and challenges

46. [Placeholder for good practices and opportunities]

47. Parties in their TNAs have identified various barriers to the development and transfer of prioritized technologies in the agriculture sector. One hundred per cent of Parties included in the *Fourth synthesis of technology needs* reported economic and financial barriers; these include a lack of or inadequate access to financial resources for the required technologies, high production costs, inappropriate financial incentives and disincentives, financial unviability, high transaction costs, and uncertain macro-economic and financial environments.[23] To address these barriers, Parties identified several enabling measures, including strengthening existing or establishing new financial mechanisms, policies, incentives, or subsidies; reviewing national policies to, for example, address price competitiveness; or create an allowance in the national budget for the prioritized technology, including for research and development activities.

48. The second most common type of barrier related to policy, legal and regulatory issues, with Parties frequently reporting insufficient legal and regulatory frameworks, insufficient enforcement, policy intermittency and uncertainty, a clash of interests between proponents of new and incumbent technologies, and red tape/bureaucracy. Options to address these barriers, as identified in TNAs, include establishing a comprehensive agriculture development policy, revising policy frameworks to, for example, improve access to and secure land, revise regulatory frameworks to include extension services and facilitate their recognition and prioritization, establish quality control systems, and facilitate accreditation and certification systems.

49. Other types of barriers cited in TNAs with respect to adaptation technologies in the agriculture sector include technical, information and awareness, human skills, market failure/imperfection, social, cultural and behavioural, and network failures. Enabling measures identified to address these and other barriers include organizing awareness campaigns, training farmers through field visits to demonstration plots, promoting and strengthening research and development programmes, and establishing coordination and communication channels and exchange of information among partners.

50. With respect to the NAPs, in some cases, Parties' had the technologies and capacities required for some of their outlined agricultural adaptation measures, whereas other measures required further capacity-building, including for water conservation, soil management, and zero-tillage practices, and additional technologies, including large-scale infrastructure such as grain storage silos. Specific and pressing research gaps and innovation needs pertaining to the agriculture sector were also cited in NAPs, including related to:

a) Crop types and varieties: drought and heat tolerant, pest and disease resistant, early maturing, appropriate alternative types and varieties;

b) Water use efficiency, efficient irrigation systems, water harvesting;

c) Farming practices: soil moisture conservation, land management, crop rotation, forecast-based farming, precision agriculture;

d) Predicting shifts in agro-ecological zonation.

51. Similarly, research-related agricultural needs were also cited in the adaptation components of NDCs, including strengthening scientific studies on modern innovative irrigation techniques and developing irrigation plans based on future water availability and needs. Related gaps are associated with, for example, methodological aspects of applying conservation agriculture technologies and practices,

[23] FCCC/SBI/2020/INF/1, paras. 100-104.

3.2. Water resources

52. In its project database, the CTCN outlines 16 projects in 15 countries focused on advancing adaptation technologies in the water sector.[24] Four of these projects are in the design phase, five are being implemented, and the remaining seven have been completed. These projects are supporting countries in advancing on their technology needs and priorities in the water sector. This includes, for example, ongoing support to Tunisia to implement a smart water supply network, through technologies such as hydraulic modelling, smart metering, and more;[25] support to Cambodia to implement a low-cost, sustainable, and locally-suitable gravity-driven membrane technology to deliver safe drinking water supplies to rural communities;[26] and identifying and promoting feasible, efficient, and effective water recycling technologies for households in Namibia.[27] Completed projects have supported, among others, Grenada to improve its water supply management through a GIS-based monitoring and control system,[28] and Bangladesh to install saline water purification technologies at the household level.[29]

53. [Placeholder for projects from the GEF, GCF, Adaptation Fund and other sources of evidence of implementation of water resources sector adaptation through technology]

54. Private enterprises are also developing and implementing innovative technologies in the water resources sector that meet some of the technological priorities and needs outlined by Parties in their plans, commitments and communications. See box 2 for an example.

Box 2: Producing drinking water through innovative water harvesting technology

SOURCE Global is a water harvesting technology company that builds solar-powered "hydropanels" that produce renewable drinking water for homes, schools, workplaces and communities by pulling moisture from the air. The company has installed thousands of these panels in around 50 countries, helping to create a reliable, resilient and affordable supply of clean drinking water.

On the island of Atauro in Timor-Leste, the small population relies on rainwater that is prone to contamination and is running out during long dry seasons, which are lengthening, partly as a result of climate change. Villagers – mostly women – must then walk long distances to reach remaining water sources. They also import single-use plastic water bottles or, as a last resort, relocate entirely until the end of the dry season, which leaves their rich marine life vulnerable to illegal plunder by outsiders. In 2018, 80 hydropanels were installed on Atauro, enabling the villagers to remain in their communities year-round and generating a clean drinking water supply that is reliable even in the face of lengthening dry seasons.

Similarly, in Maharashtra, India, students at Zilla Parishad Primary School Kolpimpri – located in a region prone to severe drought – students lacked access to safe drinking water. Hydropanels installed in the village created a source of clean, reliable drinking water that is resilient to droughts. This effort also supported the local government's initiative with the aim of transforming villages to align with the Sustainable Development Goals.

Sources: (1) https://www.aiib.org/en/news-events/media-center/blog/2021/Water-from-Air-Climate-Resilience-with-Lightsmith.html; (2) https://www.source.co/resources/case-studies/zilla-parishad-primary-school-kolpimpri/

[24] See https://www.ctc-n.org/technical-assistance/data?f%5B0%5D=ta_page_objective_facets%3A14912&f%5B1%5D=ta_page_sectors_facets%3A7
[25] See https://www.ctc-n.org/technical-assistance/projects/smart-drinking-water-network-tunisia-first-phase-sousse-and-monastir
[26] See https://www.ctc-n.org/technical-assistance/projects/application-gravity-driven-membrane-gdm-technology-supplying
[27] See https://www.ctc-n.org/technical-assistance/projects/water-recycling-technologies-namibia
[28] See https://www.ctc-n.org/technical-assistance/projects/improvement-water-supply-management-grenada-through-gis-based
[29] See https://www.ctc-n.org/technical-assistance/projects/saline-water-purification-households-and-low-cost-durable-housing

3.2.1. Good practices, gaps, needs, and challenges

55. [Placeholder for good practices and opportunities]

56. In their NAPs, Parties outlined technology- and innovation-related weaknesses and knowledge gaps that could potentially undermine the feasibility of their planned adaptation measures in the water resources sector. This includes poor water resources management, lack of modern technologies, insufficient research on climate change impacts on water resources and, specifically, a lack of hydrometeorological information and climate change projections broken down by biome, a lack of economical methods for reducing surface water evaporation from large multipurpose reservoirs, and limited information on groundwater resources, wells and aquifers, including their quality, quantity, extraction and safe yield. Some capacity needs also relate to the construction and operation of specific water-related infrastructure such as desalination plants and large dams. To help address these gaps and weaknesses, Parties plan to, among other things, pursue and promote technology transfer and related capacity-building opportunities in accordance with the principles and frameworks under the UNFCCC.

3.3. Coastal zones

57. Similar to the agriculture and water resources sectors, the CTCN is also providing support to developing countries in the area of adaptation technologies for coastal zones. It lists 10 projects across 19 countries,[30] of which three are being implemented and the remaining seven have been completed.[31] The projects being implemented include support to Panama to develop a marine dynamics database for its coastal zones to assess impacts and vulnerability to sea level rise[32] and support to Kiribati, Marshall Islands, Palau, and the Solomon Islands to build capacity to address risks in coastal zones, with actions related to assembling and cataloguing coastal terrain and bathymetric data, producing terrain models, developing and interpreting wave inundation models, and more.[33] Completed projects have supported, for example, supported Argentina to update tools for studying coastal morphology and monitoring the effects of climate change in coastal zones[34] and Mauritius to sustainably manage and nourish its beaches[35] and to conduct a climate change vulnerability and adaptation study, including an action plan, for its Port.[36]

58. [Placeholder for projects from the GEF, GCF, Adaptation Fund and other sources of evidence of implementation of coastal zone adaptation through technology]

3.3.1. Good practices, gaps, needs, and challenges

59. [Placeholder for good practices and opportunities]

60. Gaps highlighted with respect to implementing measures for coastal zones in NAPs include lack of communication, data access, and up to date information and data on coastal characteristics, dynamics, and related behavioural patterns. Further gaps that impact the application of adaptation technologies in coastal zones include lack of policies, legislation, and restrictions limiting and controlling new construction in coastal areas. Parties also highlighted equipment and technology needs for implementing their prioritized coastal zone adaptation measures, including advanced technologies for pumping sand from the sea bed to support beach nourishment and reclamation, as well as equipment and laboratories to support data collection and analysis for assessing both the vulnerability of beaches the efficacy of related adaptation measures. In a related vein, there are also capacity and training needs to bolster the knowledge and skills required for implemented these advanced technologies for nourishment and reclamation, and for operating advanced data collection and analysis equipment.

[30] Two of the projects are regional: one includes eight countries while the other includes four.
[31] See https://www.ctc-n.org/technical-assistance/data?f%5B0%5D=ta_page_objective_facets%3A14912&f%5B1%5D=ta_page_sectors_facets%3A3
[32] See https://www.ctc-n.org/technical-assistance/projects/development-marine-dynamics-database-panamanian-coasts-assess
[33] See https://www.ctc-n.org/technical-assistance/projects/capacity-development-address-risks-coastal-zones
[34] See https://www.ctc-n.org/technical-assistance/projects/technologies-coastal-management-province-buenos-aires
[35] See https://www.ctc-n.org/technical-assistance/projects/identification-characterization-and-exploitation-potential-offshore
[36] See https://www.ctc-n.org/technical-assistance/projects/climate-change-vulnerability-and-adaptation-study-port-port-louis

61. Parties also cited related needs in their NDCs, including technical expertise and financial support for mangrove restoration efforts, and in their ADCOMs, including financial support for coastal protection.

3.4. Engagement of stakeholders

62. As with adaptation and climate action more broadly, stakeholder engagement is integral to the successful development and deployment of technologies for adaptation. Stakeholders have a right to participate in the decisions that will affect their lives, livelihoods, and overall futures; what's more, the implementation and maintenance of many adaptation measures, including technologies, will depend on local expertise and active involvement (UNFCCC, 2006). In this vein, the UNFCCC Technology Executive Committee (TEC) delivered a key message to COP 20 recommending that local stakeholders are both "involved and empowered" in relation to adaptation technologies, so that local solutions can be replicated and improved, and in order to "promote the sustainable application of technologies for adaptation."[37] The NAP Technical Guidelines recognize the vital importance of engaging a wide range of stakeholders in adaptation planning and implementation (LEG, 2012), which encompasses planning for and using adaptation technologies. Stakeholder engagement is also a common feature of the TNA process. Indeed, the Handbook for conducting TNAs underscores the role of stakeholders in the process, stating that successful stakeholder engagement can give rise to key benefits, potentially "lead[ing] to transfer of new knowledge, especially local knowledge, and insights on specific technology challenges and opportunities that might otherwise have been missed" (UNDP, 2010). Parties engage stakeholders in the TNA process through different approaches, including creating working groups, consulting experts, organizing meetings and workshops, and more.[38]

63. When it comes to the successful development and deployment of adaptation technologies, the term "stakeholders" encompasses a wide range of groups and organizations that often have different but complementary roles. Table 1 below provides an overview of some of these different stakeholder groups and examples of their respective roles. The table is for illustrative purposes and is non-exhaustive; other stakeholder groups may become involved, the groups and corresponding roles may intersect with one another, and the stakeholder groups listed may take on a variety of roles beyond what is listed below.

Table 1. The roles of different stakeholder groups in developing and deploying adaptation technologies in the agriculture, water, coastal zone sectors and beyond

Stakeholder group	Roles in adaptation technology development and deployment
Communities	• Select and prioritize appropriate technologies • Deploy adaptation technologies
Research community (e.g. Universities, Research Institutes)	• Develop and tests new technologies
National governments	• Establish policies to support adaptation technologies • Facilitate an enabling environment for adaptation technologies
Local governments	• Support technology users • Assist with scaling-up small-scale or community-led technologies
Non-governmental/civil society organizations	• Research, implement, facilitate, monitor, evaluate, and finance adpatation technologies • Facilitate communication among multiple stakeholders • Promote appropriate technologies

[37] FCCC/SB/2014/3, para. 53(c)(v).
[38] FCCC/SBI/2020/INF.1, paras. 34-35.

Private sector actors	• Secure financial and non-financial resources • Develop adaptation technologies and provide related services , • Capacity-building for technology implementation
International actors (e.g. multilateral development banks, international organizations)	• Provide financial resources • Increase connections among institutions and stakeholders • Promote technologies and supportive frameworks
Youth	• Assist with identifying priorities and options • Implement adaptation technologies
Women	• Identifying priorities and suitable options • Implementing adaptation technologies
Indigenous peoples	• Identifying priorities and suitable options • Implementing indigenous technologies

Sources: TEC, 2014*;* TEC, 2020; UNFCCC, 2021.

64. Some countries identify specific measures for engaging stakeholders in the research, exchange, or use of adaptation technologies. For example, in the agriculture sector, this includes undertaking climate change assessments, crop modelling, and GIS mapping in partnership with a diverse set of stakeholders and enhancing research collaborations with communities, farmers, disadvantaged groups, and research institutions to create communities of practice and knowledge networks that facilitate innovative and adaptive agriculture practices. It also includes undertaking intermediate steps to pave the way for future stakeholder engagement, such as developing viable business models for the private sector to support the development of technologies prioritized or the import of their required elements, or the establishment of competitive financial products and services that can scale up farmers' adoption of adaptation technologies.

65. Specific approaches for implementing adaptation measures and technologies may also provide inherent opportunities for engaging stakeholders. For example, community-based adaptation can help ensure that communities play a role in the adoption of adaptation technologies, which in turn can increase the sustainability and social acceptance of these technologies (UNFCCC, 2014). There are also examples specific to the sectors addressed in this paper. Integrated water resources management not only offers "a valuable and flexible framework for adapting" water resource use to the impacts of climate change, but also points to opportunities to involve communities, including women, "who are in the best position to choose forms of water-supply adaptation that can safeguard the ecosystems on which they depend for cropping, livestock, fisheries and forestry" (UNFCCC, 2006). Climate-smart agriculture, which is reflected in many of the adaptation plans and priorities communicated by Parties, has similarly been highlighted as an opportunity to promote coordinated, multi-stakeholder collaborations.

66. Policy changes can help improve stakeholder engagement in the use of technologies for adaptation. For example, one NAP recognizes that inclusive policies can play a role in enabling women to participate in agricultural activities by ensuring that men and women have the same opportunities and access to technology, technical assistance, extension services, and related training. It further highlights the necessity of taking into account the roles of men and women in the agricultural value chain and considers how public policy can promote the transformation of gender relations so that women can participate on equal footing.

3.4.1. Innovative approaches for stakeholder engagement

67. Beyond the traditional avenues for engaging stakeholders in the adaptation process, there are emerging innovative approaches for engagement in adaptation technology research, selection, deployment, and upscaling. Mobilizing technology champions – that is, stakeholders who advance a particular technology option at the national or sectoral level – is one such approach that is emerging through the TNA process (TEC, 2020). These champions can help accelerate the implementation of climate change

technologies in developing country contexts by, for example, lobbying for a technology or incentives to support its uptake, or organizing events to showcase and promote technologies. Champions may emerge from the public, private, or non-profit sectors, or beyond, and can act based on business or personal interests, as well as in one's capacity as a representative of a stakeholder community or interest group (TEC, 2019).

68. Another type of innovative approach to stakeholder engagement in the climate technology sphere consists of empowering stakeholders to adopt new technologies through community-level knowledge exchange, as opposed to simply presenting stakeholders with new technological solutions and expecting or insisting upon their uptake (TEC, 2020). The Plantwise programme led by the Centre for Agriculture and Bioscience International (CABI), an intergovernmental not-for-profit organization, offers an example of this approach in practice. Under the programme, CABI established plant clinics in Bangladesh where farmers could seek plant health advice and solutions. Various stakeholder interventions and capacity-building initiatives were also conducted. Instead of imposing new farming technologies and practices over traditional knowledge and methods, it follows a stakeholder-oriented approach where the decisions of which solutions to apply rests with the farmers.

69. These examples depart from mechanisms of stakeholder engagement that seek limited input from stakeholders at discrete portions of the adaptation process and instead embrace forms of engagement that recognize stakeholders as key players in the uptake of adaptation technologies. Box 3 highlights an additional innovative approach that similarly involves stakeholders more directly in the research and application of adaptation technologies.

Box 3: Stakeholder engagement through citizen science

Consultations, workshops, working groups and other similar stakeholder participation mechanisms are mainstays in adaptation action. There are, however, other options that can engage stakeholders in a much more hands-on way, which can be especially valuable for piloting and implementing adaptation technologies. Citizen science initiatives, for example, engage the public directly in scientific research.

A project led by Bioversity, in collaboration with the International Center for Tropical Agriculture and regional and local partners in Central America, Kenya, Ethiopia, and India sought to scale out a „farmer citizen science" approach to advance the adoption of climate-smart agriculture. This approach has farmers test and rank agricultural technologies – for example, crop varieties and management practices – characterize local conditions using cheap but reliable weather sensors, and share related information via mobile phone. As a result, the farmer citizen science approach helped generate empirical and location-specific advice for farmers on climate-smart technologies and practices that can advance adaptation in the agriculture sector.

Sources: (1) https://citizenscience.org/ (2) https://ccafs.cgiar.org/research/projects/citizen-science-approach-climate-adaptation

3.4.2. Good practices, gaps, needs, and challenges

70. In terms of good practices, stakeholder engagement should be approached as an opportunity to co-design adaptation technology solutions, projects, and programmes with various groups and organizations, rather than an invitation for stakeholders to rubber stamp the use of solutions decided upon elsewhere. This helps to increase the social acceptance of technology projects and programmes (TEC, 2020). This, in turn, may also enhance the long-term sustainability of implemented solutions, as well as their ultimate effectiveness in building resilience or reducing vulnerability to the impacts of climate change.

71. When engaging the private sector, governments can improve their partnerships by creating a dedicated framework for private sector engagement (TEC, 2020). This could include a communications strategy that makes clear how engagement in a particular project or programme contributes to broader goals, and what types of contributions are envisioned from partners.

72. [Placeholder for further good practices and opportunities, as well as gaps, needs, and challenges]

3.5. Regulatory issues

73. Beyond stakeholder engagement, policies and regulations have an important role to play in facilitating the development and uptake of adaptation technologies. In their fifth assessment report, the IPCC concluded that strengthening policy and regulatory environments, alongside capacities to absorb, employ and improve technologies suited to local circumstances, may also influence the success of technology transfer (Mimura et al., 2014). Regulations encompass measures such as standards and obligations, zoning and spatial planning, disclosure obligation, building codes, and related rules (Nachmany, Byrnes, and Surminski, 2019).

74. As part of the orgware-related measures Parties highlight in their national documents, several reference plans to update or introduce regulatory measures to support their adaptation measures in relation to agriculture, water resources, and coastal zones. Related to coastal zones, plans to improve the regulatory framework to combat coastal erosion or develop and implement regulations, laws, and policies that integrate climate change resilience into infrastructure planning and development have been highlighted in NAPs; with respect to infrastructure, this includes developing design criteria to protect assets in flood risk areas, such as protecting mangrove forests and prohibiting coastal sand and shell ridge removal. [Placeholder for further examples, including from agriculture and water resources sectors.]

3.5.1. Innovative approaches

75. [Placeholder for examples of innovative approaches to regulatory issues, including case studies if applicable]

3.5.2. Good practices, gaps, needs, and challenges

76. [Placeholder for discussion of gaps, needs, challenges, and good practices related to regulatory issues]

77. An enabling policy environment more generally can support the creation and adoption of adaptation technologies. This includes both supply-side policies – which help boost the development and availability of new technologies - and demand-side policies – which help create a market pull for technological and other climate innovations. On the supply-side, governments can use policy tools to bolster research and development of adaptation technologies, including direct funding of the research and development process through loans and grants or tax credits and other fiscal incentives (OECD, World Bank, and UN Environment, 2018). Public research specifically can play a role in not only stimulating the creation of new technologies, but also investigating how to deliver systemic innovations by also investigating related socioeconomic and political factors that may influence, for example, behaviours underlying the acceptance and adoption of new technologies. For more on systemic innovation, see section 3.6 below.

3.6. Innovative technologies and approaches

78. Innovation can be defined as "the process by which new ideas are developed to respond to societal, environmental, and economic needs" (UNFCCC, 2018). Although many adaptation measures can be implemented with existing technologies and management practices, technologies can nonetheless "expand the range of adaptation possibilities"(Mimura et al., 2014). Indeed, the Paris Agreement states that "[a]ccelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development."[39] Innovation can thus play an important role in meeting the adaptation-related goals of the Paris Agreement and achieving the Sustainable Development goals, given that the new products, services, businesses, behavioural change, and organizational models generated through innovation can scale and speed up climate action (UNFCCC, 2018).

79. Frontier technologies – that is, technologies that are new, cutting-edge, innovative, and often disruptive – have significant potential to address climate change and help tackle other environmental challenges (ITU et al., 2020). These technologies continue to proliferate, and include artificial intelligence, digitalization and big data, 5G, the Internet of Things, and more. While these technologies may be a "double-edged sword" that sometimes "bring unintended consequence to the detriment of the environment and societies" (ITU et al., 2020), it is nonetheless worth exploring the potential application of these technologies

[39] Article10, para. 5 of the Paris Agreement.

to enhancing adaptive capacity, building resilience, and reducing vulnerability to the impacts of climate change. Indeed, technology choices and systems generally can both reduce and exacerbate climate risks depending on the timeframe and other circumstances (Mimura et al., 2014), and frontier technologies are no different in that respect.

80. Artificial intelligence, or AI, is a growing field “which combines computer science and robust datasets, to enable problem-solving” (IBM Cloud Education, 2020). Among its sub-fields are machine learning and deep learning, in which AI algorithms are used to build expert systems capable of making predictions or classifications based on data. Under the UN system, there are existing efforts to apply AI to reduce hydrological risk. For example, UNESCO’s International Hydrological Programme, in partnership with the Center for Hydrometeorology and Remote Sensing at the University of California, Irvine, developed the G-WADI PERSIANN-CCS[40] Geoserver, which uses remote sensing technologies in combination with AI to estimate real-time precipitation (ITU et al., 2020). It does so by using an adaptive neural network algorithm that combines information drawn from various satellites, with a cloud classification system algorithm that is optimized for observing extreme precipitation.[41] This tool helps inform emergency management and planning for droughts, floods, and other hydrological risks around the world. In Namibia, for example, the Namibian Drought Hydrological Services prepares daily bulletins for local communities containing up-to-date information on flood and drought conditions.

81. There are also private sector enterprises that are beginning to offer related services. For example, the company One Concern combines AI/machine learning with human-centric disaster science through probabilistic models that generate dynamic predictions. These predictions facilitate disaster preparedness, response, and mitigation.[42] The company is aiming to create “the world’s digital twin” by building a digital architecture mirroring the natural and built environments and the complex systems in which they’re embedded.[43] The models use data from various sources, including open source providers, private providers, and the individual clients that the company works with; the models learn, evolve, and scale as more data is fed into them. Their tools can, for example, generate block-by-block level impact predictions for specific events, which help to assess the likelihood of damage in multiple disaster scenarios. This, in turn, allows for improved identification of shelters and assessment of shelter locations post-disaster.

82. Cervest, another company, provides asset-level analysis that helps clients to anticipate and act on climate risks by combining machine learning, climate science, and scalable computing.[44] The company’s services are powered by earth science AI technologies, which fuse real-time data from global sensors with historic data and forecasts to shed light onto the past, present, and future. These services are suitable for various clients, including businesses, insurance companies, and governments.

83. These companies represent only two examples of a growing fields of start-ups that offer what they term climate intelligence services or resilience-as-a-service; their tools, which integrate frontier technologies, can be applied to advance adaptation action across a range of sectors and locations.

84. In the agriculture sector specifically, the practice of precision agriculture is also being advanced by AI technologies, and by start-ups providing related services. Precision agriculture, in contrast to conventional agricultural management, entails “the application of modern information technologies to provide, process, and analyse multisource data of high spatial and temporal resolution for decision making and operations in the management of crop production” (National Research Council, 1997). By using AI in the agriculture sector, farmers are able to improve their crop yields using fewer inputs, such as seeds, water, pesticides, and herbicides, as well as fewer emissions; such data-driven management can help grow more with less, and contribute to overcoming some of the challenges to the sector posed by climate change and population growth (Linaza et al., 2021). Despite this potential, the adoption of these technologies is not currently widespread due to lack of knowledge, among other factors. Indeed, the underlying algorithms can often

[40] The abbreviation stands for Global Network on Water and Development Information for Arid Lands (G-WADI) Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks - Cloud Classification System (PERSIANN-CCS).
[41] See https://gwadi.org/persiann-family-precipitation-estimation-products
[42] See https://oneconcern.com/en/platform/
[43] See https://oneconcern.com/en/technology/
[44] See https://cervest.earth/

"look like black box systems for farmers," and their results can be difficult to understand (Linaza et al., 2021). In response, various start-ups are now providing AI-powered precision agriculture tools and insights tailored to farmers. Examples include Prospera,[45] which uses AI and machine learning to help farmers optimize factors from fertilization to pollination, and Ceres,[46] which focuses on irrigation, helping to detect problems like clogs and leaks, quantify various issues and their potential impact on yields, and improve systems by correcting overwatering and underwatering and optimizing system design and scheduling to terrain and soil conditions. What's more, these firms strive to present the information in ways that enable decision-making by farmers; for example, Ceres' services are designed to integrate with existing farm management software. While these new ventures and technological applications show great promise, it will be important to consider how these products and services can be distributed to the people and places who stand to gain in order to fully realize their potential. Notably in the agriculture sector, this includes smallholder farmers, who often "lack access to inputs, technical advice, credit and other financial services" and therefore "are unable to access technologies that improve the resilience of crop systems to specific climate stressors and reduce yield gaps" (FAO, 2021).

85. Innovation is not limited to the development and deployment of new and disruptive "hard" technologies, but also encompasses changes in institutions and organizations, as well as new business models and services (OECD, World Bank, and UN Environment, 2018). Beyond innovations in individual technologies, systemic innovations are increasingly recognized as integral to addressing the challenge of climate change (EIT Climate-KIC, 2020). EIT Climate-KIC, a knowledge and innovation community (KIC) supported by the European Institute of Innovation and Technology, aims to catalyse such innovation through "deep demonstrations." These demonstrations are large-scale projects through which bespoke innovation portfolios are developed in order to catalyse systems change. Many of these deep demonstrations aim at facilitating mitigation and adaptation in the agriculture and land-use sector. For example, the "Friendly Fruit" project is aiming to transform agricultural practices in strawberry and apple cultivation through innovations "such as pest-resistant and high-performing fruit varieties better adapted to weather changes, mechanical weeding systems intended to decrease herbicide use, and subsoil smart-sensors which monitor water levels." The project seeks to systematise sustainable agricultural practices and strengthen agricultural supply chains facing challenges ranging from early and erratic crop flowering and lower fruit quality to new diseases and water supply issues. Another initiative – EIT Climate-KIC's Carbon Farming project – is deploying a systemic approach to increase soil carbon sequestration (SCS), a nature-based solution that offers both mitigation and adaptation benefits. On the adaptation side, the storage of carbon in the soil increases its organic matter, leading to increased water retention capacity and fertility, which in turn help crops better adjust to drought conditions. The project currently has components in France, Switzerland, the Netherlands, and Sweden.[47] For example, in France, corn farmers are being encouraged to grow cover crops like clover, which are grown primarily for the benefit of the soil and help suppress weeds, enhance fertility and quality, reduce erosion, promote biodiversity, and discourage pests and diseases. In addition to benefits such as improved yields and lower input costs from pesticide and fertilizer, farmers are also incentivized by a carbon premium of approximately €75 per tonne of carbon permanently fixed in the soil. Remote sensing technologies are also being deployed through the project to provide a simple evaluation of the SCS.

86. One important component of orgware that can support technological innovation is the national system of innovation, which encompasses the organizations, systems, and incentives in a given country that stimulate technology generation and adaptation (Nelson, 1993). Indeed, the importance of these systems – in particular for the water and agriculture sectors - has been recognized in some Parties' NAPs, wherein some prioritize supporting and establishing systems of innovation to promote adaptation technology and development transfer. The national system of innovation, in turn, is the foundation on which a country's entrepreneurial ecosystem rests; entrepreneurial ecosystems refer to "sets of actors, institutions, social networks, and cultural values that produce and sustain entrepreneurial activity" (Roundy, Bradshaw, and Brockman, 2018). Entrepreneurial ecosystems are important in supporting the various stages of technology development and entrepreneurship and the different actors that participate in entrepreneurial activities, including start-ups who develop new climate technologies and existing enterprises "who adopt and adapt

[45] See https://www.prospera.ag/main
[46] See https://www.ceresimaging.net/
[47] See https://www.climate-kic.org/innovation-spotlight/carbon-farming-is-innovating-land-use/

climate technologies" (UNFCCC, 2018). Incubators and accelerators are increasingly important parts of these ecosystems that provide support to start-ups and can, in turn, help catalyse technology entrepreneurship for adaptation. The term "incubator" encapsulates a range of institutions and environments that support start-ups through services such as physical locations; business, marketing, information and technical services; financial support, and networking. Accelerators, by contrast, are institutions that provide short-term services such as mentoring, peer review, and skills transfer with the aim of speeding up the successful creation of ventures, generally seeking a shareholding percentage in return. There have been doubts raised about the capacity for accelerators to facilitate climate-related technology entrepreneurship – given, for example, the short time periods which are well suited to digital technologies but may be insufficient for hardware related start-ups, such as those producing drip irrigation systems (Racine, 2017), and that there are sometimes uncertain paths to commercialization in the climate technology space (Malek, Maine, and McCarthy, 2014) – but there are existing attempts to adapt the accelerator model to better serve climate entrepreneurship, including the World Bank's infoDev programme (UNFCCC, 2018).

87. It is estimated that about 70 incubators and accelerators worldwide – under two per cent of the total - focus on climate technology, with the majority of these located in Europe and North America (UNFCCC, 2018). Many of these focus on mitigation technologies, though there are examples of incubators and accelerators supporting the development of adaptation technologies, including in the agriculture and water sectors. For example, the United Nations Development Organization global cleantech innovation programme has supported the development of Tarla.io Risk, a one-click service climate risk information service for farmers, by Turkish entrepreneurs. It helps farmers boost their yield and resulting profits by offering hyperlocal statistics and insights that enable climate-informed crop planting. Another example is the Kenya Climate Innovation Centre, which supports adaptation technology development especially in the agriculture and water sectors. It supported, for example, SwissQuest Water Supplies, a venture offering smart water metering solutions that increase water use efficiency through prepaid water meters equipped with water valve control functions and radio communication. Other adaptation technologies supported by the Centre in the water sector include filters, purifiers, and desalination units, while those supported in the agriculture sector relate to irrigation, fertilizers, land management, and more.

88. While it is thus important to set up the conditions to encourage and support innovation domestically, it is also critical to ensure that adaptation innovations in the agriculture, water resources, and coastal zone sectors and beyond are made widely available. Considering that "no single government has all the technological, scientific, financial and other resources needed" to adapt to climate change and more broadly address the climate crisis, "it is important that strong national policies for innovation are accompanied by effective international cooperation in the development and diffusion of innovations" (OECD, World Bank, and UN Environment, 2018). Developing and least developed countries in particular should be supported in both accessing innovative technologies for adaptation and bolstering their capacity to generate such innovations domestically.

3.7. Additional good practices, gaps, needs, and challenges

89. While there is evidently widespread demand for adaptation technologies in the agriculture, water resources, and coastal zones sectors, there are enduring challenges, gaps, and needs that stand in the way of ensuring that current and future technologies fulfil their potential in driving forward adaptation action. According to the *Fourth synthesis of technology needs*, almost all Parties included in the analysis reported barriers to the development and transfer of prioritized adaptation technologies in the following areas: economic and financial (including lack of or inadequate access to financial resources as one of the main barriers); policy, legal and regulatory (including insufficient legal and regulatory frameworks as one of the main barriers); institutional and organizational capacity; and human skills.[48] It is no surprise, then, that the most commonly cited enabler of prioritized adaptation technologies was increasing the financial resources available for adaptation technologies; this could be achieved by, for example, introducing or increasing the allocation for such technologies in national budgets or identifying and creating financial schemes, funds, mechanisms or policies.[49]

[48] FCCC/SBI/2020/INF.1, para. 13.
[49] FCCC/SBI/2020/INF.1, para. 15.

90. There are also barriers specific to innovation that emerging and developing economies may face. This includes:

a) the fact that markets may undersupply innovation when firms do not capture all the benefits arising from their innovations,

b) that the demand or innovation may be tempered where households or firms do not have to pay for environmental costs or services,

c) information asymmetries – potentially exacerbated by uncertain future policies – can limit financing by new market participants of ambitious or radical innovations; and

d) trade barriers and low country capacity to adopt, adapt, and deploy new technologies can undermine the spread of new climate technologies internationally (OECD, World Bank, and UN Environment, 2018).

91. Further, there are various roadblocks in the process of transitioning from the research and development of adaptation technologies to their commercialization, including "poor understanding of adaptation markets, weak policy frameworks, and few suitable financial mechanisms that are able to effectively blend public and private finance, reduce investment risk and shorten the time needed for a return on investment" (UNFCCC, 2019). Challenges in the commercialization of adaptation technologies also inevitably affect the availability and upscaling of these technologies. The TNA process continues to be an important avenue for countries' seeking to identify and meet their climate technology needs and overcome the associated challenges. Indeed, an important first step towards commercializing adaptation technologies is ensuring that TNAs and their associated technology action plans are completed and up-to-date. As part of the TNA process, countries identify barriers to the deployment and diffusion of prioritized technologies in the national context, as well as measures to overcome these barriers.[50] The process culminates in a technology action plan, which outlines specific actions and associated enabling activities, thereby paving the way for various actors to work towards implementation of the prioritized technologies. More broadly, in addition to the TNA process, measures to develop legal, regulatory, and policy frameworks conducive to adaptation technology commercialization, as well as building partnerships with relevant industry associations, can also accelerate adaptation technology commercialization and deployment (UNFCCC, 2019).

92. [Paragraph(s) on general good practices and opportunities]

4. Conclusion and next steps

93. Technologies are a critical component of adapting to climate change. Adaptation technologies are in especially high demand in the agriculture and water sectors, as well as in coastal zones. This is evidenced by the variety and prevalence of priorities and needs for adaptation technologies in these areas, as documented in TNAs, NAPs, NDCs, and ADCOMs, as well as the continual pursuit of implementing these technologies around the world. While most Parties prioritize longstanding adaptation technologies in these sectors, there are increasingly innovative technologies and approaches that may offer new adaptation solutions and improve upon the related processes and institutions. Adaptation technologies are not, however, a panacea, and they must be embedded in comprehensive and iterative adaptation processes, and implemented alongside ambitious greenhouse gas mitigation, in order to mount an effective response to the climate crisis.

94. At AC20, the AC may wish to:

a) Provide its feedback on this first, work-in-progress draft of the technical paper;

b) Engage with the TEC, CTCN and NAP Task Force to refine and finalize the paper ahead of AC21; and

c) Consider how to reflect any potential follow-up work in the draft 2022-2024 workplan.

[50] See https://www.ctc-n.org/technologies/technology-needs-assessments

References

Adaptation Committee. 2019. *25 Years of Adaptation under the UNFCCC: Report by the Adaptation Committee*. Bonn: UNFCCC. Available at https://unfccc.int/documents/204710.

Christiansen L, Olhoff A and Trærup S. 2011. *Technologies for adaptation: Perspectives and practical experiences*. Roskilde, Denmark: UNEP Risø Centre.

EIT Climate-KIC. 2020. *Innovations in land use*. EIT Climate-KIC. Available at https://www.climate-kic.org/wp-content/uploads/2020/08/Land-Case-Studies-Full-Booklet-v9.pdf.

FAO. 2021. *Climate smart agriculture case studies 2021: Projects from around the world*. Rome: FAO. Available at http://www.fao.org/3/cb5359en/cb5359en.pdf.

FAO. 2016. *The State of Food and Agriculture: climate Change, Agriculture and Food Security*. Rome: FAO.

IBM Cloud Education. 2020. *What is Artificial Intelligence (AI)?* Available at https://www.ibm.com/cloud/learn/what-is-artificial-intelligence.

IPCC. 2018. Annex I: Glossary. *In*: JBR Mattews, V Masson-Delmotte, P Zhai, et al. (eds.). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate povert*. Geneva: IPCC. Available at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_AnnexI_Glossary.pdf.

IPCC. 2000. *Methodological and Technological Issues in Technology Transfer*. B Metz, OR Davidson, J-W

Martens, et al. (eds.). Cambridge: Cambridge University Press.

IPCC. 2014. Summary for Policymakers. *In*: CB Field, VR Barros, DJ Dokken, et al. (eds.). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/ar5/wg2/.

ITU, UNECE, UNESCO, et al. 2020. *Frontier Technologies to Protect the Environment and Tackle Climate Change*. ITU. Available at https://www.itu.int/en/action/environment-and-climate-change/Documents/frontier-technologies-to-protect-the-environment-and-tackle-climate-change.pdf.

Khor M. 2012. *Climate Change, Technology and Intellectual Property Rights: Context and Recent Negotiations*. South Centre Research Papers 45. Geneva: South Centre.

LEG. 2012. *National adaptation plans: technical guidelines for the national adaptation plan process*. Bonn: UNFCCC. Available at https://www4.unfccc.int/sites/NAPC/Guidelines/Pages/Technical-guidelines.aspx.

Linaza MT, Posada J, Bund J, et al. 2021. Artificial Intelligence Applications for Sustainable Agriculture. *Agronomy*. 11(1227): .

Malek K, Maine E and McCarthy IP. 2014. A Typology of Clean Technology Commercialization Accelerators. *Journal of Engineering and Technology Management*. 32: .

Mimura N, R.S. P, D.M. D, et al. 2014. 2014: Adaptation planning and implementation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. *IPCC*. : pp.869–898. Available at https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap15_FINAL.pdf.

Nachmany M, Byrnes R and Surminski S. 2019. *National laws and policies on climate change adaptation: a global review*. Granthan Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy. Available at https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2019/12/National-laws-and-policies-on-climate-change-adaptation_A-global-review.pdf.

National Research Council. 1997. *Precision Agriculture in the 21st Century: Geospatial and Information Technologies in Crop Management*. Washington, D.C.: The National Academies Press.

Nelson RR. 1993. *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.

OECD, World Bank and UN Environment. 2018. *Financing Climate Futures: Rethinking Infrastructure*. OECD. Available at https://www.oecd-ilibrary.org/docserver/9789264308114-en.pdf?expires=1629122787&id=id&accname=guest&checksum=DEBC5E9279D5CC93437EBCCBFF4E9F58.

Racine J-L. 2017. Why Startup Accelerators Won't Create the Global Climate Technology Revolution. NextBillion Available at https://nextbillion.net/why-startup-accelerators-wont-create-the-global-climate-technology-revolution/.

Roundy PT, Bradshaw M and Brockman BK. 2018. The emergence of entrepreneurial ecosystems: A complex adaptive systems approach. *Journal of Business Research*. 86: pp.1–10.

TEC. 2019. *Draft paper on experiences, lessons learned and good practices in conducting TNAs and implementing their results*. Bonn: UNFCCC. Available at https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/tn_meetings/9c6eeaa690534874bbcbb85bada9882c/b566fb9540cd4932b5503a0518d2af94.pdf.

TEC. 2020. *Innovative Approaches to Accelerating and Scaling up Climate Technology Implementation for Mitigation and Adaptation*. Bonn: UNFCCC. Available at https://unfccc.int/ttclear/tec/innovativeapproaches.

TEC. 2014a. *Technologies for Adaptation in the Agriculture Sector*. Bonn: UNFCCC.

TEC. 2014b. *Technologies for adaptation in the water sector*. Bonn: UNFCCC. Available at https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_column_L/0cac6640a3b945c08e7a54f8e496223e/55e192e14cd6495f975f4098843baf7e.pdf.

UN Water and UNESCO. 2021. *The United Nations World Water Development Report 2021: Valuing Water*. UNESCO. Available at https://unesdoc.unesco.org/in/documentViewer.xhtml?v=2.1.196&id=p::usmarcdef_0000375724&file=/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_db06f7c4-b33f-4833-be56-bbf54afdee3f%3F_%3D375724eng.pdf&locale=en&multi=true&ark=/ark:/48223/pf0000375724/PDF/375724eng.pdf#WWDR%202021%20EN%20report.indd%3A.56356%3A2357.

UNCTAD. 2007. *The Least Developed Countries Report 2007*. Geneva: UNCTAD. Available at https://unctad.org/system/files/official-document/ldc2007_en.pdf.

UNDP. 2010. *Handbook for Conducting Technology Needs Assessment for Climate Change*. New York: UNDP. Available at https://unfccc.int/sites/default/files/1529e639caec4b53a4945ce009921053.pdf.

UNEP. 2021. *Adaptation Gap Report 2020*. Nairobi: UNEP. Available at http://www.unenvironment.org/resources/adaptation-gap-report-2020.

UNFCCC. 2014. *Background Paper on Technologies for Adaptation: Background Paper for the UNFCCC Technology Executive Committee Workshop on Technologies for Adaptation*. Bonn: UNFCCC. Available at https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/events_workshops_adaptationtechs/f1b531ab99084107950d65c2c2de1d6d/d02425f42d614aa99c40fe39758b3ded.pdf.

UNFCCC. 2018. *Climate Technology Incubators and Accelerators*. Bonn: UNFCCC. Available at https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/climate_technology_incubators_and_accelerators.pdf.

UNFCCC. 2019. *Opportunities and oprtions for adaptation finance, including the private sector*. Bonn: UNFCCC. Available at http://tep-a.org/wp-content/uploads/2020/07/TEPA2019_TP_OpportunitiesandOptionsforAdaptationFinance.pdf.

UNFCCC. 2021. *Opportunities and options for enhancing adaptation action through education and training, and public and youth participation: Technical paper by the secretariat*. Bonn: UNFCCC. Available at http://tep-a.org/wp-content/uploads/2021/05/TEPA_2020_TP.pdf.

UNFCCC. 2006. *Technologies for adaptation to climate change*. Bonn: UNFCCC. Available at https://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf.

WIM Executive Committee and TEC. 2020. *Policy Brief: Technologies for Averting, Minimizing and Addressing Loss and Damage in Coastal Zones*. Bonn: UNFCCC. Available at https://unfccc.int/node/231688.

Document information

Version	*Date*	*Description*
Draft 01.0	2 September 2021	AC 20 The AC is invited to consider this work-in-progress draft technical paper, to provide guidance on completing the paper, continue engaging with the CTCN and the NAP Task Force when refining and finalizing the paper, and consider whether to include any follow-up activities in its new 2022-2024 flexible workplan.

Keywords: Adaptation technologies, agriculture, water resources, waste, coastal zones.