Meeting Global Challenges through Better Governance

INTERNATIONAL CO-OPERATION IN SCIENCE, TECHNOLOGY AND INNOVATION

OECD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

In recent years, the need to address social and environmental challenges has grown in urgency. Climate change, global health, food security and many other global challenges cross national borders and affect a wide range of actors. Yet, in most cases, single governments cannot provide effective solutions. Global challenges call for co-operation on a global scale to build capacity in science, technology and innovation (STI) at both national and international levels. How can international co-operation in STI be scaled up and its scope broadened? How do different modes of governance of international co-operation in STI function and which modes lead to effective and efficient collaboration?

To tackle these issues the OECD's Committee for Scientific and Technological Policy (CSTP) established a Steering Group on International Co-operation on Science, Technology and Innovation for Global Challenges (STIG) to explore the governance frameworks of international STI collaborations that address global challenges. To carry out the work, Delegates nominated an international group of experts to prepare the case studies compiled in this volume and to undertake a more in-depth analysis of the main dimensions of governance.

The case studies were prepared by: Pierre Fabre, Baoqing Wang (Chapter 2); Lisa Scordato, Frode Hovaland Søreide, Magnus Gulbrandsen (Chapter 3); Imraan Saloojee, Erika Kraemer-Mbula (Chapter 4); Andreas Stamm, Young-sik Choi, Shabnam Mirsaeedi (Chapter 5); Lidija Christmann (Chapter 6); Aurelia Figueroa (Chapter 7); Florian Holzinger, Susanne Meyer and Wolfgang Polt (Chapter 8).

In addition, expert teams prepared background papers on various dimensions of governance. Chapter 9, by René Carraz, draws on the extensive input provided by:

- The Austrian team: Wolfgang Polt and Florian Holzinger (Joanneum Research).
- The German team: Andreas Stamm and Aurelia Figueroa (German Development Institute) with support from Harriet Harden-Davies (Australian Academy of Technological Sciences and Engineering, ATSE).
- The Norwegian team: Magnus Gulbrandsen and Frode Hovland Søreide (University of Oslo) and Egil Kallerud and Lisa Scordato (Nordic Institute for Studies in Innovation, Research and Education).
- The South African team: Erika Kraemer-Mbula (Institute for Economic Research on Innovation, IERI) and Imraan Saloojee (Department of Science and Technology, DST).

Andreas Stamm, assisted by Aurelia Figueroa, co-ordinated the work of the expert teams and wrote Chapter 10. Along with Lisa Scordato, they also served as general editors of the case studies and wrote Chapter 1.

The project has benefited from the expertise of the STIG bureau: Per Koch (Norway), the Chair; Robin Batterham (Australia); Klaus Matthes (Germany); and Young-sik Choi (Korea). It also benefited from the input of Wolfgang Hein (Austria), Michael Jansen (France), Thomas Auf Der Heyde (South Africa), Callum Searle (European Commission), Fred Gault (UNU-MERIT and TUT-IERI) and many other country experts, national officials, delegates of the Steering Group and the CSTP, and participants at the workshops on International Co-operation to Address Global Challenges: New Approaches and Governance Mechanisms for Multinational Science and Technology Co-operation, held in Paris on 25-26 March 2009, and on International Co-operation in Science, Technology and Innovation to Address Global Challenges, held in Oslo on 18-20 May 2011. Sincere thanks go to the interviewees who contributed valuable information and gave generously of their time.

A number of staff from the OECD Directorate for Science and Technology and Industry contributed to the project. Gang Zhang managed the first phase of the project, including its conceptualisation and methodology, under the direction of Iain Gillespie. He was assisted by Jana-Marie Mehrtens, who co-ordinated the expert team while they carried out the case studies in 2010. Ester Basri was responsible for leading the second phase of the project, including its implementation and the preparation of this publication. Mineko Mohri prepared a background paper on the governance of knowledge sharing and intellectual property for Chapter 9. The work benefited from the input and comments of Yuko Harayama and Ken Guy. Marion Barberis, Stella Horsin and Cilla Cerredo-Williamson provided secretarial support. Joseph Loux and Julia Acas prepared the final manuscript for publication.

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Acronyms

AAAS	American Association for the Advancement of Science
AR4D	Agricultural Research for Development
BBSRC	Biotechnology and Biological Sciences Research Council
CATHALAC	Water Centre for the Humid Tropics of Latin America and the Caribbean
CC	Collaborating centre
CERT	Committee on Energy Research and Technology
CGIAR	Consultative Group on International Agricultural Research
CRN	Collaborative research network
CRP	Co-ordinated research project
CTI	Climate Technology Initiative
EC	European Commission
ECBCS	Energy Conservation in Buildings and Community Systems
ERA	European Research Area
ETDE	Energy Technology Data Exchange
ETSAP	Energy Technology Systems Analysis
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
FP	Framework Programme
FP7	European Union 7th Framework Programme
GAVI	Global Alliance for Vaccines and Immunisation
GCARD	Global Conference on Agricultural Research for Development
GEO	Group on Earth Observations
GEOBENE	Global Earth Observation Benefit Estimation: Now, Next and Emerging
GEOBON	Group on Earth Observations Biodiversity Observation Network
GEONETCAST	Global Network of Satellite-based Data Dissemination Systems designed to distribute space-based, air-borne and in situ data, metadata and products to low-cost receiving stations maintained by users in near real time
GEOSS	Global Earth Observation System of Systems
GFAR	Global Forum on Agricultural Research

GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
GPC	High Level Group for Joint Programming
IA	Implementing Agreement
IAEA	International Atomic Energy Agency
IAI	Inter-American Institute for Global Change Research
IAI-DIS	IAI Data and Information System
IARC	International Agricultural Research Centre
ICSU	International Council for Science
IEA	International Energy Agency
IEP	International Energy Programme
IFFIMm	International Financing Facility for Immunisation
INRA	Institut national de la recherche agronomique
IPR	Intellectual property rights
ISGAN	International Smart Grid Action Network
ISPC	Independent Science and Partnership Council
ITER	International Thermonuclear Experimental Reactor
JPI	Joint Programming Initiative
MDG	Millennium Development Goal
NASA	National Aeronautics and Space Administration
NGO	Non-governmental organisation
NIH	US National Institutes of Health
NSF US	National Science Foundation
PATH	Programme for Appropriate Technology in Health
PDP	Product Development Partnership
PFAN	Private Financing Advisory Network
RCMRD	Regional Center for Mapping of Resources for Development
RFP	Reversed field pinch
RTDI	Research, technological development and innovation
SCAR	Standing Committee on Agricultural Research
SGP-HD	Small Grants Programme: Human Dimensions
SRF	Strategy and Results Framework
STI	Science, technology and innovation
TC	Technical Co-operation
UNAIDS	United Nations Programme on HIV/AIDS

UNCED	United Nations Conference on Environment and Development
UNDAF	UN Development Assistance Framework
UNFPA	United Nations Populations Fund
UNICEF	United Nations Children's Fund
USGS	United States Geological Survey
WHO	World Health Organization
WMO	World Meteorological Organization

Executive summary

Global challenges are not new…

The world has always faced immense challenges. Food crises have repeatedly led, and still lead, to hunger and emigration. Disease has often ravaged the world's populations, from the Black Death in the 14th century to the "Spanish flu" pandemic that again killed millions in the early 20th century. Atmospheric pollution resulted in acid rain, which severely damaged forested areas and surface water, and chlorofluorocarbons (CFCs) significantly weakened the planet's protective ozone layer.

…but have increased in scope and are more urgent.

Today's more globalised world has increased the sources and geographic extent of such challenges. Global warming and climate change affect the entire planet. The free movement of people and goods means that infectious diseases, for example, readily cross borders and can spread worldwide and also that greater demands are now placed on the world's public goods. In addition, some of the processes that are creating global challenges run the risk of reaching the critical thresholds, called "tipping points", which may lead to irreversible damages to the complex systems that are essential for our survival and welfare.

Science, technology and innovation can play an essential role in meeting them.

At the same time, the level of the world's scientific knowledge and resources available to understand the origins of global challenges and to develop mitigation strategies and adequate technologies is unprecedented. Science, technology, and innovation (STI) are being put to work to address them. In short, some of the processes that have contributed to today's global challenges have also made it possible to address them.

However, STI co-operative efforts at the international level...

Fully unlocking this potential requires more effective international co-operation and an appropriate sharing of burdens and benefits in order to protect the global "commons" and the world's public goods. This implies the pooling of financial resources, the sharing of large-scale research infrastructure, and the improvement of the global knowledge base.

…can be hard to achieve.

However, this does not happen easily, and public and private STI spending still largely takes place in national contexts, where it is easier to justify to taxpayers and can rely on past performance to help evaluate the risks involved. International co-operation and network building for STI involves higher transaction costs (search, bargaining, enforce-

ment, reporting, evaluating), greater risks of failure, and the inclusion of a broader range of actors. Yet international co-operation also significantly raises the visibility of domestic research efforts; this greater recognition can make research policy makers and implementing agencies more willing to fund collaborative international STI efforts.

Addressing such complex issues calls for effective governance mechanisms...

Effective governance mechanisms can help to address such problems, but what constitutes effective governance of international co-operation in STI to meet global challenges is not clear. It involves organising STI co-operation to deal not only with technical issues but also with the various agendas, expectations, resources, capabilities and powers of the many actors involved.

...but there are no simple solutions.

Given the nature and variety of global challenges and the significant differences between national STI systems, there is no simple answer and no easy list of "do's and don'ts" to guide policy makers. Yet, as this volume demonstrates, lessons can be drawn from the analysis of case studies on international STI co-operation in agriculture, health, energy and climate change which offer a range of governance mechanisms used for international co-operation in STI to address global challenges and examine their relative strengths and weaknesses. The case studies cover organisations with a broad variety of funding mechanisms, different types of membership, lengths of existence, topics covered and scope of the projects undertaken.

Case studies of existing collaborations look at five dimensions of governance…

The case studies followed a common structure in order to draw out general lessons. They examine five main dimensions of governance: priority setting, funding and spending arrangements, knowledge sharing and intellectual property, putting STI into practice, and capacity building for research and innovation. An introductory chapter discusses the importance of STI co-operation to meet global challenges, the relation of existing governance literature to global challenges and some potential pitfalls for international collaborative efforts.

…in organisations that address global challenges including agriculture, food security, health,…

The international organisations take a variety of forms and address a number of global challenges, notably food security, agriculture, health, energy, and climate change. Those with a specific focus include the Consultative Group on International Agricultural Research (CGIAR), which is concerned with sustainable food security and agriculture (Chapter 2). A long-standing initiative, it has undergone significant reforms in its governance and provides valuable lessons both in this respect and related to capacity building. The Bill and Melinda Gates Foundation focuses on global health (Chapter 3). It differs from the other case studies in that it is a private and philanthropic organisation. The Group on Earth Observations (GEO) offers lessons on the benefits and challenges of

informal and non-legally binding collaboration on a very wide scale (Chapter 4). In addition, two mini case studies discuss the Global Carbon Capture and Storage Institute and the International Arabidopsis Genome Project (Annexes A and B).

…energy and climate change…

However, several of the case studies discuss organisations that address multiple global challenges. Through the application of nuclear technologies for non-energy related applications the International Atomic Energy Agency (IAEA) addresses climate change, agriculture and food security (Chapter 5). At the International Energy Agency (IEA), over 40 multilateral technology initiatives, known as implementing agreements, involve both public and private actors in addressing global challenges in the areas of energy supply and climate change (Chapter 7).

…and bring together various types of actors.

For its part, the mission of the Inter-American Institute for Global Change Research (IAI) is to bring together regional STI actors for joint research to addresses global challenges such as climate change, energy supply, and agriculture and food security (Chapter 6). Similarly, the recently created European Joint Programming Initiative (JPI) on Agricultural, Food Security, and Climate Change (FACCE) addresses multiple global challenges. (Chapter 8).

The studies shed light on elements of good governance practices.

Each of the case studies brings out elements of good practice for the governance of international co-operation in STI to meet global challenges. To add to the analysis contained in the case studies and to draw some lessons for the governance of international STI to meet global challenges, Chapter 9 draws on the empirical findings in the case studies and in the wider literature on governance to give a more comprehensive view of the challenges and to derive governance options based upon this analysis. In conclusion, Chapter 10 summarises key findings, offers some policy options, and sketches possibilities for further research.

The institutional framework for priority setting should be flexible.

In general, the five dimensions analysed in the case studies show the value of governance modes that are responsive and adaptable. The institutional framework for priority setting should be flexible, as this allows for adapting to the changing nature of global challenges, to contingencies and to new needs. However, long-term goals should not be sacrificed: effective governance modes provide for both short-term flexibility and long-term predictability. Priority setting also benefits from the inclusion of a broad range of actors in order to appreciate the scope and depth of the challenges and to distribute solutions widely. The case studies reveal various ways of involving many stakeholders in international collaborations without developing cumbersome decision-making processes. Governance modes are a deciding factor in reducing related transaction costs.

Flexible funding and spending mechanisms help ensure stability

Funding and spending mechanisms should also be flexible, so as to respond to arising needs without sacrificing long-term goals. Offering donors a variety of funding options can help to increase funding and maintaining long-term funds can provide the stability needed for multi-year research projects. In that respect, an appropriate balance between core and project funding appears to be essential for international STI funding.

Knowledge sharing and intellectual property require a tailored approach

Governance modes related to knowledge sharing and intellectual property should encourage diffusion where possible while still allowing inventors and innovators to benefit from their findings. As for other governance dimensions, a tailored approach to specific circumstances can achieve a balance between encouraging information sharing and maintaining incentives to invest in the generation of knowledge. Policy makers can initiate and facilitate beneficial exchanges of intellectual property as well as open and flexible mechanisms to create favourable conditions for innovation. Typically, more challenges arise, and require greater attention and adapted frameworks, as a technology nears market release.

Outreach is indispensable for putting STI into practice.

Putting STI into practice requires outreach. This puts pressure on already demanding research schedules. Moreover, many researchers have not gained the communication skills needed to translate results and diffuse them to a broader community. Special budgets, forums and information releases can improve communication with industry, policy makers, stakeholders and the broader public. However, these communication efforts require a budget, time and perhaps other resources, such as knowledge brokers.

International collaboration needs to include actors with weaker STI capacities.

International collaboration in STI mostly occurs among actors with equivalent capacities and seeks to avoid duplication. This means that actors with lower research capabilities may be excluded from the priority setting and collaboration process. However, the inclusion and integration of countries with weaker STI capacities is indispensable to achieve the goal of such collaboration – to find and implement solutions to challenges that affect the nations of the world, regardless of their STI capacities. Indeed, these countries may be those most affected by certain global challenges. Their integration can allow them to contribute their specific knowledge and expertise and can help build their STI capacities. Furthermore, their integration should not be viewed as an accessory to economic development.

A number of key governance options can facilitate international collaboration to meet global challenges…

The analysis of five dimensions of governance for international STI co-operation to meet global challenges points to some important policy lessons. It shows the importance of high-level co-ordination or at least compelling reasons to do the work. The governance structure adopted must be a "learning system" tailored to the needs of the specific collaboration, and allow for active and responsive adaptation. It must establish and maintain linkages between local, regional, national and international levels to help to avoid duplication and create transparency among stakeholders. Outreach from the research community to other stakeholders should be a priority at several stages of a project. Knowledge sharing and IP provisions should be adapted to each phase of the collaboration life cycle. Funding and spending mechanisms should contain contingency provisions and means of ensuring funding for multi-annual research projects. For most global challenges, research contributions are needed from a wide array of countries at all levels of STI capacities. Capacity building should be an element of joint efforts to address these challenges.

…but further efforts are needed to address emerging global challenges.

The policy options that emerge from this study are based on case studies of organisations concerned with STI co-operation in the broad field of human-environment relations. Global challenges also arise within exclusively human-made systems, such as the present international financial crisis, and may also severely affect human welfare. Most of the organisations studied were formed in the last decades and under conditions of less advanced globalisation and more traditional science-society-policy interaction. The current dimensions and urgency of global challenges, on the one hand, and the new and more open means of knowledge generation, sharing and application, on the other, may point to the development of more radical proposals for the future governance of STI to find effective solutions to global challenges. This volume takes a first step towards understanding the complexity of governance of international STI collaboration and provides a basis for future research.

Synthèse

Les grands défis mondiaux ne sont pas nouveaux …

De tous temps, notre planète a dû faire face à d'immenses fléaux. Des crises alimentaires répétées ont entraîné et continuent d'entraîner la faim et l'émigration. Des épidémies ont ravagé les populations à maintes reprises – la Peste Noire au quatorzième siècle, ou la « grippe espagnole » au début du 20e, qui a également fait des millions de morts. Des pluies acides provoquées par la pollution atmosphérique ont dégradé les forêts et les eaux de ruissellement ; les chlorofluorocarbones (CFC) ont détérioré la couche d'ozone qui protège la planète.

… mais ils ont aujourd'hui une ampleur et une urgence inédites.

Dans notre monde mondialisé, ces défis ont des sources plus nombreuses et peuvent avoir des répercussions géographiquement plus étendues que par le passé. Le réchauffement planétaire et le changement climatique concernent toute la planète. Avec la libre circulation des personnes et des biens, ce sont aussi les maladies infectieuses, par exemple, qui traversent les frontières sans encombre et peuvent se propager à l'échelle de la planète ; les biens publics de la planète sont aussi soumis à des exigences plus lourdes. De plus, certains des processus qui causent ces défis mondiaux risquent d'atteindre des seuils critiques, des « points de basculement », qui pourraient compromettre irrémédiablement des systèmes complexes essentiels à notre survie et à notre bien-être.

La science, la technologie et l'innovation peuvent jouer un rôle essentiel face à ces défis.

L'humanité a toutefois à sa disposition plus de connaissances et de ressources scientifiques que jamais pour analyser les causes des défis mondiaux et élaborer des stratégies d'atténuation et des solutions technologiques. La science, la technologie et l'innovation (STI) sont appelées à la rescousse. En d'autres termes, les mêmes activités qui ont contribué à créer les problèmes planétaires que nous connaissons aujourd'hui renferment aussi des solutions pour y faire face.

Toutefois, la coopération internationale dans le domaine de la STI …

Pour que toutes les promesses de la STI soient tenues, il faut davantage de coopération internationale et une meilleure répartition des charges et des avantages de la préservation du patrimoine mondial et des biens publics de la planète. Cela passe par la mise en commun de ressources financières, par le partage d'infrastructures de recherche à grande échelle et par l'enrichissement de la base mondiale de connaissances.

... peut être difficile à mettre en place.

Un tel objectif est difficile à concrétiser. Les investissements en STI, qu'ils soient publics ou privés, restent largement limités à un cadre national, où ils sont plus faciles à faire justifier auprès des contribuables, et où l'évaluation des risques encourus peut s'appuyer sur l'expérience passée. La coopération internationale et la constitution de réseaux en STI ne sont d'ailleurs pas sans inconvénients : coûts de transaction plus élevés (chercher des partenaires, négocier, organiser, rendre compte, évaluer), plus grands risques d'échec et implication d'un plus grand nombre d'acteurs. En revanche, la coopération internationale accroît nettement la visibilité de la recherche nationale ; cette plus forte reconnaissance peut motiver les décideurs des politiques de la recherche et les institutions qui les administrent à financer des travaux de STI menés en collaboration internationale.

Pour répondre à des problèmes aussi complexes, il faut des mécanismes de gouvernance efficaces ...

La qualité des mécanismes de gouvernance joue beaucoup, mais définir ce qui fait de bons mécanismes de gouvernance de la coopération en STI pour répondre aux défis mondiaux est loin d'être évident. Cette coopération doit être organisée compte tenu, non seulement des difficultés techniques, mais aussi des différences de priorités, d'attentes, de ressources, de capacités et de compétences entre les multiples acteurs concernés.

... mais il n'existe pas de solutions simples.

Étant donné le caractère et la diversité des défis planétaires et la grande disparité des systèmes de STI nationaux, il n'existe ni réponses simples ni solutions toutes faites à fournir aux décideurs politiques. Il leur sera toutefois utile de s'inspirer de l'analyse des études de cas de coopération internationale en STI présentées dans cet ouvrage. Ces études couvrent plusieurs domaines : agriculture, santé, énergie et changement climatique. Elles représentent différents dispositifs de gouvernance utilisés pour la coopération en STI en réponse aux défis planétaires, et passent en revue leurs avantages et inconvénients respectifs. Elles illustrent enfin une grande diversité de modes de financement, de choix des membres, de durées d'existence, de thèmes de recherche et d'ampleur des projets entrepris.

Des études de cas sur des collaborations en cours examinent cinq dimensions de la gouvernance ...

Les études de cas obéissent à une même structure, afin de faire ressortir des enseignements généraux. Cinq aspects de la gouvernance sont examinés : la hiérarchisation des priorités, les dispositifs de financement et de dépense, le partage des connaissances et de la propriété intellectuelle, les applications pratiques des STI et le renforcement des capacités de recherche et d'innovation. Un chapitre d'introduction rappelle l'importance de la coopération en STI pour répondre aux grands défis mondiaux, la relation entre la littérature existante en matière de gouvernance et les défis mondiaux et quelques pièges à éviter en matière de collaboration internationale.

… dans des organisations actives face aux défis mondiaux en matière d'agriculture, de sécurité alimentaire, de santé …

Les structures internationales prennent une diversité de formes et s'occupent de différents domaines : sécurité alimentaire, agriculture, santé, énergie et changement climatique, notamment. Parmi les structures spécialisées, le Groupe consultatif pour la recherche agricole internationale (CGIAR) œuvre pour la sécurité alimentaire et pour une agriculture éco-responsable (chapitre 2). C'est une initiative déjà ancienne dont la gouvernance a plusieurs fois été profondément remaniée et qui offre une illustration intéressante, tant en termes de gouvernance que par son travail dans le renforcement des capacités. La Bill and Melinda Gates Foundation, active dans le domaine de la santé dans le monde (chapitre 3), est une organisation privée et philanthropique, à la différence des autres études de cas. Le Groupe sur l'observation de la Terre (GEO) est riche d'enseignements sur les atouts et les faiblesses de la coopération informelle à très grande échelle sans obligation contractuelle (chapitre 4). Par ailleurs, deux mini-études de cas sont consacrées à l'Institut mondial pour la capture et le stockage du carbone (IGS) et au projet International Arabidopsis Genome (annexe A).

… d'énergie et de changement climatique …

D'autres études de cas décrivent des organisations actives sur plusieurs fronts. Ainsi, à travers les applications non énergétiques des technologies nucléaires, l'Agence internationale de l'énergie atomique (AIEA) travaille sur le changement climatique, l'agriculture et la sécurité alimentaire (chapitre 5). Au sein de l'Agence internationale de l'énergie (AIE), plus de 40 initiatives technologiques multilatérales, appelées contrats d'exécution, associent acteurs publics et privés dans des projets sur l'offre d'énergie et le changement climatique (chapitre 7).

… qui réunissent différents types d'acteurs.

L'Institut interaméricain de recherches sur les changements à l'échelle du globe (IIRCG) a quant à lui pour objet de rassembler des acteurs des STI du continent américain autour de recherches collaboratives pour trouver des solutions en matière de changement climatique, de fourniture d'énergie, d'agriculture et de sécurité alimentaire (chapitre 6). De même, l'Initiative européenne de programmation conjointe (JPI) « Agriculture, sécurité alimentaire et changement climatique » (FACCE), créée récemment, travaille sur plusieurs problèmes mondiaux (chapitre 8).

Les études de cas portent un éclairage sur les bonnes pratiques de gouvernance.

Chacune de ces études de cas fait ressortir des éléments de bonnes pratiques de gouvernance pour la coopération internationale en STI face aux grands problèmes mondiaux. En complément de l'analyse contenue dans ces études de cas et pour tirer des enseignements sur la gouvernance de la STI internationale face aux problèmes mondiaux, le chapitre 9 s'appuie sur la littérature générale sur la gouvernance afin de traiter plus exhaustivement les problèmes posés et de déduire des solutions de gouvernance découlant de cette analyse. En conclusion, le chapitre 10 fait la synthèse des enseignements, propose quelques options stratégiques et esquisse des voies de recherche possibles pour l'avenir.

Le cadre institutionnel qui régit la hiérarchisation des priorités doit être flexible.

En général, les cinq dimensions analysées dans les études de cas démontrent la supériorité des modes de gouvernance réactifs et adaptables. Le cadre institutionnel qui régit l'établissement des priorités doit être flexible, pour qu'elles puissent être adaptées au gré de défis mondiaux par nature évolutifs, en fonction des circonstances et des besoins qui se font jour. Les objectifs à long terme ne doivent toutefois pas être sacrifiés : les bons modes de gouvernance doivent combiner flexibilité à court terme et prévisibilité à long terme. L'établissement des priorités est aussi favorisé par la concertation avec un large éventail d'acteurs afin d'apprécier l'étendue et la profondeur des problèmes et de répartir largement les solutions apportées. Les études de cas montrent différentes manières d'associer beaucoup de parties prenantes à des initiatives collaboratives internationales, sans pour autant recourir à des processus décisionnels lourds. Les modes de gouvernance sont un facteur décisif pour diminuer les coûts de transaction.

La flexibilité des mécanismes de financement et de dépense est un gage de leur stabilité.

Il faut aussi que les mécanismes de financement et de dépense soient flexibles afin de pouvoir répondre aux besoins émergents sans sacrifier les objectifs à long terme. Lorsque différentes options sont proposées aux bailleurs de fonds, les financements tendent à être plus importants, et la pérennisation de fonds offre la stabilité nécessaire aux projets de recherche qui s'étendent sur plusieurs années. À cet égard, en matière de financement de la STI internationale, il apparaît essentiel de trouver le bon équilibre entre le financement de base et le financement de projets.

Le partage des connaissances et la propriété intellectuelle nécessite une approche au cas par cas.

Les modes de gouvernance qui s'appliquent au partage des connaissances et à la propriété intellectuelle doivent, dans la mesure du possible, favoriser leur diffusion, tout en permettant aux inventeurs et aux innovateurs de profiter de leurs succès. Quant aux autres dimensions de la gouvernance, par une approche au cas par cas, on doit rechercher le juste équilibre entre, d'une part, encourager le partage des connaissances, et de l'autre, sauvegarder la motivation à investir dans la production de savoir. Les décideurs politiques peuvent prendre l'initiative ou favoriser des échanges d'actifs intellectuels bénéfiques à tous. Ils peuvent aussi établir des mécanismes ouverts et flexibles qui créeront des conditions favorables à l'innovation. Le plus souvent, à mesure que l'on approche de la commercialisation des technologies, de nouveaux problèmes surviennent, nécessitant plus d'attention et des cadres adaptés.

Communiquer vers l'extérieur est indispensable pour mettre en pratique la STI.

La STI nécessite de communiquer vers l'extérieur. Cet impératif vient rajouter de la pression sur des calendriers de recherche déjà exigeants. De plus, beaucoup de scientifiques n'ont pas acquis les compétences nécessaires pour communiquer sur leurs résultats et les diffuser vers un public plus large. Des budgets *ad hoc*, des forums et des communiqués de presse peuvent améliorer la communication avec les entreprises, les

responsables des politiques, les parties prenantes et le grand public. Mais tout cela nécessite des moyens financiers, du temps et peut-être d'autres ressources, comme des « courtiers du savoir ».

La collaboration internationale doit associer des acteurs ayant de plus faibles capacités STI.

La collaboration internationale en STI associe généralement des acteurs aux capacités équivalentes, et vise à éviter les double-emplois. Cela signifie que les acteurs ayant de faibles capacités de recherche peuvent se retrouver exclus des processus d'établissement des priorités et de collaboration. Pourtant, l'inclusion et l'intégration de pays aux faibles capacités en STI est indispensable à la poursuite des objectifs de ces collaborations – c'est-à-dire trouver et mettre en œuvre des solutions aux problèmes qui affectent tous les pays du monde, quelles que soient leurs capacités en STI. Ce sont d'ailleurs parfois ces mêmes pays qui sont les plus pénalisés par certains problèmes mondiaux. En étant intégrés aux collaborations, ils peuvent mettre leurs connaissances et leur expertise à contribution et renforcer ainsi leurs capacités STI. Par ailleurs, cette intégration ne saurait être considérée comme accessoire au développement économique.

Quelques options clés en matière de gouvernance peuvent faciliter les collaborations internationales pour répondre aux défis mondiaux …

L'analyse de cinq dimensions de la gouvernance de la coopération internationale face aux défis mondiaux révèle un certain nombre d'enseignements importants. Elle montre l'importance d'une coordination à haut niveau ou du moins donne de bonnes raisons pour que ce travail soit fait. La structure de gouvernance adoptée doit être celle d'un « système apprenant » défini spécifiquement en fonction des nécessités de chaque collaboration, et capable d'adaptation active et réactive. Des liaisons doivent être établies et entretenues entre les niveaux local, régional, national et international afin d'éviter les double-emplois et d'assurer la transparence entre les parties prenantes. La communication avec les autres parties prenantes doit être une priorité pour la communauté de la recherche à plusieurs étapes d'un projet. Les dispositions concernant le partage des connaissances et la propriété intellectuelle doivent être adaptées à chaque phase du cycle de vie de la collaboration. Les mécanismes de financement et de dépense doivent contenir des clauses contingentes et des moyens de garantir un financement aux projets de recherche pluriannuels. Pour la plupart des défis mondiaux, il faut des contributions de recherche de pays à tous niveaux de capacités STI. Le renforcement des capacités doit être une composante de l'effort commun face à ces défis.

… mais il faut faire davantage pour répondre à des défis mondiaux émergents.

Les stratégies qui ressortent de cette étude sont inspirées des études de cas d'organisations concernées par la coopération en STI dans le domaine général des relations entre l'être humain et l'environnement. D'autres défis mondiaux s'inscrivent au sein de systèmes de nature exclusivement humaine – comme la crise financière actuelle – et peuvent aussi durement compromettre le bien-être humain. La plupart des organisations étudiées datent de quelques dizaines d'années, à une époque où la mondialisation était moins poussée qu'aujourd'hui et où les interactions entre science, société et politiques

étaient plus traditionnelles. L'ampleur et l'urgence actuelles des défis mondiaux, d'une part, et les nouveaux moyens – caractérisés par une plus grande ouverture – de production, de partage et d'application du savoir, d'autre part, pourraient rendre nécessaires des propositions plus audacieuses pour la gouvernance future des STI afin de trouver des solutions efficaces pour faire face aux défis mondiaux. Cet ouvrage est une première étape dans la compréhension de la complexité de la gouvernance des collaborations internationales en STI, et se veut une base pour les recherches ultérieures.

Chapter 1

Addressing global challenges through collaboration in science, technology and innovation

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This chapter discusses international co-operation in science, technology and innovation (STI) as a way to meet a number of global challenges. For some fields, it points to the need for scientific research to make policy makers more aware of links between human action and global change. It also addresses the need for technology development and broad-based implementation of technological, organisational and social innovations. It argues that, to this end, international co-operation in STI has to be scaled up and its scope broadened. Suitable modes of governance have to be developed to reap the benefits of international co-operation while minimising transaction costs and risks. The chapter concludes with a brief description of the case studies that constitute the bulk of the volume.

1.1. Introduction

The security and sustainability of energy and the food supply, the threat of (re-)emerging infectious diseases, climate change and the loss of biodiversity are only a few of the global challenges facing the world today. Addressing these challenges adequately is difficult, as it requires taking account of the many dimensions of human behaviour. However, inaction or insufficient efforts carry significant risks. Growing populations require more electricity and fuel and cleaner, more efficient sources of energy. In many places, they require more, and more nutritious, food and more sustainable farming and agriculture. Health care must reach larger populations and deliver solutions to diseases that continue to ravage populations, and it must improve prevention of disease and the living conditions of people with chronic diseases (OECD, 2010, p. 171).

Many global challenges are interlinked across regions and disciplines. Global climate change is believed to have both direct and indirect impacts on human health. For example, it can broaden the geographical distribution of diseases such as malaria, yellow fever and Hantavirus (McMichael *et al.*, 1996). At the same time, potential solutions to one challenge may negatively affect another: fertilisers that improve crop yields and provide greater food security also release nitrogen and thus influence climate change. Use of biofuels for mobility of goods and people may contribute to the reduction of greenhouse gases, but also to rising food prices and to threats to biodiversity. Such effects have to be thoroughly understood in order to develop effective solutions.

Tackling global challenges requires targeted, decisive action in different public policy fields, often in close co-operation with the private sector and civil society. Science, technology and innovation (STI) play a central role in understanding the interaction of the relevant environmental, technological and social factors, in assessing risks and the possible unintended negative consequences of strategies, and in developing solutions. This role is increasingly recognised by countries and by the international community.[1] Because global challenges cross national borders and affect a wide range of actors, they call for co-operation to address them and for building STI capacity at both national and international levels.

Global challenges and means of addressing them

Global challenges call for co-operation on a global scale in order to create a public good or protect the global commons (Kaul *et al.,* 2003). For example, a stable climate is a global public good. It can be endangered by the global warming that results from the emission of excessive levels of greenhouse gases due to the combined actions of many individuals and societies. The "tragedy of the commons" (Hardin, 1968) plagues the management of global public goods. If a resource is accessible to a multitude of actors, each will seek to take a maximum share. Over-fishing of global fish stocks is a classic example. When the number of actors is relatively small, the problem may not arise, but if the number of actors surpasses a certain limit, the commons risk being exhausted.

However, effective governance mechanisms can help to deal with this problem. Ostrom (1999, 2008) provides conceptual and empirical evidence of institutional settings that can lead to sustainable management of "common pool" resources.[2] In most cases, single governments cannot ensure effective solutions, and internationally co-ordinated action and collaboration are required. This does not necessarily imply the need for the entire world community to agree on joint action, as this would lead to excessively high transaction costs and delays in the response to urgent challenges.

In fact, groups of countries often set the stage for addressing global challenges. In some cases, adequate action is pioneered by countries with responsibility for a given challenge, followed by broader groups of actors. For example, the United States pioneered action to protect the ozone layer by banning – as early as 1978 – the use of chlorofluorocarbons (CFCs) as propellants for non-essential aerosol sprays. It did so in response to scientific findings about ozone depletion due to man-made chemicals. In 1985 the Vienna Protocol for negotiating international regulations on ozone-depleting substances was approved by 28 countries, including most of the major CFC producers. In 1987 the Montreal Protocol was signed by 46 countries which agreed to phase out the production of these chemicals. By 2007 the protocol had been ratified by 191 countries (EU, 2007, p. 5; Royal Society, 2011, p. 73; Biermann *et al.,* 2009, p. 20).

However, the governance mechanisms to address global challenges depend on the characteristics of the specific challenge, its urgency, the causative factors, the actors involved and their specific interests, power relations, etc. There is no simple formula. The issue has led, since the 1990s, to a huge body of literature devoted to global governance (Dingwerth and Pattberg, 2006), which has, to date, dealt only marginally with STI. Biermann *et al.* (2009, p. 15), for instance, in their work on the fragmentation of global governance architectures, mention "international security, finance, trade, and protection of the environment", but not research, as important areas of international relations.

Challenges to international co-operation abound. Most problems faced by global governance institutions and processes in other areas, such as incentives to be unco-operative (prisoner's dilemma) and free-riding, apply equally to international STI co-operation. The temptation to benefit from the efforts of others (free-ride) is strong. If some actors invest to find solutions to global challenges, those that do not may still reap the benefits.

The global divide in available research infrastructure, human resources and financial means to support STI also creates difficulties for international co-operation to address global challenges. Yet scientific input is required from a diversity of countries throughout the innovation cycle from agenda setting to the deployment of new solutions, if adequate answers to global challenges are to be found. An integrated and co-operative approach is required that involves traditionally separate policy fields, international STI policies, capacity building and technology transfer.

The role of STI in finding solutions to global challenges

Countries' STI systems are not the only source of responses to global challenges. The measures taken to protect the ozone layer, for example, were due to determined action on the part of global environmental policy. However, STI played a catalysing role: research led to crucial understanding of the relation between human action (use of chloro-fluorocarbons [CFCs]) and an observed environmental impact (depletion of the ozone layer). Scientific endeavours also showed the consequences of this degradation for human well-being such as increased skin cancers. Technological innovations provided industry with alternative, environmentally less harmful substances for propelling aerosols and for refrigeration. As a result, banning of CFCs was politically relatively easy to implement because few players were opposed.

In the past, radical innovations,[3] such as new and effective vaccines, have led to the significant improvement, and in some cases, the eradication of scourges that earlier created pandemics such as smallpox with massive loss of human life (Royal Society, 2011, p. 74). Yet, incremental innovations can also provide solutions to pressing problems. In the health

area, for example, mosquito nets coated with insecticides have proved an effective tool against the spread of malaria (IRD, 2009; WHO, 2007). "Frugal innovations" that provide innovative goods and services at low cost will also be needed to address global challenges that affect the poor (OECD, 2011b, p. 6). Indeed, such frugal innovations may have value far beyond poor populations and reduce cost-related disincentives to mitigate behaviours that exacerbate global challenges as well as encourage adaptation to the reality imposed by these challenges.

Similar observations can be made for global food production. At different moments of history scientific and technological breakthroughs have resulted in significant increases in agricultural productivity and thus higher levels of food security. The discovery and development of super-phosphates as a powerful fertiliser in the 1840s led to significantly greater food security in Europe in the second half of the 19th century. Likewise, the massive dissemination of high-yield crops in developing countries had a major effect beginning in the 1950s ("the Green Revolution"). Here again, it is not only radical innovation that makes the difference. Incremental innovations, such as gradual improvements in crop rotation or irrigation schemes, can also contribute greatly to higher and more stable crop yields. Similar points can be made regarding most global challenges.

STI is also important for the Green Growth agenda (OECD, 2011a). One of the key challenges is to safeguard the global availability of energy while containing climate change. Climate protection and the finite nature of fossil fuels call for rapid transformation of the energy supply. Some of the technologies required to move towards a low-carbon economy have already reached, or are very close to, the fully commercial stage. However, others are still in the pre-commercial or experimental phase (IEA, 2008, p. 15). Technological advances may come in the form of radical breakthroughs or incremental steps, such as gradually enhancing the efficiency of photovoltaic systems, lowering costs through process innovations or combining different renewable energy sources in mini-grids to provide electricity in areas out of the reach of large power grids (del Río, 2011).

Solutions must be urgently but responsibly sought

Global challenges require solutions that are effective and quickly deployable on a large scale. The reason for this urgency relates to the concept of "tipping points", a term coined in the late 1950s by Grodzins (1958) and later formalised by Schelling (1971, 1972). It captures the assumption that at some point in time, gradual changes in complex (social and natural) interactions lead to a "point of no return" that engenders a vicious circle of deterioration of formerly stable systems. Many, but not all, global challenges concern complex systems that may change incrementally for quite a long time, adapting to changing external conditions, and may have critical thresholds – "tipping points" – "at which the system shifts abruptly from one state to another" (Scheffer *et al*., 2001, p. 53). Therefore, it is important to take action early enough to avoid breaching the tipping point. Climate is not the only challenge concerned: many complex systems can demonstrate unstable behaviour and undergo rapid change.[4]

The need to find applicable solutions as soon as possible is also related to the fact that many technical and innovative solutions require considerable time to mature and to have significant impact. For instance, depletion of the ozone layer continued years after the phasing out of CFCs. Similar inertia can be expected in the case of many current global challenges. For example, once highly effective solar power (CSP) stations are tested and commercially available, the timeframe for replacing a reasonable share of the power

stations based on fossil fuels will not be years, but decades, owing to supply constraints and construction times.

Finally, there are ethical reasons for finding effective and quickly deployable solutions to global challenges through STI. Given the intellectual, technological and financial means available for developing solutions, unnecessary delays in making innovations available to overcome severe problems afflicting large parts of the world population should not be accepted.

What makes international STI policy and related co-operation efforts especially challenging is the need to act urgently without losing sight of the "imperative of responsibility" with respect to technological progress (Jonas, 1984). Any strategy for using STI to address global challenges must address potential unintended negative effects. Many of today's challenges, including climate change, are partly consequences of the use of new technologies and innovations. The combustion engine is one source of the current CO_2 challenges. A recent report of the United Nations Environmental Programme (UNEP) highlights the significant externalities (in the form of soil degradation, water pollution, loss of human lives through intoxication) caused by the use of agricultural technologies that increase productivity and financial returns in agriculture but do not preserve ecosystems (UNEP, 2011). Because a solution to one problem may cause new and equally dangerous problems, the use of STI cannot be reduced to a simple "technology fix". Such strategies must be accompanied by research on the social, technical, biological and geophysical systems involved to ensure well-grounded predictions about the possible effects of new lines of actions.

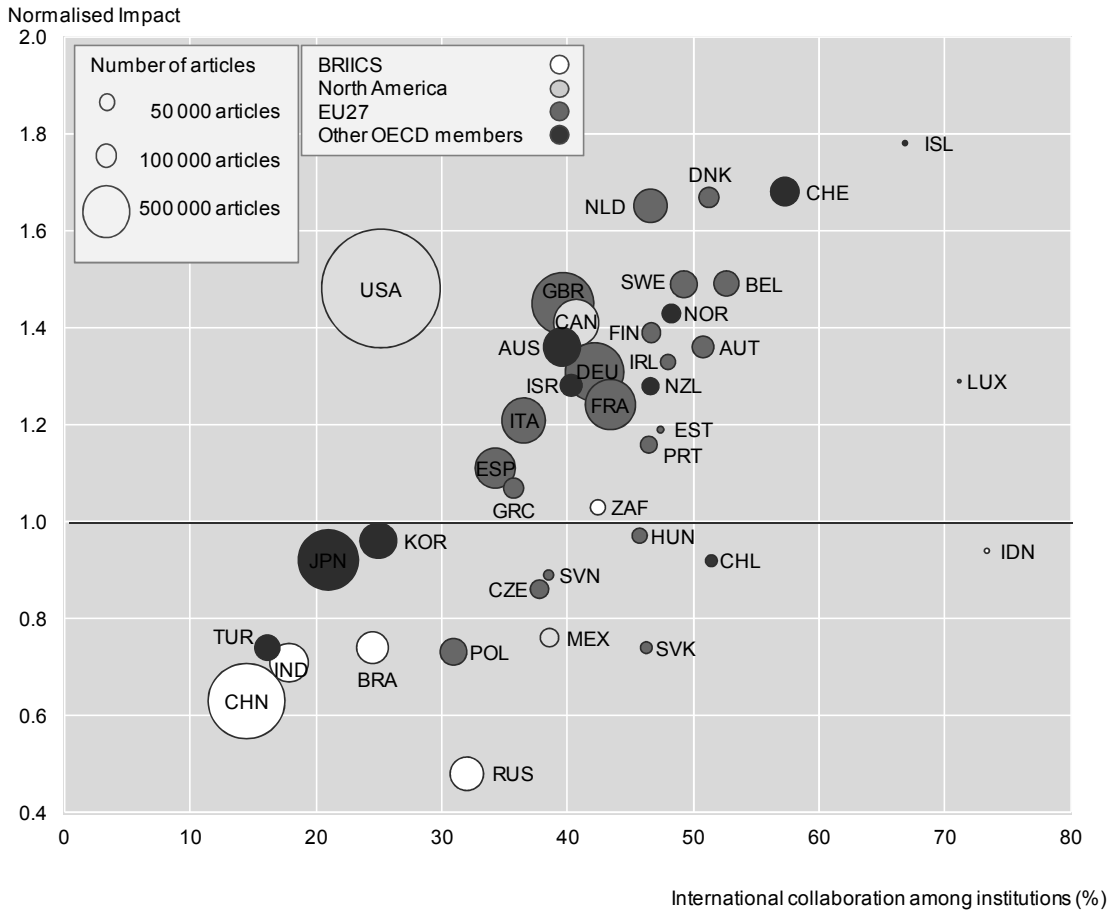
Issues affecting the status of international STI co-operation to address global challenges

Several indicators point to a significant internationalisation of research, often beyond the direct control of research funding agencies and donors (Wagner, 2006, p. 165). For instance, flows of academics into the United States increased by 77% between 1994 and 2007, to about 106 000 persons. Similar trends can be observed for other countries and regions, *e.g.* Korea, Japan and the European Union (OECD, 2009, p. 160). This increase in mobility is also apparent in the growth of internationally co-authored scientific articles. Between 1998 and 2005, the number of collaborative articles rose from 8% to 18% of all scientific articles (OECD, 2009, p. 161). Likewise, the Royal Society (2011, p. 40) indicates that 35% of articles published in international journals today involve international collaboration, up from 25% 15 years ago.

There is some evidence that international research collaboration can enhance the impact of scientific publications, measured in terms of citations. This suggests that it might be in the interest of national policy makers to support the international networking of researchers. Figure 1.1 clearly shows that citation impact increases with the number of international organisations with which an institution co-operates.[5]

Figure 1.1. The impact of scientific production and the extent of international scientific collaboration

2003-09



BRIICS = Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa.

Note: The normalised impact is the ratio between the average number of citations received by the documents published by a specific unit (country, institution and author) and the world average of citations of the same time period, document type and subject area. For instance, 1.3 means the unit is cited 30% above the world average.

Source: OECD (2011c), p. 47.

Even with some evidence of the benefits of international co-operation, there is obvious reluctance to invest financial resources in global STI undertakings. Even within the EU – after six decades of efforts at integration – some 85% of all public research and development (R&D) is programmed, financed, monitored and evaluated at the national level (European Commission, 2008). The main reason for this reluctance seems to be that national governments face complex legitimacy issues. A government has to justify to the electorate why it should spend finite financial resources on R&D and not on projects often more highly valued by the electorate, such as infrastructure or social security, and why it makes sense to spend taxpayers' money on international collaboration rather than on national research projects. In many countries, voters have a basic understanding of the potential impact of public investments in STI, but this relates to the general perception of welfare increases through innovation and to direct benefits to the national economy in

terms of international competitiveness and thus of employment and income generation. They are less aware of the need to achieve long-term benefits by preventing human distress and avoiding future hazards through international co-operation on STI.

This is why it is usually much easier for governments to draw a plausible scenario from R&D spending to tangible benefits for the taxpayers in a national rather than an international context. Policy makers concerned with building up and maintaining legitimacy have clear disincentives to spend available R&D funding on multilateral undertakings. This situation is aggravated by the fact that national R&D spending usually follows long-established frameworks and procedures that minimise transaction costs and often involve considerable sunk costs. Finally, these routines and established knowledge about R&D implementing agencies, their strengths and possible weaknesses, help contain the risk of unsuccessful R&D projects. Given all of this, the scaling-up of multilateral R&D projects requires a clear expression of political will to enhance international co-operation, accompanied by efforts to create tangible incentives and lower individual risks for decision makers and programme implementers.

Endogenous growth theory shows a link between public R&D spending and economic prosperity, but the link is somewhat indirect and rather long-term. Therefore, R&D expenditures are often the subject of political disputes, especially in times of tight public budgets. This is particularly true for STI expenditures to meet global challenges, as they address global public goods and are often characterised by market failures, so that potential payback times for R&D expenditures are especially long. Advocacy efforts in this area have to make it clear that the economic costs of not acting may far exceed the expenditure for preventive measures, including for STI. Stern (2006) showed that the long-term costs of unconfined climate change, for example, will lead to a loss of around 5% of global economic output, while determined measures to prevent global warming may correspond to only 1% of world product.[6] Moreover, investments in new technologies and new knowledge can be an investment in future growth, as they can create strong demand for products, processes and services that may help prevent or alleviate the unwanted effects of the challenges. In many cases, demand for sustainable solutions rises once policy measures that help overcome market failure and factor in negative externalities are implemented. Countries that invest in such technologies now can realise a first-mover advantage in the markets of the future. It is therefore wrong to look at STI investments for global challenges simply as a burden.

Financial resources for international STI co-operation on global challenges may be especially prone to cuts in times of tightening budgets, as it is often difficult to trace the benefits back to organisations (firms, research centres) in the home country and to provide clear metrics to donors and to the electorate alike. However, scattered national STI undertakings will in many cases not deliver effective solutions in a reasonably short time. International co-operation can lead to the bundling of financial and intellectual resources, thus exploiting economies of scale (cost savings due to specialisation, complementarities of resources and skills) and economies of scope (cost savings due to cross-fertilisation of ideas and intermediate results) (*e.g.* Henderson and Cockburn, 1996, pp. 33ff.). Thus, international co-operation is *more* and not *less* necessary in moments of tight public budgets, although governments need to make evidence-based and convincing arguments to show voters why the spending is justified.

Following this line of argument, some policy makers and researchers have suggested that to address global challenges such as climate change effectively, international "Apollo-project" type programmes should be launched (*e.g.* Friedman, 2005). This would imply a massive concentration of the resources required to address global warming through the development of low-carbon technologies for energy generation and use. Such ideas have been firmly rejected by others for their unilateral focus on technology push or the supply side of technological innovations and disregard for the demand side (Yang and Oppenheimer, 2007). Most governments see investment in technology as a lever for competitive advantage, but do not see how an international "Apollo project" would deliver competitive advantage to individual participants. This raises the question, among others, of the role of intellectual property in pursuing solutions to global challenges.

Beyond arguments directly related to scale economies, there is another argument for international co-operation for the development of solutions to global challenges. In many cases, technologies will only be rolled out if a country's or world region's ecological, economic, social and cultural conditions are adequately addressed. Factoring these conditions in from the inception of an R&D undertaking will support the smooth transition of R&D outcomes into deployable innovations. Involving researchers and research institutes from different world regions at an early stage may help to shorten the innovation cycle considerably. Inclusive co-operation is vital to ensure products and policies that are adapted to a given setting. The innovation process should be recognised as a complex social process that requires the inclusion of a variety of actors from the public and private sector, academia, and civil society. The innovative capacity of a nation is determined, among other things, by its "absorptive capacity" which in turn depends on its learning, both formal and informal.

The important role of STI and international co-operation in addressing global challenges is increasingly recognised in international policy arenas. For instance, in 2009 the European Union established the Strategy Forum for International S&T Cooperation (SFIC). In June 2008 at the G8+7 Science and Technology Ministerial Meeting, ministers from G8 countries as well as from Brazil, China, India, Mexico, the Philippines, Korea and South Africa emphasised the important role that science and technology have to play in understanding the global challenges facing our societies and in developing appropriate solutions. Again in 2011, the G8 communiqué from Deauville highlighted "the importance of international cooperation in research, leveraging resources and talents to find solutions to common challenges".[7] Also in 2011, the Budapest World Science Forum's Declaration called for the world's scientific establishments to assume new roles to address the growing complexity of these challenges.[8]

Co-ordination, collaboration and integration: levels of international interaction in STI

International STI exchanges may involve information on current or projected research, expected outputs and outcomes, actors and time frames. On the basis of such information, actors may decide to adjust their R&D activities in order to avoid duplication of effort, obtain complementary knowledge, build upon the results of others, or create more structured co-ordination, collaboration or integration with their peers (Edler, 2010, pp. 7ff.):

- *Co-ordination* brings different elements of the STI system into a more "harmonious" or efficient relationship. The elements maintain their overall autonomy, with STI policy co-ordination mainly trying to improve synergies.

- *Collaboration* involves working jointly to achieve common goals, pool expertise or resources. This can enhance the efficiency or effectiveness of knowledge production. At the policy level, international collaboration would require more complex co-operation schemes, but would not entail a shift of competencies to a new policy level.
- *Integration* would imply a shift of competencies or autonomy in order to combine activities or structures so that they form a new whole. This would require delegating authority to a new structure or institutions.

On the governance of international STI co-operation

In this volume, the term "governance" is used to refer to the interaction of state and non-state actors in the area of STI co-operation, co-ordination and policy making. It is not a synonym for "government" or "steering". Governance in not necessarily ensured by governments or international organisations to which they delegate authority. Non-governmental organisations, private firms, associations and research communities – often in association with governmental bodies – engage in governance: the process of defining principles, norms, regulations and decision-making procedures (Biermann *et al.*, 2009, p. 15).

At the national level the importance of governance and the role of the institutional characteristics of the national system for the design of suitable innovation policies is already recognised (Lundvall and Borrás, 2005). In the international arena, governance processes and the global governance architecture are very fragmented, with a large number of formal and informal institutions. For instance, more than 700 multilateral agreements concerning the environment are currently in force (Biermann *et al.*, 2009, p. 18). Research on global governance has not yet reached the point at which clear statements might be made about the pros and cons of specific institutional settings.

1.2. International STI governance: Case studies and analytical framework

This volume presents in Chapters 2-8 seven case studies on international organisations active in inducing, funding, co-ordinating, carrying out, monitoring and evaluating international STI to meet global challenges in areas such as food security, agriculture, health, energy and climate change (Table 1.1; see also Annex 1.1 for a brief overview of their characteristics). Two mini-studies were also carried out (Annexes A and B). The case studies pay particular attention to governance mechanisms, as these strongly affect the efficacy and the success of the organisation's operations. In addition, Chapter 9 draws on the literature and background material to analyse in detail relevant issues emerging from the studies as they relate to governance. The case studies specifically address five governance dimensions, namely:

- *Priority setting*. What are the mechanisms for defining agendas and priorities in international STI collaborations? How can their strengths and weaknesses be assessed against the backdrop of sometimes conflicting objectives?
- *Funding and spending*. How are existing international co-operative STI projects financed? What lessons might be drawn for future collaborations, possibly on a larger scale than those already established?

- *Knowledge sharing and intellectual property*. How do international organisations approach issues of ownership of knowledge generated through international STI efforts? What are the mechanisms for knowledge and benefit sharing?
- *Putting STI into practice*. What are the mechanisms to facilitate swift application of new knowledge, generated through collaborative STI efforts?
- *Capacity building for research and innovation*. To what extent do international organisations see a mandate to upgrade STI capacities in weaker partner countries? How is capacity development conceptualised and ensured?

These five dimensions are also addressed in the literature dealing with the functions of innovation systems. However, while the literature on innovation systems has broadened significantly during the last years, many studies still focus on the national innovation system as the analytical unit (Edquist, 2005, pp. 181-208). Jacobsson and Johnson (2000) also mention functions that effective and goal-oriented innovation systems have to fulfil. Like their work on new renewable energy technologies, the case studies in this volume take governance dimensions as the starting point for analysing the generation of new knowledge and technologies. Unlike their studies, the case studies do not involve comprehensive innovation systems but do cut across national boundaries:

- *Guidance of the search*. The expected outcome of international collaborative STI efforts is partly driven by expectations in the international policy arena (*e.g.* international environmental agreements), which have to be translated into concrete STI programmes. This process is captured by the governance dimension "priority setting".
- *Resource mobilisation*. STI funding on the national level is by far the most important way to mobilise resources for research. STI funders' legitimacy issues and trade-offs between *juste retour* expectations and the public good character of STI to meet global challenges make resource mobilisation for international efforts a complex issue. This is captured in the governance dimension "funding and spending".
- *Knowledge diffusion, market formation, entrepreneurial activities*. STI to address global challenges necessarily has to attach weight to the issue of diffusing new knowledge, new products and processes to generate a broad impact. The ways to achieve this are addressed in the governance dimensions "putting research into practice" and "knowledge sharing and intellectual property".
- *Knowledge development (learning)* can be seen as the core of any innovation process, including learning by searching, learning by doing and learning by interacting. In international STI efforts involving different world regions, it is crucial to strengthen the capacities of societies with insufficiently developed innovation systems and a lack of personnel and institutional capacities. Ways to do this through national and international efforts are covered in the governance dimension "capacity building for research and innovation".

The case studies contained in this volume were chosen on the basis of a detailed selection process (see Box 1.1).

Table 1.1. Global challenges addressed by the case studies

Organisation	**Chapter 2. Consultative Group on International Agricultural Research (CGIAR)**
Global challenge	Food security and agriculture
Description	It was established in 1971 as a network of international research centres aimed at developing agriculture in developing countries in order to reduce food insecurity. It is the leading multilateral body co-ordinating agrarian research and contributing to food security mainly in poor countries.
Organisation	**Chapter 3. The Bill and Melinda Gates Foundation**
Global challenge	Health (among others; the focus of this case study is on the its work in the field of global health)
Description	The world's largest private foundation. Since its establishment it has become a major contributor to and a central actor in shaping international health policy. The initial focus on child and mother health has developed goals around immunisation and neglected diseases, in particular the eradication of malaria.
Organisation	**Chapter 4. Group on Earth Observation (GEO)**
Global challenge	Multiple; nine "societal benefit areas": disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity
Description	Voluntary partnership of governments and international organisations, co-ordinating efforts to build the Global Earth Observation System of Systems; functions on a best efforts basis. Members include 80 governments, the EC, and 58 intergovernmental, international, and regional organisations.
Organisation	**Chapter 5. Inter-American Institute for Global Change Research (IAI)**
Global challenge	Food security, climate change
Description	International partnership including both developing and developed countries. The IAI is a regional intergovernmental organisation that mobilises, co-ordinates and engages in research related to climate change, biodiversity and water resources.
Organisation	**Chapter 6. The International Atomic Energy Agency (IAEA)**
Global challenge	Food security, health, etc. (the focus here is its work in research and implementation of nuclear technologies in non-energy related fields to address food security and water issues)
Description	International organisation in a working relation with the UN. Beyond its task in verification of the Treaty on the Non-Proliferation of Nuclear Weapons, it promotes collaborative research in the application of nuclear technologies for sustainable development and offers technical co-operation to strengthen capacities.
Organisation	**Chapter 7. The International Energy Agency (IEA)**
Global challenge	Energy supply and use, climate change
Description	It acts as an energy policy advisor to its member countries and has a mandate to address three aspects of balanced energy policymaking: energy security, economic development and environmental protection. The focus of the case study is on the IEA implementing agreements — multilateral technology initiatives.
Organisation	**Chapter 8. Joint Programming Initiatives (JPI) – Agriculture, food security and climate change (FACCE)**
Global challenge	Food security and climate change
Description	An example of the efforts of the European Union to tackle "grand challenges" through joint programming (JP). Among the various initiatives being implemented, the case study focuses on co-operation related to agriculture in relation to food security and climate change.
The following two organisations are included as "mini" case studies in Annex A and B.	
Organisation	**Global Carbon Capture and Storage Institute (Global CCS Institute)**
Global challenge	Climate change
Description	It aims to speed the deployment of CCS technology. To this end, its three core functions are knowledge sharing, fact-based advocacy and project assistance.
Organisation	**The International Arabidopsis Genome Research Project**
Global challenge	Food security and agriculture
Description	This project uses Arabidopsis as an experimental model system to improve the understanding of a flowering plant. The long-term goal is to improve the yield and nutritional value of crops by enhancing resistance to disease, drought and other stresses, while reducing dependence on chemical pesticides.

Box 1.1. Case study selection process

At an OECD workshop in February 2010 participants agreed to undertake a set of case studies to provide the groundwork for a more in-depth study of the governance mechanisms that underlie international STI co-operation to meet global challenges. The case studies would examine how existing institutions operate and highlight the main strengths and weaknesses in their governance. They should:

- Relate to at least one of the global challenges defined in the preparation of the project (*i.e.* climate change, food security and agriculture, global health and energy).
- As much as possible, cover different forms of co-operation (*e.g.* jointly funded science and technology programmes, joint institutes or laboratories, mechanisms to co-ordinate/align national activities, development of common/joint science and technology infrastructures).
- Be able to contribute to the development of policy options for the governance of international STI co-operation to address global challenges.

Furthermore, the sample should, insofar as possible, represent diverse actors (government, private sector, private foundations, international organisations), sizes, governance modes, lengths of existence (several decades, recently formed), geographical scope (regional, international) and funding structures (*e.g.* in-kind, task-sharing), among others.

To bridge possible gaps, a number of smaller institutional case studies were proposed to complement the in-depth core case studies. They broadly followed the same approach as the large case studies but were more concise.

The proposals for the case studies were provided by experts and workshop delegates. The OECD Secretariat clustered the proposals into five groups: climate change, food security and agriculture, global health, energy, and miscellaneous. Delegates and experts presented their priorities.[1] The final sample included collaborations among participants of equal capacity and some that focus upon upgrading capacities in participant countries or institutions. Some co-ordinate research efforts while others conduct basic and applied research.

1. There were 36 proposals, nine of which were put on the shortlist. The final seven core case studies and two mini case studies are presented in this volume.

The case studies were carried out by expert teams from several OECD member countries (Austria, France, Germany, Korea, Norway) and two enhanced engagement countries (People's Republic of China, South Africa). Each case study was conducted independently, although experts interacted throughout the research process in both formal and informal settings. The case studies were based on a combination of semi-structured interviews with stakeholders and observers and analysis of written materials available online or provided by interviewees. Face-to-face and remote interviews were conducted with relevant individuals over the course of 2010 and 2011. Interviewees included people both inside and outside of the organisation, at both "high-policy" and "operational" levels. In cases where individuals were "outsiders" to the organisation, they had significant expert knowledge and/or prior involvement with the entity which justified their inclusion.

The analysis arising from the case studies provides a first step in achieving an understanding of how different modes of governance of international co-operation in STI function and in finding what may be promising approaches. It sets the stage for further in-depth research and aims to provide valuable input for more in-depth studies on the five governance dimensions. Chapter 10 provides some lessons learned from the studies and draws a conclusion.

Annex 1.1
Overview of the case studies

		Group on Earth Observations (GEO)	International Atomic Energy Agency (IAEA)	Inter-American Institute for Global Change Research (IAI)	Consultative Group on Agricultural Research (CGIAR)	Joint Programming Initiative (JPI) - Agriculture, Food Security and Climate Change (FACCE JPI)	Bill and Melinda Gates Foundation	International Energy Agency (IEA) Implementing Agreements (IAs)
Basic facts	**Year of formation**	2006	1957	1994	1971	2010	1994	1974 (IEA)
	Number of staff	19	Ca. 2 300	13	8 000	N/A	Ca. 870	Ca. 220
	Location of headquarters	Geneva, Switzerland	Vienna, Austria	São José dos Campos, Brazil	Washington, United States	Paris, France (FACCE JPI)	Seattle, United States	IEA Headquarters: Paris, France
	Number of member countries	84 members and 56 participating organisations	151	19	47 members and 17 participating organisations	20	N/A	28 (IEA); members and non-members participate in IAs
Basic institutional character	**Type of organisation**	Intergovernmental organisation (IGO) with so-called participating organisations	UN Related Organisation	IGO co-ordinating and funding a network of scientists and decision makers throughout the Americas	Partnership between research organisations and funders; work conducted by 15 members of the Consortium of International Agricultural Research Centres	JPIs aim to align on a self-organised basis national RTDI policies and programmes; Voluntary, bottom-up approach combined with strategic European level guidance	Private foundation	Intergovemmental organisation, IAs are independent bodies operating within a framework which allows for multilateral collaboration
	Regional or global	Global	Global	Regional	Global	Regional	Global	Global
	Research responsibilities	Co-ordinating and undertaking research	Co-ordinating and implementing	Co-ordinating and funding	Co-ordinating, implementing and funding	Co-ordinating national research and implementing	Funding	Co-ordinating and implementing

Annex 1.1
Overview of the case studies (cont'd)

		Group on Earth Observations (GEO)	International Atomic Energy Agency (IAEA)	Inter-American Institute for Global Change Research (IAI)	Consultative Group on Agricultural Research (CGIAR)	Joint Programming Initiative (JPI) - Agriculture, Food Security and Climate Change (FACCE JPI)	Bill and Melinda Gates Foundation	International Energy Agency (IEA) Implementing Agreements (IAs)
Funding	**Annual fund**	CHF 5.5 million (operational budget)	2008: EUR 285 million regular budget and USD 80 million voluntary contributions	2009/2010: USD 2 270 793 (core budget)	2009: USD 629 million 2008: USD 553 million	N/A	Total 2009 grant payments: USD 3.0 billion	Various
	Main funding mechanism from member countries	Voluntary contributions to special projects	Contribution of members is based on UN member payment scheme; Extra budgetary contributions are voluntary	Voluntary contributions allocated among members and based on annually approved budget	Funded by donor contributions from members and others, and by Centre-earned income	Still in its start-up phase; no funding structure for JPI FACCE yet in place	Tax-exempt private foundation that is structured as a charitable trust	IAs operate under a cost or task sharing scheme or a combination of both
Institutional arrangements	**Highest decision-making organ**	GEO Plenary	General Conference (consists of representatives of all members)	Conference of the Parties (CoP) consisting of all members	Two-pillar management structure: Consortium Board and fund donors	FACCE JPI: Interim governance mode until the end of 2011 is the Interim Governing Board	Management Committee; Grant-making priorities and goals are set out by Bill and Melinda Gates, Bill Gates Senior and Warren Buffett	IEA Secretariat: Governing Board; Each IA Executive Committee acts as the 'board of directors' of the IA
	Impact evaluation	Established a monitoring and evaluation framework, should enable GEO to evaluate whether strategic targets have been met; Conducted in 2009 a mid-term evaluation	No impact evaluation, only project evaluation of all projects	No	Standing Panel on Impact Assessment assesses impacts of CGIAR outputs, supports centres in their assessment activities, provides feedback to CGIAR on priority setting and develops links to *ex ante* assessment and overall planning	The Strategic Research Agenda establishes the evaluation procedures of a JPI and the Competiveness Council monitors the progress of JPIs	Every three to five years evaluations of the Foundation's overall strategy are made, sometimes by third party evaluators. Generally, these evaluations are not published	Regular process established by the IEA to review the efficiency and effectiveness of the IAs: Each IA is subject to review every five years prior to extension of the activity

Notes

1. In exploring the interrelations between STI and global challenges, the following definitions seem pertinent. Science refers to research the main purpose of which is to generate knowledge that helps to explain or understand natural or social phenomena and/or can assist human endeavour. Technology refers to the creation and use of technical means and their relation to life, society and the environment. The *Oslo Manual* defines innovation as "the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD and Eurostat, 2005, p. 46).

2. Common pool resources differ from public goods in that they may face problems of overuse or depletion. Their size or characteristics, however, make it costly, but not impossible, to exclude potential beneficiaries from obtaining benefits from their use (Ostrom, 2008).

3. Innovation research distinguishes between radical innovations, often an outcome of research and development (R&D), and incremental innovations, often the result of continuous improvement of existing products and processes. Radical innovation is often related to the Schumpeterian concept of "creative destruction", with new solutions ousting incumbent technologies and companies. Incremental innovations are not necessarily related to structural changes in markets and company structures (Fagerberg, 2005, p. 7).

4. For example, a recent study by McClanahan *et al*. (2011) quantified a critical point for the fish stocks required to ensure the survival of the populations in the complex ecosystem of coral reefs.

5. However, as stated by the Royal Society (2011, p. 59), with respect to a similar observation, "Citation is not a direct measure of quality. A multi-authored piece may provide a 'network effect' in that it is seen by more people (...) and therefore becomes more cited". Citation is commonly used as a proxy for quality and expresses how well the information contained is used. However, important dimensions of the impact of research are not covered by citation indices, especially when the usefulness of research output for problem solving is concerned.

6. The Stern Report, more correctly The Stern Review on the Economics of Climate Change, has received highly positive response from both policy makers and researchers. It has also been heavily criticised for supposedly over-rating the costs of climate change, while under-estimating the costs of determined mitigation action, see *e.g.* Weitzman (2007).

7. *www.g20-g8.com/g8-g20/g8/english/live/news/renewed-commitment-for-freedom-and-democracy.1314.html*.

8. *www.sciforum.hu/declaration/index.html*.

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Chapter 2

The Consultative Group on International Agricultural Research*

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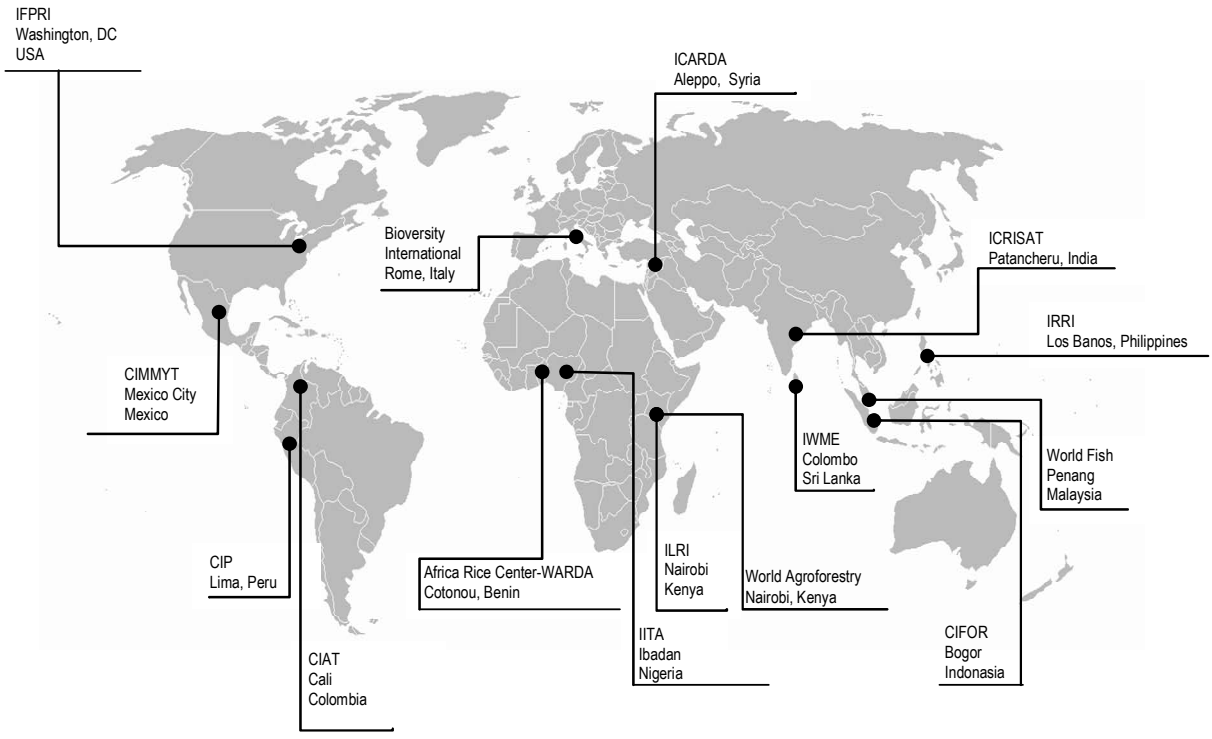
The Consultative Group on International Agricultural Research (CGIAR) is a 40-year-old strategic partnership that supports a network of 15 international agricultural research centres working for the eradication of hunger and poverty at the global level. Lessons from its recent reform encompass the adjustment of its organisational structure (separating "doers" and "funders"), shifting from an institutional to a programmatic approach, consultation with stakeholders to discuss long-term strategy and research priorities, the importance of a broad partnership involving local and emerging research organisations, and management of the process of change.

* The Consultative Group on International Agricultural Research (CGIAR), a global research partnership for a food-secure future, was granted the status of an international organisation on 2 March 2012; however, the original acronym was not changed.

2.1. Introduction

The Consultative Group on International Agricultural Research (CGIAR) is composed of 64 countries and other entities. These include countries from the North (22) and South (25), private foundations (the Bill and Melinda Gates Foundation, the Rockefeller Foundation, Syngenta), regional organisations and multilateral donors and sponsors (the World Bank, the International Fund for Agricultural Development, the UN Food and Agriculture Organization, the UN Development Programme). It is a strategic partnership of 15 international agricultural research centres (IARCs) with over 8 000 staff throughout the world (Figure 2.1 and Box 2.1). Its objective is sustainable agricultural growth to benefit the poor in developing countries: to reduce poverty and hunger, improve human health and nutrition, and increase ecosystem resilience. It collaborates with governments and civil society organisations as well as private businesses around the world. The new crop varieties, knowledge and other products resulting from the CGIAR's collaborative research are made widely available to individuals and organisations throughout the world.

Figure 2.1. The CGIAR global network



Source: CGIAR.

Box 2.1. The 15 international agricultural research centres

Africa Rice Center (formerly WARDA) (headquartered in Cotonou, Benin)
Bioversity International, formerly IPGRI (Rome, Italy)
CIAT: Centro Internacional de Agricultura Tropical (Cali, Colombia)
CIFOR: Center for International Forestry Research (Bogor, Indonesia)
CIMMYT: Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico City, Mexico)
CIP: Centro Internacional de la Papa (Lima, Peru)
ICARDA: International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
ICRISAT: International Crops Research Institute for the Semi-Arid Tropics (Patencheru, India)
IFPRI: International Food Policy Research Institute (Washington, DC, United States)
IITA: International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILRI: International Livestock Research Institute (Nairobi, Kenya)
IRRI: International Rice Research Institute (Los Baños, Philippines)
IWMI: International Water Management Institute (Colombo, Sri Lanka)
World Agroforestry Centre, formerly ICRAF (Nairobi, Kenya)
WorldFish Center (Panang, Malaysia)

The CGIAR was formally launched on 19 May 1971 by the World Bank and 16 donors, including governments of industrialised countries and other organisations, and has since been hosted by the World Bank. CGIAR has become a major player for world agricultural research and a reference in terms of how scientific research can help develop agricultural solutions for the poor (Science Council, 2005). It contributes to technological progress both directly and in partnership with national and regional agricultural research systems and development organisations involved in technology transfer and innovation. It has built on the success of the initial green revolution in alleviating hunger in poor areas of Asia and Latin America and has progressively widened its focus and research strategies from breeding and genetic improvement of a few staple crops (*i.e.* wheat, rice, maize), with the accompanying technical package, to a larger number of food crops (*i.e.* potatoes, groundnuts, bananas) and even animals (*i.e.* livestock, fish). It has also widened its focus to new approaches based on the eco-regional dimension of agriculture, greater focus on the use of natural resources and biodiversity, and policy and institutional dimensions. The IARCs' research teams undertake many activities to link science and development. Early on, several IARCs were given a mandate to conserve the world's genetic resources of major staple crops.[1] The IARCs thus played their part in meeting the global challenge of genetic conservation long before concerns about global biodiversity emerged. The CGIAR may be considered as one of the first multilateral efforts to organise the international community's response to a "global challenge" and the only institution with a clear mandate on science and technology development for the eradication of hunger and poverty at the global level (Science Council, 2005).

The CGIAR fulfils a critical role in the global Agricultural Research for Development system: producing, assembling and delivering research outputs in collaboration with research and development partners. It delivers international public goods and helps to solve development problems which have been identified and prioritised with the collaboration of developing countries.

2.2. CGIAR reform process

In the early 2000s, the CGIAR undertook efforts to increase its ability to cope with the new global economic and environmental context. This led to extensive governance reforms in 2007 and a decision, two years later, to restructure the CGIAR system. Its vision was redefined in December 2009 "*to reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership*".[2] The reform prioritised three strategic objectives:

- *Food for People*. Create and accelerate sustainable increases in the productivity and production of healthy food by and for the poor.
- *Environment for People*. Conserve, enhance and sustainably use natural resources and biodiversity to improve the livelihood of the poor in response to climate change and other factors.
- *Policies for People.* Promote policy and institutional change that will stimulate agricultural growth and equity to benefit the poor, especially rural women and other disadvantaged groups.

In 2008 and 2009 a strong and dedicated nucleus of donors, centres and partners devoted substantial resources to undertaking a thoroughgoing reform. The results of their work were unanimously adopted by all CGIAR members in December 2009. This vast reform is now being put in practice. At the time of writing, full implementation of the new system will probably require another two to five years.

The new organisation (see Figure 2.A1) separates the "doers" (the centres) and the "funders" (mainly CGIAR members) in order to reduce transaction costs and internal duplication and to allow for more operational and managerial capabilities and better partnership. It has:

- Created a fund, hosted by the World Bank, to collect funds for the system and the CGIAR research programmes in order to harmonise members' contributions.
- Created a consortium of the 15 centres, and the Consortium Board, with international legal status, to manage for results.
- Created a set of CGIAR research programmes to facilitate optimal organisation of the division of labour between IARCs and with their partners (national, regional, international) on issues relevant to the new global context.
- Created the Independent Science and Partnership Council to make sure that the best science is mobilised.
- Created links with the Global Forum on Agricultural Research (GFAR) to organise biennially a Global Conference on Agricultural Research for Development (GCARD) to discuss the building of the CGIAR's Strategy and Results Framework (SRF) with all stakeholders.

In addition to resulting in a new structure and management, the reform process offered seven critical lessons:

- The need to adjust "purpose" and "structure" by working out a set of principles to be adopted by the CGIAR members: to harmonise their approach to funding; to manage for results; to ensure effective governance and efficient operations by adopting "business-like" procedures; and to collaborate and partner with all stakeholders.
- The need for a managerial structure that clarifies the complex CGIAR system by separating the "doers" (the operational research and development organisations) and the "funders" (whose interventions in operations must be strictly regulated).
- The need to shift from funding centres and projects to funding programmes. The CGIAR's strategic approach builds on four "strategic outcomes"[3] to be pursued in future international agricultural research, with CGIAR research programmes as the main instrument to "align" research outputs with the strategic outcomes. This implies a focus on the content of the research and not on the institutions (the 15 IARCs).
- The need for a strong link with the stakeholders concerned by the global challenges and involved in the resulting development efforts. This requires taking account of some of the main features of agricultural development: stakeholders are diverse (for example, farmers, suppliers, processors, traders), spread over many territories and in large numbers (millions). To facilitate a demand-led approach, a partnership was established with the Global Forum on Agricultural Research, an international body representing all stakeholders, to discuss priorities and to monitor results and progress made.
- The need for a balance between avoidance of duplication of effort in the short run and capacity building in the weak/developing nations in the long run.
- The need to shift away from the dominance of the advanced research institutes of OECD countries through multilateral co-operative strategies to boost global science capacity and the generation of innovations. The role of emerging national advanced research institutes must be acknowledged and their special skills used to strengthen the capacities of the developing countries.
- The need for a group of committed high-level representatives of the members and of the CGIAR bodies to manage the reform, to create group dynamics, to bridge with their constituencies and bring forward questions and proposals on the mission before elaborating new governance mechanisms.

2.3. Main characteristics of the overall governance model

The following analysis of the governance model refers both to the CGIAR's past and to its new organisation (see Annex 2.1 for details).

Partnerships, stakeholder involvement and co-operative relationships

CGIAR cannot produce and deliver on its own the international public goods that are the core of its mandate (new crop varieties, agricultural practices, policy advice). Therefore, the IARCs mobilise science for development and play a translational role between the science and technologies developed by the advanced research institutes of industrialised countries and the national agricultural research systems of developing countries. The latter conduct adaptive research (adaptation to local agricultural conditions, including natural resources and environment, socioeconomic context and policy framework) and dissemination functions. This is mainly worked out through activities shared as part of research projects and through capacity building.

Partnership with local research centres is at the forefront of the CGIAR mission. CGIAR centres have a widespread presence in the developing world where they have a long history of interaction with national agricultural research systems. However, many stakeholders question the effectiveness of CGIAR action in this area. In the last thorough review of the CGIAR system (MacAllister *et al*., 2008), the panel noted that while the centres show evidence of a range of partnerships with measurable added value, on the whole the CGIAR and its centres fall far short of developing the strategic potential of partnerships. Furthermore, the CGIAR's 2006 Stakeholder Perceptions Survey found that the quality of its partnerships was a perceived weakness. Survey respondents indicated that the two areas most in need of improvement were collaboration with external organisations and research collaboration with partners (CGIAR, 2006).

Every six years, the CGIAR develops a new Strategy and Results Framework (SRF). It consults with a large number of stakeholders to define the framework's programmes. The SRF is also discussed in the Global Conference on Agricultural Research for Development, which seeks to ensure open and transparent interaction between CGIAR and agricultural research stakeholders in documenting areas of work and priorities.

The Global Forum on Agricultural Research is the main organiser of the Global Conference on Agricultural Research for Development. Its membership is grouped on a regional basis. It includes scientists from national agricultural research systems, advanced research institutes and IARCs, farmers' organisations, private-sector and civil society organisations (CSO) representatives, *i.e.* the main constituents of the national/local innovation systems. It provides the opportunity for a general discussion of the CGIAR's SRF and, every two years, the possibility to discuss and monitor the transformation of the Agricultural Research for Development system, *i.e.* the evolution of the partnership within the global research and innovation system.

The creation of the CGIAR's global-scale research programmes are also intended to increase linkages and collaboration with science and technology organisations. These are still being established and lessons are being learned to improve the quality of the partnerships in the CGIAR research programmes.

Agenda and priority setting

The Strategy and Results Framework is the key reference document (CGIAR, 2010). It indicates the priorities and the development rationale of the proposed global-scale research programmes. Priority setting is intended to be concretely linked to future activities and is carried out by the centres and the Consortium with their chosen partners. Once the SRF is prepared by the Consortium and discussed by the GCARD to provide an opportunity to engage a larger set of stakeholders in discussing these priorities, it is endorsed by the Funders Forum. It can then be used as a basis for preparing the performance agreements to be financed by the Fund Council.

The complexity of developing a comprehensive partnership involving all stakeholders (*i.e.* centres, the Consortium, farmers' organisations, the private sector) makes it difficult to reach full agreement on priorities. Therefore, while the priority-setting process is open and consultative, it is ultimately on the decision of the Consortium Board and Fund Council. An Independent Science and Partnership Council acts as counsellor to the Fund Council. Its recommendations offer a further possibility to check and adjust priorities and activities.

The first round of this process, held in 2010-11, demonstrated that the formula will have to be improved to ensure the proper linkages with the resulting research programmes.

Funding and spending

Financial contributions come from CGIAR members (donors). For specific projects, financial contributions may come from any agency – even non-members – interested in mobilising the science resources of the centres' teams. The total 2010 budget amounts to over USD 673 million.

Until the Fund was created, the CGIAR was only an intermediary between members and centres, with no authority in budget allocation. Since 2000, members' contributions have tended to be directed towards specific projects (so-called "restricted funds") rather than towards the general activities and overall programmes of the IARCs (so called "unrestricted" or "core funds"). Between 2000 and 2010, the restricted funds were about two-thirds of total funding. The result was a form of "direct management" of the centres' activities by members (mainly government agencies).

This situation resulted in a crisis that was reinforced by free-riding and difficulties due to delayed announcement and disbursement of the annual contributions. The crisis was both financial and managerial in that the centres could not implement their scientific strategy because they were dependent on a "jigsaw of special projects" and found it difficult to make long-term plans and stick to strategic priorities. It also severely increased transaction costs because of the reporting, monitoring and evaluation processes attached to every project by each contributing donor (each of which had its own rules).

With the reform the situation changed as the new Fund has real budget allocation authority. Following the reform, financial support for the CGIAR is harmonised through a multi-donor trust fund (the CGIAR Fund) which is intended to serve as a strategic financing facility for multi-year support of CGIAR research. Donors can decide on the use of their funds by allocating them to three "windows":

- The entire CGIAR programme portfolio (*i.e.* unrestricted funding to be allocated by the Fund Council to research programmes or centres in consultation with the Consortium Board).

- Specific CGIAR research programmes that are part of the agreed programme portfolio (programme funding).
- One or more centres (institutional funding for activities under the SRF). These funds are not subject to review, allocation or approval by the Consortium or Fund Council.

These three windows give donors flexibility to choose their preferred use of funds while maintaining coherence in operations. Allocations by the Fund Council are based on the Consortium's proposals, a more centralised decision process than in the past, which focuses on programmes instead of centres. This new funding scheme is rooted in the principle of "harmonisation", which states that CGIAR funders will:

- Seek to provide adequate and predictable funding for implementation of the SRF.
- Convene and collaborate through the Funders Forum.
- Fund all costs associated with CGIAR-wide functions based on a cost structure and financing plan developed by the Consortium Board in conjunction with the Fund Council and endorsed by participants in the Funders Forum.
- Respond to Consortium requests to address over- and under-funding.
- Join the Fund if, when, and to the extent possible.
- Seek to refrain from providing funding for the SRF outside the common operational framework.

In addition, the bilateral funds going directly to the centres for specific projects must also contribute to activities in line with the agreed SRF and CGIAR research programmes. Fiduciary accountability for proper spending of the allocated budgets is two-fold:

- A "Consortium performance agreement" (including deliverables and impact pathways) between the Fund and the Consortium.[4]
- A set of implementation performance contracts (including clear deliverables and outcomes) between the Consortium and the lead centres of the various CGIAR research programmes, and possibly some important partners.

A remaining problem is the fact that dependency on annual budgets does not allow for good planning of research, while donors' contributions are made on an annual basis. Centres have asked for multiannual commitments from donors in order to plan multi-year research programmes with some clear view of the managerial constraints. Only a few donors have pledged to make a multi-annual commitment.

Intellectual property

As the purpose of the CGIAR is to produce regional or global public goods, its new technology and knowledge are in principle freely transferred or shared (public disclosure). Its intellectual assets are not meant to be used to raise income and research results are not to be privatised.

Because of the CGIAR's mandate regarding genetic resources of particular importance for agriculture, a specific policy (ISPC-CGIAR, 2010) establishes common standards and procedures for CGIAR centres to acquire, manage and release intellectual assets. Guidelines were discussed in 1996 and refined in 2008. The Consortium Board

recently approved a Policy on the Management of Intellectual Assets, which lays the ground for tackling issues relating to stewardship and liability.[5]

Bridging research and practice

Global or regional public goods are produced in various ways, including:

- Conservation of core collections of germplasm and knowledge. The collections of crop and animal germplasm, supported by resources such as databases[6] and information about the collections, are a core asset of the CGIAR. Their utility and value is likely to increase owing to growing demand created, for example, by climate change.
- Fostering of research and technological, social, economic and institutional innovation and leveraging of resources and competencies of other actors in support of shared objectives. This may involve collaboration, brokerage and networking; facilitating spillovers and scaling up of technologies; mobilisation of funding; and the establishment of regional and global technical facilities.
- Support for policy and decision making to respond to increasing demand from decision makers at global, regional and national levels for dedicated decision support systems and tools to facilitate evidence-based policy formulation.

The 15 CGIAR centres are located in key areas (*e.g.* research stations located in a diversity of agro-ecosystems) and provide an extensive global research infrastructure. With their long history of interaction with national agricultural research systems, they are able to link research to the realities of agriculture, by drawing on scientists from various disciplines with knowledge of key agro-ecosystems. The centres develop various means of distributing the information and technologies produced, *e.g.* by working with extension services or "farmers' field schools", by organising workshops and by building Internet-based instruments.

Capacity building and technology transfer

The CGIAR invests about 20% of its resources in capacity building to support technology delivery, particularly by strengthening national agricultural research systems. Centres have units responsible for capacity building and technology transfer. To enhance these functions, a global platform is being considered. The CGIAR's capacity-strengthening function contributes to the global agricultural knowledge system by training hundreds of agricultural scientists and supporting institutional development. These activities enhance synergies with national agricultural research systems.

However, there are very few impact evaluations of this activity. Those that have been undertaken have encountered methodological challenges with respect to causality and the measurement of tangible impact on production. The recent CGIAR system evaluation noted that although several qualitative analyses tell convincing stories of human capital formation and institutional effectiveness, they do not provide a rigorous empirical evaluation (MacAllister *et al*., 2008).

Table 2.1. The strengths, weaknesses, threats and opportunities of the CGIAR

Strengths	• CGIAR's mandate to produce international (global and regional) public goods. • Public trust in CGIAR as an honest broker acting in the interest of the world's poor. • 15 centres located in key areas of the world provide a global research infrastructure, a critical mass of scientists from various disciplines with accumulated knowledge of key agro-ecosystems and, altogether, a widespread presence and long history of interaction with national agricultural research systems. • Specific mandate relating to genetic resources allows for a strong impact on the use of genetic diversity for development. *Governance:* • No financial threshold to be a member and contribute to the fund, which allows poor countries to be part of the organisation. Fair and equitable distribution of seats (North and South, large and small contributors) in the Fund Council. • Clear budget rules and three financing windows offer donors several options. • Formal discussion of the Strategy and Results Framework document in the GCARD, allowing for wider views on the content and quality of work. • Open and transparent reform process that mobilised a large number of partners.
Weaknesses	• Insufficient resources invested in participation of stakeholders and beneficiaries. • Difficulty for meeting advanced science and effective development criteria at the same time. *Governance*: • Weak representation of "non-research" stakeholders and beneficiaries. • Complexity of the overall partnership (*i.e.* centres, Consortium, stakeholders) makes it difficult to reach global agreement on priorities. • Annual budgets do not allow for sufficient funding predictability, which makes it difficult to plan long-term research programmes.
Threats	• Insufficient participation of stakeholders in the definition and formulation of the programmes can create reluctance or even opposition to CGIAR activities. • Pressure to ease the GCARD process in order to strengthen control by the centres, the Consortium or the fund. • Internal difficulties of GFAR could spread to the GCARD process, thus undermining the "planning stage" of the CGIAR. • Willingness to capture (financial) resources detrimental to sound partnership.
Opportunities	• Clear engagement through performance contracts can stimulate funding of research as deliverables are clearly defined. • Ongoing reform should enhance the importance of impact and the involvement of key research and development partners. • GCARD process (governance) and research programmes (science) offer a new opportunity to link with stakeholders as well as with national agricultural research systems and advanced research partners, and to allow for periodic adjustments, questioning of priorities, and raising new issues. • Integration of fast-growing economies emerging research systems into the governance and operations of international agricultural research.

2.4. Overall impact

The CGIAR has developed a strong "culture of impact" by integrating most of its scientific activities into "impact pathways". Several assessments have been conducted over the years and a 2003 meta-analysis of these *ex post* impact assessments tried to evaluate the CGIAR's impact. It estimated that since the creation of the CGIAR its impact ranges from USD 14 billion to USD 120 billion (Independent Review, 2008, p. 116). Another estimate found that every dollar invested in CGIAR research activities would bring USD 9 to small family farming. On the most conservative assumptions, it was estimated that overall benefits attributable to CGIAR research would be double the costs of the research (Science Council, 2005a, 2). However, the 2008 independent review found that most of these benefits were associated with just a few of the CGIAR's many programmes, leaving the impact of its many other programmes unknown or questionable (Science Council, 2008). Nonetheless, beyond the difficulty of assessing its impact rigorously, the CGIAR has provided an impressive set of success stories, *e.g.* in terms of cultivated varieties or pest management.

The new, profoundly restructured CGIAR began operations in 2010. The implementation of the reform will, in the next couple of years, require the firm commitment of the members (the "funders") and strong managerial capacities tied to a forward-looking and inclusive mindset among the "doers" (the centres).

The CGIAR managed its reform process by bringing together a group of committed individuals, high-level representatives of members (*i.e.* with some influence in their respective institutions) and of the CGIAR bodies, to trigger a change of mindset and create a group dynamic. These individuals were able to address their constituencies and push forward proposals on the CGIAR's mission and then on its governance. In many ways this process was typical of many types of organisation.[7]

Governance of a multilateral organisation is complex and requires time and transaction costs to bring people together and find collective solutions. However, these costs are not sunk costs but investments. Partnering involves resources but they allow for the construction of long-term foundations. Table 2.1 presents an overview of CGIAR's strengths, weaknesses, threats and opportunities.

2.5. Conclusions and lessons learned

Lessons for governance in general

The CGIAR case study offers a review of the process of change/reform in the management and governance of a multilateral institution devoted to science, technology and innovation by answering the question: How does an organisation adjust its "structure" to its "purpose"?

A noteworthy feature is the critical work done by CGIAR at the inception of the reform by revisiting its vision, mission and strategic objectives in view of improving its relevance, effectiveness and efficiency. A large organisation with a diverse constituency and long-term purpose must find ways of adjusting its goals over time. In the case of the CGIAR this evolution is exemplified by the widening of its mission from "fighting hunger and poverty" to include environmental sustainability and healthy food goals. Flexibility and means to adjust the strategic framework under which the organisation operates are critical to keep pace with change. To this end CGIAR scientists widened their scope from "productivity" to "natural resource management" and "sustainable development".

Noteworthy in this process was the constant search for greater impact. This led to the adoption of four principles:

- To harmonise donors' approach to funding and implementing international agricultural research for development by creating strong structures (the Fund, the Consortium) to replace the informal organisation that prevailed during the first four decades.
- To manage for results in accordance with a visionary strategy that demonstrates the relevance of the activities (the global-scale research programmes).
- To ensure effective governance and efficient operations by adopting "business-like" procedures based on performance contracts at different levels.
- To collaborate and partner with and among funders, implementers and users of research, as well as other external partners supporting the strategy.

These four principles were adopted to lead the reform process. They constitute major lessons with far-reaching effects.

Developing a programmatic demand-led approach

An important feature of the new CGIAR is the shift from a focus on centres to a focus on programmes. For the science and technology produced to be effectively used by stakeholders and beneficiaries,[8] a sound connection must be established between the strengths of the centres and the needs/interests of their external allies. The biennial Global Conference on Agricultural Research for Development, explicitly linked to the Global Forum on Agricultural Research and its regional forums, was set up as a means to determine relevant strategic priorities and facilitate strategic partnerships. It allows the CGIAR to extend its influence and helps make the centres more receptive to demand. It is an instrument to incorporate a demand-led priority process into scientific momentum.

At the managerial level, the existence of a centre of operations (the Consortium) independent of the budgetary rules of donors, allows for "business-like" operations. It gains effectiveness by keeping key decisions separate from members' diverse – and sometimes conflicting – administrative rules. This is the essence of the separation of "funders" and "doers".

Addressing the technology gap

In agriculture and other sectors based on small, scattered enterprises, it is crucial to involve stakeholders/beneficiaries from the inception of the design of the research programmes. The science must be driven by demand. Furthermore, it should be squared with the reality of downstream aspects of the technological translation of scientific knowledge. To be sustainable, technology transfer and dissemination (the innovation process) depend on their appropriation by local actors. Developing a strong and structured multilateral organisation in this field therefore requires a balance between:

- Avoiding costly duplication of effort in the short run.
- Avoiding acting in the place of national research organisations.
- Supporting the building of complementarities and capacity building in the weak/developing nations in the long run.

In addition, multilateral science and technology co-operation to deliver public goods requires explicitly defined strong intellectual property principles.

Reshaping the global agricultural research system

The respective roles of the advanced research institutes in OECD countries and the research systems of emerging economies have to be reconsidered. The fast-growing research capacities of the latter call for new relationships. Moving away from the past scientific dominance of the former requires co-operative strategies with emerging advanced research institutions, acknowledging their role and using their special skills to reinforce the capacities of developing countries.

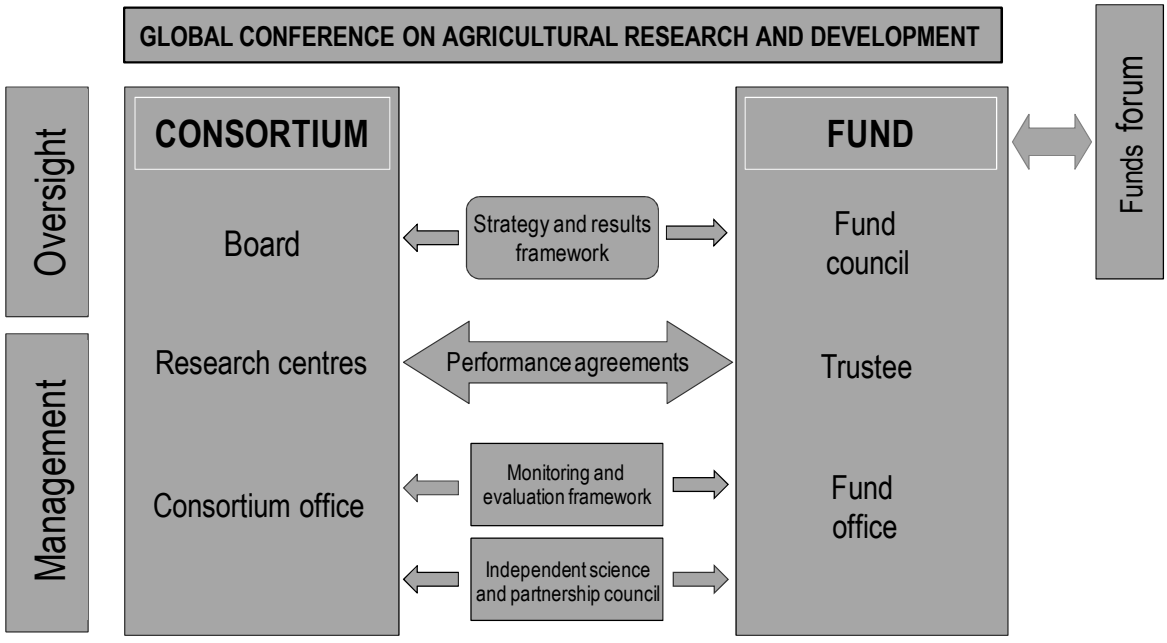
To make the best use of existing knowledge, emerging research centres have to be included as partners with the advanced research institutes of the North in global S&T programmes. Co-operation involving less developed, emerging and industrialised countries will be an important pillar of the future common international research system.

Annex 2.1

Institutional arrangements for decision making: the post-reform CGIAR

This annex provides further information on the structures and organisation of the CGIAR after the 2009 reform.

Figure 2.A1. The new governance structure of the CGIAR



Source: CGIAR.

The two pillars of the new CGIAR have different institutional arrangements:

- The Fund is managed by an office based in Washington, DC (United States) under the guidance of the Fund Council and of the Funders Forum (all Fund donors, and the Consortium Board chair and the ISPC chair as permanent observers);
- The Consortium is governed by a Consortium Board and managed by a CEO and team based in Montpellier (France).

The Fund Council is a representative body of donors and other stakeholders, composed of:

- *Donor countries* that are members of the OECD's Development Assistance Committee. The four constituencies used for Council membership purposes are: Europe, North America, Asia and Pacific. While there is no minimum for contributions to the Fund, the minimum contribution required to be eligible for representation in the Fund Council is USD 500 000.

- *Developing countries and regional organisations serving the South* with representatives for: *i)* Sub-Sahara Africa (SSA), *ii)* Asia, *iii)* Pacific, *iv)* Central and West Asia and North Africa (CWANA), *v)* Latin America and Caribbean (LAC), and *vi)* regional forums *(*constituted by countries in each developing country region).
- *Multilateral and global organisations and foundations* which are multilateral organisations and foundations that contribute to the Fund and the Global Forum for Agricultural Research (GFAR).
- The composition of the 22 seats on the Fund Council is:
  - Donor countries (8): Europe: 4; North America: 2; Asia: 1; Pacific: 1.
  - Developing countries and regional organisations (8): SSA: 2; Asia: 2; Pacific: 1: CWANA: 1; LAC: 1; Regional forums: 1.
  - Multilateral and global organisations and foundations (6): World Bank: 1; International Fund for Agricultural Development (IFAD): 1: FAO: 1; Foundations: 2; GFAR: 1.

This composition maintains an approximate North-South balance. Donor country seats take into account recognition of their share of funding (not exactly proportional), and regional balance. The chair of the Fund Council is provided by the World Bank, which has headed the CGIAR from its inception. Decisions are made by consensus. As a new body in the wake of the reform, the Fund Council's effectiveness will be reviewed as part of the external review of the system after three years. Revisions of its composition might be proposed.

Notes

1. IRRI for rice (existing collection of over 110 000 varieties), ICRISAT for groundnuts (more than 30 000 varieties), CIAT for cassava (6 500) or CIMMYT for wheat (140 000) and maize (27 000).
2. CGIAR (2012), *www.cgiar.org/who/index.html*
3. Namely reduction of rural poverty, increase in food security, improved nutrition and health, and more sustainable management of natural resources.
4. As the Consortium is not a real "parent company" of the centres, the Consortium Board will have to develop appropriate ways to manage accountability at the relevant levels.
5. In the past, some agreements entered into by some challenge programmes (global programmes involving several CGIAR centres and partners) were questioned as being inconsistent with official CGIAR policy. The new policy addresses this issue in order to ensure the public good nature of CGIAR research.
6. Such as the system-wide Information Network for Genetic Resources (SINGER), an open relational database that links the databases of 11 gene bank centres.
7. Significant governance reforms in the CGIAR context were made possible in the wider policy context of the Paris Declaration on Aid Effectiveness (2005) and the subsequent Accra Agenda for Action (2008), as they aim at a better harmonisation of co-operation practices.
8. An important feature when dealing with agriculture is the diversity of stakeholders (farmers, suppliers, processors, traders) and of territories involved.

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Chapter 3

The Bill and Melinda Gates Foundation and global health issues[1]

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Through its Global Health Program the Gates Foundation quickly established itself as a leading actor in the global health field. It is known for its focus on technological progress and particularly for its commitment to develop new vaccines. This case study looks at how the Gates Foundation seeks to achieve these goals and examines its governance mechanisms. A number of examples serve to illustrate how the foundation operates and relates to its grantees. Finally, this chapter notes some strengths and weaknesses of the foundation's strategies.

3.1. Introduction

The Bill and Melinda Gates Foundation (hereafter, the Gates Foundation, the Foundation) is the world's largest private grant-making foundation and a leading actor among the world's private philanthropic organisations. Over nearly two decades, it has become a major contributor to global health and a central actor in shaping international health policy. It is estimated that in 2007 the Foundation's expenditure on global health – approximately USD 1.65 billion – was comparable to the annual budget of the World Health Organization (WHO). The Foundation's contribution to WHO is also one of the largest and exceeds that of most G20 governments.

The Gates Foundation was established in 1994 as the William H. Gates Foundation. In 1999 it was reorganised and its name changed to the Bill and Melinda Gates Foundation. In recent years its funding capacity has been considerably strengthened by contributions from the wealthy American investor Warren Buffett. The Foundation is currently undergoing reorientation and reorganisation following Bill Gates' decision to leave his work at Microsoft to dedicate more time to the Foundation.

The Foundation has two principal activities: the awarding of grants and advocacy. For the former, it has three main programmes: the Global Development Program, focused on hunger and poverty alleviation; the Global Health Program; and the United States Programme, focused on secondary and post-secondary education. A major part of the Foundation's work is committed to the eradication of malaria and the development of vaccines. This case study focuses on the Gates Foundation's grant-making activities for global health.

Philanthropy has a long tradition in American culture and society and the Gates Foundation should be seen as part of this tradition. It is an interesting case study both because of its significance as a major global health actor and because of its innovative strategies and attention to scientific and technological development. Given its size and wealth, the Gates Foundation may not be representative of private foundations. However, the case study pinpoints a number of strengths and weaknesses in the Foundation's strategies that are likely to be relevant to other organisations, and not only foundations, that aim to encourage scientific advances for global health.

3.2. Objectives and activities to meet global health challenges

The main global health objectives

The objectives of the Foundation's Global Health Program are to "enhance health care and reduce extreme poverty". These goals are based on the founders' motto: "All lives have equal value". All operations should be in accordance with the Foundation's "guiding principles" which "reflect the Gates family's beliefs about the role of philanthropy and the impact they want the Foundation to have".

Table 3.1. Allocation of grants by the Bill and Melinda Gates Foundation during 1998-2007 by disease/health issue

Disease/health issue	Percentage of all grants
HIV/AIDS and related diseases	17.9%
Malaria	13.7%
Vaccine preventable diseases	13 %
Child health	11 %
Tuberculosis	10.8%
Neglected tropical diseases	7.8%
Non-specific – general health	5.2%
Malnutrition	2.7%
Non-HIV sexually transmitted Infections	2.3%
Maternal health	2 %
Family planning	1.6%
Sexual and reproductive health	1.5%
Cervical cancer	1.5%
Gastrointestinal diseases	1.3%
Vaccines	1.1%
Respiratory diseases	0.8%
Humanitarian aid/emergency relief	0.7%
Global health, poverty, development	0.6%

Source: McCoy *et al.*, 2009.

The Foundation's objectives have evolved over time. The initial focus on the health of children and mothers has shifted towards more specific goals around immunisation, neglected diseases and, particularly, the eradication of malaria. The allocation of funding by disease or health issue (Table 3.1) reflects the Foundation's strategy to concentrate on priority diseases (HIV/AIDS, malaria and tuberculosis) and vaccine-preventable diseases (polio, tuberculosis, measles, DPT (diphtheria, pertussis, tetanus), MNT (maternal and neonatal tetanus) and hepatitis. Child health is also an important priority area.

Four areas can be said to reflect the Foundation's future priorities. First, the eradication of polio is considered essential for success with other global health issues. Second is to scale up treatment for immunisation diseases, such as pneumococcal, Rotavirus and HIB (*Haemophilus influenzae* type B). The third is work to ensure more stable financing for drug development, bed nets and vaccines. The fourth priority is maternal health and child care with increased attention to behavioural aspects.

To meet these objectives, most funding has been allocated to research and development, mainly for vaccines and microbicides, or to basic science research (McCoy *et al.*, 2009). The second largest part of the budget is spent for "health care and delivery". Other important activities have involved enabling the supply and purchase of vaccines, applied

health research, and advocacy. A somewhat smaller amount has gone to programmes for policy and civil society development in developing countries.

While much of the funding is for research and development, the overall objectives are highly practical. Interviewees expressed this in various ways, *e.g.* mentioning "impact" and "to make a difference" as essential goals. These objectives seemed clearly communicated to grant recipients, who said that they encountered these expectations at various stages in their work with the Gates Foundation.

Partnerships and advocacy in meeting global health challenges

Global partnerships, such as the Global Fund to Fight AIDS, Tuberculosis and Malaria and the GAVI Alliance were major recipients of grants from the Foundation's Global Health Program between 1998 and 2007 (McCoy *et al*., 2009) (Box 3.1). Partnering with private organisations is important for product development. The Foundation collaborates with pharmaceutical companies such as GlaxoSmithKline to develop malaria vaccines. It is not unusual for staff of the Foundation to be former employees of private companies with which the Gates Foundation has a co-operative relationship.

Box 3.1. The GAVI Alliance

The GAVI Alliance is a global health initiative set up to enable better access to new and underused vaccines in developing countries. It is a public-private partnership (PPP) that was first formally announced at the World Economic Forum in 2000. It combines the forces of developing country and donor governments as well as the vaccine industry, philanthropic organisations, the World Health Organization, the World Bank, UNICEF and others.

As of 2011, countries with a per capita gross national income below USD 1 500 are eligible for GAVI support. Currently 56 of the world's poorest countries are eligible. UNICEF and, in the Americas, the Pan American Health Organization (PAHO) Revolving Fund, procure vaccines on behalf of GAVI. Large-scale and efficient procurement is part of an explicit strategy to shape vaccine markets and secure a sustainable and affordable supply of vaccines for member countries. According to GAVI, procurements on its behalf have led to the immunisation of 288 million children and saved the lives of over five million. In addition the Alliance supports the strengthening of health systems and local civic organisations.

GAVI has also been noted for its innovative funding models. The International Finance Facility for Immunisation (IFFIm) uses long-term pledges from donor governments to sell "vaccine bonds" in capital markets, making large volumes of funds immediately available for GAVI programmes. In the Advanced Market Mechanism, donors commit funds to guarantee the price of vaccines once they have been developed. These financial commitments provide vaccine manufacturers the incentive they need to invest in research and development and to expand manufacturing capacity.

Since its inception GAVI has had close ties to the Bill and Melinda Gates Foundation. A crucial contribution from the Foundation was the USD 750 million pledge in 1999 that helped to establish the Alliance. According to McCoy *et al*. (2009) the GAVI Alliance was the biggest recipient of Gates Foundation funding between 1998 and 2008, for a total of around USD 1.5 billion. The Foundation also holds a permanent seat on the GAVI Alliance board.

Source: GAVI Alliance (2012), *www.gavialliance.com*.

Advocacy is also a key activity. It is defined as activities "to promote more and better resources, effective policies, and greater visibility of global health".[2] Through its memberships in various high-level international health forums and its representatives on governing structures of many global health partnerships, the Foundation argues for its priorities and directions. It participates, for example, in the Global Health Council, one of the world's largest alliances dedicated to improving global health, and in Health 8 (H8),

an informal group of eight health-related organisations including the WHO, UNICEF, the United Nations Population Fund (UNFPA), UNAIDS, the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM), GAVI, the Gates Foundation, and the World Bank. H8 was established in 2007 "to stimulate a global sense of urgency" for reaching the health-related Millennium Development Goals.[3] Advocacy has come to play a significant role in the Foundation's activities, as it cannot, despite its size, solve global health major issues alone.

More unconventionally, the Foundation engages in popular culture initiatives to get its "message" to a broader audience. For fundraising and awareness purposes it has been involved in popular TV shows such as *American Idol* and in movie making. These advocacy activities in a wide sense seem to have been highly successful. However, the Foundation's high visibility also seems to have created a fear of failure or negative publicity. There is thus a clear tension between the "high-risk" rhetoric of many of the Foundation's strategic documents and the worry that huge initiatives will fail to have the desired impact.

3.3. Governance mechanisms

Priority setting, strategy development and programme implementation

Grant-awarding priorities and the goals of the Foundation's three main programmes are set by the co-chairs: Bill and Melinda Gates, Bill Gates Senior and Warren Buffett. Each of the programmes has a team to devise strategies to achieve its goals. The Foundation's principles, approaches and taxonomies, laid down in the *Guide to Actionable Measurement* (2010), are used when measuring results. The guide includes a results matrix, results hierarchy, definitions of related terms, and measurement guidelines intended to shape internal decisions about the depth, breadth and rigour of measurement across grants and within strategies (Bill and Melinda Gates Foundation, 2010a).

The preparation of grants and programmes is the responsibility of programme teams and programme directors. Advisory panels with external experts support the Foundation with independent opinion.[4] They work directly with programme presidents "to offer independent, frank assessments" of the Foundation's strategies. The experts have a varied professional background and experience but all appear to be high-profile actors and to hold positions of high political prestige in the Foundation's strategic programme areas.

Panel members of the Global Health Program occupy key functions in their respective organisations, hold important positions and sit on corporate boards. Some hold positions simultaneously in the private and public sector. Many have been or are currently in key positions in organisations, such as the Global Fund to Fight AIDS, Tuberculosis and Malaria, the WHO and the World Bank, which are major recipients of the Gates Foundation's grant programme for global health.

Several interviewees commented on the Foundation's tendency to hire the "elite" – CEOs, Nobel Prize winners, etc. – as employees or advisors. It may be argued that this can result in a too homogeneous strategy and selection process. The composition of the expert panels has thus raised questions about potential conflicts of interest and panel members' ability to make effective, independent assessments of the Foundation's strategies and evaluate its results. Even though panel members are not involved in reviewing specific grant requests or proposals, they nevertheless advise on and influence the programmes' strategies and priorities.

The programme strategy developed by the programme teams includes an assessment of risks and opportunities and a plan to measure potential short- and long-term results. During the strategy development process, the programme teams identify problems and opportunities. This results in a formal strategy for determining the execution plan and the grant budget. The proposed strategy is then submitted to the co-chairs, Bill and Melinda Gates, and the Foundation's CEO, Jeff Raikes, for approval. After the approval stage a budget is developed and grantees are identified along with milestones and time frames. Normally the grants have a duration of three to five years.

Achieving programme goals

Grants are often the result of strategic discussions concerning a topic. A lot of time is spent in the initial phases of the grant process to collect information about the main players in the field, relevant companies and what other funding organisations are doing to understand the main issues. It is important for the Foundation not to duplicate the work of other organisations. It seeks rather to engage other organisations, such as the Wellcome Trust, the US National Institutes of Health (NIH) or the WHO, to co-operate on issues which the Foundation prioritises. Dedicated policy and advocacy staff collect input from a variety of sources such as the WHO, the United Nations, the US and other governments.

In this respect, so-called product-development partnerships (PDPs) are important Foundation instruments.[5] PDPs are not-for-profit organisations, many of which were set up early in the life of the Foundation together with other organisations. There is an annual meeting of the PDPs. An external advisory group is being put together to deal with the Foundation's engagement in PDPs on diseases, on the interface with industry and product development, and on the grant process.

The Foundation's grants are legally binding contracts that set out the scope of work, the budget, the resources and any legal aspects. Typically, a set of milestones to be achieved over the course of the grant are linked to the project. These milestones are written jointly, or written by the grantee and critiqued and adopted by the Foundation. "Management around milestones" is perceived as a strength compared to practices in other funding agencies, such as the NIH. Recipients are required to report on milestones and to submit an annual report. Flexibility and willingness to review the goals of a particular grant are characteristic of the Foundation's operations, and allow project holders to adjust or revise initial project plans and milestones. The revisions are often made in co-operation with the Foundation.

Proposals must include a "global access plan" which is part of the selection criteria. This is a description of how the grantee will ensure that the funding they receive can ultimately lead to accessible and affordable interventions for global health, *i.e.* "impact". These are discussed and negotiated between the grantees and the Foundation. Because of its focus on impact the Gates Foundation is highly user-oriented. Means of achieving impact must be part of the proposal and the description of milestones.

The Foundation assesses results against goals through annual updates and planning processes. Recommendations for change have to be approved by the programme director and/or the co-chairs. Changes in external circumstances can lead to adaptation and reallocation of funds. The annual updates are part of the annual plan/budget process and the means of delegating authority to award grants for the coming year. The combined update and budget process is reflected in the annual plan/update document.

The lifecycle process foresees that every strategy will need to be "refreshed" every three to five years to account for new circumstances, new information, new knowledge and new players (Bill and Melinda Gates Foundation, 2008a). Therefore, evaluations of the Foundation's overall strategy are made every three to five years. External peer review has been strengthened in recent years. Third-party evaluations may be commissioned and specific programmes may be reviewed, often with the participation of external advisors and experts. Generally, the evaluations are not published. Compared to public funding agencies like the NIH, the Foundation is able to change priorities rapidly, since these are primarily set by the trustees themselves.

Grantees' perceptions of the Foundation are measured periodically in surveys. The Foundation receives strong ratings for its work in grantees' fields and for its positive impact on knowledge, policy and practice in the Foundation's strategy areas (Bill and Melinda Gates Foundation, 2010c). Nevertheless, a majority of grantees find the Foundation insufficiently clear about its goals and strategies. Many grantees were confused by the Foundation's decision-making and grant-awarding processes. They found the Foundation inconsistent in its communications and often unresponsive. While some grantees had difficulty communicating with the Foundation during the course of a project, others praised the Foundation for its active interest in their project. The Foundation is developing ways to improve communication with users and partners. A possible reason for the somewhat remote relationship with certain grantees was the Foundation's recent rapid growth which may have had a negative impact on communication and the responsiveness of staff and project officers.

Funding and spending arrangements

In 2006 the Foundation's financial structure was divided into two parts. One entity, the Bill and Melinda Gates Foundation, distributes money to grantees; the second, the Bill and Melinda Gates Foundation Trust, manages the Foundation's endowment. The Trust makes contributions to the Foundation to fund its grant-making activities and operating costs. Its trustees are Bill and Melinda Gates, William H. Gates Senior (the father of Bill Gates), and Warren Buffet.

The Foundation and the Trust are separate legal entities with independently audited financial statements. In this way, investments are separated from the grant process to avoid potential conflicts of interest between the two activities. The Trust is subject to the federal excise tax imposed on private foundations at 2% or at 1% if certain conditions are met. In 2008 the Trust qualified for a 1% tax rate. The Foundation is also subject to federal legislation regulating private non-profit organisations. Under this regulatory framework the Foundation is obliged to spend 5% of its assets each year. These conditions have created some funding challenges as the recent Buffett donation almost doubled the assets.

Contributions to the Trust in 2008 were provided mainly by Bill Gates and Warren Buffet. Warren Buffett's contribution amounted to around USD 1.8 billion in the form of 451 250 shares of Berkshire Hathaway "B" stock. Bill Gates' contribution was USD 183 million in investment management services. In addition, several other private donors contributed to the Trust and Foundation (Bill and Melinda Gates Foundation, 2008b).

The Gates Foundation awards grants to its three main grant programmes. The Global Health Program is by far the largest recipient (61%), followed by the United States programme (26%) and the global development programme (13%). According to the Gates

Foundation, grants are also awarded to three non-programme areas: charitable sector support, employee matching gifts, and sponsorships and family interest grants.

The Foundation makes most of its grants to US-based tax-exempt organisations independently identified by the Foundation's programme officers. In accordance with the Foundation's charter it does not provide grants to individuals. Grant recipients can be grouped as follows in terms of the amount of funding received.

When organised according to types of organisations that received funding the organisations that received the greatest amount of funding under the Global Health Program for 1998-2007 were non-governmental organisations (NGOs) or non-profit organisations. The NGO that received the largest amount of funding was the Programme for Appropriate Technology in Health (PATH) located in Seattle, Washington. During 1998-2009 PATH was awarded 47 grants worth a total of USD 949 million, mostly for medical research and development. The second and third largest beneficiaries in this category were two other US-based organisations, the Institute for OneWorld Health (which focuses on developing new drugs for neglected diseases) and the Save the Children Federation.

Next in line were global health partnerships such as GAVI and the Global Fund to Fight AIDS, Tuberculosis and Malaria. Universities were the third largest category of recipients. Approximately 60% of this funding went to universities in the United States and the United Kingdom. Intergovernmental organisations were the fourth biggest category with about 8% of all funding. In order of magnitude, this funding went to the WHO, the World Bank, the International Vaccine Institute and UNICEF. Government agencies and for-profit companies, on the other hand, only rarely receive funding (McCoy *et al*., 2009). The Foundation funds relatively little policy-related research.

Only a small percentage of grants are awarded through requests for proposals (RFPs). The Gates Foundation thus differs from other funding institutions, such as the US NIH or USAID, which operate exclusively through public offerings. As a result, only a few grants are awarded after a competitive bidding process. According to some interviewees, the Gates Foundation puts a lot of effort into preparing the bids in comparison to other funding organisations.

The Grand Challenges Programme

The Grand Challenges Programme was launched in 2003 by the Gates Foundation in co-operation with the Canadian Institutes of Health Research, the Foundation for the National Institutes of Health and the Wellcome Trust to address the needs of developing countries (Varmus *et al.,* 2003). As part of this initiative, the Foundation launched in 2008 Grand Challenges Explorations, a USD 100 million programme for innovative, early-stage projects. This programme addresses 14 major global health challenges with the aim of supporting cross-disciplinary scientific research on health issues in the developing world. In terms of a strategy to seek out new innovations the establishment of the Explorations programme appears to be a sound way to widen the scope of research and possibly paves the way for more ground-breaking, high-risk research. It also creates a much larger network from which the Gates Foundation can obtain information.

Grand Challenges projects include research into new vaccines, drugs, diagnostic products and other technologies for treating diseases that predominantly affect developing countries. The grant programme is designed to be open to anyone from any country or discipline, from students to tenured professors, and from any organisation – colleges and

universities, government laboratories, research institutions, non-profit organisations and for-profit companies.

The grant process is described as agile and rapid. Applications are submitted on line, and winning grants are chosen approximately four months after the submission deadline. Initial grants of USD 100 000 are awarded semi-annually. Successful projects may receive a follow-on grant of up to USD 1 million.

The selection process is somewhat different from that of traditional programmes and is described by the Foundation as a unique scientific grant programme in terms of the selection and funding of grants. Applications are sent for evaluation to a panel of reviewers with expertise and experience in innovative research, without applicant details or organisational information. Each panel member is empowered to select one to two proposals he/she finds most pioneering based on the creativity of the idea and the experimental plan described in the proposal. No consensus is needed for an idea to be awarded a Grand Challenges Explorations grant.

Intellectual property rights

Intellectual property rights (IPR) are handled by the Foundation's legal team and are negotiated as part of the contractual agreement. The basic principle is that all scientific and technological advances should be distributed and disseminated as widely as possible. The intellectual property arrangements should contribute to this goal. The Gates Foundation makes no claim on the IPR and is not opposed to companies profiting from the results as long as the desired impact is achieved. Pharmaceutical companies can for instance profit from selling the drugs they have agreed to sell at marginal price in developing countries by selling them at market price in developed countries. In other words, the IPR policy is flexible but based on certain principles related to global access. Grantees need to present a plan for managing the IP. The Foundation discusses this with the technology transfer office or lawyer which then negotiates with the company or the university.

Putting science, technology and innovation to work

The Gates Foundation is very impact-oriented, as its global access strategy demonstrates. Unlike the investigator-funded research of the NIH, for example, where the focus is largely on academic outcomes such as publications, the Foundation requires research to yield tangible results. It should lead to products that can have an immediate effect on the health of people living in developing countries. How impact is to be achieved is a required part of the proposal and the description of milestones. A scientific discovery or new product is perceived as a failure if it is not affordable or available to the market.

The Global Health Program, in the words of the Foundation, focuses on harnessing the "advances in science and technology to save lives in poor countries". Perhaps the most obvious example is the focus on the development of drugs and prophylactics for diseases which had previously not received much attention owing to the low purchasing power of the countries hardest hit by these diseases. These include research and development for drugs to combat diseases such as AIDS, malaria and tuberculosis. The Gates Foundation puts much emphasis on making drugs and vaccines already used in developed countries available in developing countries.

To this end, the Gates Foundation has been a very strong proponent of some relatively new organisational set-ups. A good example is its instrumental role in setting up the first Advanced Market Commitment (AMC) together with the governments of Canada, Italy, Norway, Russia and the United Kingdom. The AMC is intended to create a market stimulus for the development of a new pneumococcal vaccine that will protect against more strains of the disease. The AMC guarantees to buy the vaccine at a set price when it is developed, and thus creates a market where none previously existed.

Capacity building

In its Global Health Program, the Gates Foundation does not appear to put much emphasis on capacity building, at least not in terms of strengthening the health system, and it is not mentioned as one of their priority areas (Bill and Melinda Gates Foundation Annual Report, 2010). It is possible, however, that the foundation deals more rigorously with these issues through its Global Development Program. Nonetheless, the Foundation is aware that some of the health issues with which it is concerned, such as perinatal care, depend on a functioning health system. Also, some of the organisations the Foundation works through, such as the Global Fund and PATH, do fund health-system strengthening.

The interviewee from the Gates Foundation views the monitoring and evaluation performed by the Institute for Health Metrics and Evaluation as a way to strengthen the global health system. This broad view of capacity building could logically be extended to the funding of research on neglected diseases, since there was previously little funding capacity in this field. However, according to McCoy *et al*. (2009, p. 1650), most of the Foundation's funding goes to developed countries, leaving few opportunities for research capacity building in developing countries: "Once supranational recipients were excluded from the analysis, US-based recipients accounted for 82% of the total amount paid out between 1998 and 2007".

3.4. Conclusions

The Gates Foundation shares certain challenges with other science, technology and innovation organisations. These are linked to project selection, monitoring and evaluation, the balance between supporting the best and the need to support the new and promising, and the need to integrate the demand side into strategic and operational decision-making. At the same time, the Foundation's funding initiatives differ in some important respects from those of conventional funding agencies. These are summarised below.

Lack of solicitation. Most grants do not appear to be awarded through direct competition or completely open requests for proposals. The Foundation often approaches (or is approached by) an organisation which it has found to be a leader in a particular area and negotiates a project directly. The process is flexible, rapid and non-bureaucratic but may be seen to lack transparency and legitimacy in terms of democratic decision making. Because the Gates Foundation is based on private money, legitimacy and accountability issues may differ from those relating to funding based on public money. Legitimacy issues arise basically because the size of the Foundation enables it to define to a large extent the global health agenda, a role formerly assigned to more democratically controlled organisations, mainly the WHO.

Preparatory work. The Gates Foundation puts a lot of effort into studying the state of knowledge and the important actors before entering a specific area. It therefore has a high level of knowledge of a subject before entering into new partnerships. This seems to allow for better alignment of the goals of the Foundation and its grantees.

Concentrated decision-making. The Foundation's broad strategic decisions are made by a handful of people, mainly the trustees, so that a very small group of people determine where large amounts of money go. This is seen as problematic, as strictly speaking they are not experts, despite their commitment to global health issues. According to interviewees, the lack of a well-functioning board with people from diverse backgrounds and countries is a weakness. The way priorities are set is seen not only as a problem of legitimacy but also as an obstacle to innovation. This relates to findings in innovation literature that *users*, rather than states, small groups of individuals or single companies, are normally in the best position to pick technologies.

It could be that the two major activities of the Foundation – creating impact based on science, technology and innovation and engaging other actors through advocacy – require very different actions to gain legitimacy. Whereas the first might benefit from a broader and more heterogeneous set of activities and involved actors, the latter could benefit from a more representative high-level board. A related criticism is insufficient transparency regarding the priority-setting process and the solicitation and awarding of grants.

Follow-up through milestones. Whereas other funders follow up on projects through annual reports on results, the Gates Foundation defines, together with grantees, a set of milestones to be reached during various stages of the projects. The actual effects are not really clear, but it does put stronger emphasis on progress and impact in line with the Foundation's orientation.

Deliverables. The Gates Foundation makes clear that it is ultimately not interested in scientific publications or new technologies for their own sake but rather in impact. Grantees are well aware of this and some praise the Foundation for being more flexible in terms of deliverables.

3.5. Lessons learned

During the last two decades the Gates Foundation has become a major stakeholder on the international health scene. The world's biggest contributors to global health issues are grantees from the Gates Foundation. Apart from its grant-awarding activities the Foundation actively engages in policy and advocacy as a way of "promoting more and better resources, effective policies, and greater visibility of global health". A recurring criticism of agenda setting for health research is the lack of balance between research to address the burden of disease and ill health in developing countries and research on health issues of populations in wealthy, industrialised countries. The work of the Gates Foundation is a response to this criticism.

Proponents see the effects of the Gates Foundation's work on world health as important achievements that highlight the urgent need to increase funding for neglected diseases. A major contribution is the large multiplier effect achieved for funding of vaccines and immunisation both in terms of governments' engagements to support GAVI and the private sector's support for the International Financing Facility for Immunisation (IFFIm).

Critics point out that, paradoxically, these neglected diseases are no longer neglected once they receive attention from the Gates Foundation. They argue that the power to influence the direction of health priorities should be balanced by greater accountability regarding the choices made.

The multiplier effect that the Gates Foundation has had on health funding carries its own set of problems, of which the Gates Foundation seems acutely aware. Should one of the very ambitious, high-profile projects fail (*i.e.* not have impact), there is concern that other funders may become disillusioned with the particular project or global health funding as a whole, with a dramatic decrease in multilateral funding.

The eradication of malaria is currently one of the Foundation's top priorities and several African countries have signed the eradication pledge. This creates a potential danger of promoting a single goal but neglecting other equally or even more urgent diseases, and if not successful, also has negative implications for future funding for similar initiatives. Another and more positive implication of the Foundation's work is that such pledges may have a significant long-run impact on developed countries because its funding has allowed bright young scientists and innovators to build a career by working on diseases common in poorer regions, thereby expanding the knowledge base and building capacity.

A few interviewees were critical about the extent to which the Gates Foundation is in touch with public opinion and priorities. They criticised it for having advisors at the strategic level that lack experience at the "grass roots level". This is, however, a strategic choice on the part of the Foundation; it does not intend to be operational, *i.e.* "out in the field delivering vaccines", unlike some other foundations. The Gates Foundation has many partnerships with such organisations; it "works through others". It also partners with governments, public agencies, universities and private companies. It emphasises that the Grand Challenges innovation awards, which are smaller, are an initiative aimed at more "bottom-up" initiatives and ideas.

The Foundation's rapid growth seems to have had a somewhat negative impact on its ability to communicate with grantees. According to interviewees, it seems to have some serious organisational difficulties related to its size and top-down structure. Despite its history and self-perception of constituting an alternative to public bureaucracies, it is starting to become fairly bureaucratic.

Grantees see the Foundation's flexibility and willingness to review the goals of a particular grant as a comparative strength. A project's length, size, evaluation criteria and IPR are all open to negotiation as long as the Foundation's focus areas and basic principles (such as global access) are respected. The Foundation allows for unexpected difficulties and does not necessarily withdraw funding if milestones are not met in strict accordance with the timetable. Its flexible management of IPR, which allows profit-seeking companies to offset the cost of the development of new drugs by selling them at market price in developed countries, for example, appears to be both popular and effective in engaging the private sector.

Although some breakthroughs have been made in developing new vaccines, it is too early to see the full effect of the Gates Foundation's contribution, given the average time for bringing such products to market. However, it has already made significant contributions by making available technology accessible to new users. Furthermore, it has been instrumental in creating new and original organisational setups and funding mechanisms.

The case study indicates some fundamental implications of the work of the Gates Foundation for international co-operation on science, technology and innovation (STI). First, it draws attention to asymmetries between contributions and benefits; and second, it raises the issue of trade-offs between effectiveness and accountability.

First, addressing global challenges will inevitably require tackling issues relating to the extremely uneven distribution of STI capacity and resources, and hence the capacity of different nations and communities to profit from STI solutions to these challenges. A key issue in these contexts will be how to weaken the "juste retour"[6] concerns that are often an integral part of international research collaboration. This may mean an important role for "altruistic" contributions, *e.g.* from foundations and charities, that go beyond health issues.

Second, while many STI initiatives to address global challenges are funded by governments, it is increasingly recognised that philanthropists and industry can play an important role in supporting high-risk research projects (Royal Society, 2011). However, when discussing the involvement of private actors in this context, problems of legitimacy and accountability are often raised (Biermann, 2007; Biermann *et al*., 2010). While private organisations may derive legitimacy at home through their members or donors, disparities of wealth and power make accountability and legitimacy more complicated elsewhere (Biermann *et al.*, 2010). As philanthropic organisations are mostly headquartered in industrialised countries and most funds donated to their causes originate from public and private actors in those countries, it is necessary to address the tensions between accountability and the effectiveness of procedures and implementation.

Notes

1. The authors of this case study are grateful for the valuable contributions and comments from interviewees in the following organisations: The Institute for Health Metrics and Evaluation, Washington University; the Bill and Melinda Gates Foundation; the *Seattle Times*; the World Health Organization; The Global Fund; PATH. The interviews took place in August 2010 in Seattle, Washington, United States, and in Geneva, Switzerland.
2. Gates Foundation Global Health Policy Strategy, *www.gatesfoundation.org/global-health/Documents/global-health-policy-strategy.pdf.*
3. UNAIDS, Future Story, Health 8 group meet to discuss maximizing health outcomes with available resources and getting "more health for the money", 23 February 2011, *www.unaids.org/en/resources/presscentre/featurestories/2011/february/20110223bh8/.*
4. Press Release Bill & Melinda Gates Foundation, 19 September 2007, Program Advisory Panels Announced by the Bill & Melinda Gates Foundation, Panelists Will Provide Strategic Input to Program Presidents.
5. Global Health Strategy Overview, 23 September 2010, Strategy Documents, Bill & Melinda Gates Foundation, *www.gatesfoundation.org/global-health/Documents/global-health-strategy-overview.pdf.*
6. *Juste retour* refers to a country's expectation to receive from a programme an amount of subsidy for its own researchers, institutions, etc., proportional to its contribution to the programme's budget.

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Chapter 4

The Group on Earth Observations

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The Group on Earth Observations (GEO) is an intergovernmental entity focused on co-ordinating and integrating global activities related to the production and dissemination of Earth observations to meet global challenges such as climate change, agriculture and health. It aims to develop the Global Earth Observation System of Systems (GEOSS) within ten years. This case study discusses its approach to achieving this goal. It describes its governance model and examines the strengths and weaknesses of its different components.

4.1. Introduction

The Earth is a complex "system of systems", in which its atmospheric, terrestrial and oceanic systems constantly interact and influence each other. To understand the physical underpinnings of the Earth system, and thereby improve predictions of its behaviour and develop appropriate responses to societal challenges, such as climate change, requires data and information from a multitude of sources, a task that no single nation or organisation is able to undertake alone.

The Group on Earth Observations (GEO) is an inter-governmental group, open to all member states of the United Nations that support its vision for creating a Global Earth Observation System of Systems (GEOSS). Other participants in GEO include specialised agencies of the United Nations and other inter-governmental, international and regional organisations, with a mandate in Earth observation or related activities.

GEO is a "best effort" activity of a group of interested countries and organisations that have agreed to promote a co-ordinated approach to Earth observations, sharing of data and building the capacity of individuals, institutions and systems. It oversees the development and implementation of the GEOSS, a co-ordinating and integrating network of Earth observing and information systems contributed on a voluntary basis by GEO members and participating organisations. The GEO envisages that the GEOSS will be created within a ten-year time frame. Once established GEOSS will enable all countries to access Earth observations in order "to address urgent challenges that are faced by an increasingly vulnerable global society" (GEO, 2007, p. 1).

GEO was formally established in 2006, through a series of ministerial-level Earth observation summits. It currently includes 86 countries and the European Commission (EC) (the members), 61 inter-governmental, international and regional organisations (the participants) and six observers (Annex 4.1). GEO operates on a modest budget consisting of voluntary contributions by its members and participants. The GEO is a voluntary organisation with no legally binding documents and is based on the idea of common benefit and a shared understanding of the necessity of the aims of GEO.

GEO is governed through a Plenary of its members during which decisions are taken by consensus. Participants are recognised in the Plenary, but only GEO members formally take decisions. The GEO Plenary meets at least once a year at the level of senior officials and every three years at the ministerial level. An Executive Committee oversees GEO activities when the Plenary is not in session. This includes the activities of four standing committees charged with co-ordinating the cross-cutting GEO issues: *i)* architecture and data; *ii)* user engagement; *iii)* science and technology; and *iv)* capacity building. The Executive Committee consists of representatives from 13 member states, elected from the five GEO regions: four from Asia, two from Africa, one from the Commonwealth of Independent States, and three each from the Americas and Europe.

Box 4.1. Transverse areas of the work of GEO/GEOSS

Architecture and data management: Achieve sustained operation, continuity and interoperability of existing and new systems that provide essential environmental observations and information, including the GEOSS Common Infrastructure which facilitates access to, and use of, these observations and information. For this purpose, the system needs to provide a shared, easily accessible, timely, sustained stream of comprehensive data of documented quality, as well as metadata and information products, for informed decision making.

Capacity building: Enhance co-ordination of efforts to strengthen individual, institutional and infrastructure capacities, particularly in developing countries, to produce and use Earth observations and derived information products.

Science and technology: Ensure full interaction and engagement of relevant science and technology communities such that GEOSS advances through integration of innovations in Earth observation science and technology, enabling the research community to fully benefit from GEOSS accomplishments.

User engagement: Ensure critical user information needs for decision making are recognised and met through Earth observations.

Source: GEO (2009a) Rules of Procedure.

GEO activities, including those of the four standing committees, are initiated, funded and carried out by members and/or participants. The GEO Secretariat does not have the funding capacity to implement programmes. However, it provides ideas and suggestions about new activities to be funded and executed through the activities of members. The value added of GEO is its capacity to bridge complementary and related activities of its members and participants and provide a unified framework for their implementation. By building bridges among projects and programmes that benefit from such interconnectivity, GEO seeks to ensure that these initiatives reach beneficiaries on a wider scale.

4.2. Approach to addressing global challenges

GEO was established through a series of three ministerial-level Earth observation summits in response to calls from the World Summit on Sustainable Development (Johannesburg, 2002) and the G8 Evian Summit (2002) for strengthened international co-operation and co-ordination on global observation of the environment. The first of these Earth Observation Summits, in Washington, DC (2003), recognised the need for continuous, timely, quality, long-term global information in order to enhance understanding of Earth processes, improve prediction capability and manage the implementation of environmental treaty obligations (GEO, 2003).

At the time of the establishment of GEO, a list of shortcomings was noted. These broadly related to: *i)* limited exchange, use and dissemination of data systems; *ii)* inadequate involvement of data users in specifying information requirements; *iii)* deficiencies and global inequalities in data access, quality of data and coverage (spatial and temporal); *iv)* total lack of data on vital topics and data redundancy in certain areas; *v)* observed limitations of some users in accessing relevant data (speed and cost limitations); *vi)* observed incompatibilities of measures which hinder data combination and comparison across countries. Addressing these shortcomings successfully would facilitate informed decision-making.

Box 4.2. Societal benefit areas of the GEO/GEOSS

- *Agriculture:* Improve the utilisation of Earth observations, expand application capabilities to advance sustainable agriculture, aquaculture, fisheries and forestry, including early warning, risk assessment, food security, market efficiency, and combating desertification.
- *Biodiversity:* Establish, in conjunction with a comprehensive ecosystem monitoring capability, a worldwide biodiversity observation network to collect, manage, share and analyse observations of the status and trends of the world's biodiversity, and enable decision making in support of the conservation and improved management of natural resources.
- *Climate:* Achieve effective and sustained operation of the global climate observing system and reliable delivery of climate information of a quality needed for predicting, mitigating and adapting to climate variability and change, including for better understanding of the global carbon cycle.
- *Disasters:* Enable the global co-ordination of observing and information systems to support all phases of the risk management cycle associated with hazards (mitigation and preparedness, early warning, response, and recovery).
- *Ecosystems:* Establish, in conjunction with a comprehensive biodiversity observation network, a wide-ranging monitoring capability for all ecosystems and the human impacts on them, to improve the assessment, protection and sustainable management of terrestrial, coastal and marine resources and the delivery of associated ecosystem services.
- *Energy:* Close critical gaps in energy-related Earth observations and increase their use in all energy sectors in support of energy operations, as well as energy policy planning and implementation, to enable affordable energy with minimised environmental impact while moving towards a low-carbon footprint.
- *Health:* Substantially expand the availability, use and application of environmental information for public health decision making in areas of health that include allergens, toxins, infectious diseases, food-borne diseases, and chronic diseases, particularly with regard to the impact of climate and ecosystem changes.
- *Water:* Produce comprehensive sets of data and information products to support decision making for efficient management of the world's water resources, based on co-ordinated, sustained observations of the water cycle on multiple scales.
- *Weather:* Close critical gaps in meteorological and related ocean observations, and enhance observational and information capabilities for the protection of life and property, especially with regard to high-impact events, and in the developing world.

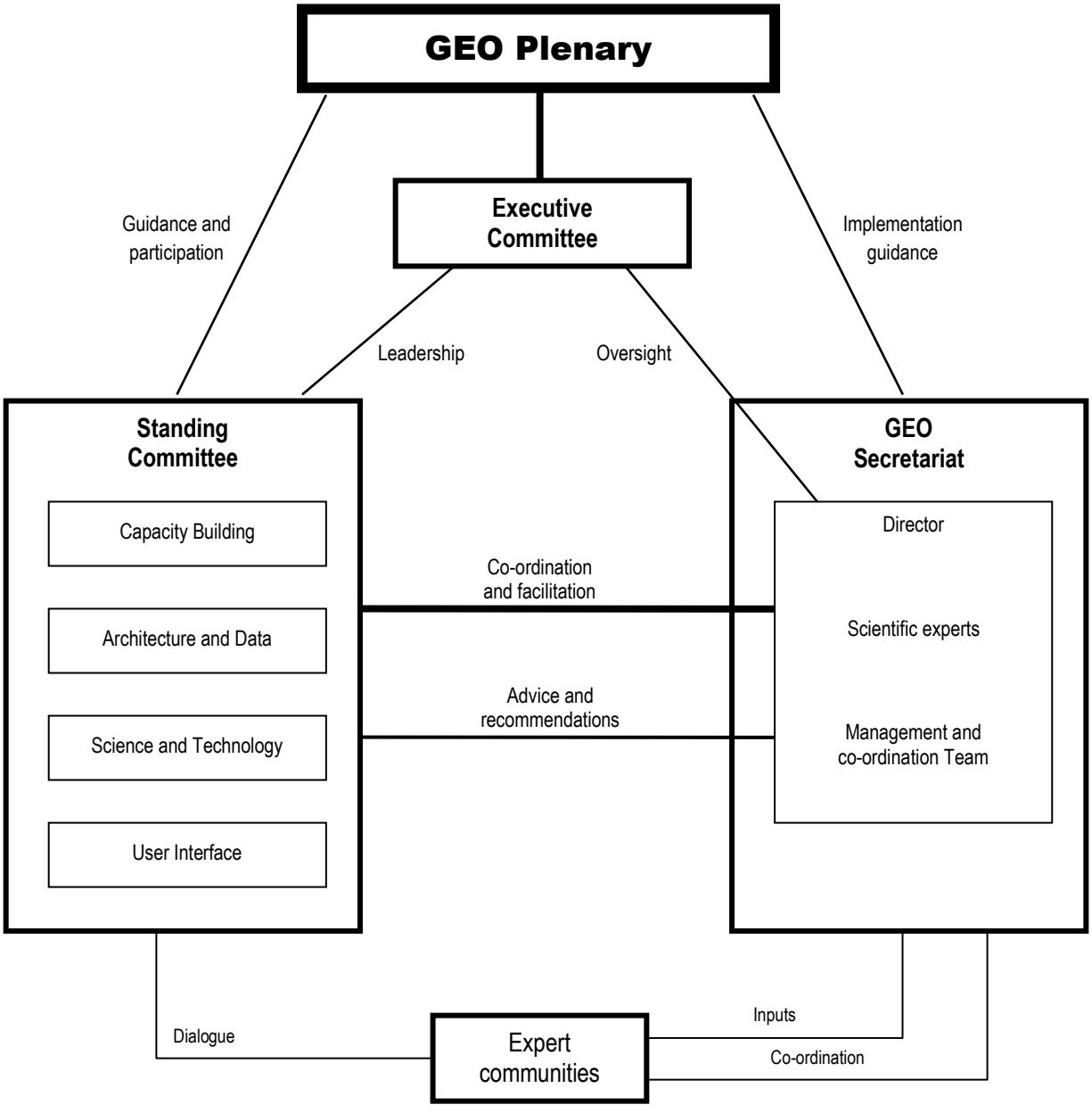
Source: GEO (2004), Framework for a 10-Year Implementation Plan.

Sixty developed and developing countries, as well as more than 40 international organisations, including the United Nations Specialised Agencies – led by the United States, the European Commission, Japan and South Africa – initially collaborated to establish the GEO.

With the plan to establish GEOSS, GEO has provided a common vision for its members and participants to focus their mobilising and co-ordinating efforts. The GEOSS ten-year implementation plan describes the vision and mission of GEOSS as follows: "The vision for GEOSS is to realise a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information" (GEO, 2005a, p. 199). It continues: "The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth system" (GEO, 2005a, p. 199).

The original implementation plan, formulated in 2006, identified close to 200 targets across four transverse areas (Box 4.1) and nine societal benefits (Box 4.2). These targets were later refined and refocused, and in 2009, the GEO Plenary accepted a revised version of the ten-year implementation plan targets (GEO, 2009b). The restated strategic goals constituted the collective, refined commitment of the GEO Community to an operational GEOSS by 2015.

Figure 4.1. Basic features of the GEO governance



Source: GEO (2009c), GEO Science and Technology Roadmap and Annex.

4.3. The governance structure

The key elements of GEO's governance structure are shown in Figure 4.1 and consist of: a Plenary, its highest decision-making body; an Executive Committee which provides leadership and oversight between sessions; four standing committees organised around the four thematic areas (Box 4.1) which provide guidance and effective member participation; and a Secretariat that implements Plenary and Executive Committee decisions, co-ordinates and facilitates the work of GEO, provides support to the four standing committees and engages in outreach to expert communities.

GEO members elect four co-chairs who preside over both the Plenary and the Executive Committee. Executive Committee members, including those serving as co-chairs, are nominated through caucuses of the five GEO regions and are approved by the GEO Plenary. GEO co-chairs and Executive Committee members serve a renewable two-year term and are elected annually. To ensure continuity, the terms of co-chairs and Executive Committee members are staggered. The co-chairs of the four GEO standing committees are nominated by GEO members and participants annually.

The GEO Plenary takes decisions by consensus of its members. Decisions on implementation are based upon sound scientific and technical advice obtained through appropriate consultation with the research and observation communities.

The role of the Executive Committee is to facilitate the decisions of the GEO Plenary and to oversee and to make recommendations on the implementation of those decisions. The duties of the Executive Committee include oversight of the GEO Secretariat and strategic management of GEO between GEO Plenaries.

The four standing committees have the following functions:

- The Architecture and Data Committee supports the GEO in all architecture and data management aspects of the design, co-ordination and implementation of the GEOSS.
- The Capacity Building Committee supports the GEO in strengthening the capability of all countries, in particular developing countries, to use Earth observation data and products in a sustainable manner and to contribute observations and systems to GEOSS.
- The Science and Technology Committee engages the scientific and technological communities in the development, implementation and use of a sustained GEOSS in order to ensure that GEO has access to sound scientific and technological advice.
- The User Interface Committee engages users in the nine societal benefit areas in the development, implementation and use of a sustained GEOSS that provides the data and information required by user groups on national, regional and global scales. It has a specific goal to address cross-cutting issues by co-ordinating user communities of practice, ensuring continuity and avoiding duplication.

The Secretariat, led by its director, facilitates and supports GEO activities. Its duties involve developing the annual GEO work plan as well as co-ordinating and liaising with GEO member and participant activities in pursuit of the work plan. The operations of the Secretariat are managed through a trust fund formed by the voluntary contributions of members and participants and managed by the World Meteorological Organization (WMO), the host organisation for the GEO Secretariat. The GEO-WMO Trust Fund supports the direct and indirect costs of GEO and its Secretariat as well as activities related to GEOSS implementation.

Box 4.3. GEO communities of practice

On its website (*http://earthobservations.org/cop.shtml*) GEO defines a community of practice as a "user-led forum of stakeholders, from providers to the final beneficiaries of Earth observation data and information, with a common interest in specific aspects of societal benefits to be realized by GEOSS implementation". Individuals from members and participants as well as any other stakeholders with related interests can participate. Participation is therefore broad and not restricted to GEO members and participants. These communities of practice aim at enabling the development of user community needs, providing a forum for co-operation to ensure that GEOSS adds value to existing initiatives and fostering the development of linkages and opportunities for collaboration. They also aim at providing a scientific and user-based advisory function for GEO.

To date, nine communities have been formed, many reflecting themes of the former Integrated Global Observing Strategy Partnership (IGOS-P), including those established for air quality, biodiversity, coastal zones, carbon, energy, forests, geohazards, global agricultural monitoring, health and environment, the cryosphere, and the water cycle. Some, such as the Biodiversity Observation Network (GEOBON), have been extremely successful. GEOBON has brought together around 100 governmental and non-governmental organisations to make their biodiversity data, information and forecasts available for users at all levels.

GEO, as a newly established and evolving entity, has inevitably had to make adjustments to the governance structures established at its inception. In addition to needs related to its maturing, these changes were also a response to the growing and changing needs of members. Originally, the Executive Committee consisted of 12 representatives elected from the five GEO regions (or GEO caucuses), including three each from the Americas, Europe and Asia/Oceania, two from Africa and one from the Commonwealth of Independent States. At its 2009 Plenary, GEO accepted a recommendation from the Asia/Oceania region to increase their regional quota on the Executive Committee from three to four. These changes were necessitated by the need to ensure fair and effective representation from a caucus with a large geographic extent and a growing number of GEO members, although it is still too early to see the effect of wider representation in the Executive Committee. An additional motivation was to accommodate the leadership aspirations and interests of leading Earth observation countries in the region.

4.3. Main characteristics of the overall governance model

GEO has maintained the governance and partnership structure established at its inception in 2006. It is primarily a voluntary association, not legally binding, of a group of member states of the United Nations and the European Commission.

Partnerships and stakeholder involvement

There are no founding documents, memoranda of understanding or treaties that states are required to sign and/or ratify in order to become GEO members. Membership is achieved by endorsing the ten-year implementation plan.

The first Earth Observation Summit was attended by 33 countries, the EC and 21 international organisations involved in Earth observations. Through outreach efforts, GEO has now expanded its membership to 86 governments and the EC, and 61 inter-governmental, international and regional organisations. It has thus become a more globally representative organisation.

Governments have primacy within GEO. They are its members and participate through senior-level officials in the Plenary. GEO takes decisions by consensus of its members: they participate in the Executive Committee and select the director of the GEO

Secretariat. Members are largely, though not exclusively, responsible for GEOSS funding and seconding staff to the Secretariat. Through their national agencies, GEO members contribute Earth observation systems, data and information to GEOSS. Every three years, ministers from the GEO members participate in an Earth Observation Summit. This ministerial participation provides high political visibility to GEO and is one of the distinguishing characteristics of GEO.

GEO participants are international organisations and civil society structures that use Earth observations to develop products and services in the nine societal benefit areas, operate Earth observation systems and conduct research and development in Earth observations. They include the specialised agencies of the United Nations, intergovernmental space agencies, international research institutions and organisations, and Earth observation advocacy bodies. Participants are, together with governments, major contributors of systems, data and information to GEOSS. They participate in the GEO Plenary but have no representation on the Executive Committee and, therefore, no decision-making power.

GEO has yet to formally define its relationship and engagement with the private sector although an effort is now under way to discuss this issue and eventually reach a clear definition. Increasingly, and in synergy with national and international public-sector institutions, the private sector is becoming a provider of Earth observations infrastructure, data and value added products and services. The private sector is also increasingly an end user of Earth observations and thereby a potential user of GEOSS. The private sector has engaged with GEO as a potential provider of components of the GEOSS Common Infrastructure, as well as in the development of new Earth observation infrastructure such as new satellite missions. GEO is attempting to engage donor agencies and private foundations as potential funders, but also as important users of Earth observation data and information.

Strengths, weaknesses, threats and opportunities of partnerships and stakeholder involvement

GEO provides a forum for establishing global dialogue and networking on Earth observations. It brings together a mix of countries and organisations in an inclusive collaborative partnership that embraces the contributions of all in the conduct of GEOSS tasks. As a result of GEO, a group of countries is taking integrated Earth observation more seriously and at a higher level in government than would otherwise have been the case.

In some countries the establishment of GEO has promoted openness and co-ordination of Earth observations across government, but in others it is treated exclusively within specific communities (*e.g.* only the space community). These differences partly reflect the different institutional and political backgrounds of each country and the degree of political support that GEO has received in each context. Many interviewees echoed the sentiment that the "voluntary" nature of GEO, in which no member can be "compelled" to do something, represents both GEO's greatest strength and potentially its greatest weakness.

GEO's non-binding character also allows it to respond relatively quickly to new priorities. The development of a GEOSS data-sharing action plan and the voluntary in-kind contributions made by members and participants to develop the GEOSS common infrastructure are testimony to this (see below). However, a weakness of the voluntary nature of GEO is that only a few make contributions, which diminishes its capacity to meet the aspirations and needs of stakeholders.

Decisions are taken by consensus and are not binding upon GEO members. This can lead to situations in which a GEO member may aspire to a certain action, but owing to local restrictions may be unable to carry it out. This inability, however, does not inhibit supporting other GEO members to carry it out, often in the hope that the action of other members will provide the evidence required for a change in policy in their own country. While its voluntary nature can be seen as an important strength of GEO's governance structure, there is also fear that it can become a weakness if GEO members begin to exercise their "right to veto", a right that the decision-making process effectively gives them. To date, however, this has not yet happened.

GEO emphasises the central role of members. This also has both strengths and weaknesses. On the positive side, it provides a high level of political support at the level of ministers. The GEO ministerials and Earth observation summits provide an opportunity for direct engagement with political decision makers. It must however be noted that this high level of engagement has not always translated into consistently high-level representation across all GEO member governments in the GEO Plenary outside ministerial years.

On the other hand, the emphasis on members is at the expense of the lack of involvement of participants in the GEO governance mechanisms and in the Executive Committee in particular. Participants contribute major systems towards the realisation of GEOSS, and building GEOSS relies as much on them as it does on members. Not having a voice diminishes participants' ability to steer GEO and GEOSS, and could leave valuable stakeholders such as the specialised agencies of the United Nations (UN) and the private sector out of decision making.

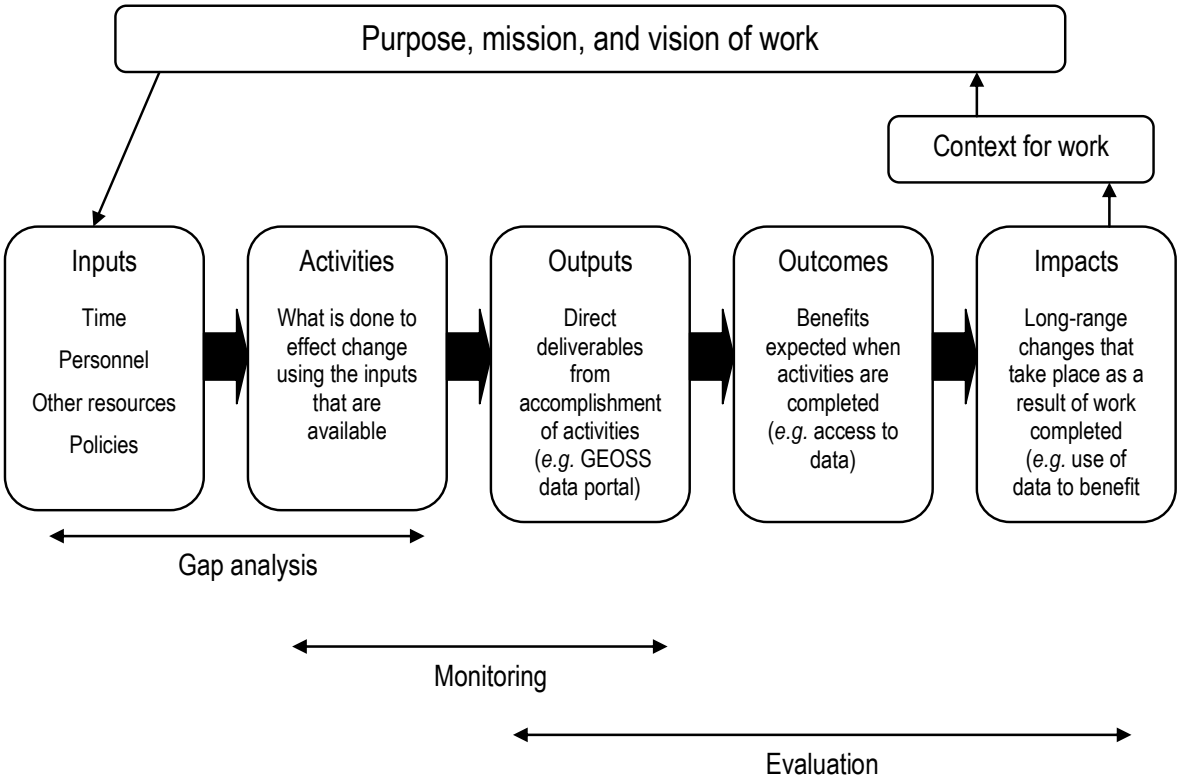
Agenda and priority setting

At the highest level, priorities for GEO are set through ministerial-level declarations. For instance, the development of GEOSS data-sharing principles and the data-sharing action plan resulted from the 2007 Cape Town Ministerial Declaration. Ministerial-level summits are held approximately every three years.

The high-level long-term objectives, overall agenda and priorities of GEO were set in 2006 with the GEOSS ten-year implementation plan. These targets were revised and consolidated in 2009 into a set of high-level strategic targets, which now form the basis for implementing GEOSS. Through the Plenary, GEO members and participants are directly involved in setting GEO's priorities. The four GEO committees contribute to defining priorities and activities in the areas of GEOSS architecture, science and technology, user engagement and capacity building. The work plan constitutes a third level of priority setting and includes inputs from the various GEO committees and work groups. It is structured around GEO activities that, when implemented, will contribute to achieving the strategic targets of GEOSS in the nine societal benefit areas and four transverse areas. The GEO Plenary meets annually to approve the work plan or updates to the work plan and to define priorities for the next year. Hence, the ministerial declarations, the ten-year implementation plan, the strategic targets and the three-year work plan articulate a clear agenda in terms of what GEO wants to do and how it intends to do it.

GEO members and participants contribute to and co-operate on the implementation of GEOSS through the three-year work plan. The implementation of the work plan is supported by the GEO Secretariat. Although developed for a three-year period, the work plan is updated annually through a consultation process with member states and participants. The high-level GEOSS priorities, set through the strategic targets, are designed with a 2015 time frame in mind and are unlikely to be substantially changed before then. However, based on a logic model that has been adapted for use in the context of GEOSS, a monitoring and evaluation framework has been developed (Figure 4.2). This framework, together with the support of additional gap analyses, enables the adjustment of priorities both at the level of strategic targets and the GEOSS work plan. The Executive Committee and the GEO committees meet at least twice a year to consider progress, respond to developments and adjust or identify new priority areas.

Figure 4.2. GEOSS monitoring and evaluation framework



Source: GEO (2010).

The GEO governance system is set up in a way that mitigates potential conflicts of interest. This is in large part due to the fact that: *i)* participation is issue- or problem-driven, *i.e.* all GEO members actively want to find solutions and make progress in the field of Earth observations; and *ii)* the voluntary nature of the GEO means that decisions taken by consensus are not "binding" upon members. The non-binding, voluntary nature of GEO means that GEO members will not seek to inhibit other GEO members' activities that do not coincide with their own priorities or policies. The fact that all contributions to GEO are welcomed and all efforts are considered valuable also plays a role in mitigating the negative consequences of diverging interests.

On the negative side, this also makes it difficult to focus on priorities, particularly those of developing countries. Although GEO's work plan addresses some developing country priorities, the articulation of priorities tends to be dominated by developed countries, owing to the maturity and strengths of their systems. The strategic targets are defined through consultations among members, participants and experts in the nine societal benefit areas and reflect a consensus. Agenda and priority setting is therefore a combination of a top-down (decisions by Executive Committee) and bottom-up (horizontal consultations) approach.

Generally, priority setting has not resulted in broadening the base of contributions to GEO or in increased contributions of financial resources. An analysis of financial contributions to the GEO-WMO Trust Fund shows a constant, if not declining, contribution from members.

Strengths, weaknesses, threats and opportunities of current modes of agenda and priority setting

A voluntary, inclusive, accommodating and wide-ranging agenda ensures that GEO and GEOSS priorities are congruent with the priorities of GEO members and participants. While this facilitates buy-in, it has also meant that different GEO activities seem to have equal priority and that priorities are driven by the available funding rather than by an overall strategy. Inevitably those that contribute the most or have the most to offer will be viewed as driving the agenda, even if that is not the case.

The strategic targets can be seen as extremely ambitious in light of the voluntary nature of GEOSS. Without some directed funding from governments, organisations and the GEO community, there is a danger that they will not be achieved. The extent to which priorities set at global level have been followed by financial and other resource commitments is not yet clear.

A criticism that has been made, particularly with respect to the relationship with the specialised agencies of the United Nations, is that the GEO mechanism lacks a way to include the key issues and priorities of the intergovernmental sponsors of its major component systems. This criticism is largely based on the fact that GEO, owing to its relatively small membership, does not reflect the priorities of all countries.

The monitoring and evaluation system should enable GEO to assess the achievement of strategic targets and identify gaps more consistently. However, the challenge of aligning the voluntary contributions of GEO members and participants to the strategic targets remains.

Funding and spending

The total cost of implementing GEOSS would include the costs of a myriad of national, regional and international programmes that directly or indirectly contribute to improve Earth observations. This implies large uncertainties in the estimation of the costs as well as the benefits. A recent cost-benefit analysis of GEO, the EC project GEO-BENE (Global Earth Observations – Benefit Estimation Now, Next and Emerging), indicated that some GEO costs and benefits are qualitative and cannot be expressed in monetary terms (for instance incremental improvements in decision making).

The ten-year implementation plan envisaged that most of the resources for implementing GEOSS would be provided through existing national and international mechanisms and by voluntary contributions to special projects. GEO does not have control over Earth observation funding. Meeting the priorities of its strategic targets will require commitment and resources from governments, organisations and the GEO community. Given its voluntary nature, GEO cannot "oblige" its members to provide these resources, only identify the needs and "encourage" them to address these within the scope of their national mandates.

In 2009, the operational budget for the GEO Secretariat, which includes the salary of permanent staff and contractors (including the director), mission travel, hosting of GEO meetings and support for developing country participation was approximately CHF 5.5 million. This amount also included in-kind contributions from members and participants in terms of seconded staff and office space.

The operations of the Secretariat are managed through the GEO-WMO Trust Fund, which supports the direct and indirect costs of GEO, its Secretariat and implementation activities. Voluntary contributions towards the Secretariat's operations are made by GEO members and participating organisations directly into the Trust Fund, and contributions are often made for specific projects. Voluntary contributions to the Trust Fund are made by only a handful of GEO member countries and participants. They are made annually and to a large extent in response to the GEO's three-year work plans.

An operations budget is prepared by the Secretariat for consideration by the Executive Committee and is presented for adoption to the GEO Plenary. The Plenary has constituted an informal budget committee to provide an opinion and make recommendations to the Executive Committee on the budget. Contributions to the GEO work plan are in-kind contributions and are thus controlled by the contributing institution.

Specific in-kind contributions have been made by members and participants to develop the GEOSS common infrastructure and address gaps within the work plan. For instance, the Food and Agriculture Organization's (FAO) Agricultural Development Economics Division contributed to the development of the GEOSS portal, the US Geological Survey contributed to the development of the GEOSS clearinghouse and the Institute of Electrical and Electronics Engineers assisted in the development of the GEOSS components registry.

Voluntary contributions put countries at a relative advantage in terms of priority setting. Countries that make significant contributions often want to have their priorities respected. In general, negotiations on priority setting and funding have led to consensual agreements that accommodate most members. However, finding a common denominator implies that, in some cases, priorities of contributing countries are not included.

A mechanism that is increasingly significant with respect to funding activities in the GEO work plan is the European Union's Seventh Framework Programme (FP7), and more specifically its calls for proposals on environment and space. GEOSS strategic targets have increasingly been the subject of recent calls, including capacity-building priorities. The calls have managed to build global consortia of developed and developing countries.

The GEO Trust Fund operates under the rules and regulations of the WMO and is therefore subject to its protocols for monitoring and evaluation. The interviews suggested that adherence to this type of procedural norms could be beneficial to GEO in the long run. Financial arrangements for administration of the GEO Trust Fund are specified in: *i)* the GEO-WMO Standing Arrangement; *ii)* the WMO financial rules and regulations;

and *iii)* delegations of responsibility from the WMO secretary-general to the GEO director. Under the Standing Arrangement, WMO staff and financial rules and regulations apply to GEO transactions. In terms of the financial rules and regulations, an annual independent financial audit is completed for GEO and presented to the Executive Committee and Plenary for acceptance (GEO, 2009a).

Strengths, weaknesses, threats and opportunities of funding and spending arrangements

The voluntary and in-kind nature of contributions, which largely gives members and participants control of funding, has enabled GEO to be established relatively quickly and make significant progress through effective "buy-in". This funding system allows members to spend on their own priorities and align these with the GEO, developing synergies between priorities and contributions of members and participants. The GEO adds value by avoiding duplication of effort, promoting complementarities and strengthening synergies between programmes.

At the same time, the voluntary "best effort" approach and the lack of ability to steer funding is also viewed as a weakness. Voluntary contributions do not always ensure that critical gaps and stakeholder needs are effectively addressed, and these gaps and needs often fall outside members' and participants' priorities. Limited ability to steer funding also means that GEO members can co-ordinate their funding, but do not always have a compelling reason to do so. As a result, some GEO communities find that GEO has leveraged insufficient resources for integrated Earth observations.

In establishing GEOSS, GEO raises expectations with regard to access to data, information and products in each of the nine societal benefit areas. To sustain GEOSS operations in the future will require regular and constant funding. However, the small pool of resources obtained from GEO's voluntary funding mechanism indicates that this cannot ensure a sustainable common infrastructure. Only 12-15 out of a combined total of 147 members and participants currently contribute to the GEOSS Trust Fund. The mid-term review completed at the end of 2010 stated (GEO, 2010, p. 8): "GEO should develop a long-term strategy to ensure the sustainability of GEOSS beyond 2015." New funding approaches are being explored. Examples include the alignment of relevant parts of the EC Framework Programme with GEO objectives and priorities and the development of funding partnerships with industry.

Capacity building and technology transfer

For the GEO the aim of capacity building is to enhance the co-ordination of capacity development efforts in order to strengthen individual, institutional and infrastructure capacities, particularly in developing countries, and to produce and use Earth observations and derived information products. Through the contributions of members and participants, a section of the GEO work plan addresses capacity building in six areas: *i)* resource mobilisation, *ii)* building individual capacity in Earth observations, *iii)* building institutional capacity to use Earth observation, *iv)* capacity building needs and gap assessment, *v)* infrastructure development and technology transfer for information access; and *vi)* building capacity through outreach and awareness raising.

Box 4.4. GEO capacity building and technology transfer programmes

GEONETCAST is a low-cost data dissemination and delivery system that gives users worldwide access to data across all of the nine GEO societal benefit areas. It was collaboratively established by GEO members and participants (EUMETSAT; US National Oceanic and Atmospheric Administration; and China Meteorological Administration) for distribution of data in low-bandwidth environments. The delivery of data and information directly from providers to users gives them the means to take decisions based upon the information provided rather than rely on third parties for such services.

SERVIR integrates satellite observations and predictive models with other geographic information to monitor and forecast ecological changes and respond to natural disasters. This evolving regional visualisation and monitoring platform is being established in Africa to improve scientific knowledge and decision making in a range of application areas (*e.g.* biodiversity conservation, disaster management, agricultural development, climate change adaptation, etc.). In 2008, the US National Aeronautics and Space Administration (NASA) and the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) partnered with the Regional Center for Mapping of Resources for Development (RCMRD) based in Nairobi, Kenya, to begin setting up SERVIR's East Africa node. The SERVIR-Africa project builds upon the existing strengths of the RCMRD and augments its data management and training capability. These efforts complement the core mission of the RCMRD and provide a springboard for the development of applications customised for RCMRD members. Similar SERVIR facilities have been established in Panama and Nepal.

GEONETCAB, a FP7-funded project, promotes capacity-building activities in support of GEO. It focuses in part on brokering support for Earth observation capacity-building projects and activities in developing countries. GEONETCAB focuses on all GEO societal benefit areas but places special emphasis on climate monitoring. To this end, GEONETCAB's focus includes identification of capacity-building needs, identification of potential resource providers for capacity-building activities, developing mechanisms that facilitate co-operation between stakeholders and resource providers and access to a global network of expertise for education and training in Earth observation.

Capacity building is a vital element of GEO activities and has been explicitly recognised in the GEO structure from its inception. There is a clear and well-defined capacity building strategy and target. The current GEO work plan includes many activities to achieve its capacity-building target. The open and inclusive nature of the GEO offers members many technology transfer opportunities. Two examples are the establishment of the GEONETCAST system and the SERVIR facility established in Kenya, and the FP-funded GEONETCAB (Box 4.4).

The primary mechanisms through which knowledge and benefit sharing within GEO occurs are the GEOSS data-sharing principles and the GEOSS Common Infrastructure, the architectural framework for implementing the data-sharing principles. The ten-year implementation plan states that "[t]he societal benefits of Earth observations cannot be achieved without data sharing" and sets out the GEOSS data-sharing principles, endorsed by all GEO members:

- There will be full and open exchange of data, metadata and products shared within GEOSS, recognising relevant international instruments and national policies and legislation.
- All shared data, metadata and products will be made available with minimum time delay and at minimum cost.
- All GEO members are encouraged to share data, metadata and products free of charge or no more than cost of reproduction for research and education.

Specific actions, endorsed by the second GEO ministerial summit at the end of 2010, were developed to implement the principle of the "full and open exchange of data". Actions include the creation of a GEOSS Data Collection of Open Resources for

Everyone (GEOSS Data-CORE). The GEOSS Data-CORE is an easily accessible pool of documented datasets, contributed by the GEO community on the basis of full and open unrestricted access and at no more than the cost of reproduction and distribution.

The implementation of the GEOSS data-sharing principles can be seen in the sharing of Landsat archives by the United States Geological Survey and the free downloads of China-Brazil Earth Resources Satellite data provided by China and Brazil to all African countries (GEO, 2009e). GEO's efforts to make Earth observation data and information fully and openly accessible can bring great benefits, provided that the issues of data delivery, which is uneven across the world, and subsequent use are addressed. The GEONETCAST initiative provides an excellent example of how GEO is working to address differences in capacity.

Strengths, weaknesses, threats and opportunities of existing mechanisms for capacity building and technology transfer

The GEONETCAST initiative, the SERVIR facility and other GEO initiatives demonstrate its approach to capacity development, based on identification of needs and building capacity through knowledge transfer and data sharing.

The major difficulty for building capacity is the basic challenge for the GEO: obtaining the resources necessary to meet its aspirations. Its "best effort", voluntary contributions ethos may limit its impact as a global system. The explicit treatment of capacity building may also allow it to become an isolated issue, with the result that it is not woven into broader GEO discussions. Capacity building should not be a concern mostly to developing countries, but rather an essential component of all GEO activities of all members.

Bridging research and practice

One GEO target group is the global research community active in areas that can obtain important benefits from accurate and up-to-date data on Earth processes related to areas such as climate change, energy and food. Another is decision makers from governments, civil society and the private sector. The aim is to ensure the full interaction and engagement of science and technology (S&T) communities relevant to the work of GEO. It is envisaged that innovations in Earth observation science and technology will enable the research community to fully benefit from GEOSS. GEO aims at:

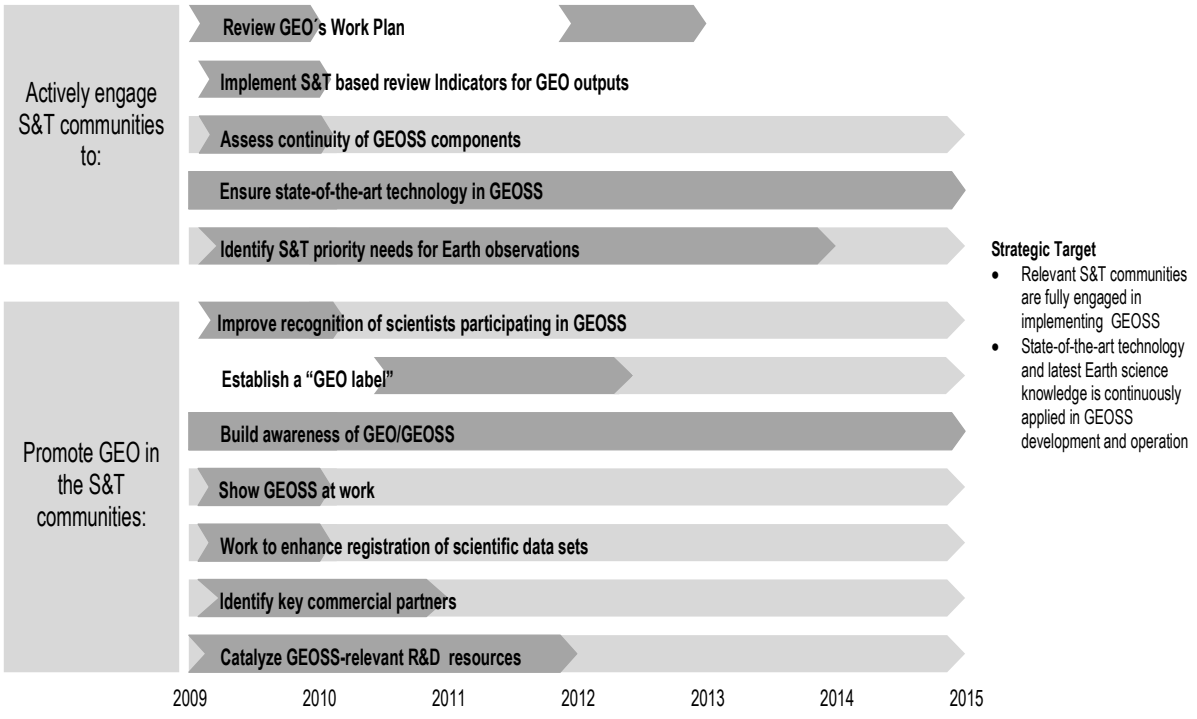
1. Promotion of research and development (R&D) in key areas of Earth sciences to facilitate, on an ongoing basis, improvements to Earth observation systems. This includes R&D for models, data assimilation modules, and new or improved algorithms for global and regional services and products.
2. Inclusion of societal needs in new research and of research considerations in planning of operational observing systems. This involves encouraging and facilitating the transition in systems and techniques from research to operations by fostering collaboration and partnership between the operational and research communities.
3. Improving the interoperability of global observing systems and modelling systems.
4. Incorporation of S&T outcomes that improve observing systems and observational capacity. This will be demonstrated by greater accessibility of data and improved co-ordination and maintenance of observational systems through GEOSS by the research community.

There is no special budget for translating science and technology into practice or policy advice. Scientific and technological questions in GEO are addressed primarily by the Science and Technology Committee which engages the S&T communities in the development, implementation and use of GEOSS in order to ensure GEO access to sound S&T advice. The committee has the following functions:

- To enable GEO to make decisions on the best available, sound scientific and technological advice by soliciting input from a broad, transdisciplinary scientific and technological community.
- To ensure the scientific and technological integrity and soundness of GEO work plans.
- To monitor and review output and deliverables of GEO work plans.
- In collaboration with GEO members and participants and through transparent processes, to identify individual experts and groups to participate in GEO working groups.
- To facilitate linkages and partnership with major relevant international research programmes as well as organisations willing to contribute to GEO activities.

The GEO S&T roadmap (Figure 4.3) has two broad objectives: the active engagement of the S&T communities in the development of GEOSS, through a revolving scientific review of the scientific and technological soundness and completeness of each work plan; and the creation of incentives to promote GEO in S&T communities in order to realise the GEOSS vision.

Figure 4.3. Science and technology roadmap



Source: GEO (2009c), GEO Science and Technology Roadmap and Annex.

Strengths, weaknesses, threats and opportunities of existing transfer mechanisms

Engaging the scientific community in GEO remains a challenge, although some progress is being made through the implementation of the roadmap described above. The challenge is primarily due to the fact that GEO is largely a "facilitating" organisation close to end users and therefore has limited appeal to the S&T community. It has been said that a more formal engagement by the International Council for Science (ICSU) would be helpful in positioning GEO in the S&T world (GEO, 2008).

Many observation systems are developed for research purposes and it is generally difficult to maintain them as operational systems, mostly because of a lack of funding. GEO therefore has an opportunity to co-ordinate the transfer of such research systems to operational systems, although this would require drastic changes in existing funding arrangements. It would require moving beyond the voluntary funding provided by a handful of members to longer-term funding arrangements that allow for the continuity that operational systems require.

Some of the indirect mechanisms to put research into practice relate, for example, to the GEOSS Common Infrastructure and GEONETCAST, as they provide platforms for information dissemination that individuals, organisations and governments can use to make decisions (*e.g.* on policy). In this sense, capacity building and putting research into practice are closely related. Dissemination of information and interaction can change and influence decision-making processes at various levels.

4.4. Summary and conclusions

GEO has been highly successful in developing a globally co-ordinated, system of systems approach to integrate Earth observations. Its success has been largely attributed to the level of political support that GEO enjoys. GEO was born of an idea expressed at the World Summit on Sustainable Development, has featured on the agenda of G8 summits since 2003, and has had five ministerial-level summits since its establishment. GEO has also been championed by leading Earth observation countries and organisations.

This strong political commitment has fostered collaboration with existing organisations in very diverse areas. It has also raised the global profile of integrated Earth observation and led more countries to focus on the use of Earth observations for decision making at a higher level than would otherwise have been the case.

Political commitment, however, is perceived negatively by some members and participants in that it appears to create competition between GEO and existing observing systems for political profile and resources. The Group's high political visibility has also raised concerns in other organisations that operate under resource constraints. These concerns are largely based on the occasional misinterpretation of GEO as a new, competing organisation in the field of Earth observations rather than as an initiative to co-ordinate existing efforts.

Developing a compelling vision

GEO provides a means to enable dialogue and exchange of expertise, as it brings together governments and international organisations, users and producers of Earth observations, policy makers and scientists to address gaps and needs collaboratively. A key element of its success is the development of a compelling vision that shows members the need for co-ordination of efforts and the mutual benefit that could result. Voluntary contributions to the GEO work plan, such as the release of data from the China-Brazil

Earth Resources Satellite for all African states, the availability of Landsat archives for global distribution, the collaborative development of the GEOSS Common Infrastructure and the creation of GEONETCAST, are examples of the mutual benefit gained from being united and sharing information.

Reassuring members and participants that GEO would not supplant existing mandates but would base co-ordination on existing efforts was essential in developing consensus for its establishment. GEO has not yet been completely successful in positioning itself as a supporting and enabling platform for facilitating and providing value through co-ordination. The confusion that exists in some communities about the role that GEO and GEOSS play in Earth observation may also be the source of perceived competition and the lack of effective collaboration with established organisations with similar charters and goals.

The development of GEOSS data-sharing principles and a data-sharing implementation plan resulted from a clear vision and a commitment to reach consensus. Agreement on data-sharing principles is notoriously difficult to reach, given the plethora of relevant national policies and legislations (GEO, 2009e). By agreeing on an open data policy at its establishment, GEO members and participants were able to define practical mechanisms, such as the GEOSS Data-CORE, that enabled definition of the vision but were able to respect each member's or participant's constraints. However, there is evidence of a lack of common understanding of the GEOSS vision and ineffective communication of the value added of GEOSS, which could undermine goodwill towards its realisation.

A voluntary and inclusive basis

Another key element of success for GEO has been the voluntary, inclusive and collaborative nature of the partnership. It has allowed members and participants to exercise control and move forward from the lowest common denominator.

The voluntary funding mechanism and system of in-kind contributions to the GEOSS work plan helped to develop GEOSS from existing elements. However, this also meant that crucial gaps, particularly in developing countries, were unlikely to be addressed since in-kind contributions primarily reflect the priorities of contributors. The funding base of GEO needs to be broadened to mitigate this. The focus on GEOSS implementation in the European Union's FP7 programme is a step in this direction.

GEO was originally conceived as a light structure with minimal bureaucracy. The scope of GEO and the task of co-ordinating such diverse contributions have, however, resulted in a complex and often confusing structure that has to some extent impeded its effectiveness.

The legally non-binding, voluntary nature of an organisation based on "best effort" contributions facilitated the swift establishment of GEO. From concept to implementation, GEO was in operation within three years. This allowed countries, international and regional organisations and a global scientific community to interact to address the general problem of access to data and the use of Earth observations for societal benefit. The informality of the approach facilitated consensus building between participating actors. However, the lack of a legally binding mechanism or treaty is recognised as a serious challenge to the sustainability and effectiveness of the GEO.

Annex 4.A

GEO members, participating organisations and observers

GEO members

Membership in GEO is open to all member states of the United Nations and to the European Commission. Membership in GEO is contingent upon formal endorsement of the GEOSS ten-year implementation plan. All members belong to a regional caucus. Current GEO members include 83 countries and the European Commission (see table below).

Africa	Americas	Asia and Oceania
Algeria	Argentina	Australia
Burkina Faso	The Bahamas	Bahrain
Cameroon	Belize	Bangladesh
Central African Republic	Brazil	China
Congo, Republic of the	Canada	India
Egypt	Chile	Indonesia
Ethiopia	Costa Rica	Iran
Gabon	Honduras	Israels
Guinea-Bissau	Mexico	Japan
Guinea, Republic of	Panama	Korea
Madagascar	Paraguay	Malaysia
Mali	Peru	Nepal
Mauritius	United States	New Zealand
Morocco		Pakistan
Niger		Philippines
Nigeria		Thailand
South Africa		
Sudan		
Tunisia		
Uganda		

Commonwealth of Independent States (CIS)	Europe	
Kazakhstan	Austria	Ireland
Moldova	Belgium	Italy
Russian Federation	Croatia	Latvia
Ukraine	Cyprus*	Luxembourg
Uzbekistan	Czech Republic	Malta
	Denmark	Netherlands
	Estonia	Norway
	European Commission	Portugal
	Finland	Romania
	France	Slovakia
	Germany	Slovenia
	Greece	Spain
	Hungary	Sweden
	Iceland	Switzerland
		Turkey
		United Kingdom

Note by Turkey:
"The information in this document with reference to 'Cyprus' relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

Note by all the European Union member states of the OECD and the European Commission:
"The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Participating organisations

GEO member governments welcome the engagement of participating organisations. The participation of intergovernmental, international and regional organisations with a mandate in Earth observation or related activities is subject to the approval of GEO members meeting in Plenary. Membership and participation in GEO is also contingent upon formal endorsement of the GEOSS ten-year implementation plan. GEO currently has 58 participants:

- AARSE: African Association of Remote Sensing of the Environment
- ADIE: Association for the Development of Environmental Information
- APN: Asia-Pacific Network for Global Change Research
- CATHALAC: Water Center for the Humid Tropics of Latin America and the Caribbean
- CEOS: Committee on Earth Observation Satellites
- CGMS: Coordination Group for Meteorological Satellites
- CMO: Caribbean Meteorological Organization
- COSPAR: Committee on Space Research
- DANTE: Delivery of Advanced Network Technology to Europe
- DIVERSITAS
- ECMWF: European Centre for Medium-Range Weather Forecasts
- EEA: European Environmental Agency
- EIS-AFRICA: Environmental Information Systems - AFRICA
- ESA: European Space Agency
- ESEAS: European Sea Level Service
- EUMETNET: Network of European Meteorological Services/Composite Observing System
- EUMETSAT: European Organization for the Exploitation of Meteorological Satellites
- EuroGeoSurveys: The Association of the Geological Surveys of the European Union
- FAO: Food and Agriculture Organization of the United Nations
- FDSN: Federation of Digital Broad-Band Seismograph Networks
- GBIF: Global Biodiversity Information Facility
- GCOS: Global Climate Observing System
- GLOBE: Global Learning and Observations to Benefit the Environment
- GSDI: Global Spatial Data Infrastructure
- GOOS: Global Programme
- UNESCO: United Nations Educational, Scientific and Cultural Organization
- UNFCCC: United Nations Framework Convention on Climate Change
- UNITAR: United Nations Institute for Training and Research
- UNOOSA: United Nations Office for Outer Space Affairs
- UNU-EHS: United Nations University, Institute for Environment and Human Security
- WCRP: World Climate Research Programme
- WFPHA: World Federation of Public Health Associations
- WMO: World Meteorological Organization

Observers

GEO may invite other relevant entities to support its work as observers. Observers may be invited to send representatives to GEO committees and to engage fully in specific GEO activities. There are currently six observers (one country and five organisations):

Countries

- Bolivia

Organisations

- EGY: Electronic Geophysical Year
- ESIP: Federation of Earth Science Information Partners
- GEBCO: General Bathymetric Chart of the Oceans
- ISC: International Seismological Centre
- START: SysTem for Analysis, Research and Training

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Chapter 5

The International Atomic Energy Agency*

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Since its establishment in 1957 the broad mandate of the IAEA has concerned the contribution of nuclear technologies to sustainable development throughout the world and the verification of their peaceful use. This case study focuses on two IAEA programmes directly related to international co-operation on science, technology and innovation and the deployment of new knowledge and innovations. The IAEA combines joint research, knowledge exchange, technical co-operation and capacity building to address global challenges through the development and implementation of sustainable solutions. In the absence of an implementing structure at the country level it has built partnerships with member country organisations or countries belonging to the United Nations.

* The case study was prepared by the above-named authors, who analysed published literature and documents on the Internet or made available by the International Atomic Energy Agency (IAEA). A series of semi-structured interviews were conducted with IAEA representatives to obtain complementary information. The IAEA revised the study in terms of its factual information, but any judgements are those of the authors.

5.1. Introduction

The International Atomic Energy Agency (IAEA, the Agency) was founded in 1957, with the overall objective to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". (Article II of the IAEA Statute). From 81 founding member states (here, members) in 1957, the agency currently has 151. The IAEA Secretariat headquarters are located in Vienna. It has two liaison offices in New York and Geneva, two safeguard regional offices in Tokyo and Toronto, and scientific laboratories in Vienna, Seibersdorf (Austria) and Monaco. Overall employment (including professional and support staff) numbers around 2 300. In 2010 the total regular budget was programmed at EUR 318 million; for the same year, the target for voluntary contributions to the Technical Co-operation (TC) Fund was USD 85 million (IAEA, 2011).

The Agency is known mainly for its role in the verification of the Treaty on Non-Proliferation of Nuclear Weapons, not least because of the Nobel Peace Prize awarded to the Agency and its then Director General in 2005. Indeed, a significant portion of the annual regular budget is spent on nuclear verification.[1] However, from the very beginning, the mission of the IAEA was much wider and included the promotion of science, technology and innovation (STI) in the field of nuclear technologies for energy generation and beyond. In fact, three of the seven paragraphs of Article III ("Functions") of the Agency's Statute explicitly refer to encouragement of research and development (R&D), the exchange of scientific and technical information and the exchange and training of scientists and experts in the peaceful use of nuclear energy. The Agency defines itself as a provider of a broad set of services to its members to address global challenges related to nuclear technology, including energy security, human health, food security and safety, and water resource management, as well as nuclear safety and security and non-proliferation.

The IAEA was established as an autonomous intergovernmental organisation with a working relation to the United Nations (UN) system (IAEA, 1959). What distinguishes IAEA from the United Nations' specialised agencies is the fact that its mandate does not focus on a specific development goal or field of intervention, as in the case of industrial development (UNIDO), education (UNESCO) or global health (WHO). Rather, the activities of IAEA obtain their coherence through reference to a specific scientific discipline and related technologies: atomic energy for peaceful purposes.

Governance[2] of IAEA activities differs in its lines of activities, mainly between the promotion of co-operation in R&D and the implementation of technical co-operation projects. This case study focuses on the governance of activities in the field of research co-operation and technical co-operation.

5.2. Approaches and activities to address global challenges

The Medium-Term Strategy 2012-2017 has the following six strategic objectives, to be pursued in a co-ordinated and mutually reinforcing manner (IAEA, 2012):

- To facilitate access to nuclear power.
- To strengthen promotion of nuclear science, technology and applications.
- To improve nuclear safety and security.
- To provide effective technical co-operation.

- To strengthen the effectiveness and improve the efficiency of the Agency's safeguards and other verification activities.
- To provide efficient, innovative management and strategic planning.

The IAEA plays a clear lead role and has primary responsibility in services related to nuclear safety and security and in furthering knowledge about energy generation by nuclear fission techniques. For its non-energy-related goals, the Agency complements other organisations such as the World Health Organization (WHO) or the Food and Agriculture Organization (FAO).[3] The present study focuses on activities to promote co-operation in science and technology and on implementation (innovation) in partner countries.

The work of the IAEA in non-power applications of nuclear techniques covers three main programme areas, each of which contributes to achieving the Millennium Development Goals (MDGs), to which the world community committed in 2000/01:[4]

- *Human Health (MDG4 and MDG5: Reduce Child Mortality and Improve Maternal Health).* The Agency has supported members' development of their capacity to apply nuclear technologies for the prevention, diagnosis and treatment of diseases. Examples include: advancing knowledge about the relationship between nutrition and HIV/AIDS, diagnosis of drug resistance in malaria and tuberculosis, and development of sterile insect techniques to reduce mosquito populations.
- *Food and Agriculture (MDG1: Eradicate Extreme Poverty and Hunger).* Services provided by the Agency, together with the FAO, help to control major insect pests that threaten food crops and to improve livestock production and develop new varieties of crops. They also help improve quality control in food and agricultural production, and protect the environment.
- *Water, environment and climate change (MDG7: Ensuring Environmental Sustainability, Enhancing Access to Clean Drinking Water).* The IAEA provides services in mapping and managing ground water resources as well as better protecting ocean, marine and land ecosystems, using isotope technologies. In the area of climate change, it works closely with the OECD Nuclear Energy Agency to develop nuclear applications that allow scientists to estimate the effect of future climate developments. It has also been active in developing and evaluating land management to capture CO_2 in soils and reduce N_2O emissions to mitigate climate change and improve crop growth.

The work programme of the IAEA in STI-related activities includes four broad types of collaboration.[5] First, co-ordinated research projects (CRPs) are the key tool for research collaboration at the IAEA. Second, the Technical Co-operation (TC) Programme supports members' capacity-building efforts, including in research, through the implementation of national TC programmes. Both of these programmes are seen as collaboration mechanisms or part of the "IAEA toolbox" to facilitate collaboration. Third, collaborating centres (Box 5.1) are a relatively new initiative which has only recently been rolled out on a significant scale. Fourth, the Joint FAO/IAEA Division (Box 5.2) is a division of both the FAO and the IAEA and can utilise the "toolboxes" of both to foster members' food security and agricultural development.

Box 5.1. IAEA collaborating centres

The IAEA designates selected institutions as official IAEA collaborating centres (IAEA-CCs). These are, in general, scientific institutions such as laboratories, universities, research facilities, etc. They receive public recognition from the IAEA and collaborate with the Agency in a variety of fields. One of the goals of the IAEA-CCs is to help developing members expand their capabilities in these areas.

Selection of an IAEA-CC depends on a variety of criteria, including their adherence to nuclear safety and security guidelines and a proven record of collaboration with the IAEA. The IAEA works with CCs in accordance with a time-limited plan of up to four years. The work must have clearly defined targets and expected results and meet the objectives of the IAEA's ongoing projects.

CCs carry out the work at no cost to the IAEA. Nevertheless, in certain cases, the IAEA may agree to provide limited funding for supplies, materials or services necessary for work plan implementation.

The first CC to be designated as such was the Institute of Nuclear Agricultural Sciences of the Zhejiang University of China in 2004. In July 2011, there were 20 CCs, with several in Asia-Pacific and covering a broad range of fields from neutron scattering techniques, through studies on harmful algal blooms to the development and application of the sterile insect technique (SIT) against fruit flies.

Source: www-naweb.iaea.org/na/resources-na/NA-Factsheets_CollaboratingCentres.pdf.

Box 5.2. An institutional partnership within the UN family: The Joint FAO-IAEA Division

Since its inception, the IAEA has collaborated closely with the FAO. In 1964 they joined forces by creating the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and brought to an end jurisdictional disputes and arguments between the Secretariats of the two agencies about the role of nuclear energy in food and agriculture (Fischer, 1997, p. 434). In comparison with other collaboration programmes, the Joint Division has characteristics that greatly enhance collaboration:

a) Joint funding: Its budget comes from both organisations, with about 80% of its regular budget from the IAEA and 20% from the FAO.

b) Joint entity: It is considered a single entity with joint staff. To form a homogeneous group permanent FAO staff are stationed at the IAEA headquarters and laboratories.

c) Joint programme: The collaboration has three concrete objectives: food security, poverty alleviation and sustainable agriculture. To this end it supports and co-ordinates R&D activities, provides capacity building and technical services and policy advice for members, and promotes the benefits of nuclear techniques in food and agriculture by collecting and disseminating information.

d) Joint governance: The division is led by a steering committee of two senior members of the FAO and two senior members of the IAEA. The committee decides the Joint Division's two-year major work programme.

The Joint Division's work focuses on five general topics: soil and water management and crop nutrition, plant breeding and genetics, animal production and health, insect pest control, and food and environmental protection. The work is carried out in the FAO/IAEA laboratories and the division's research projects.

Sources: IAEA/FAO 2008; interview with Qu Liang.

The co-ordinated research activities were designed to encourage research on and development of atomic energy for peaceful uses and to foster the exchange of information in the nuclear field. They seek to stimulate and co-ordinate research work by bringing scientists together. They are generally implemented through co-ordinated research projects that bring research institutes in developing and developed member countries together to collaborate on research topics of common interest. Also supported within this programme are individual contracts granted to scientists at research institutes and doctoral training to strengthen the promotion of research on nuclear technologies in developing members. The services provided include a PhD training component at the contract holder's institute.

While the co-ordinated research programmes and the collaborating centres promote research co-operation directly, other services support STI and international co-operation more indirectly, by:

- Educating and training professional and support staff in the field of nuclear and radiation safety and technology.
- Supporting the establishment and the work of scientific and technical knowledge networks on the regional and global level.
- Organising and disseminating statistics and data.
- Supplying reference material (nuclear, environmental, biological, marine).

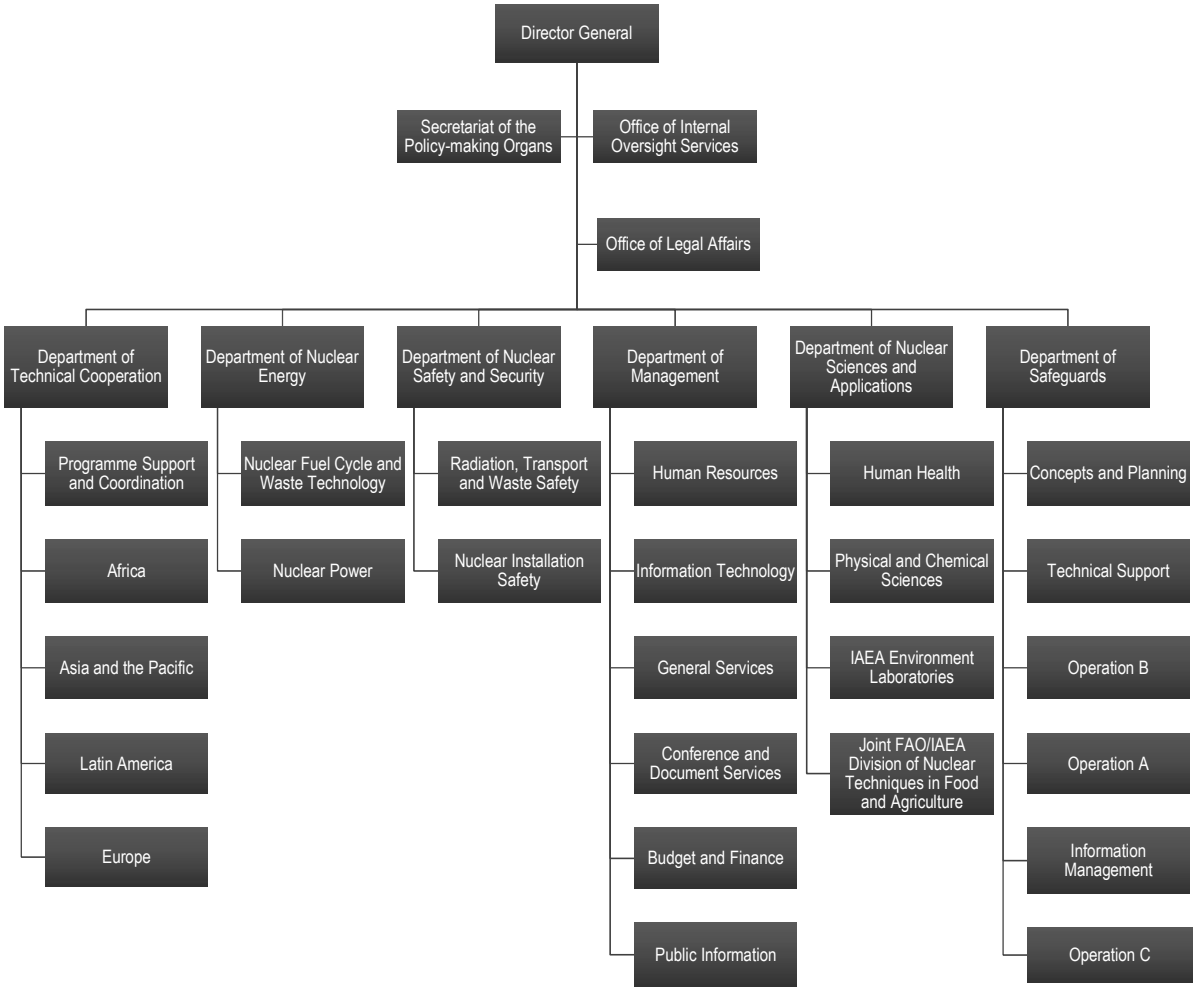
To deliver its services, the Agency draws on the skills of its six departments: Nuclear Energy, Nuclear Sciences and Applications, Nuclear Safety and Security, Safeguards, Management, and Technical Co-operation (Figure 5.1). While its services are usually aligned with the Agency's organisational structure, the IAEA combines the expertise of different departments and seeks to maximise international co-operation by applying a "one house" approach. For substantive input the Secretariat often relies on expertise in members.

The decision to construct a functional laboratory – in the face of hesitations in Western Europe and opposition by the USSR – was taken in 1959. The laboratory was located at Seibersdorf, 33 km southeast of Vienna and adjacent to the Austrian national nuclear research centre. It started operations early in 1961 (Fischer, 1997, pp. 80ff.). It amplified the range of services the Agency could offer. These include:

- Analysis of samples of contaminated radioactive fallout from the testing of nuclear weapons.
- Preparation of international radioactive standards.
- Calibration of equipment for measuring radioactivity.
- Control of special materials used in nuclear technology.
- Measurement and analysis of IAEA health and safety and safeguards work.
- A service to members that want to use the facilities to carry out the above tasks.

After the creation of the FAO/IAEA Joint Division of Food and Agriculture in 1964 (Box 5.2), the laboratory's work in support of research on agriculture and nutrition and on applications of radiation began to expand, and in 1965 the FAO and the IAEA established a plant breeding unit. In 1968, the two agencies set up an entomology unit and in 1986 they completed construction of a new agriculture wing.

Figure 5.1. Organisational chart of the IAEA



Source: www.iaea.org/Publications/Factsheets/English/iaea-primer.pdf.

The FAO/IAEA Agriculture and Biotechnology Laboratory helps members to develop and adapt agricultural technologies involving isotopes and radiation for local requirements and environmental conditions. The projects focus on soil science, plant breeding, animal production and health, control of major insect pests, and food safety and environmental protection. Further services include the utilisation of available TC funding for individual training through fellowships or national, regional and interregional group training courses. Other training opportunities include analytical quality control and assurance for counterpart laboratories and training in the maintenance of equipment and instruments.

In 1986, the International Laboratory of Marine Radioactivity, based in Monaco since its establishment in 1961, became a division of the Department of Research and Isotopes (currently Department of Nuclear Sciences and Applications) of the IAEA, with its own programme and budget. In 1991 its name was changed to the Marine Environment Laboratory.[6]

The Technical Co-operation Programme is the Agency's main means of making more widely available the benefits of nuclear science and technology for peaceful purposes, "with due consideration for the needs of the under-developed areas of the world" (IAEA Statute, Article III/2). Technical assistance by the Agency started as early as 1958 (Gaillard *et al.,* 2006, p. 180), IAEA 2007). In 2010, the overall budget for the TC Programme was around USD 161 million, including the TC Fund, extra-budgetary resources and in-kind contributions. The TC Fund alone amounted to USD 85 million.

The TC Department, with some 190 staff, is the interface between members and the Secretariat for technical co-operation assistance financed by the TC programme. All members are stakeholders in the TC programme and eligible for support; in practice TC activities focus on the needs and priorities of developing countries. The Department of Technical Co-operation co-ordinates the contributions of the different departments to the development, implementation, monitoring and evaluation of the programme.

5.3. Main characteristics of the overall governance model

The IAEA Statute has undergone few changes since 1957. The IAEA was formally established as an autonomous international organisation "in working relations with the UN" (IAEA, 1959; Sharma, 1995, p. 10). Although it is an autonomous organisation, the IAEA Statute stipulates that the Agency reports directly to the General Assembly, in addition to the Economic and Social Council. Since the application of international safeguards may concern international security it was also stipulated that the Agency should submit reports to the Security Council.[7]

Because it is an intergovernmental organisation, the governments of member countries are its stakeholders. Initially, a country became a member by signing the Statute within 90 days after it was opened for signature on 26 October 1956. Following that period, a country had to apply for membership, and the application had to be approved by the General Conference upon the recommendation of the Board of Governors. Later, applicants were also obliged to deposit an instrument of acceptance of the Statute. This procedure is still in force. When a country joins the IAEA, it must sign the "Revised Supplementary Agreement Concerning the Provision of Technical Assistance" by the IAEA before it can participate in the TC Programme. Under this agreement a country commits itself to adhering to internationally agreed safety and safeguards standards. Furthermore, before any radioactive source can be transferred to a member under a TC project, the country has to have achieved the safety milestones set by the IAEA. All Agency members have the same rights and benefits.

The IAEA governance structure consists of two main policy bodies:

- The General Conference, consisting of representatives of all members, meeting in annual sessions and, additionally, in special sessions convened by the Director General at the request of the Board of Governors or of a majority of members. It takes strategic decisions, such as electing the members of the Board of Governors, approving states for membership and suspending members from the privileges and rights of membership, approving the budget and any agreement between the Agency and the UN or any other organisation. Its main function is to serve as a forum for debate on current issues and policies.
- The Board of Governors, consisting of 35 members, elected by the General Conference according to the criteria defined by Article VI of the IAEA Statute. The Board of Governors has the authority to carry out the Agency's functions,

reports to the General Conference and prepares IAEA reports to the UN or other organisations for submission to the General Conference. It generally meets five times a year. The established election mode ensures adequate representation of the ten members most advanced in nuclear technologies and the eight geographical areas mentioned in Article VI.1 of the Statute.

Both policy-making bodies receive support from the Secretariat which has a staff of around 2 300. The Secretariat is headed by the Director General and Deputy Directors General who head the six departments (Figure 5.1).

Stakeholder involvement and partnerships

While the core stakeholders of the IAEA are the member governments, since its inception the IAEA has also entered into agreements with other international and non-governmental organisations. Article III of the Statute encourages exchange of research and information on relevant scientific and technological issues and co-ordination with other institutions.

In its early years, the IAEA granted consultative status to a series of non-governmental organisations (NGOs). These NGOs had the right to be present at certain meetings and give their views to the IAEA. Up to 1959, the Board of Governors granted 19 NGOs this special status. However, when the World Federation of Scientific Workers asked for "consultative status" in that year, the Western members refused, as the Federation was considered a "mouthpiece of the extreme Left" (Fischer, 1997, p. 78). This led to a general blockage of all further applications for consultative status.

Today, collaboration with international policy-making NGOs is modest and largely limited to their participation in the IAEA's annual General Conference. This is due less to the conflicts in the early years of the Agency's history than to the nature of its work. In nearly 70% of its technical co-operation projects the IAEA does not hold the lead mandate. The projects are generally the responsibility of other UN agencies such as the Food and Agriculture Organization (FAO) or the United Nations Children's Fund (UNICEF). In these instances, the IAEA relies on the lead institution's network and mainly engages indirectly with the NGOs. In only slightly over 25% of technical co-operation project collaborations is the IAEA the lead institution. These projects focus on nuclear applications and topics for which the UN has determined the IAEA to be the leading institution. In these projects the IAEA engages with international, national and local NGOs to implement the projects in members.

An example of the involvement of stakeholders other than members is the IAEA's collaboration with the Nuclear Threat Initiative. This non-profit organisation works to strengthen global security by reducing the risk of use and preventing the spread of nuclear, biological and chemical weapons. It collaborates in a network with IAEA and other organisations in developing country-specific strategies.[8] It has pledged a contribution of USD 50 million to the IAEA Low Enriched Uranium Fuel Bank.

Many activities of the IAEA are, *de facto*, limited to state actors, as non-state actors often do not have, or cannot obtain, their government's permission to participate in projects involving nuclear technology or materials. Activities funded by the TC Fund are less open to non-state actors than activities funded by the regular budget. Disbursements from the TC Fund are made for projects developed jointly by members and the IAEA and are based on members' expressed needs and national priorities. While the IAEA may suggest involving other stakeholders, it is the members' prerogative to accept or decline

its suggestions. The IAEA TC Department is striving to improve co-ordination of activities with other UN agencies and to link its projects better to ongoing or planned programme activities of UN country teams. Outreach to other key development stakeholders broadens their knowledge of the Agency's contributions to development and helps widen the scope and impact of technical co-operation projects.

To date, 22 UN Development Assistance Frameworks (UNDAFs) have been signed by the IAEA, which is actively participating in 81 ongoing or planned UNDAFs.[9] This has been an important step towards making the IAEA's activities in member countries more transparent. However, since most IAEA counterparts in members are associated with the nuclear sector and tend to be highly technical, their exposure to developmental issues and their linkages with organisations such as the FAO and the WHO may be somewhat limited. They may not see the need to involve additional stakeholders in the projects they manage. This is a challenge that needs to be overcome.

The TC Programme also has regional agreements, such as the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA); the Cooperative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA); the Regional Cooperative Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) and the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific (RCA). South-South co-operation can be an important supplement to knowledge and technology transfer between the technologically advanced and developing countries, as it is based on more equal levels of competences and capacities.

Agenda and priority setting

Discussions at the annual General Conference influence the high-level discussions and general programmatic direction of the IAEA. The topics considered crucial are also addressed in the different departments. Members approve a biannual programme and budget that lays out the details of the work programme which the IAEA implements and reports on in meetings of the so-called policy-making organs.

Other mechanisms, such as the Scientific Forum, which meets annually during the IAEA's General Conference, allow for a broader debate among stakeholders. The forum debates various topics and allows for highly specialised deliberations. Accredited NGOs and experts from around the world are invited to participate. Although the forum is open to non-state actors, the highly scientific and technical discussions normally do not lend themselves to participation by less specialised stakeholders or the general public. While this may appear a disadvantage, these technical discussions are often considered a useful and efficient way to drive the agenda forward.

The detailed agenda and priority setting process differs in the various programme areas. Agenda and priority setting in the TC Programme is mainly driven by members' interest. The members submit suggestions for projects to the TC Department based on their national priorities. During the project design phase, the IAEA can propose the inclusion of additional stakeholders but members are not obliged to accept; it is their right to request what is required in support of their own national development.

The collaborative research activities, mainly in the form of co-ordinated research programmes, are often initiated by a researcher or project officer at one of the technical departments. These individuals identify problems that may be of significant interest to members and suggest further action in these areas.

Additionally, the different sections of the technical departments hold periodic working groups in which members interested the topic discuss current research in their country. These meetings can reveal overlapping research areas and suggest ideas for CRPs. Individual members or stakeholders can also bring forward projects of interest to the international community. International organisations or networks may also suggest emerging topics of interests.

Despite these potentially different ways of influencing agenda setting, almost all ideas submitted for CRPs come from the technical departments and the expert meetings. As a complement to the analysis of what the most pressing global issues may be and what can be accomplished in laboratories, the (expected or explicit) interests of members are taken into account when initiating CRPs, in many of which 10-15 members co-operate. This shows that the issues on the agenda reach far beyond national priorities and are often of regional or global importance.

The Joint FAO/IAEA Division sets its agenda and work programme through its steering committee (two senior members of both the IAEA and the FAO). To determine the priorities for the next two years the committee draws on information from members, from its completed and evaluated projects as well as from the technical departments.

One of the weaknesses mentioned by interviewees is the lack of *ex post* evaluation of projects carried out by the TC Department. The main reason given for this gap in the governance cycle is the fact that the TC Department employs only around 190 persons (slightly more than 7% of the overall IAEA staff), only some of whom are programme officers (non-administrative personnel). This makes *ex post* evaluation a challenge.

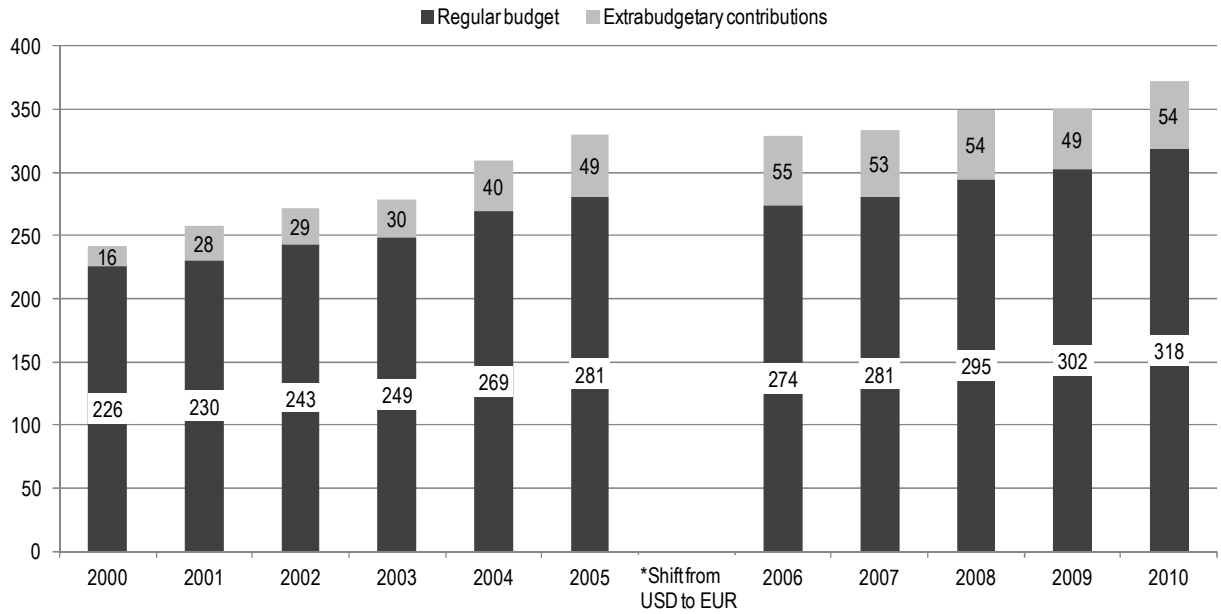
Basic characteristics of funding and spending arrangements

Members currently account for the bulk of the IAEA budget. Extra-budgetary contributions constitute a minor part (Figure 5.2). The last years have seen some fluctuations in the budget, but, overall, it is increasing.

Members' regular contribution is based on the assessment scale used for regular UN budgets (Weinlich, 2011, p. 38). On this basis, more developed members contribute a larger share than developing members. The contributions are determined and paid annually to the IAEA. In 2010 the total regular budget was programmed at EUR 318 million and the target for voluntary contributions to the TC Fund was USD 85 million.[10] The lack of field offices and the associated expenses have allowed the Agency to maintain a relatively small budget compared to other international organisations.

An interesting characteristic of the IAEA budget is the relatively large amount that is considered official development assistance: 100% of the TC Fund and 33% of the IAEA regular budget, or approximately 50% of the total IAEA budget.

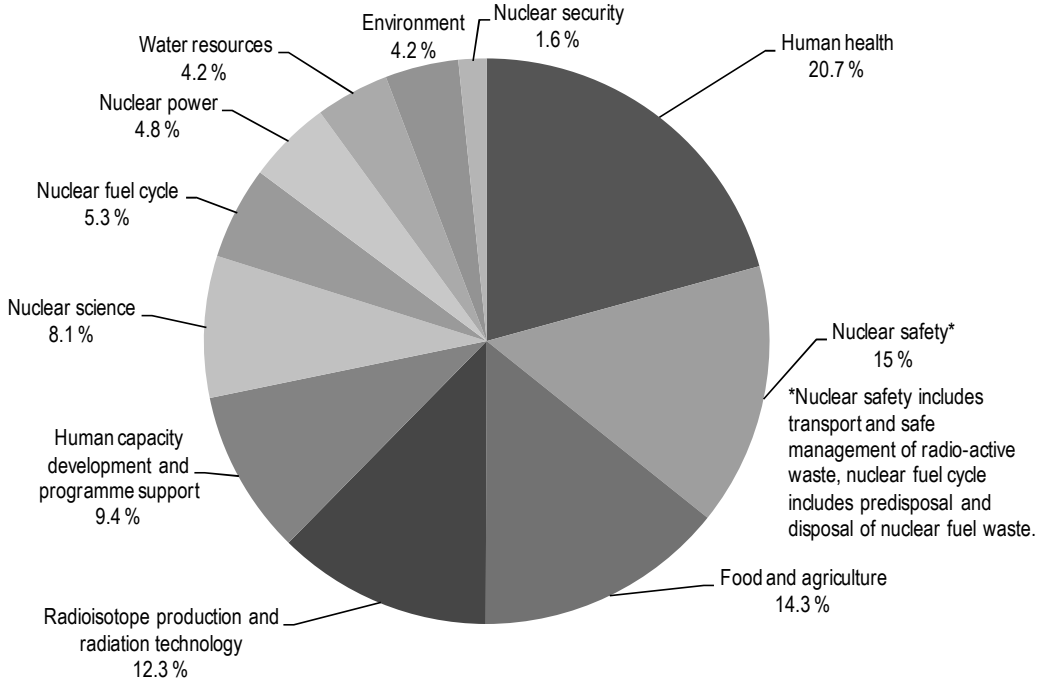
Figure 5.2. The IAEA budget, 2000-10



Note: *From 2000-05, the IAEA budget was denominated in USD. From 2006-10, it was denominated in EUR.

Source: IAEA (2010) Annual Report 2010, Vienna.

Figure 5.3. Distribution of the TC budget by application fields, 2009



Source: IAEA (2010) Annual Report 2010, Vienna.

In 2009, the total budget for co-ordinated research activities amounted to EUR 6.7 million (EUR 6.4 million from the regular budget and EUR 0.2 million from extra-budgetary resources). This supported 978 research, technical and doctoral contracts and 610 research agreements with institutes in 114 member states. More than 90% of the funds were used for contracts in institutions in developing countries, primarily in the food, agriculture and health areas. The majority of the CRPs in 2009 concentrated on topics related to nuclear techniques for development and environmental protection (budget of EUR 5.4 million), followed by nuclear power, fuel cycle and nuclear science (EUR 0.8 million) and nuclear safety and security (EUR 0.4 million).

For the same year, the adjusted budget for the TC programme amounted to USD 130.7 million, with disbursements (including in-kind) of USD 85.4 million. The highest share went to programmes related to human health (20.7%), followed by nuclear safety (15.0%),[11] and food and agriculture (14.3%) (Figure 5.3).

Putting research into practice

With its different programmes and services, the IAEA has the means to address global challenges through innovation, at least in areas that do not require high investments for putting research into practice (as is the case with nuclear power). It can do this by drawing on the scientific knowledge embodied in its scientific staff or in that of countries participating in CRPs, by generating new knowledge in its own laboratories, or by implementing projects in the countries partnering in the TC programme. To some extent, the supply and the demand side of innovation systems can be linked within the Agency and through its activities.

Box 5.3. The IAEA INPRO Project

In 2000, the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was established with the goal of ensuring that nuclear energy is available to contribute sustainably to the energy needs of the 21st century. INPRO provides a forum for experts and policy makers from industrialised and developing countries to discuss and co-operate on sustainable nuclear energy planning, development and deployment. At the same time, another international initiative was set up, the Generation IV International Forum (GIF). While INPRO is open to all IAEA members, GIF membership is limited to countries that can bring substantial resources and expertise to its R&D programmes.

INPRO is a membership-based project, led by a Steering Committee in which all INPRO members are represented. Today, INPRO has 34 members (33 IAEA members and the European Commission), who together account for 76% of the world's GDP and 66% of the world population. Several other countries and international organisations participate in projects on a working level or attend INPRO meetings as observers as they consider membership. The results of INPRO's activities are made available to all IAEA members.

INPRO has increased members' understanding that the implementation of nuclear energy and the development of a sustainable nuclear energy system require a holistic approach and a long-term strategy. Successful deployment of nuclear energy is enhanced by taking full advantage of innovations. INPRO plays an important role in helping members to become familiar with technological and institutional innovations that are being developed around the world and to incorporate these in their nuclear energy planning. INPRO's work involves four major projects: national long-range nuclear energy strategies; global nuclear energy scenarios; technical and institutional innovations; and the INPRO Dialogue Forum on Nuclear Energy Innovations.

Since 2003, GIF and INPRO have been co-operating to create synergy in nuclear technology development. There have been several meetings to co-ordinate the two initiatives. The IAEA participates in GIF policy meetings and select working groups, and INPRO and GIF have developed a common action plan for co-ordination and information exchange.

Source: www.iaea.org/INPRO.

Some interviewees have indicated that the implementation of new technologies is not completely satisfying. In some cases, this can be traced back to structural issues, such as the absorptive capacities of members, as the transfer of technical knowledge requires certain levels of know-how. Other factors may be more related to the mindset of actors, and whether their attitudes regarding the application of new technologies are positive or negative. The two issues are related. As has been mentioned, IAEA has no field offices in partner countries that could facilitate the transfer of knowledge created (or brought together) at the headquarters or in the laboratories into practical application by policy makers, society or the business sector. This means that the responsibility for putting new technological knowledge and innovations into practice lies essentially with the members. The effectiveness of technology deployment depends, in turn, on the capacities of the counterpart organisations and the degree to which they are part of the relevant fields and have a direct impact on policy making.

In some cases, the Agency's direct counterpart organisations are active in the field of nuclear technologies and thus may not be the best partners for carrying out projects to promote sustainable development.[12] In this context, close co-operation with certain UN organisations (WHO, FAO, UNICEF, etc.) can be an advantage, as this facilitates the involvement of development-oriented line ministries and relevant non-governmental organisations. Particular attention has been given to increase such co-operation through co-ordination with UN country teams and the inclusion of the IAEA in a country's UN Development Assistance Framework.

Another factor mentioned in the interviews that may make the smooth transfer of new knowledge related to the application of nuclear technologies into practice rather difficult is also encountered in other research fields: research scientists have strong incentives to deliver high-quality research, while their incentives to implement and pursue development impact on the ground may be weaker.

Related to this orientation towards generating scientific output as a public good is the fact that IAEA has no policy to generate income through the commercialisation of knowledge or technologies. Currently the IAEA owns all the research results and potential intellectual property rights. This also applies to output from collaborative projects, *e.g.* in the Joint FAO-IAEA Division or in collaborations with universities. This regulatory framework has made collaboration with other organisations and institutions difficult to manage with respect to shared patent rights, in particular with universities owing to differences in intellectual property objectives. Nonetheless, while the IAEA owns the intellectual property stemming from collaborations (*e.g.* CRPs) universities are free to use the results.

The TC Programme has been acting as an interface between IAEA expertise on nuclear matters, scientists and members to help to overcome the implementation hurdle. Two initiatives have been mentioned by interviewees as promising in this regard:

- One is to improve implementation through intensification of the follow-up reviews that have recently been initiated in the TC Programme. The Office for Internal Oversight Services has a mandate to conduct evaluations which include field visits and interviews with stakeholders. The TC Programme is currently developing a self-assessment mechanism for members, particularly their project teams, to evaluate their performance against international standards.
- The second has been the creation of patenting initiatives to motivate scientists to bring their inventions to the market and implement them with members. Contacts initiated with the World Intellectual Property Rights Organization (WIPO) aim to inform scientists of their opportunities.

Capacity building and technology transfer for research co-operation

An important cross-cutting area of the Agency's activities involves capacity building and transfer of technologies. Building members' capacities to work responsibly with nuclear technologies (for development, environmental protection, energy generation and other applications) has been a core element of the Agency's mission since its inception. These activities often aim at developing countries and are supported by the IAEA and developed countries. This development orientation is mirrored by the fact that almost 50% of the IAEA's budget is recognised as official development assistance by the OECD's Development Assistance Committee.

One way of ensuring capacity building is the Agency's emphasis in its projects on the "mix" of developing and developed countries to further North-South collaborations. Approximately two-thirds of participants in a CRP, for example, are required to be developing countries, with the remaining one-third consisting of developed countries. The knowledge transfer that occurs through such collaboration is considered an important aspect of CRPs. However, the knowledge providers are not necessarily developed countries. In the TC Programme, transfer of know-how also occurs between developing countries, building on the experiences of those with advanced uses of nuclear applications, such as Brazil or Pakistan.

The TC Programme is the primary development-oriented programme of the IAEA and explicitly addresses members' needs for capacity building and technology transfer. To this end, it uses a variety of means, such as training courses, expert missions, fellowships, scientific visits and the disbursement of equipment. Currently, the TC Programme has more than 800 projects.

Recent efforts to align IAEA activities to national development priorities (country programme frameworks) and to co-ordinate them with those of other UN agencies (UNDAFs) can be seen as important steps in bringing the IAEA TC Programme in line with the agendas agreed by the international community (Paris Agenda, Accra Agenda for Action).

5.4. Conclusions and lessons learned

The mandate of the IAEA allows it to address several global challenges by mobilising the potential of nuclear applications for development. Many other international organisations address a specific challenge or field, such as global health in the case of the WHO or food security in the case of the Consultative Group on International Agricultural Research. To address this challenge they draw on a variety of scientific disciplines and related technologies. The core organisational principle of the IAEA is, instead, related to a specific discipline (nuclear techniques and applications) that can be used for different purposes, such as improving agricultural production, addressing a variety of health-related problems, or monitoring changes in the natural environment triggered by global warming or other problems induced by human activities, such as overexploitation of soils through inadequate agricultural practices.

The Agency has an important potential to contribute to mitigating or overcoming global challenges through innovation. It can combine its different programmes and the knowledge embodied in its professional staff or partner organisations with technical co-operation activities that contribute to implementation and capacity building. However, analysis of possible barriers to a rapid transition from joint research to the application of knowledge can provide important lessons for effective governance of international

research to address global challenges. Some initial insights may be derived from the analysis of relevant documents and the interviews conducted for the present study.

The Agency's human resources and knowledge-generating activities are largely concentrated in the headquarters in Vienna and its laboratories in Seibersdorf and Monaco. The Agency has no field offices in the member countries that might constitute an implementation arm. While this has been mentioned as a factor allowing for a lean structure and for containing costs, it makes impact very much the responsibility of members and of the capacities of partner organisations.

In this context, the IAEA's long-standing institutional partnerships with the FAO and the WHO, which arose from the desire to avoid duplication of efforts between different bodies of the UN system, are an important asset, as these organisations' national counterparts have closer links to sustainable development. A similar effect can be expected from the closer alignment of activities with national development plans and joint activities of UN agencies that is reflected in the Agency's increasing involvement in the UN Development Assistance Framework processes.

A structural barrier might be the fact that the staffing of the TC department of the IAEA, the department most directly linked to implementation activities, is a rather small component of the Agency.

Other reasons mentioned as hampering a swift translation of newly generated knowledge into applications on the ground are related to "soft" factors. The IAEA's highly qualified research staff focuses on the development of solutions based on world-class research at the agency's laboratories and in collaborative undertakings. How new knowledge as the *output* of high-quality research can be converted into innovations with concrete impact (*outcome*) has not traditionally been a significant part of the concerns of individual staff members or organisational units. Indeed, the Agency has only recently considered an intellectual property regime that would create institutional or individual incentives for the application of knowledge on the ground (patents, licences). More generally, this reflects the tensions between the need to create new knowledge as a global public good to solve global challenges and the difficulty of bridging the "last mile" between research output and an outcome that advances sustainable development.

Finally, there is the problem, one that was mentioned repeatedly, that even in members and in the general public, knowledge about the IAEA's broad mission and the services it can offer to foster sustainable development is very limited. Often, the Agency is mainly or exclusively associated with its role in nuclear verification and/or promoting nuclear safety, *e.g.* the prevention and handling of accidents. The development-oriented part of its range of activities seems very much overshadowed by these missions. The human and financial resources the Agency may invest in awareness raising seem insufficient for communicating knowledge about this aspect of its mission to potential stakeholders in members and to the public.

Notes

1. In 2010 spending for this purpose was approximately 39%. See IAEA (2011); *www.iaea.org/About/budget.html*.
2. Here, the term "governance" is used, as elsewhere in this volume, to describe the process of co-operation, co-ordination and policy making in a broad sense, not simply as a synonym for government or steering. Final decision making lies with the Director General, the Board of Governors and the General Conference.
3. The provision of affordable energy is clearly a key to sustainable development, even if it is not mentioned in the relevant global policy documents, such as the Millennium Declaration. While the present chapter focuses on IAEA activities unrelated to nuclear energy generation, an important example of an energy-related project is described in Box 5.3 (International Project on Innovative Nuclear Reactors and Fuel Cycles – INPRO).
4. *www.un.org/millenniumgoals/*, accessed 15 May 2011.
5. Other ways of delivery include technical meetings and documents, standards and reference materials, quality control services, etc.
6. IAEA (2011); *www.iaea.org/monaco*, accessed 20 August 2011.
7. All IAEA members' safety standards are assessed annually. If these are not met or upheld, the IAEA can stop project activities until the member meets the requirements. This mechanism can facilitate greater adherence to safety and security standards.
8. In 2009 the IAEA and the WHO launched the Joint Programme on Cancer Control, aimed at strengthening and accelerating efforts to fight cancer in the developing world, *www.who.int/mediacentre/news/releases/2009/who_iaea_cancer_programme_20090526/en/*.
9. As of 25 July 2011, information provided by the IAEA's TC Department.
10. *www.iaea.org/About/budget.html*, accessed 20 August 2011.
11. Including transport safety and safe management of radioactive waste.
12. This is not always the case, as some counterpart organisations are clearly service-oriented (hospitals, etc.) and contribute to development to achieve the MDGs.

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Chapter 6

The Inter-American Institute for Global Change Research

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This case study discusses a regional organisation that deals with the impact of global change in a specific part of the world. The Inter-American Institute for Global Change Research (IAI) is a regional intergovernmental organisation that is successfully funding and supporting networks of collaborative research while building capacity in the less-developed countries of Latin America. With rather limited financial resources, IAI successfully catalyses collaboration in science, technology and innovation in various fields related to global change. An important challenge is the lack of strong buy-in from some members. This affects funding as well as the organisation's science-policy interaction.

6.1. Introduction

The Inter-American Institute for Global Change Research (IAI, the Institute) was established by an international agreement, concluded among 16 countries in the Americas, on 13 May 1992 in Montevideo, Uruguay. It is an intergovernmental organisation established for the purpose of co-ordinating and promoting scientific research and providing accurate and timely information related to global change to policy makers in the Americas. It currently has 19 members, representing the region's industrialised countries and most of its developing countries.[1]

The organisation was created in the run-up to the United Nations Conference on Environment and Development (UNCED) in order to demonstrate the members' practical commitment to the environment and sustainable development. Its establishment was timely, as world leaders at the UNCED called for the formation of an international entity to take a regional approach to addressing global environmental change. They acknowledged that multinational collaborative research needed to be undertaken and new scientific knowledge produced in order to increase scientific understanding of global change and the environment, a task that no one nation could undertake independently. In addition to the IAI, two other regional institutes for global change research – the European Network for Research on Global Change and the Asia-Pacific Network for Global Change Research – were formed to facilitate regional integration of global change research programmes. The objectives of the IAI are:

- To fund regional scientific programmes and projects for which the research cannot be pursued by an individual country or institution.
- To promote regional and international co-operation and co-ordination on global change programmes.

The Institute's primary mission is to develop the capacity to understand the impact of present and future global change on regional and continental environments in the Americas and to promote collaborative research and informed action at all levels. An important aspect of its work is to develop scientific networks that work collaboratively on global change issues of regional importance. As such, the IAI acts much like a funding institution in assessing applications and awarding grants to research networks composed of multiple institutions in the Americas.

Each country participating in the IAI is supposed to benefit from the enhancement of regional relationships, from the establishment of new institutional arrangements, from the open exchange of scientific data and information generated by the IAI's research programmes, and from its training and education programmes.

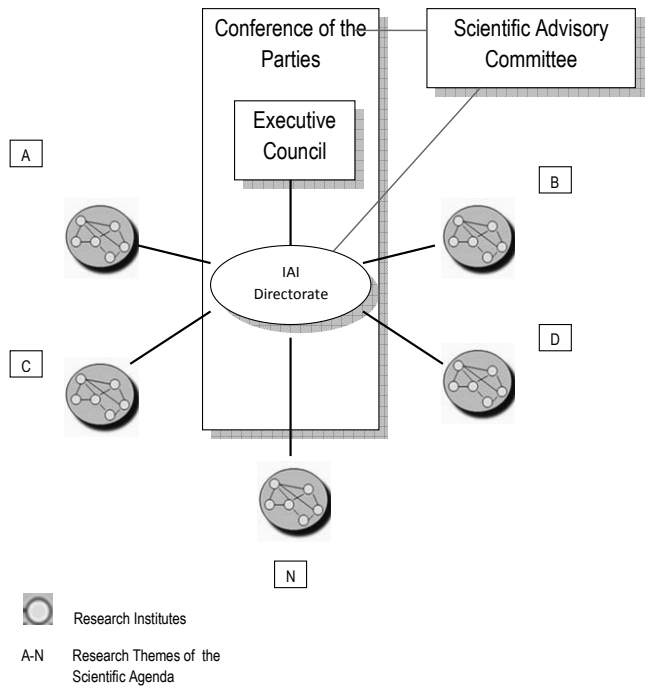
The United States National Science Foundation hosted the IAI Secretariat for almost two years. In March 1996, the IAI became fully operational, with a directorate located at the Brazilian National Space Research Institute (*Instituto Nacional de Pesquisas Espaciais*) in São José dos Campos, Brazil.

6.2. Main characteristics of the overall governance model

The institutional set-up of the IAI has four permanent organs (Figure 6.1). The Conference of the Parties (the Conference) is the principal policy-making organ of the IAI.[2] It includes representatives from the 19 member states. It meets annually and has the following main functions:

- To consider and adopt measures to establish, review and update the policies and procedures of the Institute, as well as to evaluate its work and the accomplishment of its objectives.
- To review periodically and approve, on the basis of recommendations of the Scientific Advisory Committee, the scientific agenda of the Institute and to consider and approve its long-range plans and annual programme and budget.
- To consider and approve the financial policies, the annual budget and the financial records of the Institute submitted by the director.
- To elect the members of the Executive Council and of the Scientific Advisory Committee, and the director.
- To establish *ad hoc* committees as necessary.
- To approve amendments to the IAI Agreement and to perform other functions as necessary to achieve the objectives of the Institute.

Figure 6.1. Overall governance structure of the IAI



Source: Adapted from figure on the IAI website: *www.iai.int/index.php?option=com_content&view=article&id=14&Itemid=61.*

The Executive Council is the executive organ of the IAI. It is composed of nine members, each of whom is elected by the Conference for a two-year term and serves in his or her individual capacity. Its primary functions are to develop policy recommendations for approval by the Conference and ensure implementation of those policies by the IAI Directorate. The Financial and Administrative *ad hoc* Committee assists the Executive Council in matters relating to planning, preparation and implementation of IAI financial, administrative and project management issues.

The Scientific Advisory Committee is the principal scientific advisory body and has ten members, elected by the Conference for three-year terms. Six members are nominated by the Parties; three nominations are received from the Scientific Advisory Committee; and one member is nominated by the Institute's associates. [3] The Committee makes recommendations to the Conference regarding the science agenda, long-term plans, the Institute's annual programme, and science programmes to be funded. In addition, it assesses the scientific outcome of the research funded by the Institute. Interviewees indicated that this last function is not yet well implemented. The Scientific Advisory Committee has no standing rules on voting procedures, procedures for debate, rules for agenda preparation and amendment, etc. It is supposed to set its own rules on these matters.

The Directorate is the Institute's primary administrative organ and is presently composed of: a director and assistant directors for the science programmes, for finance and administration, and for capacity building; an information technology manager; a collaborative research network project manager; and support staff. It is responsible for day-to-day operations and the implementation of policies and scientific programmes as determined by the Conference and the Executive Council. It operates under the leadership of the Executive Director and currently has a staff of 13.

The institutional link to member governments is ensured through their representatives in the Conference and their nomination of official country representatives. Beyond this, the IAI seeks to ensure that scientific research is brought to the attention of policy makers at the local and national level through its networks, its staff and to a lesser extent through the government's official representatives who are responsible for relations with the IAI. Country focal points are also crucial for the organisation's effective translation of science into policy action.

The IAI's relationship with member states varies. At governmental level it is strong with some members, somewhat weaker with others, and almost non-existent with a very few. This has resulted in an unbalanced and far from optimal participation in Conference meetings and hence in constraints on effective inter-governmental governance of the IAI. In the past, this has even put the Conference at risk of not reaching the quorum needed to act legally and potentially being unable to approve a budget or country contributions.

Beyond the Americas, one of the mandates of the IAI is to link its researchers to the world scientific community. The IAI co-operates in various ways with other institutions. For example, it has an active observer role with the United Nations Framework Convention on Climate Change. The Institute has had observer status since 2006 and has since provided inputs, mainly to the Subsidiary Body for Scientific and Technological Advice. According to the Director, the IAI also has more or less regular co-operation with other global change programmes. Short-term programmatic, institutional and financial collaborations at regional as well as international level evolve primarily through joint training and capacity-building activities.

Agenda and priority setting

The Institute's long-term mission and agenda are defined in the Agreement establishing the IAI.[4] The Agreement lists seven rather highly aggregated topics, from the "study of tropical ecosystems and biogeochemical cycles" to "high latitude processes" (IAI Agreement, Article III). The detailed policy and science agenda is approved by the Conference. Furthermore, the Conference considers and approves – on the recommendation of the Executive Council and the Scientific Advisory Committee – the IAI's long-range plans and annual programme. Therefore, the IAI applies a "top-down approach" to agenda and priority setting, which is partially balanced by the efforts of the Directorate to integrate micro-level views. Generally, decisions of the Conference are made by a majority vote of the accredited Parties. Priorities are reviewed by the Conference with the support of the Scientific Advisory Committee and input from the Directorate. For instance, the previous Scientific Advisory Committee chair pushed forward a social science agenda, a topic that was not previously a priority area. As a result the IAI now has a human dimensions programme.

Since its establishment the IAI has undergone a few changes to, but no significant reforms of, its governance structure. The changes concerned the leadership of the IAI and occurred primarily with the appointment in 2005 of a new director, who introduced new management practices. These included new financial reporting requirements and a review of standard agreements with partner institutions. The changes basically concerned the IAI flagship programme, the Collaborative Research Network (CRN) Programme, created with the idea of developing networks of scientists and scientific institutions working together in an integrated fashion on global change issues of regional importance. The CRN projects promote co-operation by interdisciplinary teams within the region, with at least four countries involved in each project. These networks are encouraged to expand through institutional incentives.

The CRN Programme has gone through two major research phases: CRN I (1996-2006) and CRN II (2006-11). Changes introduced in the transition from CRN I to CRN II included moving from support for individual projects to cross-programme networking with more international appeal and to regionally more relevant and generally more coherent programmes. Improvements important to the IAI's work included synthesising the output of all projects, integrating human dimensions and economic analysis with the natural sciences, and emphasising a stronger science-policy interface. This integrated programming approach is important for the Institution's policy relevance in the area of global change and hence for its governance.

CRN priority setting (and funding) covers a cycle of five years, which ensures a longer-term perspective. At the same time, flexibility is an important element of the science agenda. The Agreement establishing the IAI states that the agenda should be dynamic and evolve to incorporate new scientific priorities, address changes in the needs of the region's countries, and address changes in the ability of the scientific community to carry out research that contributes to the solution of specific problems. This flexibility is important for ensuring the policy relevance of the organisation's science programmes.

Priorities are reviewed by the Conference with the support of the Scientific Advisory Committee and input from the Directorate. The Scientific Advisory Committee plays a crucial role in setting the research agenda and ensures the integration of the scientific view in the decision-making process of the IAI. According to the Director, the Scientific Advisory Committee is expected to play an important role in defining the next call for proposals for CRN III, provided that funds for the organisation of Scientific Advisory

Committee meetings are available. However, in 2010 the Committee had difficulty executing its functions effectively owing to a lack of financial resources. The lessons learned from CRN II will also influence how the programme will evolve. The Director monitors the implementation of the defined priorities with respect to their policy implications.

The provisional agenda of each regular Conference meeting is prepared by the Director in consultation with the Chair of the Executive Council, taking into account the decisions of the previous meeting, the recommendations of the Executive Council, and the proposals of the Parties. The Director also takes into account feedback from the principal investigators of the different CRN networks.

The operations of the Institute have improved in recent years, owing in part to a dedicated and stable Directorate. The IAI also benefits from its access to a range of leaders in the scientific and political arenas who participate in the Conference, the Executive Council and the Scientific Advisory Committee, and who could serve as ambassadors for the Institute. These participants need to be fully engaged in IAI operations to shape the organisation's priorities and scientific agenda. To realise its full potential, the IAI must clearly define the roles and responsibilities of each IAI participant (AAAS, 2007, p. 4).

Funding and spending arrangements

Pursuant to the IAI Agreement provisions, the 19 members make annual pledges to provide "voluntary contributions" to support the IAI Directorate's core operational expenses, major research and capacity building programmes, and specific projects. According to the Agreement the pledges are in increments of USD 5 000 but since 2007 the increments have been of USD 1 000. Specific project funding also comes from other bodies (*e.g.* the World Meteorological Organization's Global Environment Facility, the MacArthur Foundation). The core funding covers operational expenses, including salaries and basic support for the Directorate, Scientific Advisory Committee and Executive Council. The IAI Agreement calls upon the Parties to "recognize that regular contributions to the operational budget are essential to the success of the Institute". The adoption of the annual budget is taken by consensus of the Parties.

The programme funds are dedicated exclusively to research or capacity building. The IAI Agreement (Article XIII, 2) specifies that its major research programmes and specific projects can also be supported by donations from associates of the Institute, by states outside the region, by regional or international intergovernmental organisations, and by industry and other non-governmental and private organisations.

The IAI's science programme is largely funded by grants from the US National Science Foundation (NSF), which has provided the major part of the funding by far, followed by Canada and Argentina. According to the IAI, other member states often provide in-kind contributions for scientific research. In practice, NSF funds represent up to 60% of the core budget and cover all programme funding with the exception of the grants of the MacArthur Foundation and Canada's International Development Research Centre. Effectively, the United States funds 79% of the IAI's activities.

The main programmes are:

1. The Collaborative Research Network Programme, which receives the major part of the funding.[5] The IAI is able to complement the programme when needs are identified. For example, about USD 800 000 from CRN II was not committed to projects but is being used to promote a scientific synthesis of the programme's projects and to develop stakeholder interaction processes.[6]
2. Small grants and seed programmes ("Initial Science" programmes) were maintained in the past "to support the initiation of research, capacity building, and planning activities that would facilitate the development of larger science programmes and research networks". This instrument is now being used for the human dimensions projects.
3. The Small Grants Programme: Human Dimensions (SGP-HD) was created in 2007 to promote human dimensions research and builds on the interdisciplinary networks created in CRN II.[7] It is intended to merge this line of activity with the CRN in future calls to provide better integration of the human and natural sciences.

Flexibility in funding and spending is viewed as essential for successful project implementation and management. At the same time, stable financial contributions and funds are important for the organisation's functioning.

The Directorate, jointly with the Executive Council's Financial and Administrative Committee,[8] develops the budget plan and draft budget for the following year and makes it available to members of the Executive Council who are invited to comment via e-mail within 15 days on the plan and budget.

The financial policy and budget documents are prepared and submitted to the Conference by the Director, through the Executive Council, which makes recommendations. The Conference considers the recommendations and approves the Institute's financial policies, the annual budget and the financial records. The Director is also responsible for submitting annually adjusted allocations to the Directorate, for implementing the financial policies and the budget and for maintaining detailed records of all revenue and expenditure of the Institute.

Through the Financial and Administrative Committee, the Executive Council appoints an external auditor and reviews the annual external audit of the financial records submitted annually by the director to the Conference. The Executive Council annually discusses the auditor's report on the financial statement provided by the IAI Directorate, which is then presented to the Conference. Beneficiaries of the science programme are required to submit annual financial and scientific reports. Their frequency and format (and the cases in which they need to be certified by an auditor) are defined in the grant agreement. Based on the project reports, and possibly also with the support of presentations made by the principal investigator, the IAI conducts annual reviews of progress. The reviews are a useful tool for deciding whether to continue financial support for the project. In the event of a negative outcome of a review, the IAI Directorate may decide to suspend the project pending corrective action, or to terminate the grant agreement. Ideally the IAI should involve independent experts (peer review) in this process.

Knowledge sharing and intellectual property

The IAI Agreement (Article II) establishes the full and open exchange of scientific information and data with a view to informed decision making: "The Institute shall pursue the principles of scientific excellence, international cooperation, and the full and open exchange of scientific information, relevant to global change." The Institute is therefore seeking to improve information management and to develop a culture of data sharing among IAI members (*IAI Biennial Report 2007-2009*, p. 27). Furthermore, the IAI has adopted an approved Data Policy Statement to ensure free and open access to data generated by IAI-funded projects.

The IAI requires a continuing commitment from the CRN grantee regarding the establishment, maintenance, validation, description, accessibility and distribution of high-quality, long-term data sets that may result from research supported by a grant (Point 2.6 of the *CRN Policy Guidelines*, July 1999). Principal investigators can request initial periods of exclusive data use only under special circumstances. In such cases, the IAI negotiates the duration of the exclusive use period. Furthermore, where applicable, grantees need to submit a fully documented data set to the IAI for distribution on the IAI Data and Information System (IAI-DIS); alternatively, the grantee supplies electronic pointers for the IAI-DIS.

In principle, researchers must publish their research results in international journals and books. This helps to ensure the scientific excellence and standing of IAI's research. If researchers publish in a copyright-protected organ, the IAI-DIS system only includes a reference to the book or the article but does not provide direct access to the content. The IAI-DIS could also be developed as an important tool for inter-institutional communication throughout the Americas.

In 2007, a review conducted by the American Association for the Advancement of Science (AAAS) found that the data and information system was not realising its goal – to serve science and society and inform action – and recommended that strategies should be developed for sharing research outcomes and data with regional and international scientists more effectively (AAAS, 2007, p. 4). It recommended that IAI develop and implement a plan to upgrade the IAI data and information system (USGCRP, 2009). However, such a plan was still not in place by the end of 2010.

The Directorate has developed an Internet database that references information produced by the IAI's scientific projects. Technically, these references are metadata, that is, information about data such as publications, final and partial reports from the scientific programmes, posters, presentations, workshops, and other programmes and projects. The IAI plans to continue to update the system to improve its features, make it more user-friendly, and, in particular, more interoperable with similar systems in other institutions and organisations. The compatibility of data systems of different organisations and institutions has proved to be crucial for the effective and efficient use of the open access system.

The IAI also uses a variety of communication and outreach mechanisms to increase its visibility, make information about its activities and programmes available to the scientific and policy-making communities and the general public, and make known the results of its scientific research and capacity-building efforts. These mechanisms include the newsletter, the IAI website, the IAI Listserv, the IAI biennial report, policy briefs and communiqués, scientific publications, and other material.

From research to implementation

The AAAS report found that policy makers across the Americas have had difficulty using the results of the Institute's science to inform their policy action (AAAS, 2007, p. 5). In 1999, the IAI launched its interdisciplinary training institutes to promote the human dimensions aspect of environmental change and address the need for a science-policy interface to ensure that relevant scientific findings are accessible to and usable by policy makers. The training focuses on themes of priority to the governments of the Americas and on science-policy linkages and facilitates attendees' development as leaders in science in their respective countries. The success of these programmes in fostering communication between natural and social scientists and promoting multi-national and multidisciplinary collaboration led the IAI to plan further institutes.

The aim of the IAI's future training institutes is expected to focus on policy relevance and effective ways to apply scientific data to policy development and on capacity building. To this end the Institute seeks to establish new and strengthen existing institutional and financial partnerships with other national and international organisations. Co-planning and joint implementation can strengthen the linkages among the participating agencies and institutions and maximise the use of financial and human resources.

Some research funded by the IAI already influences planning and policy. IAI projects that deal with balancing CO_2 in South America are one example of multinational collaboration. Two collaborative research networks, funded by the NSF through the IAI, illustrate how important the understanding of local as well as regional processes is to the mitigation of climate change. One team, led by the *Servicio de Hidrografía Naval* of Argentina, collaborates with scientists in Argentina, Brazil, Chile, the United States and Uruguay and is identifying the physical and biological mechanisms that control the exchanges of CO_2 between the ocean and the atmosphere. This research provides important input to discussions of climate change at regional level (IAI, 2010).

Capacity building

The Institute's greatest contribution has come from successfully building scientific capacity throughout the Americas. This effort has been closely coupled with its efforts to support interdisciplinary, collaborative research. The capacity-building efforts of the organisation have proved successful in terms not only of workshops and training institutes, but also of institutional capacities to handle international science, networks and complex projects with complex funding mechanisms that require special agreements among institutions in different countries.

The IAI supports training and education by granting fellowships and research opportunities to students and professionals from many countries of the Americas. In the past ten years, it has supported thousands of professionals who are important for their country's development through technical workshops and seminars. Students have received support for their studies at the undergraduate, graduate and postgraduate levels. Recipients of academic grants not only receive resources to conduct their studies, but also benefit from exposure to scientific environments and from opportunities to link their degree studies with current research (through field trips, laboratory experiments, related studies in other countries, and exchange of scientific data and knowledge with other investigators in the IAI network). The IAI also supports other training and education efforts and initiatives, such as scientific and technical workshops, training institutes, and seminars.

To the IAI, capacity building means providing knowledge and know-how, developing opportunities for collaboration and means of communication, and strengthening local and regional capacities to deal with global change and its impacts. By bringing together participants from different scientific, professional and cultural backgrounds, IAI training activities expand the boundaries of "traditional" education to integrate a range of social actors, policy and decision makers, thereby promoting dialogue and enriching individual perspectives. The aim is to provide professionals with the capacity to understand the overall impact of past, present and future global changes on regional and continental environments, to promote collaboration in multilateral networks and to foster informed action.

To build capacity the IAI's tasks include: to encourage networking between natural and social scientists; to engage small countries and under-represented communities in its activities; to promote outreach to end users, decision makers and planners; and to make complex networks of research and outreach successful and self-sustaining. To address these challenges, the IAI has developed new means of integrating different institutional, programmatic, financial, educational and scientific objectives (IAI, 2007). The IAI has only 13 staff, two of whom are responsible for managing capacity building.

6.3. Summary of strengths, weaknesses, opportunities and threats

The Institute's greatest regional contribution has been its success in building scientific capacity throughout the Americas, in terms both of human resources and institutions, via its research networks, training institutes, workshops, small grants and seed project support. The IAI has trained more than 1 000 scientists and researchers from 46 countries, including all 19 IAI members and 27 non-member countries in the Americas. The mixing of participants from various disciplines and with different backgrounds has proved effective. The AAAS review considered capacity building the IAI's greatest regional contribution, a view confirmed in the interviews, and considered it important to expand the programme in order to involve more people. IAI-supported science has also enhanced the region's contribution to global change research.

A clear strength of the IAI is its well-developed multidisciplinary networks that enable scientists to collaborate at a regional level, to exchange knowledge and experiences and to learn from each other. However, its relations with some members need to be strengthened, enhanced and developed. This may also lead to a more equal distribution of CRN activities among member countries. Participants from all member states should be involved to provide for an equitable regional distribution. Furthermore, the IAI needs the involvement of its members not only in their own countries but also in neighbours that are not members. This may lead to the inclusion of more countries in the IAI and an increase in its reach in the Americas.

On the downside, the policy community remains relatively unaware of the IAI and of the importance of its results. It is therefore important to translate the IAI's progress in science and excellence in scientific capacity building into policy-relevant discourse and action. The IAI has started addressing this gap with new activities such as joint policy-science training seminars and policy briefs specifically aimed at decision makers. Its efforts to link the natural and social sciences to dialogue with decision makers are essential to this endeavour and need to be further developed. The challenge is to support decision-making and inform policy-making, a challenge not only for the IAI, but for countries and institutions around the globe. Although this is difficult, it is essential because the science that the IAI sponsors as an intergovernmental institution does not reach a crucial target of its efforts, government policy makers. By improving its communication with regional scientists and decision makers at multiple levels, and by

enhancing work on the human dimensions of global change research, the IAI will become more relevant to the development and policy needs of the Americas (Swap, 2008, p. 402).

The IAI has the potential to facilitate informed policy action. This means making science available to decision makers and synthesising scientific results in a form that can be understood and used by decision makers, by civil society and by social actors. It needs to strengthen the communication of its results to decision makers and to the public as a whole so as to be in a position to influence discussions usefully and contribute significantly to the region's policy making in the area of global change research. CRN activities and the CRN II synthesis workshop in August 2010 have shown that to use science for informed action requires processing information so that it can be used and anchored in time and space. The biggest challenge for organisations such as the IAI is to be able to present complex findings in an understandable and applicable way.

The IAI promotes full and open exchange of information and data with a view to informed decision making. Researchers should therefore be strongly motivated to insert all their data in the data system, which should also be subject to qualitative monitoring. The IAI's information system requires further development. Data integration, discovery and interconnectivity need to be improved, protocols for data sharing among projects need to be defined, metadata display and visualisation tools need to be developed, and an interdisciplinary thesaurus should be developed.[9] The data system could be made more user-friendly and the shared data, metadata and products could be more accessible for research and education.

Among the specific challenges in regard to the IAI's partnerships are: lack of attendance of country member representatives at the annual Conference meetings, which negatively affects the effectiveness of the IAI's governing body; the need to involve the Scientific Advisory Committee more in the evaluation and review of the scientific outcomes of the projects; a lack of financial and human resources; and the lack of a long-range plan for developing and strengthening partnerships. The Institute could consider extending its partnerships and collaborating more with complementary organisations for joint study of issues such as risk, vulnerability and adaptation. Partnering with other global change research institutions is essential for IAI's strategic partnerships. While the IAI has developed some relationships, there is potential for expanding them. Partnering with complementary inter-American groups and the creation of strategic thematic partnerships, with the aim of attracting additional public and private funders, may lead to additional financing.

The IAI depends on the sustained efforts of member states to meet their commitments, and the flow of adequate resources is critical to the future success of the IAI. A strength of its funding scheme is that the IAI generally deals with just one contact per country in order to receive funding. This contact is also involved in IAI activities and is, therefore, knowledgeable about the IAI. This facilitates funding and requests for support for new programmes. However, funding is a serious challenge for various reasons:

- The disparities between member states' commitments and actual voluntary contributions.
- The fact that not all members have paid their agreed-upon voluntary contributions.
- Limited core resources have made it difficult for the IAI to accomplish some basic functions, such as financing the meetings of the Scientific Advisory Committee.
- The narrow base of consistent (and substantial) resources to support research and capacity building.

The Institute was originally conceived as an institution that would channel funding for science from all of its members. So far this has not happened as planned. With the exception of the United States, all members receive more funding than they provide. Probably the most significant weakness of the IAI is that members have not taken advantage of the Institute as a lean and convenient way to make funds accessible for science in their countries. In particular the IAI Conference needs to address disparities between commitments and actual contributions of member states. As member states are made aware of the IAI's successes in research and capacity building, and as they are also properly recognised for their in-kind support, they may be more inclined to meet their current commitments and perhaps provide additional support (AAAS, 2007, p. 3). It is also important for the IAI to attract more members and to increase its independence through external financing.

6.4. Conclusions

The science of global environmental change has come of age, and there is increased public awareness of its importance. The IAI's capacity-building work has established successful networks of social and natural scientists and institutional and local decision makers which have led to greater willingness to collaborate and share results, techniques and information by social and life scientists and administrators. All this contributes to the IAI's mission, in which the critical point continues to be translating scientific knowledge into informed action. Although the awareness of the IAI among the international policy community is still relatively low, the IAI has developed innovative approaches and activities such as joint policy-science training seminars and policy briefs aimed specifically at decision-makers to successfully close this gap. The efforts to couple natural and social science are critical to this endeavour.

As an intergovernmental organisation the IAI aims to allow scientists and decision makers of countries throughout the Americas to address jointly the critical cross-border issues associated with global change. It is successfully funding and supporting networks of high-quality research under its science programme and building capacity in the region. Indeed, it has relatively high impact in terms of science collaboration yet with limited financial resources for administrative support. However, as the problems associated with the funding and budget illustrate, countries still need to be convinced that the work that the IAI is doing is worthwhile and that it is valuable to all participating countries.

An aspect of the value added that the IAI brings through its science funding programmes is its experience in managing international networks, contracts, administrative problems, etc. It has a comparative advantage in this respect compared to funding agencies that operate in a single country. It has opened up new avenues for scientists by providing them with opportunities to engage in regional exchanges with colleagues from different countries in the Americas. Before the establishment of the IAI, there was no real collaboration on global environmental change between research institutions and universities of different Latin-American countries, as interviewees repeatedly observed. The networks motivate scientists who otherwise work in isolation to interact with one another, South–South and North–South. Their scientific exchanges contribute significantly to regional capacity to deal with global change phenomena. Other international global change organisations and programmes are starting to show increasing interest in linking to and networking with the IAI.

Notes

1. Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, the United States, Uruguay, and Venezuela.
2. Article V.1. of the Agreement establishing the IAI, *www.iai.int/files/communications/publications/ institutional/agree_en.pdf*, accessed 20 October 2011.
3. The IAI Agreement, paragraph XI.1, states that "the Conference of the Parties may invite States outside the region, regional or international intergovernmental organizations, and industries and other nongovernmental and private organizations interested in supporting the Scientific Agenda and programmatic activities of the Institute, to become Associates of the Institute".
4. *www.iai.int/files/communications/publications/institutional/agree_en.pdf*, accessed 20 October 2011.
5. CRN I funded 14 projects for a total of USD 11.5 million. CRN II funds 13 projects for a total of USD 9.6 million. Source: IAI Biannual reports 2004-2006 and 2007-2009, available at *www.iai.int/files/communications/publications/institutional/Biennial_Report_2004_2006_EN.pdf* and *www.iai.int/files/communications/publications/institutional/Biennial_Report_2007_2009_EN.pdf.*
6. The IAI was granted additional funds from Canada's IDRC and from the John D. and Catherine T. MacArthur Foundation.
7. Six projects are being funded under this programme for a total of about USD 800 000 (and two more projects on human dimensions are being supported with additional funds from CRN II). As of October 2010, five of these projects had been extended with NSF funds for another year for a total of about USD 500 000. SGP-HD funding was provided by NSF.
8. Its members are elected for a renewable two-year term by the Executive Council.
9. See the conclusions of the IAI training event in Panama in February 2008, "Training Institute on Information Management: free and open access to, and use of data and information" reported in the *Biennial Report 2007-2009*, *www.iai.int/files/communications/publications/institutional/Biennial_Report_2007_2009_EN.pdf.*

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Chapter 7

International Energy Agency Implementing Agreements

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The International Energy Agency fosters multilateral research collaboration on energy-related issues in a number of ways. Multilateral technology initiatives called implementing agreements are a key aspect of this collaboration. Implementing agreements include IEA member and non-member countries, as well as industry, international organisations and non-governmental organisations. They pursue a broad range of research topics and are financially independent from the IEA Secretariat. They share costs and tasks and are mostly collaborations among actors of equal or nearly equal capacities. A few focus on scaling up capacities in less developed countries.

7.1. Introduction

In 1973 the world faced growing political tensions that would culminate in an oil embargo on the United States and other countries. The urgency of the resulting oil crisis created a new focus on energy efficiency, reduction of energy consumption and alternative energy sources. In the wake of the crisis the OECD established the Energy Co-ordination Group, which met and discussed the terms, scope and activities of the Agreement on an International Energy Programme (IEP), the treaty that formed the basis for the establishment of the International Energy Agency (IEA) in 1974.

The IEA, an intergovernmental organisation, acts as an energy policy advisor to its member countries.[1] Through its work, the IEA supports their efforts to ensure reliable, affordable and clean energy for their citizens. The mandate of the IEA addresses three aspects (the "three E's") of balanced energy policy making: energy security, economic development and environmental protection. The IEA also provides opportunities for exploring alternative sources of energy and energy conservation measures through long-term co-operation, as provided for in the IEP Agreement. This co-operation takes many forms, including through the IEA multilateral technology initiatives, called implementing agreements (IAs), which are the focus of this case study.

IAs are a flexible, demand-driven mechanism that provide a legal framework whereby IEA and OECD member and non-member countries, businesses, industries, international organisations and non-governmental organisations may share, on an equitable basis, the costs and benefits of collaboration and work together to carry out programmes and projects on energy technology research, development and deployment. The work consists of technology-related research and other activities, including policy work that supports the "three E's".

To date, IA activities typically include one, or a combination of, the following: scientist exchanges, information exchange on research results and programmes, database development, basic and applied research, technology development and pilot plants, technology assessment, feasibility studies, market analysis, environmental impact studies, expert networks, and modelling and systems analysis (IEA, 2010, p. 97).

The themes of IEA IAs have evolved over the decades. In the 1970s they focused primarily on fossil fuels (oil and coal) and industry activities. In the 1980s, the focus moved to energy conservation and renewable energy sources. In the 1990s, it became the reduction of greenhouse gas emissions, demand-side management[2] and technology transfer. As an indicator of more recent trends, the three most recently created IEA IAs were Electricity Networks Analysis, Research & Development, established in 2006, Efficient Electrical End-Use Equipment, established in 2009, and the International Smart Grid Action Network, established in 2011. Talks are currently under way to establish an IA focused on offshore oil and gas exploration and production.

As of July 2011, there were 42 IAs covering five areas: cross-cutting activities (research database, modelling, technology transfer); end-use technologies (buildings, electricity, industry, transport); fossil fuels; fusion power; and renewable energies and hydrogen. This case study reviews at least one IA in each of the five areas. Some are composed primarily of industry participants while others are comprised mainly of academics and researchers.

IAs work towards solutions to global challenges by carrying out joint research and development (R&D) for the efficient use of existing energy sources, exploring new energy technologies and processes, and reducing greenhouse gas emissions in supply and end-use sectors. Others contribute to topics such as technology transfer and capacity building. New IAs are often created to meet technology and innovation research needs, and as general support for a given topic. As such, the main objectives and mission statement of individual agreements are constantly adapted to current scenarios.

This case study offers several key lessons regarding the governance of international research collaboration to address global challenges. They centre upon the following themes: multi-tiered autonomy and feedback processes; the dynamic networks within the IEA IA collaborative structure that link IAs with one another, where appropriate, and facilitate the exchange of expertise between them and the IEA Secretariat; the challenge of communication and outreach; the challenge of including international research programmes in national agenda and priority setting; and strategic tools for maintaining flexible operations to respond to arising changes and research needs in the global energy landscape.

7.2. Main characteristics of the overall governance model

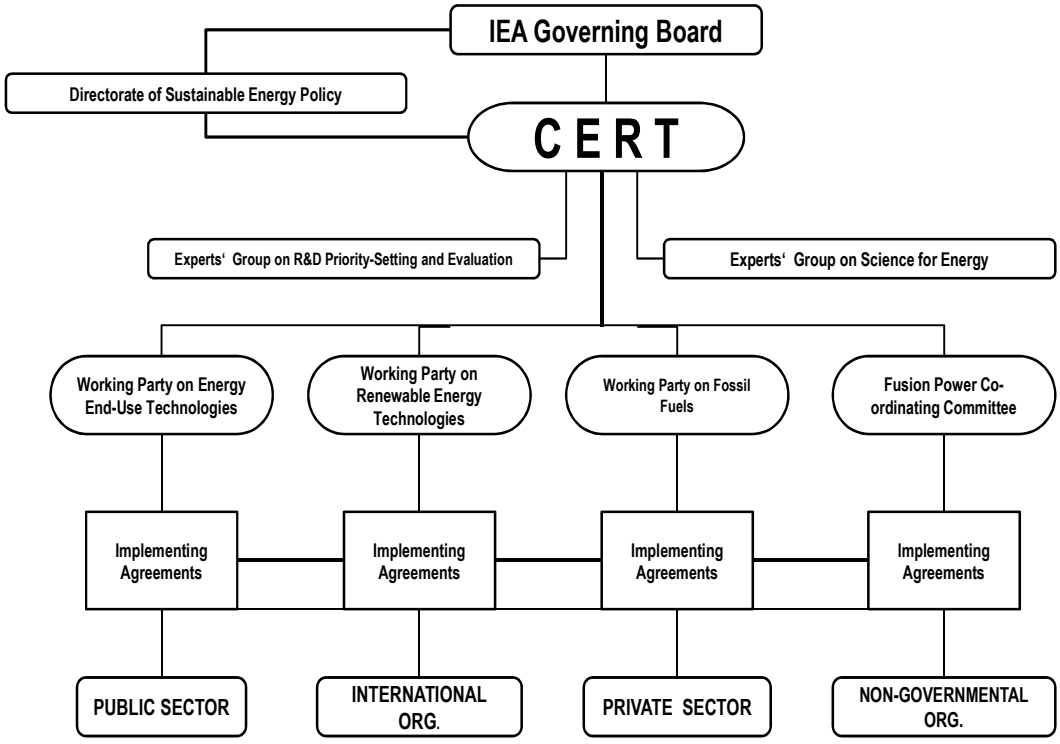
The IEA Framework for International Energy Technology Co-operation ("the Framework") outlines the general principles for IAs (mandate and nature) and applicable rules (participation, admissions, withdrawal, length of term, intellectual property, responsibilities of the Executive Committee, copyright, and reports to the IEA). However, each IA is operationally and financially independent from the IEA Secretariat.

IAs are established in response to the participants' needs. Therefore, their structure, funding and other aspects of the research projects may vary widely (Scott, 1994, p. 266). The IEA Secretariat provides them with ongoing advice, administrative support, visibility through a dedicated newsletter and publication, outreach opportunities, and links to Secretariat analysis and legal support through the IEA legal department. The Secretariat also serves as a link between policy makers and IAs.

IAs are the core of a senior expert network, the IEA Energy Technology Network, made up of the IEA Committee on Energy Research and Technology (CERT), the four IEA working parties and two expert groups. Figure 7.1 illustrates the governance structure of the network.

Three main groups of actors at the IEA Secretariat are involved in the oversight and co-ordination of, and/or contribution to, IA efforts. They are: the IEA Governing Board, the CERT and the IEA working parties. The Governing Board is the supreme governing body of the IEA. The CERT is the standing committee with IA oversight responsibility. It also co-ordinates and promotes the development, demonstration and deployment of technology to meet energy-sector challenges, and enables experts from across the globe to co-operate and share results.

Figure 7.1. Organisation chart of the IEA Energy Technology Network



Source: IEA (2010), p. 13.

Each IA reports to one of the four working parties,[3] depending on the research focus (*i.e.* fossil fuels, fusion power and renewable energy). Along with providing advice to the IEA, the working parties serve as a valuable link to connect IAs with complementary work programmes to one another. The CERT and the working parties also collaborate with IAs in cross-cutting discussions. In addition, expert groups provide advice on topics including R&D priority setting, evaluation and basic science research for energy.

One of the key roles of the IEA CERT is "to provide leadership by guiding these groups to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed" (IEA, 2010, p. 12). The CERT and the working parties review the accomplishments of IAs during the request for extension process, which occurs every five years for each IA.

Through this process, IA activities are evaluated by the CERT, together with recommendations from the respective working party, to determine whether it should continue (Scott, 1994, p. 281). This review includes an end-of-term report and strategy plan which must be submitted by each IA. IA participants note the value of this process for their own stock-taking during the preparation of these reports, which typically starts approximately two years before they are due for submission to IEA headquarters. The IEA CERT also carries out an *ex post* evaluation of each IA using the following criteria:

- Strategic direction.
- Scope.
- Contractual and management requirements.
- Technology evolution/progress.
- Technology deployment/market facilitation.
- Environmental protection.
- Information dissemination.
- Policy relevance.
- Outreach to IEA non-members.
- Added value.

The Directorate of Sustainable Energy Policy and Technology and its Technology Network Unit, the Renewable Energy Division in the Directorate of Energy Markets and Security, and the Office of Legal Counsel also provide guidance, analysis and support to IAs. Furthermore, countries participating in IAs also participate in national co-ordination efforts through many bodies and methods.

All IAs have an Executive Committee, a board of directors from each of the IA participants that supervises the projects and activities. Directed projects in which IA participants elect to participate (referred to as annexes, or tasks) may involve all or some Executive Committee participants; they are carried out separately, often with separate governance, though the Executive Committee is responsible for overall approval (IEA, 2010, p. 102). The proposed structure, activities and operation of IAs are laid out in the text of their implementing agreement. In addition, tasks have an agreement text in which operational and governance aspects are addressed.

Box 7.1. The creation of an implementing agreement

The International Smart Grid Action Network (ISGAN) can serve as an example of how an IA is created to respond to a high-level initiative.

April 2009. The ISGAN IA is initiated indirectly via a request on behalf of the Major Economies Forum in the L'Aquila for Technology Action Plans for ten climate-related technologies identified by the IEA to address more than 80% of CO_2 emissions from the energy sector. One of the technologies identified by the IEA is smart grids.

December 2009. The Technology Action Plan on Smart Grids is approved by the Major Economies Forum at a meeting in Copenhagen. It contains recommendations for the successful deployment of smart grids, including the creation of a global smart grids partnership.

July 2010. ISGAN is officially launched in Washington, DC, at the first Clean Energy Ministerial. Participating governments are: Australia, Belgium, Canada, the People's Republic of China, the European Commission, France, India, Italy, Japan, Korea, Mexico, Norway, Sweden, the United Kingdom and the United States. The United States pledges USD 4 million to assist with the launch of ISGAN.

November 2010. Ten governments and the IEA meet in Jeju Island, Republic of Korea, to drive forward the ISGAN IA, and reach agreement to commence work on initial projects.

April 2011. The ISGAN Implementing Agreement is signed by participating countries at the second Clean Energy Ministerial in Abu Dhabi.

As of *July 2011*, the work of the ISGAN IA is carried out by the ISGAN Contracting Parties (all original signatories in July 2010 plus Germany and Russia) in five topic areas: policy, standards and regulation; finance and business models; technology and systems development; user and consumer engagement; and workforce, skills and knowledge. The interim ISGAN Secretariat is hosted at the Korean Smart Grid Institute.

Each IA Executive Committee must approve new IA participants, called contracting parties. Countries participating in IEA IAs may designate government departments, research laboratories and industry representatives to represent them on the IA Executive Committee. As of 2003, IEA non-member industrial entities may participate in IAs as sponsors. Sponsors are defined by the IEA as a "participant in an IA which is an entity in a country that is not designated by the government of that country to participate in an IA or a non-intergovernmental international entity in which one or more countries participate".

Most sponsors participate in IAs on fossil fuels or renewable energies (IEA, 2010, pp. 103, 87). Contracting parties from IEA member or non-member countries and sponsors have equitable rights and obligations, except that sponsors cannot be elected chair or vice-chair. The changes in the IEA IA structure that allowed the admission of sponsors from IEA non-member countries had their source at the IA level and responded to the need of IAs to include entities from IEA non-member countries in their work.

Industry involvement reaches back almost to the first IAs. The first was created in 1975, and in 1977 companies began participating. In 1979, the first company (the Austrian oil company OMV) was designated to represent the country's national government. The private sector continues to be involved in a number of IEA IAs, primarily those focusing on fossil fuels or renewable energies.

In addition to the minimum rules and regulations stipulated in the IEA Framework, each IA may have more explicit or restrictive rules. For example, they may determine the types of participation available to private-sector participants; in general, industry may have a position on the Executive Committee. As IA participants have noted, industry involvement presents both potential advantages and drawbacks in relation to agenda and priority setting. They most often note as positive the diversity it brings to groups primarily composed of government organisations and research institutes. At the same time, companies have their own agenda which they may attempt to realise through the work programme; this may conflict in particular with the interests of other private-sector participants and thus potentially affect the effectiveness and efficiency of an IA. However, as participants have noted, when these challenges are balanced, private-sector participants, and the information and experience they bring, are a source of value.[4]

Apart from direct private-sector involvement, IAs also seek industry input and partnerships. These informal communications have been mentioned as perhaps the most important form of industrial input to IAs. Industry can provide input by providing data, or by identifying applications and guiding research, depending upon the focus of the IA (IEA, 2010, pp. 24-26).

The two key roles in IAs are the leader or federator (chair) and the executive (secretary at the IA level, or operating agent at the task level). Executive Committee chairs (and vice-chairs) are elected by majority vote on a rotating basis, or chosen from volunteers. Apart from one or two exceptional cases in which a chair carries out this function on a full-time basis as an in-kind contribution from one of the contracting parties, the responsibilities of Executive Committee chairs and vice chairs are in addition to their responsibilities in their own organisations.

As demonstrated by ISGAN and other IAs, IAs may elect to have a secretariat. This may be funded by IA member contributions, or the work may be donated in kind by a member. If a secretariat is established, it may take on the broader administrative work of the IA and be responsible for the organisation of IA conferences, fund collection and disbursement, and other activities. It may be an office in which only IA participants work,

or it may be a person who carries out work for the IA in tandem with other professional responsibilities (for example, a staff member from a national research organisation). IA secretaries or IA task operating agents may be paid to carry out their functions or responsibilities in addition to their responsibilities in their own organisations. Their tasks are largely administrative. The balance between the leadership and the executive depends on each IA. In some cases the chair serves as the "visible" leader while the operating agent is in effect the leader or manager of the group.

For each IA, collaboration may be formal or informal. The latter has been found to create more meaningful, long-term relationships that serve to form the basis for a broader network and for building the participants' capacity over time. Some IA participants credit the strong degree of collegiality and informality within their IA for its success, including the establishment of exchange programmes between national laboratories. Continuity of Executive Committee members also helps to foster collegiality and to build strong, long-term networks that assist in IA work, in building networks beyond the IA and in fostering the retention of institutional memory.

IAs may be dissolved at the request of the participants, or in extreme situations, of mismanagement at the behest of the IEA (to date this has not been necessary). A new IA may be created at any time, provided at least two IEA members agree to collaborate, and provided the CERT and the IEA Governing Board give their approval.

Agenda and priority setting

Agenda and priority setting at the IA level occurs primarily at the Executive Committee among all participants. Executive Committee meetings typically occur semi-annually; IA participants consider this the right frequency, as more meetings could be difficult to manage and fewer could create gaps in the decision-making process, depending upon the scope of the IA.[5] Executive Committee meetings include status reports on ongoing projects, discussion and decision on new projects, financial reports and outreach efforts. The IA Executive Committee votes on proposed projects, and if they are approved, IA members may choose to participate. Decision making, agenda and priority setting takes place at the level of the projects, although reports to the IA Executive Committee are required.

Box 7.2. Agenda and priority setting from the bottom up

Agenda and priority setting can also take place in IAs from the bottom up, as the Clean Coal Centre (CCC) IA demonstrates. Each year, all members and staff of the CCC IA are requested to submit key topics for inclusion in the work programme of the coming year, along with a brief explanation. Once the proposals are assembled, they are distributed to all members and staff, who are asked to rank them using a Likert-type scale (in this case, 0-5) according to their perceived relevance and importance for the work programme. The leading topics following this ranking are then submitted to the CCC IA Executive Committee for review and discussion. Through this process, major trends are recognised and projects are selected for inclusion in the coming work programme.

This CCC IA has found this process beneficial, particularly because of the expertise and diversity of experience of those submitting the suggestions. It is also a useful way to engage a large number of stakeholders in the agenda and priority setting process and benefits the development of the work programme and definition of strategic goals.

IAs use a strategic plan to co-ordinate their efforts, align goals, funding and other resources, and to identify priority areas and activities. As the Bioenergy IA[6] and others have demonstrated, a strategic plan can be especially valuable when it can be amended as necessary to reflect the changing needs and aspirations of IA participants. A strategic plan may include communication plans, or a communication plan may be separately drafted. IA participants have frequently noted the value of a communication plan when it exists, or the need for one if it is lacking. IA participants find effective communication to be a key determinant of the inclusion of IA research in national agenda and priority setting.

The inclusion of IA work and priorities in national agenda and priority setting was identified during interviews with IA participants as a basis for consistent and quality IA membership and as necessary for effective collaboration. When IAs are not included in national priorities, challenges to participation may be encountered, including, but not limited to, denial of leave or travel funds to attend Executive Committee meetings and other IA-related events, lack of continuity in Executive Committee membership (and potentially in organisational memory), and lack of funding for IA initiatives.

At the national level, countries may hold regular co-ordination meetings among all the participants in the IEA Energy Technology Network (CERT, working parties, *ad hoc* and expert groups and IAs). These provide a forum for interaction and collaboration among participants on other projects as well. Some national co-ordination groups include representatives from government agencies, national laboratories, research institutions, universities, and industry. These activities are most beneficial when the volume of work and time frame warrant the effort required to assemble the team and when "there is a critical need to share information with industry" (Evans, 2008, pp. 5-6). Industry associations also serve an important role in communicating industry priorities to IAs.

Funding and spending

IAs operate under a cost- or task-sharing scheme, or some combination of both. Task sharing (in-kind contributions) is most appropriate for the IAs that are largely academic in scope: those on a highly specialised topic with limited resources (29% of IAs). Cost-sharing (34% of IAs) is more appropriate for IAs with a more professional scope: a broad range of projects, visible outcomes, large membership and significant resources. Other IAs may choose a combination system (37% of IAs), for example contributing to a common fund to cover costs of administering the IA, while annexes and tasks may be carried out on an in-kind basis. As the scope of an IA's activities develops, its funding regime may change.

For IAs that are task-sharing, the IA has only indirect links with funding, as the funding comes from hosting countries, each with its various means and schemes for funding the research. The IA serves as an opportunity to share and to build research projects and shape priorities co-operatively. It helps, for example, in the elaboration and promotion of successful research plans, funding mechanisms and exchange of scientists.

In cost-sharing IAs, there are various methods of determining financial contributions (*e.g.* based on gross domestic product [GDP] or ratio of research and development [R&D] expenditures to GDP). Tasks may also require separate financial contributions from participants. For IAs that establish a common fund, audits and other oversight reviews of financial integrity are provided for (Scott, 1994, p. 267). When a cost-sharing structure prevails, funds may also be distributed among tasks, sometimes with individual accounts.

Task fund contributions may also allow for the creation of strategic funding mechanisms that can adapt to changing research needs. For example, to respond swiftly to emerging research needs, the Bioenergy IA created a strategic fund, equal to 10% of all annual financial contributions to the Bioenergy IA tasks. Funds may be disbursed to address strategic projects of the Executive Committee, thereby enabling the Bioenergy IA to respond to arising research needs. The Bioenergy IA Executive Committee must approve disbursement of these funds, which, like all IA Bioenergy funds, are managed by the secretary.

An evaluation carried out by the United States Department of Energy noted the value of IAs from a cost perspective: "In the absence of such a framework, the transaction costs associated with the start-up of international collaborative projects can easily be prohibitive" (Evans, 2008, p. 3). For example, the costs to a single country of constructing pilot plant facilities can be significantly reduced. In the Wind IA,[7] five laboratories in four countries tested the aerodynamics of wind turbines for a total estimated cost of USD 2-4 million. It was estimated that the cost to each participant country acting alone would have been USD 3 million (for a total combined expenditure of more than USD 40 million). In addition, data collection carried out in parallel with a variety of wind and atmospheric conditions that were not readily available to individual countries accelerated the progress of the research (IEA, 1999, p. 13).

The improved rate of technological progress along with the increased flow of information resulting from IA activities and the networks created thereby are added benefits (IEA, 1999, pp. 7, 13). Economies of scale may also be realised through IA collaboration, while at the same time allowing participants to capitalise on the diversity of expertise of their peers.

Some IAs receive income and may even become self-sustaining from revenue received for example from conferences, licensing databases and models, or publication sales. Still, IA participants noted that most barriers to collaboration have to do with funding, particularly at this time in the wake of a financial crisis.

IA participants and IA secretaries or operating agents have noted the problem of late or even non-submission of membership fees. Given that there is no mechanism to compel payment, this is a significant challenge. The Clean Coal Centre IA has a useful mechanism with which to address this potential issue. It requires all new IA entrants to submit a one-off payment equivalent to 50% of the annual fee for the contracting party in question (this payment is not required from sponsors). The funds from this one-off payment can be used by the operating agent to offset the late submission of IA subscription payments. This payment is refundable if the participant withdraws from the IA.

Intellectual property

According to Framework Article 2.2, participation in an IA is to be based on equitable sharing of obligations, contributions, rights and benefits. This includes anything that results from the collaboration, including what is considered intellectual property. Patents resulting from work may be filed in countries as appropriate by the inventing participant, and participants may be required not to disclose information related to these patents for a fixed period. OECD members are encouraged by the IA operating agent to make available all confidential information relevant to the task.

As Philibert (2004, p. 28) notes, no "unique set of provisions" exist for addressing intellectual property in IAs, other than for the protection of the IEA copyright. Treatment of intellectual property is left to the IAs to formulate and varies among IAs and within IA tasks. Many agreements prohibit participants that publish information resulting from their IA work to profit from such publication.

IAs may define specific clauses with regard to intellectual property, particularly as a technology progresses from applied research to deployment, or when industrial partners show interest in the technology. In collaborations on near-commercial processes and products intellectual property tends to become more of an issue (Evans, 2008, p. 3; Tirpak, 2009, p. 13). IA participants also noted that the closer a technology is to market deployment, the greater the likelihood of IP being or becoming an issue. A US Department of Energy study noted that IAs play particularly important roles for projects that are "less likely to yield proprietary intellectual property" (Evans, 2008, p. 3).

In the Bioenergy IA, each participant and operating agent is responsible for identifying which information is proprietary and ensuring it is appropriately indicated. The task operating agent has the responsibility of deciding the relevant issues and informing the Executive Committee. Each participant in a task holds the copyright for its own work. As a result the intellectual property guidelines are well tailored to the needs of the specific task, with the result that very few problems arise. There lesson here is the need to adjust the framework to each situation, including the IA's specific work programme (tasks) as necessary.

Bridging research and practice

Since their start in 1975, IEA IAs have carried out over 1 200 programmes (not including subtasks within projects, conferences, seminars and technical workshops). These projects have advanced technology development and deployment, including basic and applied research, scientist exchanges, specialised networks, pilot and demonstration plants, summer schools, feasibility studies, guidebooks, databases, models, toolkits, technology transfer, project finance, capacity building, conferences and patent development.

Some IAs have engaged directly in demonstration and deployment. In 1975, the Implementing Agreement for a Project for Fluidized Coal Combustion was created for the sole purpose of building a demonstration plant. The project had four stages: procurement of design; tendering for construction of the plant; construction and acceptance; and plant operation. The three participants (Germany, the United Kingdom and the United States), shared the total cost of the project equally (GBP 11.1 million in 1975 prices). In another concrete illustration of the deployment of IA research, the Multiphase Flow Sciences IA[8] led to the development and patenting of new non-invasive probes that measure the concentration and velocity of solids near the wall of industrial facilities at temperatures up to 1 000°C (IEA, 1999, p. 24).

Box 7.3. Private-sector involvement in IEA implementing agreements

The private sector is a vital bridge from IA research to practice. While IA membership consists primarily of governmental and academic entities with significant capabilities in research and policy making, their capacities in terms of market deployment are often much less developed. The private sector therefore provides an important bridge in this regard. While industry also brings with it significant research capacities, an important benefit of industry involvement in IAs is its proximity to the market and its related knowledge and experience. It can identify what is needed from a research perspective in terms of innovation and how to deploy the research output.

This has many positive aspects in terms of bridging research and practice: greater knowledge about market needs and conditions, the needs of industry in terms of harmonised IPR frameworks, benchmarking and standards, and a greater ability to facilitate market deployment, including into new market areas (by theme and region). Many industry participants hail from IEA non-member countries and bring further elements of diversity and potential points of entry into new markets and governments.

The networks that IAs have and create with the private sector play an important role in identifying research gaps, accelerating knowledge sharing and gaining access to IEA non-member governments and markets alike.

Industry and the private sector are an important element in the linking of research, technology and practice/policy in IEA IAs (Box 7.3). The translation of IA research into practice is also aided by linkages with the IEA Secretariat and other international organisations and national governments, particularly when they serve on IA Executive Committees. Through these frameworks, IAs have a direct line to the policy-making arena and their research gains more opportunities to be translated into practice as a result of policy. The IEA Secretariat fosters collaboration and communication among IAs by hosting co-ordination meetings for different end-use sectors: buildings, electricity, industry and transport. These not only provide opportunities for the IAs in a given area to exchange best practice and learn of new research topics, they also offer a venue for IEA experts to present current projects and recent results. The CERT also regularly holds cross-cutting and thematic discussions, on topics such as smart grids or energy storage, in which relevant IEA energy technology network participants are invited to take an active role.

It is vital to effectively communicate IA results and interests to policy makers. IA participants noted that this could be particularly difficult to co-ordinate in view of the demands of existing research programmes and the lack of expertise among IA members in the area of communications. To improve communication, some IAs have created national teams or scheduled regular meetings to address communication and co-ordination issues at the national level. This has proved useful. At the IA level, a position (such as a technical co-ordinator) responsible for co-ordinating IA activities but also outreach has proven beneficial. For example, the Bioenergy IA has instituted a technical co-ordinator, a paid position with responsibility for co-ordinating multi-task initiatives in order to improve the momentum of policy-relevant outputs. The technical co-ordinator is also expected to initiate and plan strategic Executive Committee workshops, strengthen relationships with other IAs and ensure timely communication with external stakeholders including IEA Headquarters. The position has been successful and the number of policy-relevant outputs has increased significantly. Finally, the IEA Secretariat makes IA work known through the IEA website, dedicated publications (Energy Technology Initiatives), a dedicated newsletter (OPEN Bulletin), analytical works such as Energy Technology Perspectives, and by participating in the consultation process and design of IEA Energy Technology Roadmaps.

IAs also feed into other large international research undertakings. As an example, the IAs concerned with fusion, such as the Reversed Field Pinches (RFP) IA, collaborate with the International Thermonuclear Experimental Reactor (ITER), a multi-national, multi-billion euro pilot programme aiming to deliver ten times the power it consumes through fusion energy. Because of complementarities in these two research initiatives, the work of the RFP IA is able to benefit that of ITER.[9] To this end, the RFP collaborates with ITER and contributes to its success in various ways, including through interaction between ITER and RFP scientists and management to communicate the needs of ITER; design and organisation RFP scientific work programmes to take account of ITER needs; execution of experiments, in which output is directly or indirectly interesting for ITER; the development of models that address physics problems relevant to ITER; and exchange of personnel and common experiments with existing devices on topics of relevance to ITER.

Capacity building and technology transfer

For many IAs, capacity building comes as a result of collaboration, rather than a goal. According to the IEA Framework, all IA participants (countries, companies[10] and international organisations) have equitable rights and obligations. This implies that each participant should gain as much as they contribute to the collaboration. For cost-shared IAs, countries outside the OECD region able to pay the membership fees therefore stand to increase their national research capacities and knowledge base. For task-sharing IAs this poses more of a problem, as it depends on the magnitude and sophistication of national research capabilities.

IAs must find an appropriate balance between robust research portfolios and knowledge sharing/capacity building. IA participation is based on mutual agreement. For example, the Bioenergy IA chooses prospective participants based on their capacity (financial, operational and institutional R&D) to contribute actively to the work of the tasks. This serves to maintain a broad portfolio of tasks with significant results. By engaging a large number of participants in tasks that involve government departments, research institutions, universities and industry, IAs create a network that facilitates technology transfer. Meetings, workshops, online exchanges and numerous other media and events arranged according to tasks contribute to a useful exchange with stakeholders.

Three IAs specifically concern technology transfer and capacity building: the Energy Technology Data Exchange (ETDE IA),[11] the Energy Technology Systems Analysis Programme[12] (ETSAP IA), and the Climate Technology Initiative (CTI) IA (Box 7.4). The goal of the ETDE IA is to provide governments and industry with energy-related scientific, technical and policy research literature through an online database on energy research and technology information. The ETDE IA provides free access to some 80 countries outside the OECD region.

Universities also play an important role in the work of IAs. For example, all of the experiments of the Reversed Field Pinches IA take place in a university environment. One noted benefit is the guarantee of a continuous influx of students. This gives IA member laboratories an important role as “nurseries” for international fusion research by cultivating future generations of researchers in the field.

Box 7.4. When capacity building is the goal of collaboration

Capacity building is a goal of the CTI IA which carries out technology needs assessments and hosts the Private Financing Advisory Network (PFAN), among other activities. Technology needs assessments are country-driven initiatives that provide technical assistance to selected countries in partnership with multilateral organisations and the private sector, identifying priority technology sectors and connecting key country stakeholders to develop a strategy for advancing technology transfer at a national level. PFAN, which was launched in co-operation with the United Nations Framework Convention on Climate Change Expert Group on Technology Transfer in 2006, assists project developers in IEA non-member countries in the development, planning, finance and implementation of small- and medium-sized environmentally sound projects.

PFAN work is carried out through project financing and regional workshops that provide opportunities for project developers in emerging economies to meet with potential financiers. Projects are selected for PFAN assistance on the following criteria: competent management, technical and economic viability, sustainability, environmental benefits, social responsibility, and ability to contribute to a reduction in greenhouse gas emissions. Once selected, they are provided with advice and guidance, technical assistance, and investor matching. PFAN has been instrumental in facilitating the financing of technology transfer. Founded in 2006, PFAN has already achieved over USD 200 million in project financing and leveraged a total of USD 283 million in financing for 23 projects which will lead to an installed clean energy generation capacity of some 250 MW, an annual reduction of greenhouse gases of ca. 1.6 million tonnes of CO_2 and annual energy savings of 61.3 GW hours (CTI, 2010).

The ETSAP IA aims to assist decision makers in assessing energy technologies and policies to meet the challenges of energy supply, economic development and greenhouse gas (GHG) mitigation through the development of numerical modelling systems (MARKAL and TIMES) that analyse energy, economic, and environmental issues. These models are used by more than 250 groups in 70 countries. Eighteen countries plus the European Commission participate in the ETSAP IA, which regularly hosts workshops to engage with non-member countries.

Given that approximately half of global energy consumption occurs in IEA non-member countries, outreach to IEA non-member countries is particularly important. It is ensured in many ways. For example, the IEA Secretariat hosts multilateral technical-level meetings at which energy experts from energy-producing and consuming countries are able to meet to foster understanding and communication. Seminars and workshops on topics such as energy efficiency and regulatory issues in non-member countries are also a means of outreach. IEA working party meetings are also held in non-member countries to increase engagement. As an example, the IEA Working Party on Fossil Fuels has two meetings a year, one of which is held in a non-member country. IAs also engage in outreach to non-member countries. While they may do so independently, IAs frequently make use of existing IEA outreach initiatives to extend networks among IEA member and non-member countries.

In addition, the CERT has established the Networks of Expertise in Energy Technology (NEET) initiative, which was designed to build on the existing IEA Energy Technology Network by linking IA experts with policy makers, researchers and other stakeholders in IEA non-member countries. The aim of the programme has been to enhance awareness of existing research, development and deployment networks and to facilitate broader participation and collaboration between the IEA Energy Technology Network and Brazil, China, India, Mexico, Russia, South Africa and other key IEA non-member countries. Four recent NEET workshops – in Singapore, Kazakhstan, South Africa, and Mexico – and one in preparation in China in 2012 – have supported the increased integration of non-member countries in the IEA Energy Technology Network and have strengthened collaboration between developed and developing country participants in existing networks.

The Clean Coal Centre IA is an example of successful outreach to IEA non-member countries. Thanks in part to the structures of the IEA Secretariat, it has been able to include a number of non-member countries in its work. These include: Anglo American Coal (represented by their South Africa operation), the Beijing Research Institute of Coal Chemistry (China), Banpu (Thailand), the Siberian Energy Coal Company (Russia), Bharat Heavy Electricals Limited (India), Eletrobras (Brazil), and Eskom (South Africa), which is now the contracting party representing South Africa. The CCC IA reduces membership fees for IEA non-member countries according to their GDP at purchasing power parity. This reduces their annual subscription and can lower potential barriers to participation.

Participation in IAs by IEA non-member countries, particularly the BRICS countries (Brazil, Russia, India, China and South Africa) has increased significantly in recent years and currently represents 10% of total government participation in IAs. India, a participant in the Demand Side Management Implementing Agreement,[13] not only participates but is the first IEA non-member country to be a project leader. After joining the IA, India proposed an energy-efficiency branding project which became Annex 20. The participants, including the United States, are sharing information from their experience with similar work with India and providing funding and country experts for this project.

7.3. Overall assessment, strengths and weaknesses

Originally designed as government-led initiatives, IAs have grown to include a diverse array of participants. By responding to external requests (*i.e.* G8 declarations) or IA needs (*i.e.* the inclusion of sponsors from non-member countries), the IA framework has been able to address challenges facing policy makers and the energy industry alike.

IA participants note the value of this established and flexible framework, and new initiatives (*e.g.* ISGAN) adopt it in recognition of its strengths for the co-ordination of international projects. A major strength of the IA framework is the multi-tiered autonomy it provides from the proposal of an IA to its dissolution. Within the IA, this flexibility is provided for, to varying degrees, in annexes and tasks.

A balance to this autonomy is ensured by feedback and accountability mechanisms at all levels. An example is the required progress reports to the IEA Secretariat at the IA level, and to the IA Executive Committee at the IA annex and task level. These reviews not only provide feedback to IAs regarding project work, they also assist in reviewing the governance dimensions and in identifying future strategic research paths, taking advantage of energy policy expertise at the IEA Secretariat. At the IA level, thorough Executive Committee evaluations of membership applications and proposed and ongoing projects are essential to ensuring beneficial and efficient growth.

Research carried out in IAs is often made directly available to policy makers, and is often incorporated into the policy arena. IAs also provide a basis for data and research to flagship IEA publications (*World Energy Outlook* and *Energy Technology Perspectives*), as well as the IEA technology roadmaps, and many other efforts. They feed into all aspects of IEA work. Many IA participants also take part in technology platforms of the European Commission, as well as specialised international networks.

One of the greatest strengths of IAs is the multitude of networks created among them. Not only does a new network come into being with the creation of an IA, networks are further linked through the IEA working party structure. This helps IAs to capitalise on other knowledge bases, and at the same time to avoid costly duplication and/or overlap. These interwoven networks help to make knowledge transfer more dynamic and timely and thus better co-ordinate efforts and respond to shifts in global challenges.

Other global initiatives (*e.g.* the Global Environment Facility), have identified the lack of private-sector mobilisation as a key challenge to successful implementation (Porter *et al.*, 2008). Many IAs have successfully addressed this issue by involving the private sector and weaving it directly into their efforts.

In addition, IAs have initiated a combination of specific positions and mechanisms to ensure efficiency, strategic sensitivity and communication. Their value has been demonstrated and includes:

- *Secretariat.* Whether funded by IA contracting parties or provided in kind, a secretariat can greatly assist in IA administration (including the provision of legal advice) and thus allow researchers to focus on research. Interviewees mentioned as a potential weakness that a power imbalance in research planning may arise if IA contracting parties fail to take initiative in this respect and the secretariat does so instead.
- *Technical co-ordinator.* A position in which a person with a strong background in the field of research conducted by the IA co-ordinates IA research efforts and communicates both within and outside of the IA its research agendas and outcomes. As demonstrated by the Bioenergy IA and others, this position is a key aspect of effective communication and knowledge transfer.
- *Strategic plan.* Required by the request for extension process reviewed by the IEA CERT, this provides a useful roadmap for IA activities and funding. Furthermore, if the strategic plan can be amended as necessary, it will be more responsive to the changing nature of global challenges. It can also be useful to dedicate time at each Executive Committee meeting to address issues of a strategic nature.
- *Strategic fund.* This may be a percentage or fixed amount of existing funding that is set aside and able to be directed to projects as needed, providing the ability to adjust quickly to changes in policy and technology needs. This has very high potential value as the IA is not required to re-work existing finance structures.
- *Communication plan.* Like the strategic plan, this can help to co-ordinate efforts and set clear goals and means with which to achieve them. Given the challenge of communication noted by IA participants, it can be of great value.
- *National team/task leaders.* These serve the important function of communicating IA projects to potential stakeholders at the national level and co-ordinating work among existing participants. This can be especially useful in ensuring alignment of IA activities with national priorities and accountability.

Interviewees mentioned a number of challenges to effective collaboration, including:

- Communication and priority setting at the national level, within the scientific community and with the broader public. A possible means of addressing this challenge could be the inclusion in IAs of a specific task focused on communication and outreach.
- Maintaining stable leadership and representation among IA participants, an issue closely linked to communication efforts and priority setting at the national level. This is important for building a strong foundation for long-term, effective collaborative networks and the maintenance of institutional memory.
- Balancing long-term planning with the need to be responsive to the changing nature of global challenges. IAs deal with the refinement of existing technologies and, as such, are long-standing. They need to remain aware of the changing circumstances in their area of research and be flexible. Some interviewees noted that while flexibility in IA funding and spending mechanisms allows IAs to be more responsive, it may also introduce an element of unpredictability.
- The need for the right mix of actors at the policy and operational level, in the science community and in the private sector. It is important to have a broad range of participants but still maintain a "lean" and efficient bureaucratic process.
- Insufficient capacity building and outreach to developing and emerging economies. Efforts are being made by various IAs to make their work known and available to developing countries.

These challenges are not unique to IEA IAs, of course, but shared to some degree by various other international collaborative initiatives.

7.4. Conclusions and lessons learned

The urgency of linking research and practice, and the need for a science-policy interface, call for responsive collaborative frameworks in which actors at all levels share the burden and benefit of research collaboration to address global challenges. The IA framework has proven adept at co-ordinating international research on specific topics in the energy industry. The multi-tiered autonomy afforded by this demand-driven structure allows for a tailored approach to research collaboration that is able to respond to arising needs and reduce transaction costs.

At the IEA Secretariat and the IA levels, attention to strategic needs and to input from policy makers, industry and end users helps to ensure relevant work programmes. The continual feedback loop with the IEA Secretariat, especially with the CERT, helps IAs to develop and evolve. It also helps to ensure policy relevance and a policy interface with the IEA and through the IAs with government bodies, especially when they are contracting parties.

The creation and strengthening of networks through IAs and through the Secretariat is a major benefit of collaboration. Broader technology and policy networks are formed within the IAs, through the broader IA community, and particularly through IEA Secretariat structures (*i.e.* working parties), the production of publications, events including expert workshops and cross-cutting discussions. This helps to ensure capitalisation on existing knowledge, while avoiding costly duplication.

IAs have continually attracted top capabilities to address key global challenges through collaborative – largely technical and scientific – research. While challenges arise, they are likely to be detected early through the feedback process. Most challenges are related to communication and administration rather than to more substantive concerns. Nonetheless, they can greatly affect agenda and priority setting at the national level, and thus the quality of IA participation and funding.

Budgeting and other resource planning mechanisms cover costs directly related to research but mechanisms for effective communication are often lacking. It may be useful to dedicate resources to this area where feasible, possibly by including communication and outreach as a particular work programme or task within IAs. Where appropriate, it may be useful for the IEA Secretariat to arrange workshops for IAs on the topic of science communication.

The IEA CERT includes outreach to non-member countries as a criterion in its evaluation of each IA. As IA membership continues to expand beyond IEA members, opportunities for capacity building and technology transfer to developing and emerging economies will continue to increase. Already, some IAs (notably CTI, ETDE and ETSAP) provide a framework for engaging with and working to increase capacity in countries with fewer resources. Moreover, technology development in emerging economies contributes greatly to the work of the IAs.

At the IA level, benefits to collaboration are realised when a communication plan is in place and communication occurs among national stakeholders at multiple levels. Similarly, a strategic plan can help to align goals over the short and long term, and various mechanisms (including a strategic fund, for example) can deliver swift response mechanisms.

While the process of collaboration can create challenges, the IEA IA framework has made significant contributions to research that addresses global challenges. It has allowed for greater project scale, reduced cost, expanded and linked networks, improved research-policy links, accelerated development and deployment, and harmonised technical standards, to name but a few. The efficacy of many of the governance structures in place in the IA framework has played a significant role in the collaboration that has brought about these accomplishments.

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Notes

1. Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway (participates under a special Agreement since 1974), Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States.
2. Demand-side management refers to the modification of consumer demand and behaviour through methods including financial [dis]incentives and education.
3. The Working Party on Fossil Fuels, The Working Party on Renewable Energy Technologies, the Working Party on End-Use Technologies, and the Fusion Power Co-ordinating Committee.
4. These benefits are significant and are reviewed in greater detail in Box 7.3.
5. In order to reduce transaction costs and encourage a more efficient decision-making process, IAs also conduct remote voting through online balloting procedures as necessary.
6. Implementing Agreement for a Programme of Research, Development and Demonstration on Bioenergy.
7. Implementing Agreement for Co-operation in the Research, Development and Deployment of Wind Energy Systems.
8. Implementing Agreement for a Programme of Research on Fossil Fuel Multiphase Flow Sciences.
9. The RFP, as a stellarator, is studied in parallel to the ITER tokamak and contributes to understanding and solving of physics and technology problems commonly occurring in tokamaks.
10. However private entities, or sponsors, cannot be elected as chair or vice chair of an IA. In addition, individual IAs may have more restrictive provisions.
11. Implementing Agreement for the Establishment of the IEA Energy Technology Data Exchange.
12. Implementing Agreement for a Programme of Energy Technology Systems Analysis.
13. Implementing Agreement for Co-operation on Technologies and Programmes for Demand-Side Management.

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Chapter 8

European Joint Programming Initiatives

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Europe is one of the world's science, technology and innovation (STI) hubs, but in the European Union some 85% of all public spending on research and development (R&D) is still at the national level. This has recently been identified as a major reason for the inefficiencies of the European research and innovation system. Joint programming initiatives (JPIs) are being established by European countries to introduce a new means of aligning national R&D undertakings. This case study provides an introduction to the JPI approach as such and a more detailed account of the JPI on Agriculture, Food Security and Climate Change (FACCE). Although the JPI process is still very young, some lessons for international STI governance can already be drawn.

8.1. Introduction

Europe is one of the world's leading science, technology, and innovation (STI) hubs. In 2007, European countries spent an estimated 27% of global research and development (R&D) spending (UNESCO Institute for Statistics, 2011). The so-called Lisbon Agenda of 2000 aimed to further strengthen the position of the Europe Union (EU). Within the EU, some 85% of all public R&D is programmed, financed, monitored and evaluated at the national level (European Commission, 2008). This makes it especially important to align national R&D undertakings with efforts at the EU level to strengthen joint R&D directly.

Joint programming initiatives (JPIs) are being established as a new means of European research co-operation. JPIs aim at aligning national STI policies and programmes. In addition, they can create new transnational programmes which can complement existing programmes at the EU level. Co-ordination of these programmes will be ensured on voluntary basis (this is referred to as "variable geometry") and will involve all or a subset of EU members.

JPIs are a response to repeated calls from the European Council and the European Parliament for more and better research co-operation owing to the perceived limitations of existing policy instruments (*e.g.* lack of collaboration and co-ordination between national public R&D programmes). The European Framework Programme (FP) for Research, Technological Development and Demonstration Activities is the main EU funding programme to encourage research collaboration in the European Research Area (ERA). Its specific objectives and actions vary between funding periods. The interim evaluation of the current FP identified room for major improvement in terms of strategic alignment of national R&D efforts of European countries.

JPIs are a voluntary, bottom-up approach combined with strategic European-level guidance and the introduction of tailored approaches to international STI co-ordination. They are perceived by the European Commission as having the potential to become at least as important as the FPs in establishing a true European Research Area (European Commission, 2008).

This case study has two parts. The first provides a general introduction to JPIs. It describes the underlying approach and shows how JPIs have been made operational at European and national levels. The second part focuses on the FACCE JPI (agriculture, food security and climate change). It describes the global issues addressed by the FACCE JPI, the governance structure, agenda and priority setting, funding and spending arrangements, and the involvement of stakeholders. Since the FACCE JPI is still in its start-up phase, it is too early to address issues such as intellectual property rights (IPR), bridging research and practice, and technology transfer.[2] Hence, the focus is on the structures established so far and their envisaged mode of operation. The main challenges raised by JPIs in general and by the FACCE JPI in particular are described. The lessons drawn from the case study are based on a collection of information and materials and the authors' assessment (as of July2011).

JPIs have been considered to have high potential for interlinking national and European research more effectively. However, the JPI process in general and the FACCE JPI in particular raise issues for the international governance of STI. While the policy rationale behind JPI seems sound, the case study reveals major challenges for implementation. Experience so far demonstrates that priority setting for particular topics requires

some sort of strategic policy intelligence in order to be sufficiently evidence-based. Incentive mechanisms for participation should be designed to avoid free riding and moral hazard. Finally, processes for linking national to international priority setting should be closely examined at the national policy level and should take care not to leave national stakeholders (including the private sector) behind.

8.2. Towards joint programming initiatives

Embedding JPIs in the existing European research landscape

The Lisbon Strategy was adopted in 2000 and called upon Europe to become "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion" (European Parliament, 2000). The European FP has been the main instrument of the Lisbon Strategy.[3]

To encourage the alignment of European and national research programmes, the European Commission's Green Paper on the European Research Area (2007) argues for the free circulation of technology and knowledge among members, as well as effective European-level co-ordination of national and regional research activities, programmes and policies. In response, the Ljubljana Process was set up in 2008, understood as "an enhanced partnership between the Member States, associated countries, stakeholders and the Commission to make European research more effective" (European Commission, 2011b). In May 2010, the "Europe 2020" concept was approved and aimed for "smart, sustainable, inclusive growth" (European Commission, 2010a). It can be understood as a follow-up to the Lisbon Process.

Both processes set as a target that 3% of European gross domestic product (GDP) should be invested in R&D (initially by 2010, currently by 2020). Against a background of increasing globalisation of R&D activities and the still clear dominance of national R&D funding and programming in Europe, several attempts have been made to increase R&D co-operation in Europe (European Commission, 2007, 2006; Edler, 2008).

In the course of these attempts to invigorate European R&D co-operation, JPIs were introduced as an additional means of policy co-operation that would emphasise European and global economic, social and environmental challenges. Their main targets are (European Commission, 2008):

- To induce EU members to define strategic research agendas based on a common vision for addressing major European and global challenges (*e.g.* ageing population, migration flows, climate change, food security, urbanisation).
- To have a critical mass of resources and scope of research to develop common solutions, to pool data and expertise across Europe, to enable cross-border researcher mobility and training, to disseminate research findings and to speak with one voice in the international arena.
- On the European level to pool resources (joint planning, collective monitoring and review processes), eliminate cross-European programme duplication, reduce fragmentation in the European research system and decrease programme management costs.

- On a national level, to review, reorganise and align national and regional R&D budgets, programmes and agencies on European research objectives, while still addressing national needs and priorities.
- To be formed through a voluntary, bottom-up and open-access process among some or all EU members, with the participation of FP-associated states.[4]
- To have joint framework conditions regulating peer review procedures, foresight activities, evaluation, funding of cross-border research, dissemination and use of research findings, protection, management and sharing of IPRs.

Making JPIs operational on the European level

In July 2008 the European Commission (EC) published "Towards Joint Programming" (European Commission, 2008). In December 2008 the Competitiveness Council adopted the approach proposed by the Commission and established a High Level Group for Joint Programming (GPC – *Groupe de haut niveau pour la programmation conjointe*), a dedicated body of the European Research Area Committee. The GPC is composed of up to two high-level representatives from every EU member. Associated states can be observers (Council of the European Union, 2009). The GPC has the following main responsibilities:

- To identify the themes of JPIs following broad public consultation of the regional, national and European scientific communities and of the private sector where appropriate.
- To contribute to the preparation of the debates and decisions of the Competitiveness Council on JPIs within the mandate of the European Research Area Committee (Council of the European Union, 2009).

The EC acts only as a facilitator but is invited, within the remit of its competences, to contribute to the preparation of the JPIs (Council of the European Union, 2009). The Competitiveness Council oversees and regularly monitors JPIs' progress and, if necessary, considers further steps to ensure their effective implementation (European Commission, 2008).

Beginning in February 2009, the GPC started to discuss and identify suitable themes for JPIs, based on proposals from one or several member states. Each member state decided which JPI it wanted to support or which themes it wanted to suggest or contribute to. The JPI is expected to follow a set of broadly defined criteria:

- It addresses European or global challenge and are sufficiently focused.
- There is sufficient commitment from member states.
- It adds value to current research and has impact for EU citizens and competitiveness.
- It increases the efficiency and impact of policies.
- There are adequate human, scientific and technical resources for implementation.

The Competitiveness Council noted additional issues to be considered in formulating JPIs (Competitiveness Council, 2008, §8):

- Coherent framework conditions should be established for funding of cross-border research, peer review procedures and evaluation.
- A coherent approach to foresight activities should be introduced.
- Measures to ensure the optimal dissemination and use of research findings should be put in place, *e.g.* via common practices for the protection, management and sharing of IPRs.
- The relevant scientific and, where appropriate, industry communities should be involved.

The broad involvement of scientific and private stakeholders in defining JPI strategic research agendas is a distinct feature of JPIs. As JPIs are driven by member states, it is their responsibility to involve and consult with stakeholders. These may include research organisations, research funding agencies, industrial representatives, end-user groups, other networks, etc. The group of countries supporting a specific JPI is asked to identify national and international stakeholders which are then invited to contribute to the development of the JPIs.

Box 8.1. Research themes of joint programming initiatives, 2009 and 2010

Confirmed in December 2009:

- Neurodegenerative diseases/Alzheimer's (pilot project as of December 2008)
- Agriculture, food security and climate change (FACCE)
- A healthy diet for a healthy life
- Cultural heritage & global change

Confirmed in May 2010:

- Urban Europe
- Climate knowledge for Europe (CliK'EU)
- More years, better lives
- Antimicrobial resistance
- Water challenges for a changing world
- Healthy and productive seas and oceans

The GPC approved the first wave in November 2009 and the second in April 2010. These were confirmed by the Competitiveness Council in December 2009 and May 2010, respectively (Box 8.1). Currently, there are no plans to re-open this process.

Moving JPIs towards maturity on the European and national level

JPIs need to develop a governance structure for co-ordinating action among participating countries. As JPIs should contribute to the establishment and development of a less fragmented European Research Area, the Spanish EU presidency proposed common basic principles for a JPI governance structure in 2010; however, these were not adopted by the GPC or by the Council. They distinguished administrative bodies (a secretariat, the managing and co-ordinating board), governing bodies (a management board to develop the JPI's

strategic orientation and framework conditions and oversees the implementation of its activities and an executive board to implement decisions taken by the management or programme boards) and advisory bodies (scientific advisory board, stakeholders consultative board), with their respective terms of reference.

This proposal aimed "to launch a debate on the simplification of JPI governance structures in a way to make them most cost efficient and flexible enough to cater for the needs of each selected theme" (Scientific and Technical Research Committee, 2010, p. 3). The High Level Group for Joint Programming (2010a, S.4) emphasised that "recent experiences with ERA-NETs, Joint Technology Initiatives and Article 185 (ex Article 169) Initiatives seem to indicate that striking the right balance between developing a 'standard model' and 'flexibility within the model' is crucial to prevent a fragmented landscape deriving from applying a completely different set of rules to each initiative".

It is the responsibility of each JPI to adapt the recommended structure to its needs. As this can lead to quite different administrative settings and thus increase complexity, the EC proposed to streamline the governance and management structures of the JPIs (Competitiveness Council, 2008, §15).

In light of the tensions between common frameworks and bottom-up definitions of operating rules, it remains to be seen whether the joint programming process can help to create a European Research Area with closer ties and connections between different regions, clusters and research agendas or whether it adds to the diversity and complexity of policy instruments, thus making coherent international governance of STI even more difficult.

The JPIs start with the development of a common vision to be translated into a strategic research agenda with specific, measurable, achievable, realistic and time-based objectives. It is usually developed using standard visioning techniques and discussed during a series of workshops in which representatives of research organisations and ministries (national and EU-level), as well as stakeholders, work together. In this process, existing programmes and capacities are screened and evaluated. The goal of the strategic research agenda is to operationalise the vision and link its objectives to existing competences in Europe or new ones to be developed. The resulting strategic research agenda provides the framework for defining specific pilot projects and their research programmes. The agenda must be approved by all countries participating in the JPI. Awareness building and lobbying are crucial to promote the JPI and gain support for it through workshops and platform meetings at European and national level.

The Council Conclusions on Joint Programming of 2 December 2008 encouraged member countries, with the support of the EC, to define voluntary guidelines on framework conditions and a tentative roadmap for the effective development and implementation of JPIs. The guidelines include peer review processes, foresight, evaluation, funding of cross-border research, dissemination and use of research findings as well as protection, management and sharing of IPR (High Level Group for Joint Programming, 2010a). The development of voluntary guidelines lasted about a year (January-December 2010) and were approved by the GPC and presented to the Competitiveness Council (High Level Group for Joint Programming, 2010b).

The joint development of a research agenda and framework conditions are the basis for the implementation of a pilot phase. The full toolbox of public research instruments (*e.g.* joint calls by national and regional research programmes, inter-governmental research organisations and collaborative schemes, research infrastructures, mobility schemes) should

be used to implement individual JPIs. This may or may not include EU funding and FP instruments. Part of the pilot phase should also include foresight activities.

It is the responsibility of the EC to monitor and assess the maturity of the JPI proposals, based on criteria such as the challenge addressed, the contribution to EU 2020 objectives, the potential for increased efficiency and impact of public R&D, the existence of sufficient and effective commitment by member countries, the state of the JPI structure, the contacts between the EC and the participating countries, and the potential timetable (High Level Group for Joint Programming, 2011; European Commission, 2011a). In its communication on the "Innovation Union" (European Commission, 2011c), the EC envisaged using a certain number of JPI themes to guide priority setting in the FP starting in 2014.

Main challenges for JPIs

JPIs are a new process in the making. As of yet, there has been no assessment or concurrent evaluation. However, based on conceptual and empirical information and material available from the different JPIs, it is possible to identify and assess certain common challenges. Hence, the following mostly describes what the authors see as potential threats that concern not only JPIs but are also more generally relevant to international STI co-operation.[5]

- *The process of identifying European and global challenges suitable for JPIs was quite unsystematic.* The identification of JPI themes followed no clear procedure. The scope and concreteness of the themes originally differed greatly. Few were based on some sort of "strategic intelligence" (*e.g.* foresight, technology assessment, policy dialogue). Some (such as the FACCE JPI) were evidence-based in other contexts and initiatives. Overall, the definition of themes was the result of systematic and evidence-based priority setting only to a limited extent.
- *Governance structures and framework conditions are very heterogeneous.* A high level of heterogeneity is very likely to jeopardise the objective of contributing to a less fragmented European Research Area. The EU presidencies of 2010 (Spain, Belgium) developed recommendations for common governance structures and framework conditions as a result of experience with the first JPIs. These recommendations are not binding and it remains to be seen whether they will be applied.
- *Establishing common budget solutions is one of the greatest challenges.* Discussions on the common setup of governing bodies, framework conditions and a research agenda require limited financial commitments or in-kind contributions. Joint mobilisation of research budgets will be the real challenge.
- *The interests of JPIs and the EC are divergent:* The joint programming process is guided by the principles of voluntary participation and a bottom-up approach primarily based on member state initiatives. The EC so far only supports the development of the JPI themes and has an observer position on the governing boards of JPIs. There seems to be a clear division of responsibilities between the EC, the GPC and members in the JPI process. For the future it will be interesting to see how JPIs handle differences in their members' and the EC's interests.

- *The decision-making process in the GPC is very much influenced by members' national interests.* The JPI setup process is not strictly structured and formalised. This flexibility has positive aspects, such as low entrance barriers and capacity to adapt to unforeseen circumstances. However, it also widens the scope for specific national interests to influence the JPI process.
- *Participation differs quite significantly among members.* Hardly any new EU members (the 12 that entered the EU in May 2004 or later) are represented in JPIs and they do not take a leading role in their establishment. Although the JPI process is formally open to all members, all do not necessarily have the means to participate on an equal footing.
- *Establishing and streamlining national research efforts requires strong commitment.* The main objective of the JPI process is to overcome the lack of collaboration and co-ordination between different national public R&D programmes. JPIs aim to establish common research agendas and priorities shared by the participating countries. Collective action of this sort requires strong and well-orchestrated commitment to avoid free-rider and moral hazard phenomena.[6] As of now, most JPIs have established very low entry barriers in terms of budgetary commitment to the setup process. It is not clear how best to avoid free-rider behaviour.
- *There is limited interaction between JPIs.* The creation of JPIs has involved limited exchanges among them (regarding the establishment of the JPI and the governance structure, the pilot phase, budgets, etc.). There was no platform for mutual interaction and joint learning. JPIs repeatedly encountered difficulties already experienced and sometimes solved by other JPIs. More institutional learning would have been beneficial.
- *JPIs were created as a new European process alongside existing ones to meet the same policy goals:* There is a danger of overlaps and redundancies (*e.g.* the Knowledge and Innovation Communities of the European Institute of Innovation and Technology, Article 185 Initiatives, the Strategic Energy Technology Plan, ERA-NETs, etc.). The most appropriate way to foster international STI collaboration between EU countries remains to be seen.

8.3. JPI "Agriculture, food security and climate change"

Global challenges addressed and framework conditions

The Initiative on Agriculture, Food Security and Climate Change (FACCE JPI) was established as part of the first round of JPIs. The development of a first proposal for the FACCE JPI started in July 2009. The proposal was prepared by France, the United Kingdom, Italy, Germany and Spain and was supported by Austria, Denmark, Estonia, Finland, Ireland, the Netherlands and Norway. The GPC accepted the proposed theme in November 2009.

The main impetus for the establishment of the FACCE JPI is the challenge presented by climate change and food security. Climate change threatens the world's food production and security. Steep rises in food prices – as in 2008 – could become more frequent. A food crisis would threaten social and political stability in the affected regions. While these are mostly outside Europe, Europe would also be directly or indirectly affected, *e.g.* loss of economic opportunities owing to political instability or a potential rise in migration to Europe (FACCE, 2011).

The general objective of this JPI is "to integrate adaptation, mitigation and food security in the agriculture, forestry and land use sector" (FACCE, 2009, p. 6). It aims to identify and promote measures that provide benefits in terms of reduced greenhouse gas emissions and more resilient farming, forestry and biodiversity. A central agenda item will be to gain more detailed knowledge of the regional impact of climate change. Much attention will be paid to instruments to assess and evaluate the feasibility and success of these measures at the local or farm level.

The challenges of climate change and food security need an integrated approach and "require a long-lasting and large base research endeavour" (FACCE, 2009, p. 5). The main objective of the FACCE JPI, stated in the proposal to the GPC, is to "integrate relevant approaches and create a vision and framework for future activity" (FACCE, 2009, p. 5) in this interdisciplinary field of study. It seeks to co-ordinate European agricultural research to concentrate efforts, knowledge, infrastructure and possibly funds to make "a great leap forward in developing the concept of multifunctional and sustainable food production for different agro-ecological zones and regions within Europe and within other regions that are key to European interests" (FACCE, 2009, p. 11).

The challenges addressed by FACCE are referred to in various EU policy documents on agriculture and climate change. These documents emphasise the importance of measures to mitigate the effects of agriculture and food production on the climate and to allow for their adaptation to the impacts of climate change. The EU White Paper on adapting to climate change (European Commission, 2009a) recommends integrating adaptation and mitigation into all key European policies and fostering co-operation in this respect at all levels of governance. The European Commission (2009b) also suggests that adaptation and mitigation objectives should be better integrated in the Common Agricultural Policy instruments (European Commission, 2009b). The objectives of the FACCE JPI therefore strongly reflect EU policy objectives.

The FACCE JPI is still in the start-up phase (the last update of progress on FACCE JPI was in July 2011). Support is given by the Coordination and Support Action of FP7 started in May 2011. Operations and working structures are based on an interim governance mode. By July 2011, regulations for research funding, capacity building, IPR regimes, etc., had not yet been adopted. Since the fundamental structures are still being established, little can as yet be said about their suitability for future tasks.

Main characteristics of the overall governance model

The FACCE JPI vision and proposal was developed in discussions of an internal working group of the Standing Committee on Agricultural Research (SCAR) and was based on the results of the second SCAR foresight process. SCAR was established in 1974 by a Regulation of the Council of the EU and is an intergovernmental body. It has significant influence on agricultural research in Europe. The conclusions of the foresight process (European Commission, 2011a) note the need for a more co-ordinated and interdisciplinary research effort on the European level to tackle challenges connected to climate change and food security (European Commission, 2009c).

These conclusions directly influenced the establishment of the FACCE JPI, and the evidence base of the proposal had a considerable impact on the decision to name FACCE as one of the first JPI themes. SCAR is a driving force behind the FACCE JPI proposal, and there are strong personal and institutional connections between FACCE and SCAR. The leading partners of the FACCE JPI already collaborated in the SCAR working groups. The common understanding of themes, challenges, research questions and visions

that guided the design of the proposal was reached within SCAR. This facilitated the co-ordination and elaboration of the FACCE JPI proposal.

In May 2011, 19 countries participate in the FACCE JPI.[7] Among the proposing countries, France (*Institut national de la recherche agronomique* – INRA) and the United Kingdom (Biotechnology and Biological Sciences Research Council – BBSRC) have taken a leading position. Human resources for the Secretariat, which is responsible for organisational and management issues (see below), were provided by INRA and BBSRC in the start-up phase.

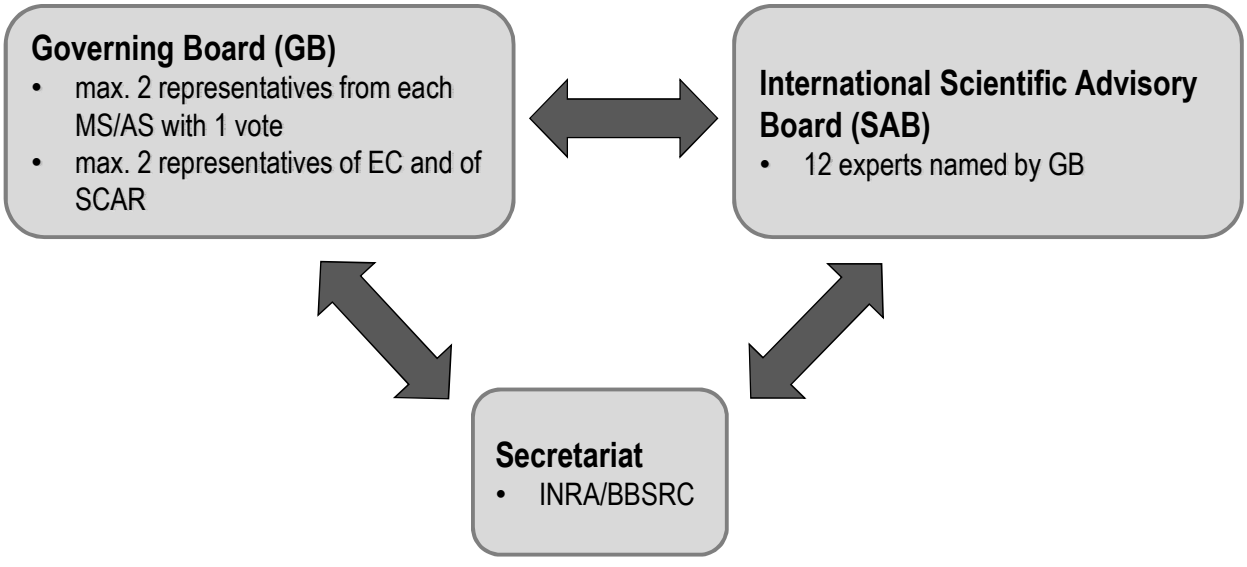
Governance structure of FACCE

In line with the bottom-up approach adopted, each JPI confirmed in the first and second wave can decide independently on its governance structure and "no binding structures should be…imposed on them" (Scientific and Technical Research Committee, 2010, p. 3). However, as noted above, the Spanish presidency proposed common basic principles for their governance structure. The first four initiatives accepted (including FACCE JPI) developed governance structures which are very different and could "lead to dispersion of efforts as well as to confusion" (Spanish Presidency, 2010, S. 1).

The governance structure of the FACCE JPI is still being developed. An interim governance structure was put in place at the first official FACCE JPI meeting in January 2010 for a maximum of two years. A proposal for a permanent governance structure will be presented to the Interim Governing Board in November 2011. It is not expected to differ substantially from the interim one.

The main decision-making body is the Interim Governing Board which is composed of representatives of all member and associate states participating in the JPI (Figure 8.1). It is supported by an Interim Scientific Advisory Board, which provides advice on scientific governance and develops a common strategic vision for the FACCE JPI. The boards are assisted by the Secretariat. The FACCE JPI governance structure corresponds only slightly to the recommendation of the Spanish presidency.

Figure 8.1. Interim governance structure of JPI FACCE



Source: Authors' draft based on Interim Governance of FACCE JPI (FACCE, 2010).

In the FACCE JPI each participating state is allowed to send two representatives to the Governing Board. To be valid, the board's meetings require a quorum of at least two-thirds of the participating member and associate states. Each participating country has one vote and the vote is indivisible. Members need to be nominated by the competent authority and therefore have a governmental mandate. The Governing Board's rules distinguish between a designated spokesperson and a designated voting member.

The national representatives of the 19 participating countries come from different institutional backgrounds. Some countries send representatives from national ministries, others from funding agencies, research councils, research institutions or other organisations. As a result, the Governing Board comprises different levels of representation and possibilities for engagement. This is a challenge as the representatives have different capacities to act and influence national or regional policies. A member of the Governing Board with a right to vote pays a fee of EUR 5 000.

The Governing Board also has two representatives with observer status, from the EC, SCAR and the Scientific Advisory Board. External experts can be invited to meetings; they have a consultative position and do not have the right to vote. Their terms of references were adopted at the second meeting in April 2010.

Box 8.2. The responsibilities of the Governing Board

- Prepare and validate the rules of governance.
- Adopt a management structure and terms of reference for existing bodies such as the Governing Board, the Scientific Advisory Board and the Secretariat, and for future groups.
- Name the interim Scientific Advisory Board.
- Map existing national and international research programmes.
- Validate the scientific vision and the scientific research agenda.
- Adopt the proposal for a Coordinate and Support Action submitted to the 7th FP.
- Co-ordinate the different national stakeholders (responsibility of each Governing Board member).
- Ensure the exchange of information among relevant actors (*i.e.* members, associates, EC, GPC, European Research Area Committee).
- Establish working groups on specific issues to promote implementation of the JPI (on framework conditions, foresight activities, etc.).
- SCAR representatives provide the results of the working groups on foresights and infrastructure.

Supporting joint actions is voluntary; no country is obliged to take part in and to support joint actions or activities. The question has arisen of how many countries have to agree on joint activities or joint actions. This raises the more critical issue of the majority needed in the Governing Board to establish a joint action or call for proposal. Do countries that will not participate in specific calls or joint actions also have the right to vote on these issues? Do joint actions or activities depend on the agreement of members who will then not participate in and support these actions? A pressing issue is whether joint actions or calls have to be approved by all countries, even by those that will not participate. In this case, countries that have no need for or interest in participating have quite a strong bargaining position. This can give rise to quite high bargaining costs.

The Scientific Advisory Board's main functions are to advise the Governing Board on scientific issues and to develop a recommendation for the scientific direction of FACCE. It has 12 members, of whom eight have a European background and four are from outside

of Europe or from international organisations. Each participating country can nominate experts for the Scientific Advisory Board. Members are appointed for two years; re-appointment is possible with the approval of the Governing Board. The following criteria were defined by the participating countries for the nomination of members:

- Recent and active participation in international scientific expertise building and foresight.
- Broad vision of the agriculture, food security and climate change issue.
- Outstanding academic record and international visibility.
- Need for the diversity of disciplines involved in the JPI FACCE (FACCE, 2010, p. 7).

Scientific Advisory Board members are elected through an online system. Each participating country has one vote. The experts who get most votes are appointed. Only one woman was appointed. Gender equality was not a criterion in the first round but will be added to the list. Additional members covering missing areas of expertise will join the team.

Box 8.3. The responsibilities of the Scientific Advisory Board

- Elaboration of a common strategic vision based on the JPI FACCE proposal.
- Advice on scientific governance for JPI FACCE implementation.
- Proposal on the research objectives and the scope and priorities of the JPI FACCE.
- Proposal of the competences needed to cover the priorities defined.
- Proposal of experts for specific groups (evaluation panels, implementation groups, etc.).
- Board members can be part of expert teams for the Governing Board and of FACCE working groups.

The Secretariat is responsible for the management of the JPI. It prepares and co-ordinates the Governing Board and Scientific Advisory Board meetings and writes the minutes. It therefore has a central role in distributing information and facilitating communication between members of the Governing Board and Scientific Advisory Board. It also ensures communication and linkages to other relevant stakeholders and organisations that do not participate in the FACCE JPI. It is responsible for preparing the annual budget for the Governing Board. Currently INRA and BBSRC provide the resources for the Secretariat. Since May 2011, it has received additional support of around EUR 2 million from the EC through the Coordination and Support Action of FP7. These resources cannot be used to fund calls for proposals; the latter will rely on resources made available by FACCE JPI Governing Board members or by the EC.

Agenda and priority setting

The *scientific* research agenda (not the *strategic* research agenda) contains a shared scientific vision for the FACCE JPI. It was elaborated by the Scientific Advisory Board and submitted to the Governing Board which commented on the draft agenda. The final scientific research agenda was approved by the Governing Board in December 2010 and defines the scope of the FACCE JPI, establishes a common scientific vision and core research themes:

- "Sustainable food security under climate change, based on an integrated food systems perspective: modelling, benchmarking and policy research perspective.
- "Environmentally sustainable growth and intensification of agricultural systems under current and future climate and resource availability.
- "Assessing and reducing trade-offs between food production, biodiversity and ecosystem services.
- "Adaptation to climate change throughout the whole food chain, including market repercussions.
- "Greenhouse gas (GHG) mitigation: N_2O and CH_4 mitigation in the agriculture and forestry sector, carbon sequestration, fossil fuel substitution and mitigating GHG emissions induced by indirect land use change." (FACCE, 2011, p. 7)

The scientific research agenda also includes a list of priority actions for short-, medium- and long-term implementation of each of the five core themes. It will be revised by the Scientific Advisory Board every two years. An *ex post* evaluation is envisaged by the FACCE JPI Secretariat but details were not available in July 2011. Although there were substantial discussions on the content of the scientific research agenda by the Governing Board, no fundamental disagreements were reported between members of the Governing Board and/or members of the Scientific Advisory Board.

The Secretariat of FACCE JPI noted that focusing the discussion on scientific issues facilitated national representatives' agreement on the scientific research agenda. This was also facilitated by the Scientific Advisory Board which is composed of well-known experts from different world regions who are not constrained by specific national interests.

The scientific research agenda will be further developed into a strategic research agenda that will address the means to achieve the scientific objectives. Framework conditions (budgets, evaluation criteria, peer review, etc.) and stakeholder involvement will be defined.

Priority setting in the FACCE JPI is mainly determined by members of the Scientific Advisory Board and national representatives in the Governing Board. Priorities are formulated and set at the international or transnational level. Policy co-ordination will be needed to involve actors at other levels (*e.g.* national or regional research organisations) or activity (*e.g.* research funding agencies, policy makers, firms).

As emphasised in a study of European innovation policy, successful vertical policy co-ordination "largely depends on the existence of co-ordination mechanisms within the member states and the willingness of local and regional actors to subscribe to targets which have been defined at the European level" (Kaiser and Prange, 2004, p. 253).

This raises the question of the involvement of local and regional (non-governmental) actors/stakeholders in the priority-setting and implementation process. Priority-setting processes are more complex than the decision-making process in the Scientific Advisory Board and the Governing Board, and national priorities are formulated and shaped in different ways in different countries. Some may have broad processes involving the expertise and interests of all relevant stakeholders, while in others national priorities and agendas may be formulated by a small group of primarily governmental actors. Because priority setting may also involve different actors and procedures at the national and regional level, this raises the question of the legitimacy, accountability and acceptance of decisions taken at a supranational or transnational level. In the JPIs the national

representative on the Governing Board is responsible for the national co-ordination process. There is no common national co-ordination process for FACCE JPI member and supporting countries.

Due to the differences in the co-ordination of the FACCE JPI activities in supporting countries, an implementation strategy for the scientific research agenda is currently (as of July 2011) being formulated. A task force was established to discuss framework conditions for a joint pilot action called "A detailed climate change risk assessment for European agriculture and food security". It is envisaged to intensify co-ordination of national modelling activities and to bundle national resources and capacities. A FACCE JPI knowledge hub was created to connect the relevant research groups from JPI member countries.

The knowledge hub is a network and a virtual centre of expertise and collaboration. This first joint action will not fund research but will cover the costs of co-ordination of different research groups. It is envisaged to use the knowledge hub in activities of the FACCE JPI starting from late 2011. The activities and results of this joint pilot action will also be co-ordinated with the Agricultural Model Intercomparison and Improvement Project, a worldwide initiative to improve future scenarios of climate change and its impact on risks of world hunger and food security.

Not all countries participating in FACCE JPI are active in the task force that is preparing the framework conditions for the first call for proposals. The Governing Board has to find a solution to include the different countries and ensure they are integrated in the pilot phase.

Funding and spending

Currently, members of the Governing Board have to transfer a lump-sum payment of EUR 5 000 to the JPI. The funds contribute to the expenses of the interim Scientific Advisory Board and cover Secretariat expenses. Even at this stage of financial commitment some members and associates had difficulty transferring the money owing to national or organisational financial regulations.

So far the FACCE JPI does not have structures and regulations for funding and spending arrangements. The GPC's recommendations on framework conditions for JPIs (discussed above) do not include preferred instruments for joint research funding.

For research funding, many interviewees favour a so-called "real common pot" solution for the FACCE JPI in which national resources are pooled in a jointly administered budget. This would require changing some countries' legal framework conditions. The use of a real common pot will be affected by a research project's position in the innovation cycle as applied research is usually more limited to national boundaries for competitiveness and intellectual property reasons.

Some countries (*e.g.* Denmark) have already introduced regulations to enable participation in real common pot solutions. Other countries lack such regulations. A "virtual common pot" solution therefore seems likely to be adopted in the short term. Given differences in national regulations it is conceivable that a mix of different financial instruments will be used. The task force on modelling of climate change is discussing these issues and will suggest flexible solutions so that all countries are in principle able to participate in joint calls and other activities. These suggestions can be signposts for future activities.

The framework conditions for JPIs, which were agreed by the GPC and can be taken up on voluntary basis, highlight the advantages and problems of different funding tools (Table 8.1).

Table 8.1. Advantages and disadvantages of different funding tools

	Advantages	Disadvantages/Problems
Money follows co-operation line	Stimulates cross-border funding	National legislation or administrative rules might need modification
Money follows researchers	Allows better exploitation of individual expertise	Salary differentials and imbalances
Virtual common pot	Compatible with independent financial planning by funding bodies Funding only within national borders simplifies rules	Some proposals approved to be funded may be declined Potential conflict between the funding of "excellence" and available national contributions
Real common pot	Proposal selection always follows the ranking list Simpler selection procedure	Difficult to set up Cross-border funding might seem to clash with national interests Need for an agreed system to determine contributions, eligible costs, overheads, etc. Possible exclusion of some players on the grounds of national legislation
Balanced common pot	Proposal selection might follow ranking list, without the problems of a real common pot Topping-up money could be made available by EU ERA-NET Plus experience	Long term commitment required Distorted exploitation of the system needs to be avoided

Source: High Level Group for Joint Programming (2010a, S. 39).

There are as yet no regulations to guide access to research programmes, funding and other activities in the FACCE JPI pilot phase or subsequently. The question that arises is whether the research results and their exploitation and application are open to all countries participating in the Governing Board or restricted to those supporting the joint action. The former might lead to a free-rider problem whereas the latter might hamper free access to publicly funded research results.

Involvement of stakeholders

For newly established initiatives such as the FACCE JPI it is very important to connect to existing initiatives, organisations and networks. The challenge is to link diverse groups of stakeholders. Involving relevant stakeholders can help to transfer knowledge and experience and to align activities to co-ordinate the use of resources and facilitate the dissemination of research results. The Governing Board automatically establishes links to the following stakeholders:

- SCAR is represented as observer on the Governing Board.
- The EC is represented as observer on the Governing Board.
- ERA-NETs have personal links as some members of the Governing Board also participate in ERA-NETs.
- European technology platforms have personal links as some members of the Governing Board also participate in technology platforms.

Links to other institutions are established through members of the Scientific Advisory Board and their background organisations. FACCE JPI clearly addresses the need to connect and co-ordinate its activities with existing international programmes.[8] It is envisaged to establish a fourth governance body (in addition to the Governing Board, the Scientific Advisory Board and the Secretariat) that would bring these stakeholders together. Other international or transnational stakeholders including representatives of farmers, extension services, etc., will be involved in FACCE JPI more indirectly, *e.g.* through consultation via questionnaires. The results and inputs of this stakeholder consultation process will be incorporated into the strategic research agenda that will serve as a guideline for FACCE JPI activities.

At the moment, regular stakeholder workshops are not envisaged. As there are personal links between the FACCE JPI and this group of relevant stakeholders and as activities are closely co-ordinated, there will be a constant exchange of information and experiences. Therefore it seems necessary to establish a more permanent platform of exchange and interaction with relevant stakeholders.

Main challenges for FACCE

The JPI FACCE is still in its start-up phase. Its further development will depend on experience with the interim governance structure and on its effectiveness. It is too early to assess its effectiveness and practicality. Nevertheless, it is useful to try to summarise briefly some challenges and crucial points to be faced for establishing a well-functioning JPI FACCE:

- *Decision-making process*. The large number of Governing Board members (21) makes decision making difficult. So far, no crucial decisions have had to be made. It seems likely that when it comes to deciding on the agenda, annual budgets, funding and spending arrangements, etc., issues will be much more complex. In the future, higher barriers for access to strategic decision making (in terms of financial commitment) may also be necessary.
- *Co-ordination between FACCE JPI and national activities*. National landscapes of funding agencies, research institutions and stakeholders are often very diverse and fragmented. These institutions and stakeholders are not fully represented in the Governing Board. Therefore, each national Governing Board representative will have to serve as the interface to national stakeholders and institutions. This task is formally assigned to all Governing Board members, but there are no recommendations for facilitating national co-ordination. It is very likely that this will depend on the national status of each Governing Board representative.
- *Stakeholder involvement*. There is as yet no clear vision on stakeholder involvement or on which organisations and institutions will be considered stakeholders. As in other JPIs, the great diversity of stakeholders poses a difficult challenge for sensible stakeholder involvement.

- *Intensity and strength of co-ordination of joint research activities and programmes between JPI FACCE partner countries*. Will it be possible to achieve tightly co-ordinated research activities with joint funding arrangements and a common pot solution? Or will there be only weak collaborative structures that will not overcome the fragmentation of the European Research Area? An indication of a more strongly co-ordinated approach is the fact that JPI FACCE is widely supported by SCAR. Agreements on JPI FACCE activities and objectives were discussed in this international organisation. Many of the Governing Board members know each other from SCAR meetings and working groups. The foundation of JPI FACCE is already based on existing international collaborations.

8.4. Overall assessment and lessons learned

JPIs seek to strengthen international collaboration on STI policy in Europe beyond what has been achieved by various EU-level instruments. As the vast majority of R&D funding in Europe is still channelled through national programmes, this initiative aims at increasing STI policy coherence by encouraging bottom-up co-ordination of national policies to address major European and global challenges. In choosing this as their basis JPIs certainly address a weak spot in European STI collaboration and offer a potential entry point for joint policy action.

The following analysis of the JPI scheme is based on existing documents and interviews. While JPIs are still at an early stage of their existence, they can provide some lessons for international STI collaborations.

As a means of establishing an international (European) framework for STI collaboration, JPIs are unusual in that they are meant to evolve in a bottom-up fashion (though guided by some non-binding EC recommendations) instead of on the basis of commonly defined rules and institutional settings. This can be considered both a strength and a weakness: on the one hand, it allows for greater freedom and diversity (with respect both to the identification of themes and to finding the most appropriate institutional solution); on the other, there is the danger of adding further complexity to the already very complex toolbox of European STI policy collaboration.

In addition, the absence of organisational role models and some characteristics of the JPI process (duration, ambiguities regarding the respective roles of members and the EC), have left individual JPIs to face considerable uncertainties. While the general policy rationale behind JPIs seems well established, major challenges arise with respect to their appropriate design and implementation.

Current experience with the implementation of JPIs offers some general lessons for international STI collaboration:

- *Priority setting for international STI governance needs some strategic policy intelligence* in order to be sufficiently evidence-based. In this respect, the overall JPI process is less than satisfactory. Priority setting in the JPI is rather unsystematic and only in some cases based on systematic strategic policy intelligence. Individual JPIs might remedy the lack of an evidence base by their own activities (technology foresight, monitoring, etc.).
- *Decision-making bodies of transnational research programmes should have a clear profile and clear tasks*. In the case of JPIs the GPC is the EU-level body that selects research themes for JPIs. The GPC is composed of policy makers with

national interests. This makes independent scientific decision making on potential research projects difficult.

- The divergent interests and varying roles of supporting countries, transnational bodies (*e.g.* the EU) and existing transnational research initiatives need to be weighed and balanced sensibly. STI policy is still predominantly the remit of nations. Different perceptions of the role of actors and stakeholders can lower the speed and performance of the process.
- *Incentive mechanisms for participation should be designed to avoid free riding and moral hazard.* A formal status more strongly tied to commitment might solve the problem of decision-making bodies becoming too large for strategic decisions. Moreover, transnational research programmes should ensure that potential participating countries can enter on equal footing.
- Processes of *linking national to international priority setting should be given high attention* and should be carefully crafted so as not to leave national stakeholders (including the private sector) behind.
- *Transnational research programmes depend on the commitment* of participating countries. The JPI approach requires stability of commitment in terms of general participation, agenda setting, funding, etc. Commitment of participating countries is voluntary and might be affected by changes in national policy, elections, etc. This does not provide ideal conditions for international R&D projects.
- While flexibility and variability can be assets during the identification of joint research areas, *coherence in the institutional settings* (governance structure, agenda setting, framework conditions) of JPIs in general and their various bodies is important to avoid adding to the existing complexity of policy tools. This is especially true for funding arrangements.
- *Platforms for mutual learning* with other transnational STI governance programmes are highly recommended. These have been only partially developed in JPIs.

Notes

1. The authors would like to thank the Austrian Federal Ministry for Science and Research and the Austrian Federal Ministry for Transport, Innovation and Technology for funding this research.
2. JPI FACCE was chosen for the case study because it was among the first launched and can already provide some empirical evidence.
3. 7th Framework Programme, *http://cordis.europa.eu/fp7/home_en.html*; 6th Framework Programme, *http://cordis.europa.eu/fp6/dc/index.cfm?fuseaction=UserSite.FP6HomePage*.
4. Associated countries are Switzerland, Israel, Norway, Iceland, Liechtenstein, Turkey, Croatia, the Former Yugoslav Republic of Macedonia and Serbia, Albania, Montenegro, Bosnia & Herzegovina, Faroe Islands.
5. The authors had first-hand experience with the process of establishing JPIs by supporting the Austrian government in its involvement in JPIs and by participating in several GPC meetings and in the setup of the JPI on Urban Europe.
6. For example, countries that postpone commitment do not have to share the setup costs with other countries.
7. Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, the Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, Turkey and the United Kingdom.
8. These include: Consultative Group on International Agricultural Research (CGIAR), Earth System Science Partnership (ESSP), Challenge Program on Climate Change, Agriculture and Food Security (CCAFS), Food and Agriculture Organisation (FAO), Global Research Alliance on Agricultural Greenhouse Gases, The Climate Knowledge and Innovation Community.

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Chapter 9

Improving science, technology and innovation governance to meet global challenges

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This chapter reviews the literature on five dimensions of international science, technology and innovation (STI) governance: i) *priority setting,* ii) *funding and spending arrangements,* iii) *intellectual property,* iv) *putting STI into practice and* v) *capacity building. It is supported by the case studies presented in the preceding chapters. Finally, it presents preliminary steps towards governance options and some paths for further research.*

9.1. Introduction

This chapter considers how governance mechanisms to facilitate international co-operation in science, technology and innovation (STI) can help to respond to global challenges. It reviews the literature and draws on the case studies contained in this volume and on other sources to propose a set of governance options for tackling global challenges and reducing their negative social and economic impacts.

The case studies presented in Chapters 2 to 8 describe a number of projects, mechanisms and organisations established in various fields, at various times and with diverse structures to meet important global challenges. This chapter analyses the five dimensions of governance on which the case studies focus: *i)* priority setting, *ii)* funding and spending, *iii)* knowledge sharing and intellectual property, *iv)* putting STI into practice and *v)* capacity building for research and innovation. It also draws on in-depth analyses of these governance dimensions that accompanied the case studies that were prepared by the expert teams from Austria, Germany, Norway and South Africa. Its overall aim is to identify the main strengths and weaknesses in their governance in order to point to governance options to facilitate timely action for international STI co-operation to meet global challenges.

For each of the dimensions considered, the analysis reviews the literature, synthesises the salient features of governance in the case studies, and considers the challenges and governance options. The chapter concludes with a synthesis of the prominent assumptions and their implications for each dimension as a basis for sound governance.

9.2. Priority setting[1]

The literature on STI priority setting mainly focuses on national contexts, given that most STI efforts and thus priority setting have been national endeavours. A synthesis of the case studies highlights salient features of the present governance of priority setting and offers some insight into the challenges facing priority setting in the context of international STI co-operation. The various trade-offs that are needed to ensure that priority-setting processes support the delivery of the desired global public goods are discussed and the governance options outlined.

STI priority setting: Definition and main features

Priority setting can be defined as a negotiation process in which diverse actors and stakeholders seek to agree on common goals, objectives and actions. Agenda setting concerns the public discourse designed to raise awareness of specific problems and challenges. The successful tackling of global challenges implies a sustained effort to put the relevant issues on the agenda on a broad scale and on a long-term basis. It is assumed here that the identification of global challenges and their presence on the agenda is a prerequisite for priority setting.

Priority setting can be classified according to its drivers or according to its goals. Stewart (1995) defined three priority-setting models based on drivers: user-based, institutional and political. Selection of priorities is determined by users' needs, by rewards for researchers or by broader policy choices. Priority setting may also depend on thematic or structural priorities. Since STI priority setting involves various stakeholders, drivers may differ. They can target the economic efficiency of public research and public research funding management (OECD, 2010a, p. 8) and thus create tensions with the scientific

community, which emphasises excellence of research results. Alternatively, they can pursue political and societal goals so that research contributes to people's welfare and social well-being, sustains internal and external security, and delivers solutions to global challenges.

Other sources of tension can appear during STI priority-setting processes: specialisation *vs.* diversification, choice of the targeted stage of the STI process, supply- *vs.* demand-led orientation, varying time horizons, uncertainty about resources and the actual state of the world. This leads to diversity and complexity in designing priorities to address global challenges (OECD, 2010a; Dalrymple, 2006).

Historically, there have been four main approaches to STI priority setting. A traditional mission-led (*i.e.* application-led) approach, a technology-oriented approach based on the identification of key technologies for civilian industrial purposes, a systems-oriented approach to enhance national innovation systems, and the more recent "new mission-led approach" for technologies to cope with new societal challenges (Gassler *et al*., 2008). The last of these combines social needs and technological input, identifies and selects priorities in a decentralised manner, involves multiple actors from different sectors, and favours the fastest path to implementation (*e.g.* incremental innovations). Governance is not confined to governmental or government-authorised actors but involves stakeholders from other areas that form policy or negotiating networks. Whereas traditional governmental policy is based on the distribution of public goods provided by the government, new modes of governance establish co-production of public goods whereby different actors (public and private) contribute to public benefits.

Finally, different phases can be identified in the priority-setting process:

- *i)* formation of priorities; and *ii)* implementation of priorities (Salo and Liesiö, 2006).
- *i)* creation of a framework; *ii)* identification and selection of priorities; and *iii)* provisioning the implementation of the chosen priorities (Mahroum *et al.*, 2005).

Priority setting does not end with the definition and establishment of topics or areas of research. Strategies for implementing the selected priorities and establishing the relevant research programmes should be considered concomitantly with the priority-selecting process. Although the priority-setting phase is distinct from the implementation phase, it is important to consider the resources and capacities (knowledge, networks and money) that are available or have to be made available to implement the chosen priorities. These estimations should be a key part of the related strategic plans.

Lessons from the case studies

Different levels of involvement and control

Most of the forms of international STI collaboration investigated feature a principal policy-making organ in which full members hold decision-making powers. This body is also responsible for decisions on research priorities and implementation strategies. When a scientific advisory board exists, it is mainly responsible for developing a scientific research agenda and has limited power. Stakeholders are sometimes involved, in more or less formalised ways, in the definition of programmes and priorities.

Forms of international STI collaboration such as the Group on Earth Observation (GEO), the Joint Programming Initiatives (JPI) or the Consultative Group on International Agricultural Research (CGIAR) try to involve a broad set of stakeholders in priority setting even though they are established and governed by governments or by government-authorised actors that dominate the decision-making bodies and process. Implementation of priorities is dependent on resources made available by members, *e.g.* by aligning national activities or by contributing to a common pot devoted to specific activities/priorities. This of course favours the implementation of priorities formulated and driven by the interests of the main contributors. In some instances this could be detrimental to priorities of common interest.

For instance, the Agriculture, Food Security and Climate Change (FACCE) JPI has applied a "variable geometry approach" which means that not all participating countries need to be involved in specific topics or tasks. This provides opportunities for flexible priority-setting arrangements. However, the principle of variable geometry is quite prone to capture by the interests of powerful and well-endowed actors. An indication of this is the low level of participation of new EU members in proposing themes for the European Commission's JPIs. Similarly, the decisions of GEO, which are the result of an open and bottom-up process involving many governmental actors, are constrained by the support received from national governments. The GEO therefore seems to face the same challenge as JPIs: a flexible approach can favour the interests of powerful and well-endowed actors or states.

Some international agencies have succeeded in counterbalancing the power of their most influential members. The International Atomic Energy Agency (IAEA) and its personnel, for instance, have developed their own strategic interests which they try to pursue along with the interests of members. STI priority setting within the IAEA is therefore conducted "top-down" but is also influenced by IAEA scientists who try to steer priorities away from the often subjective interests of member states. The IAEA also tries to overcome conflicting and diverging national interests by putting on the agenda problems that go beyond solely national interests and are of regional or global importance.

Selection of priorities: broad vs. narrow

In international STI collaborations priorities are often defined very broadly. Broad definitions of priorities ensure that all actors have a chance to recognise their specific interests and that the priorities will have broad legitimacy and support. However, the translation of priorities into specific actions or tasks is challenging as priorities can be implemented in different ways with different orientations. Strategies for and means of implementing priorities should be considered to achieve narrower and operational definitions of the selected priorities.

Challenges for international STI priority setting

One essential characteristic of contemporary global governance is its fragmentation. This means that no central authority has regulatory powers (Messner, 2003; Biermann *et al.*, 2009). Priority setting has to be organised to allow a wide range of societal groups to bring their interests, needs and knowledge to bear on the framing of the agenda and the setting of priorities (Kaul *et al.,* 1999a). However, a large number or diversity of actors and differences in the distribution of power and capacities leads to high transaction costs or even to stalemate. Indeed, broad participation of all relevant stakeholders is often seen

as an obstacle to efficient governance. A trade-off seems to exist between efficiency of governance and participatory or democratic approaches with broad stakeholder involvement.

However, while there are disadvantages to broad participation there are also dangers in modes of governance that involve a small number of actors. These closed or exclusive modes of governance are very vulnerable to capture[2] and likely to act not in the public interest but in the interests of a rather small and powerful group (Mattli and Woods, 2009). For example, strong vested interests are very common in transnational STI collaboration efforts and are basically related to national STI interests. These well-established and strong national STI interests are likely to build biases into deliberative processes on international STI collaboration which need to be overcome. Involving a diversity of stakeholders and balancing the competing interests of diverse actors, countries and regions is therefore a key challenge in setting STI priorities for global collaboration and developing common overall objectives and priorities.

Providing knowledge on the causes of global challenges and on the mutual benefits of co-operation can help to reduce barriers to collaboration. Difficulties in creating a broad consensus through priority-setting processes can arise from differences in the perception of global challenges and of their urgency. Even if they are called global challenges, their causes and effects are not evenly distributed among countries and world regions (Weber, 2007). Even when the causes and effects of global challenges are generally recognised, stakeholders may still hold diverging views on approaches to solutions. One way to mitigate differences in perceptions of the issues would involve the use of the tools of "strategic policy intelligence" (SPI) to the extent possible in the priority-setting process. Quite often, lack of or asymmetrically distributed information hampers evidence-based priority setting. The use of foresight exercises and other SPI tools could facilitate common understanding and consensus building.

Fragmentation, diversity of stakeholders and vested interests also generate information asymmetries. For STI, this is especially relevant in negotiations among policy makers and stakeholders from civil society and from the scientific community, as they rely on different sources of information and have different types and depths of knowledge on the issues involved. In this context the role of scientific evidence and the involvement of experts are particularly important in deliberative processes to establish a common understanding and to reach consensus. As noted by Martin (1999, p. 51), "By changing the informational environment, [institutions] change state strategies in such a way that self-interested states find it easier to cooperate reliably with one another".

Governance options

The challenge of establishing broad stakeholder participation leads to the question of how institutional arrangements for priority setting should be designed to facilitate a balance between competing interests and yet achieve efficiency goals.

Governance scholars point out the need for mechanisms that facilitate broad participation by different stakeholders (Walk, 2007). Due process mechanisms and formal regulation of processes and procedures are a prerequisite for broad participation and inclusion of stakeholders; they also counter unequal distribution of power and resources between stakeholders (Albin, 2003).

It is not sufficient for a deliberative process to be open in principle to all relevant stakeholders. Stakeholders also need to be encouraged to participate and their participation must be actively supported by providing resources and/or information (Kaul *et al.*, 1999b). More equity and enhanced representation by weaker countries and international civil society and organisations will lead to more equitable outcomes.

A combination of bottom-up and top-down approaches reduces the risk of possible biases in priority-setting activities because more actors and interests are involved. Selected priorities should reflect existing research competencies and capacities as well as emerging societal needs and challenges (Salo and Liesiö, 2006). Supply-led and demand-informed approaches for priority setting driven by scientific communities on the one hand and society and policy on the other should not be viewed as mutually exclusive.

Although priority setting is distinct from implementation, it is very important to consider in advance what kinds of resources and capacities (knowledge, networks and funding) will be available or will have to be made available to implement the selected priorities. Priority setting should be closely linked to budgetary issues and negotiations, bearing in mind that the higher the level of resources secured beforehand, and the more equitable the priority-setting process, the more likely its outputs will be relevant to meeting the challenges faced. In short, an effective priority-setting process should:

- Include broad and active participation of relevant stakeholders and support information flows to achieve common understanding and consensus.
- Mix different approaches, such as bottom-up and top-down, supply-led and demand-informed, to avoid possible bias in the selection process.
- Be linked from the outset to budgetary and implementation issues.

9.3. Funding and spending arrangements[3]

Funding and spending are key dimensions of the governance of STI collaborations aimed at meeting global challenges. Funding refers to the way in which actors provide money for a specific STI initiative, while spending refers to the allocation of money for activities, tasks, sub-organisations, etc. The two may be interrelated in funding models in which the funding agreement contains decisions on spending, but this is not necessarily the case. Funding and spending have many intersections with other governance dimensions. For example, funding is closely related to issues of priority setting, and both may have elements relating to intellectual property rights (IPRs), capacity building and so on. A key challenge is to find ways to scale up funding while maintaining accountability, efficiency and co-ordination.

The four aspects of funding and spending discussed here are: *i)* funding models; *ii)* asymmetries and absorptive capacity; *iii)* market and system failures and incentives for private participation; and *iv)* effectiveness and accountability through monitoring and evaluation.

Funding models

Many different funding models are employed in multinational frameworks for STI collaborations.[4] Cultural, economic and political contexts matter, as do the characteristics of the collaborations themselves. Failure to appreciate, for example, the different processes involved in creating new scientific knowledge and supporting innovation is likely to be detrimental to any funding model.

A fundamental aspect of STI funding is the balance between core and project funding. Many organisations involved in international STI collaboration struggle to maintain this balance, as sufficient core funding is often difficult to obtain, while often volatile, in-kind and project contributions make long-term planning difficult. Categories such as "real common pot", "virtual common pot", "mixed mode pot" or "no common pot" (see Table 8.1 in Chapter 8 for a detailed overview of these categories) all have context-dependent advantages and drawbacks. The case studies in Chapters 2 to 8 show that voluntary, in-kind contributions may be useful for securing funds relatively quickly, but may also impede the shaping of coherent long-term strategies. It is crucial to strike a balance between mandatory core funding and allowing for more flexible in-kind and project funding.

The CGIAR has succeeded in establishing a flexible funding mechanism. Financial support for the CGIAR is harmonised through a multi-donor trust fund (the CGIAR Fund) which is intended to serve as a strategic financing facility for multi-year support of CGIAR research. Donors can decide on the use of their funds by allocating them to three "windows": the entire CGIAR programme portfolio as unrestricted funding; specific research programmes that are part of the agreed programme portfolio (programme funding); one or more CGIAR centres. Experience has shown that these three windows provide the flexibility needed to allow donors to fund single activities according to their preferences while maintaining coherence in operations through a certain level of core funding.

Asymmetries between contributors and beneficiaries and in development and absorptive capacity

STI capacities are unevenly distributed across the world, and global challenges affect different nations and regions in different ways. The differences between STI capacity and the effect of global challenges on different communities have to be taken into account when designing STI funding.

Policies of *juste retour* or "fair return" are common in intergovernmental STI activities; they ensure that national governments get a "return" on their STI investments.[5] To ensure sufficient upscaling of the STI funds needed to address global challenges, the principle of fair return must most likely be tempered. An element of "altruism" may be needed, as in the field of global health, where a number of very visible and highly influential foundations support STI activities. Such an approach, coupled with more conventional foreign aid, can be a valuable resource for STI endeavours to address global issues. Moreover, deficiencies in STI funding point to the need for new and more effective institutional frameworks for international STI collaboration.

Currently, a sizeable amount of funding is directed towards research activities in OECD countries, though indicators show that collaborative research between advanced and developing country scientists is rising (Wagner *et al.*, 2001; OECD 2011a). To tackle global challenges effectively will require local capacity and absorptive capacity building in many cases (see the section on capacity building). This may require a better allocation of resources to developing countries and the establishment of close links between STI and development policy. However, there may be tensions between capacity building and efficiency (Wagner *et al.,* 2001). Many collaborative research projects seek to address this issue. It should also be emphasised that technological fixes alone cannot deal with all of the components of global challenges; broader political and social issues may also need to be addressed (Leach and Scoones, 2006).

Market failures and incentives for private participation

STI endeavours are risky and rife with issues of non-appropriability (Arrow, 1962) and information asymmetries; they may therefore suffer from underinvestment. In addition, innovation is a complex social process and can be affected by path dependencies and lock-ins. Innovation theory stresses that innovation takes place within the context of firms, organisations, universities and legal frameworks (Metcalfe, 1995; Smith, 2000). This understanding of the innovation process opens up the possibility of policies to change institutional frameworks through education, IPR regulations, capital markets and regulated industries, which emphasise both competition and co-operation (Lundvall and Borrás, 2005). The funding and spending models represented by the JPI, the CGIAR and the Bill and Melinda Gates Foundation exemplify attempts to change the institutional context and alleviate market and system failures.

The severity of global challenges is arguably too great for the public sector to bear the cost alone.[6] The private sector needs to be engaged to a much greater extent than is currently common, perhaps especially in developing countries where the private sector supports a significantly smaller share of total R&D than in developed countries (OECD, 2009; Marr and Chancellor, 2005). For the private sector to participate in such research, it needs to expect reasonable returns on its investments. Thus issues of demand, access to markets, and legal and institutional frameworks, including IPRs, have to be looked at. It also helps to make opportunities clear to the private sector and to facilitate co-funding schemes.

Among the case studies, the Bill and Melinda Gates Foundation is arguably the organisation that has, in various ways, been the most successful in facilitating co-funding schemes and co-operation by public and private entities. One of the Foundation's prominent characteristics is its attention to public-private partnerships that are able to harvest the resources of a range of public, private and non-profit organisations. By allowing for flexibility in their projects, especially with regard to IPRs and research contracts, the Foundation has been able to make collaborative research initiatives attractive to the private sector.

Effectiveness, accountability, monitoring and evaluation

The high level of private-sector involvement needed to tackle global challenges efficiently raises issues of legitimacy that differ to some extent from those of public actors (Biermann, 2007; Biermann *et al*., 2010). Although the involvement of the private sector can be beneficial in several ways (and can provide a diversity of opinions), the increasing need for privately financed research creates concerns regarding the transfer of more rights and responsibilities to non-state actors. Policies that protect the interests of civil society are needed (Biermann *et al*., 2010; Royal Society, 2011). A balance between accountability and efficiency, as well as between input accountability (related to priorities and influences on them) and output accountability (related to efficiency) must be struck.

The link between funder and recipient can be considered in terms of a principal-agent relationship, as significant authority is delegated from political to scientific actors (Guston, 1996, 2003). Such relationships are often associated with problems of information asymmetries, moral hazard and adverse selection (Van der Meulen, 1998). Monitoring and evaluation can reduce these problems but are also associated with costs which need to be considered. Different organisations use different methods of monitoring and evaluation, including *ex post* and *ex ante* evaluation, peer review and foresight (Hansen Hanne Foss, 2009). Reporting requirements vary from annual reports to milestone project

management. A fair amount of experimentation is most likely needed to find good solutions in each case.

With increased attention to accountability, efficiency and effectiveness in government-led research, monitoring has gained importance in most OECD countries. There has also been a shift from focusing on legitimising past initiatives to improving understanding and establishing better policies for the future (Kuhlmann, 2003). The learning ability of a project is a very important function of monitoring and evaluation. Large differences in monitoring and evaluation practices between countries, together with increasing concern with the link between evaluation and strategy building, offer opportunities for policy learning. Indeed, these differences pose challenges for the organisation of monitoring and evaluation of international co-operation in STI to address global challenges which policy makers need to take into consideration.

Governance options

Some options emerge from the literature and the case studies.

First, there is no single best funding and spending model. On the contrary, solutions seem highly dependent on the context and the global challenge concerned, on asymmetries in capacity, and, not least, on the nature of the collaborative effort (science, technology and/or innovation). Structural arrangements need to be flexible enough to be adapted as experience accumulates and circumstances change.

Second, the balance between core and project funding appears to be a fundamental issue for international STI funding. An appropriate balance is needed to allow for flexible approaches and to reach solutions that most often involve various trade-offs, for example between inclusiveness and efficiency in the priority-setting process or between broad accountability and efficient decision making, and to reduce endowment asymmetries.

Finally, questions of funding and spending for STI collaboration cannot be viewed in isolation. They need to be better integrated in discussions regarding the other governance dimensions in order to facilitate implementation.

9.4. Knowledge sharing and intellectual property: The international collaborative framework[7]

Intellectual property rights (IPRs) influence innovation and play an important role in diffusing knowledge and creating value (OECD, 2010b, p. 147). For example, they encourage investment in research and development (R&D) by enabling firms to recover investment costs. They may also stimulate the transfer of technologies that foster local innovation (Cavazos Cepeda *et al*., 2010; Park and Lippoldt, 2008).

However, IPRs that give owners exclusive rights may restrict timely innovative activities to address global challenges. For example, in drug development for neglected infectious diseases, an area with little funding, small markets and low levels of interest for owners of IPRs, patent laws do not help to stimulate further R&D. In such areas, it is especially important for researchers to maintain access to research data, tools and research with intellectual property (IP) protection. Circulation of knowledge is critical.

This section discusses international IP frameworks and the development of international collaborative frameworks and includes: *i)* an overview of international IP frameworks for each of the global challenges addressed; *ii)* concepts of collaboration and potential models

for IP sharing; and *iii)* examples from the case studies. It concludes by proposing governance options.

International IP frameworks and issues for global challenges

IP and its ownership and protection affect R&D that is relevant to global challenges. International IP frameworks are governed by conventions and treaties, but national IP legislation varies and the role of IP varies in different sectors and industries. The range of types of IPRs and the diversity of stakeholders and interests create challenges for designing effective IP frameworks that facilitate international collaboration and help to address global challenges.

International IP frameworks

Currently, members of the World Trade Organization (WTO) must implement the minimum standard of IP protection specified by the Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPS Agreement). Under this agreement, IP laws protect different types of intangible knowledge: patents, copyrights, trademarks, designs and trade secrets. For example, in wind-power technology, IPRs may include a patent for the wind turbine, a copyright for software related to aerodynamics, generators and blade controllers, a design for the appearance of the turbine, and a registered trademark for the brand. In addition, the manufacturing process is covered by the concept of trade secret (undisclosed commercial information).

There is no single approach to IPRs and global challenges. The role of patents and their monopoly effects differ depending on the industry, technology and products. Even within a single industry, such as the energy industry, the role of patents differs depending on the technology, from solar photovoltaic to biofuel to wind. The following illustrates some of the challenges and tensions created by current IP legislation in terms of global challenges: access to medicines, especially drugs for neglected diseases and generic pharmaceuticals; green technologies, including biofuels and renewable energy; and food security innovations such as protection of plant varieties and genetically modified crops.

International collaborative frameworks

Addressing global challenges requires frameworks and mechanisms to enable access to protected IP. IPRs are sometimes considered a barrier to international STI collaboration, as they exclude other parties from using IP-protected knowledge and exclusive rights. However, once IPRs are licensed, that knowledge can be used in several places simultaneously. Information sharing, technology transfer, and co-operation and collaboration are strategies to enhance research and innovation to address global challenges.

Some important trends in innovation processes may result in new IP management. As innovation processes and strategies became more open, the term "open innovation" was coined (Chesbrough, 2003). The shift toward openness requires more open IP management (*e.g.* licensing in from external sources, licensing out unused technologies) as opposed to keeping IPRs to defend against competition. In addition, not only firms but also individual consumers are increasingly able to innovate (von Hippel, 2005). Innovative end users often openly reveal their proprietary information to the public, and the information becomes a public good (Harhoff *et al.*, 2003). In light of such trends, owners of IP restrict the use of their IP-protected information less and think about "what is best kept private and what is best freely revealed" (von Hippel, 2005, p. 117).

Some frameworks for international collaboration exist and illustrate strategies for making information on IP (*e.g.* owners, specifications, duration of rights, databases, etc.) and IPRs accessible. Patent offices, which catalogue and register IPRs, are one potential resource. IP licensing practices can be encouraged by reducing transaction costs, as is done through some databases. Multilateral collaboration mechanisms are in use in a few places, and there are experiments in open access.

Using patent offices to make IPR information accessible

IP information is first collected at national and regional patent offices, which have the resources and capacity to help accelerate registration and make information publicly available. Quellette (forthcoming, 2012) recently analysed the usefulness of disclosure requirements for patents in the life sciences.

For technologies in the area of climate change, the US Patent and Trademark Office's (USPTO's) accelerated registration programme, the Green Technology Pilot Program, is considered useful. Tran (2011) recently proposed making the Green Technology Pilot Program permanent in order to promote innovation and commercialisation of these technologies. In addition, the global online libraries – the European Patent Office's (EPO) "Espacenet" and Korea's Green IP project – demonstrate the effective use of patent offices for making IP information accessible.

Reducing transaction costs for IP licensing practices

Reducing transaction costs is important for enhancing technology transfer. The OECD, together with the EPO and the University of Tokyo, conducted a survey on the licensing out of patents (Pluvia Zuniga and Guellec, 2009). The survey identified the difficulty many companies face when they want to license their patents: the inability to identify potential licensees and partners. The most effective transfer requires a "package" of three components: IP information, relevant know-how and guidance for implementing the technology. Each component has associated costs, and the challenge in enhancing the attractiveness of technology transfer is to find ways to provide all three components in a cost-effective manner.

Using multilateral collaborative mechanisms

Collaborative mechanisms – patent pools, clearinghouses, consortiums and joint ventures – all have their advantages. Among these multilateral collaborative mechanisms, consortiums and joint ventures have the advantage of sharing goals and strategies among the partners. In addition, they take a relatively shorter time from planning and launching the project to producing results.

Patent pools with a clear philanthropic purpose have been established in the health and agriculture fields (Box 9.1). Well-tailored pools can serve economic and social goals such as public health and food security. However, patent pools have two drawbacks: potentially long timeframes for setting them up and challenges for putting the products on the market. The SARS and the Golden Rice patent pools illustrate these shortcomings. R&D initiatives such as patent pools take more time to establish than bilateral technology transfer but can make a significant impact when they are led and governed openly and efficiently. The patent pool framework is also important in the green technology area, as a means of creating a technology standard in industry, for example, for the receptacles used to charge electric vehicles.

Box 9.1. Collaborative mechanisms: Patent pools

A patent pool is an agreement between two or more patent owners to license one or more patents essential to a specific area of technology. Patents are licensed to third parties on a non-exclusive basis with a royalty payment, which is then distributed among the pool's patent owners. Licence agreements are generally administered by an independent entity as licensing agency. In the past, patent pools emerged for the aircraft industry, the electronics and telecommunication industries, the moving picture expert group, DVD-Video, DVD ROM, and third-generation mobile communication systems.

Patent pools have been often used to prevent some patent holders from preventing the development of new products or to establish a common technological standard for an industry. A more recent type of pool aims at overcoming transaction costs in order to serve public, rather than commercial, interests. Such patent pools with a clear philanthropic approach are more applicable in the life sciences (OECD, 2011b, Chapter 3), and ensure that particular products are made available on a not-for-profit basis. The following are examples of this type of patent pools.

Medicines Patent Pool for HIV medicines

The Medicines Patent Pool was established with the support of UNITAID in July 2010. It is the first patent pool aiming to make HIV medicines more affordable in developing countries and to facilitate the development of new medicines, including formulations for children. The original concept was proposed by the Consumer Project on Technology (currently Knowledge Ecology International, KEI) at the International AIDS Conference in Barcelona in 2002. In 2006, together with Médecins Sans Frontières, KEI proposed to UNITAID a patent pool for medicines. In 2008, the World Health Assembly at the World Health Organization (WHO) agreed that the pool was a feasible mechanism to accelerate the availability of low-cost newer medicines in developing countries. UNITAID's board decided to explore the possibility of a patent pool and, in December 2009, agreed to create the Medicines Patent Pool. UNITAID provides the funding for the pool.

The pool is a "one-stop shop" for patent holders and manufacturers of generic drugs. Multiple patents are "pooled" and licensed out by one entity in order to reduce transaction costs for all parties involved. Not only will the pool help speed up the process of providing urgently needed newer and improved HIV medicines at much more affordable prices, it will also foster the development of needed products that do not yet exist, such as certain fixed-dose combination pills containing two or more newer medicines in one pill. In 2011, the WHO expert committee on essential medicines endorsed a list of missing fixed-dose combinations submitted by the Medicines Patent Pool, UNITAID and WHO (WHO, 2011).

An attempt at a SARS patent pool

In response to the outbreak of severe acute respiratory syndrome (SARS), a network of laboratories set up by the WHO isolated the causative virus and the sequenced its genome (Verbeure *et al.*, 2006). The WHO set up a SARS consultation group, which proposed "that a strategy be developed, in consultation with stakeholders, to address potential SARS corona virus related intellectual property issues and, thus, enhance development of intervention approaches". The WHO SARS Consultation Group created an IP working group, which proposed in 2005 the pooling of all relevant patents in order to make SARS vaccine and treatments available in the event of a future pandemic.

The relevant parties have been identified, and an agreement of principle has been signed. However, the proposed SARS patent pool is not yet operating. Establishing patent pools in multinational settings is a long process; the Medicines Patent Pool took almost eight years to launch. When the relevant parties have signed a full agreement, the patent pool will be set up in the United States, followed by efforts to set up similar SARS pools elsewhere (Simon *et al.*, 2005).

Golden Rice Humanitarian Project

One of the most noted examples of humanitarian IP management involves vitamin A-enriched "golden rice". The Golden Rice project aimed at producing genetically modified "golden rice" in order to combat vitamin A deficiency. According to the WHO, vitamin A deficiency causes night blindness and overall blindness, and increases anaemia and risk of infection (WHO, 2009). The programme was developed mainly with public-sector funding and research, and approximately 30 companies and public institutions (universities) provided around 45 patents associated with golden rice.

…/…

Box 9.1. Collaborative mechanisms: Patent pools *(cont'd)*

Access to IPRs was achieved in 2000. The key patent holders gathered and agreed to create a public-private partnership between the inventors and the agrichemicals company AstraZeneca (now Syngenta). The partnership facilitated access to a number of key technologies in the field of biotechnology and allowed the current Golden Rice Organization to grant licences, free of charge, to developing countries, with the right to sub-licences. The rice is expected to receive regulatory approval in the Philippines in 2013 and in Bangladesh in 2015 (Nayar, 2011). This example shows that even after the patent pool has been established, it may be many years before a product reaches the market.

Compared to patent pools, clearinghouses offer more flexibility and less formality. They are also easier and less costly to set up and generally require less administration. They provide a particularly useful mechanism if the IP covers the upstream technologies needed to develop future products (OECD, 2010b). In 2011, The World Intellectual Property Organization (WIPO), in co-operation with BIO Ventures for Global Health, launched "WIPO Re:Search", a clearinghouse for sharing IP and know-how in order to seek new treatments for neglected tropical diseases. However, clearinghouses work well only if the receiving parties identify their needs and participate in the search for the best way to obtain the needed technology.

Open access

Lastly, making research results available through private open-access initiatives such as the Glaxo SmithKline Open Lab or through national policy increases the potential for further research. Scientific progress requires the sharing of information – a commons of data, ideas and insights. In 2007 the OECD introduced guidelines to facilitate access to research from public funding (OECD, 2007). In 2009 a number of countries reported they were now adopting free-access policies for government databases.

Examples from the case studies

Some efforts are being made to establish international collaborative frameworks that make IP information accessible. The case studies illustrate some initiatives for sharing knowledge through licensing policy, patent pools and open data exchange.

Benefit sharing through licensing

The Global Carbon Capture and Storage Institute (Global CCS Institute) and the IAEA both have licensing policies that provide free access to IP-protected knowledge; however, in both cases, their free-access policy applies only to collaborators. For instance, partners of the Global CCS Institute can obtain IPRs resulting from their activities; however the IPRs are also to be made widely accessible to the members of the institute.

By contrast, the International Energy Agency (IEA) does not set any specific conditions on IPR ownership by its collaborators or project participants. IEA implementing agreements (IAs) have adopted a variety of arrangements and the Implementing Agreement Framework affords significant flexibility.

Collaborative mechanism: patent pools

The CGIAR uses patent pools as a collaborative mechanism. The case study shows that the CGIAR aims to "produce public goods at regional or global level" (Chapter 2). The CGIAR plays a major role in collecting, characterising and conserving plant genetic resources. The CGIAR's 15 international agricultural research centres maintain over 650 000 samples of crop, forage and agroforestry genetic resources in the public domain. The CGIAR gene banks hold in trust the genetic material of this vast number of food and agriculture crops, and the material is freely available.

Open data initiatives

The case studies introduce some open data initiatives. For example, the Group on Earth Observations, an international partnership, implements the principle of "full and open exchange of data". Its collection of data, the GEOSS Data Collection of Open Resource for Everyone, is an easily accessible pool of datasets and allows full and unrestricted access. Similarly, the Inter-American Institute for Global Change Research (IAI) aims to improve full and open exchange of scientific information and ensures free access to data generated by IAI-funded projects.

Governance options

The current and most widely accepted argument for IP protection is that the ability to exclude others from using protected knowledge creates incentives to invest in R&D and helps create opportunities for innovation. However, this argument needs to be reconsidered when effective and timely innovative actions are required and when innovation processes are becoming more open. Managing IPRs is critical for creating conditions for collaboration, because IPRs exclude other users from accessing and using the proprietary knowledge.

Sharing the benefits of IPRs in the context of STI collaboration to address global challenges could be promoted in the following four ways: *i)* using national authorities such as patent offices as a framework for sharing information on IP; *ii)* reducing the transaction costs associated with IP licensing; *iii)* establishing multilateral collaborative mechanisms; and *iv)* instituting open access policies.

Developing effective management strategies for IP resulting from research collaborations largely depends on learning how to respond to different configurations of influential factors: types of IPRs, sizes of private companies, sizes of sectors and public research organisations. Although IP legislation applies the same basic principles to all industries, intermediary markets for IP-protected knowledge can create flexible mechanisms that suit particular fields and stakeholders and thus facilitate beneficial IP exchange among different stakeholders.

Most collaborations relating to global challenges are promoted with the involvement of the public sector. Policy makers have an important role to play in helping to initiate and facilitate beneficial IP exchanges to create conditions for innovation. The broad concept of producing freely accessible "public goods" could be advanced through public policy regarding global challenges. Policy makers need to facilitate such open and flexible mechanisms for areas requiring effective and timely innovative efforts:

- They can lead open access initiatives by identifying the general framework and providing the initial funding for setting up such initiatives.
- They can bring together a wide range of players in the public and private sectors to set up collaborative IP mechanisms for creating efficiencies in the exchange of IP and for clearing IP blocks (*e.g.* through knowledge networks, open innovation). Policy makers need to encourage the private sector to work for the public interest.
- They can act as anti-trust authorities by examining the governance of IP transactions and patent pools with respect to competition and anti-trust laws.

9.5. Putting STI into practice: The need to bridge research and practice[8]

The process of transferring knowledge into action or practice is commonly referred to as "knowledge transfer" or "knowledge translation". It is broadly understood to encompass the exchange, synthesis and application of research results and other evidence between academic and practical settings (Graham *et al.*, 2006). This requires collaborative arrangements that combine the nature of the problem to be solved and the system of inquiry used to acquire and process information (Caplan, 1979). The academic literature stresses the importance of exchange of knowledge, "conceived as a virtuous circle of multiple-track engagement between knowledge producers (typically scientists, but potentially all academics) and knowledge users (typically policy makers, practitioners, stakeholders, businesses, social enterprises and others) so that the boundaries between the producers and users ultimately become merged*"* (Hagen, 2008, p. 113).

Using an "interactive model" rather than a "linear model" as the framework for the exchange of knowledge between research users and producers (Best and Holmes, 2010) implies complex interactions between researchers and users. The more sustained and intense the interaction between researchers and users, the more likely the research results will be used (Landry *et al.*, 2001).

The failure to translate research results into practice occurs often, but it is especially serious when it relates to global challenges. Multilateral STI collaborations are crucial for meeting global challenges, but to be fully effective, the means of delivering results is extremely important. This section stresses the need to consider four important dimensions of the effective bridging of research and practice. The first is communication throughout user and producer interactions so that practice will be informed by available knowledge. The second is brokering and thus facilitating at the individual level the hatching of knowledge brokers, and at the organisational level the creation of a "boundary organisation"[9] to improve communication, translation and diffusion of research results among all of a project's stakeholders. The third is training of STI producers and users, and more generally, actors of the knowledge-to-action process, to exchange knowledge. The fourth is to identify the relevant knowledge producers and knowledge users and bring them together in a comprehensive and communication-rich network.

Communication: Inclusive communication among stakeholders

Studies on international co-operation have shown that effectiveness suffers when communication fails to take place. For example, experts may assume, erroneously, that decision makers want a certain kind of information, or decision makers may assume that experts can readily furnish the information they want (Cash *et al.*, 2003). Successful STI research collaboration requires active, iterative and inclusive communication among experts, decision makers and end-users. Indeed, many communication channels have to

be open to resolve the fundamental tension that arises for scientists and decision makers when science enters the policy arena: maintaining scientific credibility while ensuring political importance (Jasanoff, 1987).

The ability to mobilise knowledge for action is also hampered when communication is infrequent or takes place only at the outset of a project. Furthermore, effectiveness declines when stakeholders from either the expert or decision-making communities see themselves as excluded from discussions about the mobilisation of knowledge. Excluded parties often question the legitimacy of information emerging from such discussions, regardless of the information's credibility (Cash *et al*., 2003).

The IEA IAs appear to have created successful mechanisms for fostering multilateral communication of research results and information related to energy issues. These mechanisms take many forms. Collaboration and communication among IAs is fostered by the IEA Secretariat, which hosts co-ordination meetings for the different end-use sectors: buildings, electricity, industry and transport. Moreover, some IAs have created national teams or regularly scheduled meetings to address communication and co-ordination issues at the national level, and some have dedicated positions (such as a technical co-ordinator to facilitate communication with external stakeholders, see Chapter 7) charged with co-ordinating IA activities and outreach. Such initiatives appear to be conducive to better communication of research results through co-ordination activities, exchange of information and best practices, and the building of a community of practice.

Translation: The role of knowledge brokers

While putting knowledge into practice requires open channels of communication between experts, decision makers and end-users, it also requires the involvement of participants in discussions to understand each other. However, mutual understanding is often hindered by jargon, language, training, expectations and experience. The breaking down of such communication barriers is increasingly ensured by specific actors, called "knowledge brokers". Knowledge brokering encompasses "all the activity that links decision makers with researchers, facilitating their interaction so that they are able to better understand each other's goals and professional cultures, influence each other's work, forge new partnerships, and promote the use of research-based evidence in decision-making" (Lomas, 2007, p. 131; Canadian Health Services Research Foundation, 2003; CHSRF, 2003). The knowledge broker is an intermediary between users and scientists, and is fluent in both worlds.

Brokers have been very successful in the Pacific El Niño/Southern Oscillation Applications Center (PEAC) where they have worked with climate knowledge producers (at the university) and users (often public officials) to increase the usability of seasonal climate forecasting in planning and decision making. For instance, PEAC devised mechanisms to produce forecasts in which final outputs used language that would be readily understood by target audiences. In this case, studies showed that the language of historical analogy was more understandable than the language of probabilities. PEAC used scientists proficient in both languages who could translate between them and identified the most effective language (Cash *et al.*, 2003, 2006).

Knowledge brokering activities can involve either individuals or organisations. Their central role in the knowledge translation process suggests the need to encourage the education and training of professionals who are at least literate but ideally fluent in the contexts of both knowledge production and use (Jacobs *et al.*, 2005). At the organisational

level, the "boundary organisations" play the role of broker. These organisations operate in a dynamic environment, attempting to strengthen linkages between science and policy by facilitating a two-way flow of information.

Empowering people: Training producers/users to transfer knowledge

Knowledge transfer activities are not necessarily the primary focus of researchers, while policy experts and practitioners are not necessarily sensitive to research results. The expectations of policy makers, practitioners and scientists are usually very different, owing to difference in their cultural settings and institutional constraints. Culturally, scientists rely on rigorous analysis of facts and data sets, while policy makers look for the best available information at the time, ideally in a well-packaged, easily applied format. This suggests the need to train producers and users in knowledge transfer as a requirement for the successful exchange of information or knowledge between scientists and policy makers, and more generally, end users.

A successful example is found in an initiative launched by the Inter-American Institute for Global Change Research (IAI). In 1999, it launched its interdisciplinary training institutes to promote the human dimensions of environmental change and the consequent need for a science–policy interface to ensure that relevant scientific findings are accessible to and usable by policy makers. Their success in fostering communication between natural and social scientists and promoting multinational and multidisciplinary collaboration led the IAI to plan further institutes.

International STI networks and communities

In the management literature, networks are regarded as the emerging organisational mode in environments of complex technologies and rapid technological change. In science- and technology-based fields, the advantages of diverse sources of information and resources are considerable. Not surprisingly, as the commercialisation of knowledge has assumed greater importance in economic growth, collaboration across organisational boundaries has become more commonplace. Inter-organisational networks allow organisations to pool or exchange resources and jointly develop new ideas and skills. In fields where scientific or technological progress is developing rapidly, and the sources of knowledge are widely distributed, no single organisation has all the necessary skills to comprehend and put to use all areas of progress and bring innovations to market (Powell and Grodal, 2005). Networks also play an important role in mediating different views among collaborating partners.

Networks are constituted not only by organisations but also by actors who are a part of a community or engaged in a community activity. Science policy and management scholars have identified two types of communities. Based on the work of Hass (1991), Court and Young (2004) describe how epistemic communities − colleagues who share a similar approach or a similar position on an issue and maintain contact with each other across their various locations and fields − create new channels for information and discussing new perspectives. From the management science perspective, communities of practice (CoP) have been identified as a key factor in the learning process. According to Oborn *et al.* (2010, p. 10), "Brown and Duguid (1991) develop the idea of evolving CoP to account for organizational interactions that take place between fluid and interpretative groups as opposed to bounded individuals."

To produce good results, international networks formed to put STI into practice must integrate the various types of communities concerned and offer them a permanent platform for interaction. Cohesion across national and cultural borders can be created through the sharing of scientific expertise within the community, constantly updated in conferences, workshops, etc., and a common understanding of the need to act and of the general direction of the required action. Well-functioning epistemic communities can influence policy making in all countries involved, provided that their members are linked not only internationally, but also to their home governments.[10]

The leadership dimension

Nevertheless, spontaneously organised networks of individuals, organisations or communities are only one aspect of successful governance of international STI collaboration. Another key element of efficient translation of STI into practice at the global level is leadership to co-ordinate the activities that will put research into practice. In most of the cases presented in this volume, the organisation did not have an explicit leadership role but played a supportive role, often directed at horizontal co-operation at a given stage of the knowledge cycle process. An exception is the CGIAR, according to its mission statement as redefined in December 2009: "To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership *and leadership*." The same is true to some extent of the IAEA, whose "core organisational principle is related to *global leadership* in one specific discipline (atomic energy and related technologies) that can be used for different purposes" (CGIAR, 2010) although it does not focus on a given global challenge.

The diversity of actors involved in putting STI into practice, combined with the need to draw on local, dispersed and often independent practitioners, points to the necessity of clearly attributing leadership or a mandate to an existing or *ad hoc* institution and empowering it for building and fostering networks. The comprehensiveness and responsiveness of the concerned networks will be crucial for the time needed for putting research into practice to address global challenges.

Governance options

The literature review clearly points to a knowledge-to-action cycle, an interactive and multidirectional process involving many different actors and activities. The case studies highlight that the main organisational pitfalls of existing institutions that address global challenges are: *i)* missing or dysfunctional links at critical points of the process; and *ii)* the lack of a clearly identified leader in charge of building and activating the network of stakeholders. Putting STI more effectively into practice to address global challenges would thus require:

- Identifying relevant knowledge producers (epistemic communities) and knowledge users (communities of practice, policy makers) to bring them together in a comprehensive and dynamic network that is active at all of the stages of research.
- Enhancing communication throughout the network so that practice is informed by available knowledge and knowledge gaps in STI can be identified and addressed.
- Facilitating at the individual level the development of knowledge brokers and at the organisational level the creation of "boundary organisations" to enhance the communication, translation and diffusion of research results among all of a project's stakeholders.

- Training STI producers and users, and more generally actors in the knowledge-to-action process, to exchange knowledge.

9.6. STI capacity building[11]

Global challenges by definition do not stop at national borders; they have an impact on all countries. In many instances, such as infectious diseases or the effects of climate change, negative consequences are more acute in developing countries. Comprehensive solutions to global challenges require a co-ordinated international response, but also require all partners to help find scientific and technological solutions in their own communities and geographical regions. Efforts are needed to: *i)* improve STI capacities in a multidisciplinary global context; and *ii)* ensure that STI capacities are linked to societal needs and national development goals. Attention should focus not only on how much STI is produced, but also on how STI can be assimilated and put to use in local contexts. This section first considers the characterisation of capacity building. It then looks at how the multiple aspects of STI can be used to understand and support capacity building. Next, important elements arising from the case studies are presented, followed by some governance options.

"Broad" vs. "narrow" view

Despite the enthusiasm for and wide use of the concept of capacity building, there is little empirical evidence on its scope and influence (World Bank, 2009) and little agreement on ways to identify and measure the capacity-building process. This makes it difficult to assess capacity gaps between partners and evaluate the impacts of capacity-building programmes (Duane, 2007). Nevertheless, the literature differentiates several levels of capacity building: the individual level, the organisational and community level, and the national and institutional level. Young and Kannemeyer (2001) have shown that the main approaches to capacity building are networking, training, research partnership and institution building.

To understand the different rationales behind STI collaborations and their effects on capacity building it is useful to distinguish between a "narrow" and a "broad" STI co-operation paradigm (Boekholt *et al*., 2009). The former puts a priority on achieving research excellence, with a focus on building scientific and technological capacities *stricto sensu*. The latter has scientific and non-scientific objectives in order to reach broad policy goals and tackle societal challenges. Although the "narrow" mode predominates in international research collaborations, the urgency of global challenges calls for a "broader" approach to international STI collaborations. This requires combining scientific and broader sources of knowledge and reconsideration of the role of partners from developing countries.

In the "narrow" paradigm, one of the goals of scientific research collaboration is the realisation of "state of the art" research, and this was a goal of all of the case studies in this volume. However, too exclusive a focus on scientific capacities entails the risk of a linear, mechanistic interpretation of the relations between advanced economies – generally the suppliers of research – and developing countries – the recipients. It is now realised that while it is important to produce "state of the art" research, its integration and interaction with other sources of knowledge in a sector or country are equally crucial (Hall and Dijkman, 2006).

Traditional support for STI capacity building is similar to technical assistance, with the provision of either training or hardware (Horton *et al.*, 2003). While there has been much progress in the last decades in several sectors, the limitations of an approach based solely on technical assistance and scientific capacities have often been stressed (WBI, 2006). There is a need for a more systemic approach, a "broad" paradigm involving broader sources of knowledge and interactions among a wide range of stakeholders (universities, firms, farmers, government organisations, etc.) through which individuals and organisations learn, put new ways of working to use, and open up new technological pathways (Klerkx *et al.*, 2009; Lundvall *et al.*, 2009). This socioeconomic and institutional context is constantly changing, and capacity building also needs to evolve as the context and the needs change.

Addressing the multiple dimensions of STI capacities

Building STI capacities is by definition a multidimensional process encompassing science, technology and innovation. Most practical approaches to capacity building remain largely focused on scientific capacities in developing countries. While these investments are essential, capacity building also involves strengthening many skills and activities, including the ability to search for, select and use existing scientific and technological knowledge and products and the ability to develop new solutions or innovate through the combination of different types of knowledge. To this end, developing countries should be seen as dynamic partners and should be helped in their efforts to strengthen their local system of innovation.

This is now happening. In particular, the BRIICS economies (Brazil, the Russian Federation, India, Indonesia, the People's Republic of China, South Africa) are becoming important partners in scientific and innovation networks (OECD, 2011a). In their case, there is a visible shift from unidirectional transfers of knowledge and technology – from advanced to developing countries – towards joint investments, reciprocity and a search for mutual interests (Cornwall and Eade, 2010). The evidence shows that collaborative research between scientists in advanced and developing countries is increasing, and that these activities are building advanced scientific capacity in participating countries (Wagner *et al*., 2001; Strigl, 2007; Wagner, 2008). The success of a few emerging economies should nonetheless not hide the fact that developing countries are at a clear scientific and technical disadvantage in terms of trained scientists, number of scientific publications and patents, and investment in R&D (UNESCO, 2010).

Meeting global challenges requires not only scientific progress, but also the successful application of new technologies. However, technology diffusion and adoption appear to require substantial and well-directed technological efforts (Lall, 2001). For example, science and technology promotion by the government played an important role in the promotion of economic growth and industrialisation in Japan and later in many successful East Asian economies (Amsden and Hikino, 1993).

As developing countries build up their domestic scientific and technological capacities, they become better able to access, assess, use and assimilate foreign technologies. Cohen and Levinthal (1989, 1990) proposed the notion of "absorptive capacity" to refer to a firm's ability to utilise outside knowledge efficiently. They argued that this capacity is a function of the firm's own investment in R&D. For Lim (2006) absorptive capacity is primarily a function of the connectedness of a firm's scientists to counterparts outside the firm. This suggests the need for active involvement in scientific and technological networks. This concept has entered the literature on developing countries (Criscuolo and

Narula, 2002; Zahra and George, 2002). Authors generally agree that absorptive capacity is critical and that it is important for developing countries to build their absorptive capacities by focusing on exploiting existing technologies. In practice however, this is almost exclusively associated with a narrow view of STI linked to the accumulation of human capital and infrastructure building.

Innovative capacity refers to the ability to develop alternative solutions to existing problems by combining a variety of knowledge sources. Innovation takes place in productive enterprises (*i.e.* firms and farms) but also in other organisational and institutional structures. A focus on innovative capacities highlights the importance of combining different types of knowledge through networking, interactive learning and collaboration (Lundvall, 1992; Edquist, 1997). Strengthening innovative capacities requires proactive and committed partnerships among multiple actors with a view to the accumulation of scientific knowledge, the absorption of existing technologies, and solutions based on new combinations of knowledge. This last element is crucial, as recent work has shown that technology acquisition is more effective when coupled with domestic innovation (Marin and Bell, 2006; Marin and Sasidharan, 2008). Building innovative capacities requires effective partnerships and inclusive, collaborative networks as well as shared infrastructures, not only physical but also digital and institutional.

Lessons from the case studies

Nature of capacity-building efforts

Capacity building is a core mission for three of the organisations studied in this volume: GEO, CGIAR and IAI. GEO made capacity building one of its strategic goals. It intends to "build the capacity of individuals, institutions and infrastructures to benefit from and contribute to Global Earth Observation System of Systems (GEOSS), particularly in developing countries" (GEO, 2009). Capacity building has been explicitly recognised in the GEO structure from its inception, and has a clear and well-defined strategy and target. The GEO has designated a Capacity Building Committee to strengthen the capacities of all members. Similarly, CGIAR allocates about 20% of its budget to fund capacity building and technology transfer. The IAI has closely coupled its efforts to support interdisciplinary, collaborative research with the goal of building scientific capacity throughout the Americas. To this end, the IAI developed new ways to integrate different institutional, programmatic, financial, educational and scientific objectives, and it has assigned two of its 13 staff to manage capacity building. For the other organisations studied, however, capacity building is not an explicit goal. They pursue the advancement of scientific research in terms of equal contributions rather than assisting partners with lower STI capacities.

Nevertheless, in the majority of organisations described in the case studies, developed and developing countries collaborate on topics of mutual interest. These collaborations do not always take into account the weaker STI capacities of less developed countries. A notable exception is the CGIAR's research centres which conduct adaptive research tailored to local agricultural conditions. In other instances (*e.g.* the IAEA), the participation of developing countries has depended on their ability to contribute to the task. From the case studies, it emerges that differences in partners' scientific and technological capacities were often viewed as an obstacle to research of a high standard. This view of the need for "equal capacities" in order to deliver high-quality research gives a clear advantage to middle-income countries. It puts low-income developing countries at a clear disadvantage and could lead to further marginalisation. More importantly, perhaps, this method, based on the "narrow" paradigm defined above, is bound to miss possibilities for

interactive learning and exchange of different types of knowledge that are crucial to tackle the complexity of global challenges.

Types of capacity building

The most frequently used channel for capacity building is the training of scientists and researchers, followed closely by technology transfer. Almost all initiatives mention training scientists as a key element in their strategy. For instance, training and education activities are a core mission of the IAI. Over the last ten years, it has supported thousands of students and professionals, through fellowships, workshops and research opportunities. But, with the exception of CGIAR and IAI, the strengthening of local institutions to ensure the assimilation and adaptation of foreign science and technology has been infrequent.

All seven initiatives described in the case studies pursue high-quality, "state of the art" research. As the impacts of global challenges expand beyond the domain of pure science, the need for interdisciplinary, problem-centred, multi-stakeholder research becomes apparent. The mixing of participants from various disciplines and different backgrounds is critical to address both geographic and disciplinary cross-border issues related to global challenges. In that direction, the IAI has built global environmental networks in the Americas involving social and natural scientists, institutional and local decision makers to build trust and common understanding and facilitate collaboration. Other initiatives also understand the importance of broader participation of stakeholders. Indeed, partnering with a wide range of beneficiaries and stakeholders seems to generate a demand for capacities to meet the needs created by the STI gap in developing countries. In general, however, all of the initiatives appear to pay insufficient attention to inter-disciplinarity.

Lack of vision and leadership

The evidence from the case studies in this volume suggests that in many cases the selection of tools for capacity building is done on an *ad hoc* basis rather than as the result of a well-structured strategy. For capacity building to be successful, it needs to be relevant to the country and situation to which it is directed. In this respect, developing countries must determine and drive activities from conception to implementation to evaluation. The European and Developing Countries Clinical Trials Partnership (EDCTP) is an example of good practice in the area of capacity building through international co-operation to address global challenges (Mattee *et al.*, 2009; Zumla *et al.*, 2010). It includes elements favouring a more equal partnership among partners by including recipient countries in the decision process. It shows, as well, that mainstreaming capacity building is an important element in the success of international co-operation involving participants with different capacities, and that the integration of regional research networks in the priority-setting process, together with consideration for demand-led capacity building, leads to successful results (Box 9.2).

Box 9.2. A true partnership: The EDCTP

The European and Developing Countries Clinical Trials Partnership (EDCTP) was founded in 2003 by the European Parliament and Council. It is a partnership of 14 European Union (EU) member states, Norway, Switzerland, and 43 developing countries, and was formed to fund acceleration of new clinical trial interventions in the sub-Saharan African region.

The EDCTP capacity building strategy in Africa is unique, as it offers full support only to African scientists, promotes African ownership of projects, and receives backing from regional networks of excellence in sub-Saharan Africa. It receives scientific advice from the Partnership Board, half of whose membership is African. Research networks are pursued among research institutions with complementary research expertise that provide training and mentorship to less endowed centres in their regions to bring them to the level at which they can participate more effectively in multi-centre clinical trials. This will provide a good working environment for health research scientists and help to retain them in Africa. In addition, the insistence on stronger institutions building capacity in less endowed ones within the clinical trials has helped to ensure that there is equitable distribution of funds for capacity building in Africa.

Source: Matee *et al.* (2009).

Governance options

From the literature and the case studies, it appears that capacity building involves more than strengthening individual capacities to conduct scientific research. It also involves support for many skills and activities, including elements of the ability to search for, select and use scientific and technological knowledge and products; the ability to develop the means to improve existing scientific and technological knowledge to address local needs; the development of structures and partnerships to build domestic innovation capacities; and the management and governance experience necessary to organise and manage international co-operation among partners with different levels of STI capacities. Given this, effective capacity building should formulate explicit targets, goals and ways to measure the results. Greater effectiveness could be achieved through:

- A shift in emphasis from one-way technology transfer and scientific training to participatory learning and capacity building.
- A reassessment of the current approach focused on producing "state of the art" research to include the establishment of mechanisms for STI initiatives to be more closely linked to local needs and stakeholder demands.
- The active engagement of recipients in the conception, implementation and evaluation of capacity-building activities that directly concern them.

9.7. Conclusion

Despite the urgency of many global challenges, some of which are the subject of the case studies, there is no single, coherent governance mechanism for dealing with the issues they raise. They present a complex picture and show the need to deal with specific situations and environmental factors. This does not mean that there are no common themes, best practices or necessary conditions for success. The case studies and the review of the literature indicate some recurrent themes and dimensions that appear to shape the environment for STI and make it more favourable to co-ordinated efforts for tackling global problems.

At the outset, a comprehensive vision will increase the likelihood of successful international collaboration. Priority setting should therefore be closely linked to budgetary issues and negotiations, while greater representation of states with weaker STI capacities, international civil society and organisations will lead to more equitable outcomes. It is also necessary to identify pertinent producers and users of knowledge and to bring them together in a comprehensive network, with an emphasis on communication, translation and utilisation of research results among all stakeholders. Mechanisms to facilitate exchange and adoption of knowledge will be needed. Special attention should be paid to the selection of intellectual property regimes (from exclusive patents to open access policies), to differences in partners' capacities, and to linking STI initiatives closely to local needs and stakeholders' demands.

The policy co-ordination required to meet global challenges entails strong structures that are sufficiently empowered to have a certain level of independence from the individual interests of the various stakeholders and actors (whether states, scientific communities, practitioners, business entities, civil society or NGOs) but that still ensure broad access to priority-setting processes. Such structures need to be able to weigh and resist external interests and flexible enough to adapt as experience accumulates or the environment changes. Successful management of STI to address global challenges implies autonomy in the decision process and a level of independence from funding bodies. This autonomy, in turn, implies the definition of clear priorities so that the results achieved can be evaluated, internally or externally. This will increase the project's legitimacy. A large consensus among stakeholders on these priorities will facilitate participatory evaluation and self-assessment.

The global dimension of the public goods to be produced means that issues related to resource asymmetries between the different actors must be addressed in order to avoid capture by "vested" interests, to balance efficiency, legitimacy and accountability concerns, and to achieve broad implementation of solutions. Transparency, legitimacy and fairness are required at all stages in order to involve a wide range of stakeholders and facilitate the creation and adoption of the results achieved by the STI systems concerned.

The resolution of the various trade-offs that necessarily arise in such processes may suggest a case for structures composed of a permanent core associated with project-based mechanisms. They would have broad fund-raising capabilities, could gather and disseminate information, ensure informal and formal communication on a broad scale and act both as forums for discussion and as STI policy makers or co-ordinators. Such structures might also be composed of "networks of networks" that bring stakeholders together as needed or of existing international entities that can act as boundary organisations, depending on the global challenge to be addressed.

The importance of information and transparency for mobilising STI effectively implies a substantial and continuous effort to sustain broad awareness of ongoing processes to enhance communication between and among different types of stakeholders in order to overcome information asymmetries and to avoid duplication, and to make rules and procedures widely available to the public at large.

Together, the literature reviews and the case studies point to strong leadership as a necessary condition of effective STI policy making, funding and implementation at the international level. Given the number and diversity of stakeholders and interests, the large range of existing efforts and the scarcity of resources, clearly identified decision makers and a flexible structure seem most likely to energise co-ordinated STI efforts and channel them to address global challenges efficiently.

This chapter has analysed five dimensions of governance relating to the implementation of policies for dealing with global challenges. What remains to be done is to address more precisely whether the options proposed are in harmony or in conflict with one other. Ideally, any decision should take into account the positive and negative expected effects of the instruments chosen. The "policy mix" should be able to provide an overall net benefit, given the inherent uncertainties and limitations. In order to implement strategies, policy makers should also consider how interdependent actors shape the overall performances of a project to tackle global challenges.

In designing governance mechanisms to address global challenges through STI co-operation, policy makers, and more generally all the stakeholders of a project, could benefit from considering the whole range of activities to be pursued and the linkages to be formed on the way to the desired outcomes. Two types of linkages must be considered, *within* and *across* governance dimensions. Two examples can illustrate their interdependency. As an example of a linkage *within* governance dimensions, the need for broad and active participation by relevant stakeholders to ensure legitimacy of the priority-setting process carries the risk of generating an increasing number of priorities and can lead to potentially incompatible or counterproductive inputs in the decision process. In terms of linkages *across* governance dimensions, the diversity of actors involved in the process, combined with the need to draw on dispersed and often independent practitioners, calls for an interactive and multi-directional process of knowledge exchange in order to put knowledge into practice. To achieve this goal, that diversity has to be acknowledged in the priority-setting process; funding schemes and IPR regimes have to be designed to facilitate interaction; and differences in terms of STI capacities have to be addressed to manage international co-operation among diverse partners. These varied interactions among governance dimensions call for more detailed analysis stressing trade-offs and feedback within and across governance dimensions.

The main conclusions concerning governance options, summarised below, are presented as a list, but should be understood not as independent but rather as interdependent aspects to be balanced:

- Broad and active participation of relevant stakeholders and permanent support for information flows to achieve common understanding and consensus are paramount.
- A mix of different approaches, such as bottom-up and top-down, supply-led and demand-informed, is required to avoid possible bias in the selection process.
- Priority setting, budgetary and implementation issues must be linked from the outset.
- Structural arrangements need to be flexible enough to be adapted to an increased knowledge base and to any other changes.
- An adequate balance between core and project funding appears to be a fundamental condition for sustained and dependable international STI funding and a necessary tool to overcome endowment asymmetries.
- Solutions most often involve various trade-offs arising, for example, between capacity building and one-shot efficiency or between broad accountability and efficient decision-making.

- Questions of funding and spending for STI collaborations cannot be viewed in isolation but need to be fully integrated with the other governance dimensions to facilitate their implementation.
- The association of a wide range of players in the public and private sectors is needed to set up collaborative IP mechanisms to improve efficiencies in the exchange of IP, clearing IP blocking positions, and favouring open access initiatives;
- Communication throughout the relevant networks must be enhanced so that practice can be informed by available knowledge and knowledge gaps in STI can be identified and addressed.
- Hatching of knowledge brokers must be facilitated to enhance communication, translation and diffusion of research results among all the stakeholders of a project.
- STI producers and users, in the knowledge-to-action process, should be trained in knowledge exchange.

Notes

1. This section draws on input provided by Wolfgang Polt and Florian Holzinger of the Joanneum Research Institute. They would like to thank the Austrian Federal Ministry for Science and Research and the Austrian Federal Ministry for Transport, Innovation and Technology for funding their research.
2. "Capture is the control of the regulatory process by those whom it is supposed to regulate or by a narrow subset of those affected by regulation, with the consequence that regulatory outcomes favor the narrow 'few' at the expenses of society as a whole." (Mattli and Woods 2009, p. 12)
3. This section draws on input provided by Magnus Gulbrandsen and Frode Hovland Søreide of the University of Oslo and by Egil Kallerud and Lisa Scordato of the Nordic Institute for Studies in Innovation, Research and Education. They would like to thank the Norwegian Ministry of Education for funding their research.
4. See High Level Group for Joint Programming (2010) for a comparison of the advantages and disadvantages of alternative funding tools.
5. On this point, see for instance Gornitzka and Langfeldt (2008).
6. The public sector definitely plays an important role in addressing market failures and in producing the public goods needed to mitigate and alleviate the effects of global challenges.
7. This section draws on input provided by Mineko Mohri of the OECD Secretariat.
8. This section draws on input provided by Andreas Stamm and Aurelia Figueroa (German Development Institute) with support from Harriet Harden-Davies (Australian Academy of Technological Sciences and Engineering (ATSE). The German Development Institute would like to thank the German Federal Ministry of Research and Education/ Bundesministerium für Bildung und Forschung (BMBF) for funding their research.
9. "Boundary organisations" act as brokers between science and policy. They attempt to link scientific research to policy decisions and public action by initiating two-way interactions.
10. For a review of knowledge management and the role of communities, see Amin and Roberts (2008).
11. This section draws on input provided by Erika Kraemer-Mbula (Institute for Economic Research on Innovation, and Imraan Saloojee (Department of Science and Technology of South Africa). They would like to thank the Department of Science and Technology for funding their research.

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Chapter 10

Effective international science, technology and innovation collaboration: From lessons learned to policy change

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The aim of this chapter is to glean useful lessons from the findings of the preceding chapters for effective and efficient governance structures in international science, technology and innovation (STI) collaboration to meet global challenges. Lessons are presented for each of the five governance dimensions: priority setting, funding and spending, knowledge sharing and intellectual property, putting STI into practice, and capacity building for research and innovation. Cross-case analysis draws lessons in each of these dimensions and offers initial conclusions on effective modes of governance in a variety of circumstances. In conclusion, the chapter notes progress made and new challenges.

10.1. Introduction

International co-operation is increasingly seen as vital in order to reap the benefits of scientific research, technology development and innovation (STI) in order to address global challenges. Global challenges call for urgent and effective international responses by research and innovation systems, for well-informed policy making and for broad-based deployment of knowledge-based solutions in the business sector and in society. This has been repeatedly stressed in the international arena, most recently by the World Science Forum in November 2011 in Budapest, which declared that "(t)he growing complexity of grand challenges including population growth, climate change, food supply, energy shortages, natural and technological catastrophes, epidemics, and sustainability require that the world's scientific establishment assume new roles". The declaration notes the emergence of a new multi-polar world of science, accompanied by the rise of new scientific powerhouses. It recommends better international co-ordination of research on global challenges and stresses the need to support developing countries in their efforts to build their research capacities.

By far the major part of the available resources for research promotion is still programmed, spent, monitored and evaluated at the national level (European Commission, 2008). In this regard, STI remains rather reluctant to be part of the globalisation processes that characterise many other areas. The reasons for this inertia can be found in severe legitimacy issues and a lack of incentives for policy makers to invest available resources in international projects that are not yet proven and are characterised by higher transaction costs and risks than national programmes (see Chapter 1).

Whether and to what degree the potential for international STI co-operation can be realised depends upon the modes of governance of international undertakings and the extent to which they lead to effective and efficient collaborative research. This has been the guiding assumption of this volume.

Research conducted with the aim of responding to global challenges differs from research in other STI areas in that it addresses global public goods and responds to problems that require urgent solutions. All of the cases analysed in the present volume are a response to some of the most pressing global challenges. In most of the cases, promoting collaborative STI is at the heart of the organisation's mission, or at least one of its basic elements.

Internationally co-ordinated or collective STI can generate advantageous economies of scale. This is especially valuable for research initiatives that require investments beyond what national STI budgets can support. Without the pooling of financial resources, several large-scale research infrastructures would not exist. Where high levels of required investments go hand in hand with high levels of uncertainty and possibilities of failure, pooling resources internationally also has an important element of risk sharing. In some STI disciplines, pooling of internationally available resources may not be indispensable to achieve results, but may significantly shorten the innovation cycle. This is the logic behind the "Apollo-project type" research undertakings proposed by some observers in order to give timely answers to global challenges, *e.g.* concerning climate change and clean energy provision (Friedman, 2005), for which time is a crucial factor in avoiding further worsening of the situation and the danger of system collapses. Others reject these ideas, arguing that they assign the state too direct a role and neglect the demand side of the innovation process (Yang and Oppenheimer, 2007).

Still, the pooling of financial resources is not necessary in all cases to address global challenges adequately. The history of science and technology shows that important discoveries and developments originated in single laboratories or in collaborative undertakings involving only a few actors, such as the development of the powerful fertiliser superphosphate in German and British labs in Germany in the mid-nineteenth century. So-called golden rice, a rice variety modified through genetic engineering to produce a precursor of vitamin A, and thus improve the state of nutrition in poor developing countries, was mainly a co-development of a Swiss research institute (the Swiss Federal Institute of Technology) and a German university (the University of Freiburg) (see Chapter 9). However, in both cases the developments were embedded in internationally available fundamental advances in relevant disciplines, such as soil sciences and plant nutrition in the case of the former and genetic engineering in the case of the latter.

The value of international co-operation in STI goes beyond the scaling up of financial resources. Economies of scope apply, as communication and co-operation among researchers and research groups allows for cross-fertilisation of ideas and intermediate outcomes of undertakings with common goals achieved in different ways. Research on innovation systems has shown that technological developments in national systems of innovation tend to be based on a limited range of alternatives; this reinforces incumbent technologies (path dependency, technological lock-ins), even if superior alternatives may be available. International co-operation significantly enlarges the range of available knowledge and competencies, often embodied in individual researchers or institutions. This broadens the scope for the creative re-combination of available factors and thus for innovation.

While conducting international research on global challenges offers a number of benefits, these come at a cost in terms of transaction costs and risks. Transaction costs of all forms (search, bargaining, and enforcement costs) rise not only with the number of actors, but also with the number of countries or the variety of institutional settings. Identifying suitable research partners with similar interests and complementary assets (knowledge, research infrastructure, etc.) is usually much easier in a single country. This is because the density of relevant knowledge – not only explicit, but also tacit – about research lines and interests, capability, performance and reliability of actors is usually much greater than beyond national and cultural borders. Additionally, when a STI project is sponsored by various sources, this often implies multiple reporting and evaluation requirements.

Countries' STI funding mechanisms may vary significantly (*e.g.* shares of institutional *versus* project funding) as may, for instance, rules for public-private co-operation or patenting regimes. Reconciling diverse regimes within a collaborative STI undertaking may require expensive and time-consuming search and communication processes. Related to these higher transaction costs in international STI undertakings is the higher risk of failure, first in the phase preceding the actual collaborative project, *e.g.* because all of the involved parties cannot reach an agreement. Second, international co-operation may fail in the course of the project because certain actors fail, free-ride or drop out. Effective and efficient governance modes that foster quality outputs help to ensure the continued involvement of participants and attract valuable new contributors as they demonstrate the value of the collaboration. It is for these reasons, among others, that the efficiency and efficacy of governance modes are a key element of successful international STI collaboration.

10.2. Key themes and lessons from the analysis

The research compiled in this volume helps to understand the nature of global challenges and the responses of STI systems. It sheds some light on good practices in the governance of international STI to meet global challenges. It also reveals the complex nature of this governance: in some cases, aspects of the governance mode may have positive effects on some elements of the innovation chain but lead to problems in others. It may therefore be necessary to deal with tensions and trade-offs. Recognising and balancing these benefits and trade-offs is an important challenge.

Several effective and efficient modes of governance were identified in the case studies. Some factors of a collaboration may present a challenge in terms of balancing two governance modes that may appear contradictory. However, this need not create an "either/or" situation. For example, a project may rely on both top-down and bottom-up agenda and priority setting, with benefits of each realised in appropriate circumstances. An example is the Clean Coal Centre Implementing Agreement (International Energy Agency, see Chapter 7), which draws on bottom-up input to define its agenda but makes final decisions in a top-down fashion. As this and other examples show, governance modes may be combined and used in tandem to achieve a balanced approach adapted to arising needs and the changing requirements in the life cycle of international collaboration. Flexibility in governance approaches is an advantage.

The following sections review the themes and lessons learnt from the case studies as analysed through the lenses of the five governance dimensions (priority setting, funding and spending, knowledge sharing and intellectual property, putting STI into practice, capacity building for research and innovation). Table 10.1 summarises the findings of each of the main case studies.

Prior to agenda setting: Mobilising actors, attention and resources for international STI efforts to meet global challenges

As mentioned above, there is no overall global organisation to support the globalisation of STI and the formation of knowledge networks across national boundaries, and it is difficult to generate and maintain interest among political decision makers and researchers regarding international STI co-operation to address global challenges. The case studies show that two factors can be helpful. First, high-level political commitment to address global challenges co-operatively or collectively through research collaboration; second, alignment of international co-operation programmes with national STI priorities. The first factor is clearly positive in most cases but rather difficult to achieve. The second factor, as will be seen, presents clear trade-offs.

One way to increase international STI collaboration to meet global challenges is to organise high-level political support, *e.g.* by embedding international STI co-operation in overarching processes and modes of global governance with high international visibility. In the case of environmental regimes, this may occur through agreements and related organisations such as the United Nations Framework Convention on Climate Change (UNFCCC) (as the International Energy Agency Climate Technology Initiative Implementing Agreement has done) or other relevant UN conventions.

The Global Earth Observation (GEO) Ministerial and Earth observation summits provide an opportunity for direct engagement with political decision makers. GEO had five ministerial-level summits in its first six years of existence. It has also been championed by leading Earth observation countries and organisations. This political support has facilitated

collaboration in a highly diverse initiative. It has also raised the profile of integrated Earth observations and positively influenced countries' awareness of the value of Earth observations for decision making.

One factor that binds participating countries and organisations together in international research on global challenges and mobilises joint efforts is a strong and specific mandate formally or informally given to a network or organisation by the international community. In this context "specific" means that the mandate for a policy field or global challenge is clearly given to a certain group of actors. This appears to enhance ownership and a sense of responsibility. A firm mandate at the outset of an international collaborative effort facilitates recognition and trust. It is a key element of an effective foundation for international collaboration.

In the case of CGIAR, the international community provided a mandate for the conservation of the world's genetic resources of major staple crops to several international agricultural research centres. This gave these centres a clear role as "provider of a global public good" and recognition of their importance in protecting genetic diversity as a basis for future developments.

A similar observation can be made with regard to GEO. This collaboration scheme is a direct response to calls at the World Summit on Sustainable Development (Johannesburg, 2002) and the G8 Evian Summit (2002) for strengthened international co-operation and co-ordination on global observations of the environment. It received and still receives high-level political support, through steering meetings at ministerial level.

When the need for international STI collaboration cannot be derived from global conventions or agreements and from declared political will at the top, a strict demand-led approach seems most promising to ensure that participants clearly see the relevance and invest the required resources for a successful collaboration driven from the bottom up. This is also an important element of success in international collaborations initiated through declared political will.

Lessons:

- A strong mandate helps to support commitment and ownership and thus enhances possibilities for the success of international collaboration.
- Where international STI collaboration cannot be derived from high-level political will to address global challenges in a collaborative or collective manner, demand-driven approaches seem most promising.

Aligning national and international STI programmes

It is important to link the content of international STI collaborations with agenda and priority setting at the national level in order to ensure support (financial, political and otherwise). The quality of representation that countries delegate to an international collaboration is important. The case studies demonstrate that if international collaboration is linked to national-level priorities, national representatives are more dedicated as they have the necessary resources (work time, travel budgets, staff, and other resources) to commit themselves fully to the international collaboration.

Several of the case studies – International Energy Agency (IEA) implementing agreements (IAs); Inter-American Institute for Global Change Research (IAI); Joint Programming Initiatives (JPI); and Global Earth Observation (GEO) – demonstrate this. In

the case of IAI, high-quality representatives are defined as "sufficiently empowered by their respective governments to make or influence resource commitments" (see Chapter 6), have strong links to national scientific organisations, and are able to link the IAI to other international arrangements and initiatives. In IEA implementing agreements (IAs, Chapter 7), interviewees repeatedly stressed that linking the work of the IA to national agenda and priority setting directly affected the quality of representation among IA members and the quality of the collaboration.

This indicates that the effectiveness and efficiency of international STI co-operation to address global challenges can be enhanced if the programmes are aligned with national research priorities. This observation is in line with one conclusion in the report of the Royal Society, *Knowledge, Networks and Nations*, that "International activities and collaboration should be embedded in national science and innovation strategies." (Royal Society, 2011, p. 105)

However, while the linking of national and multinational research programmes reflects current priority setting in most countries, it is not free from contradictions and conflicting interests. Excessive stress on the national basis of funding might create a serious imbalance in the agenda and priority setting of international STI efforts. Some global challenges may affect poorer countries with less advanced STI capacities disproportionally, but such challenges might have low priority if international programming is more or less directly derived from the national agendas of research-strong countries. To a certain extent, the problem of neglected diseases had its roots in such imbalances until international organisations and charities pushed them onto the global health research agenda. Therefore, aligning international agendas with national R&D agendas should be seen as a means to increase, in the short run, ownership of international R&D co-operation by key international funders and performers of STI in order to achieve a solid base of support even in times of economic turmoil and budget cuts. In the long run, however, addressing global challenges should be driven by a logic based on scientifically grounded and neutral assessment of their priority and urgency.

Lessons:

- The effectiveness and efficiency of international STI co-operation to address global challenges can be enhanced if the programmes are aligned with national research priorities. This helps to establish legitimacy and networks of support while fostering a link to holders of the purse strings and decision makers.
- While linking international programming to agenda and priority setting at the national level may be vital to success in the short run, it is not sufficient in the long run. Indeed, addressing global challenges may run counter to or – more likely – may have to be conceptualised independently of national research agendas.
- Achieving legitimacy for policy makers and ownership in the research communities of international STI collaboration will require targeted measures to raise public awareness of the chains that link investment in international STI collaboration to mitigation of current hazards and prevention of future hazards and distress.
- International co-operation generally leads to higher citation impact and the resulting visibility of domestic research efforts can be used more offensively to enhance the willingness of research policy makers and executing agencies to fund collaborative international STI efforts.

Priority setting: Broad range of actors vs. lean processes, bottom-up vs. top-down governance

While the inclusion of a broad number of actors may be instrumental in the effort to address global challenges, a broad approach to international research partnerships can also have its drawbacks, as it may prolong processes and make it difficult to reach consensus. Limiting inclusion may promote more efficient bureaucratic processes, but may also exclude some or many stakeholders, thereby limiting inputs and reducing buy-in and support. In terms of governance structures, some of the case studies demonstrate that it is useful to develop a structure that allows for both the independence of research programmes (*i.e.* largely "bottom-up") and a "targeted" decision-making process among certain stakeholders (*i.e.* largely "top-down"). Such an approach helps to reduce bargaining costs and the costs of satisfying possible veto holders and gatekeepers.

Different aspects of international collaboration may require different approaches. As one example, the case study on the Bill and Melinda Gates Foundation notes two of its major activities: creating impact based on STI, and engaging other actors through advocacy. Each of these activities requires different approaches from the perspective of inclusiveness. The former may benefit from a broadly inclusive process which brings in a diverse set of actors and activities, while the latter may achieve inclusiveness through a quantitatively more restricted but more high-level representation.

In the case of GEO, broad inclusion is congruent with the priorities of GEO members and participating organisations, and ensures buy-in. However, drawbacks are observed in the formation of priorities. The inclusive process identifies a large number of priorities and it is difficult to ascertain the most effective focal points. As a result, decisions are made from the perspective of major donors, rather than by GEO. So, while the overall process may be inclusive, it eventually creates problems, as truly research-informed priorities are not identified at the outset. The funding structure has also negatively affected priorities related to developing country needs. Although GEO has, through its work plan, addressed some developing country priorities, the articulation of priorities tends to be dominated by developed countries, due to the maturity and strengths of their systems.

A potential counterweight to such difficulties is a clear identification of roles and responsibilities. This makes it possible to include a large number of actors, but only on topics that are germane to their expertise, background or interests. This can foster an efficient governance process, as noted by the IAI, among others. Another approach consists of including stakeholders in an overall input process, but then delegating decision making to a select group to reduce transaction costs and the time required. In the case of CGIAR, the complexity of a large and comprehensive partnership, comprised of research centres, consortiums and diverse stakeholders, can make it difficult to reach global agreement on priorities. In recognition of this, while the process of priority setting is open and consultative, decisions eventually rely on the Consortium Board and the Fund Council.

Similarly, the Clean Coal Centre (CCC) IA has managed to ensure both inclusion and lean decision-making processes in its agenda and priority setting. While it asks a broad and diverse group of stakeholders to submit proposals for the work agenda of the coming year (a process that supports buy-in and inclusion), it delegates responsibility for the selection process, which goes through several rounds. The selection committee is formed of progressively smaller groups of people, thereby lowering transaction costs and fostering a more efficient decision-making process.

Directed decision-making processes need not eschew accountability. In IEA IAs delegation of decision making is balanced by accountability within the IA. IAs are independent from the IEA Secretariat and make their own decisions, but their effectiveness and outcomes are regularly reviewed by the relevant working party and the IEA Committee on Energy Research and Technology. Within individual IAs, work programmes and decision making are delegated to specific projects (or "tasks", see Chapter 7), which are independent from the larger IA, save for the necessary progress reports and other accountability measures.

Broad-based stakeholder participation *versus* efficient decision making is not the only challenge arising in agenda and priority setting. The case studies also exhibit more bottom-up or more top-down processes. Bottom-up approaches can help to ensure programmes that are demand-driven from a grassroots or micro level, while top-down approaches ensure that programmes are embedded in the larger picture of global challenges (macro perspective) with high-level political support at an early stage of an initiative. Both have benefits and drawbacks. JPIs take a primarily bottom-up approach (though they are partly guided by non-binding recommendations from the European Commission). This approach has allowed for freedom and diversity in the identification of research themes and in the formation of the institutional framework.

In GEO, a combination approach has been employed, with strategic targets derived through consultation with members, participating organisations and experts. These targets, in nine societal benefit areas, reflect the consensus of stakeholders. At the same time, decisions are made from a top-down perspective, by the Executive Committee. As a result, the process includes a bottom-up approach through horizontal consultation with stakeholders and a top-down approach through decisions taken by a designated governing body (Executive Committee).

In the case of IEA IAs, all Executive Committee members must approve the formation of a directed work programme. This helps to prevent the pursuit of programmes of work that do not provide value to all IA participants.

One of the major challenges for the institutional governance of international research co-operation is to channel the different interests of the decision makers involved. In the case of intergovernmental structures this entails consolidating the different interests of stakeholders so that the global challenge can still be effectively addressed. Some institutions try to resolve this by developing a flexible approach that allows members to organise specific work programmes (for example, IEA IAs). In this way, frameworks are created within the larger institution to address a particular programme of work, perhaps with some degree of autonomy. This type of institutional framework provides for separation of tasks and allows members to channel financial and/or in-kind input in a more targeted way to their specific area of interest.

Lessons:

- Including a broad range of stakeholders and participants in agenda and priority setting is important to achieve a larger and more detailed picture of the global challenge at hand and ensure buy-in by as many actors as possible. However, suitable governance mechanisms have to ensure that inclusion does not lead to an inefficient agenda- and priority-setting process.

- In order to achieve both an efficient agenda- and priority-setting process and inclusion, decision making may be directed to relevant stakeholders or bodies of oversight. This helps to reduce transaction costs, while maintaining transparency of the decision-making process.
- A combination of bottom-up and top-down approaches to governance may help to ensure an intelligent agenda- and priority-setting process that reaps the benefit of both approaches.

Formal versus informal or "best effort" arrangements

Collaborative initiatives may adopt formal or informal processes (or something in between). Both have drawbacks and benefits. The former may allow for clearer delegation of roles and responsibilities, and more clearly defined timelines and agendas. However, formal structures are only valuable so long as participants respect the rules and processes. Interviewees frequently noted that informal processes are beneficial for long-term collaboration and best-faith efforts. They may also, as JPI for example has found, allow for swifter adaptation to unforeseeable circumstances and lower entrance barriers. At the same time, a low level of formalisation may widen the scope for national interests to influence the JPI process.

A key aspect of the governance of GEO is its voluntary and informal structure. GEO has no legally binding documents. It is based on the premise of common benefit and a shared understanding of the need for contributions by all GEO members. As in JPI, this informal structure allows for quick response mechanisms. Members have noted that the voluntary nature of GEO is both its greatest strength and potentially its greatest weakness. One of the major drawbacks is that only a few GEO members and participating organisations make contributions; this reduces GEO's capacity to meet the needs of its stakeholders. This absence of a legally binding mechanism may also create challenges at the country level, as decisions are taken by consensus and are not binding upon GEO members. As a result, a GEO member may desire a certain action, but be prevented from carrying it out because of local restrictions. However, such members may still be able to provide support to other GEO members' efforts, perhaps in the hope that a successful endeavour by another member would give the activity political support in the member's country.

Other international collaborations have found the challenges of informal structures to be a reason to move to a formal structure. As an example, the Climate Technology Initiative (CTI) began as an in-kind initiative. Over time, this arrangement suffered from unpredictable donations. As a result, the CTI decided to adopt the IEA Implementing Agreement Framework to govern its collaboration more formally. Thus, modes of governance may evolve over time to respond to the changing needs of international collaboration.

Lessons:

- Informal governance has been shown in the case studies to generate solid support. Such governance also enables swifter response mechanisms.
- Informal governance may also involve a lack of predictability, which can create significant challenges for long-term and goal-oriented international collaboration.

- Modes of governance may evolve and be adapted over time, with informal governance ensuring ownership and motivation, and formal governance guaranteeing predictability and long-term impact.

Developing responsive agenda- and priority-setting mechanisms

A challenge noted by some case studies (for example, IEA implementing agreements and CGIAR) is that of balancing the need to be responsive to short-term needs while working towards long-term goals. This can be problematic because in order to address a specific short-term goal, resources may be re-directed from the long-term goal, making the latter's achievement more difficult. Ensuring a balance between these two aspects is vital for international collaboration in order to adapt to the evolving nature of global challenges and to reach long-term goals.

To this end, international collaboration should seek to develop both agenda- and priority-setting and funding and spending mechanisms that can be swiftly adapted in light of emerging issues in the landscape of global challenges. Examples of how this balance is achieved (*e.g.* the Bioenergy Implementing Agreement, see Chapter 7) include discussion of emerging challenges at each meeting and a "living" strategic plan with a governance mechanism that allows for adaptability. In short, developing resources (time, money, and so on) to address short-term goals can reduce the need to draw on resources for long-term goals and thereby avoid the disruption of long-term planning while still realising near-term adaptability.

Lesson:

- It is important to develop response mechanisms to respond to short-term needs without sacrificing long-term goals.

Funding and spending arrangements

STI to address global challenges is largely embedded in international research efforts, which are mainly driven by nation states. By far the largest amount of public spending for international R&D[1] is programmed, financed, monitored and evaluated at the national level, with limited collaboration or co-ordination by countries (European Commission, 2008).

Countries and world regions still mainly seek to become or remain economically competitive in a globalising economy. As a result, the scale-up of research to address global challenges stands in a complex relationship with STI for national or regional purposes.[2] In some of the case studies, collaboration depends upon national budgeting and in others (notably the Bill and Melinda Gates Foundation) it does not. In short, the organisations analysed have very different funding mechanisms and challenges as regards resource mobilisation.

Funding stability and a variety of funding opportunities are both important

Policy makers are clearly reluctant to invest significant resources in international R&D, and they face legitimacy issues and concerns about transaction costs and risks. As a first step they might scale up funding for the international mobility of researchers. By linking existing national research projects they might also broaden the scope for bottom-up international collaboration, induce learning processes that can reduce transaction costs and risks, and thus build ownership for larger funding of co-operative undertakings.

Another effective way to achieve results with a minimum of new funds is to convince existing funders with significant available funds to orient their calls or include in their calls the goals of the international governance institution. For instance, strategic targets of GEO/GEOSS have become the subject of recent calls of the European Union's FP7.

As the case studies have shown, core funding for international and collaborative STI endeavours can be quite small and based on voluntary contributions by some countries with additional funding for extra-budgetary activities from existing international organisations, funding mechanisms and/or national governments (GEO, IAI). Common funding also involves in-kind contributions, whereby countries finance national experts that work at the agency's headquarters or conduct R&D (GEO, IEA IAs). Private charities play an increasing role in research funding, particularly in health research (the most prominent example is the Bill and Melinda Gates Foundation, see Chapter 3).

Funding for specific projects rather than more generic funding to support the work of international organisations can create management challenges. In the case of CGIAR, funds directed towards specific projects accounted for two-thirds of total funding over the last decade. This led to a form of direct management of the activities of the centres by the members (mainly government agencies) and to a crisis that was reinforced by free riding and difficulties due to late announcement of annual contributions.

The crisis was both financial and managerial, as the centres were dependent on a "jigsaw" of special projects and found it difficult to make long-term plans and respect their strategic priorities. It also increased transaction costs, given the reporting, monitoring and evaluation processes required for each project by each contributing donor. In response to these challenges, CGIAR harmonised its funding scheme, requiring funders to: provide adequate and predictable funding, collaborate with one another, respond to Consortium requests to address over- and under-funding, and seek to refrain from providing funding outside the common operational framework (see Chapter 2).

Furthermore, CGIAR recognised that annual funding schemes do not always allow for effective research planning. However, donor contributions are made to CGIAR on an annual basis. Therefore, the centres have asked donors for multi-annual commitments so as to plan multi-year research programmes, but as only a few donors have done so, challenges remain in terms of funding predictability and the planning of long-term research projects.

Other CGIAR funding reforms give donors several options: they may contribute to the CGIAR programme portfolio in its entirety, to specific programmes, or to one or several centres. This allows donors to fund according to their preferences. At the same time, CGIAR has developed a multi-donor trust fund (the CGIAR Fund) for multi-year support of CGIAR research.

Other initiatives have also seen the value of establishing multiple funds, including the IAI and the IEA IAs. The IAI uses specific funds to develop a scientific synthesis of the projects of the programme and interactions among stakeholders. IEA IAs have a number of funding tools to provide both adaptability and stability. For example, in the Bioenergy IA, 10% of the task (project) funds are set aside to create a "strategic fund" that may be directed to needs arising for the Executive Committee. In the Clean Coal Centre IA, stability is provided through a one-time fee that must be submitted by all members (equal to 50% of the annual fee). The funds from this one-off payment can be used to offset late submissions of IA subscription payments, which can create problems for the co-ordination of research. The IAI has witnessed challenges resulting from late contributions to the core budget, which have reduced its dynamism.

Lessons:

- As policy makers remain reluctant to invest large amounts of money in international collaboration, funding of international mobility and similar early-stage funding may help to link ongoing research programmes and create the basis for more significant funding in the future.
- Another effective way to achieve results with a minimum of new funds is to convince existing funders to orient their calls or to include in their calls the goals of the international governance institution.
- Funding of specific projects as opposed to core institutional funding can create difficulties for the co-ordination of research and can increase transaction costs. Harmonisation of funding encourages stability.
- Annual donor contributions can make it difficult to co-ordinate multi-year research projects. If multi-annual funding by donors is not possible, funds may be created within agencies to provide multi-year funding and thus ensure stability.
- The late submission of funds negatively affects co-operation. To offset this potential hazard, a fund to provide a backstop in the case of late submission can be established.
- A dedicated fund that may be drawn upon to address arising needs provides flexibility and helps to ensure responsiveness to emerging topics without distracting from long-term plans.

Knowledge sharing and intellectual property

International co-operation in STI to address global challenges raises particularly difficult questions regarding the protection of the data, information and knowledge that result. On the one hand, vital key actors, *e.g.* from the private sector, will only invest financial and human resources and take risks of project failure if they can expect a reasonable return in the case of success. On the other hand, swift diffusion of new products and processes (clean energy technologies, drugs, enriched food) is crucial to have a significant impact on global challenges. Diffusion may be hampered if prices for innovations are too high and there are no funding mechanisms to make them broadly available.

Intellectual property rights (IPR) have an important role and influence and shape the nature of the collaboration, the agenda and its success. The success of international collaborations to address global challenges will depend upon efficient IPR frameworks that take account of the different interests of stakeholders. Innovative ways to deal with the questions of access to knowledge and intellectual property (IP) in STI to address global challenges are needed (see the example of patent pools in Chapter 9, Box 9.1).

Given the complexity of IPR issues, flexibility may be helpful in IPR regimes. In the Bioenergy IA, each participant and operating agent is responsible for identifying which information is proprietary and ensuring it is appropriately indicated. The task operating agent is in charge of deciding IP issues and informing the Executive Committee. Each participant holds the rights to its own work. As a result the IP guidelines are well-tailored to the needs of the specific task and very few problems arise.

Agreement on data sharing principles is notoriously difficult, given the plethora of national policies and laws. By agreeing on an open data policy at its establishment, GEO members and participating organisations were able to define practical mechanisms, such as the GEO-DATA-CORE, to respect the constraints under which each member or participating organisation operated.

As the International Arabidopsis Genome Project (Annex B) demonstrates, when the public sector funds research it can play a vital role by establishing policies that encourage timely data sharing, by requiring grantees to develop a data management plan acceptable to the scientific community as part of their research proposal, and by helping researchers identify appropriate repositories for the research results.

The Gates Foundation also endeavours to achieve the widest possible distribution and dissemination of scientific and technological advances and works towards IP arrangements that contribute to this goal. The Foundation makes no claim on IPR, and while it is not opposed to profiting from research results, it believes this should occur as part of the desired impact as well. The example provided in Chapter 2, for instance, is that drugs are sold essentially at cost in developing countries, but at market prices in developed countries. In short, the Foundation has a flexible IPR policy, but one that is based on the principle of global access. Each grantee must present an IP management plan, which is discussed with the technology transfer office or a lawyer, which negotiates with the grantee.

The closer a new technology is to market deployment, the more challenging IPR issues become (Evans, 2008, p. 3; Tirpak, 2009, p. 13). A US Department of Energy study noted that IEA IAs play particularly important roles for projects that are "less likely to yield proprietary intellectual property" (Evans, 2008, p. 3). However, approaches tailored to the specific needs of the collaboration that allow inventors/innovators to realise gains while still sharing results are also possible. For example, while the International Atomic Energy Agency (IAEA) owns IPRs stemming from collaborations, collaborators are free to use the results.

IPR issues are especially critical for global health concerns, as the investments and lead time needed to develop a new drug or vaccine can be very high. Yet, making at least essential medicines[3] available independently of people's purchasing power is a vital ethical concern. Funders and charities have become active in this field, and formats such as the advanced market mechanism (see Chapter 3 and specifically Box 3.1) may mobilise market forces if very significant public or charitable funding is available.

In the case of the Global Carbon Capture and Storage (CCS) Institute, (Annex A) intellectual property issues have played an important role since the early planning stage. The solution found with assistance of an international consulting group can be summarised as protecting the rights of IP holders related to the Institute, with endeavours to make IP created through the Institute's activities widely accessible to members, while collecting, packaging and sharing non-proprietary information related to CCS.

Lessons:

- The relevance of IP issues varies depending on the type of global challenge, the distance or proximity to market release, and the combination of public and private actors involved. This prohibits any "one size fits all" solution. Rather, tailored approaches need to consider research needs as well as the subsequent implementation.
- Inventors and innovators may realise gains while still sharing results. Governance approaches that encourage sharing help to diffuse research findings and build a common knowledge base.
- With regard to global health, innovative models are being implemented which mobilise the innovative power of private business, while ensuring rapid deployment of new solutions. These models should be analysed to determine their suitability in other fields.

Putting STI into practice

One of the key characteristics of global challenges is their urgency. The conversion of the output of international STI co-operation into innovative solutions on a large scale is crucial in order to reduce environmental pressures and alleviate hardships due to insufficient access to food, epidemic diseases, etc. This conversion of research into new practices occurs through evidence-based policy making, changes in societal practice and/or the diffusion of new products and processes in the business sector. Each of these modes requires specific translation mechanisms.

The importance of outreach both within and outside of the scientific community: broadening the actor constellations in international co-operation

Bridging research and policy making and/or societal practices is difficult, as policy processes are complex and rarely linear or logical (Young and Mendizabal, 2009). Success in transferring knowledge to policy makers and/or the broader public largely depends on the institutional arrangement of the co-operation mechanism and the type of actors involved. Where new knowledge is mainly or exclusively generated through scientific research, application and diffusion of new solutions may be hampered by the lack of a link to societal and economic practice. Planning of STI undertakings has to include strategies for the transfer of knowledge to policy makers and civil society stakeholders. Therefore, international collaborations should include in their agenda- and priority-setting plans the need to communicate their findings to stakeholder groups and, where appropriate, engage them in their research. More generally, efforts are needed to raise societies' awareness and acceptance of science- and technology-driven solutions that may imply the need to change living styles and societal habits.

Moving from research to political, societal or business practice requires a variety of settings and actors from the scientific community (national universities and laboratories, etc.), policy makers (at both decision-making and operational levels), funding agencies, the private sector, civil society organisations and even individuals. It should ideally be a dynamic process, occurring at several points in the research phase: before the start of a research programme to ensure that the research agenda corresponds to the knowledge

needed, during the research programme to encourage an active feedback process and to adjust the framework if necessary, and after the research is completed. The last point is particularly important for the diffusion of results and findings, and to demonstrate value to funders.

To ensure that policy making is adequately informed by research, policy makers must be aware of the relevance of STI and open to advice from other actors. Such openness cannot be taken for granted anywhere, but may be less widespread in some world regions.[4] For example, as awareness of the IAI among the policy community in Latin America is relatively low, and this has likely hindered the translation of research into policy-relevant discourse and action. The IAI has begun to address this gap with new activities, such as joint policy-science training seminars and policy briefs aimed specifically at decision makers. The IAI's efforts to link natural and social sciences with decision makers are also critical to these endeavours.

One problem mentioned in the case studies is the fact that the skills of a good policy advisor are not necessarily among the skills of an excellent researcher nor are they a necessary part of the training of future researchers. Johnson and Mendizabal (2009, p. 2) argue that in order to influence policy a good "policy entrepreneur" must be able to understand the relevant political economy, to present research results in terms of simple and compelling stories, and to network well with all stakeholders. Such a policy entrepreneur must also be able to use these skills simultaneously and in a bi-directional (*i.e.* policy-research and research-policy) manner throughout the research process. Similarly, researchers in multidisciplinary teams must work with researchers with different, complementary skills. In some of the initiatives analysed, different sections or departments of an organisation help to assemble the various skills required. At the IAEA, the Technical Department mainly interacts with knowledge users, complementing the work of departments in charge of the development of technical knowledge and applications.

As the CGIAR demonstrates, impact evaluations are essential in order to shape and refine work programmes to achieve the desired results. Plans of action must be dynamic, and evaluations are required to facilitate adaptation to changing circumstances and to achieve the desired goal most efficiently.

For many global challenges, the private sector can and should play an important role, as the business sector is generally better equipped than public actors to bring research outputs swiftly to commercial and societal application. The private sector is also an important source of STI funding. Most of the seven organisations studied are mainly or exclusively driven by public actors. An exception is the Bill and Melinda Gates Foundation, a privately owned and governed body; however, as a non-profit charity it addresses public goods.

The IEA involves industry and private entities in its IAs as an important way to accelerate knowledge sharing and to transmit to the research initiatives the needs of industry and in some cases those of end users. GEO has not yet formally defined its relationship and engagement with the private sector. However, it is currently working to reach a clear definition. This is particularly important as the private sector is increasingly a provider of Earth observations infrastructure, data and value-added products and services. It is also becoming, to a greater extent, an end user of Earth observations.

Lessons:

- International STI co-operation to address global challenges becomes operative when it leads to an efficient roll-out of innovative solutions in the business sector and society or to better policy making, informed by research.
- Evidence-based policy making must take account of the fact that researchers and policy makers are part of different environments, with different incentives, time horizons, languages, etc. Communication tools must be shaped with this in mind (*e.g.* policy briefs). Bringing representatives from both communities together at different points of the STI cycle can improve interaction between the two spheres.
- Science- and technology-based solutions to global challenges that may require adapting societal practices and habits have to be addressed by policy makers in order to ensure awareness and acceptance and a swift transition from research to practice.
- Introducing evaluations to assess the implementation of research results will support efforts to consider outcomes and impact from the beginning.
- Industry involvement is important for putting research into practice and communicating market needs. As in the case of science-policy interaction, modes of co-operation between researchers and representatives of the private sector have to consider their different interests, incentives, expectations, risk perceptions, etc. Here too, an iterative interaction process can facilitate mutual adaptation.

Capacity building for research and innovation

Most of the organisations examined in this volume do not consider capacity building and technology transfer an aspect of their mission. They see as their mission to conduct or facilitate co-operation on equal terms; this does not include helping to improve STI capacities of partners with lower R&D capabilities. Even so, implicit capacity building and technology transfer may occur if partners with less advanced R&D capacities participate in co-operative projects and carry out tasks in meetings and other types of exchanges, both in-person and virtually ("learning by doing", "learning by interacting"). However, these ways of building scientific capacities only occur if co-operation is on equal terms.

Nonetheless, some organisations explicitly make capacity building and technology transfer part of their mission. For instance, the CGIAR invests about 20% of its resources in capacity building and technology transfer, particularly by strengthening national agricultural research systems. Other examples are the Climate Technology Initiative or the Energy Technology Data Exchange under the IEA Implementing Agreement Framework which explicitly focus on technology and knowledge transfer to developing countries.[5]

An issue relative to capacity building noted in the CGIAR case study was the effort to avoid duplication; in particular, research done at the international level should not "mirror" activities done at the national level. While the avoidance of duplication is a worthwhile pursuit in the short term, there remains the challenge of building capacity in participant countries and organisations in the long term. If capacity building does not take place by "doing" it needs to do so in other ways. Therefore, North-South and South-South capacity building and knowledge transfer should be an important part of international research collaboration. In the case of the IAEA and other organisations, links with UN organisations such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) may be useful in this regard.

Reconciling STI and development agendas

In addressing global challenges, the involvement of developing countries is of special importance: "As the issues are global, involving less developed countries with few financial means to engage in research and technology is essential for its success (and for tackling the impacts on those particular countries)." (Boekholt *et al.*, 2009, p. 15) Yet, international research co-operation has traditionally occurred either among the scientifically and technologically most advanced countries in the North or through rather limited North-South co-operation projects.[6] Patterns of scientific collaboration are also influenced by language and historical links among different countries and world regions.

Some of the case studies in this volume indicate that international undertakings can help to dissolve these traditional patterns of co-operation and reshuffle partner structures, thereby enhancing the potential for a creative recombination of production factors, including specific knowledge and capabilities, in different local environments. This also includes South-South co-operation in STI, traditionally a weak field of international research collaboration.

The most obvious case in this sense is IAI, conceptualised as a regional mode of co-operation, with a strong focus (including the location of headquarters) in the developing and emerging countries of Latin America. Prior to IAI's establishment, collaboration between research institutions and universities in Latin America was underdeveloped. The IAI governance and management structure supported regional co-operation and enabled the creation of international and multidisciplinary networks among leading scientists in the Americas. The resulting scientific exchanges have contributed significantly to the region's capacity to engage in research on global change phenomena, and there are possibilities for further linking IAI to other international organisations dealing with global change.

The IAEA has also fostered regional networks. One example is the regional and co-operative agreements in Africa, the Middle East, Latin America and the Caribbean, and Asia and the Pacific. These regional networks also serve an important function in South-South co-operation and knowledge exchange.

By bringing together a wide array of international researchers that represent both the public and private sector, IEA IAs have created multiple networks simply through their establishment. The inclusion of policy makers in IA Executive Committees further diversifies this interaction (and helps to create research-policy links). Networking also occurs with the IEA Secretariat, including working groups, expert groups, and other entities. Furthermore, IAs with complementary work programmes are linked through a number of IEA structures where relevant. These interlinked networks make knowledge sharing more dynamic and effective.

CGIAR has been successful in involving developing countries in its work, partly because of the absence of a financial threshold to be a member and/or contributor. Furthermore, seats in the Fund Council are distributed fairly among North and South countries and donor contributors. At the IAEA, the combination of promoting collaborative research and technical co-operation programmes is especially promising in terms of generating new knowledge and – at the same time – ensuring its application in a large variety of countries.

It can be challenging, however, to meet advanced science and effective development criteria simultaneously. This is recognised in some of the organisations studied, notably the IEA IAs. As these are primarily burden- and benefit-sharing agreements, it is rather difficult to include developing countries in the work programme. This may be easier when the barrier to joining is an annual fee and harder when it requires significant national infrastructure for conducting advanced research.

In order to utilise existing knowledge and to link to research initiatives in the South, CGIAR has included emerging research centres as partners along with advanced research institutes of the North. In this way, triangular collaborations of less developed, emerging and industrialised countries shape the international research system of the future through three-way co-operation. CGIAR also catalyses research and innovation by leveraging the resources and competencies of other actors through collaboration, brokerage and networking; facilitating spillover and scaling-up of technologies; funding mobilisation; and the establishment of regional and global technical facilities.

Through the GEONETCAST initiative, GEO is working to address differences in capacity. This low-cost data dissemination and delivery system was established to distribute data in low bandwidth environments. GEO has also developed GEONETCAB, which aims to promote capacity-building activities in support of GEO. It focuses partly on brokering support for Earth observation capacity-building projects and activities in developing countries; it addresses all GEO societal benefit areas but places special emphasis on climate monitoring. GEONETCAB identifies capacity-building needs and potential resource providers for capacity-building activities. It develops mechanisms to facilitate co-operation among stakeholders and resource providers and access to a global network of expertise for education and training in Earth observation. In its work on capacity building, GEO does not treat this as a niche that concerns developing countries, but rather as an essential component of all GEO activities.

The IAEA does not have field offices in partner countries and depends on partner organisations to conduct outreach activities. Capacity building and technology transfer are important elements of IAEA activities. Building members' capacities to work responsibly with nuclear technologies (for energy generation and beyond) has been a core element of the Agency's mission since its inception. In its work to support developing countries IAEA has realised the benefits of a bottom-up approach to governance.

Lessons:

- STI capacity is crucial for addressing global challenges through international research collaboration. Challenges such as food insecurity, climate change, environmental degradation, infectious diseases and shortage of energy supply require STI-based responses even in countries with relatively small STI capacities.
- Bridging the knowledge gap requires considerable investments in STI capacities in developing countries. Linking different initiatives can help to foster capacity building, specifically by linking international STI collaboration, and thus processes of learning by doing and learning by interacting, with development assistance, which has capacity building as a core mission.
- International collaboration can foster South-South co-operation, an important element of STI capacity building. As this mode of co-operation is rather new, it should be given higher priority in the design of multilateral and international STI endeavours.

- Treating capacity building as a "niche" element of governance relating only to developing countries is not helpful. It should be part of all governance approaches, as STI capacities also diverge in the more advanced countries and between disciplines and sectors.

10.3. Conclusion and further research perspectives

Organising international STI co-operation appropriately is not just a technical challenge. It also implies dealing with a diversity of expectations, resources, capabilities and powers of decision. Notwithstanding such differences, many actors have to be engaged in addressing global challenges and need to align their co-operative activities to meet this goal.

International co-operation can unlock important potentials of STI to deal with major concerns of humankind today. However, increased collaboration may come at the expense of efficient processes of planning, conducting and monitoring research. As complex and networked co-operation across national and cultural boundaries leads to significantly rising transaction costs and risks, the net benefit of international STI co-operation is directly related to the organisation of the phases of collaboration. These organisational methods constitute the governance of international STI co-operative endeavours. Table 10.1 represents the governance dimensions analysed throughout the work in rows. The columns identify three manifestations of these governance dimensions ("modes of governance"). In a rather stylised manner, the columns represent "poor", "improved" and "good" modes of governance. The main qualifying factor is the aptitude of governance to adapt to changing framework conditions and to the varying requirements in the life cycle of collaboration.

Considering the importance of international STI co-operation in the field of global challenges, and the need to organise it efficiently, the relative scarcity of relevant conceptual and empirical literature is striking. In many other fields (*e.g.* environment, trade, finance), international and multi-level governance has recently ranked high on the scientific and political agenda.

The complexity of the task of governance and the idiosyncrasies of individual global challenges make it clear that no set of simple "do's and don'ts" will help national and global policy makers to solve the many issues related to international STI co-operation easily. Nevertheless, the research presented in this volume offers some valuable orientations although further research is clearly needed.

Table 10.1. Governance modes illustrated in the case studies

Governance dimension	Governance mode (sub-optimal)	Governance mode (improved, but not adaptive or responsive)	Governance mode (adaptive and responsive)
Priority setting *Stakeholder involvement*	A limited number of stakeholders are involved, reducing input, buy-in and transparency	A broad range of actors is included in the decision-making process, but transaction costs are increased	A "directed" decision-making process minimises transaction costs by closely defining the decision-making "jurisdiction" of stakeholders
Flexibility in priority setting	Flexibility to adjust priorities to address arising needs does not exist	Flexibility to adjust priorities to address short-term needs is provided for, but without balancing the need to provide for long-term priorities	Governance mechanisms allow for flexibility to address short-term needs without sacrificing resources for long-term goals
Funding and spending *Nature of contributions*	Funding and spending requirements and commitments are not clearly defined	Funding and spending requirements and commitments are clearly defined, but do not provide for contingencies	Funding and spending requirements and commitments are clearly defined, and include contingency funding for late submission of payment, and balance project financing with longer-term general funds, *inter alia* to support continuity and stability
Flexibility in funding and spending mechanisms	Funding and spending mechanisms do not allow for adjustment to address unpredicted needs	Funding and spending mechanisms allow for flexibility and re-adjustment in order to address arising needs but without balancing the need to maintain resources for long-term goals	Funding and spending mechanisms allow for the realisation of long-term goals while responding to short-term needs (*i.e.* a strategic fund that provides for short-term funding while not drawing on long-term funding)
Knowledge sharing and intellectual property	IP provisions are undefined	IP provisions are defined for the duration of the project, but do not allow for adjustment during the project life cycle	Defined IP provisions allow for adaptation during the project life cycle – this includes IP provisions adapted to the life cycle of the collaboration
Putting STI into practice *Outreach to end-users and broader society*	Research is conducted without a plan or the resources for sharing results	Research is conducted with a plan and the resources to share results, but fails to engage in two-way communication with end-users throughout the project life cycle	Research is conducted to share research agendas, activities and results throughout the project life cycle while maintaining a two-way exchange process with end-users; awareness raising and acceptance building are essential elements of the outreach activities
Capacity building for research and innovation *Avoiding duplication*	Research is conducted without building capacity in partner countries	Capacities are built up by conducting joint research, but duplicate activities, results and errors	Capacities are built up while maintaining a focus on avoiding duplication of activities, results and errors by sharing research agendas and co-ordinating efforts

The research and analysis contained in Chapter 9 are thus the basis for some first policy options that have emerged from the empirical research. They are proposed as a means of establishing initial framework conditions for effective governance. When a new mechanism for international co-operation in STI for global challenges is formed, or an existing one assessed, the case studies point to an initial "checklist" of policy options.

- *The importance of high-level co-ordination of the project.* International STI co-operation is especially likely to succeed if it can be derived from high-level political commitment to act collectively to address a particular challenge and/or achieve a certain goal. This can give researchers and their organisation a strong mandate and enhances ownership and buy-in by many governments and funders.
- *Need for a compelling reason to do the work.* Where a link to high-level political commitments cannot be made, a demand-led approach seems most promising. Co-operation should focus on fields with clear knowledge needs shared by many decentralised actors who perceive clear benefits to international co-operation when compared to acting on their own.
- *The governance structure must be a "learning system".* Governance structures should be tailored to the needs of the specific collaboration, and allow for active and responsive adaptation. Provisions, including impact evaluations to assess the efficacy of activities, should exist to change governance modes as and if required to support efficiency and effectiveness. The evolving nature of global challenges further highlights the need for structures that are adaptable in all governance dimensions. Regular evaluations are an essential tool for catalysing institutional learning.
- *System linkages are important.* Effective multi-level governance, understood as establishing and maintaining linkages between different system levels (local, regional, national, international), should be sought in order to avoid duplication and encourage transparency. Linkages should seek to include a broad and relevant range of stakeholders while maintaining an effective decision-making process. Responsibilities and decision-making should be delegated in order to reduce transaction costs while maintaining broad stakeholder involvement.
- *Outreach and knowledge flows outside the project.* Outreach from the research community to other stakeholders should be a priority. This is essential to ensure support (political, financial and otherwise) for international collaboration, to disseminate results, and to demonstrate to existing and potential participants the value of the collaboration. Outreach should occur at multiple phases: pre-research, during research, innovation and post-research. Outreach should target a wide variety of actors: voters, decision makers, the research community, the private sector and others.
- *Knowledge flows and knowledge protection.* Knowledge sharing and IP provisions should be adapted as necessary to each phase of the collaboration life cycle. This is particularly important given that IP issues tend to increase in importance as a product nears market deployment.
- *Contingency management.* Funding and spending mechanisms should contain contingency provisions. In the case of delayed payments, or the need to fund multi-annual research projects with annual funding, mechanisms are needed to provide for funding and spending stability.

- *Combining co-operation with capacity building.* With regard to global challenges, the traditionally strict separation between evenly balanced co-operation in STI (equal contributions, equal benefits) on the one hand; and capacity building on the other, should give way to a more integrated approach. For most global challenges, research contributions are needed from a wide array of countries, rather independently from their STI capacities. Capacity building is an important element of joint efforts to address these challenges, and should not be seen as a support mechanism only, or not even mainly, in the interest of the less developed country.

These options emerge from the analysis of the seven case studies on existing STI collaborations dealing with global challenges. Given this, several points should be considered. First, these are successful examples of international STI collaborations in the field of global challenges, although some are more successful than others. Second, the case studies all focus on international STI co-operation related to the interaction of human activities and the natural environment, and mostly deal with limited natural resources. In the last three to four years it has become very clear that global challenges with potentially catastrophic consequences can also arise in human-made systems, *i.e.* the global financial system. Here, as in human-nature interactions, certain elements of the system may change gradually (subprime loans in the banking system, public debt) until the point at which a further shift can lead to a catastrophic breakdown of the whole system. These purely human-made global challenges are another area for further research.

Third, all of the case studies, with the exception of the rather recent JPI and the Global Carbon Capture and Storage Institute, analyse institutional settings that were politically feasible and adopted under much less globalised conditions and with much less awareness of the global challenges than is the case today. This might have led to certain degree of path-dependent thinking in the policy options proposed above. Incremental improvements in governance patterns may not seem to be an adequate response to the magnitude of problems mankind faces today. More radical alternatives might also be available through new trends in the way knowledge is sourced.

The scale and urgency of the need to mobilise STI to address global challenges and the new modes of generating, sharing and applying knowledge mean that more radical means of international research governance than those described in this chapter may need to be found. This volume has proposed a starting point based on a number of successful efforts but suggests the need for "out of the box" thinking and further work in order to meet emerging challenges.

Notes

1. In many countries, the private sector spends the most for STI and tends to be rather cautious about investing financial resources for strategic R&D beyond the firm's home country (*e.g.* Belitz, 2010).
2. The tensions are at least partially reflected in official documents. For instance, in February 2005 the European Commission refocused the Lisbon Agenda, which initially focused exclusively on Europe's competitiveness, on actions that "promote growth and jobs in a manner that is fully consistent with the objective of sustainable development".
3. See 't Hoen (2010), p. 129ff. on the concept of essential medicines.
4. For instance, in the United Kingdom, evidence-based policy making has gained momentum since the first Labour government of 1997, which declared evidence-based policy a core element of its commitment to modernising government (Sanderson, 2002, p. 4).
5. See Box 9.2 on the European and Developing Countries Clinical Trials Partnership (EDCTP).
6. A recent study indicated that only 3% of Southern African Development Community (SADC) papers during 2005-08 were jointly authored by researchers from two or more SADC countries, and only 5% of SADC papers were jointly authored with researchers from African countries outside the SADC. In contrast, 47% of SADC papers were co-authored with scientists from high-income countries (Boshoff, 2010).

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Annex A[1]

Mini Case Study: Global Carbon Capture and Storage Institute

Prepared by the Delegation of Australia

Introduction

Approximately 100 new conventional large-scale power stations are currently being constructed around the world each year. Carbon capture and storage provides a solution for existing fossil fuel plants, as well as plants that will be built in the coming years. The technology involves capturing CO_2 that would otherwise be emitted to the atmosphere, compressing it, transporting it to a suitable site and injecting it into deep geological formations where it can be safely stored.

The Global Carbon Capture and Storage (CCS) Institute focuses on addressing the global challenge of climate change. Although established only in 2009, its experience to date offers lessons for governance structures to facilitate international co-operation and provide solution for climate change.

The International Panel on Climate Change (IPCC) estimates that global CO_2 emissions must be reduced by 50% to 85% by 2050 compared to 2000 levels in order to prevent the global mean temperature from rising by more than 2.0°C to 2.4°C, the threshold at which climate change becomes severe. Electricity sourced from fossil fuels accounts for more than 40% of the world's energy-related CO_2 emissions. A further 25% comes from industrial processes including iron and steel production, cement making, natural gas processing and petroleum refining. CCS is a technology that can reduce emissions from power plants and industry to levels approaching zero. To achieve the goal of limiting global average temperatures to 2°C above pre-industrial levels by 2050, the International Energy Agency (IEA) found that CCS must contribute one-fifth of the lowest-cost emissions-reduction solution. Without CCS, overall costs to achieve this goal increase by up to 70%.

Establishment of the Global CCS Institute

In September 2008, the Australian government announced that it would establish the Global CCS Institute to help shape an international solution to climate change by building momentum for the deployment of CCS technology. The Global CCS Institute was formally launched in April 2009. It became a legal entity in June 2009 when it was incorporated under the *Australian Corporations Act* (2001) as a public company. It began operating independently as of July 2009. The Global CCS Institute is a not-for-profit entity, limited by guarantee, and owned by its members. The Australian government initially committed annual funding of AUD 100 million for a four-year period.

In 2008 at the Hokkaido Toyako Summit, G8 leaders affirmed their support for the launching of 20 large-scale CCS demonstration projects by 2010 with a view to broad deployment of CCS by 2020. The overarching objective of the Global CCS Institute is to facilitate the achievement of the G8 goal to accelerate the broad deployment of

1. As noted in Chapter 1 and Box 1.1, two smaller institutional case studies were undertaken to complement the in-depth core case studies, and one is presented in this annex.

commercial CCS to ensure that the technology plays a role in responding to the world's need for a low-carbon energy future. The achievement of this objective requires the following: a global portfolio of integrated CCS demonstration projects to demonstrate the technology at industrial scale; a set of "enablers" to facilitate commercial roll-out; policy, financial, and public awareness; capacity building and knowledge sharing. A strategic framework guides the Global CCS Institute's work on demonstration projects and on strategic enablers to support the longer-term commercial deployment of CCS.

Institutional arrangements

Detailed consultations among research and global stakeholders preceded the decision on the governance arrangements of the Global CCS Institute. The Australian government engaged the Boston Consulting Group (BCG) to advise on the most suitable business model, to present the model to stakeholders and incorporate their feedback, and assist in its implementation. The model had to reflect the Australian government's vision of the Global CCS Institute as a truly global entity rather than an Australian entity acting globally. The governance structure needed to allow the Global CCS Institute to operate independently of government and have a responsive and dynamic governance structure in order to accelerate the commercial deployment of CCS.

A meeting of global stakeholders was held in London in November 2008 to discuss the legal and governance structure. An issues paper was developed outlining the objectives in choosing a legal and governance structure that:

a) Allowed for governments, research organisations and industry bodies (wherever located) to be members of the Institute as the arrangements for the Institute evolved, thereby facilitating its truly global nature.
b) Did not preclude a range of models for the governance of the entity;
c) Supported the view that the Governing Board should act in the interests of the Institute as a whole rather than any individual member.
d) Enabled a CEO to have legal responsibility to act in the interests of the Institute and report to the Governing Board.
e) Provided flexibility in determining employment and secondment arrangements for the CEO and the technical experts to ensure that the Institute would be recognised as a centre of excellence in CCS.
f) Provided a potential shield from liability should members be concerned about incurring legal liability as a result of activities performed by the Institute.
g) Provided accountability and transparency.
h) Was a legal concept well understood by governments, industry participants and researchers.
i) Enabled members to easily terminate their membership.
j) Was consistent with the Institute's "not for profit" status.
k) Enabled the Institute to enter readily into legally binding commitments with demonstration project parties (*i.e.* parties wishing to provide funding to the Institute and others wishing to receive services from the Institute).
l) Ensured that the Institute is not hindered by government processes and can respond quickly to emerging scenarios.
m) Did not exclude stakeholders from decision making on any changes to the activities or governance arrangements concerning the Institute.

n) Allowed all stakeholders to have a role in determining the governance arrangements and other activities of the Institute equivalent to that of the Australian government if they provide comparable levels of funding and other forms of commitment.

A range of alternative legal models was considered: a company limited by shares; a trust; an international organisation; an unincorporated joint venture; an Australian government agency; and a transitional hybrid for a company limited by guarantee. Analysis of the options, supported by legal advice and broad consultation with stakeholders, concluded that a multi-member not-for-profit company limited by guarantee was the optimal legal structure to achieve the stated objectives.

When the Global CCS Institute was launched in April 2009 it had 15 governments and more than 40 major companies and industry groups as foundation members. By October 2010 membership had increased to 263 members, including 26 national governments. The criteria for membership are set out in its constitution. It is open to any government, corporation or organisation that can demonstrate a legitimate interest in the advancement of CCS. There is no application fee to become a member though there is a small contingent liability (AUD 10) should the Global CCS Institute be wound up and unable to discharge its liabilities.

The Global CCS Institute is governed by a board of directors based in Australia, France, Japan and the United Kingdom. The board seeks input from an International Advisory Panel and a Technical Advisory Committee. In relation to decisions that determine the direction of the organisation, the constitution distinguishes between various classes of members. Voting rights are specified for government, major industry and general members. Each group is able to appoint two members to the Board Selection Panel. This guarantees that the views of government and major industry groups are still heard when their proportion of overall membership base is diluted with the growth of new members.

On an operational level the Global CCS Institute has built close working relationships with international organisations with complementary skills and a vested interest in the deployment of CCS. Two examples are the IEA and the Carbon Sequestration Leadership Forum. These close ties help to avoid duplication of effort and to create synergies from the respective strengths of each organisation.

Global CCS Institute – the first and second years

Although the Global CCS Institute is a newcomer, it has closely considered the efficacy of various governance dimensions. For example, the theme of the Global CCS Institute members' meeting held in Kyoto in October 2010 was "Building Project Capability through Knowledge Sharing". Attended by over 130 representatives from over 90 members, the event launched a new digital platform to facilitate collaboration among members. Breakout sessions investigated members' preferences for the right mix of collaboration via digital technology and face-to-face meetings.

At the Kyoto meeting the first round of project support funding was announced: AUD 18 million were allocated to address specific technical barriers related to six projects around the world. As a condition of receiving funding from the Global CCS Institute, projects needed to commit to knowledge sharing for the benefit of the global CCS community. A number of informative presentations at the meeting provided valuable lessons for the benefit of all delegates.

Not surprisingly, in its first year of operation the Global CCS Institute emphasised setting up its operations, establishing relationships with other key stakeholders, and determining a forward work programme that met the needs of its rapidly growing membership base. In its second year, the emphasis shifted from set-up to execution, with a continuing focus on co-operation and collaboration with other organisations.

The Institute's membership continued to grow, and reached 330 by November 2011, including 27 national governments and the European Commission. This membership is spread across all inhabited continents. To reflect its global status and the need to service its diverse membership, the Institute opened offices in Washington, DC, and Tokyo in 2011, adding to its presence in Paris and Canberra. Global CCS Institute staff are also present in Canada, the United Kingdom, Belgium and the Netherlands. Full-scale members' meetings continue to be rotated through different regions of the world. Meetings were held in Europe and Australia during 2011, following meetings in the United States and Japan in 2010. A programme of local member workshops was also instituted during 2011; meetings were held in Australia, Japan, Korea, the United States, Canada, the United Kingdom and Poland.

Specialist thematic groups of members were also formed around certain issues to bring together organisations with common interests to share information on technical issues relating to CCS, and to provide input to the Institute's work programme. Some of these groups or networks used the Institute's knowledge platform to facilitate knowledge sharing through document exchange and online discussion groups. The knowledge platform was also used as an outreach mechanism to disseminate information related to CCS in many different forms, including publications authored by the Institute and other organisations (more than 100 published on the Institute's website), blogs by a wide variety of contributors, and a "community" space open to anyone who registers interest.

Collaboration with other international organisations also increased during the year. The Institute is a member of the Carbon Capture, Use, and Storage Action Group under the Clean Energy Ministerial; a collaborating international organisation with the Carbon Sequestration Leadership Forum (CSLF); funds the IEA CCS Unit; provides monies to capacity development trust funds administered by the World Bank, the Asian Development Bank and the CSLF; and became an accredited observer organisation to the United Nations Framework Convention on Climate Change. It works closely with all these organisations, and has established close working relationships with many non-governmental organisations (NGOs) with an interest in CCS.

The governance structure adopted by the Institute has proven effective for meeting the objectives set out by stakeholders in 2008. Broad support from a wide and increasing membership shows that governments, corporations and research bodies see the Institute as independent and not captured by specific stakeholders. Recommendations on the treatment of intellectual property (IP) have been adopted by the Institute and have led to close relationships with project developers. Under these recommendations, sensitive commercial issues can be discussed, but such information can be protected; only non-proprietary information can be released. The independent, not-for-profit status of the Institute facilitates the development of such relationships. On the basis of relationships and the significant start-up funding provided to the Institute, a large amount of technical and project-specific knowledge is now being generated and widely disseminated. This information dissemination role is very well received, as demonstrated by the number of web downloads and attendance at both online and face-to face seminars and workshops.

The Institute's governance structure has also allowed it to establish and implement a work programme quickly, as it is not constrained by the "consensus" or committee-based decision making which is a feature of many international organisations. The Institute is answerable to its membership, but the company structure means that members are not intimately involved in day-to-day decision making. This freedom has allowed the Institute to make an impact and establish itself as a major voice for CCS within its first two years. The model adopted in setting up the Institute appears to be a good example of how to achieve global collaboration across government, industry and NGOs for effective results in a relatively short period of time.

Intellectual property has received considerable attention since the early planning stages of the Global CCS Institute. The BCG developed some general principles regarding how IP should be treated by the Institute and included the following recommendations for the Institute's conduct of IP:

- Gather and package non-proprietary information about CCS and make it accessible to all stakeholders;
- Endeavour to make IP generated through programme activities as widely accessible to members as practical.
- Seek to make IP jointly generated by the Institute and its partners through Institute activities available on reasonable terms to other Institute activities (including demonstration projects).
- Respect the IP rights of partners and project proponents, and the right of IP holders to profit from their work.

Knowledge sharing remains pivotal to the work of the Global CCS Institute. In fact it is one of the following three core functions:

1. Sharing knowledge
   - Collect information to create a central repository for CCS knowledge.
   - Create and share information to fill gaps and build capacity.
2. Fact-based advocacy
   - Inform and shape domestic and international low-carbon energy policies.
   - Increase awareness of the benefits of CCS and the role it plays in a portfolio of low-carbon technologies.
   - Project assistance
   - Tackle specific barriers, particularly among early movers.
   - Bridge knowledge gaps between demonstration efforts.

Summary

The Global CCS Institute has a governance structure designed to incorporate the diverse views of its membership and to remain independent from government and sufficiently responsive to make the deployment of CCS technologies a reality. It is too soon to draw lessons from the Global CCS Institute. However, the growth in the membership base would indicate that many consider this model of international collaboration an option worthy of close consideration when looking to address global challenges.

Annex B[1]

Mini case study: International Arabidopsis Genome Research Project

Prepared by the Delegation of the United States

History

In the late 1980s, the Human Genome Project was being established in the United States and Europe. For the model organism genome project, the US National Institutes of Health (NIH) selected *E. coli*, yeast, and *C. elegans* (a worm), but decided not to include a plant. However, the National Science Foundation (NSF) recognised the importance of a plant genome project, and held a workshop attended by NIH, the Department of Energy (DOE), the Department of Agriculture (USDA) and NSF programme officials as well as plant science researchers from universities and private industry. The workshop participants recommended the establishment of an international plant genome project using Arabidopsis as the model system. A series of workshops were held to develop an international Arabidopsis genome project.

In the 1990s, nine Arabidopsis researchers from the United States, Europe, Australia and Japan formed an *ad hoc* committee and drafted a long-range plan for the Multinational Co-ordinated Arabidopsis Thaliana Genome Project. The draft plan was discussed at the International Conference on Arabidopsis Research held in Vienna and approved by the approximately 400 attendees.

The Multinational Arabidopsis Steering Committee was established in the 1990s to: *i)* co-ordinate programmatic aspects of the Arabidopsis genome project; *ii)* communicate with the informatics and biological resource centres that were to be established; *iii)* monitor and summarise progress of scientific activities in participating laboratories; *iv)* serve as liaison to the broader plant biology community; *v)* identify needs and opportunities of the Arabidopsis research community and communicate these to the funding agencies of participating nations; and *vi)* periodically update the long-range plan.

In 1996, an international consortium consisting of the United States and the United Kingdom supported by the European Commission, France and Japan began sequencing the Arabidopsis genome. In 2000, the sequencing was completed. In 2001, the Multinational Co-ordinated Arabidopsis Functional Genome Project was established as a follow-up to the Multinational Co-ordinated Arabidopsis Genome Project. In 2002, The Multinational Arabidopsis Steering Committee published a long-range plan for the follow-up project.

From 2001 to 2010, various funding agencies around the world established programmes to support this international effort: the NSF's Arabidopsis 2010 Project; the UK Biotechnology and Biological Sciences Research Council's (BBSRC) "Genomic

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Arabidopsis Resource Network (GARNeT); and the German Research Foundation's (DFG) Arabidopsis Functional Genomics Network (AFGN), to name a few.

In 2010, The Multinational Arabidopsis Steering Committee discussed developing the next long-range plan at its annual meeting held in Yokohama, Japan, during the 21st International Conference on Arabidopsis Research. There were 1 400 attendees at the Yokohama conference (compared to 400 in 1990 in Vienna.)

Why Arabidopsis?

The plant scientific community identified Arabidopsis as the ideal model for several reasons. Arabidopsis is a plant that is easily manipulated, genetically tractable, and about which much was already known. Arabidopsis also has a relatively small genome consisting of approximately 25 500 genes. It therefore allowed for testing hypotheses quickly in the laboratory. In 2002, the Multinational Arabidopsis Steering Committee acknowledged the importance of collaboration: "We have put forth a goal of no less than complete understanding of the biology of an organism: the only way to achieve success is to work together with realization that we are all wedded to the same goal."

The Arabidopsis Project has had two phases. The first resulted in a complete annotated genetic sequence and the adoption of ontological standards. Once this phase was completed, the scientific community began work "to determine the role of every gene in the control of the metabolic and developmental processes of the plant".

The stated mission of the project was to increase the knowledge and understanding of a flowering plant, using Arabidopsis as an experimental model system. The long-term goal is to increase crop yields and nutritional value, enhance resistance to drought, disease and other stresses, and decrease dependence on chemical pesticides. In addition to producing more and higher-quality food, the research also advances understanding of plants for use in sustainable energy and pharmaceutical products.

Project management

The project was driven by science and managed by scientists. The Multinational Arabidopsis Steering Committee met once a year at the annual International Conference on Arabidopsis Research and issued annual progress reports. Funding agency programme staff (especially NSF, EC, BBSRC and DFG) worked closely together and with the Multinational Arabidopsis Steering Committee. For joint activities, such as the whole genome sequencing project, funding agencies co-ordinated funding although funds were never co-mingled.

Since 2001, NSF, DFG and BBSRC have provided funding for a co-ordinator of the Multinational Arabidopsis Steering Committee. All co-ordinating activities have been carried out over 20 years without any memoranda of understanding or other officially signed agreements.

Factors of efficiency and effectiveness in modes of governance

- Open communication and immediate sharing of information, data, as well as biological and research resources.
- Sense of ownership by the research community.
- Commitment to the project by international leaders in the field.
- Common goals shared by all participating researchers and funding agencies.
- Stable leadership at funding agencies.
- No initial issues with respect to data release and industry because Arabidopsis is a model system and has no commercial value as a crop plant.
- Establishment of a co-ordinator to assist the Steering Committee in the co-ordination of international research efforts.
- Establishment of repositories for long-term storage and dissemination of data and biological resources in the United States and the United Kingdom.

Challenges to effective collaboration

During the functional phase, some of the researchers who received industry funding encountered obstacles for sharing data and research resources. Over time, the scientific community became more educated about management of IP and related issues and developed solutions to enable them to share the data as they were generated.

Communicating the value of research on Arabidopsis to decision makers and the public has been difficult. Participating scientists must be constantly reminded of their obligations to communicate the value of their work to the taxpayers.

Benefits and outcomes

Arabidopsis has become the model for sequencing the genomes of plants. The techniques and standards developed in the Arabidopsis project became a model for studies of all plants, including rice and maize. The Arabidopsis Project was not inexpensive; it cost approximately USD 75 million. The knowledge gained by the Arabidopsis project enabled subsequent sequencing efforts to be carried out at a much lower cost.

The Arabidopsis Project has had broader impacts, including the development of enabling technologies for sequencing. It resulted in an increase in US utility patents. The first sequence was published in 1996. The Multinational Coordinated Function Genomic Project Annual Report for 2008 maps (p. 22, Figure 3) US utility patents referencing Arabidopsis from 1987-2007. The data demonstrate that dissemination of the sequence information correlates with a significant increase in utility patents; sharing of the sequence information enabled scientific studies that led to patent inventions.

The Arabidopsis Project has advanced knowledge of plant biology, moved the field of plant biology to the age of systems biology, and led to the development of more advanced tools to sequence and elucidate the function of plant genes. It has served as a model for sequencing the genomes of plants with greater commercial potential. This research is crucial to increasing food feed, and fibre production and addressing the global challenge of food security.

Lessons learned

- It is very important for the international scientific community to agree on a data and research materials release policy at the beginning of the project.
- The Arabidopsis Project was successful because it was science-driven and had broad support from the international scientific community. The science community identified the need to sequence a flowering plant to advance plant genomic research and identified Arabidopsis as the ideal candidate. Both phases of the project were successfully implemented without formal international arrangements.
- The government role in the project, however, was also critical to its success. Federal funding agencies funded critical research under the project and facilitated sharing of the resulting sequencing and functional data by requiring that they be shared with the project partners in a timely manner.
- In addition to funding research, national funding agencies can play a crucial role by establishing policies that encourage timely data sharing, requiring grantees to develop a data management plan acceptable to the scientific community as part of their research proposal, and assisting researchers in the identification of appropriate repositories for the results of the research.

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