Technology Executive Committee

02 November 2020

Twenty-first meeting

Virtual meeting, 17–20 November 2020

Compilation of good practices and lessons learned on countries research, development and demonstration

Background note

I. Background

1. As per activity 2 of the thematic area Innovation of its workplan for 2019–2022, the TEC is to identify and analyze overview of international research, development and demonstration (RD&D) partnerships and initiatives, and approaches for collaborative RD&D available for countries to participate as well as to compile countries experiences, good practices and lessons learned, on RD&D policies & activities. The deliverable of this activity for 2020 is a compilation of good practices and lessons learned on countries RD&D, including international RD&D partnerships and various approaches for collaborative RD&D. For 2021, executive summaries on RD&D for targeted audience will be developed.

2. The task force on Innovation worked inter-sessionally to prepare a draft compilation of good practices and lessons learned on international collaborative RD&D initiatives of climate technology. At TEC 21, the task force on Innovation, with the support of the secretariat and a consultant, will be invited to present a draft compilation of good practices and lessons learned on countries RD&D for the TEC's consideration.

II. Scope of the note

3. The annex to this note contains the draft compilation of good practices and lessons learned on international collaborative RD&D initiatives of climate technology, as prepared by the task force on Innovation.

III. Possible action by the Technology Executive Committee

4. The TEC will be invited to consider and agree on the draft compilation.

Annex

Draft Compilation of good practices and lessons learned on international collaborative research, development and demonstration initiatives of climate technology

Foreword

[Foreword by the TEC Chair and Vice-chair to be inserted]

Table of contents

Abbreviations and acronyms

AFACI	Asian Food and Agriculture Cooperation Initiative
COP	Conference of the Parties to the UNFCCC
CGIAR	Consultative Group on International Agricultural Research (former name)
CYTED	Ibero-American Programme for Science, Technology and Development
EC	European Commission
EU	European Union
IEA TCP	International Energy Agency Technology Collaboration Programmes
IP(R)	Intellectual Property (Rights)
JCERDC	Indo-US Joint Clean Energy Research and Development Center
JIRI	Joint Initiative on Research, Innovation and Technology between LAC and the EU
LAC	Latin America and the Caribbean
MI	Mission Innovation
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution
N-S	North-South Cooperation
R&D	Research & Development
RD&D	Research, Development & Demonstration
RT&D	Research & Technology Development
SDG	UN Sustainable Development Goals
SIDS	Small Island Developing States
S-S, SSC	South-South Cooperation
S&T	Science & Technology
TEC	Technology Executive Committee
TLR	Technology Readiness Level
TNA	Technology Needs Assessment
TrC	Triangular Cooperation
UNFCCC	UN Framework Convention on Climate Change

1. Highlights

As stipulated in Article 10, paragraph 5, of the Paris Agreement, accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Fostering innovation can be done through various means, one of which is effective international collaborative approaches to enhance climate technology RD&D.

This brief aims to facilitate the sharing of information on international technology RD&D partnerships and initiatives. From a broad compilation of such initiatives, it selects and analyses a set of representative case studies and draws some lessons and good practices from these cases.

General observations from a broad mapping of initiatives can be summarized as follows:

- While there are a large number of international collaborations on climate technology RD&D, only a limited number is engaged in actual funding or implementation of research, development or demonstration of 'hardware'. Instead, many focus on RD&D strategies, policy dialogues, information sharing and capacity building, or on the commercialisation and deployment of technology. This confirms earlier work by the TEC.[1]
- Among the joint (funding of) RD&D initiatives, there are relatively few that cover climate change adaptation.
- While some initiatives are set up specifically to address identified RD&D needs, with dedicated institutions set up for this purpose, in other cases, the initiative is a result of a primary objective to strengthen international relations.
- The bulk of initiatives identified are public sector-led. Although various initiatives have made a special effort to engage with the private sector, its involvement in the early stages of the technology cycle is limited. Private sector mostly gets involved in the demonstration, incubation, commercialisation and diffusion phases.

Eight case studies are selected from the mapping. While each of the case study initiatives has been declared a success, and with no reason to doubt that initiatives are reaching their goals, only limited independent evaluations are available. More independent, public evaluations would allow for robust conclusions on factors that contribute to the success or failure of the initiatives, and further identification of lessons that can be learned from them. Having said that, based on the information that was publicly available, the case studies suggest the following good practices:

1) High-level political buy-in, combined with structural, pragmatic implementation processes;
2) Joint ownership and funding, and equal partnership between developed and developing country participants;
3) Broad participation and stakeholder engagement from the beginning;
4) Alignment with national priorities, needs and capabilities;
5) Alignment of the initiative's design with the technology and its context;
6) Suitable governance and management processes of initiatives;
7) Structured evaluation and continual adjustment;
8) Design for long-term sustainability, and
9) Combine technological hardware RD&D with 'soft- and orgware' activities.

The core recommendations are:

- One, strengthen assessment and learning on successful collaborative RD&D initiatives, so that lessons learned are transparent and independently established. Currently, only few initiatives undertake regular independent, publicly available evaluations that are transparently reflected in organisations and allow others to learn as well.
- Two, facilitate flexible and evolving participation of countries in line with national needs and capacities, taking into account that those can be very different across contexts.
- Three, particular attention needs to be paid to the "how" of private sector-participation. Relevant private sector actors (and other stakeholders) are often involved too late to still incorporate their needs, for instance for IP arrangements.

[1] TEC, 2016, Scoping paper on Climate technology research, development and demonstration, Technology Executive Committee TEC/2016/13/15, 22 August 2016, 13th meeting of the Technology Executive Committee, 6–9 September 2016, https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEM_TEC_meetings/f0108ae8497a4309baaf7c7183bb85ed/ab999650c52349959509b29590410b18.pdf

- Four, more hardware technological RD&D is needed as many initiatives are focussed only on dialogue or coordination. However, to enable smooth transition into deployment and diffusion, this enhanced RD&D needs to be consistently accompanied by 'soft- and orgware' activities such as policy dialogue and research, standard- and norm-setting, capacity building and public engagement.

Importantly in the context of the Paris Agreement goals of international collaborative RD&D initiatives, local presence and capacity building in developing countries appears to be a crucial part of effective developing country participation. For international RD&D collaboration, all engaged researchers need to be able to cooperate on an equal footing. Given the weaker innovation systems and funding of academics and researchers, this is a much greater challenge in developing countries than in developed countries. All initiatives that are successful in terms of developing country participation have invested considerably in local capacity., Meaningful participation of developing country researchers requires some external funding by donors, which needs to be structured in such a way that ownership is not negatively affected.

Although much can be said already from the assessment in this brief, gaps in knowledge remain. While some initiatives are set up specifically to address identified RD&D needs, with dedicated institutions set up for this purpose, in other cases, the initiative is a result of a primary objective to strengthen political relations. The case studies were selected as initiatives of significance and have indeed demonstrated various good practices and valuable lessons learned. However, this does not address whether they are actually the optimal response to the need for international RD&D collaboration in the climate change space, or whether other forms would have been more effective in addressing that need. This could be worthwhile areas for further analysis.

2. Concepts, definitions and approach

The compilation looks at **international collaborative climate technology RD&D initiatives**.

'Climate technology' is defined as 'any piece of equipment, technique, practical knowledge or skills for performing a particular activity that can be used to face climate change'.[2] It covers both mitigation and adaptation.

'RD&D' covers activities in the technology life cycle stage from Research (TRL1) to Demonstration (TLR7).[3]

Thus, '**international collaborative climate technology RD&D initiatives'** refer to initiatives in which different countries or regions jointly conduct (or fund) such RD&D activities.

Activities such as commercialisation, market introduction, deployment, and scaling up are crucial for achieving large-scale implementation of climate technology, but they are not part of RD&D. Therefore, initiatives solely focusing on these activities are not included here. Activities that include both such activities and RD&D activities are covered.

Similarly, initiatives that promote dialog among research, industry and policy actors as well as knowledge sharing and capacity building are also not considered as part of RD&D, though they are crucial in supporting RD&D. Initiatives solely focusing on this type of activities are also not covered here, while combinations of such supporting activities with RD&D activities do fall within the scope of the analyses.

Each collaborative RD&D initiative is characterized in terms of its (i) geography, (ii) number of countries involved, (iii) the form of cooperation, and (iv) the scale of activities, as elaborated below.

In terms of geography, the initiatives are characterized based on their geographical scope (country, regional, global), the types of countries involved and the specific countries and regions that participate in the initiative. The types of countries involved are reflected in the cooperation, in terms of North-South, South-South or Triangular cooperation,

[2] IPCC, 2000, Methodological and Technological Issues in Technology Transfer (IPCC SRTT - Special Report on Techonolology Transfer), Bert Metz, Ogunlade Davidson, Jan-Willem Martens, Sascha Van Rooijen and Laura Van Wie Mcgrory (Eds.) Cambridge University Press, UK. https://www.ipcc.ch/report/methodological-and-technological-issues-in-technology-transfer/

[3] Technology Readiness Levels, a scale ranging from 1 ('basic principles observed') to 9 (actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies). TLR7 is defined as 'system prototype demonstration in operational environment'. For more details and definitions, see e.g.

in line with the definitions in the Framework of operational guidelines on United Nations support to South-South and triangular cooperation.[4]

North-South cooperation occurs when a developed country supports a less-developed country economically or with another kind of resources.[5] **South-South cooperation** (SSC) is defined as "a process whereby two or more developing countries pursue their individual and/or shared national capacity development objectives through exchanges of knowledge, skills, resources and technical know-how, and through regional and interregional collective actions, including partnerships involving Governments, regional organizations, civil society, academia and the private sector, for their individual and/or mutual benefit within and across regions. South-South cooperation is not a substitute for, but rather a complement to, North-South cooperation". **Triangular cooperation** (TrC) is defined as "Southern-driven partnerships between two or more developing countries, supported by a developed country(ies) or multilateral organization(s), to implement development cooperation programmes and projects".

The organization of the collaboration is further characterised in terms of:

- The number of countries involved.
  This distinguishes **bilateral** cooperation (between 2 countries), **plurilateral** cooperation (involving more than 2 countries but limited to a relatively small number) and **multilateral** cooperation (involving a large number or all countries).
- The form of the cooperation.
  Collaboration can be organised as a **consortium** (i.e., consisting of a number of organizations participating in a joint RD&D effort through a contractual arrangement, e.g. a specific project), a **network** (i.e., involving organisations that can cooperate on activities in different compositions at different points in time) or as a **platform** facilitating cooperation between interested parties. In other words, from consortium through network to platform the extent of organisation and formalisation decreases.
- The scale of the activities.
  This specifies whether activities comprise a single **project** or are organised in a **programme** of multiple projects.

The initial list of collaborative RD&D initiatives was created by a broad scoping exercise which involved desk research and inputs from TEC members, members of the Innovation Task Force and the UNFCCC Secretariat. The individual case studies draw on primary literature sources, including self-reported information by the initiatives in the form of planning documents, informational and evaluation reports and websites, as well as third-party evaluations, where available.

3. Introduction and mapping of collaborative initiatives

Article 10, paragraph 5, of the Paris Agreement states that "accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development" and that this should be supported by collaborative research and development.[6]

The objective of this brief is to understand what lessons can be learned from existing international RD&D collaborations relevant to the technology framework in the Paris Agreement. To this end, an overview of known existing international collaborative RD&D initiatives is provided, a number of selected case studies is further analysed, and a set of good practices and lessons learned on collaborative RD&D is compiled.

The selection of case studies was undertaken as a three-step process:

- A long-list (57) of international collaborative RD&D initiatives on climate technology was created, outlining their main characteristics, including scope (mitigation/ adaptation, sector/technology/geographical scope), maturity, objectives and the type of activities (including the stage of the technology cycle).[7]

[4] UNDP, Frequently Asked Questions - South-South and Triangular Cooperation, https://www.undp.org/content/dam/undp/library/Poverty%20Reduction/Development%20Cooperation%20and%20Finance/SSC_FAQ%20v1.pdf

[5] https://www.un.org/development/desa/en/news/intergovernmental-coordination/south-south-cooperation-2019.html#:~:text=North%2DSouth%20cooperation%2C%20which%20is,disaster%20or%20a%20humanitarian%20crisis.

[6] FCCC/CP/2015/10/Add.1

[7] [The list will be uploaded on TT:CLEAR and relevant link added here in the footnote]

- A short-list (25) of initiatives suitable for providing lessons learned was drawn up on the basis of the criteria and definitions outlined in the previous section, and inputs from TEC members and the UNFCCC Secretariat. These initiatives were further examined in terms of the organisation of the initiatives, the activities implemented, budgets and outcomes.[8]
- Eight case studies were selected from this short list for further analysis, keeping in mind the need for diverse and sufficiently representative observations. This list and some key characteristics are in Table 1.

The cases cover various regions and type of countries involved (N-S, S-S, Triangular), as well as a range of activities in terms of mitigation and/or adaptation and sectoral/technological focus. Other considerations in the selection of case studies included:

- Whether the initiative would be replicable to other countries or regions and/or could be scaled up;
- Whether the results would be sustainable in the longer term;
- Whether the initiatives are inclusive in terms of the actors involved;
- Whether there is private sector involvement and/or private sector funding involved.

The case studies were analysed in detail to understand their origin, organization, governance, scope and outcomes, with the aim of providing lessons learned and identifying good practices that could be relevant for other RD&D collaboration efforts.

The next section describes the selected initiatives, providing lessons learned and identifying good practices that may be relevant for a broader audience. The subsequent sections bring together the cross-cutting lessons learned and good practices (across case studies) and provide recommendations for strengthening and scaling up of international collaboration on climate technology RD&D.

[8] [as above]

Table 1 Overview of key characteristics of the selected case studies

#	Name of initiative	Mitigation/ Adaptation	Technology cycle stage	Type of collaboration	Project or program	Sectoral/ Tech focus	Rationale	Geography		Size
								Geographical scope	Region	
1	Indo-US JCERDC	Mitigation	R&D	Bilateral; Network of consortia	Programme	Energy	Seen as a "success" story; good information availability	country, N-S	US, India	Small
2	Mission Innovation	Mitigation	R&D to demonstration	Multilateral; Platform	Programme	Energy	Major initiative	Global, N-N, N-S, S-S, Triangular	All	Large
3	IEA TCP	Mitigation	R&D to commercializatio n	Plurilateral Platform	Programme	Energy	Major initiative	Global, N-N, N-S, S-S, Triangular	All	Large
4	Dewfora	Adaptation	Prototype, demonstration	Plurilateral Consortium	Project	Water-drought management	Joint development of tools, geography	Regional; N-S	Africa, Europe	Small
5	CGIAR	Mitigation, adaption (not climate-specific)	R&D to commercializatio n	Plurilateral Network	Programme	Agriculture	Major initiative, long-standing; much studied	International, N-N, S-S, N-S	All	Large
6	JIRI	Mitigation, adaptation (not climate specific)	R&D financing	Plurilateral Platform	Programme	Cross-cutting	Format of coop, shift to more S-S	International/Regiona l; N-S, S-S	Europe, LAC, SIDS	Small
7	CYTED	Mitigation, adaptation (not climate specific)	R&D to commercializatio n	Multilateral Platform	Programme	Cross-cutting	Format of coop, N-S/S-S	International/Regiona l, country; N-S, S-S	Spain, Portuga l, LAC	Large
8	AFACI	Adaptation (not climate specific)	R&D to commercializatio n	Multilateral; Network	Projects/ Programme	Agriculture	Significant regional initiatives + repli-cated across regions	Regional, S-S, Triangular	Asia-Pacific	Small

4. Case studies

4.1. Indo-US Joint Clean Energy R&D Center (JCERDC)

4.1.1. Key characteristics

Focus	Mitigation/Adaptation	Mitigation
	Technology cycle stage	R&D
	Sector	Energy
	Geographical scope	Country; N-S
	Geographical participation	USA, India
Organisation	Format	Bilateral network of consortia
	Actors	Governments, government implementing agencies, research and academic organisations, industry
Budget	Phase 1 (2012-2017)	$125 million ($25 million from US and Indian govts each; $75 million from participating private partners)
	Phase 2 (2017-2022)	$ 30 million ($7.5 million from US and Indian govts each; 50% cost share by consortium partners).

4.1.2. The Initiative

The Indo-US Joint Clean Energy Research and Development Center (JCERDC) was established as a virtual center in November 2010 through an agreement between the U.S. Department of Energy (DOE) and the Government of India. The JCERDC, the first **bilateral initiative** designed specifically to promote clean energy innovation by teams of scientists and engineers from India and the United States, was seen as a priority initiative of the 2009 US-India Partnership to Advance Clean Energy, which was part of the U.S.-India Memorandum of Understanding to enhance cooperation on Energy Security, Energy Efficiency, Clean Energy and Climate Change.[9]

The overall **objective** of the JCERDC is to facilitate joint research and development on clean energy to improve energy access and promote low-carbon growth. To achieve this objective, the Indo-US JCERDC is a bilateral partnership that has supported a number of **multi-institutional consortia** using a public-private partnership funding model with the intention of enabling research, the results of which can be translated into quick deployment.

In Phase 1 (2012-2017), the JCERDC **focus** was on three areas seen as critically important and of mutual interest: (a) solar energy, including solar electricity production, nanoscale designs of interfaces and cells, advanced photovoltaic technologies, concentrating solar power technologies; (b) second generation biofuels, including conversion technologies for advanced biofuels, optimal characterization for ligno-cellulosic feedstock, algal biofuel, standards and certification for different biofuels and co-product with end-use applications; and (c) energy efficiency of buildings, including cooling, cool roofs, advanced lighting, energy-efficient building materials, software for building design and operations, and building-integrated photovoltaics.

In terms of **governance and organisation**, the JCERDC is overseen by the Indo-U.S. Steering Committee on Clean Energy Science and Technology Cooperation, co-chaired by India's Deputy Chairman of the Planning Commission and the United States Secretary of Energy (see Figure *1*). This committee provided high-level review and guidance for the activities of the JCERDC. A Joint High-Level Experts Panel of twelve prominent experts from the private and public sectors and academia provided the JCERDC with critical suggestions and insights and acted as an advisory body for the Steering Committee. Additionally, Project Monitoring Committees – consisting of relevant technical experts as well government representatives –were set up to monitor the progress in each of the three areas in relation

[9] Indo-US JCERDC Status Report, 2012, Ministry of Science and Technology, Government of India

to their defined objectives and targets. The program was administered by the Indo-U.S. Science and Technology Forum (IUSSTF), an existing institution with well-developed administrative infrastructure.

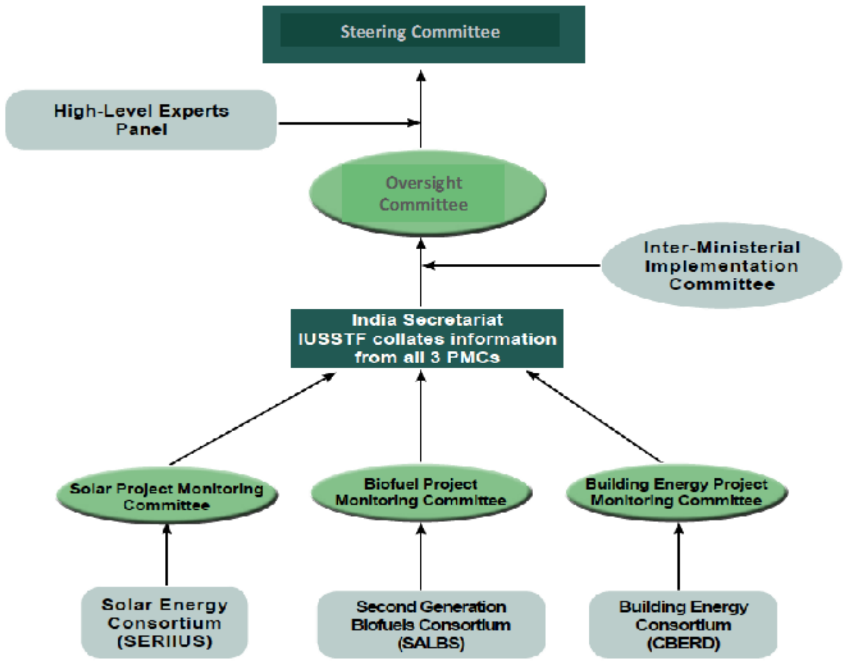

Figure 1: Governance Structure of JCERDC (Phase 1). For Phase 2 the topic-specific virtual centers changes (bottom rows in the figure above), the rest of the structure remained the same. Source: Indo-US JCERDC Status Report, Sept 2015, Ministry of Science and Technology, Government of India.

Table 2: Government funding allocation in Phase 1. Source: Indo-US S&T Forum Annual Report 2017-18. IUSSTF, New Delhi, India

	Solar Energy	Building energy efficiency	Second-generation biofuels
GOI funding (Total $25 million)	59%	26%	15%
DOE funding (Total $25 million)	54%	23%	23%

The JCERDC established virtual entities to coordinate and shepherd the work in each area, namely the Solar Energy Research Institute for India and the United States (SERIIUS), the US-India Joint Center for Building Energy Research and Development (CBERD), and the US-India Consortium for Development of Sustainable Advanced Lignocellulosic Biofuel Systems (SALBS). The parties to set up and manage each of these virtual entities were selected through a **public tendering procedure**. Government funds allocated to each of the areas are show in *Table 2*.

The process of selecting the winning consortia started with a meeting in New Delhi to provide potential applicants with an overview of the JCERDC and engage them in an open discussion. Subsequently, potential applicants had a chance to comment on a draft Funding Opportunity Announcement (FOA), after which the final FOA and call for proposals was posted online and advertised in national newspapers and journals. For Phase 1, IUSSTF and DOE received a total of 21 applications, of which 19 were found to comply with the requirements of the call and suitable for further review. A Joint Merit Review Panel (JMRP) for each priority area was constituted, with equal representation from the U.S. and India to evaluate the applications.[10] Additional reviews were also requested from

[10] Evaluation criteria outlined in the Final FOA are: Scientific and Technical Merit (35%);

Guest Evaluators to supplement the views of the JMRPs. The reviews, scores, and recommendations of the JMRPs were then provided to the Joint Appraisal Committee (JAC), which consisted of senior officeholders from relevant Indian and US government agencies. The JAC then selected the consortia to receive the award.

SERIIUS was led jointly by the Indian Institute of Science (IISc) and the U.S. National Renewable Energy Laboratory (NREL). The **overall goal** of SERIIUS was to accelerate the development of solar electric technologies by lowering the cost per watt of photovoltaics (PV) and concentrated solar power (CSP) through the development of deployable technologies. SERIIUS **focused** not only on fundamental and applied research to develop novel and disruptive technologies, but also analyse critical technical, economic, and policy issues for solar energy development and deployment in India, workforce development, and outreach. This would contribute to India's Jawaharlal Nehru National Solar Energy Mission and the U.S. DOE SunShot Initiative. The consortium approach involving participants from academia and industry from both countries was chosen to accelerate the translation of knowledge from research to application. SERIIUS's **governance structure** comprised the SERIIUS Council - which included the joint US and Indian Directors of this entity, research thrust leaders, competency coordinators, and industry representatives - and an Executive Oversight Board, which included the leadership of the key organizations in the consortium.

CBERD was led jointly by CEPT University (Ahmedabad, India) and Lawrence Berkeley National Laboratory (LBNL, Berkeley, CA, US). Its overall **objective** was the improvement of energy efficiency in commercial and high-rise residential buildings through the integration of information technology with building systems. In order to achieve this objective, CBERD efforts **focused** on building energy model & energy simulations, monitoring and energy benchmarking, integrated sensors and controls, advanced HVAC system, building envelopes, and climate responsive design. The work programme of CBERD was overseen by a Consortium Management Office.

The major **objective** of SALBS, jointly led by the Indian Institute of Chemical Technology and the University of Florida, was to develop and optimize selected non-food biomass-based advanced biofuels systems and bio-based products like biogas and lignin-based by-products for U.S. and India. In order to do so, the consortium **focused** on a range of activities including improving feedstock production and quality of locally-adapted cultivars, help optimize the production system through development of soil criteria, catalysts, logistics, and waste stream minimization and recovery, and certification protocols and standards, and supply chain management. SALBS was managed by a Project Steering Committee, while the technical aspects were reviewed and guided by a Technical Advisory Committee.

A review of the Phase 1 activities carried out by a committee of eminent experts and representatives from Indian government and IUSSTF in 2019 concluded that the three programmes had all been successful in achieving their objectives and mandates. *Table 3* lists the **key achievements** in the three areas of Phase 1 and *Table 4* lists the **key deployable outcomes** in each area.

Table 3: Key outcomes in Phase 1 Source: Indo-US S&T Forum Annual Report 2017-18, IUSSTF, New Delhi, India

	Solar Energy	Building energy efficiency	Second-generation biofuels
Journal Publications	266	21	79
Conference Proceedings	396	57	108
Patents	9	3	6
Joint workshops	14	-	-
PhDs and Post-docs trained	51	12	7
Students exchanges	39	54	31

Technical Approach, Management Plan, Understanding of Project Objectives (35%);
Applicant/Team Capabilities, Experience, Organization, Facilities, Management Capabilities (30%).

Table 4: Key Deliverables and Deployable Outcomes in Phase 1 Source: Indo-US S&T Forum Annual Report 2017-18. IUSSTF, New Delhi, India

Solar Energy	Building energy efficiency	Second-generation biofuels
Heliostat development	COMFEN India & eDOT	High biomass yielding abiotic stress tolerant sorghum, pearl millet and bamboo
Reliability Studies for Photovoltaics in India	Cool Roof Calculator	Low-input advanced feedstock production system
Soiling Mitigation for PV Modules	Phase change material ceiling tiles	Efficient pre-treatment & fermentation process
Super-critical CO_2 laboratory scale test loop facility	Laser Cut Panels	Standardization & Certification protocols
Small-scale solar receivers for s-CO_2	Dedicated Outdoor Air System	
New absorber coating material with high thermal stability and high corrosion resistant property	Indirect evaporative space cooling	
Use of Flexible Glass for Substrates and Encapsulation	Affordable smart power strip	
Novel Processing for Silicon Solar Cells	Low energy wireless motion sensor	
	Energy Information System Packages	

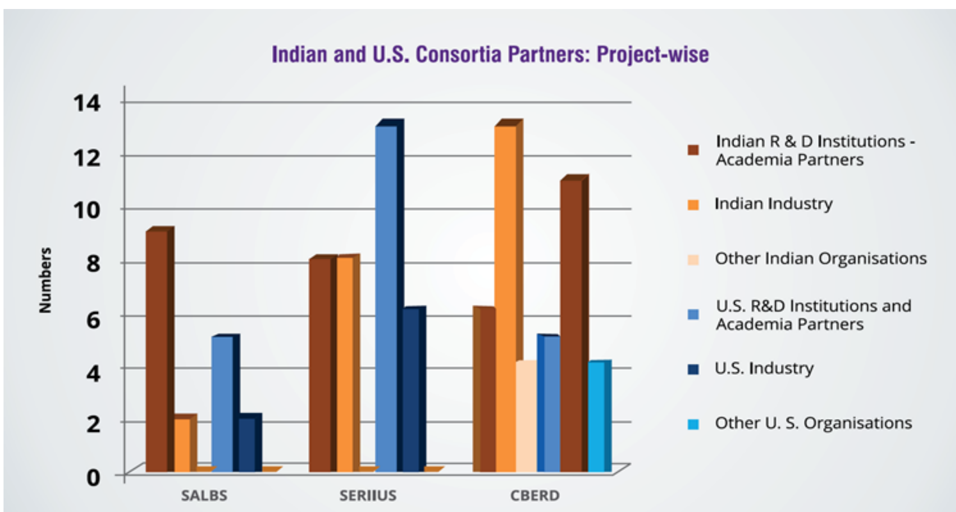

Figure 2: Participation in JCERDC consortia, Phase 1. Source: Indo-US S&T Forum Annual Report 2017-18. IUSSTF, New Delhi, India.

Given the successful review of Phase 1, both countries agreed to continue with a second phase of JCERDC (2017-2022) in two new research areas, Smart Grids and Energy Storage, that could help strengthen the electric power system's ability to support a clean energy transition. Each government has committed $1.5 million annually for a five-year period (with 50% cost share coming in from the consortium partners). The consortium (UI-ASSIST: U.S.-India collAborative for smart diStribution System wIth STorage), selected through a process similar to that in Phase 1, involves multiple academic and industrial partners and is led by researchers from the Indian Institute of Technology (IIT) Kanpur and Washington State University, Pullman. The objectives of this consortium's work are to develop and demonstrate the Distribution System Operator functions for optimal utilization and management of distributed energy resources, while also exploring the broader implications and requirements of such an energy system such as data and security needs, resiliency, and workforce requirements. The consortium has started engaging on its research programme, with exchange visits, workshops, and some journal publications. However, it is too early to conclude whether its objectives will be met. The governance structure for Phase 2 is broadly along the same lines as that of Phase 1.

4.1.3. Key success factors and lessons learned

JCERDC is a high-profile effort that has **high-level political buy-in** in both India and the US. In fact, the joint center was established under the 2005 umbrella Agreement on S&T Cooperation between India and the United States. The success of the JCERDC also rests on other factors: **the topics chosen were seen as being salient and important to both countries** and had sufficient ongoing academic and industrial efforts in both countries to underpin the R&D programmes.

The award and establishment of the virtual entities in each of the research areas was the result of a **competitive and systematic process**, as detailed in the previous section. The **inclusive and transparent nature of the selection process**, even though quite lengthy (taking almost 18 months) ensured that the call was **responsive to the views of the stakeholders**, there was wide participation in the application process, and the selection was carried out systematically with the appropriate expert input.

Intellectual Property Rights (IPR) arrangements were clear from the beginning: they were to follow the detailed and comprehensive IPR Annex (Annex I) of the 2005 Agreement on Science and Technology Cooperation between the US and Indian governments and the respective IPR provisions of the governments and the project annexes of the participants to the extent these did not contravene with the IPR annex and the associated IP framework allocation document.

The **consortium approach** was successful in attracting a large number of participants from academia and the **private sector** (see **Error! Reference source not found.**) and even more, funding from private players to complement the public funding. Part of this obviously was due to the choice of work areas attractive to a large number of actors. The administration of the JCERDC by the Indo-US S&T Forum likely also helped.[11] The Forum has a track record of engaging with a variety of actors in the S&T space and a solid organizational and management infrastructure that served it well in programmatically administering the JCERDC.

Regular reviews by the Project Monitoring Committee (six over the course of Phase 1) ensured that the projects were moving forward appropriately and were given feedback as necessary.

4.1.4. Identified good practices:

- **Ensuring an inclusive and transparent process** to sensitize/inform stakeholders about the possible opportunity, engaging with them during the call design, and then selecting on the basis of pre-announced criteria both ensures broad and fruitful participation by stakeholders and trust in the process.
- **Providing sufficient funding and reasonable time horizon** for the projects to make participation both attractive and feasible.
- **Employing a multi-institutional consortium model for the virtual entities**, which allows for broad participation by a range of stakeholders and therefore allows horizontal learning even among the members of the group.
- **Having clear IPR rules** together with industry participation facilitates the development of deployable technologies.
- Understanding that the successful deployment of technologies needs a **focus not just on technical issues** but also topics such as economics, policy, workforce development, and standards.
- **Establishing secondary objectives such as strengthening human resources** through PhD and post-doctoral training and student exchange opportunities (along with the main objective of developing deployable technologies) helps in long-term and ecosystem level benefits of the programme.
- Ensuring smooth and streamlined management of the programme by anchoring it an existing institution with well-developed administrative infrastructure.

[11] The Indo-US S&T Forum is an autonomous bilateral entity established in 2000 to promote Science & Technology (S&T) and innovation through interactions with academia, industry, and government, jointly-funded by India and the US.

4.2. Mission Innovation (MI)

4.2.1. Key characteristics

Focus	Mitigation/Adaptation	Mitigation
	Technology cycle stage	RD&D
	Sector	Energy
	Geographical scope	Global, N-N, N-S, S-S, Triangular
	Geographical participation	Americas, Europe, Asia
Organisation	Format	Multilateral platform
	Actors	Governments, government implementing agencies, research and educational organisations, industry
Budget		$1.3 billion between 2015 and 2019

4.2.2. The Initiative

Mission Innovation (MI), announced at COP21 in Paris in November 2015, is a global inter-governmental initiative now involving 24 countries and the European Union "to reinvigorate and accelerate global clean energy innovation with the objective to make clean energy widely affordable." The MI members together account for about 80% of the global clean energy R&D spending.[12]

The **objective** of MI, "in support of economic growth, energy access and security, and an urgent and lasting global response to climate change", is "to accelerate the pace of clean energy innovation to achieve performance breakthroughs and cost reductions to provide widely affordable and reliable clean energy solutions that will revolutionize energy systems throughout the world over the next two decades and beyond." Not surprisingly, given these lofty ambitions and broad scope, MI effectively involves all parts of the energy sector (i.e., energy supply, energy demand, as well as emissions).

At the time of the launch, MI members committed to:[13]

1. Seek to double their governmental and/or state-directed clean energy research, development and demonstration investments over five years.
2. Work closely with the private sector as it increases its investment in the early-stage clean energy companies that emerge from government programmes.
3. Build and improve technology innovation roadmaps and other tools to help in innovation efforts, to understand where RD&D is already happening, and to identify gaps and opportunities for new kinds of innovation.
4. Provide, on an annual basis, transparent, easily accessible information on their respective clean energy RD&D efforts.

In terms of **organization,**[14] the work programme of MI is guided by a Steering Committee, which is comprised of a sub-set of MI member representatives serving one-year, renewable terms. The Steering Committee provides high-level strategic guidance to facilitate implementation of the Enabling Framework and the Action Plan. The MI Secretariat supports the MI Steering Committee, members and the MI Sub-Groups to help drive forward MI activities and achieve the desired outcomes and impact. The Analysis and Joint Research (AJR) Sub-Group identifies and analyzes clean energy innovation needs, priorities, challenges and opportunities for collaboration across MI members. The Business and Investor Engagement Sub-Group underpins MI members' efforts to engage with the private sector and strengthen public-private collaboration.

---

[12] http://mission-innovation.net/about-mi/overview/

[13] *ibid* .

[14] *ibid.*

Much of the collaboration in MI has been driven though the **Innovation Challenges (ICs)**, which are a key part of the MI action plan with the intention of accelerating RD&D in technology areas that could "provide significant benefits in reducing greenhouse gas emissions, increasing energy security and creating new opportunities for clean economic growth." At present, there are 8 ICs (see **Error! Reference source not found.**) that span a significant part of the technology cycle, ranging all the way from early-stage research needs assessments to technology demonstration projects.

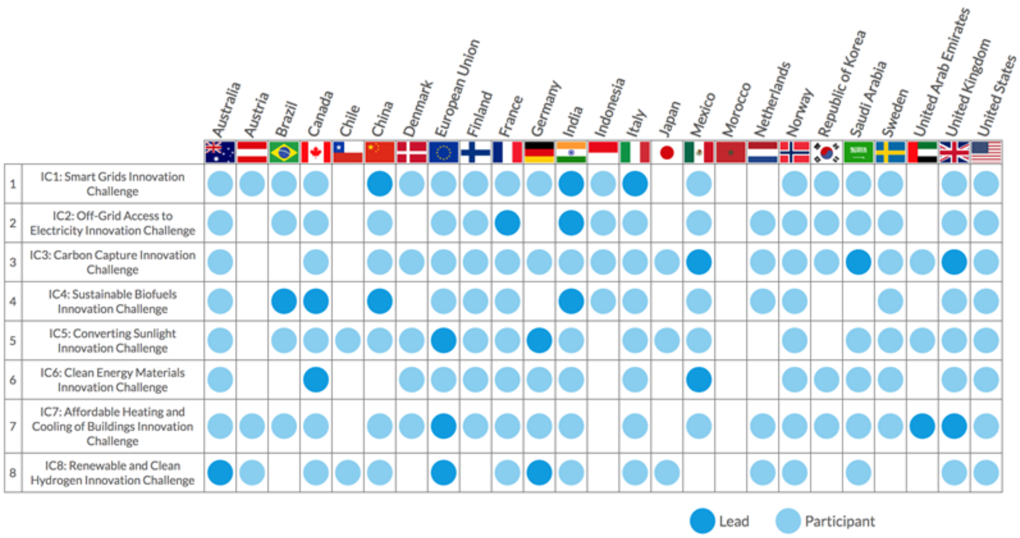

Figure 3: MI member participation in Innovation Challenges (Source: http://mission-innovation.net/our-work/innovation-challenges/)

In terms of **organization**, each IC is led by at least two countries, with a number of other countries voluntarily participating in the challenge (**Error! Reference source not found.**). The workplans of the ICs have drawn on insights from scientific experts as well as stakeholders. This has resulted in a plethora of outcomes, including international collaborative efforts, the launch of specific innovation challenges, development of programmatic funding efforts, and the establishment of an accelerator (see *Table 5*). The ICs have also helped bring together a diverse set of stakeholders such as researchers, practitioners from industry and finance, and policymakers.

The main **achievements** of MI include the following:

- MI members are **on track to meet their commitment of doubling clean energy public RD&D** within five years, having already reported an additional $4.6 billion of public-sector investment by Year 3 (which is 55% of the overall goal).[15]
- At the same time, by its own estimates, MI has resulted in **greatly strengthened bilateral and multilateral collaborative activities** in clean energy innovation, with $1.3 billion invested in 59 new cooperation activities between 2015 and 2019. These include joint RD&D programmes, coordinated funding calls, demonstration projects, and student and researcher exchanges.[16]
- MI has also successfully engaged with the **private sector** to try and ensure that the results of the R&D carried out by MI partners is successfully translated into commercial applications.

MI's **private sector engagement** has included collaboration with the Breakthrough Energy Coalition (BEC), an international group of investors committed to accelerating the commercialization of new reliable and affordable energy technologies to help tackle climate change. This has resulted in a public-private partnership with five MI member countries as well as the establishment of Breakthrough Energy Ventures Europe, which is a joint €100 million investment by the European Commission and Breakthrough Energy (an investment vehicle for BEC investors). Another example is the partnership between MI and the World Economic Forum to enhance engagement between

[15] http://mission-innovation.net/our-work/tracking-progress/

[16] http://mission-innovation.net/wp-content/uploads/2019/05/MI-Impact-Review-May-2019.pdf

leading businesses and MI members. Individual countries have also taken efforts to work with the private sector: The Indian government launched the Clean Energy International Incubation Centre, which is a partnership between the Indian Government and the Tata Trusts, intended to support start-ups from across MI members to explore the Indian market. Norway has launched a scheme PILOT-E, inspired by ARPA-E and DARPA[17] that is intended to bring innovations to market faster. Canada, through its $30 million partnership with Breakthrough Energy, is also supporting firms to help commercialize their technologies.

Table 5: MI Innovation Challenges: Objectives and Outcomes (Based on Mission Innovation Impact Report, May 2019)

Innovation Challenge	Objective	Key outcomes
IC1: Smart Grids	Enable future grids powered by affordable, reliable, decentralised renewable electricity systems.	Launched the Smart Grids Innovation Accelerator in 2019 to identify technologies and business models to enhance smart grids deployment, enlarge public-private collaborations and advance smart grid deployment more generally Cooperating with the International Smart Grid Action Network to better link innovation to deployment.
IC2: Off-Grid Access to Electricity	Develop systems that enable off-grid households and communities to access affordable, reliable renewable electricity.	France is investing €1.8M in 9 projects in Africa on various renewable energy technologies and using electricity to further economic development. India launched a $5 million off-grid competition, with the winners working with organizations from 9 MI member countries on ways to enhance energy access in areas with no/limited grid power
IC3: Carbon Capture	Enable near-zero CO2 emissions from power plants and carbon-intensive industries.	A program to find ways to address challenges to advancing CCS has been launched ($30 million from the US Department of Energy and $35 million from the Accelerating Carbon Capture and Storage Technologies consortium). The EU also has a $38 million program for industrial CCS projects involving MI members.
IC4: Sustainable Biofuels	Develop ways to produce at-scale widely affordable, advanced biofuels for transportation and industrial applications.	China has allocated $62 million to bilateral/multilateral projects involving a number of MI countries. India also has a joint research program designed to enhance collaboration between Indian researchers and those from other MI countries.
IC5: Converting Sunlight	Discover affordable ways to convert sunlight into storable solar fuels.	The European Commission launched in 2017 a €5 million Artificial Photosynthesis (AP) prize with the objective of developing a bench-scale prototype of an AP-based technology that produces synthetic fuel. AP now is also part of 7th Energy Research Programme of the German Federal Government and the Indian government research programs.
IC6: Clean Energy Materials	Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.	A key area of focus is putting into practice the concept of a materials acceleration platform (MAP) that aims to greatly accelerate discovery of new materials by combining automated robotic machinery with rapid characterization and artificial intelligence. MAPs collaborations are under development with 11 MI members.
IC7: Affordable Heating and Cooling of Buildings	Make low-carbon heating and cooling affordable for everyone.	MI members are developing, in collaboration with the IEA, "Comfort and Climate Box," which aims to provide integrated heating, cooling and energy storage in conjunction with a smart energy grid. The $3 million Global Cooling Prize funded by the Indian government has the objective of developing technologies by 2020 with the primary criteria of 5x less climate impact and not more than 2x installed cost than the baseline room air conditioner.
IC8: Renewable and Clean Hydrogen	Accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale.	One focus is on the concept of "Hydrogen valleys" (where multiple hydrogen applications are implemented in an integrated fashion in a city, a region, an island or an industrial cluster) as a pathway to scaling up and impact in the short term.

4.2.3. Key success factors and lessons learned

Perhaps the most important success factor for MI is the **political buy-in** for the programme. The programme was supported by the member country governments at a high level, which basically helped ensure support from the relevant agencies in the individual countries.

The design of the overall programme – governance and activities – also proceeded in a **structured fashion**. The first step was the development of an enabling framework, which was approved on June 1, 2016 at the first Ministerial meeting, that laid out the overall approach to MI. This included listing the key actions that would be taken by each

[17] (US) Advanced Research Project Agency-Energy and the Defence Advanced Research Project Agency

member[18] as well as outlining the broader approach.[19] This allowed individual members to make choices regarding how to implement its obligations under MI, as well as which MI collaborative activities to participate in. In other words, the initiative provided **flexibility** to member countries as to how to participate in MI activities. It also put the **focus on activities of common interest** such as information sharing, innovation analysis and roadmapping. This has been beneficial in two ways: one, it started building a common framework for data collection on RD&D investments and roadmapping for the future; and two, it also allowed members to learn from each other's approaches towards, and experiences with, innovation.

In line with the above-mentioned flexibility, participation in the main innovation activity – the Innovation Challenges – was on a **voluntary** basis, i.e. countries volunteered to lead and participate in the Challenge. At the same time, the choice and design of activities under a Challenge was also the result of deliberation by experts that had a perspective on the technological landscape and opportunities as well as the opportunities for application. Thus, each Challenge ended up taking a unique path that was tailored to that particular area. It should be noted, though, that participation in the ICs ended up being somewhat lopsided in that some members ended up participating in only a few ICs. On the other hand, a focus on engagement with the private sector helped explore new approaches to RD&D and raise additional investments to advance the commercialization of clean energy technologies.

The AJR sub-group played an important role in **supporting these processes through analysis and research** to underpin the design, implementation and assessment of the Challenges, share knowledge and learning across Challenges, and develop analytical products to advance the work program, including planning for new activities. The AJR has supported MI, for example, by carrying out reviews of the programme,[20] assessment of ongoing Innovation Challenges and assessing proposals for new ICs.[21] The AJR also developed a paper on international collaboration models on clean energy innovation to provide guidance to countries in this area.[22] The plans for Phase 2 of Mission Innovation (post-2020) are also being shaped by an evaluation of the experiences in Phase 1.

4.2.4. Identified good practices

- Providing different actors with the **flexibility** to participate in activities as perceived **relevant to their individual needs/context**. In other words, actors can choose which activities enabled by the initiative are meaningful and relevant to them.
- **Soliciting expert views systematically** in the early stages of the programme's definition to ensure that objectives, approach, and organization of the programme are as fruitful as possible. Since different issues/topics may require very different approaches depending on the technological landscape, the exploration of programme objectives as well as specific approach is well served by inputs from experts.

Assessing and learning from collaborative efforts, especially on matters of programme design, implementation, and impact, is useful for its continuing effectiveness over time as well as design of other programmes. Therefore, investment in these processes from the early stages can yield benefits.

[18] i.e., doubling investment, information sharing, innovation analysis and roadmapping, joint research and capacity building, and business and investor engagement

[19] This included allowing a member to "independently determine the best use of its own clean energy research and development funding and define its own path to reach the doubling goal according to its own priorities, policies, processes, and laws; as well as the extent to which it participates in any international collaborations"; indicating that "any steps impacting all Members would occur on a non-objection basis following an opportunity for input from all Members" but "collaborative efforts that develop[ed] organically over time may proceed with the support of two or more interested Members and not require approval by all Members. Members not adhering to a specific collaboration will not be obligated by its results."

[20] See, for example, http://mission-innovation.net/wp-content/uploads/2019/01/6.1.15-IC-midterm-results-infographic.pdf

[21] http://mission-innovation.net/about-mi/analysis-and-joint-research/

[22] http://mission-innovation.net/wp-content/uploads/2019/09/AJR-Paper-on-Multilateral-Collaboration-models_FINAL.pdf

4.3. International Energy Agency Technology Collaboration Programmes (IEA TCPs)

4.3.1. Key characteristics

Focus	Mitigation/Adaptation	Mitigation
	Technology cycle stage	R&D to commercialisation (as well as policy, industry and research dialogue)
	Sector	Energy, including industry, transport, buildings
	Geographical scope	Global, N-N, N-S, S-S, Triangular
	Geographical participation	All regions, gravitating to OECD countries
Organisation	Format	Plurilateral platform involving ca. 40 programmes
	Actors	National government agencies, industry, and research institutes
Budget	Depending on the specific TCP, cost-sharing (pooling funds) or task-sharing (practically budget-neutral to members)	

4.3.2. The initiative

The IEA Technology Collaboration Programmes (TCPs) were established in 1975 with the **aim** of enabling "IEA member countries to carry out programmes and projects on energy technology research, development and deployment".[23] In practice, this means that all TCPs share information and experiences between countries, industries and academia related to specific energy technologies or energy-related sectors. Sometimes, TCPs also share funding in a common fund and work together, in that way limit an individual country's freedom to dispose over its own RD&D resources but enhance the effectiveness of the spending for all countries that are a member to that TCP. While the IEA TCPs (formally known as IEA Implementing Agreements) are all different based on the different needs of various technologies and industries, they are based on the shared principle of "collective innovation to meet shared challenges",[24] meaning that rather than acting alone, cooperation in innovation enables addressing energy questions that are common to the group of countries aligning themselves with a TCP.

Over its 40-year history, several TCPs were created and terminated (and some merged) (see Figure *2*). In terms of their **organization**, TCPs are governed by the IEA Governance Framework,[25] which regulates the start, management and end of a TCP. TCPs can be established by two or more IEA Member Countries, with the proposal of a new TCP to be approved by the IEA Committee on Energy Research and Technology (CERT) and the IEA Governing Board. CERT is an IEA Standing Committee made up of representatives of IEA Member Countries which co-ordinates and promotes the development, demonstration and deployment of technologies to meet challenges in the energy sector. It also decides on the admittance of non-IEA member states and other actors as members of TCPs. The IEA Governing Board is "the main decision-making body of the IEA composed of energy ministers or their senior representatives".[26] Each TCP is overseen by an Executive Committee, and its activities are often organised in "Annexes", which are projects (with a start and an end-date) that provide a framework to conduct more specific technologies than the topic of the TCP, and often feature a workshop or result in a report.

---

[23] IEA Framework for International Energy Technology Co-operation, Annex 2 in IEA, 2016 (see next footnote).

[24] IEA, 2016: Technology Collaboration Programmes: Highlights and outcomes. https://webstore.iea.org/download/direct/349

[25] IEA Framework, ibid.

[26] https://www.iea.org/about/structure

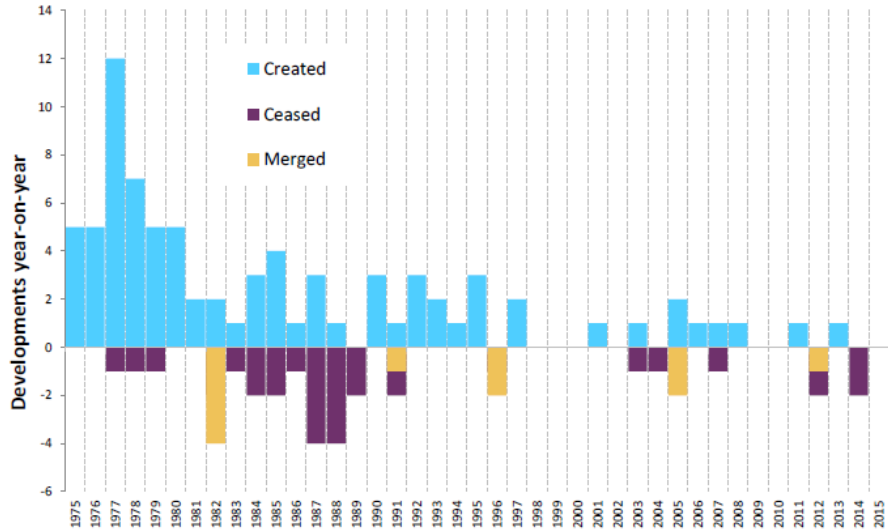

Figure 2: Numbers of TCPs created, ceased or merged since the start of the programme (source: IEA, 2016).

The 39 TCPs active as of December 2015 were in the following categories: crosscutting (2), end-use (industry (1), electricity (3), buildings (5), transport (5)), renewable energy and hydrogen (10), fossil fuels (5) and fusion power (8).[27] In terms of **R&D cycle stage**, in addition to the technology-oriented work, all cover "socio-economic issues", and most concern themselves with market introduction and sectoral analysis, as well as characterisation and in-situ testing of new energy or energy-related technologies. All TCPs in the transport, renewable energy and hydrogen, fossil fuels and fusion categories also work on basic science, although this does not necessarily mean that fundamental research experiments are actually conducted funded or initiated by the TCP.[28] The TCPs gravitate towards the steps that need to be taken towards commercialisation of the technology.

While initially the topics of the TCPs were related to strengthening energy security from both demand- and supply-side perspectives, in the 1980s the **focus** shifted to more environmentally friendly and safer technologies, for instance in nuclear energy. In the late 1990s, in response to the UNFCCC and its Kyoto Protocol, there was a further shift to technologies related to greenhouse gas emission reduction and novel renewables. In the past decade, new TCPs reflect current concerns and opportunities related to the spread of technologies such as ICT, comprising the likes of electricity networks, smart-grids, and energy use of appliances, including networked equipment. Furthermore, existing TCPs have incorporated cross-cutting issues (such as finance) and multi-disciplinary approaches (such as research related to social acceptance and policy for technologies).

As there are many TCPs, and many have been operational for decades, the **achievements** of the IEA TCPs comprise a long list, including demonstrations and meetings. Several aims have been common to all TCPs, and can be evaluated as follows:

- In all TCPs, **research coordination** is an important aim, which is generally achieved, depending on the number of participants. Meetings put together by a TCP are generally seen to reflect the cutting-edge of the technology or sector.
- **Awareness raising** was an aim of every TCP. Whether this aim was achieved has not been investigated.
- The **organisation of TCPs stayed focussed and nimble** through the IEA Governance Framework, which is generally followed.

[27] Ibid, p55.
[28] Ibid, p55.

There are as many **organisational models** as there are TCPs. One distinction that is sometimes made is between "task sharing and "cost-sharing" models (or combinations thereof).[29] In task-sharing TCPs, members all bring their own **funding** and may collaborate on R&D and exchange knowledge. An example is the Industrial Energy-related Technologies and Systems (IETS) TCP, founded in 2005 out of a merger of several more specific, industry-related programmes. The IETS "increases awareness of technology and energy efficiency in industry, contributes to synergies between different systems and technologies, and enhances international cooperation related to sustainable development".[30] Ongoing Annexes in the IETS include energy efficiency in the iron and steel industry, membrane processes in biorefineries and digitalisation.[31] These Annexes each have own work plans and activities; for instance, the digitalisation annex plans to deliver a white paper on the opportunities and impacts of digitalisation on energy efficiency and greenhouse gas emission reduction in industry.

In cost-sharing approaches, this may happen too but in this case the TCP also pools some **funding**, e.g. for a secretariat and collaborative research funding, in a Common Fund. An example is the IEA GHG R&D programme (IEA GHG), which was founded in 1991 and mostly focuses on CO_2 capture and storage (CCS). The IEA GHG aims to "assess the role that technology can play in reducing greenhouse gas emissions from both the power system and from industrial processes". Rather than the organisation hosted by one of its members and members conducting studies (like in the IETS TCP and other task-sharing TCPs), the IEA GHG employs a ten-person team that commissions studies on topics related to its mandate. Its 2019 Annual Report mentions 36 members jointly contributing over GBP1.5 million, with almost 40% of the budget going to technical reports. Recent technical reports were, for instance, reviews of how to get to zero-emission CCS or sustainable petrochemicals.[32] The IEA GHG also organises a major global research conference on CCS, the Greenhouse Gas Technologies (GHGT) conference, every year and a half, which will happen for the 15^{th} time in 2021, and which in past editions has attracted over a thousand delegates.

Both organisational models and the **type of activities** implemented have shifted over time. In the initial phase, some TCPs actually built **demonstrations**, the largest of which was a pilot plant of a fluidized bed converter, for which 60 people were employed. In recent decades, more TCPs were coordination bodies and predominantly task-sharing. By far not all TCPs focus on RD&D cooperation. The crosscutting Climate Technology Initiative, as an example, has an activity, the Private Financing Advisory Network (PFAN), which aims to bridge the gap between financeable, mostly renewable energy projects in developing countries and private sector investors, and saw through 19 project deals (for a total of 190 MW).

4.3.3. Key success factors and lessons learned of the TCP programme

A key question is whether the IEA TCPs can be seen as international RD&D cooperation as defined in this brief. While some TCPs meet the criterion of different countries or regions jointly conducting (or funding) climate technology RD&D activities, many task-sharing TCPs are focussed on knowledge exchange and coordination of an RD&D agenda, for instance through technology reviews or meetings. Nevertheless, a number of lessons and success factors for RD&D can be identified.

First, the TCPs are mostly **technology- (and sometimes sector-) specific**. This allows for the engagement of specialists, which benefits the depth of discussion in knowledge exchanges.

Second, the **combination of a top-down framework design with bottom-up flexibility** seems to be replicable. The top-down framework is prescribed and governed by the IEA. Within the framework, the TCPs themselves are organised in a bottom-up fashion, by the founding members. The TCP framework leaves sufficient room for a flexible design, adapted to the needs of the technology and the actors. For the purpose of TCPs – international coordination between relatively affluent countries - this model has proven replicable, but it does have difficulty engaging less affluent countries.

[29] IEA, 2011 Handbook for IAs: https://iea-industry.org/app/uploads/iea_handbook_for-ias_7_oct_2011.pdf; Coninck, H.C., de, C. Fischer, R. Newell, and T. Ueno (2008): International Technology-oriented Agreements to Address Climate Change. Energy Policy 36: 335-356.

[30] IETS Brochure, consulted September 2020 (available via https://www.iea.org/areas-of-work/technology-collaboration/industry).

[31] https://iea-industry.org/annexes/, consulted September 2020.

[32] https://ieaghg.org/publications/technical-reports/reports-list/9-technical-reports, consulted September 2020.

Third, the IEA Governing Board consistently maintained its interest in the TCPs. Since the Governing Board is populated by ministers of senior representatives of IEA Member States, this means that **high-level support** is maintained. As TCP Executive Committee (ExCo) members are representatives of governmental organisations, feedback of the results to the Member countries is ensured. In addition, since the organisation of the IEA TCPs is with an international organisation (and not dependent on any one country, where priorities can change), its design can be considered as **apolitical and content-focussed**.

Fourth, **what works for developed countries may not work for developing countries**. Although opening up for non-OECD countries enhanced the diversity of views brought to the table in TCPs, the TCPs still represent an OECD-dominated group of programmes. Some developing countries, though, are participating in more TCPs than some IEA countries; Mexico and China, for instance, are a member of many more TCPs than Poland or New Zealand. However, no Least-Developed Countries participate in any TCP.

A final lesson learned is that **synthesis is needed for learning lessons**. Independent assessment and evaluation of the IEA TCPs seems to have happened sparingly, or the IEA oversight has kept such evaluations internal. Robust conclusions on replicability could therefore not be drawn. This means that for this case study, only information provided by the IEA could be included.

4.3.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives:

- **Being adaptable to changes** over time allowed the topic focus of the TCPs to be modernised, reflecting the current themes.
- **Finding a good balance between top-down facilitation and bottom-up control**. In any case, allow each technology-specific programme to design its own organisation and course of action.
- **Being apolitical and identifying a broad coalition of countries** with no single country (or politician) clearly in the lead allows for continuity as priorities of individual countries may change.
- There has been little evidence of good practices related specifically to non-OECD involvement in the TCPs. In this context, it is telling that **least-developed countries are largely absent** in the TCPs. Considering pooling funding for enhanced participation could make the TCPs more inclusive.

4.4. Improved Drought Early Warning and FORecasting to strengthen preparedness to droughts in Africa (DEWFORA)

4.4.1. Key characteristics

Focus	Mitigation/Adaptation	Adaptation
	Technology cycle stage	Prototype, demonstration
	Sector	Water - drought management
	Geographical scope	Regional; N-S
	Geographical participation	Africa, EU
Organisation	Format	Plurilateral consortium
	Actors	Research institutes, universities; science application institutes; operational agencies responsible for meteorological forecasting, drought monitoring and famine warning; and established knowledge networks in Africa.
Budget	Project budget	€ 4.4 million in total (01/2011 – 01/2014)

4.4.2. The initiative

DEWFORA was a collaborative project that ran from 2011 to 2013 with the **objective** of developing a drought early warning and forecasting system, and to strengthen preparedness and adaptation in Africa.[33] The project traces its

[33] https://publicwiki.deltares.nl/display/DEWFORA/DEWFORA+-+FP7+project, consulted September 2020.

origins back to the institutional framework for RD&D and international cooperation of the Africa-EU Partnership, which was established at the first Africa-EU Summit in Cairo in 2000. This partnership provides an overarching long-term political framework for Africa-EU economic cooperation in areas of common interest, including climate change, global security, and the sustainable development goals (SDGs).[34]

In July 2009, the European Commission (EC), as part of the Framework Programme for Research and Technological Development (the EC's main instrument for funding research and innovation, known as FP7 in its latest instalment), issued a call for proposals entitled "Call for Africa".[35] The aim of the call was to address science & technology-related objectives of the Africa-EU Strategic Partnership through the funding of a wide range of research projects related to three themes, one of which was "Environment (including climate change)". One of the topics in the call for proposals was "Integrated management of water and other natural resources in Africa", which had three main **goals**:

- Improve the state of knowledge on the relation between drought and climate change and contribute to improved early warning and forecasting systems.
- Help to better identify vulnerable regions and further strengthen preparedness and planning capacities in Africa.
- Contribute to capacity building.

The call for projects aimed to incorporate knowledge from African countries and to facilitate capacity building by requiring at least two of the project consortium partners to be from African countries. The winning consortium consisted of nineteen partners, including ten from Africa and nine from Europe, as shown in Table 6.

Table 6: Overview of participants in the DEWFORA project, Source: Community Research and Development Information Service (CORDIS), European Commission (https://cordis.europa.eu/project/id/265454, consulted September 2020).

Partner type	Partner name	Country
Weather and climate service providers	Nile Forecast Center,	Egypt
	IGAD Climate Predictions and Applications Centre	Kenya
	European Centre for Medium Range Weather Forecasting	United Kingdom
Universities and research institutes	Dinder Center for Environmental Research	Sudan
	Faculty of Engineering, University Eduardo Mondlane	Mozambique
	Council for Scientific and Industrial Research	South Africa
	Deltares	Netherlands
	Joint Research Centre – Institute for Environment and Sustainability	Italy
	UNESCO-IHE Institute for Water Education	Netherlands
	Potsdam Institute for Climate Impact Research	Germany
	GFZ German Research Centre for Geoscience	Germany
	Universidad Politecnica de Madrid	Spain
	Mediterranean Agronomic Institute of Zaragoza – International Centre for Advanced Mediterranean Agronomic Studies	Spain
	Faculdade de Engenharia da Universidade do Porto	Portugal
NGO	Wetlands International – Sahelian Sub Regional Office	Mali
Private consulting firm	WR Nyabeze & Associates	South Africa
Regional networks for research and capacity building	WaterNet Trust	Zimbabwe
	Nile Basin Capacity Building Network for River Engineering	Egypt

[34] https://africa-eu-partnership.org/en, consulted September 2020.

[35] http://ec.europa.eu/research/participants/portal/doc/call/fp7/fp7-africa-2010/13072-abf_ct_201005_en.pdf, consulted September 2020.

The core work packages of the project focused on assessment of existing drought forecasting and management practices, evaluation of drought vulnerability and risk, and development of tools for drought forecasting. In parallel, the project also explicitly incorporated work packages for:[36]

(i) Implementation of the developed tools in six case studies;[37]
(ii) Working in close interaction with potential implementers and users of the drought early warning information system; and
(iii) Dissemination of knowledge to the broader scientific and policymaking communities through stakeholder meetings, conferences, development of training courses, and even two video documentaries.

The main **achievements** of DEWFORA include the following:[38]

- An assessment of the current state of drought forecasting and warning across Africa;
- The development of an approach to assessing vulnerability of exposed societies to drought, and validation of the framework at both a continental and a regional scale;
- The development of projections of changes in frequency of occurrence and severity of droughts across Africa using high-resolution simulations;
- An assessment of the skills with which existing meteorological and hydrological and, to a more limited extent, agricultural models can be used to forecast relevant drought parameters across Africa;
- The development of a protocol that can be used to develop drought forecasting and warning;
- 18 scientific articles in peer reviewed journals.

4.4.3. Key success factors and lessons learned

DEWFORA's achievements can be attributed to at least three main factors.

First, **long-term frameworks for collaborative RD&D** (specifically, the Africa-EU Strategic Partnership and the EU Framework Programme for Research and Technological Development to fund joint RTD projects) helped ensure high-level political commitment and allocation of resources for projects such as DEWFORA in the first place. These frameworks also ensure that DEWFORA is part of a larger portfolio of follow-up projects aiming at addressing other aspects of drought forecasting and warning. For example, Horizon2020 (the EU's RTD funding programme succeeding FP7) funded the AfriAlliance project (running from 2016 to 2021), which brings together 16 EU and African partners. It aims at consolidating existing networks consisting of scientists, decision makers, practitioners, citizens, and other key stakeholders to work together in the areas of water innovation, research, policy, and capacity development.[39] Similarly, the DOWN2EARTH project[40] (also funded by Horizon2020) runs from September 2020 to August 2024 and aims at translating climate information into multilevel decision support for social adaptation, policy development, and resilience to water scarcity in the Horn of Africa Drylands.

Second, from its very inception, the project's design ensured that **a variety of knowledge sources were combined** to maximize the effectiveness, utility and dissemination of the developed tools and protocols for drought forecast and warning. For example, the project partners were chosen to represent a range of expertise from different geographical

[36] https://cordis.europa.eu/docs/results/265/265454/final1-dewfora-final-report-final.pdf, consulted September 2020.

[37] Four regional case studies focused on the Easter Nile Basin, the Limpopo Basin, the Oum-er-Rbia Basin and the Niger Basin. In addition, two more case studies focused on development and testing of a Pan-African forecasting system, and a comparative review of drought forecasting in European and African river basins.

[38] https://cordis.europa.eu/docs/results/265/265454/final1-dewfora-final-report-final.pdf, consulted September 2020.

[39] The activities of AfriAlliance are organized into ten demand-driven action groups: Arid African Alluvial Aquifers for Agriculture (A4A); Upscaling the Potential of Water Harvesting Across Africa; Integrated Water Resource Management and Ethics; Efficient and Innovative Small-Scale Irrigation (EISSI); Sustainable Intensification for Resilience and Food Security (SIRAF); Tailor-Made Socio Economic Approaches for IWRM (SoWAT); Scaling of Citizen Science based Water Resource Monitoring (Ubuntu); Planning for Drought in Semi-Arid Africa (P4D); Mara Water and Wetland Watch; and The African Alliance for Water Stewardship Action Group (AWS).

[40] https://cordis.europa.eu/project/id/869550.

contexts and domains (see Table 6), enabling the project to achieve its programme design, implementation and dissemination goals. Furthermore, a systematic review of the state of the art in drought forecasting and warning in Africa revealed that in practice, **traditional knowledge** is applied more than formal systems for drought management. This pointed towards the need to link formal monitoring and early warning systems to local knowledge systems coupled with methods that support learning and adaptation. In addition, a **user-oriented approach** was taken by integrating potentially drought-affected groups at an early stage in the development of forecasting tools (learning-by-interacting), to ensure that the tool can provide user-oriented metrics that can inform decisions of local planners and farmers. Finally, a strong emphasis was placed on not only developing the tool, but also implementing it across a wide variety of contexts in the form of four case studies (learning-by-doing). This helped in validating the model, and in refining drought and vulnerability indicators based on learnings from contexts with different socio-economic conditions, organizational setups and institutional practices.

Third, the DEWFORA project placed emphasis on **development of tools and protocols that are flexible and adaptable** to different geographic (climatic, hydrological and agricultural), socio-economic and regulatory contexts in Africa. In particular, this was done by not only developing solutions for the four case studies, but also developing models that can be applied at different geographic scales (water basin, national and continental levels), and a generalized protocol that can be applied to develop and implement forecast and warning systems in different contexts.[41]

However, there are some inherent limits to the **replicability and scalability** of the developed tools due to the highly context-specific nature of resource availability, vulnerability of populations, and measures needed for effective drought preparedness, mitigation and recovery. The final project report cited "capacity gaps at different levels (policy and decision makers, researchers, meteorologists, technology transfer, farmers, communities, etc.)" as an impediment to effective drought forecasting and warning.[42] Although capacity-building was an explicit goal of the project, the relatively short time scale of the project is likely to have been insufficient to fully address these capacity gaps, thus suggesting the **need for longer-term engagement**. This emphasises the importance of ensuring continuity in follow-up activities, such as with the subsequent AfriAlliance and DOWN2EARTH projects.

4.4.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives:

- **Matching the time horizon and organization of the initiative with the nature of the collaborative RD&D activity**: for example, continued political commitment may require long-term high-level legal frameworks; the development of specific tools and protocols by multiple partners is more suited to a short to medium-term project-based mode of organization; while collaborative RD&D initiatives with longer-term goals like knowledge transfer and capacity building require continuity through long-term institutional arrangements and embedding in local actors and institutions.
- **Incorporating a variety of knowledge sources**, including from collaborative RD&D partners with expertise in different (but relevant) knowledge domains, intended users of developed technologies, and local and traditional knowledge sources.
- Designing consortia for collaborative RD&D initiatives **to include participants representing the entire technology cycle**: in this case, this includes actors that are focused not only on developing the forecasting and warning system, but also actors focused on data collection, intermediaries for knowledge dissemination, and users of the generated knowledge and solutions.
- Extensive **testing of developed technologies and tools in diverse contexts** to understand and address challenges related to their replicability and scalability.

[41] The developed protocol involves guidance on answering four key question, with the research conducted in the DEWFORA project helping answer each one. The questions are "What is the science available?", "What are the societal capacities?", "How can science be translated into policy?" and "How can society benefit from the forecast?"

[42] https://cordis.europa.eu/docs/results/265/265454/final1-dewfora-final-report-final.pdf, consulted September 2020.

4.5. CGIAR

4.5.1. Key characteristics

Focus	Mitigation/Adaptation	Mitigation and Adaptation (not climate-specific)
	Technology cycle stage	Research to commercialization
	Sector	Agriculture (food)
	Geographical scope	Global, Triangular
	Geographical participation	Global
Organisation	Format	Plurilateral network
	Actors	National government agencies, industry, and research institutes
Budget	Between 2011 and 2020, on average ca. USD 500 million annually in contributions from national governments, multilateral organisations and private foundations.	

4.5.2. The initiative

The CGIAR (previously the Consultative Group on International Agricultural Research) was established in 1971 with the **objective** to grow agricultural productivity, reduce poverty and achieve environmental sustainability.[43] It started in the early seventies with seven international agricultural research centres (IARCs). Currently its core **organization** consists of 15 IARCs spread all over the world (see Figure *3*) as the locations of collaborative agricultural research, working across five broad themes and employing some 8000 people. A key characteristic of the centres is that each centre has its own crop or sector focus, and that they are connected to the geographical region in which they are located. The objectives of the CGIAR, as well as the task allocation and focus of the centres, have varied over time (see *Table 7*), as has the number of centres. However, one of the consistent threads through the decades of CGIAR's existence is that its IARCs have played a significant role in building capabilities in agricultural innovation in their respective regions.

In June 2020, CGIAR announced a 'fundamental reform', renaming itself into One-CGIAR, and **reorganizing** itself by consolidating the 15 IARCs.[44] Because this was a recent announcement of which the consequences cannot be evaluated yet, this case study will discuss the CGIAR before One-CGIAR. However, it is worth noting that climate change was mentioned as one of the global threats (next to biodiversity and Covid-19) that have led the CGIAR to decide that a model with greater collaboration was needed to help enable the needed transformations of the food system.[45]

Figure 3: CGIARs 15 International Agricultural Research Centres (Source: CGIAR Annual Report 2017/18).

[43] Renkow, Mitch and Derek Byerlee, 2010. The impacts of CGIAR research: A review of recent evidence. Food Policy 35, pp 391-402.

[44] See Jan Ruebel, 19 June 2020, Turning many into one: CGIAR network restructures: https://www.weltohnehunger.org/full-article/cgiar.html (consulted September 2020).

[45] See One-CGIAR, questions and answers: https://storage.googleapis.com/cgiarorg/2020/05/7f11164d-qa-transition-one-cgiar-20200520.pdf (consulted September 2020).

CGIAR builds on a long history of international centres for agricultural research. The Rockefeller and Ford Foundations are often credited with the institutional innovation of international, **problem-oriented research** centres with **longer-term funding** in 1960. They, in turn, built on developments that started after the 1st World War, in particular with the US Department for Agriculture (USDA) and the Food and Agriculture Organisation (FAO).[46] This went from sharing of materials and research results to aligning research plans, to uniform testing and pooling resources into one coordinated programme in USDA. After this, the value of this new R&D cooperation model was acknowledged by the FAO, which with the US helped establish spread of knowledge and practice in post-war Europe for maize and wheat in the 1950s. Initiated in India and spread throughout South and South-East Asia, a similar process took place for rice. Partly parallel to those crops, and partly with other crops, developments took place in Latin America, in particular Mexico and Colombia, and in Africa. The Rockefeller and Ford Foundations funded the research centres that formed the early IARCs, but a different governance model was needed to upscale the collaboration and expand to different crops and regions. Eventually this culminated into the formation of the CGIAR, which pioneered a long-term funding model combined with problem-oriented research and a flexible design of its IARCs.

Table 7: IARCs in CGIAR, their entry in the CGIAR and locations[47]

Center	Location	Year of entry into CGIAR	Mandate and/or commodity	Regional focus
Africa Rice Center (formerly WARDA)	Benin	1975	Rice	Sub-Saharan Africa
Bioversity International (formerly IPGRI)	Italy	1974	Plant genetic resources	Global
CIAT – International Center for Tropical Agriculture	Colombia	1971	*Phaseolus* beans, cassava	Global
CIFOR – Center for International Forestry Research	Indonesia	1993	Sustainable forestry mgmt	Global
CIMMYT – International Maize and Wheat Improvement Center	Mexico	1971	Maize, wheat	Global
CIP – International Potato Center	Peru	1973	Potatoes, sweet potatoes, other root crops	Global
ICARDA – International Center for Agricultural Research in the Dry Areas	Syria	1975	Barley, lentils, fava beans, wheat, chickpeas	Middle East, North Africa
ICRISAT – International Crops Research Institute for the semi-arid tropics	India	1972	Sorghum, millets, pigeonpeas, chick-peas, groundnuts	Semi-arid tropics (Asia and Africa primarily)
IFPRI – International Food Policy Research Institute	USA	1980	Policy	Global
IITA – International Institute of Tropical Agriculture	Nigeria	1971	Cassava, maize, cowpeas, yams soybeans, bananas, plantains	Africa
ILRI – International Livestock Research Institute	Kenya	1995[a]	Livestock	Global (emphasis on Africa)
IRRI – International Rice Research Institute	Philippines	1971	Rice	Global
IWMI – International Water Management Institute	Sri Lanka	1991	Irrigation, water mgmt.	Global
ICRAF – World Agroforestry Centre	Kenya	1991	Agroforestry, multi-purpose trees	Global
WorldFish Center (formerly ICLARM)	Malaysia	1992	Aquatic resources management	Global

[a] Merger of two livestock Centers that were previously members of the CGIAR.

The **activities** of CGIAR span the full RD&D cycle, ranging from basic research to the commercialisation of new technologies and practices. Moreover, they include data collection and sharing, socio-economic studies spanning all scientific disciplines, and interaction with stakeholders in partnerships. For example, its Climate Change, Agriculture and Food Security (CCAFS) programme includes both adaptation and mitigation but also aspects such as gender and development. Its activities include the development of technologies and practices for climate-smart agriculture and analyses of low-emission development pathways at the global and developing country level, using tools like participatory evaluation and trials with smallholders.

The **focus** of CGIAR has changed over time. As the **private sector** claimed a larger role in the agricultural R&D landscape,[48] CGIAR had to find new niches. With agricultural productivity growing and becoming less of a concern from a technological point of view, questions around integration of agriculture with sustainable development, **adaptation to climate change** and other environmental pressures, the **mitigation of greenhouse gas emissions** of agriculture and food production, and how to improve livelihoods for low-income farming communities have gained prominence over the past two decades. This newer focus is most prominent in the abovementioned CCAFS programme, but it also plays a role in other CGIAR programmes, such as the one on Policies, Institutions and Markets.

[46] For a fuller account of the multifaceted history before the establishment of CGIAR in 1971, see Byerlee, Derek and John K. Lynam, 2020. The development of the international center model for agricultural research: A prehistory of the CGIAR. World Development 135, 105080. This paragraph is an extremely abbreviated selection of information in that publication that does not do justice to the full story preceding the CGIAR.

[47] Renkow and Byerlee, 2010.

[48] According to Pardey et al 2016 (Nature 537, pp 301-303; https://www.nature.com/news/agricultural-rd-is-on-the-move-1.20571#/feed), the private sector share in global agricultural R&D spending has increased from 42% in 1980 to over 52% in 2011, with a much larger relative increase in middle-income countries.

The current CGIAR **budget** is based on the CGIAR Trust Fund contributions in three windows:[49]

- Portfolio investments support the CGIAR as a whole, and are agreed by the funders collectively;
- Programme investments are individual funders' contributions to a component of the overall CGIAR portfolio, which is agreed by the funders collectively;
- Project investments are individual funders' contributions to CGIAR activities defined by the funders themselves, often in collaboration with partners external to CGIAR.

Over the past decade, of the total USD 4.7 billion in contributions, about a third went to portfolio investments, a little under 20% to programme investments, and roughly half to project investments, which are defined by the funders, often in collaboration with partners. The funders are a group of forty (mainly developed) countries, multilateral banks and organisations, and private foundations. The largest contribution is from the US, followed by the Bill and Melinda Gates Foundation.

In terms of **outcomes**, CGIAR is attributed with considerable successes in impactful agricultural innovations, especially in the early decades of its existence. About a third of agricultural yield growth in developing countries between 1965 and 1998 can be attributed to CGIAR crop genetic improvement.[50] Although 'green revolution' was already underway as the CGIAR was established, it can be said that international R&D cooperation that led to the CGIAR was an important part of the basis for the vast improvement of agricultural productivity in the developing world, arguably reducing the incidence of famine significantly.[51]

4.5.3. Key success factors and lessons learned

International collaboration on RD&D in **international, regionally contextualised centres** are the core success factor of the CGIAR. This started even before the CGIAR itself but could be upscaled and expanded through the formation of the **umbrella organisation** of the CGIAR, an institutional innovation that has had no rival since in any other sector. The CGIAR allowed for the expansion of funding from private foundations to public institutions, which enabled a doubling of the total budget for the IARCs. It provided exactly the efficiency, knowledge exchange and coordination needed in a then highly fragmented global agricultural research field.

The CGIAR and its IARCs have shown **flexibility in the context of changing circumstances**, although this has not been without challenges. Progress in genetic research and advancing innovation systems in several major economies have allowed private actors to reap the 'easy' benefits in terms of RD&D that quickly led to market-ready products. CGIAR, with its mission of 'substitute for weaknesses in national research programmes' and 'building national capacity' has thus faced greater difficulties in running projects with concrete results,[52] and demonstrating the impact of its activities. The more complex, less product-focussed challenges[53] that the agricultural sector faces related to natural resource management in the 1980s and 1990, broader societal issues and multidisciplinarity, and currently the SDGs, demand new models for the CGIAR. This has spurred a search for new research structures.[54] The relationship between climate change (adaptation and mitigation) and agriculture is no exception to this. Climate change is a major reason for CGIAR to embark on the One-CGIAR reform, which aims to speed up the response and learning on solutions by 'deploying scientific innovations faster, at a larger scale and at reduced cost'.

The CGIAR and its individual IARCs have been the subject of **academic investigation** over the years. In addition, an element of the CGIAR that has contributed to its success is the establishment, in the 1990s, of the Standing Panel on Impact Assessment (SPIA), which focussed on developing and promoting ex-post impact assessment for crop genetic improvement research, natural resource management and policy analysis. Having an **independent impact assessment** unit (SPIA) with scientific autonomy has helped improving research effectiveness and efficiency.

4.5.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives:

- **Establishing problem-focussed research centres** allows for the accumulation of top-notch knowledge and specialist capabilities in the specific crop or issue.

---

[49] See https://www.cgiar.org/funders/trust-fund/trust-fund-contributions-dashboard/.

[50] Renkow and Byerlee, 2010: Table 2.

[51] Byerlee, Derek and John K. Lynam, 2020.

[52] Mazzucato (2013) signals this (for other fields than agriculture) in her book "The Entrepreneurial State". Because private companies are picking the low-hanging fruit, publicly funded entities are left with the tougher research problems, which are riskier in terms of reaching outcomes.

[53] So-called 'wicked problems' – challenges for which the problem is unstructured and the – often contested – solutions change the problem

[54] Byerlee and Lynam, 2020.

- **Embedding the IARCs in specific regions** contributed to capacity building in those regions. Normally this happens in institutions in developed countries and developing country researchers need to leave their countries to find the best research facilities. It is unique that the opposite succeeded with CGIAR: some of the world-leading agricultural research was done in developing country contexts.
- **Following a mixed funding model** in three windows (portfolio, programme and project) enabled both core funding to the CGIAR and its institutes, enabling basic research infrastructure, as well as allowing funders to indicate and fund their own preferences in the project funding window.
- **Conducting evaluations and impact assessments through an independent, dedicated body** can provide credible information transparently and allows for academic reflection and research.
- Having a centralised leadership structure that showed **flexibility** in the context of a changing agricultural research landscape has allowed a large organization like CGIAR to adapt to global trends in technologies and challenges. Currently, with One-CGIAR, the organisation is trying to respond to major global threats such as climate change.

4.6. Joint Initiative on Research, Innovation and Technology (JIRI)

4.6.1. Key characteristics

Focus	Mitigation/Adaptation	Not climate-specific, covers mitigation and adaptation
	Technology cycle stage	R&D financing
	Sector	Cross-cutting
	Geographical scope	International/Regional (bi-regional); N-S, S-S
	Geographical participation	EU, Latin America and Caribbean states, SIDS
Organisation	Format	Plurilateral platform
	Actors	Governments, government implementing agencies, research and educational organisations, industry, SMEs
Budget	ERANET LAC project	€ 2.9 million in total (2013-2017) from FP7
	Joint calls for tenders	€ 37.5 million in total (2013-2018)
	JIRI	Unknown

4.6.2. The initiative

The EU and the group of Latin American and Caribbean States established a strategic partnership at the first EU-LAC Summit in 1999, in which the Community of Latin American and Caribbean States (CELAC) is the EU's official counterpart for the region-to-region partnership and summit process. The framework of the partnership commits to working ‘in an inclusive manner and on equal terms for both regions’ on the issues covered by the bi-regional declarations and action plans.[55,56,57]

In 2018, a declaration by EU_CELAC Ministers of Foreign Affairs, "Building bridges and strengthening our partnership to face global challenges”, highlighted the key role of JIRI and the progress made within the CRA to address global challenges, including climate change.[19]

The 2010 Action Plan established the Joint Initiative on Research and Innovation (JIRI) with the **objective** to promote a ‘regular bi-regional dialogue on Research & Innovation’ between the EU and LAC. The **focus** of the cooperation has been on common challenges such as **climate change** and biodiversity, bioeconomy, energy, health and ICT covered in 5 thematic Working Groups (WGs), co-chaired by representatives from both regions. The broad scope and the **organisation** of the cooperation allows each participating country to pursue activities in line with its national priorities, including where applicable its **NDC, National Adaptation Plan (NAP) and Technology Needs Assessment (TNA)**. JIRI is implemented through Senior Officials Meetings with EU-LAC representatives aiming at

55 It also refers to ‘major international conferences, summits and special sessions on issues of worldwide concern, including particularly the Third International Conference on Financing for Development and the Post-2015 Development Agenda to deliver an outcome combining poverty eradication, and sustainable development; and COP21. EU-CELAC 2015 Summit Political Declaration ‘A partnership for the next generation’.

56 1. Science, research, innovation and technology; 2. Sustainable development; environment; climate change; biodiversity; energy; 3. Regional integration and interconnectivity to promote social inclusion and cohesion; 4. Migration; 5. Education and employment to promote social inclusion and cohesion; 6. The world drug problem; 7. Gender; 8. Investments and entrepreneurship for sustainable development. 9. Higher education 10. Citizen security. EU-CELAC 2015 Summit, EU-CELAC Action Plan, https://www.consilium.europa.eu/media/23757/eu-celac-action-plan.pdf

57 European Commission, 2018, Roadmap for EU - CELAC S&T cooperation, https://ec.europa.eu/research/iscp/pdf/policy/celac_roadmap_2018.pdf

consolidating EU-LAC cooperation by 'updating common priorities, encouraging mutual policy learning and ensuring the proper implementation and effectiveness of cooperation instruments through biannual Action Plans'.[58]

The main **achievements** of JIRI include the following:

- A consolidated Science and Technology bi-regional dialogue through the WGs which identify concrete areas for thematic cooperation;[59]
- The establishment of a Common Research Area (CRA) with three 'pillars': mobility of researchers, access to research infrastructure and jointly addressing common challenges;
- The launch of the EU-funded ERANet-LAC project, with the aim to support the political process of implementing JIRI. The project started in 2013, bringing together 17 funding agencies from Europe and CELAC, co-funding calls for joint research projects. The project consortium consisted of partners from 18 countries, of which 8 from LAC countries. So far, a total of 36.5 million Euro in project funding has been allocated;
- The establishment of the EU-CELAC Interest Group (IG) to take over the role of the ERANet-LAC project consortium at the end of the project in 2017. The IG consists of 28 funding agencies from Latin America, the Caribbean and Europe that want to collaborate in bi-regional science, technology and innovation (STI), and the implementation of the CRA through joint actions;
- The establishment the EU-CELAC Platform, an information and communication website for funding agencies, universities, research centres, enterprises and individuals interested in the bi-regional cooperation on Research and Innovation. It also serves as a 'meeting point' of the IG. The Platform is supported and maintained by the Spanish Foundation for Science and Technology (FECYT).

The ERANet-LAC project and the subsequent EU-CELAC IG so far have organised four annual calls for proposals between 2013 and 2018 (see *Table 8* for details). In total, 335 proposals were submitted, of which 271 were deemed eligible for funding and 64 were actually funded, for a total budget of €36.5 million (20% of total requests for funding for all proposals). Success rates ranged across topics, from 14% for biodiversity projects and 30% for energy projects (both in share of projects funded and share in budget funded). Climate change is not identified as a separate topic area, but cuts cross across all other areas.[60] Funded projects comprise various types of activities, ranging from developing joint knowledge platforms to research on new materials, laboratory testing and piloting of (combinations of) technologies.[61]

Table 8: Number and budget of proposals funded from 2013 to 2018 (Source: EU-CELAC platform, https://www.eucelac-platform.eu/)

Scope[62]	Proposals requested/eligible	Proposals funded	Budget funded (requested) Million Euro
All	335/271	64	36.5 (186.4)
Health	122/99	29	16.2 (70.1)
Energy	27/24	8	4.9 (15.7)
Bioeconomy	78/64	14	7.3 (40.0)
Biodiversity	83/64	12	5.2 (37.4)
ICT	25/20	6	2.9 (13.2)

Of the **funding**, 68% originated from Europe and 32% for LAC countries. **Participating actors** were mostly from 'higher education' (52% of the total number of participants), 'researchers' (42%), but industry (2%), SMEs (2%) and 'other' groups (3%) also participated. [63] The organisation and activities of the funding agencies builds on the National Contact

[58] EEAS, 2018, EU-CELAC relations, https://eeas.europa.eu/headquarters/headquarters-homepage_en/13042/EU-CELAC%20relations

[59] Since 2016 there is also a cross-cutting WG on 'Research Infrastructure', with the aim of 'facilitating multilateral initiatives leading to a better use and development of research infrastructures amongst the two regions'. Its activities so far have mostly comprised meetings and policy workshops.

[60] For example, 'ICT' includes projects on disaster preparedness and sustainable transport in smart cities, 'biodiversity' on the impacts of climate change on fish or on biodiversity management and the use of microalgae for industrial purposes.

[61] Some typical examples are 'Transnational cooperation for development of a solution for saving energy and water in small near coast facilities using simple devices harnessing the ocean energy' and 'Amazonian fishes and climate change' (developing GIS tools and impact scenarios to help developing regional conservation programmes).

[62] Statistics do not identify climate change as a separate area.

[63] The EU-CELAC platform, https://www.eucelac-platform.eu/

Points (NCPs), national structures established and financed by governments of EU Member States and states associated to the EU framework funding programmes (FP7, H2020).[64] NCPs provide local personalised support. The organisation of such a NCP system can vary strongly between countries, ranging from a highly centralised approach to decentralised networks, with actors potentially involving ministries to universities, research centres and special agencies to private consulting companies. The Latin America and the Caribbean countries established the LAC NCP Network, which has been working since 2017. This comprises 28 countries in the region, including 10 SIDS.[65]

4.6.3. Key success factors and lessons learned

An important contributor to JIRI's achievements is that it is part of a long-term cooperation between the regions covering a broad scope with **high-level political commitment** and involvement, combined with **practical and technical implementation.**[66] Structural processes, with regular meetings, an overarching framework and co-chairing from both regions at all levels have resulted in real **joint ownership**. This has been concretised by involving a large community of stakeholders in individual projects through the joint funding calls, which also facilitates matching of the joint activities with each country's own needs and existing RD&D (and funding) infrastructure.[67] So, while the programme does not make a specific link to countries' **NDCs** or **TNAs**, the programme set-up facilitates directing the activities to be in line with their priorities.

JIRI has shown the ability to move from more traditional North-South support to a form of cooperation which is more North-South-South focused, transitioning from a bi-regional collaboration to a multilateral network. Or, as formulated at an OECD workshop on New EU development cooperation strategies in Latin America and the Caribbean: "the EU-Latin America relationship is moving from a *traditional* cooperation model toward a strengthened ***peer learning*** model, where the will to share experiences and to learn from innovations appears to be more decisive than the funds".[68] As concluded in an earlier case study of EU-CELAC,[69] this shows how the development or strengthening of institutions can initially be the objective of collaborative programmes, to subsequently become drivers for further collaboration in a later stage.

"The EU-Latin America relationship is moving from a *traditional* cooperation model toward a strengthened ***peer learning*** model, where the will to share experiences and to learn from innovations appears to be more decisive than the funds."

In this context, JIRI and the joint calls for tender have the advantage of being able to combine **countries in different development stages**, also within LAC. Countries with less advanced STI infrastructures can then learn by doing, learning not only from EU partners, but also from more experienced countries within the region. This was also an explicit objective of the ERANet LAC[70] project. The project consortium itself included science agencies, councils or ministries from Argentina, Brazil, Chile, Mexico, Panama, Peru, Uruguay and Barbados, with available funding used to implement activities also in countries outside the consortium such as such as Guatemala, Colombia, Bolivia, Venezuela, also including **SIDS**, such as Jamaica, the Dominican Republic and Cuba.[63] This set-up also allows for a large scope (many countries) as well as a phased **scale-up**, when countries have built up sufficient capacities and infrastructures to initiate and coordinate STI projects themselves.

The ERANET LAC project was also designed with **sustainability** of the initiative in mind.[70] The 18 consortium members, together with 11 non-partner funding organizations established the EU-CELAC IG to organize future joint actions. The project also established the EU-CELAC platform as an information platform for the funding agencies, as well as tools for finding cooperation partners and online submission of proposals. The 3rd call for tenders of December 2017 was the IG's first pilot joint call, with the participation of 23 funding organizations from 21 countries.

---

[64] European Commission, National Contact Points for Horizon 2020, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/support/ncp

[65] One addition SIDS, Barbados, was one of the consortium partners in the ERANet LAC project.

[66] See also: Tecnalia, 2018, New horizons shaping science, technology and innovation diplomacy: the case of Latin America and the Caribbean and the European Union, http://aei.pitt.edu/102628/1/2020.20.pdf

[67] This is also in line with the EU's Smart Specialisation Strategy (SSS) of 2012, with considerations on clustering in regional innovation ecosystems, in which the regional presence of a wide diversity of interrelated innovation actors are important factors for growth.

[68] http://www.oecd.org/dev/dev-week-eu-development-cooperation-strategies-latin-america-caribbeans.htm

[69] Leijten, J. 2019, Innovation policy and international relations: directions for EU diplomacy. Eur J Futures Res 7, 4 (2019). https://doi.org/10.1186/s40309-019-0156-1

[70] ERANET LAC project Final Report Summary, 2018, https://cordis.europa.eu/project/id/609484/reporting

In principle the above approach is **replicable** to other countries and regions, especially as the approach on the EU side is based on its long-term views and strategies in terms of international cooperation, supporting sustainable development in the broad sense, as well as supporting STI within Europe and abroad, and the opportunities provided by participation in the EU structural funding programmes (FP7, H2020). It would require on the side of the cooperating region the political intention as well as the institutions, processes and infrastructure for regional coordination and integration. This could be limited to a selected number of countries that can lead regional STI developments and support the development of capabilities and infrastructure in other countries in the region.

4.6.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives:

- **Embedding the RD&D collaborative initiative in a broader, long-term cooperation**, connecting high-level political processes and commitment with implementation processes and institutions at technical level as part of an overarching framework and strategy;
- **Ensuring equal partnerships and joint ownership** through the organisation of structural processes and approaches, e.g. through (1) co-chairing by both partners at all levels and (2) the inclusion of organisations from both regions in the activities in different roles, especially at the strategic level (such as the setting objectives and priorities) and the funding activities;
- **Engaging a large number and variety of countries and parties** in the programme, with the possibility of selections of those to participate in specific projects and in different roles, allowing both flexibility to match activities with national needs and capacities and twinning higher capacity and lower capacity countries and partners to facilitate mutual learning and capacity building;
- **Building on existing structures and processes** for supporting STI as far as possible, including science councils and funding agencies;
- **Designing initiatives for sustainability**, i.e. if initial support and funding for the initiative is limited in time, ensuring that during that period more structural entities, processes and funding sources are identified and set up to keep the initiative active and effective beyond that period.

4.7. Ibero-American Programme for Science, Technology and Development (CYTED)

4.7.1. Key characteristics

Focus	Mitigation/Adaptation	Not climate-specific, covers mitigation and adaptation
	Technology cycle stage	RD&D to commercialisation
	Sector	Cross-cutting
	Geographical scope	International, regional, country; N-S, S-S
	Geographical participation	Spain, Portugal + 19 Latin American & Caribbean Spanish/Portuguese-language countries
Organisation	Format	Plurilateral platform
	Actors	Governments, government implementing agencies, research and educational organisations, industry, SMEs
Budget	Programme	5M-20M USD per year
	Individual projects funded in programme	Maximum 250,000 USD per year for a maximum of 4 years
	Thematic networks	Maximum 30,000 USD per year

4.7.2. The initiative

The Ibero-American Programme for Science, Technology and Development (CYTED) was created in 1984 by 21 Spanish and Portuguese speaking countries in Europe and Latin America, with the **objective** to contribute to the 'harmonious development of the Ibero-American region through cooperation mechanisms that seek scientific and technological results, transferable to production systems and social policies'.[71] Since 1995 CYTED has been formally included in the Cooperation Programmes of the Ibero-American Summit of Heads of State and Government. CYTED acts as a bridge for interregional cooperation in Science and Technology between Europe and Latin America. Its **specific goals** are:

[71] http://www.cyted.org/

- Encouraging the integration of the Ibero-American Scientific and Technological Community, promoting an agenda of shared priorities for the region.
- Strengthening the technological development capacity of Ibero-American countries through the promotion of joint scientific research, the transfer of knowledge and techniques, and the exchange of scientists and technologists among R&D and Innovation groups in the member countries.
- Promoting the participation of business sectors from member countries interested in innovation processes, in accordance with the research and technological developments of the Ibero-American Scientific and Technological Community.

The CYTED programme **organisation** uses a decentralized model, building on the national bodies responsible for science and technology policies (ONCYT) of the 21 participating countries. The political decision-making body of the CYTED Programme is the General Assembly, and the General Secretariat is its management body. Each ONCYT is responsible for managing the programme in its own country and is represented in CYTED's administration bodies. The programme's activities are funded from the budgets of the ONCYT, with additional funding from the Inter-ministerial Commission for Science and Technology of Spain, the Spanish agency for International Cooperation, and some other volunteer contributions by different countries.71

The CYTED Programme currently has eight thematic areas, priority areas for the Ibero-American region as established by the General Assembly:

- Agrofood - solving food security problems and increasing the added value of products from agriculture, fishing and aquaculture;
- Health - improving health conditions in areas related to infectious diseases, public health and epidemiology, medical biotechnology, chronic and degenerative diseases, and medicines;[72]
- Industrial Development – addressing issues related to raw materials use, material and product design efficiency, waste and related socio-economic and environmental impacts;
- Sustainable Development – responsibly managing natural and cultural resources, food, health, biodiversity, environment and clean energy resources;
- ICT - reducing the gap between developed and developing countries caused by increased use of ICT;
- Science and Society - making science more accessible and encouraging the involvement of Ibero-American citizens in scientific and technological advances;
- Energy - promoting universal access to energy services through increased energy savings and diversification of energy sources, including renewable energy and new energy carriers.
- Business Incubator - increasing the competitiveness of national industries through access to new technologies and innovation and international markets and funds.

Climate change is not a separate thematic area, but both the Sustainable Development and Energy thematic area cover substantial mitigation activities (renewable energy, energy savings, recycling, etc). Adaptation activities are also covered under 'Sustainable Development'.[73] An example is a project that promotes adaptation to climate change through the analysis of the biodiversity and ecosystems of coral reefs, seagrasses and mangroves in active collaboration with production activities.

Each year, CYTED launches a **call for proposals** to carry out actions in the above-mentioned thematic areas. Each of the areas has an Area Manager who leads a committee in charge of analysing the regional needs in that area and designing a proposal for action based on those needs. The Area Manager and the other committee members are appointed by the General Secretariat, aiming for a balance between different professional profiles and countries. The Area Committee's role is to establish the scientific-technological guidelines for the calls, collaborate in the evaluation of the proposals, monitor ongoing actions, as well as promote the CYTED programme and its activities.

The programme's funding model is based on co-funding. A large part of the overall **budget** of 5-20 M USD per year[74] is provided by the Spanish Government (originally at least 50%), while other countries' contributions depend on their 'socioeconomic conditions'. The maximum amount of financial support available for each project is 250,000 USD per year, for a maximum of 4 years.[75] While the **type of activities** funded has varied somewhat over the years, the 2020 call for proposals distinguishes:

---

72 biomedicine, technologies for health and wellbeing, biotechnology, fundamental biology, pharmaceutical fine chemistry and traditional medicine

73 http://www.cyted.org/en/node/4799, http://www.cyted.org/en/node/4801, http://www.cyted.org/en/node/4800

74 https://stip.oecd.org/stip/policy-initiatives/2017%2Fdata%2FpolicyInitiatives%2F15252

75 European Commission, DG for Research and Innovation, 2014, European Added Value of EU Science, Technology and Innovation actions and EU-Member State Partnership in international cooperation:

- Thematic Networks: Associations of R&D groups of public or private entities in member countries, with scientific or technological activities in one of the thematic areas with the objective to exchange knowledge between R&D groups and enhance cooperation.
- Projects in Strategic Issues: Research and technological development projects between groups in different member countries that are financed both with CYTED funds and external contributions through their national organizations (ONCYT).
- Scholarships for Entrepreneurs: Opportunities for companies in the incubation period within Ibero-American Science Parks to access new markets and develop their business on an international scale.
- CYTED Forums: Meetings between Ibero-American businesses and researchers to address specialized topics sector to promote technology innovation, transfer and cooperation projects.

The Thematic Networks aim to promote among its members stable and continued scientific interactions; mutual interest exchanges of scientific and technical knowledge; synergistic enhancement and coordination of its R&D lines; exchanges and mobility of research staff; training of human resources; technical and methodological training; preparation of proposals for research/innovation projects; and technological diffusion and transfer actions between different groups or entities, provided they are technically, economically and commercially viable73.

The **results** of the programme include the generation of strategic RD&D projects involving companies and experts who access important international funds from the CYTED programme. The **beneficiaries** of CYTED financing instruments can be universities, R&D centres and innovative corporations in member countries. Since 1984, more than 28,000 Ibero-American entrepreneurs, researchers and experts in priority areas of knowledge have participated in the programme. In the period 2005 – 2016 more than 22,300 researchers and 877 companies from all the CYTED member countries have participated in the Thematic Networks funded, of which 73 were still operational in 2018, comprising more than 5,000 researchers from 1070 groups and 180 companies 76.

CYTED has also been a member of the ERANet-LAC project since its inception and has played a major role in the implementation of the public calls for research projects implemented as part of that project (see JIRI case study).

4.7.3. Key success factors and lessons learned

While CYTED was originally focused on the promotion of scientific research through cooperation among researchers from universities and public R&D centres, over time it evolved towards an **increased participation of companies** and final users, as well as the promotion of public-private partnerships. This was done through the adoption of different instruments and evaluation criteria that are more in line with the needs and capabilities of private companies and final users. This is a development seen as part of the national STI systems and policies in the member countries to address increasingly complex problems, taking into account advances in new technologies, environmental challenges and the need for social inclusion.[76] The more recent ‘Technology Based Incubator’ thematic area is an example of such a new instrument. It promotes collaboration and innovation amongst companies and research centres or higher education institutions to increase the competitiveness of national industries in the member countries. Through such collaboration, entrepreneurs gain access to international markets and funds, as well as to new technologies and innovation. Company participation is a requirement for ”IBEROEKA” certification of strategic innovation projects, which provides priority access to financing mechanisms for innovation.[77] It must be noted, however, that the cooperation seems to be more focused on the later stages of the R&D cycle (incubation, innovation) and the dissemination of technologies, less so on the earlier stages of joint research, development and demonstration of new technologies.

The type, scale and design of the actions funded and programme orientation and management were also revised to achieve **a better balance in the participation of member countries**. While Spain originally was the main funder as well as the lead country in terms of proposals submitted and awarded, the contribution of LAC countries has significantly increased over time. From 2005 and 2012, most of the 217 funded projects were coordinated by Spain (84 projects), while a small number of LAC countries also coordinated a substantial number of projects: Argentina (26), Brazil (21), Cuba (19),

Main Report, prepared by Technopolis Group and Empirica Gesellschaft für Kommunikations- und Technologieforschung mbH.

[76] The CYTED Programme and the agenda of Ibero-American cooperation in science, technology and innovation, Alberto Majó Piñeyrúa, General Manager of the Ibero-American Programme of Science and Technology for the Development (CYTED), newsletter EU-LAC 02/2018 -12, EU-LAC Foundation, Fundación EU-LAC, EU-LAC NEWSLETTER 06/2018, https://gallery.mailchimp.com/ff018e5d48206d90c38bcf278/files/730f1862-4188-41b7-8326-70cf8ff77a22/mayo_eng.pdf

[77] http://www.cyted.org/en/node/4803.

Mexico (14) and Columbia (13). The other countries usually co-ordinated only one project. The geographical participation varies across thematic areas.75 In 2018, scientific teams of all countries had participated in actions in each of the areas.[78] The number of researchers per country varied between nearly 100 for some of the Central American and Caribbean countries, and over 1000 in Argentina, Colombia, Cuba, Spain and Mexico.76

The programme's co-funding model leads to increased **ownership** of the programme and its implemented actions among the country members, also contributing to the programme's **sustainability**. The increased diversity in country participation mentioned above also resulted in a broader funding base, with more countries providing financial resources to fund the call for proposals, especially in the recently launched "Projects on strategic issues" calls·76 This is especially important as the available funding from Spain has been under pressure for a number of years, posing risks for the programme's sustainability.[75]

A strong characteristic of CYTED is the way it uses the thematic networks to build long-term, **sustainable** cooperation that can include a diverse set of countries, with different capabilities and needs in different roles, facilitating **upscaling** and learning by doing among countries in different stages of development. Together with the needs assessment-based calls for action based on the needs assessments done by the thematic area committees, this also facilitates matching proposals and implemented actions to **country needs**. So, while the programme does not explicitly links to countries' **NDCs** or **TNAs**, the programme set-up and implementation facilitates directing the activities to be in line with their priorities.

While it is unclear whether the programme has specific design elements to promote **gender** balance, it does track the degree to which women have a coordinating role within groups and projects as part of one of its networks.[79] Figure *4* below shows that this varies across thematic areas and countries, but is generally relatively high, between 20-50%. For thematic areas on ICT and energy the share is lower.[80]

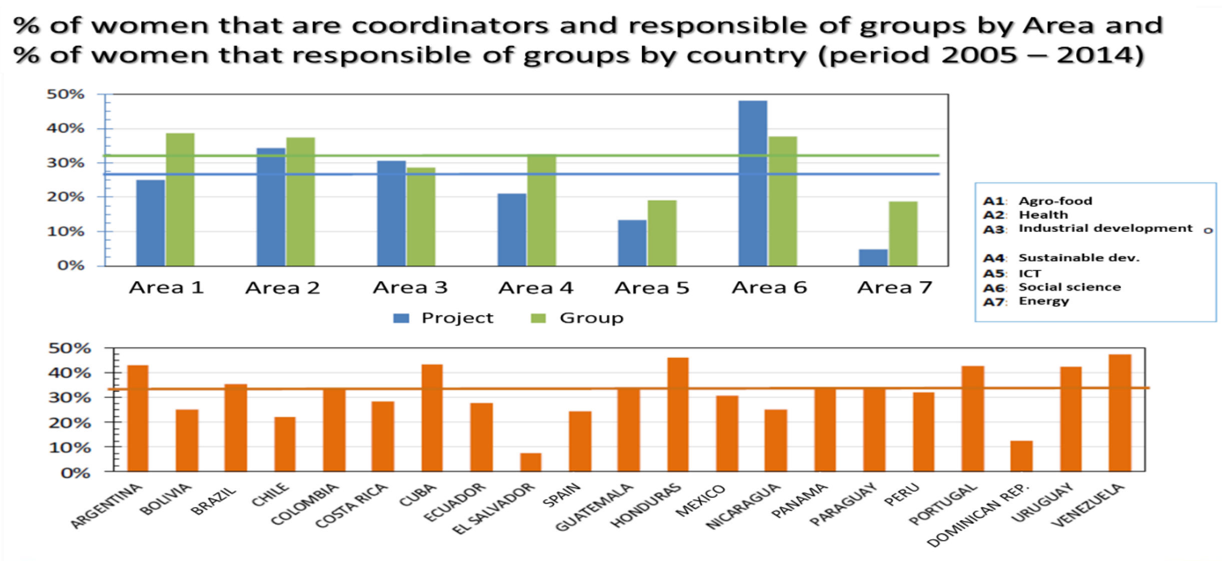

Figure 4: Participation of women in CYTED: share of women as project coordinators or group leaders per thematic area and per country (Translated from: RICYT, http://www.ricyt.org/en/page/6/)

4.7.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives:

- **Embedding the RD&D collaborative initiative in a broader, long-term cooperation**, with high-level political commitment, as part of an overarching framework and strategy;

78 except for Area 5 "Information Technology and Communication", where Honduras was not involved.

79 The Network for Science and Technology Indicators –Ibero-American and Inter-American– (RICYT) was adopted by the CYTED Programme as an Ibero-American network and by the Organization of American States (OAS) as an Inter-American network. It has also organised workshops on science and technology indicators with a gender focus.

80 http://www.cyted.org/sites/default/files/2.-%20Indicadores%20Acciones%202005-2014.pdf

- **Incorporating the needs assessment in the programme design** by identifying (and regularly updating) thematic areas in line with member country priorities and establishing calls for funding proposals based on dedicated needs assessments for each thematic area carried out by thematic area-specific committees;
- **Ensuring joint ownership** through the organisation of structural processes and approaches, e.g. representation in decision-making bodies, joint identification of needs, formulation of calls for proposal and proposal evaluation and through co-funding by member countries;
- **Engaging a large number and variety of countries and parties** in the programme, with selections of those participating in specific activities in different roles, allowing both flexibility to match activities with national needs and capacities and twinning higher capacity - lower capacity countries and partners to facilitate mutual learning and capacity building;
- **Building on existing structures and processes** for supporting STI as far as possible, including the national science and technology policy bodies;
- **Constantly evaluating and adapting the programme**'s design, instruments and topic areas to reflect broader socio-economic and technological developments and needs in the member countries;
- **Using long-term thematic networks** covering multiple types of actions and participating countries and organisations, that can expand over time to scale up and cover more countries and evolving needs.

4.8. The Asian Food and Agriculture Cooperation Initiative (AFACI)

4.8.1. Key characteristics

Focus	Mitigation/Adaptation	Not climate-specific, but covering adaptation activities
	Technology cycle stage	R&D to commercialization
	Sector	Agriculture
	Geographical scope	Regional, S-S, Triangular
	Geographical participation	Asia-Pacific
Organisation	Format	Multilateral network
	Actors	National government agencies and research institutes from Bangladesh, Bhutan, Cambodia, Lao PDR, Indonesia, Kyrgyzstan, Mongolia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam, and Korea.
Budget	Depending on the specific project.	

4.8.2. The initiative

The Asian Food and Agriculture Cooperation Initiative (AFACI) is an inter-governmental and multi-lateral cooperation initiative that aims to improve food production and support sustainable agriculture in Asian countries by conducting joint R&D and sharing knowledge on agricultural technology.[81] It was officially inaugurated in November 2009 in Seoul, South Korea, with its secretariat based in the International Technology Cooperation Center (ITCC) in the Rural Development Administration (RDA) of the South Korean Government in Jeonju.[82] As of 2020, AFACI has 14 member-countries and 5 partner institutions.[83]

AFACI aims to achieve the following five **goals**:

- Sharing of knowledge related to agricultural technologies among member countries;
- Facilitating cooperation among member countries for agricultural technology innovation;
- Human resource network building through the AFACI website;
- Providing a platform to develop a common strategy to promote sustainable agriculture in the Asian region; and
- Active participation in the international community's efforts to promote agricultural development in the Asian region.

[81] http://www.afaci.org/main, consulted September 2020.

[82] Since then, the RDA has also set up cooperation with 12 member-countries in Latin America through KoLFACI (Korea-Latin America Food & Agriculture Cooperation Initiative) and 19 member-countries in Africa through KAFACI (Korea-Africa Food & Agriculture Cooperation Initiative), which are collectively known as "the 3FACIs".

[83] The partner institutions include the Food and Fertilizer Technology Center, Biodiversity International, World Vegetable Center, International Rice Research Institute, the Asia-Pacific Islands Rural Advisory Services Network, and the International Livestock Research Institute.

By working towards these goals, AFACI aims to contribute to the Sustainable Development Goals on zero hunger, climate action and establishing partnerships to achieve sustainable development goals (SDGs 2, 13 and 17 respectively).
Member countries identify priority issues and research projects in meetings of the General Assembly, which is assisted by the Secretariat and Science and Technology Advisory Board. In addition, partner government organizations within the member countries (typically ministries and public research institutes related to the agriculture sector) are responsible for country-specific project design and implementation. Core **funding** for AFACI and its research projects is provided by the Korean Rural Development Administration, with funding for personnel and further voluntary contributions provided by the member countries.[84]

Each of the projects falls under one of five themes: Basic Technology, Food Crops, Horticulture, Animal Science and Extension. Based on the scope of participation from members, research projects are designated as Pan-Asian Projects, Regional Projects, or Country Projects. The duration of all projects is 3 years, with the possibility of extension depending on the result of **monitoring and evaluation**. In addition, AFACI conducts joint workshops, trainings and expert consultations at least once a year for dissemination of knowledge from ongoing projects, knowledge exchange and capacity building.

As of July 2020, AFACI has completed 15 projects and 5 ongoing projects. Although **climate change adaptation** is not a core focus of AFACI, several of its projects are directly or indirectly related to increasing climate resilience among its member countries, developing technologies and building capacity for climate change adaptation in the agricultural sector. One prominent example is the Agro-meteorological Information for Adaptation to Climate Change (AMIS) project (2012-2015) with participation from 11 member countries.[85] The objectives of the project were:[86]

(i) Collection of local agro-meteorological data such as air temperature, precipitation, and solar radiation, etc. in all participating countries;
(ii) Analysis of regional agro-meteorological variation and classification of agro-climatic zones;
(iii) Using basic agro-meteorological data to develop useful metrics such as drought index, GDD (growing degree days), crop period etc.; and
(iv) Improvement of capacity building for maintenance and management of an Automatic Weather System (AWS).

The main **achievements** of AFACI include the following:

- Establishment of a platform in the form of the AFACI General Assembly for the member countries to develop national, regional, and pan-Asian research priorities in agricultural technology;
- Establishment of long-term partnerships with member countries through their respective ministries and public research institutes for agriculture to ensure the uptake of research projects in national agricultural and economic policies;
- Establishment of data collection, management, exchange and dissemination systems in member countries for agro-meteorological data,[87] migratory disease and insect occurrence,[88] plant genetic resources,[89] and livestock genetic resources.[90]
- Development of technologies (and related manuals, books, training and/or certification programmes) for improved postharvest handling,[91] organic vegetable production,[92] agricultural produce safety,[93] virus-free seed potato production,[94] and mechanization for cassava harvesting.[95]
- Establishment of programmes of knowledge exchange through increased international mobility of researchers and practitioners for training visits, expert visits and workshops.

4.8.3. Key success factors and lessons learned

AFACI's achievements can be attributed to several factors related to the design of its institutions and processes.

[84] AFACI Newsletter Issue No.1 (http://www.afaci.org/bbs/list, consulted September 2020).
[85] Bangladesh, Cambodia, Indonesia, Lao PDR, Mongolia, Nepal, Philippines, Sri Lanka, Thailand, Vietnam and Korea.
[86] AMIS (Agro-meteorological Information for Adaptation to Climate Change) Country Report 2015 (http://afaci.org/bbs/view, consulted September 2020).
[87] See the "Agro-meteorological Information for the Adaptation to Climate Change" (AMIS) project.
[88] See the "Integrated Management System of Plant Genetic Resources" (IMPGR) project.
[89] See the "Integrated Management System of Plant Genetic Resources" (IMPGR) project.
[90] See the "Animal Genetic Resources" (AnGR) project.
[91] See the "Improved Postharvest Handling Technology" (Postharvest) project.
[92] See the "Asian Network for Sustainable Organic Farming Technology" (ANSOFT) project.
[93] See the "Good Agricultural Practices" (GAP) project.
[94] See the "Virus-free Seed Potato Production Technology" (Seed-potato) project.
[95] See the "Agricultural Mechanization Technology for Cassava" (Cassava) project.

First, the way research priorities are defined and projects are executed have allowed member countries to pursue **common goals while allowing for flexibility in a multilateral setting**. AFACI uses a bottom-up, member-driven approach in setting (and updating) strategic priorities and goals for RD&D projects in General Assembly meetings that are held once every three years. Thus, the research subjects **reflect existing challenges and emerging needs** of member countries.

Second, while the overall programme design provides guidelines for the high-level approach to be taken to achieve its goals, the member countries operationalize it in a way they judge to be best suited to their **national (and sub-national) needs and capacities**. For example, in the context of the AMIS project, Thailand had a relatively well-developed network of 119 meteorological stations, and thus it could focus on data interpolation and analysis. In contrast, the Philippines chose to focus on installation of a network of 100 agro-meteorological stations throughout the country as a major component of the project.

Third, direct **engagement of members' national stakeholders** (ministries, public research institutes and training institutes) provided a direct linkage for the outputs of the RD&D projects to be institutionalized and/or taken up in national agricultural and RD&D policies, thus enabling **scaling-up** and long-term **sustainability** of the research outcomes. For example, the Asian Network for Sustainable Organic Farming Technology (ANSOFT) and Good Agricultural Practices (GAP) projects provided direct inputs to Bhutan's national-level "2019 Vision of Organic Agriculture", as well as one of its "mega-projects" to support organic farming and good agricultural practices (about USD 15 million). In addition, 13 member countries have established standards for the production and certification of organic products.

Finally, AFACI conducts **periodic assessments of the effectiveness, sustainability and impact of implemented projects** to identify potential areas for long-term development of the initiative as a whole. A study conducted by the Global Agro Network in 2020 aimed to understand the status of AFACI projects, to analyse AFACI's performance by project and by country, and to identify policy recommendations for AFACI's future development.[96] It recommended that AFACI should:

(i) Strengthen its networks for information by organizing them around specific programmes, rather than simply creating networks of countries for knowledge-sharing in general;

(ii) Position itself as an initiative to strengthen the capacity of agricultural technology development in developing countries, rather than merely implementing RD&D projects;

(iii) Serve as a platform for scaling up RD&D initiatives globally by establishing cooperation projects with international organizations and donor countries beyond AFACI;

(iv) Increase the focus of RD&D projects by organizing them based on their focus in the value chain; and

(v) Extend the scope of its partnerships and activities to also include the private sector, to jointly study commercialization of agricultural technologies.

4.8.4. Identified good practice(s)

Based on the above lessons learned, the following good practices are identified that may benefit other initiatives.

- Using a **bottom-up, member-driven approach in setting strategic priorities** and common goals for individual RD&D projects.
- Giving discretion to member countries to **adapt the measures required to achieve common goals** so as to ensure their suitability to **context-specific needs and capacities**.
- Engaging with policy makers, public research institutes and/or training institutes as participants or audiences for projects with the goal of **institutionalizing and ensuring the long-term sustainability** of RD&D processes.
- **Periodically assessing the goals, design, impact and sustainability of RD&D projects** and programmes to ensure their continued relevance to member countries' (and broader societal) needs.

5. Good practices and lessons learned

This section synthesises the cases in the previous section into nine good practices and lessons learned. The clearest and most coherent characteristics that seem to have served the initiatives well include:

1. High-level support/buy-in: Many of the programs analysed have benefited from high-level buy-in and support, both in the initiation phase and for longer-term continuity. This serves different purposes: it ensures that the programs are appropriately resourced and enhances the level of engagement by the key actors involved in designing, supporting, and participating in the program. In addition, it also enhances the sustainability of the program, linking the program's focus

[96] AFACI Newsletter Issue No. 19, January 2020 (http://afaci.org/bbs/list?pageId=02060000&pageName=Newsletter, consulted September 2020).

to the policy and/or political priorities of participating countries or regions. In the case of CYTED, for example, the initiative was embedded in an existing, long-term process of the Ibero-American Summit of Heads of State and Government process in the case of CYTED; in Mission Innovation, it was initiated by Heads of State on the margins of COP-21, but again very much aligned to the broad priorities of the participating countries.

2. Joint ownership and funding, and equal partnership. High-level commitment needs to be accompanied by joint ownership from the beginning, and joint funding based on equal partnership as well as structural pragmatic implementation processes.

Being fully involved from the earliest stages of decision-making gives a sense of ownership to the participants in the initiative and also enhances the potential of the R&D output being utilized since this is driven by, and incorporates, locally-identified objectives (such as the NDCs). This approach was an important factor in Indo-US JCERDC and also in the IEA TCPs. The joint selection of areas for collaborative RD&D that suits the needs and priorities of partner countries enhances the chance of success. In JIRI, such a process helped ensure that all participants benefitted from the collaborative work, although the eventual specific nature and scope of engagement may vary from country to country.

For creating joint ownership, joint funding of the initiatives' activities is also key, i.e. not only North-South funding. This is for example the case in JIRI and CYTED, where the developing country regions (increasingly) contribute funding for the joint research activities through their national funding agencies. One aspect that helped establish strong joint ownership in JIRI where by design all working groups and meetings were co-chaired by a representative from each region, ensuring an equal partnership. Ownership is also enhanced when the initiative has the flexibility to match activities with the diverse set of national priorities, needs and capacities (see below). Here, CYTED for instance has shown in increased share of funding coming from LAC countries (rather than Spain) over time.

3. Broad participation and stakeholder engagement: Involvement of stakeholders from academia, research institutions, the private sector, funding organisations and policy-making from the earliest stages of the program to get inputs regarding its direction and design can help enhance program effectiveness. At the same time, sensitization of potential participants to the opportunities offered by the planned program is also useful for enhancing their engagement – the Indo-US JCERDC, for example, held outreach workshops explicitly to discuss upcoming project calls with potential participants. In the case of DEWFORA, the participation of a range of actors from various backgrounds allowed the marshalling of a diversity of knowledge sources, including local knowledge systems.

Since private-sector participation can significantly help with bringing technologies to market (while also helping raise additional resources), many of the cases analysed make particular efforts to enhance private-sector participation. However, although various initiatives have made a special effort to engage with the private sector, its involvement in most initiatives is limited in the early stages of the technology cycle addressed here. If private companies are involved, it is often more in the incubation, commercialisation and dissemination phase.

In the case of CYTED, for example, participation in the program helps entrepreneurs gain access to international technologies, funds, and markets, but they were only sparingly involved in the initiative's design. In the case of Mission Innovation, where enhancing private-sector participation is a key goal, many of the member countries have put in place programs to enable this. India, for example, has allocated funds specifically to promote collaboration between innovators from other MI countries and Indian institutions in support of the Innovation Challenges.

Initiatives also benefit from a broad participation in terms of the number and type of countries participating. This allows for increasing peer learning (S-S) and developing capacities in less advanced countries that take more complex roles and activities at a later stage, as shown in the CGIAR. This then also allows more alignment with national priorities, needs and capabilities, as they develop over time.

4. Alignment with national priorities, needs and capabilities: Alignment with national priorities, needs and capabilities is crucial for the ownership, impact and long-term sustainability of the initiative. The **joint priority setting** mentioned above for JCERDC is one way to support such alignment. CYTED explicitly incorporated needs assessments in the programme design by identifying (and regularly updating) thematic areas in line with member country priorities and establishing calls for funding RD&D proposals based on that. In some of the multi-country, multi-initiative platforms and networks, countries have had the flexibility to choose the activities to participate in, which they do on the basis of alignment to their national interests and capabilities. In the case of Mission Innovation, for example, different countries participated in different innovation challenges. In the case of AFACI, different member countries operationalized their participating in specific projects in a manner that commensurate with their national (and sub-national) needs and capacities. This kind of **flexibility** allows the continued engagement of countries with the collaborative effort without having to take on obligations that are misaligned with their interests. CYTED uses its thematic networks to build long-term, sustainable cooperation that can include a diverse set of countries with different capabilities and needs. Such a **diversity** of participation can also facilitate upscaling and learning across countries in different stages of development.

5. Alignment of the design of the initiative with the requirements of the technology and its context: The case studies show that there is a great diversity in the type of collaboration initiatives have used to undertake joint RD&D, ranging from bilateral projects to RD&D consortia (with different levels of participation by industry) to platform or network approaches. Within the IEA TCPs, for example, each program was tailored around the nature and needs of the relevant technology or sector. In the case of MI, which also covered a range of technologies, the choice of collaboration drew on expert input since this was seen as dependent on the nature of the technology and the kind of scientific/technological opportunities that it offered. MI has an analytical unit (AJR) that supports programme design. Accordingly, the time scales and resource provision can vary greatly.

6. Suitable governance and management processes of initiatives: Governance structures and management processes for overseeing the initiatives require due attention. A governance structure that involves all key partners allows for transparent and inclusive representation of all partner's interests and is commonly adopted by most of the initiatives examined. There often is a differentiation between governance of the overall initiative itself and the governance of specific RD&D activities being undertaken. In the former, participating countries' or organizations' interests tend to be represented by their own representative, while the latter is organised so as to achieve the scientific or technical objectives s by those partners with an interest in the particular topic. In other words, large initiatives often require a multi-level governance system, appropriate and specifically designed to meet the challenge at hand. An example here is the JCREDC, where the centre itself has a different governance structure than the individual virtual entities for each of the topic areas that have been set up as consortia, and the IEA TCPs, which all have different memberships. This can also be reflected in the funding structure, as in CGIAR, where funders can choose whether to fund all of CGIAR, specific centres or programmes, or specific projects.

The effectiveness of R&D programs also hinges on appropriate management support. In many cases, this has been provided through existing S&T organizations that have the appropriate infrastructure and experience rather than the establishment of an altogether new structure. This might work in developed countries, with relatively well-funded research institutions, but in developing countries, where funding for RD&D is extremely sparse to begin with, and researchers are overstretched, such management support may be particularly challenging. Hence, it is recommended that provisions are made to ensure that participants from developing countries, especially least-developed countries, are enabled to participate.

7. Structured review and continual adjustment: This is a key element of all successful programmes to ensure that the activities are on track and the programme is moving towards achieving its objectives. This includes the development of clear assessment criteria, periodic reviews, and refinement of programme elements, if needed. Some of the larger programmes, such as CGIAR and MI, have established units (SPIA and JCR, respectively) that are assigned responsibility for this function from the earliest stages, although, not surprisingly such an investment is really only possible for large programs. Still, it does highlight the importance of treating review and assessment as a core element of the overall effort.

Many of the long-term institutionalized programs analysed here also undertake periodic examination of various elements of their RD&D efforts ranging from the goals to design to impact to sustainability to ensure their continued relevance to member countries' (and broader societal) needs. Here, CYTED is a good example of a programme that has constantly evaluated and adapted its design, instruments and topic areas to reflect broader socio-economic and technological developments and needs in the member countries. Although the IEA TCP programme as a whole has not changed in its design, it allowed for enough flexibility to let the individual TCPs evolve over time. The CGIAR has reinvented itself several times over its almost fifty-year history and is currently undergoing another reorientation.

8. Design for long-term sustainability: In some cases, there has been an explicit effort towards ensuring long-term sustainability. In cases such as JIRI, CYTED, CGIAR and MI, the institutionalization of the efforts over time provide sustainability (backed by deep and sustained commitment by funding and/or policy entities). The TCPs leverage the IEA's long and established track record of promoting information exchange and cooperation in the area of energy among OECD member countries, which could subsequently be expanded to affiliate developing countries. Especially in case funding for the initiative is limited in time or uncertain, it is important to ensure that structural entities, processes and funding sources are identified and set up to keep the initiative active and effective. The ERANET-LAC project, launched under JIRI to issue calls for joint RD&D proposals, established the EU-CELAC Interest Group (IG) to take over the role of the project's consortium at the end of the project. The 3rd call for tenders under JIRI was the IG's first pilot joint call.

9. Combine technological hardware RD&D with 'soft- and orgware' activities. While there are many international collaborations on climate technology RD&D, only a limited number of initiatives are active in the early technology cycle, i.e. engaged in actual RD&D on hardware technologies. Of those that do, most provide funding for joint RD&D activities, rather than conducting joint RD&D themselves. The exceptions are some of the IEA TCPs and CGIAR that has its own RD&D centres. Most international initiatives that claim to focus on RD&D actually undertake RD&D strategizing, policy dialogues, information sharing and capacity building. These activities can be seen as a good practice when they are implemented *alongside* (hardware) technological RD&D. Technological RD&D can benefit from e.g. standards and policies that can play an important role in facilitating the diffusion of the technology early on. A broader perspective may also mean incorporating secondary but key objectives into the programme such as training and capacity building for the continuation or expansion of RD&D activities in the future. This helps ensure that, as RD&D progresses and technologies come closer to real-world application, other elements of the deployment system are already in place to ensure a smooth and rapid uptake of those technologies.

6. Conclusions & recommendations

This brief discusses eight international RD&D collaborations in the field of climate change of varying sizes and scopes, reflecting different aims and histories, and representing different sectors in both adaptation and mitigation. Some initiatives have been running for decades, while others are much more recent. While this coverage is only a subset of all international collaborative RD&D initiatives that were identified in the initial mapping, this set provided considerable breadth in time, geography, governance structures and sectors. A general and important observation is that many joint RD&D initiatives are not climate-specific, i.e. they have a broader scope, which includes (energy and) climate change-related topics, and there are relatively few initiatives that address climate change adaptation.

The previous section identified **nine good practices and lessons learned** that could be replicated in other locations and future initiatives: 1) high-level political buy-in; 2) joint ownership and funding, and equal partnership; 3) broad participation and stakeholder engagement from the beginning; 4) alignment with national priorities, needs and capabilities; 5) alignment of the initiative’s design with the technology and its context; 6) Suitable governance and management processes of initiatives; 7) Structured evaluation and continual adjustment; 8) design for long-term sustainability and 9) combine technological hardware RD&D with ‘soft- and orgware’ activities.

The analysis does not allow for the identification of specific good practices regarding the **form of cooperation**. Very generally speaking (with limited empirical basis), the bilateral project-oriented approach seems suitable for a one-off bounded collaborative effort with a focus on engaging with specific issues, or as part of a programmatic arrangement that supports a set of projects (with some thematic commonality) over time. The pluri- or multilateral consortium approach, involving a number of participating organizations, is more suitable for a more complex but usually time-bound research effort where different consortium members will have complementary skills. A network-based approach also requires coordination across network members to ensure that all the members are aligned in relationship to overall objectives of the network, as is the case of CGIAR. A network approach is a longer-term arrangement where independent organisations engage in information exchange or programmes/projects. Finally, the platform approach is shallower in terms of cooperation and works best for a broad and long-term arrangement where very different actors may be interested/involved in different aspects of the platform’s activities.

From the good practices identified, five key recommendations are made here.

Assessment and learning on successful collaborative RD&D initiatives needs strengthening: While some of the collaborative RD&D initiatives do have internal assessment processes, evaluation by third-party assessment is less common. It is noted that each of the initiatives analyse was declared a success. And while activities have demonstrably been implemented in each case, structured (i.e. using predefined criteria) and regular independent evaluation are only conducted with the CGIAR. Other initiatives have had one-off independent evaluations, some of which are not public. Carrying out and publishing such assessments is, however, critical for improving the understanding of factors that contribute to initiatives’ success and failure. Such understanding will be useful not only for the development of follow-on initiatives but also for the development of new initiatives by other agencies. It is therefore recommended that the costs for such evaluations should be considered as part of the initiative’s budget from the start. It also should be noted that evaluations of individual initiatives can mainly address questions such as whether the initiative’s stated objectives are met and whether improvements are necessary and feasible. Broader conclusions regarding what formats or approaches are the most effective way to collaborate on joint RD&D can only be learned from evaluations that cut across multiple initiatives. Additional lessons could also be learned is the evaluation of failed collaboration initiatives. Both could be relevant areas for further research.

Facilitate flexible and evolving participation of countries in line with national needs and capacities: In designing initiatives, it should be recognised that different countries and stakeholders have different needs, priorities and capabilities. Aside from dedicated knowledge sharing and capacity building activities, active collaboration in joint RD&D activities provides an especially effective way of learning-by-doing from peers and building up in-country capabilities.

Needs assessments used in setting scope and objectives of initiatives and its activities and projects would support this gradual build-up of capabilities and facilitate countries and stakeholders to evolve to more advanced roles and responsibilities in the collaboration.

Pay particular attention to the "how" of private sector-participation: The participation of the private sector is generally recognized as being crucial to the translation of RD&D into market deployment and many collaborative RD&D initiatives do promote the participation of industry. But greater attention needs to be paid to the nature of the private sector participation to ensure that the results of the collaborative work do lead to application and real-world outcomes. This may require providing incentives such as, for example, follow-on grants for particularly promising candidates or ensuring close connection between collaborative RD&D initiatives and incubators.

Enhance collaborative technological RD&D, and put it in a broader context: The mapping of international RD&D collaborations yielded many initiatives that claim to focus on RD&D but do not include any hardware technological component. Clearly, more attention to scientists and engineers working together on advancing technological knowledge and application is needed, to advance climate technologies but also to build capacity globally, which happens most fruitfully through problem-solving collaboration. However, advancing collaborative RD&D needs the technology hardware as well as the soft- and orgware. Application of technology requires having in place a large number of facilitating activities and efforts that support advancement of the hardware technology. These include, *inter alia*, policies to create early markets and to support broader deployment, standards to provide broad acceptability of the technology by firms while also promoting performance specifications that are likely to enhance utility to users, market research to understand the commercial potential of the technology and user characteristics, facilitating linkages with global supply chains, and training of appropriate workforce. Thus paying attention to these ecosystem-level factors even as RD&D progresses will help increase both the probability of commercial application as well as the speed with which it happens.

Make specific capacity building arrangements to enable equal and more productive partnership with developing countries: Local engagement with developing countries and capacity building are crucial elements of developing country participation. For effective international RD&D collaboration, all engaged researchers need to be able to cooperate as equal partners. But this may sometimes be a challenge, given the relatively-weaker innovation systems and funding of aca3demics and researchers in many developing countries. All initiatives that have achieved meaningful developing country participation have supported local capacity development in some form while also promoting local ownership.

In conclusion: The broader aim of international RD&D collaboration in the context of the Paris Agreement is to enable every region and country to develop the capabilities to find their own path towards a low-emission, climate resilient society and economy. This policy brief suggests that such collaboration can indeed be successful and effective, but the design and implementation of the collaborative RD&D initiatives need careful attention, need to be systemic and need to support capability building globally. This would help such initiatives better contribute to the overarching goal of strengthening climate innovation across the world to address the urgent global climate challenge.

7. Acknowledgments

The Technology Executive Committee extends its appreciation to Dian Phylipsen of SQ Consult, Heleen de Coninck of Eindhoven University of Technology, and Ambuj Sagar and Abhishek Malhotra of IIT Delhi, for the development of this compilation, and to the representatives of observer organizations participating in the TEC taskforce on Innovation for the inputs provided throughout the preparation of this document.

8. References

[References currently in footnotes will be inserted here].