TEC/2016/13/15
22 August 2016

Thirteenth meeting of the Technology Executive Committee

United Nations Campus (AHH building), Bonn, Germany
6–9 September 2016

Scoping paper

Climate technology research, development and demonstration

I. Background

1. In accordance with its 2016–2018 workplan, activity 3, the Technology Executive Committee (TEC) decided to determine and undertake further work on research, development and demonstration (RD&D), building upon previous TEC work on the issue. The agreed deliverables for this activity were an RD&D scoping paper for TEC 13, prepared by the secretariat, and further activities on RD&D, based on the scoping paper.

II. Scope of the note

1. This background note provides, in annex 1, the RD&D scoping paper prepared by the secretariat. This paper aims to provide an overview of RD&D in the context of the Paris Agreement. It explains the concept of RD&D and describes its relevance in supporting Parties to achieve the Paris Agreement's objectives. It provides an overview of current RD&D initiatives and highlight opportunities for strengthening RD&D. Finally, the paper considers how the UNFCCC may support countries and the international community to strengthen climate technology RD&D efforts.

III. Expected action by the Technology Executive Committee

2. The TEC will be invited to take note of the information contained in the scoping paper and provide guidance on further work on RD&D.

Annex 1

Scoping paper on research, development and deployment

Key findings

- Technology research, development and demonstration (RD&D) lies at the heart of innovation. It is the process through which new, improved and cheaper technologies are developed and their utility demonstrated in a real-world context.
- With the Paris Agreement highlighting RD&D, the question of how the TEC can support countries to enhance RD&D efforts takes on great salience and significance.
- To strengthen RD&D efforts, the TEC could consider a possible role in one or more of the following:
    - Enhancing knowledge of the RD&D landscape;
    - Strengthening organizational forms for RD&D;
    - Enhancing RD&D financing;
    - Building endogenous capacity of countries to undertake RD&D.

I. Background

1. COP 21 requested the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN), in supporting the implementation of the Agreement, to undertake further work relating to, inter alia, technology research, development and demonstration (RD&D).[1]

2. In response to this mandate, at its 12th meeting the TEC requested the secretariat to prepare an RD&D scoping paper for TEC 13. It also decided to undertake further activities on RD&D as part of its 2016-2018 workplan. These activities build upon earlier TEC work on RD&D and innovation. In 2013, the TEC considered how to enhance RD&D, holding a thematic dialogue on the issue.[2] In 2014 and 2015, it focused on understanding how to strengthen the technology innovation process that underpins efforts to engage in a climate technology transition.[3]

II. Rationale

3. Why should we focus on RD&D? How can RD&D support countries to achieve the Paris Agreement's objectives? This section aims to address these questions.

4. Global temperatures continue to rise to record heights.[4] In Paris, Parties agreed on the Paris Objectives of pursuing "efforts to limit the temperature increase to 1.5°C above pre-industrial levels... and increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse emissions development" (§2.1). If we are to achieve these objectives, we urgently need to replace high-emitting technologies with low-carbon alternatives. Similarly, to support effective adaptation to climate change effects that are being felt and will get more severe, there is an equally urgent need to implement suitable adaptation technologies. Accordingly, Parties specifically noted "the importance of technology for the implementation of mitigation and adaptation action." (§10.2)

5. To achieve these aims, we need to deploy at a large scale the many low-emission and adaptation technologies that are already available or coming on to the market. But in most cases, technologies cannot be simply installed as they need to be adapted to suit local conditions. Furthermore, we need to continue to develop for the longer term more effective climate technologies that have a greater impact, for a lower cost, and may be used in more different national circumstances, situations, regions and

[1] Decision 1/CP.21, paragraph 67.
[2] <http://goo.gl/2CDYhE>.
[3] See TEC Brief #7: Strengthening national systems of innovation to enhance action on climate change.
[4] <http://www.nytimes.com/2016/07/20/science/nasa-global-temperatures-2016.html>.

needs. The 1.5 °C goal, particularly, will need a revolution in technological (and other) terms. Accordingly, the Paris Agreement notes 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." (§10.5)

6. RD&D lies at the heart of the activities described above, and, in a more holistic sense, innovation. It is the process through which new, improved and cheaper technologies are developed and their utility demonstrated in a real-world context (see annex 2 for a detailed exposition of RD&D.) Since the ability of a new technology to displace an incumbent or create a new market is greatly dependent on costs or performance attributes, the role of RD&D in delivering improvements on these fronts become critical. Even though RD&D is inherently an uncertain activity (see annex 2), it is only through this process that new technologies are developed and brought to market. Significantly, the Paris Agreement specifically noted that the Technology Mechanism shall support collaborative approaches to research and development. (§10.5)

7. The benefits of effective climate tech RD&D can be immense. It can lead to:

i. Technologies which are ready to be deployed in the local conditions to address mitigation and adaptation challenges;

ii. Enhanced national capacity for RD&D and related activities, which underpin national systems of innovation;

iii. Accelerated sustainable development and increased national competitiveness.

8. These benefits serve as significant building blocks for Parties' efforts to achieve the Paris Agreement objectives. The benefits can also hold countries in good stead as they continue to address their climate and sustainable development in the longer term.

III. Current state of RD&D programmes and initiatives

9. To begin with, it should be highlighted that there is no comprehensive understanding of climate technology RD&D. This is because it encompasses many diverse sectors, because most technologies draw upon knowledge from a diversity of areas, and because RD&D takes place in a variety of venues – universities, government research laboratories, and the private sector. In addition, detailed information on RD&D is not always publicly available (especially from the private sector).

10. Having said that, there is some understanding of key trends. The most common way of measuring RD&D is through expenditure.[5] In the energy space, IEA has been collecting data on the public energy RD&D expenditures of IEA member countries, which account for the bulk of such expenditures globally (see annex 3, figure 1). This indicates that public energy RD&D expenditures have been rising, albeit rather slowly, although this is set to receive a boost with Mission Innovation (which aims to double the clean energy R&D expenditures of 20 major economies by 2020).[6] Most of this expenditure is national is scope, with national priorities determining the RD&D portfolios. While there are only limited publicly-available assessments of private RD&D investments in energy, some sources indicate that RD&D spending for renewables in the private sector rose substantially in the last decade (see annex 3, figure 2). This mirrors a rise in public RD&D investments in this area. (BNEF-Frankfurt School 2016).

11. In agriculture, the data is less detailed that for the energy sector, although there are estimates for total global public and private agricultural R&D (NRC 2014). Most recent estimates indicate that the public sector dominates R&D spending in agriculture, with developing countries contributing as much as the developed countries overall. China, India, and Brazil together account for half of the developing country total and a significant amount of the recent growth (see annex 3, figure 3) (Beintema 2012). The Consultative Group for International Agricultural Research (CGIAR) after some leveling and decline around the turn of the century has also picked up its investments, and exceeded $700 million in 2011 (see annex 2, figure 4). But it is not clear what fraction of this might be climate-relevant, although the planned budget for CGIAR's Climate Change, Agriculture and Food Security program for 2015 was just

[5] One can also measure outputs such as patents. At a broader level, there also are attempts to assess innovation capabilities and outcomes, e.g., the Global Innovation Index.
[6] <http://www.mission-innovation.net/>.

over $69 million.[7] Beyond this, there is little other specific data on climate-relevant RD&D, for example, in areas such as adaptation.

12. While there are a number of efforts to promote climate technology cooperation between developed and developing countries, many of these are focused on energy.[8] They are also mostly focused on the latter part of the innovation cycle, on enhancing deployment, with the CGIAR being the major exception. International collaborative RD&D has received relatively-limited attention (Ockwell et al., 2012). Still, there are examples of bilateral programs such as the US-China and US-India joint clean energy R&D centers or plurilateral programs such as the International Energy Agency (IEA) Technology Collaboration Programmes, which promotes cooperation on energy technology RD&D. The IEA implementing agreements (39 at present), which focus mostly on IEA countries although with some developing country participation, span research in selected areas to fill gaps, build pilot plants, carry out demonstration projects, and facilitate deployment. The CTCN is focused more on facilitating implementation, although it is now beginning to explore its role in facilitating RD&D. See annex 2 for examples of RD&D programmes at the bilateral, plurilateral and multilateral levels.

IV. Enhancing RD&D to support the Paris Agreement

13. Section II highlighted the importance of enhancing RD&D to achieve the Paris Agreement's objectives and section III the current trends regarding RD&D funding. Building on these sections, how can we strengthen RD&D efforts? Strengthening RD&D is a complex task. Breaking this down, there are four RD&D issues which may require specific focus:

i. Enhancing knowledge of the landscape;

ii. Strengthening organizational forms;

iii. Enhancing financing;

iv. Building endogenous capacity.

A. Enhancing knowledge of the landscape

14. Section III indicated that while we have some understanding of climate RD&D investments and activities, we do not have a comprehensive and systematic understanding of the public and private RD&D investments in this space. While a full understanding may be impossible, a better overall understanding, especially one that also looks carefully at all relevant sectors, will help in assessing the effectiveness of existing efforts and identifying areas which may require funding. In fact, regular and systematic data collection may be a useful area of international cooperation (especially given that many agencies and analysts are already involved such efforts). This will help in understanding the existing portfolio of activities in terms of focus, scale, and scope, and will provide guidance to efforts to identify and address RD&D gaps.

B. Strengthening organizational forms

15. How RD&D activities are organized can have a significant impact on outcomes (see annex 2, "What is RD&D"). It is therefore important to consider how we may organize RD&D efforts so as to help developing countries with their climate technology needs in an effective manner. Such organization may also help developing countries with the implementation of their nationally determined contributions (NDCs). The question arises: what are the various options to strengthen RD&D through improved organizational approaches? In addition, what might be the most effective ways to strengthen collaborative R&D?

16. On RD&D cooperation, there are many options that could be explored for strengthening collaborative RD&D, going from bilateral to multilateral programmes and sectoral to cross-sectoral programmes. Collaborative RD&D is possible in many different forms depending on the objective of the activity. It could be through industry-industry collaboration, university-university collaboration, quadrilateral university-industry efforts, CGIAR-type network of laboratories or even a global

[7] <https://ccafs.cgiar.org/publications/ccafs-program-work-and-budget-2015#.V5Gbn465KfU>.

[8] The International Experimental Thermonuclear Reactor is the largest and most prominent, although fusion technology still remains far from commercialization.

collaborative RD&D facility (see annex 3, table 1) (Ockwell et al., 2012). There are also important lessons to be learnt and policy insights to be gained from the experiences of existing activities.[9]

C. Enhancing financing

(See also the TEC paper on climate technology RD&D financing).[10]

17. It is impossible to conduct RD&D without funds (although different areas might require different amounts of financial support). And greater RD&D funding allows for a multiplicity of RD&D activities, thereby enhancing the chances of success. The first way to make available additional financing for RD&D is through greater investments that could come from national governments themselves. In the energy area, Mission Innovation has already taken a major step in this direction. Other countries may also choose to strengthen their domestic efforts in energy area and there may be similar efforts in other climate-relevant areas. For least developed countries, external finances (and other support) may be required. Other possibilities may include involvement of actors such as philanthropies, multilateral development banks and the Financial Mechanism.[11]

18. Secondly, and equally importantly, policies and programmes aimed at supporting and enhancing deployment of climate technologies can induce a rise in RD&D investments. For example, the enormous rise in renewable technology deployment worldwide has likely been a major motivator for the rise of private R&D investments in this space (although public R&D investments also spur private investments). But programmes have to be well designed to yield the appropriate outcomes. Knowledge and experience-sharing on this front is particularly useful. Thirdly, it should also be understood that countries need to make choices on where to invest efforts, depending on existing capabilities and national needs (for example, as reflected in the NDCs).

D. Building endogenous capacity

19. Capacity (in the form of human, institutional, and network capabilities) is central to technology development, transfer, and deployment broadly, and also to effective RD&D. What capacity do developing countries need and how may we support them to build it?

20. Firstly, there is a need to better understand the human and institutional capabilities required to support the RD&D process and yield long-term benefits. This has three parts: the first pertains to capabilities for planning RD&D efforts. i.e., strategic choice-making in terms of linking policy objectives and choice of technologies and pathways so that there is clarity on which areas to prioritize and how to organize the RD&D efforts. The second part pertains to the capabilities for organizing, coordinating, and managing RD&D efforts. The third relates to performing the RD&D (e.g. mainly scientific and technical capabilities). Note that national context is central to these processes; hence the critical need for endogenous capacity. By helping suitably plan and manage RD&D, such capacity increases the effectiveness of the process and thus the likelihood of successful outcomes (see annex 2, "What is RD&D").

21. Secondly, there is a need to better understand how this capacity might be best developed, drawing lessons from previous experiences in capacity building. What approaches have worked and what have not? What are the appropriate partners from both sides? What kind of capacity building arrangements have been the most effective? What might be the role of international cooperation in this process? These are the kinds of issues that need unpacking in order to put together effective capacity-building programs.

[9] For example, the United States ARPA-E program provides financing for selected high-risk, high-impact areas with greater due diligence and guidance than a standard R&D funding agency.
[10] See TEC/2016/13/14.
[11] For example, the COP, by decision 13/CP.21, requested the GCF Board to consider ways to provide support, pursuant to the modalities of the GCF, to collaborative research and development for enabling developing country Parties to enhance their mitigation and adaptation action.

Beyond research, development and deployment

It should be remembered that research, development and deployment (RD&D) is mainly a means to an end, namely that of climate-relevant technology development and deployment. The last stage of RD&D (i.e. technology demonstration) is a prelude to market introduction and larger-scale deployment. Therefore, policies and programmes to ensure smooth progression from RD&D to real-world use become key. This is particularly necessary for climate technologies that are more expensive than incumbent technologies or face other barriers to entry (such as lack of knowledge, risk-aversion on the part of users and financiers, or lack of delivery models). While these will probably vary across sector and countries, such policies and actions would also support NDC development and implementation. Here knowledge-sharing about effective practices and examples as well as support to design suitable policies and programmes may be particularly useful.

V. Role of the UNFCCC in enhancing RD&D

22. Ways that the UNFCCC could contribute to RD&D strengthening include the following:

i. Convene and coordinate stakeholders to synthesize existing information about the current state of climate-technology RD&D. Catalyze new data gathering exercises and analyses;

ii. Explore approaches to strengthen collaborative RD&D to help implement the Paris Agreement objectives (including NDC implementation);

iii. Enhance financing for RD&D and collaborative RD&D arrangements, including by exploring ways for the UNFCCC and non-traditional actors to support RD&D activities. In addition, help to share experiences and effective practices on RD&D-stimulating policies;

iv. Enhance understanding on developing country capacity needs for effective RD&D. Identify ways to strengthen their capacity.

VI. Questions for consideration

23. The TEC may consider the following guiding questions as it explores possible further activities on RD&D, in accordance with its 2016-2018 workplan:

i. How may climate technology RD&D support countries to achieve the Paris Agreement?

ii. Four key issues related to strengthening RD&D are:

    (i) Enhancing knowledge of the landscape;

    (ii) Strengthening organizational forms;

    (iii) Enhancing financing;

    (iv) Building endogenous capacity.

iii. What could the TEC do to address these issues? How could the TEC, in line with its mandate, support countries to enhance the effectiveness and scale of RD&D efforts?

Annex 2

Background information on research, development and demonstration

What is research, development and demonstration (RD&D)?

1. Research refers to the search for new knowledge and solutions, which is the beginning point of the emergence of new technologies. Development refers to next step in the innovation cycle, where new possibilities emerging from the research phase are translated into concrete technologies, although at this stage very often it may be a proof of concept. This technology is then refined through testing in the laboratory or simulated field conditions to improve its performance and give it the shape of usable product. The demonstration stage refers to the use of the product in actual field conditions where its performance and feasibility can be demonstrated and evaluated by actual or potential users. The information and feedback from this stage can be used to further improve the product to make it more amenable to users. All of these stages are pre-commercial in that the technology has still not entered the marketplace. If the results of the demonstration are positive, then it may be introduced into wider use through the marketplace or policies designed to support deployment in cases where the market may not be effective. This is the case for many climate technologies where the initial or overall costs of the technologies are higher than those of the incumbents, or there are other barriers to adoption.

2. As one goes along the innovation cycle, the risk goes down. Research outcomes are highly uncertain so it is a high-risk activity. But by the time the technology makes it to demonstration, the risk is lower since technologies not likely to have a positive outcome are already weaned out. On the other hand, the level of financial investment required increases along the innovation cycle. And lastly, while scientific technical expertise is required for research, additional expertise such as market and user requirements and product design become equally important in the later stages. While the public sector plays a central role in RD&D (especially the research stage), the private sector is critical for technology development and demonstration since the bulk of the ability to engage in design, development, and demonstration rests there. All of these have implications for the kinds of resources and actors required for effective outcomes at various stages of RD&D.

3. Note also that RD&D by definition is inherently uncertain overall in that it is impossible to guarantee a particular outcome from a specific RD&D activity. But a multiplicity of projects exploring different pathways are likely to yield some positive outcome, which is why firms and funding agencies normally have RD&D portfolios (to the extent their funds and other resources permit). Thus RD&D planning is important since it allows limited resources to be allocated to specific priority objectives and preferred pathways. Another way to enhance the probability of success (and/or the speed and efficiency of the RD&D process) is through organizational forms that can overcome barriers or contribute positively in other ways to the RD&D performance. Lastly, since the national context is key to selecting RD&D priorities, pathways, and organizational forms, the importance of endogenous capacity to guide the RD&D planning, implementation, and performance cannot be overstated.

Examples of successful RD&D programmes and initiatives

4. This section highlights three examples of successful RD&D programmes or initiatives, selecting one from the bilateral, plurilateral and international levels.

5. At the bilateral level, the India-US Joint Clean Energy R&D Center (JCERDC) was established through an agreement signed between the two countries in 2010, with $25 million funding from each country. The objective is joint R&D on clean energy technologies that could be deployed quickly, resulting in significant impact. The three initial areas of focus for the JCERDC were solar energy, energy-efficient buildings, and second-generation biofuels. The JCERDC funded, after an open call, a joint US-India consortium of research organizations in each area that have developed tools to facilitate deployment of clean energy technologies (such as building design assistance tools) as well as deployable technologies. The JCERDC was extended in 2015 and expanded to also include smart rids and grid storage.

6. As a plurilateral initiative, Mission Innovation was launched in Paris in November 2016 by twenty major energy economies to "reinvigorate and accelerate public and private global clean energy

innovation with the objective to make clean energy widely affordable".[12] To support this objective, the governments of the member countries have pledged to double their public clean energy R&D expenditures, which should result in an additional $15 billion in R&D investments by 2021. These governments also intend to work with the private sector and business leaders to promote private investments in clean energy technologies. A group of investors have formed the Breakthrough Energy Coalition[13] to advance the translation of technologies from lab to market through support for early-stage technology development for breakthroughs emerging from Mission Innovation countries.

7. At the international level, the Consultative Group for International Agricultural Research (CGIAR), established in 1971, is an international research network that initially was aimed at enhancing food security and reducing poverty in developing countries. The objectives currently have been broadened to also include nutrition security as well as improving natural resources and ecosystem services. Analyses of CGIAR research have indicated strong positive benefits in relation to investments.[14] The annual budget of the CGIAR in 2014 was over $800 million dollars. The CGIAR's Climate Change, Agriculture and Food Security (CCAFS) aims to address the challenge of climate change and food security on agricultural practices, policies and measures through a strategic collaboration between CGIAR and Future Earth. Areas of focus include climate smart agricultural practices, climate risk management, and low-emissions agriculture. The planned budget for CCAFS for 2015 was just over $69 million.

[12] <http://mission-innovation.net/>.

[13] <http://www.breakthroughenergycoalition.com/>.

[14] See, for example, Raitzer D.A., Benefit-Cost Meta-Analysis of Investment in the International Agricultural Research Centres of the CGIAR. CGIAR Science Council Secretariat, Washington, and FAO, Rome (2003); Renkow, M., and Byerlee, D., "The impacts of CGIAR research: A review of recent evidence," Food Policy, (35): 5, 391–402 (2010).

Annex 3

Reference figures and tables on research, development and deployment

Figure 1: Trends in public energy RD&D investments by IEA countries

(Source: IEA ERD&D database)

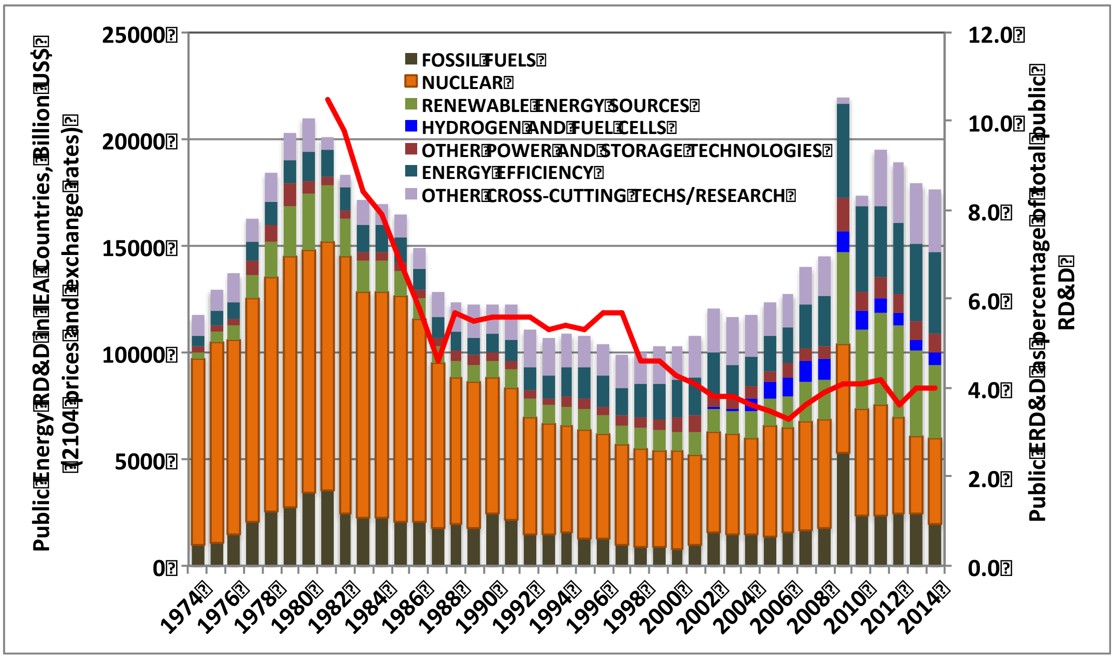

Figure 2: Trends in public and private investments in renewables R&D

(Source: Frankfurt School-UNEP Centre/BNEF, Global Trends in Renewable Energy Investment 2016)

Note that the 'drop' post-2013 is both partly as a result of comparison with the 2013 figure that represented a big jump from the recent trends and then also a reduction in R&D investments driven by falling fossil-fuel prices.

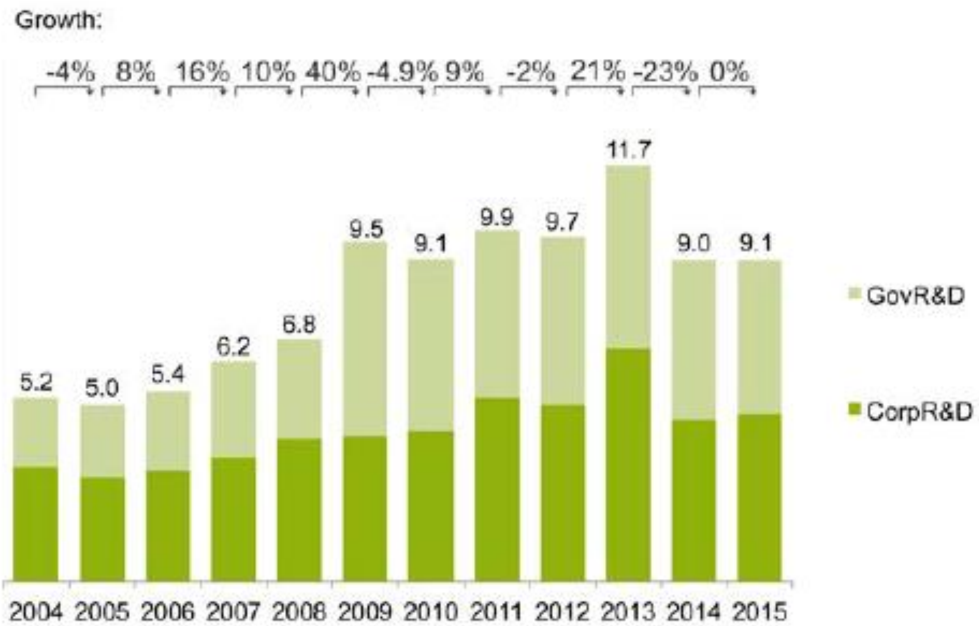

Figure 3: Trends in public and private investments in agricultural R&D

(Source: US National Research Council. Spurring Innovation in Food and Agriculture A Review of the USDA Agriculture and Food Research Initiative Program. National Academic Press: Washington DC (2014))

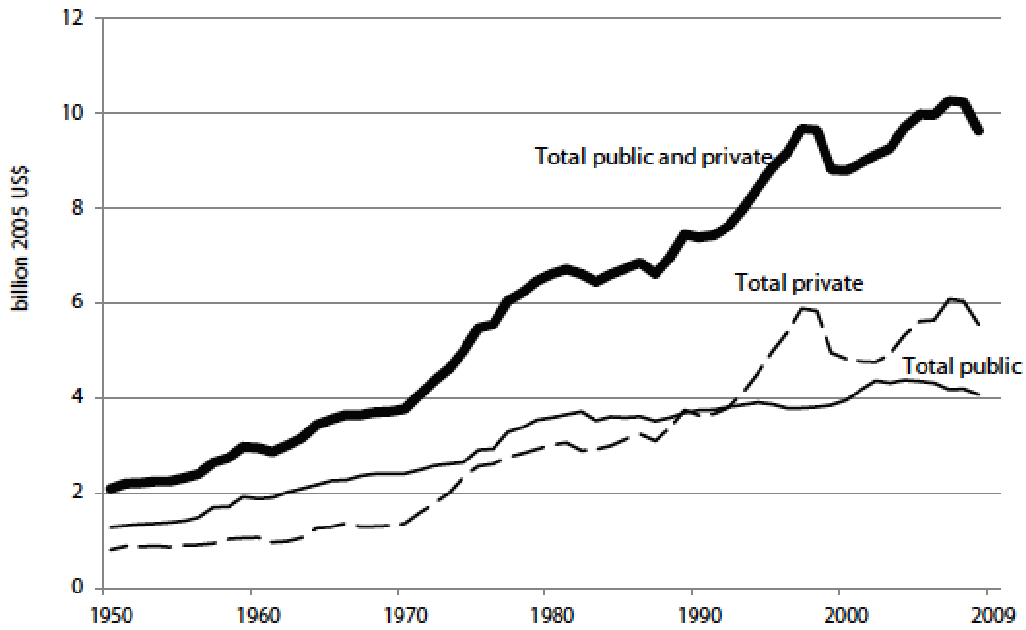

Figure 4: Trends in CGIAR funding

(Source: Beintema, N, G-J Stads, K Fuglie, and P Hei, "ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment," IFPRI: Washington, DC (2012)).

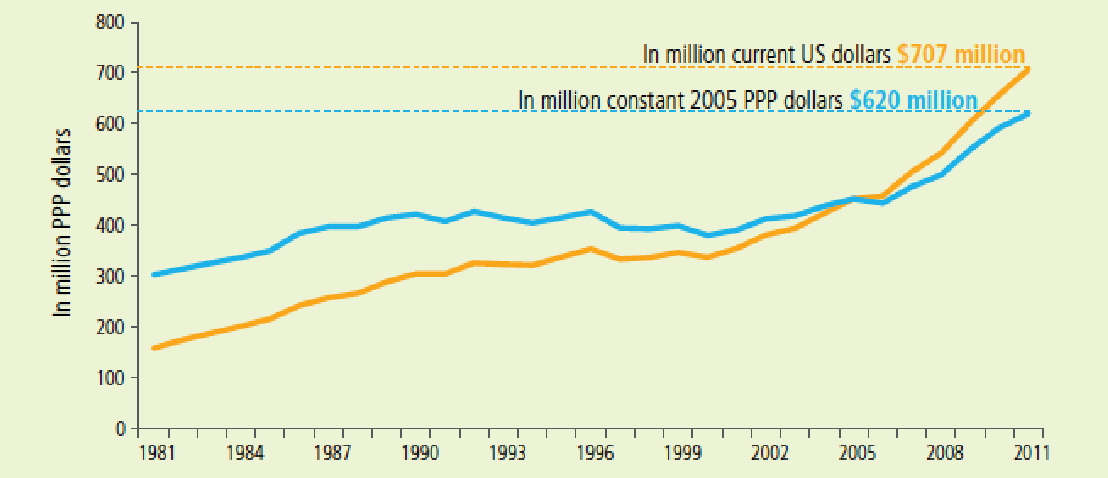

Table 1: Potential collaborative R&D arrangement for developing-country needs

Source: Ockwell, D., A.D. Sagar, and H. de Coninck, "Collaborative research and development (R&D) for climate technology transfer and uptake in developir countries: towards a needs driven approach," *Climatic Change* 131: 401 (2105)).

Goals	Innovation stage	Actors	Organisational model for collaboration	Funding	Geographical coverage
Adaptation and modification of existing technologies	Middle-stage, market-oriented	Industry, dedicated laboratories, research universities and institutes	Industry-industry	Public/private	Country/region specific
			Industry-laboratories/ universities	Public/private	
			CGIAR-type networks	Public	Globally distributed
New technologies and products for "unaddressed" needs	Middle- or early-stage, end user-oriented	Industry, dedicated laboratories, research universities and institutes, NGOs	Product-Development Partnerships	Public	Global or region-specific
			CGIAR-type networks	Public	Globally distributed
			Innovation prize-induced collaborations	Public/philanthropic	
			Industry-laboratories/ universities	Public/private	Country/region specific
Long-term R&D	Early stage	Research universities and institutes, industry, dedicated laboratories	University-university	Public (e.g., climate financing, bilateral, multilateral, philanthropy)	Country/region specific
			University-industry		
			Industry-industry		
			CGIAR-type networks		Globally distributed
			Global facility		Single-location