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Options for support for technology collaborative research and development

Summary

In response to decision B.14/2, this document presents: (1) key lessons to guide the support of the GCF on collaborative research and development (R&D); (2) a set of non-mutually exclusive options and modalities for supporting collaborative research, development and demonstration (RD&D) within the GCF business model, which are to be employed by national designated authorities and accredited entities when accessing GCF resources; and (3) elements that may serve as bases for concrete steps for the Fund to further support the matter. The draft decision contained in annex I encourages stakeholders to employ the options identified informed by key lessons and proposes the launch of a Request for Proposals (RFP) targeting strategic actors to foster innovation in support of collaborative R&D. For the purpose of this paper, the concept used is collaborative RD&D, consistent with its application by the relevant UNFCCC thematic body.

This paper is complemented by an addendum (GCF/B.18/12/Add.01) which provides additional information on the link between collaborative RD&D and climate technology and transfer. It also identifies trends in collaborative RD&D of climate technologies, financing instruments, and an analysis of the GCF investment criteria and its relationship with collaborative RD&D. Case studies are provided to help illustrate the options for support.

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I. Introduction

1. The Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC), by UNFCCC decision 7/CP.20 (GCF B.14/02), requested that the Board of the GCF is consistent with paragraph 38 of the Governing Instrument for the GCF, which states “The Board shall also ensure adequate resources for capacity-building and technology development and transfer. The GCF will also provide resources for innovative and replicable approaches”.
2. By UNFCCC decision 7/CP.21, the COP invited the Board of the GCF to consider ways to provide support, pursuant to the modalities of the GCF, for facilitating access to environmentally sound technologies in developing country Parties, and for undertaking collaborative research and development for enabling developing country Parties to enhance their mitigation and adaptation action.
3. This paper identifies concrete options on how the GCF can support collaborative research and development (R&D) in developing countries, in line with the operational modalities of the GCF, taking into account decisions B.13/11 and B.13/12, and in the context of the operational framework for complementarity and coherence with climate finance delivery channels. It is complemented by an addendum paper (GCF/B.18/12/Add.01) which provides further analysis to support the options presented, summarizing current trends in collaborative research, development and demonstration (RD&D) and how this might support climate technology development and transfer to developing countries. It then sets out key lessons that must guide the interventions of the GCF in this field, before providing detail on two different approaches through which the GCF can support collaborative RD&D and the related financing mechanisms. For the purpose of this paper, the concept used is collaborative RD&D, consistent with its application by the relevant UNFCCC thematic body.
4. Collaborative RD&D is used in the UNFCCC process as a possible means through which climate technology development and transfer to developing countries might be achieved in order to improve low-carbon and climate-resilient development. It sits within the broader context under the Convention’s commitments to increase flows and availability of climate technologies for mitigation and adaptation in developing countries. Collaborative RD&D is explicitly recognized in the Paris Agreement in relation to the technology framework: “Other areas may be explored as possible key themes, including, but not limited to: Accelerating, encouraging and enabling innovation, collaborative approaches to research, development and demonstration, and the provision of support” (FCCC/SBSTA/2016/L.8).
5. This paper builds upon the work of the Technology Mechanism of the Convention, particularly recent work by the TEC, including on collaborative RD&D and innovation, and CTCN, including on supporting “first-of-kind” climate technology.

II. Key lessons for GCF options to support collaborative RD&D

6. The analysis contained in the addendum to this document indicates the limited empirical data available to verify assumptions about the relationship between collaborative RD&D and climate technology development and transfer to developing countries. Given the importance of collaborative RD&D in the context of catalysing the development and commercialization of climate change technologies, a better understanding of the gaps and opportunities on this front is needed (TEC, 2017).¹ However, the understanding and knowledge

¹ For a full list of references, see addendum document GCF/B.18/12/Add.01, annex III.

of broader processes of innovation and how they relate to technological change and development in various developing country contexts is well developed.

7. The extensive literature on innovation and technological change in developing countries, a significant emerging part of which deals directly with the context of climate technologies, is directly relevant to informing actions under the Convention, including the funding strategies of the GCF. From this literature, two important lessons can be identified to guide the overarching approach of the GCF to funding collaborative RD&D for climate technology development and transfer. The lessons are explicitly recognized in the recent TEC report (TEC, 2017) and in several other reports/papers on the subject, including the original report on collaborative RD&D adopted under the Convention (FCCC/SBSTA/2010/INF.11). Both lessons fit directly with the investment framework of the GCF and are carefully designed to ensure options for GCF support for collaborative RD&D to maximize opportunities for delivering across all of its investment criteria. The fit between these core lessons and the GCF investment framework is illustrated in table 1 in the addendum.

2.1 Lesson: Aim to contribute to building innovation systems

8. The importance of the systemic nature of innovation and technological change is noted by the recent TEC report on collaborative RD&D (TEC, 2017):

“... innovation is a systemic process in which a range of interacting actors and resources together underpin successful technology development and deployment. Thus, effective technological change requires paying attention to all components and key functions of this system.”

9. Innovation systems (also sometimes referred to as “innovation ecosystems”) refer to the context within which all processes of technology development, transfer and uptake occur. They consist of the network of actors (e.g. firms, universities, research institutes, government departments, NGOs, technology users) within which innovation occurs, and the strength and nature of the relationships between them. The higher the capacities of these actors, and the stronger the relationships between them, the more productive any given economic sector in any given country will be (TEC, 2015).

National Innovation System Infrastructure: agencies and linkages

Source: Based on Sharif (no date)

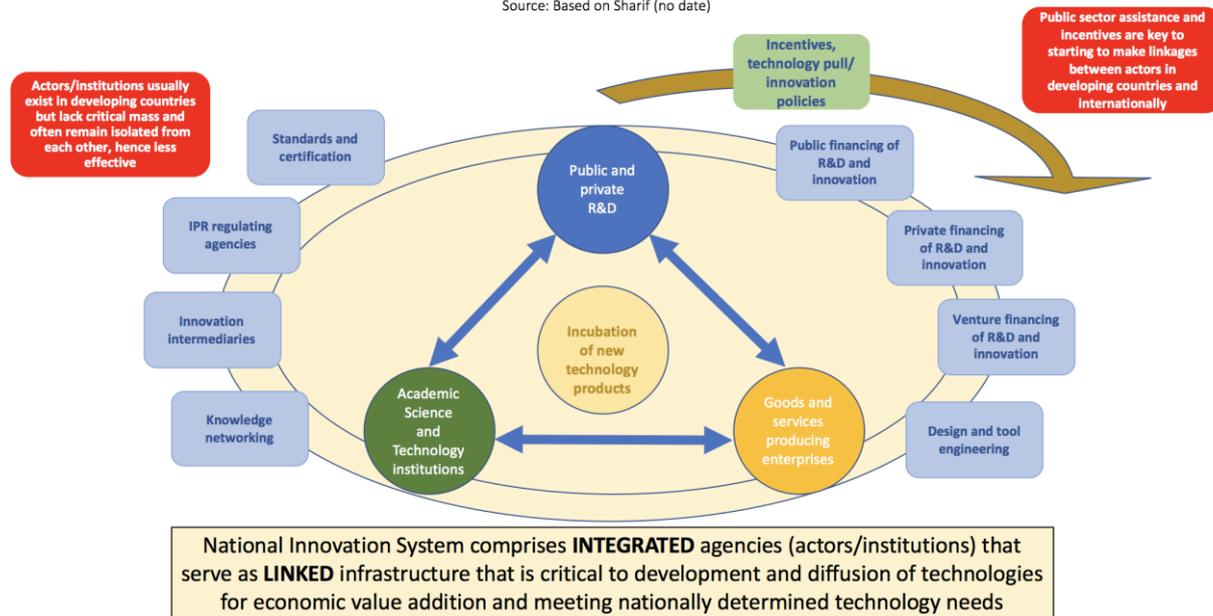


Figure 1: Components of an innovation system with reflections on developing country contexts

10. There is significant empirical evidence to support the relevance of strong innovation systems to the diffusion of new technologies. An innovation systems perspective has been used, for example, to explain China’s success in multiple low-carbon sectors (Watson et al., 2015) and Kenya’s success in developing the largest per capita market for solar PV globally (Ockwell and Byrne, 2016b).

11. The recent TEC paper on collaborative RD&D (TEC, 2017), recognizes the importance that “enhancing RD&D goes beyond RD&D financing” and asserts the centrality of building innovation systems. It is only through such a systemic perspective that funding for collaborative RD&D can have a broader, more sustained and potentially transformational impact on climate technology development, and ultimately on low-carbon and climate-resilient development. This requires a focus on the **processes** involved in innovation as opposed to the **outcomes** of innovation (e.g. a new RD&D collaboration or a resulting new technology). In turn, this highlights the critical role of innovation-enabling intermediaries who connect innovation system components and actors, as well as strengthen and accelerate innovation processes. Importantly, the innovation system literature, including recent work that translates its relevance for climate technologies (Ockwell and Byrne, 2016a)², emphasizes the critical role of “intermediaries”. These are actors that connect appropriate actors in any specific context and provide forums for nurturing and strengthening these linkages – hence strengthening the climate-relevant parts of any given innovation system. This insight is strongly supported by empirical evidence garnered by actors deeply involved in the development and scaling of new climate technologies (see Shell Foundation, World Bank’s Climate Technology Program, IFC and others).

12. When creating and supporting intermediary organizations, the entire length of the innovation chain should be considered, from collaborative R&D to demonstration, through to commercialization. To some extent, organizations such as the World Bank Climate Innovation Centers (CICs) play this kind of intermediary role. However, they tend to focus on the latter

² See also <https://steps-centre.org/blog/cribs/> for less technical coverage.

stages of the innovation cycle and on readying a limited number of start-ups seeking seed investment. Recent policy proposals for Climate Relevant Innovation-system Builders (CRIBs) have gone beyond the scope of the CICs and focused on building the full spectrum of climate innovation systems in different country contexts.

2.2 Lesson: Understand and respond to context-specific conditions and needs

13. A second key principle that will impact the effectiveness of funding for collaborative RD&D is recognizing there can be no “one policy fits all” approach. Climate technologies and climate technology needs, and the contexts within which they operate, vary enormously. Funding demands a diversified approach that can respond to and tailor responses to the very different local/national capacities, infrastructure, social, cultural and market contexts that define the conditions under which climate technologies are developed, transferred and adopted.

14. CRIBs or similar intermediary-type organizations would understand the need to build on existing national collaborative RD&D and innovation systems through new collaborations. Such organizations play a critical role in understanding context-specific climate technology needs, knowing which actors exist in any given context and connecting appropriate actors, as well as brokering international collaborations. But they should also focus efforts where innovation systems need to be built or strengthened as collaborative RD&D would not lead to scaled-up technology deployment unless the appropriate parts of the national innovation system are present and strong enough. This again emphasizes that collaborative RD&D should not be considered as a stand-alone activity, unconnected from users, markets and deployment.

15. It is also important to recognize that, increasingly, different processes for innovation and technology development are being adopted across many developing country contexts. “Grassroots innovation”, “indigenous innovation” and “inclusive innovation” may be of particular relevance in some sectors, including agriculture and clean water, and in low-income country contexts with less-obvious commercial markets at present levels of economic development. Various donor- and NGO-led initiatives are beginning to recognize and support such innovation (e.g. the approach of the Global Research Alliance to inclusive innovation). And there are increasingly more examples of innovation happening in unconventional ways, which have not been developed in universities or in the private sector (Mallett, 2015, p.298).

16. Kenya’s dairy sector is an excellent example of effective innovation in climate change adaptation. The sector’s institutional, knowledge and collaborative developments enabled the successful development and diffusion of various technological innovations. The key that unlocked innovation in the Kenyan dairy sector (in contrast to the declining coffee sector) was the cohesive interactions and knowledge-sharing between multiple community, private, and national and international public agencies (Asayehegn, 2017). This insight is afforded to us by the innovation system approach. Operationally, this requires understanding existing structures (and the extent to which they enable successful innovation) and a concerted effort to improve interactions, coordination and cooperation between the relevant actors and system components.

2.3 Lesson: Linking collaborative RD&D support and gender

17. Women form the majority of the world’s poor and are disproportionately impacted by climate change. Evidence shows that women’s involvement significantly increases the likelihood of success for climate technology and broader economic development interventions, including those focused on collaborative RD&D (OECD, 2008; World Bank, 2006). The Paris Agreement

explicitly recognizes the importance of gender equality and the development of gender-sensitive climate policies.³ Schalatek and Nakhooda (2015, p.4) highlight several considerations that help guide the GCF in funding collaborative RD&D. These are:

- Gender-responsive funding guidelines and allocation criteria for all collaborative RD&D projects funded through the GCF.
- Mandatory gender analysis of proposed projects, a gender budget, and quantitative and qualitative indicators measuring how projects contribute to gender-equality objectives, as well as the systematic collection of sex-disaggregated data.
- Regular audits of the gender impacts of funding allocations to ensure gender-responsive delivery across different scales and geographical foci of activities.
- A robust set of gender guidelines and capacity-building support for their implementation that guarantees gender equality, women's rights and women's full participation in collaborative RD&D activities.
- Independent evaluation and recourse mechanisms that are easily accessible to groups and individuals, including women, affected by climate change funding in recipient countries to allow them to voice their grievances and seek compensation and restitution.

2.4 Lesson: Recognize the role of different actors and sectors in collaborative RD&D

18. Generally, collaborative RD&D of new technologies relies more heavily on public than private funds as this is where the risk is highest and commercial viability is the most uncertain and remote. Private sector firms generally fund less-risky collaborative RD&D to improve the performance, reduce the costs of existing products, or build on the results of publicly funded, early-stage efforts. Yet it is the more prosaic and incremental collaborative RD&D that helps technology to improve its performance, adapt to new conditions and reduce costs, which, in turn, enables the large-scale deployment of commercial renewable technologies, for example (IRENA, 2015).

19. Nonetheless, companies engage in different forms of collaborative RD&D, contingent on the type of company, the available incentives and funding, and the demand (or anticipated demand) for new technologies. For instance, there is emerging evidence that an expanded set of early-stage capital providers (seed and venture funding provided by angel investors, venture capitalists, corporate ventures and corporations) are beginning to fund early stage energy demand and control technologies, while it has become much harder for renewable energy and energy storage technologies to raise seed and early stage capital (Bumpus and Comello, 2017). Early stage investors are also investing in agriculture and food, energy efficiency and transportation, which by 2016, had attracted slightly over 80 per cent of the total seed investment value from cleantech-focused organizations and angel investors. More capital-intensive sectors, such as hydro and marine power, nuclear and wind, account for a mere 2 per cent of all investments. More information on trends and actors is available in GCF/B.18/12/Add.01

2.5 Lesson: Consider the application of diverse financing instruments

20. The characteristics of finance instruments for collaborative RD&D, and the types of innovations for which they are used, depend on the financing gap to be addressed, the features of the targeted technology, the type of innovating entity and the innovation process. The

³ See http://unfccc.int/gender_and_climate_change/items/9619.php.

characteristics of public finance instruments for collaborative RD&D and the types of innovations are summarized in table 1 of GCF/B.18/12/Add.01.

21. Two types of public collaborative RD&D financing need to be considered: direct financing of collaborative RD&D (i.e. of the technology development and innovation process itself) and indirect financing of the process – either through capacity-building and partnership and network support, or through broader innovation system support. Within the direct-financing modality, two options are available: funding public collaborative RD&D (i.e. of collaborative RD&D carried out by universities, research institutes and other public agencies) and subsidizing private collaborative RD&D. Both are widely applied. Public resources are more concentrated at basic collaborative RD&D and the early stages of technology development. While subsidies for private collaborative RD&D are usually allocated to applied collaborative RD&D, including the proto-typing and testing of new technologies, and close-to-market technologies.

22. Other options are also available applying **blended financing instruments**. There is a need for a new range of financing instruments that covers the continuum of pre-commercial technology development stages, including commercial-scale demonstration and the scaling of small companies serving new and challenging markets. New financing models include tiered capital structures and grant-based instruments that allow public and private investors to participate in the same funding vehicle, according to their ability to take on risk, with donors taking first-loss positions or providing convertible grants.

23. The experience of multilateral organizations with direct financing of collaborative RD&D of environmentally-sound technologies, although limited, can also inform the application of financing instruments for collaborative RD&D. As a result of the increasing importance of the role that cleantech start-ups and entrepreneurs play in developing and bringing new climate technologies to market, multi-lateral development banks and the Global Environment Facility (GEF) have begun to deploy seed and early stage equity financing of climate technologies. The International Finance Corporation and the Inter-American Development Bank, for example, are also investing equity in early stage companies, predominantly through venture capital (VC) funds, some of which also function as accelerators. Another type of approach is adopted in a GEF-funded World Bank project in Mexico that provides sub-grants to private sector enterprises for advanced clean energy technologies at a proof-of-concept stage of development (UNFCCC, 2016).

2.6 Build on existing initiatives and mindful of trends

24. Multiple initiatives are seeking to advance collaborative R&DD, targeting different sectors and actors, including international collaborations, (e.g. Mission Innovation), and collaborations across institutions, particularly public-private collaborations (e.g. the World Bank-funded Climate Innovation Centers). Support from the GCF for any collaborative R&DD must reflect such initiatives and trends to ensure complementarity and coherence. A number of trends in the financing and institutional support for the collaborative RD&D of climate and clean technologies can be discerned that have implications for developing a programme to support the collaborative RD&D of climate technologies. An examination of these trends helps to locate the support and financing of collaborative climate technology RD&D in a context of broader processes and developments, and to take these into consideration in the formulation of options. The addendum to this document contains an illustration of ongoing trends and a set of case studies to help understand the complex and dynamic landscape of technology research and development.

25. Capital-intensive, large-scale climate technologies demand different collaborative partnerships, capacity-building and financial instruments than, for example, bottom of-the-pyramid consumer products or community-scale technologies. Similarly, a country with a fledgling climate innovation system in a particular sector will require additional support than a country which has adequate innovation structures but is, for example, weak in the support and financing of climate technology start-ups and small- and medium-sized enterprises (SMEs). The scope and possible approaches for supporting the collaborative RD&D of different types of technologies and sectors at the two levels are elaborated in the case studies section of the addendum, with examples of existing partnerships and types of support provided.

III. Options and modalities for supporting collaborative RD&D within the GCF business model

26. Section II above provides a set of overarching lessons considered for the purpose of this paper and which should be taken into account when engaging in support for collaborative RD&D. The addendum paper also includes an analysis and illustration of how key lessons assist in delivering against GCF investment criteria. Upon considering the application of these lessons and GCF investment criteria, the Board may note that support for critical climate innovation system builders or enablers that connect technology, finance, users and policy actors and bridge knowledge gaps, can greatly accelerate the creation of innovation systems around climate technologies. The creation of innovation system encompasses very divergent groups of technologies and institutions scattered across various fields and areas of science.

27. Most countries already have in place elements of innovation systems on which they can build. By generating synergies between different actors, and bridging knowledge and finance gaps, an innovation system can be created that favours collaboration. Innovation centres and other intermediary innovation enablers, and their associated networks, are key to a transformative programme that can deliver both short- and long-term impacts. Their ability to serve as platforms for collaboration, provided they are suitably resourced and enabled to do so, make these innovation system builders ideally suited to support collaborative RD&D. Nonetheless, more-narrow and targeted collaborative RD&D activities should not be excluded. Provided adequate knowledge transfer occurs, technology partnerships can create a sound basis for further deployment. The adoption of an innovation-systems approach translates operationally in a programme that does not target just one system component (e.g. access to capital or the production of knowledge), but rather addresses critical gaps in innovation and commercialization processes in support of collaborative RD&D collaboration across institutional and geographical borders. It requires a mapping and analysis of the innovation system that is being supported, of its weaknesses and strengths, to identify opportunities to strengthen existing or create new enabling innovation structures and processes.

28. The importance of aligning technological and institutional innovation must be recognized. Whilst the trends section drew attention to the different institutions that are enabling innovation in capital-light and software-based technologies, and those that support the collaborative RD&D of hardware technologies, the same core idea of alignment applies in other sectors and technologies. In the water sector for example, where technology RD&D is capital intensive and large scale, successful innovation has been driven by national water agencies that cooperate intensively with technology suppliers, utilities, industrial users and investors.

29. Based on the literature and cases considered in this paper and addendum, broad categories of collaborative RD&D models can be distinguished and a basic decision tree, based on factors influencing collaborative RD&D models depicted in figure 2, can be used to guide

options for supporting the collaborative RD&D of different types of technologies and innovations.

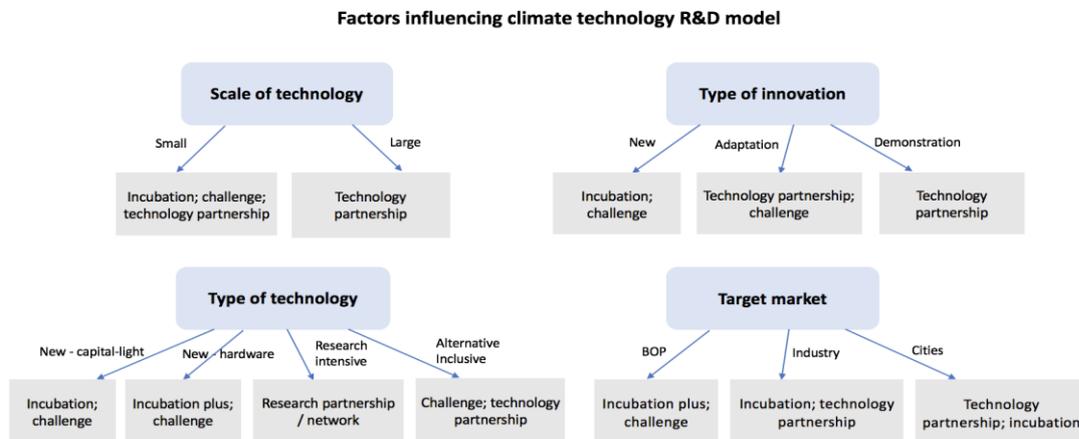
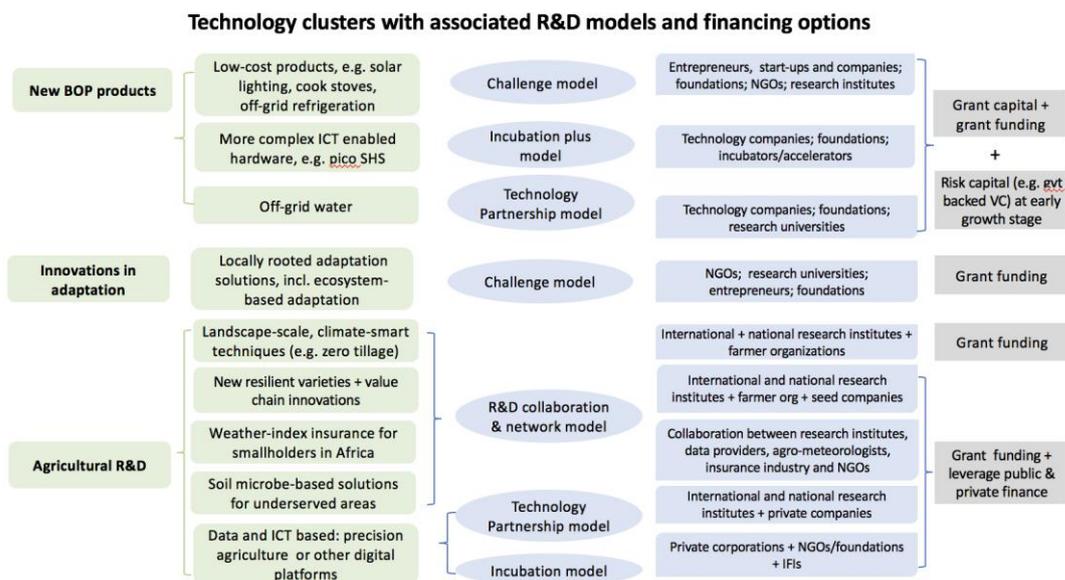


Figure 2: Collaborative R&D model decision tree

30. Furthermore, based on existing cases and practices, a list of clusters of climate technologies was compiled with corresponding options for collaborative RD&D models, partnership configuration and financing. The list is contained in figure 3.



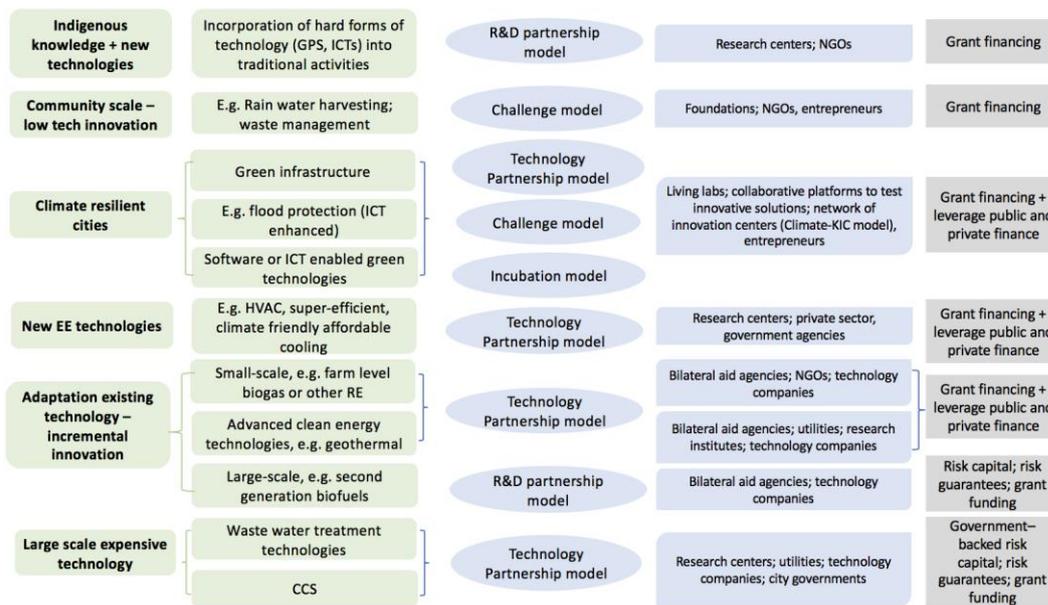


Figure 3: Clusters of climate technologies and associated RD&D models, partnership configurations and finance options.

31. Therefore, it is suggested that the GCF support for collaborative RD&D be structured around two approaches, to be considered within the modalities of the GCF and its financing instruments:

- (1) **Support directed at climate technology innovation systems** at the country, regional and global levels, with the view to facilitate and accelerate new forms of collaborative RD&D and innovation processes. A key component would be the strengthening and creation of intermediary innovation system builders. This approach would reach a range of public and private innovation actors, e.g. climate technology entrepreneurs, start-ups and SMEs, public innovation and research institutes, community organizations, utilities, local government, development actors and public and private investors.
- (2) **Targeted climate technology collaborative RD&D support with the goal of collaboratively developing, testing, demonstrating or adapting climate technologies for accelerating market penetration.** An array of such collaborative partnerships currently exists, with models seemingly contingent on the type of technology, the sector and institutional characteristics of the innovation system in which a technology is being developed.

32. Within these two approaches, the type of collaborative models and activities that could be supported, and the kind of financing instruments that would match the technology collaborative RD&D challenge and partnership configuration, will be primarily guided by the type of technology, its stage of development and deployment, the sector, and the innovation system within which the activities are taking place. Support from the GCF would need to be sensitive to these differences. The financing instruments section in the addendum provides detailed insights on which instruments match different types of collaborative technology RD&D processes. No systematic study of appropriate institutional configurations to support the collaborative RD&D of different climate technologies has been undertaken so far. The issue is under-researched and information is sparse. Moreover, in many cases, new value chain configurations are being pioneered in emerging climate innovation sectors, which in turn necessitate new forms of collaboration. The proposed activities are instead informed by lessons

offered by the innovation systems literature, insights rooted in experience with specific technologies, and selected illustrative examples in different sectors.

33. The distinction between the two approaches of support does not preclude blending targeted technology support with more systemic support for the innovation system around climate technologies. In fact, enhancing targeted technology development with strengthening innovation system components and processes would increase the likelihood of subsequent deployment. Support from the GCF to this subject could draw from the synergies between these two approaches and target specific actors who are capable of working within the different approaches.

3.1 Approach 1: Innovation system-level support

34. Two components could be considered under this approach:

- (1) Support for the creation and strengthening of intermediary innovation institutions and strengthening their ability to serve as platforms for collaborative RD&D.
- (2) Technology-pull policies.

3.1.1 Support for intermediaries

35. A key component of technology innovation systems that has gained prominence as a result of the growing role of entrepreneurs and start-ups in the collaborative RD&D and commercialization of cleantech and climate technologies is intermediaries, such as innovation hubs and centres, incubators and accelerators. Start-ups use these resources to realize their technology development and commercialization goals.

36. While the primary aim of these intermediaries is to foster a localized innovation system around climate technologies, they are also increasingly serving as platforms for regional and international collaboration in the commercialization process and facilitating market access. Incubators, accelerators and innovation centres have formed national and regional networks for coordination purposes. In turn, these networks are reaching out to relevant networks and consortia internationally. The cases of IubatEnergy Network and InnoEnergy, and the Climate-KIC are in annex II of the addendum to this document.

37. As outlined in the section on the role of the private sector, different types of intermediaries serve different purposes (section V, addendum I). What intermediaries have in common is that they facilitate a path towards technology validation and commercialization, and their ability to tap into their networks – such as local business leaders, industry, investor and donor communities, and the public sector and research communities, in support of entrepreneurs and start-ups.

38. Innovation intermediaries are much less common in developing countries, and even absent in the case of climate and clean technologies in a majority of countries. It is in the growing social impact sector where intermediaries have begun to emerge as a result of social impact funds' needs for investible companies, and while some in this sector focus on agricultural technologies, for example, they lack a climate focus. Nor are there any pure play cleantech VC funds in developing countries, except in a handful of countries where they are supported by the government.

3.1.2 Innovation pull policies

39. Technology-push policies, such as increasing funding for collaborative RD&D, are futile unless demand for climate technologies, and, therefore, an enabling environment, is created through technology-pull policies. Technology pull involves policies, market approaches to draw the private sector to climate technology markets (TEC, 2017). This may include: standards; regulations; consumer education, tenders for tranches of output; and strategic public procurement policies (TEC, 2017). Accelerating climate technology innovation requires a mix of policy and financing instruments and includes both technology ‘push’ and ‘pull’ actions (TEC, 2017). Furthermore, social and behavioral innovations are often key to unlocking the more widespread uptake of hard technologies.

3.2 Approach 2: Targeted climate technology support

40. While no systematic study of collaborative RD&D models in the field of climate change has been undertaken, the trends and role of the private sector sections provide some indication of the factors that influence collaborative RD&D models and partnership configurations. A collaborative RD&D model can be very different between sectors and vary by type and scale of technology, market and end-users. When considering supporting collaborative RD&D, it is important to consider whether this is better executed by private-sector firms, government, academia, non-profits or non-government organizations (IEA, 2012). Collaborative RD&D also presents options for bilateral, consortia, or network-based approaches (IEA, 2012).

41. A few factors that influence options for collaborative RD&D stand out, namely: scale (e.g. at small, large, medium, or community scale; whether an innovation is new or an adaptation of an existing technology to new conditions, or the development of a low-cost innovation based on existing technologies; whether it is a software or hardware based technology; scalability of the technology; target users, for example whether they are bottom-of-the-pyramid consumers, which implies a questionable return on collaborative RD&D investment, regular or commercial consumers, municipalities, utilities or farmers; or whether it involves extensive collaborative RD&D and field testing.

42. An additional factor is the vastly different cultural, economic and innovation context in which technologies are being developed and deployed. The nature and extent of RD&D support must be tailored to the capabilities of partners and the strengths and weaknesses of the innovation system. This also means that activities such as capacity-building, skills development, and coordination will be key ingredients in a collaborative RD&D programme.

3.2.3 Challenge, technical quest or needs based

43. In this model, competitive innovation funding is used whereby innovative solutions to predefined problems are induced through a challenge fund or innovation prize mechanism. These mechanisms can be used to drive technical innovation and social change and stimulate markets. They take advantage of the lessons of open innovation by opening up the resolution of the problem to all (Collings, 2015). Innovation prizes can stimulate the development and deployment of technologies and services for low-income consumers to improve their access to affordable clean energy, safe drinking water and/or resilience to climate change. Managing prizes and such competitions, however, is a time-consuming, resource-intensive process, which could be challenging for the Secretariat to handle.

44. The IFC used a challenge approach in 2008 in its Development Marketplace competition for innovative products or services tailored to Sub-Saharan Africa’s off-grid lighting market, which resulted in the selection of 16 companies for grant funding. A more recent initiative that

uses prizes is the UK Department for International Development's (DFID) Ideas to Impact programme, launched in 2014, with thematic leads on water, sanitation and hygiene, low-carbon energy, and climate adaptation. Examples of the types of technologies and innovations that have been supported include cook stoves, low-cost off-grid refrigeration and locally developed adaptation approaches.

45. While the use of prizes has become quite widespread in the USA and Europe, with governments and philanthropic foundations being major drivers, the deployment of incentive prizes in the field of international development has been limited but is growing since the 2015 Financing for Development Conference in Addis Ababa, Ethiopia (Collings, 2015; Di Bella and Minkley, 2017). At the conference, a call was launched for innovation in international development to achieve the Sustainable Development Goals. This has resulted in a proliferation of innovation in development programmes, including the use of challenge funds and innovation prizes.

46. Well-designed prizes not only promote diversity and creativity in tackling complex problems, but also encourage opportunities for collaboration, help support solutions rooted in particular contexts and put local actors in the lead, build communities of practice and raise the public profile of both the challenge and the winning innovations (Collings, 2015). A review on prizes by DFID concluded prizes work best in a context of parallel activities which support the innovation process such as policy reforms, grants and other funding and technical assistance, and recommended that prizes be developed within a wider programme of support (Collings, 2015).

47. Blurring the line between prizes and VC investment are VC-style grant competitions, organized by aid agencies such as USAID, which provide long-term capital to innovators and entrepreneurs (USAID, 2017). The GCF could consider supporting innovation prizes and challenge funds in the context of a broader programme of support for climate mitigation and adaptation.

3.2.4 Incubation model

48. The incubation model is extensively covered in the previous section on innovation system support as well as in the sections on trends and the role of the private sector. While the incubation of clean technology start-ups is widespread in developed countries, the model is in its infancy for climate technologies in developing countries and provides an opportunity for intervention by the GCF.

49. Two types of incubation models can be distinguished: (i) incubation of capital-light, quick-to-scale and profitable technologies; and (ii) the incubation of pioneering hardware technology start-ups, where technologies are slower to develop, test and scale, or have profit margins that are too low to commercially justify assigning significant levels of capital to collaborative RD&D (Shell Foundation, 2014). The first require minimal grant support, while the second need substantial capital grant financing. The second model is therefore called Incubation Plus, to designate the additional grant support and development time needed for technologies that fall under this category.

50. The incubation model also allows for collaborative ventures. An example is Factor(E), a joint venture between the Shell Foundation and the Energy Institute at Colorado State University, which was spurred by the need for more-effective investments in early stage, energy-related technology ventures. The partnership is helping entrepreneurs and investors to achieve greater impact by combining early stage capital with technology co-development. This serves to de-risk ventures and prepare them for scale (Factor(E) Ventures, 2017). One of their

major successes is Enviroid International; now one of the largest improved cookstove companies in the world.

51. The GCF could consider supporting climate technology incubation programmes of existing innovation intermediaries and innovation institutions with a broader remit, with the view of fostering a collaborative RD&D approach. Support may be more effective by focusing on parts of the technology cycle shortly after a technology has been proven to be effective in lab/trial conditions, as a way of scaling up testing and/or after pilots have been completed and now the technology is ready for dissemination into the market.

3.2.5 Technology partnerships

52. This model comprises the largest number and variety of existing collaborative RD&D configurations. Many existing bilateral and a number of multilateral projects and platforms fall under this category of technology RD&D collaboration support. Cooperation ranges from traditional bilateral RD&D collaboration between public research institutes, consortia and alliances comprising research, public and private actors, city-based platforms that bring together research institutes, technology companies and demand-side actors, collaborative agricultural RD&D supported through the CGIAR, the International Energy Agency (IEA) technology cooperation agreements, to technology cooperation around, for example, the adaptation and demonstration of small-scale renewable energy technologies such as biomass and mini-hydro.

53. Technology partnerships are borne out of the need and value of accessing and bringing to bear a broader range of resources and expertise on the collaborative RD&D and innovation process, accelerating the innovation process, sharing knowledge and development costs to improve efficiency and learning, and increasing the potential of subsequent technology deployment, market access and scaling.

54. This modality is organized in three parts:

- (i) Support for technology partnerships;
- (ii) Support for regional and international networks. Networks confer additional benefits to more limited partnerships by linking a larger number of actors and different innovation systems.
- (iii) Expanding and extending existing collaborative RD&D programmes of multilateral organizations, such as the IEA, the CGIAR and others.

3.2.3.1 Support for technology partnerships

55. Outside of the CGIAR and the IEA, the most common and traditional form of collaborative RD&D is bilateral, or involves just a handful of partners, is time limited and has a narrow objective. It is also in the adaptation, testing and demonstration stage of existing new technologies where such partnerships are often a necessity. Both small-scale renewables (e.g. biogas, mini-hydro technology) and large-scale (e.g. second-generation biomass, new wastewater treatment technologies) usually require partnerships at this stage in the innovation process. Similarly, low-cost innovations and adaptations of existing climate technologies can benefit from a partnership approach. On the other hand, other kinds of low-cost innovation – through the development of unconventional technologies that have lower capital and operating costs – could also be supported through a challenge approach. Despite the high costs and the still non-negligible technical risk, demonstration projects remain a critical component of programmes that aim to catalyse the adoption of new technologies. However, in contrast to past practice, in recent years demonstration projects have adopted a more strategic approach that

simultaneously builds the necessary institutional infrastructure to further develop and deploy the new technologies (UNFCCC, 2016).

56. Yet, as a result of the challenges posed by climate change and the opportunities created by trends in innovation of climate technologies, including through ICTs, newer forms of partnerships are emerging, for example around climate-smart and resilient cities; clean energy access; the use of data, ICT and climate challenges faced by smallholder farmers and, more broadly, climate-smart agriculture. These collaborations amplify innovation and set the stage for further deployment and market development. Other partnerships, alliances and networks have arisen from the need to address the unique challenges of specific technologies: carbon capture and storage, geothermal energy, and CSP, for example. A comprehensive overview of climate technology initiatives, partnerships and networks is available in a paper by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the UNFCCC (UNFCCC, 2016). In the agriculture sector, collaborative RD&D involving a larger number of partners has a much longer tradition, thanks to the existence of the CGIAR. A small selection of examples of existing partnerships provides an indication of the type of collaborative RD&D in different sectors that could be supported by the GCF (see annex II, addendum).

57. The GCF could support the collaborative development, testing and innovation to accelerate commercialization of technologies for climate-smart and resilient cities, in cities that face similar climate and environmental challenges. The GCF could support collaborative RD&D of water technologies that meet the needs of cities of different regions and locations. A number of renewable energy technologies, both large and small scale, would benefit from targeted collaborative RD&D of their adaptation to different conditions through technology partnerships that the GCF could support. The GCF could support a variety of collaborative climate agriculture RD&D partnerships focusing on unaddressed needs.

3.2.3.2 Support for networks

58. Networks of research institutes, experts, farmers, entrepreneurs, intermediary innovation enablers and other types of innovation and knowledge actors have a valuable role in the sharing and diffusion of technology knowledge and in articulating and coordinating shared visions and roadmaps. They can also speed up learning, reduce duplication and, therefore, the cost of collaborative RD&D, and can be an effective institutional tool in supporting the collaborative RD&D of climate technologies. While many networks, in particular those in adaptation, are focused on broad knowledge-sharing at multiple levels, in mitigation a number of regional and multi-country alliances and networks focuses on specific technologies (e.g. carbon capture and storage, solar photovoltaic, geothermal or biofuels). Still, other international networks focus on science, technology and innovation (STI) capacity-building for policy-making. collaborative RD&D oriented networks with relatively broad membership are rare, except in the context of the CGIAR and some of the IEA technology cooperation agreements.

59. A mapping of climate technology initiatives by SBSTTA in 2016 documents a wide range of networks and partnerships, from the technology-specific to those that address broader climate-relevant development issues, such as the green economy, STI, universal energy access and agriculture (UNFCCC, 2016). One particularly relevant observation in the report is the recent emergence of networks that support the earlier stages of the climate technology cycle and that focus on climate technology start-ups and private enterprises.

60. To illustrate the potential contribution of networks to cost-effective collaborative RD&D and the increased likelihood of subsequent deployment, the cases of networks, one decades old and another only recently established, are presented in the addendum document. They are concrete examples of the type of network that could be supported by the GCF. In this context, the GCF support would need to be considered on a case by case basis. Support to early

research institutions, partnerships or networks themselves may be harder to align with the investment criteria of the Fund, though there might specific activities that could advance collaborative RD&D within the operational modalities of the Fund, such as attracting venture capital and angel investors to deploy funds in developing countries to help technologies take off in non-traditional markets.

3.2.3.3 Strengthening the collaborative RD&D of research institutes

61. Although platforms for international RD&D collaboration already exist for agriculture and energy, both the scale and scope of the collaboration for climate technologies is limited. There is opportunity to build on existing programmes and for extending geographical coverage and expanding their scope (TEC, 2017). Approximately 30 developing countries are involved in CGIAR (out of a total of 45 participating countries) or the technical cooperation projects (49 participating countries). The CGIAR budget is approximately 3 per cent of global agriculture RD&D spending and currently less than 10 per cent of the budget goes directly to the Climate Change, Agriculture, and Food Security (CCAFS) programme.

62. Most of the technical cooperation projects cover renewable energy, energy efficiency and energy storage technologies but the budgets for those programmes are not available. Collaboration beyond OECD member countries is strongly supported in the energy technology network – comprising the Committee on Energy Research and Technology (CERT), the working parties, the experts groups, and the Implementing Agreements (IEA, 2012). The CERT coordinates and promotes the development, demonstration and deployment of energy technologies to meet challenges in the energy sector. Through multilateral technology initiatives known as Implementing Agreements, the IEA provides member governments with a mechanism that helps bridge the gap between energy technology experts around the globe to help meet the world's energy needs (IEA, 2012).

Annex I: Draft decision of the Board

The Board, having considered document GCF/B.18/12, titled “Options for support for technology collaborative research and development”:

- (a) Takes note of the options outlined in document GCF/B.18/12 for the GCF to support collaborative research, development and demonstration, inter alia,
 - (i) climate technology innovation systems; and
 - (ii) targeted climate technology research, development and demonstration support,
- (b) Invites national designated authorities and focal points to request support through the existing readiness activity areas to address matters related to collaborative research and development;
- (c) Requests the Secretariat to develop for consideration by the Board at its twentieth meeting a request for proposals to support climate technology incubators and accelerators; and
- (d) Also requests the Secretariat to continue to consider complementarity and coherence with other related technology initiatives and to report accordingly in the context of the Operational Framework on Complementarity and Coherence (Decision B.17/04).
