Integrating Science and Technology into Development Policies

AN INTERNATIONAL PERSPECTIVE

OECD

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

On 21-22 November 2005 the OECD and the South African Department of Science and Technology organised a workshop on "International Science and Technology Co-operation for Sustainable Development", which was held at Kwa-Maritane, Pilanesberg National Park near Johannesburg, South Africa. A steering group made up of officials and experts from Australia, Austria, Belgium, China, Finland, France, Germany, Italy, the Netherlands, Norway, the United States and the OECD Secretariat was instrumental in developing the programme and identifying speakers.

The workshop followed on the "Declaration on International Science and Technology Co-operation for Sustainable Development" adopted by Ministers at the meeting of the OECD Committee for Scientific and Technological Policy at Ministerial level in January 2004. The aims of the workshop were to identify good practices in international science and technology co-operation for sustainable development; attempt to develop indicators of these good practices; identify effective modes for S&T partnerships in the water and energy sectors with specific examples; and recommend approaches for the fuller integration of science and technology dimensions in sustainable development policies.

This publication contains the proceedings, the resolutions and a synthesis of the workshop. The Secretariat would like to thank the following persons who contributed actively and substantially to the organisation of the workshop: Bruno Bordage, Wolfgang Hein, Timo Kolu, Kirsten Broch Mathisen, Alicia Mignone, Teddie Muffels, Helena Schulte to Buhne, Monika Sormann, Griffin Thompson, William Thorn, Live Torres, Dhesigen Naidoo, Busi Madolo, Mmampei Mabusela, Kele Lekoape, Yukiko Fukasaku and Daniel Malkin. The Secretariat would also like to thank all the national experts and delegates from member and non-member countries who participated in the workshop and without whose support the workshop would not have been possible.

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Executive Summary

The Declaration on *International Science and Technology Co-operation for Sustainable Development* adopted by Ministers in 2004 at the Ministerial level meeting of the OECD Committee for Scientific and Technological Policy (CSTP) asked for:

> *"Concerned countries and relevant stakeholders to convene, in collaboration with the OECD if possible, an appropriate event such as a dedicated conference of specialists on the issues raised by this Declaration to further enhance the consensus of the World Summit on Sustainable Development (WSSD) on the application of science and technology for sustainable development."*

In response to this request, a workshop was held in South Africa, hosted by the government of South Africa. With over 150 participants, the event was more a conference than a workshop. Its two objectives were:

- To identify good practices in international science and technology co-operation, especially between OECD and developing countries, aiming at both cross-cutting goals of fostering capacity-building in science and technology, facilitating effective diffusion of scientific knowledge and technology transfer, and developing knowledge infrastructure and networks, in order to meet sustainable development objectives at national and global levels; and highlighting concrete and efficient solutions that have been implemented in the areas of water and energy.
- To consider possible indicators of good practices in international science and technology co-operation for sustainable development and methodologies to evaluate international science and technology co-operation initiatives.

The plenary speakers mainly addressed the cross-cutting goals, whereas the two breakout groups focused on concrete international co-operation initiatives and related issues in the areas of water and energy. The possible indicators of good practices were considered in two of the presentations as well as in the conclusions of the breakout sessions and in one of the panel sessions. In conclusion to the workshop, the final panel session revisited the policies that could promote good practices in international science and technology co-operation that would promote the cross-cutting goals.

Elements of good practices

The plenary speakers converged on the view that science and innovation could and should play a greater role in making the development process more sustainable in its three pillars, economic, social, as well as environmental. They also emphasised the need for greater co-ordination among the key role players to deliver effective policies and co-operation initiatives that would lead the developing economies towards a sustainable path including achieving the Millennium Development Goals.

To have the developing economies move towards sustainable development, international co-operation initiatives should be an interactive learning process involving knowledge suppliers and users; also, training should be integrated as a component on a long-term, sustainable basis. The international co-operation programmes could provide opportunities for "brain retain", "brain circulation" or "brain return", which should be able to check the one-way "brain drain" from the developing countries. The importance of the "bottom-up" element in the co-operation initiatives was stressed. Local communities, SMEs, and NGOs working at the local level need to be involved. The business sector representatives emphasised the need for a demand-driven approach to developing markets by fostering consumers who understand the benefits and the sustainable use of technologies being introduced. Attention should be paid to appropriateness in terms of costs, content and skills, as well as to adapting the technologies and products to local needs.

Building knowledge networks in the long term should be an integral part of international co-operation initiatives. Information and communication technologies could play a key role. Access to and the capacity to use relevant ICT need to be improved and the appropriate infrastructures developed. The emerging knowledge networks should link business, universities and the local community to build up local, national and regional innovation systems, especially in Africa. The key role of revitalising African universities as regional centres in harnessing science technology and innovation was stressed. Regional networks of centres of excellence could facilitate the integration of African universities and businesses into the emerging global value chains of the world economy.

Good practices in sectoral areas: water and energy

For the purpose of increasing access to water supplies including safe drinking water, the need for "integrated water management systems" in which the water cycle is viewed in the ecosystem context was stressed. The delivery of actual technologies used to supply and treat water should be designed based on the good practice elements discussed above. Also, in the developing countries, water monitoring systems using satellites and associated technologies need to be strengthened.

In the energy sector, it was suggested that international partnerships could greatly increase access to energy services in developing countries. Those that introduce technologies that enhance energy efficiency both in production and end use are key. Improved delivery of energy services could be achieved mainly through existing technologies, although co-operation initiatives to develop well-adapted applications of renewable energy sources could play an increasing role in the long term, provided that the prices are appropriate. Local adaptation and education to promote more efficient use of the appropriate energy technologies would enhance efficiency and increase access. Cleaner industrial production technologies that would also increase energy efficiency need to be delivered through co-operation initiatives in mining, chemicals and construction.

Indicators of good practices

A number of ways for conceptualising and developing good practices were explored in the two plenary presentations on this topic as well as through the breakout sessions, the first panel session, and the special informal session that took place on the morning after the workshop.

The emerging view was that indicators of good practices in international science and technology co-operation for sustainable development are very difficult to develop; and any attempt would be a long-term process. The main reason is that such indicators need to integrate the four different areas, each of which already has or would have different sets of indicators to measure effectiveness and efficiency. They are: *i)* science and innovation; *ii)* international co-operation; *iii)* development; and *iv)* sustainability.[1]

When it comes to indicators that cut across any combinations of two of the areas, the available indicators are already extremely limited. The challenge of the workshop was to consider those that cut across the four areas. Also, it was suggested that the stock of knowledge that can be gained from case studies on international co-operation initiatives and their evaluation was still lacking and needed to be built before proceeding to develop indicators. The use of the databases such as the one on WSSD Type II partnerships available through the UNCSD website or the OECD DAC database on donor *ex-post* evaluation studies were suggested for this purpose. Also, surveys such as the Community Innovation Survey (European Commission and Eurostat) could possibly provide models for a survey on indicators of good practice. Other practical approaches were also suggested such as defining a very small set of indicators based on what the policy makers would find the most useful. As for the possible forum to take this up, the newly created UNECE Working Group of the Conference of European Statisticians (also supported by the OECD) was suggested in addition to CSTP and its working parties.

Conclusions

The conference brought together government representatives, business, academics, international organisations and other stakeholders to develop a broad perspective from which the issues at the intersection of science and innovation, international co-operation, development and sustainability need to be viewed. The emerging consensus was the central role that well-designed international science and technology co-operation initiatives could play in steering developing economies towards sustainable development. Such initiatives needed to integrate certain elements including science and technology capacity building, technology and knowledge transfer in the long-term, and building effective knowledge networks with the involvement of the local community and a variety of stakeholders including business. In fact effective approaches in delivering water and energy services and managing their supply were discussed with suggestions of good practices. However, these fell far short of being comprehensive or capable of converging on a set of indicators. What was accomplished has indeed opened up a much larger set of issues for policy that warrant further discussion and analysis.

1. The third and fourth can be grouped into an integrated area of "sustainable development" reducing the number of areas to three. This was the approach taken by Fred Gault of Statistics Canada in his plenary presentation (see Chapter 8). However, when "sustainable development" is considered in the context of the "development" of developing economies, it clearly implies two different policy issue areas: economic and social development in these countries on the one hand, and the economic, social and environmental "sustainability" of the development paths. In fact, the existing indicator sets concern either one or the other, but rarely both; hence, these were separated.

Resolutions and suggestions for follow-up

At the end of the workshop the participants agreed on a set of resolutions (see p. 15). Based on these resolutions and other suggestions discussed at the workshop, the following list emerges as possible avenues of follow-up:

Indicators of good practices in international science and technology co-operation for sustainable development

As one clear outcome of the workshop was the recognition of the overwhelming difficulty of developing indicators on the topic, any forthcoming attempts to tackle the issue of indicators should be designed to constitute steps towards the ultimate objective. Also, further work on case studies should proceed in parallel. CSTP could consider taking this up with the support of its working parties, especially NESTI; also, other OECD committees and working parties, especially the Annual Meeting of Sustainable Development Experts. A CSTP workshop dedicated to this topic can be envisaged. Alternatively, the CSTP could suggest that the indicators work be undertaken by OECD-related bodies such as the Working Group of the Conference of European Statisticians. The African Science, Technology and Innovation Indicators (ASTII) group is also in the process of developing Science, Technology and Innovation indicators specifically for the African continent and can be consulted or approached.

Follow-up on practical actions through international science and technology co-operation to promote sustainable use of energy and water

Except for follow-up that may be possible as part of the work programme of the Working Party on Biotechnology, there are other committees and bodies in the OECD that are better equipped to take these up such as those under the Environment Policy Committee, the IEA and the Agricultural Policy Committee. Any follow-up on questions of water and energy need to be undertaken jointly with these bodies.

One of the thematic areas of the UN Commission on Sustainable Development in the current cycle is Energy. This forum can also be used to raise the issues related to S&T co-operation to promote the sustainable use of energy. A national process that feeds into the CSD 14 session is underway in South Africa and DST plans to have a representative speak in a panel discussion at the CSD 14 on "Enhancing means of implementation through sub-regional, regional and international co-operation" scheduled to take place in May 2006 in New York.

Follow-up activities in other sectoral areas

Suggestions were made to organise similar workshops that would take up other sectoral areas. These could be the other WEHAB areas not covered by this workshop, *i.e.* health, agriculture and biodiversity. If such events are to take place, it was suggested that they should be scheduled so that contributions to the UNCSD themes would be possible.[2]

2. The current UNCSD cycle is on thematic clusters of energy, industrial development, air pollution/atmosphere and climate change. The thematic clusters for the forthcoming cycles up to 2017 are listed at: *www.un.org/esa/sustdev/csd/csd11/CSD_mulityear_prog_work.htm.*

Follow-up activities in other cross-cutting research and innovation issues in enhancing international science and technology co-operation for sustainable development

This workshop focused on capacity building in science and technology, effective knowledge transfer and building of knowledge networks as cross-cutting issues. Other cross-cutting issues that possible follow-up could focus on include:

- **Promoting and using centres of excellence as a tool for building national and regional research and innovation systems in the developing countries.** Many international science and technology co-operation initiatives involve creating or using national or regional centres of excellence for S&T capacity building, linking diverse actors in research and innovation such as universities and businesses. How these can better be promoted for different sustainability objectives in the developing economies can be further explored.
- **International migration of the highly skilled human resources in science and technology.** The "brain drain" of university-trained researchers and engineers exerts a negative impact in building up effective research and innovation capacities and systems in the developing economies. How this trend can be diversified to brain circulation, return or retain or how diaspora could benefit the country of origin need to be explored along with improving indicators and data on the international migration of the highly skilled.
- **Enhancing access and sharing research information and data.** The issue which is being taken up by the CSTP mainly in the context of OECD member countries is an even more pertinent issue for the developing countries, because of the lack of resources and infrastructure that facilitate access. Yet access to and sharing of information and data is essential for mobilising the developing countries' research capacities in the globalising knowledge network and enhancing progress in research and innovation at the global level. The different set of issues that developing countries face for better access warrant investigation. The South African Department of Science and Technology (DST) is exploring the possibility of utilising its current G77 chairmanship tenure to address S&T issues related to investments in R&D and sharing of research data from publicly funded research institutions. A Special Science and Technology G77 + China Ministers Session is planned in 2006 to address issues on access to research data.
- **Creating a Web-based network for sharing information and experience in international S&T co-operation for sustainable development.** It was suggested that OECD or another appropriate international organisation could possibly undertake the creation of a Web platform for sharing information and experience in the different initiatives in the area of international science and technology co-operation for sustainable development.

All these cross-cutting issues could be followed-up with reference to specific sectoral area(s). Also, the best modes of follow-up, *i.e.* further workshops, analytical work including case studies and exploring available indicators and data, or joint work with other bodies, need to be considered.

OECD-South Africa Workshop
on
International Science and Technology Co-operation for Sustainable Development
21-22 November 2005

Resolutions

Preamble

Global leaders, experts, policy makers and academics from the OECD countries as well as developing countries met at Kwa Maritane, Nor West Province, South Africa, to further the work of the OECD and its partners in the area of international co-operation in science and technology for sustainable development.

As a follow-up to the World Summit on Sustainable Development held in Johannesburg in 2002, the OECD Committee for Science and Technology Policy adopted the *Declaration on International Science and Technology Co-operation for Sustainable Development* at its Ministerial session in January 2004.

There is a growing international consensus that science and technology (S&T) is a key vehicle to achieve the global sustainable development agenda. It is also an essential tool in the realization of the Millennium Development Goals within reasonable timeframes. This emerging consensus has revealed that very few countries, if any, have the capacity, knowledge platforms and resources to do this alone. We need smarter and more effective partnerships. We need co-operation between regions, between countries, between institutions and between people. This co-operation should be both north-south and south-south in nature, and by design, governments, academia and business in both OECD member countries and developing countries have important roles to play.

In this spirit, the South African government, through its Department of Science and Technology, has partnered with the OECD to advance co-operation in the areas of policy and good practices in key sustainable development domains. The themes of water and energy were chosen as the focal points of this discussion to coincide with and add value to, the work in these areas underway under the auspices of the UNCSD.

Key challenges

- To identify good practices in international science and technology co-operation, especially between OECD and developing countries, aiming at fostering capacity-building in science and technology, at facilitating effective diffusion of scientific knowledge and technology transfer, and at developing knowledge infrastructure and networks, in order to meet sustainable development objectives at national and global levels. Such good practices include highlighting concrete and efficient solutions that have been implemented in the areas of water and energy.

- To consider possible indicators of good practices in international science and technology co-operation for sustainable development and methodologies to evaluate international science and technology co-operation initiatives.

Deliberations

Using plenary sessions, breakout sessions and panel discussions, the workshop addressed issues such as:

- Effective science and technology capacity building in developing countries.
- Facilitating knowledge and technology transfer and partnerships to achieve this.
- Developing knowledge infrastructure and networks of science and innovation for sustainable development.
- Technologies that best meet the needs of the developing countries in the areas of water and efficient use of energy while meeting sustainable development objectives.
- Indicators and criteria for good practices in science and technology and S&T co-operation for sustainable development.

The principal finding was the importance of scientific and technological co-operation for sustainable development.

Resolutions

1) Participants invite OECD committees and working groups involved in the production indicators related to sustainable development, development assistance, and science and technology broadly defined to take note of the importance of science and technology co-operation for sustainable development and to consider the production of indicators to support policy development in this area.
2) The practical actions for the sustainable use of energy resources: promote the creation of innovative intellectual communities and partnerships within developing countries addressing the key technology, policy and programme issues for the efficient use of conventional and new forms of energy in pursuit of the goals of sustainable development.
3) Practical actions for sustainable use of water resources: strengthen, through demand-driven and efficient co-operation (*e.g.* partnerships, centres of excellence) in science and technology, the knowledge base of all levels of stakeholders, in order to synergistically improve access to (efficient and clean) water supply and sanitation from an integrated water resources management approach.
4) Further meetings to develop the "science and technology for sustainable development" agenda in the OECD can be envisaged to incorporate insights in other domains (biodiversity and agriculture for example) and to develop envisaged indicators.
5) Develop a paper on the cross-cutting nature of international co-operation to achieve sustainable development and the core supporting actions to mainstream the contributions of science and technology to achieve these objectives for submission to UNCSD.

Résumé

Adoptée en 2004 à la réunion du Comité de l'OCDE de la politique scientifique et technologique (CPST) au niveau ministériel, la Déclaration sur la coopération scientifique et technologique internationale en faveur du développement durable appelait :

> *« Les pays concernés et les parties prenantes intéressées à organiser, en collaboration avec l'OCDE si possible, une réunion, telle qu'une conférence de spécialistes consacrée aux questions soulevées dans la présente Déclaration, de manière à renforcer le consensus issu du Sommet mondial sur le développement durable (SMDD) sur l'application de la science et de la technologie au service du développement durable ».*

En réponse à cette demande, un atelier s'est tenu en Afrique du Sud sous l'égide du gouvernement de ce pays. Avec 150 participants, il s'apparentait davantage à une conférence qu'à un atelier. Les deux objectifs étaient les suivants :

- Caractériser les bonnes pratiques en matière de coopération scientifique et technologique internationale, notamment entre membres de l'OCDE et pays en développement, dans une double perspective transsectorielle : *i)* stimuler le développement des capacités scientifiques et technologiques, faciliter une diffusion efficace des connaissances scientifiques et les transferts de technologie, et développer les infrastructures et réseaux de savoir en vue d'atteindre les objectifs du développement durable aux échelles nationale et mondiale ; *ii)* dégager les solutions concrètes et efficientes qui ont été mises en œuvre dans les domaines de l'eau et de l'énergie.
- Envisager des indicateurs des bonnes pratiques en matière de coopération scientifique et technologique internationale au service du développement durable, ainsi que des méthodes d'évaluation des initiatives internationales de coopération.

Pendant les séances plénières, les intervenants ont surtout évoqué le premier point, tandis que les deux séances en sous-groupes ont été consacrées en priorité aux initiatives internationales concrètes de coopération et aux problèmes rencontrés dans ce domaine dans les secteurs de l'eau et de l'énergie. Les indicateurs des bonnes pratiques ont été abordés dans deux communications, dans les conclusions des séances en sous-groupes et dans l'une des séances de débat. A l'issue de la manifestation, lors d'un dernier débat, les participants sont revenus sur les mesures propices à de bonnes pratiques de coopération à même de favoriser la réalisation des objectifs transsectoriels.

Eléments de bonne pratique

En séance plénière, les intervenants étaient tous d'avis que la science et l'innovation pouvaient et devaient contribuer davantage à assurer la durabilité du processus de développement dans ses trois dimensions (économique, sociale et environnementale). Ils ont également souligné qu'il fallait renforcer la coordination entre les principaux acteurs pour mettre en place des mesures et initiatives de coopération efficaces, à même de mettre les économies en développement sur la voie de la durabilité, notamment dans l'optique d'atteindre les Objectifs du millénaire pour le développement.

Pour que les économies en développement s'orientent vers le développement durable, les initiatives internationales de coopération doivent reposer sur un processus d'apprentissage interactif faisant intervenir pourvoyeurs et utilisateurs des connaissances. En outre, il faut y intégrer la formation sur le long terme. Dans l'optique d'enrayer la fuite des cerveaux dont pâtissent les pays en développement, les programmes de coopération internationale doivent permettre de retenir les professionnels hautement qualifiés, de ne pas entraver leurs déplacements et de les faire revenir. L'importance de la dimension « décentralisée » des initiatives de coopération a été soulignée. Les collectivités locales, les PME et les ONG qui œuvrent à l'échelon local doivent être mobilisées. Les représentants du monde de l'entreprise ont insisté sur le fait que le développement des marchés devait obéir à la demande, et qu'il fallait pour ce faire appuyer les consommateurs qui comprennent les avantages et l'utilisation durable des technologies adoptées. Il convient de veiller à ce que les initiatives soient fondées, en termes de coûts, de contenu et de qualifications, et à ce que les technologies et produits soient adaptés aux besoins locaux.

La mise en place de réseaux de savoir durables devrait faire partie intégrante des initiatives internationales de coopération. A cet égard, les technologies de l'information et de la communication pourraient jouer un rôle déterminant. L'accès aux TIC nécessaires et la capacité à les exploiter doivent être améliorés, et les infrastructures indispensables doivent être développées. Les nouveaux réseaux de savoir doivent mettre en relation entreprises, universités et collectivités locales dans l'optique de bâtir des systèmes nationaux et régionaux d'innovation, particulièrement en Afrique. Des réseaux régionaux de centres d'excellence pourraient faciliter l'intégration des universités et des entreprises africaines dans les nouvelles chaînes de valeur globales de l'économie mondiale.

Bonnes pratiques dans les secteurs de l'eau et de l'énergie

Il a été souligné que, pour améliorer l'accès à l'eau, notamment à l'eau potable, il fallait des « systèmes de gestion intégrés » dans lesquels le cycle de l'eau est considéré à l'échelle de l'écosystème. La fourniture des technologies utilisées concrètement pour distribuer et traiter l'eau doit obéir aux éléments de bonnes pratiques évoqués plus haut. En outre, dans les pays en développement, il convient de recourir davantage aux systèmes de surveillance des ressources qui font appel aux satellites et aux technologies associées.

Il a été estimé que, dans le secteur de l'énergie, les partenariats internationaux pourraient notablement améliorer l'accès aux services dans les pays en développement. Ceux qui permettent l'adoption de technologies qui élèvent le rendement énergétique aussi bien dans la production que dans les utilisations finales sont déterminants. Une amélioration des services énergétiques pourrait être obtenue pour l'essentiel au moyen des technologies existantes, mais les initiatives de coopération visant à développer des applications adaptées des énergies renouvelables pourraient jouer un rôle de plus en plus important à long terme, à condition que les prix ne soient pas trop élevés. Les adaptations locales et les actions de formation destinées à favoriser une utilisation plus judicieuse de technologies énergétiques appropriées amélioreraient l'efficience et l'accès. Des initiatives de coopération qui apportent des techniques de production industrielle à la fois moins polluantes et à même d'accroître le rendement énergétique doivent être lancées dans les secteurs minier, chimique et de la construction.

Indicateurs des bonnes pratiques

Plusieurs manières de concevoir et de développer de bonnes pratiques ont été envisagées aux cours des deux séances plénières consacrées à cette thématique, ainsi que pendant les séances en sous-groupes, la première séance de débat et la séance informelle spéciale organisée dans la matinée qui a suivi la clôture de l'atelier.

Il en est ressorti qu'il était très difficile de concevoir des indicateurs des bonnes pratiques dans le domaine de la coopération scientifique et technologique internationale au service du développement durable, et toute initiative en ce sens demanderait beaucoup de temps. La raison en est que les indicateurs en question doivent prendre en compte quatre domaines distincts, pour chacun desquels différents indicateurs d'efficacité et d'efficience existent déjà ou devraient être créés. Ces quatre domaines sont les suivants : *i)* la science et l'innovation ; *ii)* la coopération internationale ; *iii)* le développement ; et *iv)* la durabilité.[1]

Les indicateurs existants qui recoupent deux de ces domaines sont déjà très rares. Il était donc difficile, dans le cadre de l'atelier, d'envisager des indicateurs qui portent simultanément sur les quatre. Par ailleurs, il a été indiqué que les informations que peuvent apporter les études de cas sur les initiatives internationales de coopération et leur évaluation restaient lacunaires, et qu'il faudrait en réunir davantage avant de concevoir des indicateurs. Les participants ont évoqué, à ce sujet, les bases de données comme celle qui porte sur les partenariats de type II découlant du SMDD, consultable sur le site web de la CDD de l'ONU, ou la base de données du CAD de l'OCDE sur les évaluations faites *a posteriori* par les donneurs. De même, des enquêtes telles que celle que la Commission européenne et Eurostat ont consacrée à l'innovation dans l'UE pourraient éventuellement servir de modèle à une enquête sur les indicateurs de bonnes pratiques. D'autres approches concrètes ont également été proposées, par exemple définir un groupe très limité d'indicateurs fondés sur les critères que les responsables de l'action publique jugeraient les plus pertinents. Outre le CPST et ses groupes de travail, le nouveau groupe de travail de la Conférence des statisticiens européens (CEE-ONU, également soutenue par l'OCDE) pourrait être chargé de cette mission.

1. En fait, les domaines trois et quatre peuvent être regroupés dans une seule et même catégorie « développement durable », ce qui ramène le total à trois. Telle a été la position adoptée par Fred Gault, de Statistique Canada, dans son intervention en séance plénière. Cependant, dans le contexte des économies en développement, le « développement durable » renvoie de toute évidence à deux domaines de l'action publique : le développement économique et social dans les pays concernés, d'une part, et la « durabilité » économique, sociale et environnementale des stratégies de développement, d'autre part. En réalité, les indicateurs existants portent en général soit sur l'un, soit sur l'autre, et rarement sur les deux. C'est pourquoi la distinction est opérée.

Conclusions

La conférence a réuni des représentants des pouvoirs publics, des entreprises, du monde de la recherche, d'organisations internationales et d'autres secteurs concernés, dans l'optique de déterminer la perspective à adopter eu égard aux problèmes qui se posent à la croisée de la science et de l'innovation, de la coopération internationale, du développement et de la durabilité. Il en est ressorti, de l'avis général, que des initiatives internationales correctement conçues de coopération scientifique et technologique pouvaient contribuer de manière capitale à attirer les économies en développement sur la voie du développement durable. Ces initiatives doivent comporter un certain nombre de volets, dont le renforcement des capacités scientifiques et technologiques, les transferts de technologie et de connaissances à long terme, et la constitution de réseaux de savoir efficaces faisant intervenir les collectivités locales et divers acteurs, y compris les entreprises. Des approches efficaces des services et de la gestion de l'approvisionnement dans les secteurs de l'eau et de l'énergie ont été examinées et des bonnes pratiques ont été suggérées à ce sujet. Cependant, elles sont loin d'être complètes ou à même de converger vers un groupe d'indicateurs. Les travaux ont en fait élargi encore l'éventail des questions qui se posent aux pouvoirs publics et qui justifient d'approfondir davantage la réflexion et les analyses.

A l'issue de l'atelier, les participants ont adopté une série de résolutions (voir les pages 23 et 24). Sur la base des résolutions et des suggestions examinées, les suites à donner à l'atelier pourraient figurer dans la liste ci-après :

Indicateurs des bonnes pratiques de coopération scientifique et technologique internationale au service du développement durable

Etant donné qu'il ressort clairement de l'atelier qu'il est extrêmement difficile de concevoir des indicateurs sur la question, toute initiative lancée à ce sujet devrait viser à poser des jalons en vue d'atteindre l'objectif ultime. En outre, les travaux sur les études de cas devraient se poursuivre en parallèle. Le CPST pourrait envisager de se charger de cette mission avec le soutien de ses groupes de travail, en particulier le GENIST, et d'autres comités et groupes de travail de l'OCDE, notamment la réunion annuelle d'experts du développement durable. Un atelier du CPST consacré à cette question peut être envisagée. Le comité pourrait aussi proposer de confier les travaux sur les indicateurs à des organismes en relation avec l'OCDE tels que le groupe de travail de la Conférence des statisticiens européens. Le groupe chargé des indicateurs de science, technologie et innovation en Afrique (ASTII) est lui aussi en train de concevoir des indicateurs spécifiquement axés sur le continent africain, et peut être consulté ou contacté.

Suites à donner concernant les actions concrètes de coopération scientifique et technologique internationale au service de l'exploitation durable de l'énergie et de l'eau

Abstraction faite des activités envisageables dans le cadre du programme de travail du Groupe de travail sur la biotechnologie, d'autres comités et organes de l'OCDE sont mieux placés pour entreprendre les travaux nécessaires, comme le Comité des politiques d'environnement, l'AIE et le Comité de l'agriculture. Toute activité concernant l'eau et l'énergie doit être réalisée en coopération avec ces organes.

L'une des thématiques abordées par la Commission du développement durable de l'ONU dans le cadre du cycle en cours est l'énergie. Cette instance peut aussi être sollicitée pour soulever les problèmes concernant la coopération scientifique et technologique dans le domaine de l'utilisation durable de l'énergie. Un processus national en rapport avec la quatorzième session de la CDD est en cours en Afrique du Sud, et la Direction de la science et de la technologie a prévu de faire intervenir un de ses représentants à l'occasion d'une table ronde de cette session sur le thème : « Enhancing means of implementation through sub-regional, regional and international co-operation » (améliorer les moyens de mise en œuvre en s'appuyant sur la coopération infrarégionale, régionale et internationale). Cette réunion est programmée le vendredi 5 mai 2006 à New York.

Suites à donner dans d'autres secteurs

Il a été suggéré de consacrer des ateliers similaires à d'autres secteurs, par exemple aux objectifs du SMDD en matière de santé, d'agriculture et de biodiversité qui n'ont pas été abordés ici. Dans cette éventualité, il a été proposé de programmer les manifestations en question de manière à ce qu'elles puissent apporter des éléments aux réflexions de la CDD de l'ONU[2].

Autres activités transsectorielles sur la recherche et l'innovation visant à promouvoir la coopération scientifique et technologique internationale au service du développement durable

S'agissant des aspects transsectoriels, l'atelier a porté sur le renforcement des capacités scientifiques et technologiques, l'efficacité des transferts de technologie et la mise en place de réseaux de savoir. Les suites qu'il serait possible de lui donner dans d'autres questions de ce type sont les suivantes :

- **Soutenir et utiliser les centres d'excellence pour créer des systèmes nationaux et régionaux de recherche et d'innovation dans les pays en développement.** Beaucoup d'initiatives internationales de coopération scientifique et technologique supposent de créer ou d'utiliser des centres d'excellence nationaux ou régionaux pour renforcer les capacités scientifiques et technologiques, en mettant en liaison les différents acteurs de la recherche et de l'innovation comme les universités et les entreprises. Les moyens à mette en œuvre pour les mettre au service de divers objectifs de durabilité dans les économies en développement peuvent être mis à l'étude.

- **Les migrations internationales des ressources humaines hautement qualifiées en science et technologie.** L'exode des chercheurs et ingénieurs formés à l'université a des retombées négatives sur la mise en place de systèmes et de capacités de recherche et d'innovation efficaces dans les pays en développement. Il faut étudier l'action à mener pour inverser cette tendance au profit de la circulation des cerveaux, de leur retour et de leur maintien dans le pays, et pour que le pays d'origine bénéficie de cette diaspora, mais aussi pour améliorer les indicateurs et les statistiques sur les migrations internationales des personnels très qualifiés.

2. Le cycle en cours de la CDD porte sur les thématiques suivantes : énergie, développement industriel, pollution de l'air/atmosphérique et changement climatique. Les thématiques prévues pour les cycles suivants, jusqu'en 2017, sont indiquées à l'adresse suivante : *www.un.org/esa/sustdev/csd/csd11/CSD_mulityear_prog_work.htm*.

- **Améliorer l'accès aux informations et aux données sur la recherche et les partager.** Etudiée par le CPST, mais principalement dans le contexte des pays membres de l'OCDE, cette question est encore plus importante pour les pays en développement, car ceux-ci manquent de ressources et d'infrastructures pour faciliter l'accès aux informations et aux données sur la recherche. En effet, l'accès aux informations et aux données et le partage de celles-ci sont essentiels pour mobiliser les capacités de recherche des pays en développement dans le réseau mondial de savoir qui est en train de se construire et pour stimuler les progrès de la recherche et de l'innovation à l'échelle planétaire. Les problèmes particuliers auxquels se heurtent en l'occurrence les pays en développement justifient des travaux sur cette question. Le ministère de la Science et de la Technologie d'Afrique du Sud étudie actuellement la possibilité de mettre à profit la présidence du G77, que le pays occupe en ce moment, pour aborder les problèmes liés aux investissements dans la R-D et au partage des données sur la recherche provenant d'organismes scientifiques financés par les fonds publics. Une réunion spéciale des ministres de la science et de la technologie des pays du G77 et de la Chine est prévue en 2006 pour évoquer les problèmes d'accès aux informations sur la recherche.
- **Créer sur le web un réseau d'échanges d'informations et d'expériences dans le domaine de la coopération scientifique et technologique au service du développement durable.** Il a été suggéré que l'OCDE ou une autre organisation internationale compétente pourrait se charger de créer une plateforme web d'échanges d'informations et d'expériences consacrée aux différentes initiatives internationales de coopération scientifique et technologique au service du développement durable.

Toutes les questions transsectorielles pourraient donner lieu à des activités concernant un ou plusieurs domaines spécifiques. En outre, il convient de s'interroger sur la forme à donner aux activités (à savoir ateliers, travaux d'analyse comprenant des études de cas et l'examen des indicateurs et données existants, ou travaux en coopération avec d'autres organes).

Atelier OCDE/Afrique du Sud
sur
La coopération scientifique et technologique internationale
au service du développement durable

Kwa Maritane, Nor West Province, Afrique du Sud
21 - 22 novembre 2005

Résolutions

Cet atelier, qui s'est tenu en Afrique de Sud à l'invitation du Ministère sud-africain de la science et de la technologie, a réuni des représentants des pouvoirs publics, des entreprises, du monde de la recherche, d'organisations internationales et d'autres secteurs concernés, dans l'optique de déterminer la perspective à adopter eu égard aux problèmes qui se posent à la croisée de la science et de l'innovation, de la coopération internationale, du développement et de la durabilité.

A la suite du Sommet mondial sur le développement durable qui s'est tenu à Johannesburg en 2002, la réunion du Comité de l'OCDE de la politique scientifique et technologique (CPST) a adopté lors de sa réunion au niveau ministériel en janvier 2004 *La Déclaration sur la coopération scientifique et technologique internationale en faveur du développement durable*.

L'exploitation, aux fins du développement durable, des possibilités offertes par la science et la technologie, figure au premier rang des objectifs de la communauté internationale depuis le SMDD et le Projet du Millénaire des Nations Unies. C'est dans cet esprit que le gouvernement de l'Afrique du Sud a formé un partenariat avec l'OCDE afin de promouvoir la coopération internationale dans des domaines scientifiques et technologiques clés au service du développement durable.

Pricipaux défis

- Caractériser les bonnes pratiques en matière de coopération scientifique et technologique internationale, notamment entre membres de l'OCDE et pays en développement, dans une double perspective transsectorielle : *i)* stimuler le développement des capacités scientifiques et technologiques, faciliter une diffusion efficace des connaissances scientifiques et les transferts de technologie, et développer les infrastructures et réseaux de savoir en vue d'atteindre les objectifs du développement durable aux échelles nationale et mondiale ; *ii)* dégager les solutions concrètes et efficientes qui ont été mises en œuvre dans les domaines de l'eau et de l'énergie.
- Envisager des indicateurs des bonnes pratiques en matière de coopération scientifique et technologique internationale au service du développement durable, ainsi que des méthodes d'évaluation des initiatives internationales de coopération.

Déliberations

Lors des séances plénières, des séances en sous-groupes et des débats, ont été abordées les questions suivantes :

- Renforcer les capacités scientifiques et technologiques des pays en développement.
- Faciliter des transferts de technologie et des connaissances en favorisant les partenariats.
- Développer les infrastructures et réseaux de savoir pour un développement durable.
- Les technologies les mieux adaptées pour répondre aux besoins des pays en développement dans les domaines de l'eau et de l'énergie.
- Indicateurs et critères de bonnes pratiques de la science et de la technologie, et en matière de coopération scientifique et technologique au service du développement durable.

Il en est ressorti, de l'avis général, l'importance de la coopération scientifique et technologique sur la voie du développement durable.

Résolutions

1) Les participants demandent au comités de l'OCDE et leurs sous-groupes concernés par la production d'indicateurs relatifs au développement durable, à l'aide au développement, et à la science et à la technologie au sens large, de prendre note de l'importance de la coopération scientifique et technologique dans le développement durable et d'envisager de produire des indicateurs utiles à la conception de l'action publique dans ce domaine.
2) Les participants recommandent instamment d'adopter des mesures concrètes en faveur d'une utilisation durable des ressources énergétiques : promouvoir, dans les pays en développement, la création de pôles et partenariats intellectuels innovants qui s'intéressent aux problèmes de technologie, d'action publique et de programme que soulève l'utilisation efficiente des énergies classiques et nouvelles dans l'optique d'atteindre les buts du développement durable.
3) Les participants recommandent instamment d'adopter des mesures concrètes en faveur d'une utilisation durable des ressources en eau : moyennant une coopération scientifique et technologique régie par la demande et efficiente (dans le cadre de partenariats et de centres d'excellence, par exemple), renforcer la base de connaissances à tous les niveaux des acteurs concernés, dans l'optique d'améliorer l'accès à des services d'eau et d'assainissement (efficients et propres) en exploitant les synergies, en s'appuyant sur une approche intégrée de la gestion des ressources et en améliorant la productivité de celles-ci dans tous les secteurs de l'économie.
4) Les participants recommandent d'organiser d'autres réunions à l'avenir en vue de mettre au point un programme pour défendre le rôle de la science et de la technologie dans le développement durable dans l'OCDE en tenant compte des enseignements d'autres domaines (biodiversité et agriculture, entre autres), et de développer les indicateurs envisagés.
5) Les participants recommandent de rédiger, à l'intention de la CDD de l'ONU, un document sur la nature transsectorielle de la coopération internationale au service du développement durable et les principales actions de soutien nécessaires pour que les contributions de la science et de la technologie soient pleinement prises en considération dans la réalisation de ces objectifs.

Part 1

INTRODUCTION

OPENING STATEMENTS

Opening address by
Rob Adam
Director-General
Department of Science and Technology
Republic of South Africa

It gives me great pleasure to welcome all of you to this South Africa-OECD workshop on International Science and Technology Co-operation for Sustainable Development. I gather from the organising committee that we have representatives from 31 countries. It is indeed a privilege for my country to host you here today.

South Africa is among many developing countries and economies in transition engaged in working relationships with the OECD. Through our official observer status in the Committee on Scientific and Technological Policy (CSTP), South Africa, through its Department of Science and Technology, participates in all aspects and working groups related to the CSTP. We are of course delighted that the CSTP has prioritised South Africa along with India, Brazil, China and the Russian Federation, the so-called BRICS, for engagement in its outreach strategy.

South Africa is quite candid that this has been a very productive partnership for us. We have made extensive use of OECD publications, such as the guidelines, best practices and working documents in a way that has strongly informed the development of our national system of innovation since 1994. An example that stands out is the development of South Africa's science and technology indicators. These have now become part of the official statistics reporting system in my country. This has had major implications for expanding the profile of science and technology issues and played a not insignificant role in the President's decision to create a discrete Science and Technology Ministry in 2004. Apart from this accreditation, the OECD has also endorsed South Africa's R&D survey which now forms part of its Science and Technology Indicators publication.

Further at its last meeting, the CSTP approved a work plan to review the South African National System of Innovation next year. This will make South Africa one of the three non-OECD members who are currently involved in OECD National Reviews of Innovation Policy exercise. The other two are the People's Republic of China and Chile.

I would now like to highlight the role played, in the view of South Africa, by the Global Science Forum (GSF) which is a subsidiary body of the CSTP, in promoting international science and technology co-operation. Whilst we of course recognise and underscore the immense value of initiatives in dealing with themes such as neuro-informatics and high-energy physics, we are convinced that the GSF, in co-operation with the CSTP, could and should also meaningfully engage with the themes of international science and technology co-operation for sustainable development.

I would like to urge that we, within the ambit of the work of the GSF, pay specific attention to the involvement of developing countries in large-scale science and technology infrastructure projects, as a critical enabling mechanism for promoting mutually beneficial international science and technology co-operation and capacity-building. The success of the Global Biodiversity Information Facility is a prime example of what can be achieved. The location of facilities such as the Square Kilometre Array radio astronomy facility in developing countries, with important concurrent human resource and capacity-building benefits, should further also receive specific consideration.

Our participation in the Global Science Forum has informed our thinking of South Africa's strategic priorities and thrusts together with our strategic planning instruments such as the foresight programme. In fact South Africa's thrust in astronomy that now includes SALT and the SKA bid has in no small measure been informed by South Africa's interactions with the OECD GSF.

South Africa is privileged to have chaired the CSTP group responsible for drafting the OECD Ministerial Declaration on International Science and Technology Co-operation for Sustainable Development adopted in January 2004 and now the process that has culminated in this workshop, an important milestone in implementing the declaration.

This workshop on the development of our knowledge for and application of science, technology and innovation to sustainable development happens in a milestone year in the global development discourse. 2005 marks the 5th anniversary of the Millennium Summit and in recognition of this landmark world leaders convened again in September to review progress made in fulfilment of the goals of the Millennium Declaration. There is global consensus on the pivotal role science and technology needs to play in the realisation of the Millenium Development Goals. There are many that says that innovation remains the key to the attainment of the MDGs in this timeframe.

The challenges are clearly huge. Very few countries are going to be able to meet their MDG targets on their own. International co-operation provides a platform for us to learn and find innovative ways of taking ownership of our development.

By its very mandate, the OECD is about building partnerships among its members. More recently, as I have indicated earlier, the partnership opportunities have been extended to non-OECD members as well. The comparative data, analyses and forecasts provided underpin multilateral co-operation yet creating space for national understanding of the rules of the game. Global partnerships must be built around enhancing human capabilities, stimulating business development and increasing participation in the global economy. These partnerships must be strategically aligned with government policy and the long-term technological needs of developing countries. We must of course ensure that this happens in a sustainable development paradigm. We must organise our efforts to have a net positive effect after considering the economic, social and environmental factors and considerations.

The extension of this partnership to include members of the developing world and economies in transition will help us develop a global resource network around science and technology for sustainable development and hopefully we have a sufficiently action orientated outcome from this meeting to develop a global community of practice in this field.

In addition to the potential of this initiative to draw our countries together into a global partnership, it should also draw our regional and sub-regional initiatives closer together. Africa has a vibrant continental science and technology platform that operates under the political guidance of African Ministers of Science and Technology with the support of the African Union Commission and the NePAD Secretariat. Minister Mangena will talk more about this. In addition there are similar initiatives around water, energy and agriculture in Africa. I choose these as they relate directly to the topics we will be considering in this workshop. These initiatives would welcome interactions with appropriate regional and sub-regional counterparts in the Americas, Australasia and Europe.

We have the privilege to have a wealth of expertise in this room today to interrogate these issues innovatively and deliver a set of concrete actions to take international science and technology co-operation for sustainable development to the next level.

Opening address by
Richard Manning
Chair
OECD Development Assistance Committee
and
OECD Annual Meeting of Sustainable Development Experts

I am very pleased to have been invited to participate in this workshop, which brings together two of my main interests – the development of poor countries and sustainable development for all.

In my role as Chair of the OECD Development Assistance Committee (DAC), I work with OECD countries to co-ordinate and improve the effectiveness of bilateral assistance provided by OECD donors to developing countries. In my role as Chair of the OECD Annual Meeting of Sustainable Development Experts (AMSDE), I work with OECD countries to promote economic growth which is made more sustainable by giving full attention to environmental and social impacts.

And in representing the OECD, I also want to underline that Science and Technology Ministers, at their OECD Ministerial meeting in 2004, issued a Declaration on International Science and Technology Co-operation for Sustainable Development – which, among other things, stressed the need to strengthen the innovation capacities of developing countries.

OECD countries recognise that they have a special responsibility to reduce poverty and to shape globalisation to the benefit of non-OECD countries, particularly the least developed. They also realise that the focus on official development assistance (ODA) in monetary terms must be supplemented with increasing aid effectiveness through capacity-building in developing countries. And there is growing acknowledgement that greater consideration must be given to environmental and social aspects alongside the purely economic inputs to development.

Science and technology can play an important role in making the economic, environmental and social dimensions of the development process more sustainable. Economically, science and technology are the main drivers of productivity increases in all sectors, from manufacturing to agriculture, and the basis of economic growth. Environmentally, science and technology provide the answers for managing resources and reducing pollution, addressing climate change and preserving biodiversity. Socially, science and technology help reduce disease and safeguard our health and well-being while maintaining the general quality of life.

This workshop will address how international co-operation in science and technology can further these three inter-related aspects of the development process. I am pleased that this workshop has a very concrete focus in looking at good practices in international S&T co-operation and, more specifically, in the areas of water and energy.

In terms of good practices, we should at the end of the workshop have identified generally what works and what does not in terms of technology transfer, enhancing capacities to absorb technologies, and building networks and partnerships. I am interested, among other things, in how donor support in these areas is perceived, and how it might be made more effective. My own experience in a bilateral aid agency suggested to me that there is a large unfinished agenda here.

In the water and energy fields, I hope that the discussion will help to identify specific technologies and approaches which are effective in improving water management and increasing energy efficiency in the varied circumstances of developing countries. We have our work cut out for us. In addition to developing a list of cross-thematic and sector-specific good practices, we are tasked with trying to formulate indicators of good practice.

By bringing together international organisations, governments, business, academics and other stakeholders, this workshop should be able to develop a broad view of these issues and come up with some interesting and innovative approaches. International organisations such as the OECD have a special role in fostering international co-operation through making use of our ability to tap in to the knowledge and expertise of different policy communities. This is true in relation to S&T as it is for other areas. It is our mission to bring countries together to co-ordinate their activities in specific areas such as environment, development or science policy.

From the sustainable development perspective, we are now trying to promote more joint activities and decision making by different ministries of governments. For example, development and environment ministries are forging new synergies. In the OECD, we have a joint Environment/Development Ministerial Meeting in April 2006. The aim is to develop a Common Plan of Action to support the integration of environment and poverty reduction at country level.

In the future, we can envisage joint meetings between environment, development and science and technology policy communities or other combinations such as finance and environment or development and energy, at whatever level is most appropriate.

One good practice which is at the core of sustainable development is the need for policy coherence and for different agencies of government to work together. This workshop is a first step in that direction. I am looking forward to helping develop practical recommendations for co-operation which will have real impacts on policy making in both OECD and non-OECD countries.

Keynote address by
Mosibudi Mangena
Minister of Science and Technology
Republic of South Africa

We have come to accept that in this rapidly globalising world, those countries that have a higher level of investment in the knowledge economy will be the more successful ones both in their ability to compete internationally, and in meeting the needs of their peoples. We also accept that the knowledge economy is driven by innovation, science and technology. In many respects science, technology and innovation has become the key to breaking the codes that will enable us to move towards global sustainable development.

This workshop, hosted under the auspices of the OECD Committee for Science and Technology Policy, has an important contribution to make to further the global sustainable development agenda as enunciated in Agenda 21 and the Johannesburg Plan of Implementation. Therefore, I am deeply humbled that you have offered my country the opportunity to host this event. I am also impressed by the enthusiasm, commitment and the drive of the organisers, contributors and participants in the run-up to the event. This gathering will seek to bring out your creativity, as you seek to find new and innovative mechanisms for international co-operation and collaboration in science and technology for sustainable development. This gathering is also critical for the developing world to form new partnerships. These partnerships, both south-south and north-south, will assist those living in the developing world to find solutions for their basic needs such as sustainable access to clean water and energy, and strengthen country initiatives to meet other Millennium Development Goals through a sustainable development paradigm.

We must point out that the issues are no longer clearly North and South. Increasingly, there are pockets of poverty and under-development in the North as there are new pockets of affluence in the South. In this context, we will all become the net beneficiaries of sharing experiences, knowledge, and where appropriate, also resources. South Africa fully subscribes to the principles of international co-operation on science and technology. This is informed by the simple rationale that the nature of innovation, science and technology is collaborative, and is nurtured by constant dialogue and co-operation.

It was through the collective efforts of the majority of her people, in partnership with the international community, that South Africa was able to ring a death knell of apartheid. Through the goodwill and collective effort of the global community, it is equally possible to repeat a similar feat, and steer the world back on a course of sustainable development and prosperity. What is important is for individual governments to provide enabling environments for the various actors within the system of innovation to collaborate across the globe. We hope that the deliberations of this week will facilitate networks for international co-operation and collaboration, and provide case studies for good practices on thematic issues under discussion.

I now wish to comment briefly on the themes of this workshop – water and energy. I understand they have been chosen to coincide with the work programme of the UN Commission for Sustainable Development.

Water and Energy are core issues in every part of the world. For the developing world, the question of access and resource availability is paramount. For the developed world, it is issues of demand management and efficiency that are important. Your deliberations will possibly reveal that these are in fact two sides of the same coin. Usually named as the key catalysts for conflict, water and energy issues can, through constructive engagement, become the bridges for world peace and sustainable development.

The World Summit on Sustainable Development identified energy as a high priority. Access to energy, through conventional and alternative means and energy efficiency is the cornerstone to sustainable development. This issue has had increased prominence recently with the implementation of extraordinarily high crude oil prices. All of our economies have had rude reminders that we need to develop new, and accelerate the implementation of existing alternative energy and energy efficiency strategies. Failure to do this will inevitably launch us on a tragic pathway of global energy crisis. Other drivers towards the same end are the attendant issues of pollution and climate change. Therefore, the need for implementing better conservation and demand management measures of world resources has never been more compelling.

To this end, contributions that alternative sources such as hydro- (large and small), nuclear, solar, wind and biomass can make towards enhancing the energy mix of most global scenarios, can never be underestimated. Such initiatives as the International Partnership for the Hydrogen Economy, are becoming increasingly prominent, and during the course of this week, my officials will share with you South Africa's plans in this regard.

The availability of clean water is another important theme under consideration by this gathering. Water is the source of life. Throughout history, in many parts of the world water has been both the driver of development and source of great conflicts. Despite the inordinate effort, usually put in by women and girls, to bring water into homes, in the African culture, not even an enemy could be denied water if he asked for it. And to this day, water is still linked to food security, health security, environmental security and trade in both the developing and the developed world.

This workshop will examine possibilities for co-operation along the entire water value chain, from better understanding of the water cycle, to smarter ways of ensuring, both in terms of quantity and quality, access for human and ecological needs.

A key challenge to scientists is to communicate ideas and outcomes in accessible ways. We need to simplify these concepts so that a person in the street can also understand how international co-operation can help solve the problems associated with the supply of basic needs and poverty eradication.

Perhaps our greatest challenge in the knowledge economy is the ability to develop and maintain sufficient scientific human capital. Issues of brain drain, aging research populations, and low interest in careers on scientific R&D among young people are sources of major concern, especially for developing countries such as South Africa.

To address some of the grave anomalies, especially in the research and development system inherited from our past dispensation, the South African government has developed an elaborate legislative and regulatory framework to encourage accelerated skills development. The challenge facing our young democracy to rapidly enlarge our science base through increasing the number of science, engineering and technology graduates, with a particular focus on the inclusion of women and Blacks. The National Research and

Development Strategy has been a key policy instrument aimed at unlocking the potential for Science and Technology skills.

My mission is to ensure that all our citizens are availed increased opportunities to acquire appropriate research and development skills to venture into all fields of scientific endeavour, especially in areas where South Africa has geographical advantage. My department is involved in several human capital development initiatives, including the development of the Youth into Science Strategy, funding of post-doctoral studies, professional development, as well as establishing Centres of Excellence. My department has entered into a collaborative relationship with the Department of Education to address the scarce SET skills.

This workshop should not only develop models for inter-country collaborations; it should also encourage mutually beneficial inter-regional co-operations.

Allow me, ladies and gentlemen, to spend a minute or two on some of the recent important developments on this continent. In response to an African Union Summit Resolution, two years ago, South Africa hosted the Inaugural meeting of the African Ministers of Science under the auspices of NePAD. This meeting launched the African Ministers' Council on Science and Technology (AMCOST), and adopted a framework for the development of a business plan for S&T on the continent. In September this year, at the second meeting of AMCOST in Senegal, Africa's Science and Technology Consolidated Plan of Action was adopted as the blueprint for Science and Technology in Africa. The plan was applauded by member states, as well as many of our international partners who attended the meeting. The meeting was also peppered with a series of side events, which dealt with issues relating to the progress being made in key initiatives under this banner. These included the African Laser Centre, The BioSciences Initiative, the Water Sciences Initiative, and the African Institute for Mathematical Sciences. This relatively young regional platform is already developing a history that is giving us great pride.

Inter-regional, country-to-country, institution-to-institution and people-to-people co-operation will ultimately constitute the foundations to successful global sustainable development.

This workshop will, I am sure, explore best practices of international science and technology co-operation for sustainable development and various science and technology initiatives, which could strengthen science and technology co-operation between the developing and the developed world.

During your next two days of deliberation, we hope that you will be able to develop sufficient momentum to significantly narrow the "science and technology divide" between the developing and the developed world. I also urge you, as many of you have come a long way, to take a little time to explore and experience some of the treasures of beautiful South Africa.

RAPPORTEUR'S SUMMARY

by
Candice Stevens
OECD Sustainable Development Advisor

Goals of the workshop

The goals of the Workshop on International Scientific and Technological Co-operation for Sustainable Development, held in South Africa on 21-22 November 2005 and jointly sponsored by the OECD and the South African Department of Science and Technology, were presented in the two opening sessions. The speakers included Mosibudi Mangena, South African Minister of Science and Technology; Calestous Juma, Professor at Harvard University and Co-ordinator of the UN Millennium Project Task Force on Science, Technology and Innovation; and Richard Manning, Chair of the OECD Development Assistance Committee (DAC) and the OECD Annual Meeting of Sustainable Development Experts (AMSDE).

These goals were to:

- Identify good practices in international science and technology co-operation for sustainable development;
- Attempt to develop indicators of these good practices;
- Identify effective modes for S&T partnerships in the water and energy sectors with specific examples; and
- Recommend approaches for the fuller integration of science and technology dimensions in sustainable development policies.

As Yukiko Fukasaku, OECD Directorate for Science, Technology and Industry, explained, the workshop had its roots in the Declaration that Science and Technology Ministers adopted on International Science and Technology Co-operation for Sustainable Development at their Ministerial level meeting in 2004. The Declaration, among other things, stressed the need to strengthen the innovation capacities of developing countries to further sustainable growth. OECD countries recognise that they have a special responsibility to reduce poverty and to shape globalisation to the benefit of non-OECD countries, particularly the least developed, and that science and technology should play a greater role.

All speakers stressed the need to bring together the development community with science and technology experts and with those more broadly interested in operationalising sustainable development concepts. The focus on official development assistance (ODA) in monetary terms must be supplemented with increasing aid effectiveness through capacity-building in developing countries. There is growing acknowledgement that greater consideration must be given to environmental and social aspects alongside the purely economic inputs to development. Science and technology can play an important role in making the economic, environmental and social dimensions of the development process more sustainable.

Economically, science and technology are the main drivers of productivity increases in all sectors, from manufacturing to agriculture, and the basis of economic growth. Environmentally, science and technology provide the answers for managing resources and reducing pollution, addressing climate change and preserving biodiversity. Socially, science and technology help reduce disease and safeguard health and well-being while maintaining the general quality of life.

The workshop was intended to address how international co-operation in science and technology can further these three inter-related aspects of the development process. It had a concrete focus on good practices in international S&T partnerships, specifically in the areas of water and energy. In terms of good practices, participants examined what works and what doesn't in three areas: *i)* enhancing capacities to absorb technologies, *ii)* transferring technology, and *iii)* building knowledge networks. In breakout sessions, participants worked to identify specific technologies and approaches which are effective in improving water management and increasing energy efficiency in the varied circumstances of developing countries. In addition to developing a list of cross-thematic and sector-specific good practices, participants were tasked with formulating indicators of good practice.

Good practices in S&T partnerships

The primary theme of the workshop was the identification of good practices in international partnerships in science and technology for sustainable development, both generally and in the areas of capacity-building, technology transfer, and knowledge networks.

As Minister Mangena and Calestous Juma emphasised, S&T partnerships should generally aim at long-term development and not at short-term relief for developing countries. Partnerships should construct a process of collective learning rather than a one-way transfer of knowledge. They should be based on data and indicators which allow for learning, feedback and evaluation. An essential component is to include training for those involved in partnerships so as to develop long-lasting human skills. Incentives could be included to help reverse the brain drain from developing countries. Such partnerships, which can be both North-South and South-South, should also be public/private in nature and involve governments, business and other stakeholders. On the government side, strong political commitment and an all-of-government approach are needed to ensure policy coherence.

In terms of good practices in capacity-building in S&T partnerships, John Mugabe, from the Secretariat of the New Partnership for Africa's Development (NEPAD), emphasised a bottom-up approach. Partnerships should be linked to local communities and use indigenous small and medium-sized enterprises (SMEs) as suppliers in an effort to develop entrepreneurial skills and support start-up firms. They should build on the practical experiences of communities and on indigenous technologies. Businesses, unions, non-governmental organisations and other stakeholders at the local level should be involved in the partnerships. A prominent role should be given to universities so as to ensure an intergenerational transfer of information and knowledge. In building capacity, S&T partnerships should above all take into consideration the effects on and costs and benefits for future generations.

Good practices in technology transfer in S&T partnerships were presented by two business representatives: Wendy Poulton of ESKOM, the South African electricity supply company, and Uwe Brekau of Bayer. They both stressed a demand-driven approach where consumers are educated on the benefits and use of technologies, and programmes are implemented to promote sustainable consumption. Without enlightened consumers, business investments in sustainable technologies will not yield useful results. Technologies transferred between countries should be appropriate to the locality in terms of costs, content and skills. Local technological content should be assured while existing, basic technologies are often most suitable for developing countries. Necessary infrastructure should be built for the appropriate use of the technology, and social and cultural aspects should be considered in adapting technology to local needs.

Building long-lasting knowledge networks is another good practice in S&T partnerships. This topic was addressed by Bob Hawkins of the World Bank and Shem Arungu-Olende of the African Academy of Science. Mr. Hawkins stressed the need to make maximum use of information technology, which would require improving the IT infrastructure in many African countries, increasing networking capacity and inter-linkages in the African region, and particularly augmenting bandwidth. As explained by Dr. Olende, such networks should build on local and national innovation systems which link business, universities and local actors in realising knowledge synergies. The integration of networked universities and centres of excellence is especially important. Knowledge networks must build on regional collaboration in Africa. With the increasing globalisation of industry, efforts should be made to integrate local African firms and suppliers into international industry supply chains.

Sectoral approaches: water and energy

Special breakout sessions were held to discuss effective approaches to S&T partnerships in the water and energy sectors. These included many technical presentations by a wide array of speakers.

As explained by the rapporteurs of the water session, Bruno Bordage and Teddie Muffels, S&T partnerships should generally aim at increasing access to safe drinking water and ensuring adequate water supplies for agriculture and industry. Many speakers stressed the need for integrated water management systems which treat national, regional and local water resources as ecosystems and consider technical, economic, environmental and social aspects in tandem. Technologies for water treatment and sanitation as well as for more efficient irrigation are particularly needed and should be affordable and suited to local conditions. Technologies for water recycling and increasing the reuse of wastewater are essential to enhancing water productivity in all sectors of the economy. National water monitoring systems, including satellites, should be strengthened. In terms of local policies, appropriate water pricing and the removal of distorting subsidies would rationalise the distribution of water and increase access to a wider population.

The rapporteurs of the energy session, Alicia Mignone and Linda Manyuchi, concluded that a main aim of S&T partnerships should be to increase access to affordable energy supplies in developing countries based largely on existing technologies. Partnerships are needed to increase energy efficiency in end-use applications, including in appliances, buildings and housing, as well as in generation and transmission. Eco-labelling and consumer education are among the routes to achieving more efficient energy use. Greater application of clean energy technologies is needed in industrial sectors such as minerals, chemicals and construction. Competitive markets should be created for renewable energy sources such as solar, wind and biomass, although these are still relatively expensive for these countries. As in the case of water, ensuring appropriate energy pricing and reducing distorting subsidies would level the playing field for greater energy access.

Indicators of good practices

Developing indicators to measure the extent of good practices in S&T partnerships for sustainable development was among the tasks of the workshop. Fred Gault, Director at Statistics Canada and Chair of the OECD Group of National Experts on S&T Indicators (NESTI), and Michael Kahn, Director at the Human Sciences Research Council (HSRC) of South Africa, suggested a number of avenues for thinking about such metrics. Qualitative and quantitative measures of the partnership good practices identified above (*e.g.* timeframe, actors, local links, technological content, etc.) would be difficult but not impossible to formulate. Lessons could also be learned from broader exercises aimed at evaluating and assessing the success of various types of partnerships.

A practical approach would be to develop case studies of the measurement of good partnership practices, perhaps selecting cases from the SD partnership inventory maintained by the UN Commission on Sustainable Development (UNCSD). Techniques developed in the Community Innovation Survey (CIS), which surveys firms on the sources of their ideas for innovative products and processes, could be applied to identifying effective approaches to S&T partnerships. In this way, questionnaires to those involved in international S&T partnerships (*e.g.* in the water and energy areas) could develop indications of the structure, content and workings of these partnerships, including their relative impacts on capacity-building, technology transfer and networking.

Recommendations from the workshop

Two sets of recommendations emerged from the workshop: one set regarding the better integration of science and technology with development policy, and the other on improving the linkages between science and technology and sustainable development.

In an OECD context, linking S&T with development is a task for the Committee on Scientific and Technological Policy (CSTP) and the Development Assistance Committee (DAC). The CSTP could expand its innovation policy reviews of non-member countries, which have been initiated for South Africa and China. The results of these country reviews, and concepts relating to national innovation systems, could be integrated in DAC country studies. The CSTP indicators group, NESTI, could devote more resources to developing S&T indicators for non-member countries and to exploring approaches for measuring good practices in S&T partnerships.

More broadly, the CSTP and the DAC could jointly examine the role of science and technology in development co-operation and how technological aspects could be more fully factored into official development assistance and donor programmes. The DAC database on donor ex-post evaluation studies could be applied to developing donor views on good practice in funding S&T co-operation for development. Specific topics to be examined at the S&T/development interface include human resource issues such as fostering S&T skills in developing countries and approaches to stemming the brain drain from these countries. Generic CSTP issues, such as the development of centres of excellence and increasing access to scientific data, are often relatively more important to non-OECD countries.

Science and technology concerns can also be more fully integrated into the work programme of the OECD Annual Meeting of Sustainable Development Experts (AMSDE) in the following ways:

- Including the workshop findings concerning good practices in S&T partnerships (and related indicators) in ongoing work on developing methodologies for evaluating sustainable development partnerships.
- Incorporating approaches to building national innovation systems in recommendations for good practices in national sustainable development strategies (NSDS).
- Including S&T indicators (*e.g.* for intellectual capital) in compilations of sustainable development statistics and indicators.
- Integrating the results of this workshop in the OECD submission to UNCSD-14 (May 2006) on the themes of energy, industry, climate change and air pollution.
- Sponsoring a follow-up conference on S&T and sustainable development in 2006–2007 to advance the work on identifying good practices in S&T partnerships for sustainable development (examining new topics such as biodiversity and natural resource management).

Conclusions

By bringing together international organisations, governments, business, academics and other stakeholders, this workshop succeeded in developing a broad view of the central issues in S&T partnerships for sustainable development and coming up with some interesting and innovative approaches to enumerating and measuring good practices. The many technical presentations (which are included in this volume) provide a practical foundation for the content of partnerships in the water and energy sectors.

International organisations such as the OECD have a special role in fostering international co-operation through making use of our ability to tap into the knowledge and expertise of different policy communities. It is the OECD mission to bring countries together to co-ordinate their activities in specific areas such as environment, development or science policy. From the sustainable development perspective, the OECD is trying to promote more joint activities and co-ordinated decision making by different government ministries and agencies. For example, development and environment ministries are forging new synergies and will have a joint OECD Environment/Development Ministerial Meeting in April 2006. The aim is to develop a Common Plan of Action to support the integration of environment and poverty reduction at country level.

A good practice which is at the core of sustainable development is the need for policy coherence and whole-of-government decision making to consider the combined economic, environmental and social impacts of policies and programmes. This workshop is one step forward in applying a sustainability perspective to the development process. In the future, joint sessions of different policy communities will act to advance sustainable development in OECD and non-OECD countries, *e.g.* dialogue between environment, development and science and technology delegates or other combinations such as finance and environment or development and energy, at whatever level is most appropriate.

Part 2

PLENARY PRESENTATIONS

Chapter 1

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: BACKGROUND AND ISSUES[1]

by
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and
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Introduction

The importance of science and technology in enabling sustainable development was affirmed at the World Summit on Sustainable Development (WSSD) in 2002 and especially at one of its major parallel events, the Science and Technology Forum on Sustainable Development, the conclusions of which[2] were reflected in the Johannesburg Plan of Implementation (JPOI). In this plan, the participating governments acknowledged the essential role of science and technology in generating solutions to environmental and developmental issues. Most notably, the document stressed the importance of enhancing development and transfer of technology to the developing countries, building capacities in science and technology so as to allow access to international research and development programmes, and building partnerships and networks among public and private actors in science and technology including knowledge institutions such as centres of excellence.

NEPAD (New Partnership for Africa's Development) is an initiative in a similar spirit to the WSSD. It is an attempt to apply the recommendations implied in the JPOI to the specific context of the African continent. Its strategy aims "to help eradicate poverty in Africa and place African countries, both individually and collectively, on a path of sustainable growth and development and thus halt the marginalisation of Africa in the globalisation process". One of its goals is the implementation of national strategies for sustainable development. Its priority areas include energy, water, human resources development including reversing the brain drain, and health and agriculture.[3] Its *Africa's*

1. The chapter has benefited from the comments of the members of the OECD-CSTP steering group set up to organise this workshop. The section devoted specifically to issues in the areas of water and energy is entirely based on drafts provided by the members of this steering group.

2. The ministerial session of the forum adopted the *Ubuntu Minute on Science and Technology for Sustainable Development.*

3. Quotes from NEPAD (2001).

Science and Technology Consolidated Plan of Action (NEPAD, 2005) puts emphasis on "developing an African system of research and technological innovation by establishing networks of centres of excellence dedicated to specific R&D and capacity building programmes". Its goals are to "enable Africa to harness and apply science, technology and related innovations to eradicate poverty and achieve sustainable development; and to ensure that Africa contributes to the global pool of scientific knowledge and technological innovations". The Plan enumerates specific flagship R&D programmes including in the areas of water and energy.

The aims of these initiatives have been to meet the Millennium Development Goals (MDGs). However, the progress made by the developing countries in implementing the MDGs has been slow and uneven, as reflected in the country reports to the United Nations Commission on Sustainable Development (UNCSD), responsible for monitoring the progress made in the recommendations included in the JPOI. One of the obstacles to progress is limited research and access to technologies. More science and innovation capacities in human resources and physical infrastructure need to be built. Knowledge and technology need to be brought to places where they are needed the most. The key role of science and innovation for development in meeting MDGs is well argued in the UN Millennium Project report on science, technology and innovation (UN Millennium Project Task Force on Science, Technology and Innovation, 2005).

International science and technology co-operation for sustainable development

International co-operation is an effective tool for building scientific and technological capacities. Moreover, the aim of that international science and technology co-operation should be "sustainable development" rather than "development". The manifestation of a number of environmental issues at the global level, such as climate change, implies that further development anywhere in the world, especially in the developing countries, needs to be "sustainable".

Many industrialised countries (most belonging to the OECD) underwent "development" without paying due attention to its "sustainability" (*i.e.* maintaining the balance between environmental, social and economic components of development). The lack of recognition of the environmental and social impacts of industrialisation has resulted in serious negative environmental legacies, social inequities and economic disruptions since the 19th century. The increasing awareness of the global environmental issues in the second half of the 20th century (*e.g.* climate change and loss of biodiversity) has finally begun to steer the policies of the industrialised countries towards sustainable development. The so-called Brundtland report (World Commission of Environment and Development, 1987) and the Rio Earth Summit have been instrumental in setting this new direction.

Attempts to change the course of economic development policies towards a sustainable development path did not come by easily. Until recently, it has been thought that environmental sustainability can be achieved only at the cost of economic growth. Current mindsets emphasise the sustainability of a development path if its impact on economic growth is positive. But for this, there is unequivocal agreement on the pivotal role of science and technology. The OECD work on sustainable development has indeed developed such a perspective (*e.g.* OECD 2001a, 2001b). Increasing economic output per unit of energy consumption in recent decades in the OECD countries and the decreasing emissions of environmental pollutants in the context of economic growth indicate that economic growth can be "decoupled" from the exertion of negative environmental effects. Such trends were brought about by the implementation of appropriate public policies (*e.g.* regulatory regimes) accompanied by rapid technological advances in energy conversion and use as well as increasing efficiency in industrial production.

These trends suggest that developing countries can benefit significantly from working together with OECD countries in developing technologies for sustainable development, and sharing experiences on developing appropriate policies for planning and managing key resources, such as energy and water. The *systemic* nature of the science and innovation enterprise in OECD countries has been revealed in recent OECD work (*e.g.* OECD, 2002). It is not investments in research and development alone that enhance the innovation capacities of a nation. It is the co-ordinated interplay between the different actors including the government, universities and other educational and research institutions, businesses and other entities such as intergovernmental organisations (IGOs) and NGOs supported by appropriate framework policies and conditions that enhance the scientific and technological capacities of a country. In other words, linking science to innovation requires effective interactions between different actors that constitute an *innovation system.*

Building research and innovation systems should lie at the base of international science and technology co-operation. Only a well-functioning innovation system can translate the fruits of scientific research into concrete benefits for all in the developing countries. The existence of such a *national system of innovation* enables a country to participate and benefit from the ongoing economic globalisation and the accompanying globalisation of science and innovation systems. Therefore, international science and technology co-operation should involve building partnerships and networks with different stakeholders, both in the developed and developing countries, and including governments, business, trade unions, academia, IGOs, NGOs, and local communities.

Based on above insights, in January 2004, the OECD Ministers of Science and Technology adopted the *Declaration on International Science and Technology Co-operation for Sustainable Development*[4] at the ministerial-level meeting of the Committee for Scientific and Technological Policy. The ministers reaffirmed "their commitment expressed at the WSSD to the promotion of sustainable development through the application of science and technology by strengthening national innovation policies and programmes and by enhancing existing global collaborative networks". They also stressed "the importance of international co-operation in science and technology to sustainable development, notably by transferring knowledge and technology among (OECD) member countries to less developed ones."

In the declaration, the ministers invited countries and relevant stakeholders to convene an appropriate event to further enhance the consensus of the WSSD. Former Science and Technology Minister Ben Ngubane made an offer for South Africa to host this event. During the WSSD, South Africa played a key role in bringing science and technology to the forefront of the development agenda. As custodians of the WSSD, South Africa has an important role to play in ensuring the successful implementation of the targets set out in the JPOI. South Africa's Department of Science and Technology shares the responsibility for continuously reaffirming the roles of science and technology in furthering the development agenda.

4. Available at *www.oecd.org/cstp2004min*

Objectives and themes of the workshop

The workshop is aimed at fostering closer collaboration and networking between the OECD and developing country partners involved in science and technology for sustainable development. Specific aims are:

- To identify good practices in international science and technology co-operation between OECD and developing countries, aiming at fostering capacity building in science and technology, facilitating effective diffusion of scientific knowledge and technology transfer, and at developing knowledge infrastructure and networks, in order to meet sustainable development objectives at national and global levels. Such good practices include highlighting concrete and efficient solutions that have been implemented in the areas of water and energy.
- To consider possible indicators of good practices in international science and technology co-operation for sustainable development and to evaluate international science and technology co-operation initiatives.

Two sectoral themes have been chosen, energy and water, in line with the work plan of the UNCSD so that the insights gained in this workshop can contribute to the work of the UNCSD.[5]

Needs and challenges for international science and technology co-operation

However desirable and urgent it may be to build effective research and innovation systems, the realities in developing countries, especially in Africa, suggest that this is a daunting task. In many countries, the elements that make up an effective research and innovation system do not exist or are in insufficient state. In addition, the institutions that steer development towards sustainability, such as effective public regulations or economic incentive schemes as well as other framework policies, are not in place.

Innovation requires well-trained scientists and engineers, including women. There is increasing evidence that less than satisfactory progress is being made in producing scientists and engineers in the developing countries. There is little emphasis on science subjects at school level and this reduces the participation of youth in science and technology-related courses at the tertiary level. There is a need for a number of policy schemes (*e.g.* student exchange programmes at school and tertiary levels, post-doctoral fellowships and internships.) to strengthen the transformation of science and technology capacity to achieve increased numbers of people working in fields that are key in the future (Government of South Africa, 2002).

Widespread poverty means that the economic base for building a research and innovation system is weak. This implies inadequate investments in research and innovation, weak infrastructure support for these, and fewer opportunities for children and youth to achieve higher levels of education and to become scientists and engineers. The small pool of the highly qualified human resources who have secured positions in their countries of origin confront meagre resources and facilities needed for research and innovation. Such a discouraging environment results in the brain drain of the valuable human resources for science and innovation.

5. CSD 12 and 13 in 2004 and 2005, respectively, have dealt with water, sanitation and human settlements. CSD 14 and 15 in 2006 and 2007 deal with energy for sustainable development; industrial development; air pollution/atmosphere and climate change.

The absence of innovation systems also implies the weak networks of agents that participate in the innovation process, especially local businesses and communities. This suggests that the knowledge and technology transferred from industrialised countries are not necessarily appropriate for the needs of the people who need them the most. The efficient flow of information and active participation of all those concerned, especially on the demand side, enables the innovation system to deliver needed knowledge and technology.

A weak economic base, a lack of capacities and disconnectedness bring about a spiral-down effect in terms of sustainable development. The lack of capacities, framework conditions and knowledge networks results in the persistence of unsustainable modes of production and consumption that increase social, economic and environmental fragility. Poor governance, incorrect institutional set-up or inappropriate choices of technology hinder innovation systems to function. International co-operation is needed to stop such negative downward spiral.

Developing countries face serious challenges in the areas of energy and water that effective international science and technology co-operation can address. There is sufficient supply of both, but the quality of the essential services is not conducive to sustainable development. The use of these resources can be greatly enhanced through co-operative development of science and technology. This applies to the Nile River, whose water cannot be used for human consumption due to lack of technology to improve water quality. The meagre supplies usually do not reach the poorest. International science and technology co-operation brings about appropriate knowledge and innovation to improve the situation considerably. It can develop efficient and cost-effective ways to deliver and use sustainable water and energy resources by tapping knowledge available to the global community of practitioners of science and innovation.

The internationally agreed development goals, including those contained in the Millennium Declaration, Agenda 21 and JPOI, will require significant increases in the flow of financial resources as elaborated in the Monterrey Consensus, including through new and additional financial resources, in particular to the developing countries, to support the implementation of national policies and programmes, improved trade opportunities, access to and transfer of environmentally sound technologies on a concessionary or preferential basis, education and awareness-raising, capacity-building and information for decision-making and scientific capabilities (WSSD, 2002).

Improving and enhancing international science and technology co-operation

Experiences in international science and technology co-operation

A large number of international science and technology co-operation programmes have attempted to address the above issues. Some of the well-known initiatives illustrate the key elements of effective international co-operation and collaboration.

Millennium Science Initiative (World Bank)

Launched in 1999 and aimed at nurturing world-class science and scientific talent in the developing world. It seeks to do this through integrated programmes of research and training planned and driven by local scientists. These programmes are linked by partnerships with other programmes, local governments and the international scientific community. The MSI programmes have various forms; some take the form of one or more

"MSI institutes" that function as centres of excellence, others consist of small groups or individual researchers.

The World Bank makes use of its existing lending instruments in this initiative, and they are designed to support projects that award large multi-year research grants to top researchers, through a transparent and highly selective competition. MSI projects aim to stimulate a part of the national science and technology system to function according to international best practice for research funding. The belief is that if these practices are followed, the quality and cost-effectiveness of research performed in the developing world could improve considerably (Holm-Nielsen, 2001).

MSI projects provide targeted support focusing on research excellence, human resources training, and linkages to partners in the international science community and the private sector. The expected direct and indirect benefits include:

- A model for transparent, merit-based allocation procedures that forge "cultures of quality".
- Increased training opportunities for young people, and reduction of "brain drain"; and.
- Global and regional networking with other researchers.

Since 1999, MSI programmes have been initiated in Chile, Brazil, Mexico, Vietnam and Africa. In Chile, the programme created competitive grants and three MSI institutes; it also provided advanced training opportunities to PhD and post-doctoral students. As a result, research productivity and international collaboration increased, as did monitoring, evaluation and accountability in scientific research. The Uganda programme provided pre-university science education, and promoted research in new universities outside Kampala. It assured coherence with health, agriculture and environment policies, and focused also on engineering, and strengthening undergraduate education.

Consultative Group on International Agricultural Research (CGIAR)

It is not directly concerned with water or energy, but this is a long-term international co-operation initiative that has produced concrete advances in putting results of agricultural research to provide concrete solutions in the developing countries. These include:

- Developing New Rice for Africa (NERICAs), a new strain of rice adapted to the conditions in West Africa, and the spread of its planting has enabled significant rice imports in countries such as Guinea.
- Integrating aquaculture/agriculture techniques resulting in increased rice and fish production in Asia through new strains of tilapia that grow 60% faster.
- Adoption of zero or low-till farming practices in Africa and Asia, minimising soil erosion and boosting farm incomes and productivity.

The CGIAR was established in 1971 and is a strategic alliance of countries, international and regional organisations and private foundations supporting 15 international agricultural centres that work with national agricultural research systems and civil society organisations including the private sector. There are approximately 8 500 CGIAR scientists and staff working in over 100 countries. CGIAR research scope is broad and mobilises agricultural science to reduce poverty, foster human well-being, promote agricultural growth and protect the environment. Its research portfolio has evolved from the original focus on increasing productivity in individual critical food crops. Today's approach recognises that biodiversity and environment research are also key components in the drive to enhance sustainable agricultural productivity. The fundamental belief of the programme is that agricultural growth and increased farm productivity in developing countries creates wealth, reduces poverty and hunger, and protects the environment (CGIAR, 2005).

Towards more effective international science and technology co-operation

The issues involved in making international science and technology co-operation effective are multi-faceted. This implies both the importance and difficulty of building up effective research and innovation systems in the developing countries.

A fundamental component of a research and innovation system is human resources. Well-educated scientists and engineers and other specialists constitute a major part of the necessary capacities. Enhanced enrolments in primary and secondary education constitute the base of scientifically literate human resources, but attention should also be paid to the tertiary level as well as specialised training in specific areas of scientific research or technological development. In the African context, the recent report of the Commission for Africa emphasised improving Africa's capacity, "starting with its system of higher education, particularly in science and technology" (Commission for Africa, 2005). This is probably the reason that the international science and technology co-operation initiatives often integrate training. The advantage of international co-operation as a means of training and human resource development is that it takes place within the context of a network of international specialists in the specific science or technology area. This means that, not only training, but also international exchange of scientists and engineers is also a part. This provides for controlled flow of scientific talents that include brain "return", not just brain "drain".

Science and technology capacity building also includes the "hardware" --the various infrastructure components for research and innovation activities. These include research institutions and industrial testing and standards centres, the suppliers of scientific instruments and tools, and the scientific and engineering information centres that provide updated information and data, which is becoming increasingly dependent on advanced ICT and the Internet. Given the realities in many of the developing countries, especially in Africa, building such infrastructure in the numerous fields of science and innovation is a long-term challenge. In the meantime, cost-effective solutions need to be found. Particular focus on building centres of excellence that bring together researchers and engineers from different countries to conduct scientific research or innovation jointly is one solution. Initiatives in many cases involve building or strengthening such centres of excellence. G8 leaders at the Gleneagles Summit in 2005 explicitly pointed to the focal role that centres of excellence could play in "helping develop skilled professionals for Africa's private and public sectors, through supporting networks of excellence between African and other countries' institutions of higher education and centres of excellence in science and technology institutions" (G8 Gleneagles, 2005).

International co-operation will not deliver concrete results if the required knowledge and technologies are not delivered to those places in the developing world where they are needed the most. In the OECD countries and in the developing world, the needed knowledge and technologies are held by businesses, governments, international institutions and universities. These resources need to be tapped into and harnessed for the needs of developing countries. Collaboration with the private sector, international co-operation between universities and science councils, and networks that promote international collaboration are key in international science and technology co-operation.

In order for science and innovation to alleviate poverty and bring about equitable economic development, required knowledge and technology should reach the local communities. This means that solution-focused research and innovation need to be conducted in close collaboration with 'local' stakeholders and decision makers. Co-operation initiatives need to be bottom-up and demand-driven. This means that smaller projects that cater for local needs should have priority over large development projects that have been agreed between decision makers at the national level.

Moving rapidly towards a sustainable development path implies deploying more of the advanced knowledge and technology that can be transferred or innovated in the developing countries. Rather than those technologies that have been available for decades which in many cases are no longer environmentally sustainable, more recently developed ones may better be suited to meet sustainable development requirements in the developing countries. This implies both opportunities and the imperative to "leapfrog." Developing countries may be the best places to diffuse technology and innovation based on advanced scientific knowledge such as ICT, biotechnology and nanotechnology. Cell phones that bypass the necessity to build landed cable infrastructures are a case in point.

Searching for suitable advanced knowledge and technology underlines the importance of creating knowledge and innovation networks globally. This is a key role that international science and technology co-operation can play. The actors in the national innovation systems need to be linked to their counterparts as well as other stakeholders in the industrialised as well as developing countries. Integration in global knowledge networks facilitates participation in the globalisation process itself.

Finally, if successful international co-operation initiatives have been long-standing initiatives, long-term sustainability of such initiatives is key to building national science and innovation systems. This does not necessarily mean detailed long-term planning and funding, but the willingness to let co-operation and collaboration activities evolve and adapt to changing conditions and the changing physical and social environments. Sustaining efforts to build science and innovation systems lead to sustainable development.

Specific issues in the areas of water and energy

Water

Introduction

The WSSD and the 3rd World Water Forum 2003 highlighted the importance of the UN Millennium Declaration and the MDGs. Water is vital for all human development and is a crosscutting issue for most of the eight MDGs. The JPOI recognises the role of science and technology in meeting water goals by committing governments to "improve water resource management and scientific understanding of the water cycle through co-operation in joint observation and research, and for this purpose encourage and promote knowledge-sharing and provide capacity-building and the transfer of technology, as mutually agreed, including remote-sensing and satellite technologies, particularly to developing countries and countries with economies in transition.". The Plan also recognises that affordable rural water technologies will be required to ensure that adequate clean water is available to marginalised communities.

CSD 13 (2005) further acknowledged the role of science and technology, emphasising implementation to:

- Develop and strengthen human and institutional capacities for effective water management and service delivery.
- Expand and improve wastewater treatment and reuse.
- Support more effective water demand and water resource management across all sectors.
- Develop and transfer low-cost technologies for safe water supply and treatment.
- Develop and strengthen national monitoring systems on quantity, quality and use of surface and groundwater resources.

Also recognised is that an interdisciplinary approach is required for the successful management of water resources. Insight into the multitude and complexity of the water management challenge are discussed below. Priorities for international co-operation in water research are highlighted, including mechanisms for such co-operation.

Endowment opportunities and threats to water resources

Life on earth would not exist without water. It is essential for the development of life, the functioning of ecosystems and preservation of the environment. A safe and stable water supply is also of vital importance for human, social and economic development. Water is globally distributed by the hydrological cycle, which is driven by the energy cycle. The circulation of water powers most of the other natural cycles and conditions the weather and the climate.

There is extreme variability in the distribution of world water resources. Africa's renewable water resources average 4050 km^3/capita/year – significantly less than the world average of 7000 m^3/capita/year (UNEP, 2002). The spatial and temporal distribution of water resources also vary. There is contrast between the arid regions and rain forests; on smaller spatial scales, contrast exists between opposite sides of a mountain range, *e.g.* the south and north flanks of the Himalayas. High variability exists on time scales of hours to decades, from short, high-intensity precipitation to marked differences between seasons in precipitation and inter-annual and inter-decadal variation (UNESCO-WWAP, 2003).

Despite the spatial and temporal variability, significant progress has been made in harnessing water resources for economic and social development. Its use in industry, mining, hydropower generation, and transport provides economies with export earnings. Water use in agriculture, livestock production, fisheries and tourism has created employment. The provision of safe water supply and sanitation is a social good – necessary for reducing morbidity and mortality rates caused by waterborne or water-related diseases such as cholera, diarrhoea and malaria. Access to safe water is inadequate but a precondition both for health and for fighting poverty and hunger in the poor communities in the developing countries.

For economic security and social well-being, the water resource base requires protection. Environmental degradation is inextricably linked to poverty, hunger, gender inequality and health. Water needs to be supplied while sustaining healthy, functional ecosystems. For this, integrated water resource management (IWRM) framework approaches are required. Climate change and variability, population growth and increasing water demand, over-exploitation and environmental degradation continue to contribute to complexity of water resource management. Extreme events also have an impact on the aquatic and terrestrial environments. Conflicts, misuses of water resources and poor water management practices have often resulted in depleted supplies, falling water tables, shrinking inland lakes, destruction of ecosystems, human and ecological disasters and pollution of water. Human (industrial) activities also cause widespread water pollution, further decreasing the quantity of water suitable for sustaining life.

Research has generated new knowledge to remedy some of these issues. Progress has been achieved in better understanding the functioning of the ecosystem as carrier of all life, with water playing vital roles, but many questions remain. Water is managed in too fragmented a way. Surface water and ground water are often considered separately without due recognition of their interdependence. Water and land resources in many places are still not managed in conjunction. Water supply schemes are usually designed, especially in developing countries, without the required matching with drainage networks and waste water treatment facilities. Quantity and quality are managed separately, so are water science and water policy. More efficient management of water resources and more accurate knowledge of the hydrological cycle require implementing a *system* approach, encompassing the social and economic dimension of sustainable development.

Strategies for international co-operation

As water resources are often a primary limiting factor for development in many regions and countries, in particular developing countries, more emphasis should be given to stronger interlinkages between scientific research, application and capacity building. Filling the gap between policies and alleviation of poverty, science and the transfer of knowledge is at the centre of achieving sustainable development in many developing as well as industrialised countries.

Capacity building and international co-operation is required to address issues such as developing:

- Scientific understanding of the water cycle in order to promote a systematic assessment of the quantity and quality of water available for development.
- Tools and methodologies for managing the impacts of climate change and human interventions in the hydrological cycle.
- Appropriate technologies for water treatment, sanitation systems and water conservation including the application of enhanced agricultural technologies and their application.
- Good practice models of linking these technologies to appropriate institutional mechanisms, such as catchment-level agencies.

Partnerships are increasingly adopted to foster international co-operation. The partnerships represent complex inter-linkages among a wide range of enterprises and are designed to reduce the risks associated with the development of new products and facilitate exchange of information. The partnerships help provide funds through licensing and upfront fees for R&D, reimbursement of expenses for products and services, royalties, profits, and other "success fees" associated with the achievement of certain milestones (UN Millennium Project Task Force on Science Technology and Innovation, 2005). South/south collaboration also creates opportunities for partnerships.

Focal issues

As a follow-up to CSD 13, the focal issues here include exploring north/south and south/south interaction and best practices for (regional) strategic planning, technology options and methodologies in the area of water science and technology. Good practices in order to find solutions for addressing water management for developing countries need to be discusses and shared. These practices should ensure a sufficient and good-quality water supply, adequate water (hazards) management, and efficient use of and sustainable access to safe water and sanitation, in particular for the poor. Proposals for successful research collaboration, including north/south partnerships, in pursuit of increased knowledge, capacity building and technological innovation in developing countries should be put forward. Integrated water resource management (IWRM), water hazards management; and capacity building for water management should be discussed.

Representation of developing and emerging market economies will ensure focusing on the needs and scope for country/region specific actions. Possible joint research efforts between developed and less developed countries, strengthening research outcomes with stake-holder training, and activities that raise awareness of the need for capacity building should be identified. Ways to improve access to data, information and knowledge and public involvement should be sought so that the transfer of knowledge and technology will be more beneficial for both the water specialists and the general public.

Issues in energy efficiency, climate change and sustainable industrial production

Introduction

The WSSD highlighted the centrality of water and energy service delivery to the goals of sustainable development. In the two formal outcomes, the JPOI and the public-private partnerships, the two themes were prominent as being necessary for economic and social development throughout the developing world. Their importance was formalised in the UNCSD work plan. However, to date, work fulfilling the objectives of the JPOI has neglected the value of energy efficiency in science and technology collaboration. The gap needs to be filled by linking efficiency programmes to climate change and industrial development and by demonstrating their contributions to sustainable development.

Endowment opportunities and threats regarding energy supply

Demand for energy is growing worldwide and the projected rate of growth in developing countries over the next 15 years far exceeds that of the industrialised nations. The Energy Information Administration estimates that the developing world's energy consumption will increase from over 100 quadrillion BTUs in 1999 to over 264 quadrillion BTUs by 2020. By 2020 it is also expected that the developing world will overtake the industrialised world in carbon dioxide emissions (EIA, 1999, 2001). Further increases in energy demand are expected if access to modern energy services is to be extended to the over 1.6 billion unserved people. While additional supply sources will form an essential component, energy efficiency in end-use applications is a critical element to ensure a cost-effective, long-term sustainable path that reduces greenhouse gas (GHG) emissions and contributes to sustainable industrial production.

The way in which we generate our energy also relates to energy efficiency. An alternative to the construction of new power plants that produce harmful emissions is to improve the efficiency of current sources of energy production. Energy efficiency technologies and practices are warranted both on the supply and demand sides. It makes little economic sense to increase power generation capacity unless it is generated efficiently.

Inefficient use of energy degrades the environment, slows economic growth and wastes precious natural resources. Improving the efficiency with which we generate, transmit, distribute and use energy is the surest way to ensure the sustainability of the energy system and catalyze economic and social development. Improving energy efficiency reduces infrastructure and investment requirements, enhances energy security by reducing fuel imports, frees up capital for other social and economic development needs, increases national and industrial competitiveness through more sustainable industrial production, and reduces air pollution and greenhouse gas emissions. Energy efficiency is among the most cost-effective options to address climate change.

Energy, environmental, and industrial policies and programmes have traditionally undervalued the contributions energy efficiency practices and technologies can make. The World Bank has recently recognised the need to scale-up energy efficiency investments and policy dialogue in order to overcome these global trends, and it has articulated a commitment to *i)* reduce the average energy consumption per unit of GDP in developing countries to 0.24 toe/USD 1 000 compared to 0.27 toe/USD 1 000 in 2001; and *ii)* reduce CO_2 emission intensity of energy use to 2.75 tons/tons of oil equivalent (t/toe) compared to 2.90 t/toe in 2001 (Saghir, 2003).

The primary drivers of energy use in many developing countries are urbanisation, industrialisation and rising incomes. Industrial end-use applications account for approximately 40% of global primary energy demand and roughly the same share of CO_2 emissions. The technical potential for energy saving ranges from 30% to 50% in existing operations, to as much as 90% in new buildings and operations, with concomitant reductions in greenhouse gas emissions. In many developing country industries, the costs of reducing energy and other input costs through more efficient practices and cleaner production options can be lower than the costs of increasing supply through new production facilities. By implementing technically advanced energy systems, developing nations could leapfrog the world's existing energy infrastructure in efficiency and sustainability. An extensive body of knowledge and history of experience in S&T collaboration exists in this field and can inform policy makers in developing countries in designing and implementing their development agenda. Unfortunately, lack of awareness and expertise, high perceived technical risks, low energy pricing, high up-front and project development costs, underdeveloped markets due to historically low supply/demand, and a lack of affordable financing have contributed to underutilisation of energy efficient technologies.

There are a number of international partnerships, initiatives and networks that have flourished in the last decade, promoting clean energy, sustainable development and the way to ensure energy services for the 1.6 billion people that do not have access. For example, for over 30 years, the International Energy Agency (IEA) international technology collaboration framework has provided a structure for governments to leverage and strengthen their national research and deployment programmes. Its 40 Implementing Agreements cover all new key technologies in energy supply and end use. Similarly, there are numerous bilateral S&T relationships that involve national laboratories and private sector R&D activities that cover energy and development issues from basic research to commercialisation.

Focal issues

The two fundamental components of science and technology collaboration--technologies and technology diffusion mechanisms (networks, partnerships, initiatives) --will be addressed. Technology issues will be thus be complemented by international co-operation mechanisms, including successes/failures of these efforts.

Technologies for energy efficiency

Selected production efficiency and end-use applications (*e.g.* power plants, industrial motors, commercial building lighting, pulp and paper, appliances) will be discussed. The technological solutions that have been implemented in the selected supply-side and end-use areas resulting in measurable efficiency gains in greenhouse gas abatement, environmental and economic benefits will be highlighted (*e.g.* industrial process upgrades and optimisation, improved lighting systems, codes and standards, motor and drive system improvements). There is a stress on the importance of integrating disparate efficiency technologies in a systemic fashion. The policies (*e.g.* energy pricing, incentives/penalties, standards/benchmarking, energy auditing) and institutional/financial arrangements that facilitate the adoption of the efficiency technology or improvement are to be examined. Solutions that have not only demonstrated their cost-effectiveness and commercial viability within a given market, but also their ability to be adopted on a sustainable, scalable and replicable manner will be highlighted. The results of energy efficiency programmes introducing new technologies that have resulted in substantial efficiency gains on the supply and/or demand side will be discussed from a **technology perspective**. Both bilateral and multilateral energy efficiency programmes will be presented.

International initiatives and partnerships for energy efficiency and renewable energy

From the point of view of **international co-operation in energy efficiency and renewable energy,** different types of initiatives/organisations will be discussed, *e.g.* partnerships launched at the WSSD, the US Clean Energy Initiative's Efficient Energy for Sustainable Development, and the Mediterranean Renewable Energy Program. Similarly, specific technology-focused partnerships such as the Collaborative Labelling and Appliance Standards Program (CLASP) and Watergy, a partnership designed to provide efficiency savings in both water and energy use, are discussed to show the various diffusion models for energy efficiency, renewable energy and climate-related technologies. Why the project/ programme was launched; the programme goals; how the project/programme addresses capacity building, technology transfer, network building; aspects of success/failure; lessons learned; who are the stakeholders that participate (in developed and developing countries) will be discussed.

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Chapter 2

TECHNOLOGICAL LEARNING AND SUSTAINABILITY TRANSITION: THE ROLE OF INSTITUTIONS OF HIGHER LEARNING IN AFRICA

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Introduction[1]

The aim of this paper is to explore the role of science, technology and innovation in sustainable development in Africa. It argues that much of the scientific and technological knowledge needed to help Africa improve its welfare while protecting the environment is available. What is needed is to create institutional mechanisms and build human resources needed to harness the knowledge and put it to effective use. In the age of international relief, donor governments worked closely with non-governmental organisations and their influence flourished. In a new era of emphasis on competence building and enhancement of human resources, higher learning institutions must play a greater role. International support should therefore go to strengthen the capacity of institutions of higher learning (referred herein for purposes of brevity as "universities") to solve local problems. The presentation focuses on the central role that universities can make in promoting sustainable development in Africa. Placing universities at the centre of economic renewal will entail adjustments in public policy in Africa and in international aid agencies. These changes will involve long periods of learning, but the first steps must be made without delay.

Technology and the Millennium Development Goals

At the Millennium Summit in September 2000, world leaders adopted the Millennium Declaration, which formally established the Millennium Development Goals (MDGs). Since then MDGs have become the international standard of reference for measuring and tracking improvements in the human condition in developing countries. MDGs are important because they are backed by a political mandate agreed upon by the leaders of all UN member states, offer a comprehensive and multidimensional development framework, and set clear quantifiable targets to be achieved in all countries by 2015.

1. This paper is partially based on C. Juma (ed.), forthcoming, *Learning to Develop: Universities in Africa's Economic Renewal* and *Innovation: Applying Knowledge in Development*, the report of the UN Millennium Project's Task Force on Science, Technology and Innovation presented to the UN Secretary-General Kofi Annan in January 2005.

Improving the welfare of developing countries is intricately intertwined with the security of all countries, making development a truly global venture. Indeed, countries such as the United States have started to classify human development challenges prevalent in developing countries, such as HIV/AIDS, as national security issues. This is the beginning of a process that recognises the emergence of a globalised world that requires collective action to deal with issues once considered strictly national.

Experts from anywhere in the world can help apply science and technology to assist developing countries to meet MDGs. But if long-term goals are to be achieved and growth and problem solving to become indigenous and sustainable, developing countries, need to develop their own capabilities for science, technology, and innovation. Meeting this goal requires an approach that views science, technology, and innovation as a system of interconnecting capabilities, including governance, education, institutions, advice, and collaboration.

The proposed strategies are meant to complement, not replace, other approaches. For example, science, technology, and innovation play an important role in addressing the challenges associated with eliminating poverty and hunger, as the case of Southeast Asia demonstrates. They reduce poverty by contributing to economic development (by creating job opportunities and raising agricultural productivity, for example). They alleviate hunger by improving nutrition, increasing yields of cash and subsistence crops, improving soil management, and creating efficient irrigation systems. In themselves, however, these scientific and technological measures do not solve the challenges of poverty and hunger; they need to be part of an integrated strategy aimed at improving overall human welfare.

Science and technology can also play an important role in facilitating implementation of the Goals on education, gender, health, and sustainable development. The World Summit on Sustainable Development affirmed the importance of science and technology, but the scientific, engineering, and technology communities have yet to be fully integrated into a system that encourages and enables development. Very capable engineering organisations and expertise are available to address acute problems, such as natural or other disasters, but the ability to put these resources to use for long-term sustainable development in developing countries is lacking.

ICTs can increase primary, secondary, and tertiary education by facilitating distance learning, providing remote access to educational resources, and enabling other solutions. Many technologies hold the promise of significantly improving the condition of women in developing countries (by improving energy sources, agricultural technology, and access to water and sanitation, for example).

Many health interventions—including the treatment and prevention of malaria, HIV/AIDS, drug-resistant tuberculosis, and vitamin and other micronutrient deficiencies—require new treatments and vaccines. The production of generic medicines holds the promise of improving poor people's access to essential medicines. Science and technology can also improve the monitoring of drug quality.

Improved scientific knowledge at the local level will be indispensable for monitoring and managing complex ecosystems, such as watersheds, forests, and seas, and for helping to predict (and thereby manage) the impact of climate change and the loss of biodiversity. Access to water and sanitation will require continuous improvement in low-cost technologies for water delivery and treatment, drip irrigation, and sanitation.

HIV/AIDS and tuberculosis are severe problems in many African and South Asian countries, where the HIV/AIDS is exacerbating what was thought to be a relatively well-controlled tuberculosis phenomenon. Malaria also remains a serious problem, with high mortality rates in most tropical regions (and rising rates in parts of Africa). Science, technology, and innovation policy needs to be oriented toward finding vaccines and cures for these diseases, while creating new institutional frameworks from which new research collaborations can spring.

A nation's ability to solve problems and initiate and sustain economic growth depends partly on its capabilities in science, technology, and innovation. Science and technology are linked to economic growth; scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food. Development trends around the world need to be reviewed to evaluate the role that science, technology, and innovation play in economic transformation in particular and sustainable development in general.

Within just a few decades, the countries of East Asia have employed appropriate science, technology, and innovation in their economic and industrial policies to achieve extraordinary economic progress. At the same time, gains made in the former Soviet bloc, a scientific and technology giant, have been eroded, where life expectancy has declined, the public health infrastructure has decayed, and legal, financial, and political institutions are functioning poorly. Possessing competence in science, technology, and innovation is not sufficient; the proper enabling environment must be present.

Technological innovation is becoming equally critical in the management of fresh water resources. So far much of the attention on fresh water has focused on market-related issues, such as privatisation. Innovation-related responses are just starting to emerge. For example, concern over water scarcity in agriculture is generating interest in alternative approaches that reduce the amount of water used to produce a unit of grain. Attention is also now turning to the development of drought-tolerant crops using both conventional breeding methods and genetic engineering. These applications need not rely only on modern technologies.

But technological innovation can only have the desired impact if it is placed in the context of long-term development strategies, especially those associated with greater regional diversity and experimentation. In this regard, regional integration efforts across Africa represent a major step in creating space for greater application of technological innovation in the implementation of MDGs in particular and the transition toward sustainable development in general.

Regional integration and stability

Promoting prosperity in Africa will require increased integration of the region into the global economy through innovation-based activities. Economic growth propelled by technological innovation can increase social cohesion, stability, and democratisation. Major conflicts in Africa arise from disputes over land, commodities, and natural resources. Diamonds fuelled conflict in Angola and Sierra Leone while oil has been at the centre of violence in Sudan and Chad. The scramble for columbite-tantalite (used in the manufacture of cell phones, jet engines, night vision goggles, fibre optics and capacitors) has helped to fuel the war in the Democratic Republic of Congo.

Opening up markets of the developed world does not automatically increase exports from Africa, unless the goods and services are competitive in price, quality and delivery. Without electric power, mineral extraction and product manufacture are not possible. Without irrigation, increased agricultural productivity is unlikely in many parts of the Africa. Without water and electric power, value-added food processing is not feasible. Without land and inland water transportation facilities together with ports and airports, export cannot be competitive in price and timely delivery and in sufficient volumes that offer economy of scale to producers and consumers alike. Modern trade and commerce presupposes that all trading parties have adequate information and communications facilities to be members of the global financial community.

In other words, African countries must have adequate national basic infrastructure services (defined to include the associated technical skills as well as research and training institutions) with necessary regional physical and electronic connectivity before they can really participate and benefit from global trade for economic growth and development.

With the requisite infrastructure services, integration into the global economy will no longer rely on export of raw materials alone. It will be replaced by knowledge-based innovations. Rudimentary production methods will be replaced by more efficient technologies that add value to Africa's natural resources. For example, mineral processing industries would be enhanced in value by knowledge workers with technical skills that pervade all economic activities.

The need for infrastructure services as prerequisite for trade and development nationally, regionally and globally has been accepted since the end of the World War II with such schemes like the Marshall Plan in Europe and institutions like the World Bank. Billions of dollars have been poured into infrastructure projects in the developing world by donors since then, however without much impact on economic growth in the recipient countries. The lessons are also well known. The majority of projects are designed, supplied and implemented by donors without much indigenous involvement.

Most of the installations were not designed to suit local needs and much of the focus has been on machinery supply rather its economic utility. There is a reawakening of the urgency of infrastructure development that is indigenous in desire, design, installation, operation, repair and maintenance. This would require indigenous technically skilled and knowledge-based human resources to realise. The role of the African universities is pivotal and urgent.

The world is increasingly deriving economic value from scientific and technical knowledge. Unlike conventional sources of wealth, knowledge is not scarce and tends to grow with greater interactions among different sections of the global society. Knowledge-based economies will not develop without conflicts of their own, but warfare based on mercantilism or land grabs will become historical anecdotes.

There are two critical starting points. First, African countries must facilitate regional technology co-operation as a basis for leveraging international partnerships. Second, international assistance to Africa should focus on modernising the region by focusing on building scientific and technological capacities.

African countries are starting to take economic integration seriously. For example, the creation of the regional economic communities could not only serve as mechanisms for creating larger markets; they could also promote peace in the region. Regional technology co-operation should be a central aspect of its implementation. Similar opportunities exist in other regional integration organisations.

The current malaise in the traditional development community is being challenged by new technology alliances involving the more developed developing countries. For example, India, Brazil and South Africa have launched a technology alliance that will focus on seeking solutions to agricultural, health and environmental challenges facing developing countries.

Developing countries are increasingly entering into bilateral partnerships to develop new technologies. India and China have created a joint steering committee that will promote coordination in their technology development efforts. Such alliances provide examples that could be emulated in new technology and trade partnerships between Africa and its allies in the industrialised countries.

Africa needs similar agreements that promote the use of regional technological capabilities in international trade. But for such alliances to benefit the region, specific measures will need to be put in place to harness the world's scientific and technological knowledge for development. Universities and other institutions of higher learning are central to this process and should therefore be brought to the centre of development planning.

Universities in development

The rising interest in Africa's future has coincided with a new awakening of interest within international development agencies in the role of technological innovation in economic growth. But much of the discussion on Africa's development only marginally addresses the need to harness the world's existing fund of knowledge. The Commission for Africa has, for example, played an important role in placing the issue on the international policy agenda. The commission also pointed out that using existing knowledge for economic development will require governments and other players to focus on strengthening the role of the academic community (as well as business) in development.

Universities and other institutions of higher learning are key players in domesticating knowledge and diffusing it into the economy. But they can only do that through close linkages with the private sector. This will require major adjustments in the way that universities function in Africa (as well as the rest of the developing world). Many universities will need to be changed from being conventional sources of graduates to becoming engines of community development. They will need to become "developmental universities", working directly in the communities they are located in.

The main role of the first generation of African universities was to create civil servants. Unfortunately, this classical model has become the template within which new universities are created, even though social and economic needs have changed radically. The continent needs a new generation of universities that can serve as engines of both community development and social renewal.

The task ahead is not simply one of raising more funds. It will require deliberate efforts by governments, academia, business and civil society to reinvent higher education and put it to the service of the African people. To achieve this, a qualitative change in the goals, functions and structure of the university is needed. Fundamental reforms will be needed in curriculum design, teaching, location, selection of students and the management of the continent's universities. Such an effort will push African leaders to the frontiers of institutional innovation; nothing less will meet the challenges.

The good news is that Africa has a large number of important innovations in higher education to learn from, many of which are from the continent itself, or elsewhere in the developing world. Take, for example, curriculum development. One of the most pioneering examples in curriculum reform is EARTH University in Costa Rica, whose curriculum is designed to match the realities of agribusiness, and is dedicated to producing a new generation of young people trained specifically to focus on changing the human condition though entrepreneurial activities. In 1948, Costa Rica abolished its army and used part of the saved revenue for health and higher education. This courageous act helped the country prosper and become an economic force in Central America. Costa Rica's EARTH University has pioneered a new educational model that trains young people to create enterprises and be employers rather than employees.

EARTH University is a private, non-profit, international university founded in 1990 with support from the US International Development Agency (USAID) and the Kellogg Foundation. It seeks to contribute to the sustainable development of the tropics through agricultural education and natural resource management. The university has nearly 400 students from 20 Latin American, African and Asian countries. It is devoted to educating professionals committed to sustainable development through environmental and social awareness, an entrepreneurial spirit, and strong interest in community service. EARTH University focuses on innovation, interactive learning, critical analysis, interdisciplinary synthesis and wider dissemination of knowledge. The overall goal is community development in the tropics.[2] A central mission of the university is to offer education to economically disadvantaged young people. Nearly half of the students receive a full scholarship, while another 30% get partial support from the university.

EARTH University offers a four-year *Licenciatura* degree in agricultural sciences. It focuses on training leaders who will help advance sustainable development in their countries. By training "agents of change", EARTH University has developed a unique curriculum based on experiential learning. It focuses on agriculture as a human activity, the integration of many academic disciplines, understanding the changing and globalising world, and the linkages between economic, social and environmental concerns.[3]

In their first year, students focus on doing practical work related to crop and animal production. This equips them with work experience and a deeper understanding of rural economies. During the next 18 months, students are required to create and run their own micro-enterprises using a USD 3 000 loan from the university. Groups of five students undertake project design, feasibility assessment, market study and business management. If the business generates a profit, two-thirds of the earnings go to the students and the remainder is paid into a fund maintained by the university to cover those enterprises that suffer losses. At the end of the study period, the enterprises are dissolved to create space for the next generation of students. During their last year, students prepare business plans, write papers or do internships.

Africa's reconstruction challenges require creating the technical competence needed to design and manage infrastructure projects. The Kigali Institute of Science, Technology and Management (KIST) in Rwanda shows how higher education institutions can help transform the communities in which they are located.

2. I would like to that Ms. Leah Aylward, Prof. Jose Zaglul and Prof. Daniel Sherrard for the information provided here on EARTH University.

3. L. Aylward, personal communication, EARTH University, Costa Rica, 2004.

Another example of business 'incubation' is the University of Zambia. This was the midwife of Zamnet, the country's largest Internet provider. Zambia's experience demonstrates that universities have great potential for creativity and innovation, even under the most difficult financial conditions. Numerous Brazilian universities have adopted a similar approach as part of their regular mission.

Imagination and creativity are probably the key resource money cannot buy. While in the US universities incubate businesses, in Asia private enterprises are key incubators of universities. For example, South Korea's Pohang Iron and Steel Company established the Pohang Science and Technology University (POSTECH) in 1986 to serve as a world class research and teaching institution. Today POSTECH is ranked as one of the top technical universities in Asia. Africa's private enterprises can learn from this example, just as they can benefit from US and other models. Brazil is another rich source of lessons. For example, the Pontifical Catholic University of Rio de Janeiro produces both graduates and enterprises nurtured in the university's Genesis Institute.

Curriculum reform is needed to create an adaptive generation of professionals. South Africa's Stellenbosch University offers a shining example of how to adjust curricula to the needs of research and development (R&D) organisations. It was the first university in the world to design and launch a micro satellite as part of its training. In Uganda, Makerere University has developed new teaching approaches that allow students to solve public health problems in their communities as part of their training. Similar approaches should be adopted by students in other technical fields. For example, engineering students should spend part of their time solving local problems in fields such as infrastructure development maintenance.

Universities can also play a key role as social entrepreneurs. For example, students at Ghana's University of Education, Winneba, tune into Radio Windy Bay to listen to lectures. The university could use radio and other tools such as "pod casting" to extend its social mission to the wider community. Universities should exploit using new telecommunications technologies and should serve as loci for diffusing knowledge in society. Education could also include designing radio programmes which would prepare the students for participation in the emerging creative industries.

Many of these examples are a result of isolated initiatives, some resulting from government foresight, others from occasional academic entrepreneurship, or just serendipity. The challenge facing Africa is to move away from relying on luck and tenacity to create an environment that helps realise the developmental role of universities across the continent. This must start with government policy. Little will happen unless governments realise the strategic role that universities can play in harnessing the world's fund of scientific and technological knowledge for development.

The issue is not simply about more funding, but redefining higher education as a developmental force. This will require efforts to align university activities with development missions. This in turn will influence the location of universities.

Many African countries depend heavily on tourism to earn foreign exchange. Given this, there is a strong case for creating institutions of higher learning that are devoted to wildlife management and are located appropriately. The sustainable management of freshwater resources—such as those of Lake Victoria and Lake Chad—requires similarly dedicated institutions of higher learning.

The way ahead involves at least three types of strategic decisions. The first is to promote reform in existing universities, in order to bring research, training and outreach activities to the service of the regions they are located in. Universities located in urban areas, for example, should forge close links with municipal authorities, and help solve the economic, social and environmental challenges that these authorities face.

Existing universities can also play an important role in promoting infrastructure development. Road and construction, for example, can benefit from local research results. Countries such as Malaysia have established a long tradition of linking road construction to the creation of civil engineering capacities at local universities. The second type of decision involves upgrading the level of academic competence at technical institutions that have already contributed to community development, while preserving their traditional role.

This, however, is only possible if existing university policies and regulations are sufficiently flexible to accommodate developmental functions. As many are not, such upgrades have often been carried out at the expense of community service. Finally, African governments are currently reviewing an increasing number of applications to set up new universities. This gives them a unique opportunity to shape the curricula, teaching and location of these institutions so that they can perform developmental tasks.

Putting universities at the service of community development will also require extensive international partnerships. Development agencies need to complement their current focus on primary education with a new vision for higher education. African countries, in turn, will need to demonstrate their commitment to long-term development by providing incentives and formulating policies that bring higher education to the service of development. Today the poor flock to the cities, many in search of the higher education that they see as the passport to their children's personal success. The time has come for higher education to show results through novel technology development and commercialisation alliances that contribute to economic development.

Strategic considerations

African universities and other institutions of higher learning represent a major foundation for promoting sustainable development. But their contributions to economic development can only be implemented thought a wider programmatic focus on long-term technological programmes. *Donor agencies can play an important role in leveraging change through support for a range of activities which include*:

Strengthening science and technology advice

Bringing science and technology to support decisions on development require adjustments in the functioning of government. So far over 100 countries worldwide have created commissions on sustainable development aimed at coordinating the diversity of state actors. However, executive leadership in national and local government continues to operate without adequate guidance on the role of science, technology and innovation in sustainable development.

One option to address this challenge is to establish offices of science and technology advice in executive offices dealing with sustainable development issues. Such offices could be established in the offices of presidents, prime ministers and specific ministries. Similar offices need to be established in the executive offices of local governments such as mayors and regional governors. Similar mechanisms are also needed among donors.

Identifying sustainable development missions

Focusing on specific local problems would serve as an organising framework from which to rally specific knowledge and other resources. This approach would require the clear identification of the problem to address as well as the options available for solving the problem and a choice of delivery mechanisms. An obvious starting point for most African countries is infrastructure development which will also serve as a foundation for technological innovation and accumulation of technological capabilities. Another area that could form a basis for sustainable development missions is the application of biotechnology to development, especially in the areas of human health, food security and environmental management.

For example, mayors can work with government, academia, industry and civil society to design missions aimed at improving the lives of specified slum dwellers. Universities located in such cities could be play key roles as loci of expertise, incubator of businesses and overall sources of operational outreach to support private and public sector activities. Similar missions could be established in the natural and water resources fields. The missions would therefore become the organising framework for fostering institutional interactions.

This approach can help the international community isolate some critical elements that are necessary when dealing with a diverse set of problems such as conservation of forests, provision of clean drinking water and improving the conditions of slum dwellers. In all these cases, the first major step is the integration of environmental considerations into development activities. This goal, however, is meaningless unless addressed within the framework of an entity that has jurisdiction of development activities having a direct impact on natural resources, safe drinking water and slum dwellers.

Bringing higher education to the service of sustainable development

Addressing the sustainability challenge requires greater investment in the generation and utilisation of scientific and technical knowledge. This goal can be achieved by aligning the missions of universities and other institutions of higher learning with sustainability goals. For example, most universities in developing countries are located in urban areas, but most do not play significant roles in helping to solve local problems. Much can be gained by adjusting the curricula, pedagogy and management of urban universities to address challenges such as sanitation and improvement of the conditions of slum dwellers. Similarly, universities and research institutions located in rural areas could serve as the locus for research, training and outreach on the management of natural resources.

Universities should work more closely with the private sector in the sustainable development activities. Promoting enterprise development, especially in the urban areas, is one of the most effective ways to address poverty. This will require programmes designed to promote enterprise creation and development, especially among the urban poor. Similar efforts need to be adopted in rural areas. More specifically, universities and other mechanisms could serve as business incubators as well as sources of ideas and support for upgrading urban and rural economic activities.

Policy alignment: African countries and regional integration organisations must align their policies and government structures with the need to place science and technology at the centre of development. This will involve the appointment of science and innovation advisors to presidents to help leaders focus on the role of innovation in development in a cost-effective manner. In Malaysia, the president of the national academy of science is also the chief scientific advisor to the prime minister.

University infrastructure rehabilitation and development: Government support will need to rehabilitate and develop university infrastructure, especially their information and communications facilities to help them be part of the global knowledge community and network with others around the world. Such links will also help them tap into their experts in diaspora.

Institutional design: Emphasise bringing research, teaching and community outreach together. For example, medical schools should be more integrated into hospitals just as agricultural research stations should have a strong teaching role. Similarly, strong links between universities and the business community should be forged. This process may involve reforms in existing universities, creation of new ones or upgrading existing institutions. There is an urgent need to take stock of the full scope of research and training facilities in the various African regions, especially those that fall outside the formal rubric of "universities" and explore how they could be harnessed to supplement the contributions of existing universities. All government ministries are involved in one or another aspect of research and training and therefore hold the seed for populating the economic space with new species of higher learning institutions adapted to specific needs.

Curriculum reform: Reform curricula by replacing outmoded sections with new approaches that encourage creativity, enquiry and entrepreneurship. These reforms should also include close co-operation with the private sector and the communities in which universities are located. In turn, government at all levels (central, urban and regional) should be at the forefront of creating space and opportunities for the contribution of universities to development.

University management: Universities should enjoy greater autonomy in management so that they can adapt in a timely manner to a rapidly-changing world. But the autonomy should be guided by the need to deliver community development and not be seen simply as an artefact of good governance. But African universities do not make these changes and make themselves relevant to local needs they become increasingly marginal and their status in society will decline. Governments, on the other, will do no better if they do not move to make knowledge the driving force for improvement.

Conclusions and the way ahead

Advancing the agenda of bringing universities to bear on sustainable development will require extensive international consultations and partnerships and institutional design driven by economic imperatives. These consultations should be based on a better understanding of Africa's intellectual resources and infrastructure as a foundation for economic growth. This knowledge would form a basis for dialogue with the industrialised countries to gain support for networks among higher education institutions and centres of excellence.

The starting point would be to agree on initial priorities based on feasibility and potential for technological learning. In light of the growing globalisation of knowledge, this process of consultation should involve right from the beginning Africans in diaspora with expertise and international connection in research, business and government. All this must be guided by a sense of urgency and determination to deliver results by learning from the experiences of other countries and by creating international partnerships.

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Chapter 3

REGIONALISM AND TECHNOLOGY DEVLOPMENT IN AFRICA

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Introduction

In the past four decades, a number of regional co-operation and integration schemes have been adopted by many African countries. There are currently more than 20 regional agreements that aim at promoting co-operation and economic integration at sub-regional and continental levels. A common feature of these agreements is their appreciation of the role that science and technology play in national and regional economic development. Indeed most regional trade, economic, political, environment and security agreements have provisions for science and technology co-operation.

This trend is based on the recognition that their individual economies are small and are poorly endowed with human, physical and financial resources necessary to develop and harness science and technology for economic change and growth. Thus, economies of scale dictate that such countries pool their resources together. Despite this, there are few concrete examples of how African countries have collectively harnessed science and technology to solve their common developmental problems. Science and technology co-operation provisions have largely remained statements of intent. The few attempts at making the transition from policy (as embodied in regional treaty or agreement provisions) to action have not been really successful. This is due to the absence of appropriate regional science and technology institutions and the failure to adjust regional economic bodies. The situation, however, is starting to change with a new wave of regionalism characterised by deliberate efforts to design and implement plans for the application of science and technology to development.

The evolution of regionalism in Africa

Regionalism[1]—a process of opening up and integration of national socio-economic and political systems—is receiving renewed interest of many African countries. Regionalism is not a new phenomenon in Africa. It can be traced to the 1960s when the newly independent African states saw opportunities for economies of scale in production and trade from a larger regional economic bloc. By engaging in regionalism, African countries wanted to break three main barriers to development: small size of their

1. For a conceptual discussion or treatment of regionalism, see Weiss (1999).

individual economies; dependence on import of high value or finished goods; and dependence on a small range of low-value primary exports, mainly natural resources.

Regionalism in Africa also emerged out of the pan-African political aspiration for a continental identity and unity as well as the need to build hegemony that would intimidate the former colonial masters. This aspiration was pronounced with the creation of the Organisation of African Unity (OAU) in 1963, transformed into the African Union (AU) in 2001. Following the creation of the OAU a plethora of regional treaties and institutions emerged including the Customs and Economic Union of Central Africa (UDEAC) established in 1964, East African Community (EAC) 1967-1977 and re-established in the early 1990s, Southern African Development Community (SADC)[2], the Economic Community of West African States (ECOWAS) established in 1975, the Common Market for Eastern and Southern Africa (COMESA) in 1995[3], and the Arab Maghreb Union (AMU) in 1989.

The UN Economic Commission for Africa (ECA), established in April 1958, was instrumental in the establishment of the regional economic groupings of Africa. The main objectives of the regional groups were the eventual elimination of all tariffs and barriers between members, the establishment of a customs union, unified fiscal policy and co-ordinated regional policies in the transport, communication, energy and other infra-structural facilities.

However, in spite of these efforts, regionalism has remained elusive to Africa. A variety of institutional, political and geographical factors have made its attainment difficult. These factors include weak regional institutions, rigidity in leadership's appeal to nationalism, intra-state conflicts and wars, the East-West Divide during the Cold War that pulled African countries to the either of the two ends, and structural barriers to trade and industrialisation.[4]

Previous efforts to promote and use regionalism in Africa have not contributed to the economic transformation of the continent. For intra-African trade to be mutually beneficial in line with economic integration goals, there should be substantial intra-regional trade. If African countries are competitive in their production of similar goods, there will be many opportunities for the substitution of the commodities of one country for another leading to more trade creation than diversion. Technology plays a major role in stimulating and sustaining economic diversity and trade creation, thus underpinning regional integration. Rather than promoting economic integration, regional economic communities have spent the last three decades resolving political and social conflicts in some of its member countries such as Angola, Rwanda, Burundi, Liberia, Sierra Leone, Guinea Bissau and Niger.

Science and technology in regional agreements or treaties

Regionalism is receiving renewed attention of African countries. The number of regional economic and trade agreements has increased in the last decade. The past several years have witnessed a plethora of proposals for new bilateral and multilateral preferential trade arrangements. There is also increasing attention to bilateral and

2. Formerly the Southern African Development Coordinating Conference (SADCC) established in 1980.

3. Existed earlier as the Preferential Trade Area (PTA) established in 1981.

4. For a comprehensive review of the performance of regional economic communities see UNECA, (2004).

multilateral science and technology co-operation. Science and technology co-operation is increasingly being written in economic and trade agreements. This trend is taking place at a time of the economic globalisation and the associated rapid advances in technology. Regionalisation is being driven by advances in the technology of transport, information and communications as well as policy and politics. This is evident in the increasing trans-boundary movement of people, finance and products in the region. Intra-regional foreign direct investment flows are also increasing.

Africa has a wide range of regional instruments that articulate the importance of science and technology co-operation. Most regional and sub-regional economic, political and trade treaties make explicit reference to the need to strengthen co-operation in various science and technology fields. Article 13 of the Constitutive Act of the African Union (AU) gives authority to the Executive Committee of the AU to formulate policies that promote science and technology co-operation. The Declaration and Treaty establishing the Southern Africa Development Community (SADC) aims at promoting the development, transfer and mastery of technology. The Treaty Establishing the East African Community (EAC) contains several provisions on science and technology. Similar provisions are found in the Common Market for Eastern and Southern African (COMESA).

Regionalism offers platforms on which scientifically and technologically weak countries articulate their demand for technology, innovation policy and related institutional adjustments. It can provide a good foundation for restoring and enlarging Africa's confidence in its own abilities to generate and manage knowledge for economic change and human development. African countries have signed and ratified a wide range of other multilateral agreements that contain provisions on international scientific and technological co-operation, including the Convention on Biological Diversity (CBD), the United Nations Framework on Climate Change (UNFCC) and the Montreal Protocol. Many are also members of the World Trade Organisation (WTO) where issues of technical co-operation and technology transfer preoccupy most of the negotiations.

International co-operation in science and technology is increasing in intensity and complexity. Recent studies show that co-operation in scientific and technological activities has increased among developed countries and between some developed and developing countries.[5] This is stimulated by a variety of factors, including globalisation and increasing recognition of benefits of such co-operation. Most recent international and regional economic, trade, security and environmental agreements or treaties contain provisions on co-operation in science and technology. In Montreal Protocol (1987), the CBD (1992), the UNFCC (1992), the Trade Related Intellectual Property Rights (TRIPS) agreement of the WTO (1994) and the Cartagena Protocol on Biosafety (2001) the contracting parties are obliged to invest in joint science and technology programmes and engage in co-operation through exchange of expertise and information as well as sharing of research facilities. Also, Agenda 21 adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 devotes a lot of attention to the need for international co-operation in science and technology. The Johannesburg Plan of Implementation adopted by governments at the World Summit on Sustainable Development (WSSD) is largely about the role of science and technology in meeting sustainable development goals. Many of its recommendations are about mobilising and directing science and technology to solve problems associated with energy deficiency,

5. See, for example, Advisory Council on Science and Technology (2000); also see C. Wagner *et al.* (2000).

food insecurity, environmental degradation, diseases, water insecurity and many other sustainable development challenges.

There is increasing recognition and articulation of the role of co-operation in fostering the application of science and technology for sustainable development. Scientific and technological development is a learning process that is largely achieved by countries through co-operative or collaborative efforts of sharing experiences, information, infrastructure and human or financial resources. The ability of countries and firms to innovate is largely determined by strategic alliances forged both within industry and across sectors. Furthermore, for industrial firms to become successful in generating innovation, they often have to create partnership with public R&D institutions. This is clearly manifest in such fields as biotechnology.

Co-operation in science and technology can take various forms, including joint science projects, sharing of information, conferences, building and sharing joint laboratories, setting common standards for R&D, and exchange of expertise. Its advantages for developing countries, particularly those of Africa include:

- Access to new knowledge, foreign skills and training opportunities.
- Access to large and often expensive research facilities.
- Avoiding the costs of duplication of research.
- Enrichment of political and social relations between countries.
- Opportunities to establish multidisciplinary research activities and teams.
- Favourable basis for international funding.
- Building or strengthening domestic R&D institutions.

In addition to multilateral instruments, many countries have exchanged a number of bilateral science and technology co-operation agreements including Egypt, South Africa, Nigeria and Kenya. South Africa alone has entered into bilateral co-operation agreements with at least seven African countries, the European Union, Poland, the United States, France, Germany, United Kingdom, Belgium, Hungary, Italy, Norway, India and several other countries. To implement its agreement with the EU, South Africa established a special fund to enhance existing co-operation in the fields of biotechnology, new materials, information and communication technology, environmental management, rural development, and urban renewal.

Most African countries recognise that international co-operation in science and technology does matter. However, there is little evidence that many have instituted specific programmes and institutional arrangements to implement the provisions of the agreements. Some of the reasons for this are:

- Inadequate financial resources.
- Lack of explicit linkages between science and technology policies and foreign policies.
- Weak capacity to effectively negotiate and monitor implementation of co-operation agreements.
- Weak national science and technology systems.

For African countries to achieve high levels of scientific and technological development to enhance economic growth and environmental sustainability, reduce poverty and improve health, they need to place increased emphasis on pursuing science and technology in regional and international contexts. National approaches isolated from regional and international programmes will not provide opportunities to benefit from the globalisation of science and innovation. Increased regional co-operation can facilitate access to scientific and technological advances that are made in other regions of the world. A large portion of all scientific articles and patents are generated outside Africa. Most African countries do not have the necessary research facilities in such areas as genomics since these tend to be relatively expensive. International and regional collaboration is necessary in order to enable Africa to access such facilities. For this, Africa needs world-class researchers who collaborate with the best scientists around the world. The challenge is for the continent to invest in creating a cadre of scientists that will be able to peer with developed country scientists on specific international projects.

From policy intentions to practice: illustrative cases

Agricultural research and technology development

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is a non-political organisation of the National Agricultural Research Institutes (NARIs) of ten countries: Burundi, D.R. Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda. It aims at increasing the efficiency of agricultural research in the region so as to facilitate economic growth, food security and export competitiveness through productive and sustainable agriculture. This regional association was built on positive experiences of regional collaboration in achieving economies of scale and facilitating technology spillovers across national boundaries.

ASARECA was established, following the approval of the “Framework for Action for Agricultural Research in Eastern and Central Africa”. This had three broad objectives: to improve the relevance, quality and cost-effectiveness of agricultural research; to establish and support regional mechanisms to reinforce and improve research collaboration among the National Agricultural Research Systems; and to improve the delivery of new appropriate information and technology.

ASARECA carries out its activities through regional research networks, programmes and projects. Twelve of these are currently operational with seven due to begin soon. However, before ASARECA came into existence, there was already some collaborative research within the region which was brought under the ambit of ASARECA. These are the research networks on potato and sweet potato, agro-forestry, root crops, and beans. The second-generation networks on banana, post-harvest processing, animal agriculture, maize and wheat, highlands, technology transfer, agricultural policy analysis, and electronic connectivity were established in 1990s.

African laser technology

Initially designed for a few countries, African Laser Technology Centre (ALC) has acquired a continental outlook. The vision of the ALC is to “Boost Africa into the forefront of science and technology.” Its mission states: “Enable African nations to collaborate with each other and internationally to play a major role in utilising light to advance science and technology, thereby contributing to the strengthening of their economies, their global competitiveness, education and welfare of their people. This co-operation will take place in the spirit of NEPAD and an African Union."[6]

The ALC is a virtual centre of excellence for the African continent. It has been designed as an open non-exclusive partnership to stimulate innovation, research and technology development in lasers and their application. The ALC is actively promoting collaboration among laser researchers throughout Africa and between African laser institutions (see Table 3.1) and their international counterparts. One novel aspect of the ALC is its reliance on African governments that are hosting the facilities as the main sources of funding.

Table 3.1. African Laser Technology Centre (ALC) facilities

Facility	City and country	Field of Specialisation
National Laser Centre	Pretoria, South Africa	Manufacturing, Machining, and Materials Processing
University of Cheikh Anta Diop	Dakar, Senegal	Atomic and Molecular Physics and Laser Spectroscopy and Processing
Laser and Fibre Optics Centre	Cape Coast, Ghana	Agricultural and Environmental Science
National Institute of Laser Enhanced Science	Cairo, Egypt	Medical and Biological Applications of Lasers
Tunis el Manar University	Tunis, Tunisia	Plant and Environmental Science and Molecular Spectroscopy
Advanced Technologies Development Centre	Algiers, Algeria	Laser Spectroscopy and Surface Studies

Regionalism for renewed focus on science and technology

Africa entered this millennium with renewed determination to secure sustainable development. After many decades of economic and social marginalisation, political instability and conflicts, the continent and its people are now more than ever determined to eradicate poverty and be fully integrated into the global knowledge economy. Their leaders have set ambitious sustainable development goals embodied in a new framework: the New Partnership for Africa's Development (NEPAD).

The creation and evolution of NEPAD is a clear manifestation of the determination of African leaders to institute measures to increase agricultural production and food security, stem environmental degradation, improve infrastructure and communication, fight disease, end conflicts, and increase industrial production. African leaders have also subscribed to the United Nations Millennium Development Goals (MDGs). Realising NEPAD goals and the MDGs will require science and technology. Indeed science and technology play a central role in meeting human development needs while maintaining the integrity of the natural environment. The gap between poor and rich countries in terms of real income is largely accounted for by differences in the accumulation and utilisation of science and technology. Closing this gap will require deliberate measures to build scientific and technological capabilities in the poor countries.

In the past, African countries have not done much to harness science and technology for their development, due largely to the following factors. *First*, in most countries the links between science enterprises and political institutions are weak. Political organisations have not accorded science and technology much attention in their manifestos and parliamentary activities. Technological change is a complex process that is influenced by many political factors, and to manage this process, countries require the support of high-

6. *www.csir.co.za*

level political institutions. These institutions often determine the nature and levels of resources that go into public research and development activities and the overall governance of science and innovation. There is a need to build strong political constituencies for science and technology development in Africa.

Second, most African countries formulated their science and technology policies in the 1970s and 1980s when priority was placed on organisational aspects rather than programmatic issues. Countries have been preoccupied with the creation of commissions or secretariats to promote science and technology, and have paid little attention to long-term programmatic aspects of science and technology development. These commissions and secretariats never really built the necessary programmes to anticipate and respond to emerging scientific and technological developments.

Third, African countries have devoted considerably low, and in many cases declining, funding to research and development (R&D) reflecting the low priority that countries have given to science and technology. Most of them spend less than 0.5% of their gross domestic product (GDP) on R&D. This is so despite the declaration in the Lagos Plan of Action and in national science and technology policies that each country would allocate at least 1% of its GDP to R&D. In agriculture, R&D funding has declined to the extent that the region's ability to achieve and sustain food security is being impaired.

Fourth, there is declining quality of science and engineering education at all levels in Africa. Student enrolment in science and engineering subjects at primary, secondary and tertiary levels is also falling. These developments undermine the continent's aspiration to build up its numbers of scientists, engineers and technicians.

Fifth, the number of African scientists and technicians leaving the continent for employment abroad is growing. This 'brain drain' is caused by a variety of factors including poor research infrastructure and remuneration packages. While other regions, *e.g.* Asia, have developed and adopted strategies to mobilise and utilise their diasporas, Africa lacks such measures. It needs to design ways to tap and use the enormous scientific and technical talents of Africans abroad for its own scientific and technological development.

Sixth, African countries need to strengthen and/or build institutions dedicated to scientific and technological innovation. In fact, R&D institutions in many countries are getting weaker. Most countries have not organised their institutions in such ways as to efficiently mobilise their scarce financial and human resources. They tend to spread their resources thinly across the institutional terrain. The region has a whole has not been able to grow 'centres of excellence' in such areas as biotechnology, space science and information and communication technologies (ICTs).

Seventh, links between public R&D institutions and industry are generally weak. Research results of public R&D do not often get accessed and used by local industries, particularly small and medium-sized enterprises (SMEs) despite most African industrial policies of putting emphasis on building and strengthening SMEs. Thus, there is mismatch between R&D activities and national industrial development goals and strategies

Sources of optimism and action

African policy-makers and politicians recognise that the barriers to the continent's scientific and technological development need to be removed if NEPAD goals are to be realised. They have embarked on a collective effort to establish foundations for science and technology at the first NEPAD ministerial conference on science and technology in November 2003 through specific commitments and actions.

First, the African Ministerial Council for Science and Technology was established. This high-level forum has started to critically examine and dialogue on emerging science and technology questions and their implications for Africa's sustainable development. It provides policy and political guidance on the development and application of science and technology in Africa.

The second major set of actions is the creation and strengthening of networks of centres of excellence in science and innovation. In addition to the ALC, African countries have launched the NEPAD Biosciences Network. This is a new initiative to support African countries to develop and apply bioscience research expertise to produce technologies that help poor farmers to improve agricultural productivity. NEPAD has been instrumental in mobilising resources to upgrade and network world-class laboratories in East and Central Africa. The initiative, Biosciences East and Central Africa (BECA), was launched because of the need in biosciences research for a critical mass of infrastructure, equipment, services, and support technicians to provide an environment conducive to high quality research. There was a lack of such facilities in the sub-region and since it was not realistic to develop individual national institutions with such capacities; thus leading to the concept of a strong shared hub.

In subsequent deliberations spearheaded by NEPAD, it was recognised that for the hub to produce research outputs with impact on development, laboratories with complementary capacities to transform research results into concrete products was required. The network concept was thus seen as composed of a hub, nodes and a broader set of members. The nodes would provide certain services to other members and receive certain critical investments to make them effective in their specific service. BECA is an investment to enable the region to do strategic research that addresses poverty. The laboratories are being dedicated to research and innovation in such areas as genomics and proteomics.

In addition to the above efforts, African countries have also committed themselves to improve science, technology and innovation policies. Specific actions include the establishment an advisory panel on biotechnology, working group to design common African indicators or benchmarks to assess the status of science and technology, and a task force to promote African women's engagement or participation in science and engineering. The countries have also committed themselves to increase their national annual public expenditure on R&D to at least 1% of their Gross Domestic Product (GDP). These efforts will be bolstered with the proposed establishment of a continental financial mechanism for regional research and innovation programmes. There are now concerted efforts to promote science and technology in Africa. Its leadership has pronounced commitment to ensure that science and technology are harnessed and applied to promote human development and the continent's integration into the global economy. What is need are measures to sustain and enlarge these developments.

Strengthening science and technology focus in regionalism

One of the reasons that the African aspirations to use regionalism for technology development have not materialised is the lack of institutionalisation of science and technology programmes into Regional Economic Communities (RECs). Such bodies as SADC, ECOWAS and EAC do not have offices or departments dedicated to science and technology matters. To enable them to build capacity for science and technology, NEPAD has facilitated the organisation of regional workshops that have identified concrete projects and programmes. A key outcome of these workshops is the establishment of science desks in each of the RECs in Africa. NEPAD plans to mobilise and provide resources for the establishment and sustenance of the Science Desks.

Another important factor is regional leadership. Technology is crucial to increase the region's economic productivity and political stability. African leaders need to put more emphasis on the role of technology in national and regional development. Establishing a culture committed to technological innovation and development requires political leadership. Examples of Asian industrialisation show that political leaders are crucial to establish and sustain a national vision of a technology-led development strategy.[7] NEPAD is starting to play a major role of building national political leadership for technological development in Africa. However, to effectively play that role, it will require support in terms of policy research and analysis. The United Nations agencies and international universities as well as regional centres such as the African Technology Policy Studies Network (ATPS) and the African Centre for Technology Studies (ACTS) can support NEPAD in this.

7. See Anyang' Nyongo and Coughlin (1991).

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Chapter 4

ELEMENTS OF EFFECTIVE TECHNOLOGY TRANSFER AND STIMULATING ENTREPRENEURSHIP

by
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Introduction

Innovation and technology transfer are issues which receive considerable attention from business. Technological innovation, dissemination and adaptation are essential elements of many sustainable development goals. Business and industry are a primary source of innovation and provide optimum benefits when short- and long-term enabling frameworks encourage the development, commercialisation and dissemination of technologies. Business does not do this in isolation and they form partnerships with a variety of other players and thus leverage resources and benefits. Business, also by developing and commercialising technologies, creates new markets, promotes small and medium-sized enterprises (SMEs) and transfers knowledge and builds capacity.

The process of transferring technology is not however without its problems. Some of the barriers to technology transfer are as follows:

- Technology developers/owners are not necessarily good commercialisers/marketers.
- Those needing the technology may not have the capacity to search and negotiate or even absorb/adapt the technology.
- Firms are ignorant about the consequences of the effects.
- There can be a reluctance to change.
- Low foreign investments coupled to technology investments.
- Government barriers (regulations) to technology transfer (import and export).
- No or little incentives/deterrence.
- Low public awareness/public pressure.
- Existing asset base.
- Existing technology and infrastructure base.

A critical set of circumstances also needs to be in place for the successful transfer of technology and these include:

- The technology must be needs-driven.
- The technology must be adaptable to local conditions.
- Life cycle management is essential to ensure sustainability.
- Ownership.
- Appropriate technology.
- Support infrastructure is required.
- Alignment with skills base and local capacity.
- Full cost accounting.

Thus the issue is a complex one and requires a complex and multifaceted response. The issues have been addressed in many ways by businesses across the world. One example of this is the World Business Council for Sustainable Development (WBCSD) project on Sustainable Livelihoods.

Sustainable livelihoods project of the World Business Council for Sustainable Development

The concept of doing business with the poor and in fledgling markets calls companies to think beyond conventional wisdom. Thus the WBCSD initiated a project called Sustainable Livelihoods as it was felt that WBCSD members and regional partners can and should be on the front lines of efforts to bring the poor into the market, thereby alleviating poverty and increasing prosperity and opportunity for all. The role of business in this issue was also recognised by Kofi Annan, the Secretary-General of the United Nations, when he said *"There are many positive ways for business to make a difference in the lives of the poor – not through philanthropy, though that is also very important, but through initiatives that, over time, will help to build new markets."*

How to develop and engage in these business opportunities and "**do well by doing good**", is what the WBCSD Sustainable Livelihoods Project attempts to address. The 'blended values' approach is an approach in which social and financial values are blended and has to do with doing business within the norms, laws, and expectations of society.

Business cannot succeed in a society that fails – and a planet of over four billion poor people looks much like a failing global society. Thus business needs to seek out new markets and framework conditions in many developing countries. Communications are faster and cheaper, making the world a smaller place and public expectations of corporations are changing. In addition, new, and better, partners are available and aid and investment are beginning to reinforce one another.

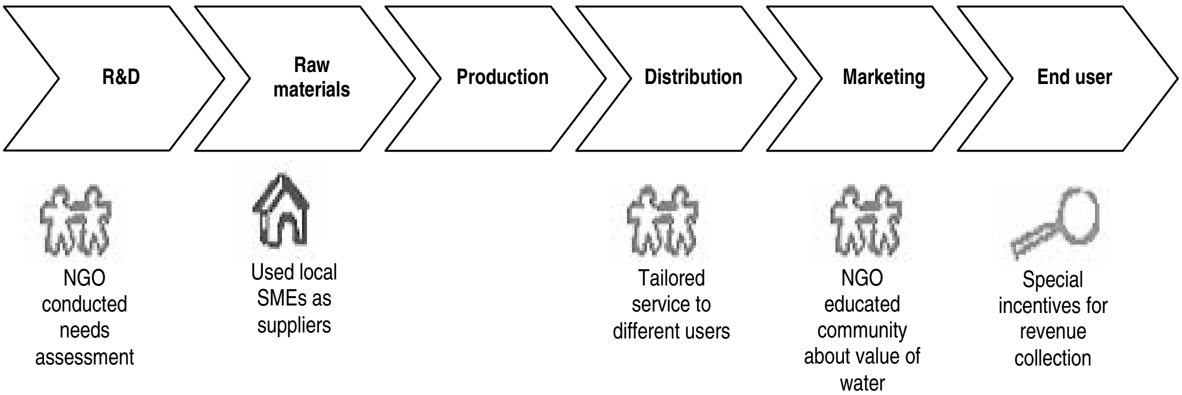
The benefits for companies and communities of this business approach have been identified by the WBCSD as detailed in Table 4.1.

Table 4.1. Benefits for companies and communities

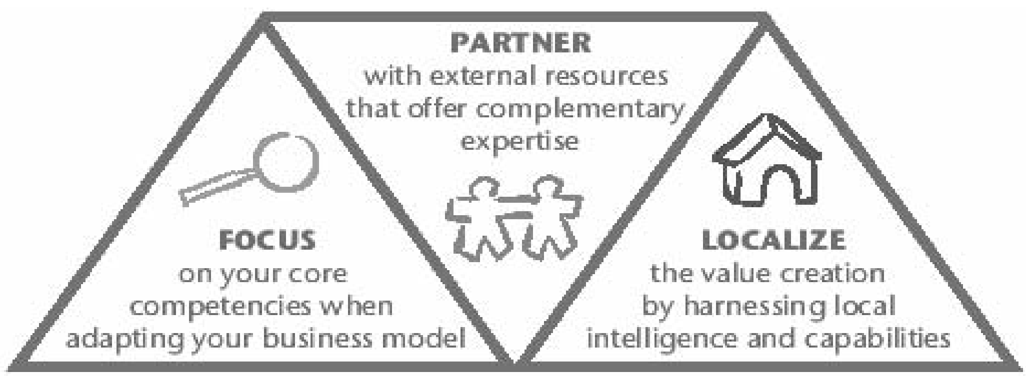
The poor as a resource pool		Poor communities as consumers	
Business benefits	**Community benefits**	**Business benefits**	**Community benefits**
• Reduced labour costs • Shared risk • Local knowledge and capabilities • Better government relations •Fair trade branding	• Job creation • Capability building for local SMEs • Know-how and technology transfer • Improved business environment and investment climate	• New markets, revenue growth • Increased brand value, positioning to capture future market growth • Transfer product innovations to existing markets	• Greater access to quality products and services • Lower prices • Improved quality of life • Improved productivity

This work identified that innovation and technology transfer play a key role in realising the benefits of this approach to both the community and business. Capacity building was also identified as an important issue.

The WBCSD Sustainable Livelihoods project also looked at the value chain and where innovation could play a role in maximising benefits as detailed in the following diagram.



The key areas identified by the WBCSD for successful sustainable livelihoods businesses are described in the diagram below.



Another important consideration in the development of new business markets is that of partnering with other businesses with some shared objectives. The advantages of this type of approach were identified by the WBCSD as follows:

- Cost reduction: shared market research, joint distribution and/or billing.
- Revenue enhancement: complimentary products, promotion of economic development.
- Access to capital: shared contacts and knowledge, some funding explicitly supports business linkages.
- Technological and product innovation: mutual benefits from combining different perspectives, joint development activities.

Again, innovation and technological aspects were identified as being important.

As part of the Sustainable Livelihoods project, the field guide which was developed was "road tested" in various ways. One of these was a joint workshop held between the WBCSD, the National Business Initiative (WBCSD's regional network partner in South Africa) and Eskom. Many issues were explored, in particular, the role of SMEs, a key issue for South African business. Some of the focus areas were identified as follows:

- Understanding the informal versus the formal sectors of the economy.
- The identification of clear targets in order to focus effort.
- To build capacity within the SME sector that currently lacks the business skills required to meet big business' expectations.
- Identifying appropriate partners.
- Defining the business case and accessing funding.

Case study – efficient lighting initiative of Eskom

One case study which encompasses many of the issues detailed above and highlights how innovation, technology transfer and capacity building can be leveraged to meet sustainable development goals, is the Efficient Lighting Initiative.

South Africa's marked economic growth in recent years has propelled electricity peak demand to rise at around 4% a year in a high growth scenario (Eskom Integrated Strategic Electricity Plan). Consequently, unless something is done, by 2007 peak-period demand will exceed Eskom's ability to supply electricity during these periods, and by 2010 additional base load capacity will be required. Thus, Eskom is addressing this challenge by the expansion of supply options, return to services programme of three mothballed power stations and the Demand Side Management (DSM) programme.

DSM allows Eskom to influence electricity usage patterns of consumers. Eskom is implementing DSM in South Africa through collaboration with the Department of Minerals and Energy (DME) and the National Electricity Regulator (NER). Eskom's DSM strategy comprises a dual approach: to reduce electricity demand at peak periods (07:00-10:00 and 18:00-20:00) by shifting load to off-peak periods and by overall electricity consumption reduction (24-hour reduction) by installing energy efficient equipment and optimising industrial processes. Sustainable DSM projects often involve a combination of both methods.

From small beginnings in 1991, starting with research, pilot studies and time-of-use tariffs, Eskom's DSM programme has grown into a concerted national electricity-saving effort officially initiated in the last quarter of 2002.

The 1999 launch of the local efficient lighting initiative called Bonesa was among the major milestones in the early phase of DSM in South Africa. This was jointly funded by the Global Environment Facility and Eskom over a period of three years. Now the use of compact fluorescent lamps (CFLs) through customer education, advertising and marketing is being promoted. The focus is to lower the price of energy efficient globes. The CFLs were originally priced between ZAR 60 and R80 per lamp and in 2004 the price for CFLs dropped to between ZAR 13 and ZAR 20 due to joint sales promotions with local suppliers and increased volumes of CFLs.

In September 2002 the DSM Fund was approved and 2003 was spent mainly on setting up the DSM business model and operations, customer awareness and education campaigns as well as the establishment of Energy Services Company (ESCo) industry. DSM aims to achieve a market-driven business environment by 2007.

Conclusions

Innovation, technology transfer and capacity building are critical components in developing new markets and stimulating entrepreneurship. The correct enabling frameworks need to be put in place in order to facilitate innovation and technology transfer to minimise barriers as much as possible. Partnerships have also been identified as key enablers for successful progress in this area. There are many examples of where this has been successfully implemented and the future challenge will be to replicate those successes and increase the benefits to the developing countries.

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Chapter 5

EFFECTIVE TECHNOLOGY TRANSFER AND STIMULATING ENTREPRENEURSHIP: STRATEGY AND EXAMPLES

by
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Introduction

The business environment will be determined for about the next 30 years by "global megatrends" in the economic, environmental and social aspects of sustainability. Global megatrends include the increasing speed of innovation, the scarcity of natural resources and the explosion of the world's population. These developments lead to changes in markets, technologies and the relevant regulatory environment. The challenge is to identify future value drivers for our business and to assess in what ways they are influenced by the global megatrends. An objective is the long-range optimisation of our portfolio, and meeting the challenges needs to be accompanied by the strategic alignment of the enterprise.

Industry challenges: identifying the impact on value drivers

To successfully move towards sustainable development, we have to address the global megatrends. Our reaction, as well as value drivers, are triggered by responses to the following questions:

- What are Bayer's fields of expertise?
- Where is Bayer outperforming the market?

The focus of Bayer's attention is "to make life better" by using our expertise in the core business areas of health care, crop science and material science. Our business model is based on improving the quality of life in the areas that are undergoing significant changes and consequently facing material challenges. Consider, for example, the mega-trends of population growth or the scarcity of natural resources.

Structure and values of the Bayer Group

Bayer is a global enterprise with core competencies in the fields of health care, nutrition and high-technology materials. Our products are designed to benefit people and improve their quality of life. At the same time we want to create value through innovation, growth and improved earning power. Bayer is now organised as a management holding company. The strategic management from the Bayer Group is kept separate from everyday business activities. The subgroups and service companies operate independently under the leadership of the management holding company, Bayer AG, which defines the common values, goals and strategies for the entire company. The Corporate Center supports the Group Management Board in its tasks and performs certain common functions for the subgroups. The subgroups of health care, crop science, and material science are supported by three service companies.

Bayer is focusing on innovation and growth in these three core areas. We underscore our willingness as an inventor company to help shape the future and our determination to come up with innovations that benefit humankind. Expressing this spirit, we developed common values and leadership principles that form the basis for our day-to-day activities. These may be summarised as:

- A will to succeed.
- A passion for our stakeholders.
- Integrity, openness and honesty.
- Respect for people and nature.
- Sustainability for our actions.

At the end of 2005, Bayer employed 93 700 people worldwide in more than 170 countries and on over 300 sites. Because our manifold activities in both production and marketing interact between society, animals and the environment, Bayer senses a responsibility for the society at large.

Co-operation through business activities

Business activities to benefit people may be classified in three categories, each of equal importance, but they need to be implemented to different extents in different regions in light of local circumstances.

Regular business activities

The effect of foreign direct investment must not be underestimated. Bayer creates jobs not only at its own sites but also in the supply chain and at service providers as well, thus contributing to increased income through the extension of markets. People gain access to products that contribute to an improved standard of living. For example, we employ about 8 000 people in Latin America and Mexico, 4 000 people in India and 2 000 people in China. Foreign direct investment can only be carried out if there is already an infrastructure and a basic market in place. This is a way forward mainly for the emerging economies.

Future business activities

In doing regular business today in our core activities, we must not neglect innovation as a basic driving force for improving the quality of human life. We carefully investigate global megatrends for future challenges. This is a broad area for co-operation. Population growth as the challenge and biotechnology as the innovative solution is a prominent example. But this research-based approach only works in countries with an infrastructure for conducting research that has developed at least to a certain extent.

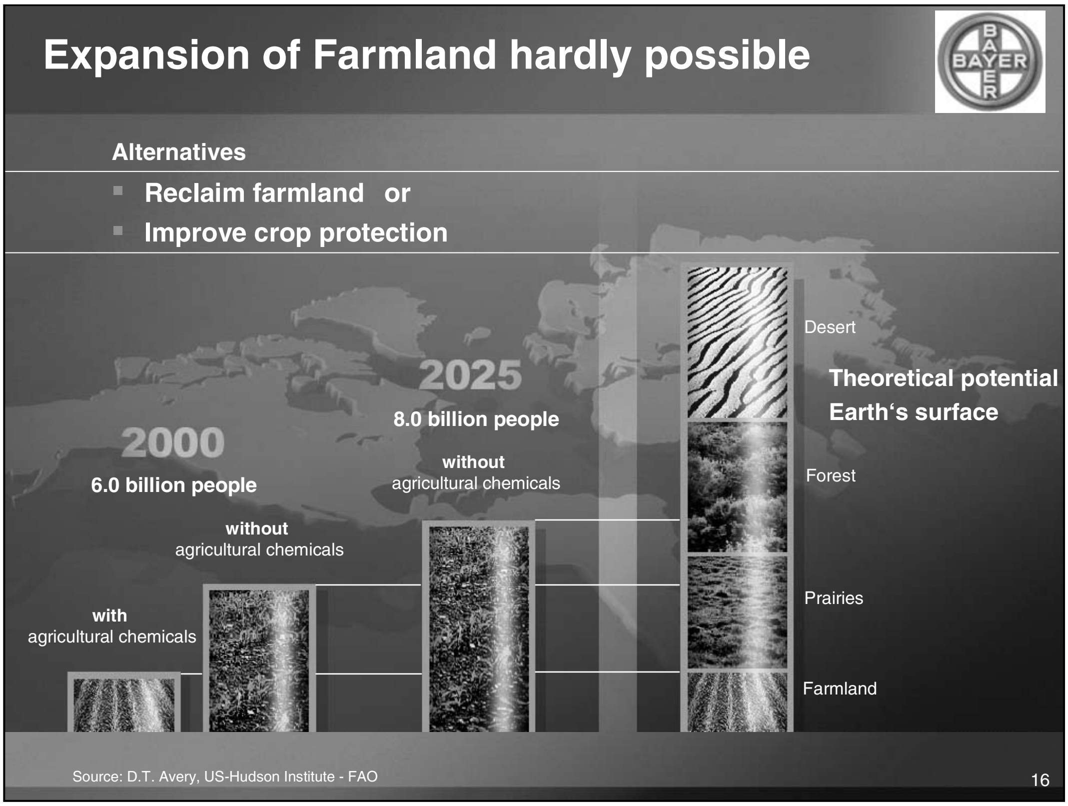
Preparing the ground for future business

How can we proceed in countries with hardly any infrastructure in place? In such cases, Bayer's project strategy is to help build an infrastructure by providing projects in our core business areas. Our project approach will be explained below.

Future challenge – expansion of farmland hardly possible

A very small part of our planet's surface is used as farmland today. Prairies and forests are important ecological compensation surfaces. The biggest part of the earth's surface is desert and therefore not suitable for agricultural use due to its infertility. Without crop protection, available farmland is already insufficient to supply the earth's population with food. And what will we need in 2025 without crop protection? We have the following choice: either we improve crop protection, methods of cultivation and the productivity potential of the agricultural crop plants, or we have to transform prairies and forests into farmland on a large scale in order to supply mankind's nutrition needs. From a practical standpoint, this is not possible and ecologically it is very disadvantageous.

We need a variety of measures to solve the problem: These measures may be categorised in four areas. In addition to irrigation, the use of fertilizers and crop protection, biotechnology is a decisive technology in providing sufficient food for all. We are not only talking about on food supply in the western world. As a global player, Bayer takes the problem seriously on a world-wide basis. It is a social challenge and an ethical one as well.



Investment rationale

Further to this, I want to explain our project strategy mainly used to prepare the ground for future business activities. Bayer focuses its investments in areas where social and economic interests intersect.

There are three types of co-operation to prepare the ground for business:

- Communal engagement (mostly as a regional activity).
- Extending networks, which means forming new networks as well as fostering and maintaining good, co-operative and constructive relationships.
- A global approach, *i.e.* investing in social areas or issues that stand in the way of our business.

More detailed examples are provided below:

Sustainability at Bayer AG

How are we ensuring sustainable growth in the end and fulfilling the expectations of our stakeholders? It is the triad of systems, involvement and innovation.

- Bayer ensures sustainability by implementing a variety of different and effective systems.
- Co-operation with stakeholders means involvement. This is implemented as a leadership principle at Bayer.
- Innovation in creation of new products and careful treatment of resources supports society in shaping a future that is worth living.

With Bayer's products in the core areas we offer our solutions/support to solve outstanding questions concerning the abovementioned megatrends.

An enterprise should not only pay attention to daily share prices to achieve "sustainable success". Precise strategic analysis as well as an analysis of strengths and weaknesses is necessary. A proper portfolio orientation as a result of this analysis is then needed. The development of methods and tools finalises the process. This process has been undertaken at Bayer.

Success criteria for project implementation

It is of paramount importance to interlock the business strategy with the global mega-trends. Partnerships and co-operation are most successful when core knowledge from core business activities is involved. It is of very high importance that partners for co-operation are involved on the basis of equity. A systematic approach supports success.

Chapter 6

THE PERSISTENT BANDWIDTH DIVIDE IN AFRICA: FINDINGS OF THE AFRICAN TERTIARY INSTITUTION CONNECTIVITY STUDY AND LESSONS FOR DEVELOPING KNOWLEDGE INFRASTRUCTURE AND NETWORKS IN AFRICA

by
Robert Hawkins
World Bank

In the knowledge economy, universities around the world are being looked upon to take an increasingly greater role in producing the human resources necessary to help their countries become more competitive globally. Universities face the challenge of preparing the next generation of leaders with the requisite skills to create value and contribute to their societies. Universities also support the academics who are conducting the cutting edge research that will generate the new ideas to propel development. To facilitate this learning, universities also must provide the requisite infrastructure for their students, professors and researchers to engage in research and the development of new knowledge that will keep them at the forefront of innovation.

The Internet continues to be an essential tool for universities to engage in this research and development that is being demanded of them. As collaboration lies at the heart of research, academics and researchers use the network for a myriad of purposes. Every day university students and faculty use the Internet to search for information, to collaborate with colleagues around the world, to access remote laboratories for experiments in chemical engineering or microelectronics for instance, and even to log into radio telescopes to view the stars. As more of these applications and tools become accessible over the Internet, the speed and capacity of the pipes connecting universities together become increasingly important.

Looking back over the history of the Internet, universities have always played a central role in its development. After the Defense Advanced Research Projects Agency (DARPA) developed the ARPANET as the first prototype of the Internet, the next stage of development and popularisation of the Internet took off at the universities. The first ARPANET connections for instance took place between UCLA, the Stanford Research Institute, University of California Santa Barbara, and the University of Utah. By 1970, MIT and Harvard joined the network, followed soon thereafter by Carnegie-Mellon, Case-Western Reserve, University of Illinois and many others.

Similarly, in Africa the first wave of development of the Internet occurred at the universities. Unlike the US and Europe however, African universities did not connect to each other but rather to the existing backbone developed outside the continent. The poor state of telecommunications infrastructure, existing monopolies and unfavourable regulatory regimes can account for much of this slow pace in development, but more than ten years later, African universities still lag far behind counterparts in the rest of the world with regard to Internet connectivity.

In June 2004, the World Bank commissioned a study, "The African Tertiary Institution Connectivity Study (ATICS)" to try to learn more about the current state of African university connectivity. Between August and November 2004, consultants surveyed 83 institutions of higher education in 40 countries across the continent. The objectives of the study were to assess:

- The types of connectivity, bandwidth capacity and costs currently existing at tertiary institutions.
- The existing types of Internet service providers servicing the universities.
- The use of VSAT technologies as the primary choice for connectivity and the various licensing agreements to use the technology.
- The levels of computer infrastructure at the various institutions.
- The degree to which bandwidth is monitored and managed by the network managers.
- The extent to which new ICT initiatives were being planned as well as the degree to which e-learning is being employed at the institutions.

Bandwidth availability

The first finding of the study reveals that the average university in Africa has no more bandwidth than the amount found in a residential connection in Europe or the United States. In the study, the average reported bandwidth for the sample was 537 Kbps up and 769 Kbps down. Needless to say that this quantity of bandwidth serves an academic community of tens of thousands as opposed to the mother, father and 2.2 children found in your average US or European residential home. With this limited amount of bandwidth, the study also shows that university networks are used at almost full capacity with large demand for the scarce connectivity at most institutions. For instance, the average percentage of time where links were at 100% capacity is over 60% of the time which is an extremely high figure given that the measurement covers a 24 hour time period every day of the month.

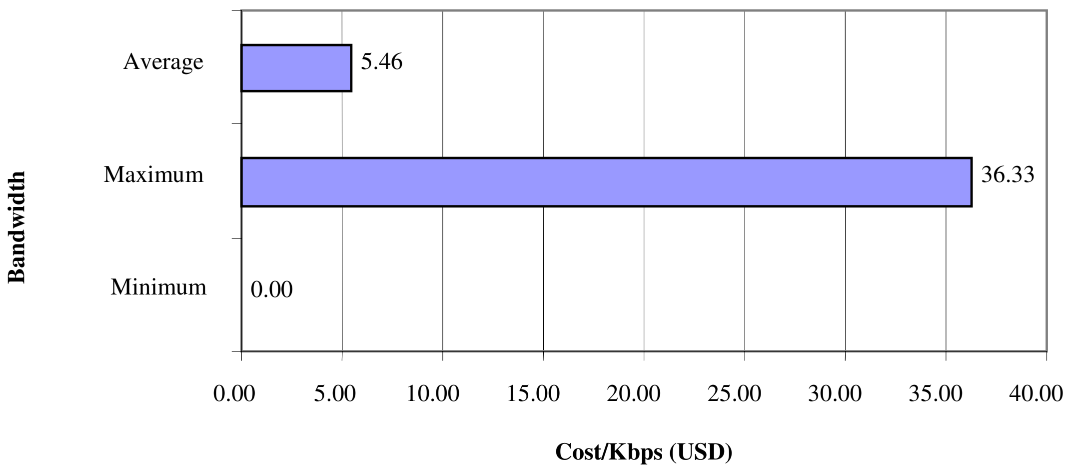
Bandwidth cost

The study reveals that African universities are paying exorbitant costs for their limited bandwidth. On average, African tertiary institutions pay USD 5.46 per Kbps/month, which is roughly the equivalent of 50 times what a typical US university would pay for the same quantity of bandwidth. Analysing regional disparities shows that institutions from West Africa pay the highest amount or about USD 8 per Kbps/month while institutions in North Africa pay the least at USD 0.52 per Kbps/month. The main cause for this disparity in cost is that the North African universities have access to reasonably priced fibre connectivity in the Mediterranean and have also formed a consortium (EUMED Connect) to pool demand and negotiate favourable terms for access to this fibre.

Figure 6.1.

Average cost per Kbps

n=70



Source: ATICS 2004 *(www.atics.info).*

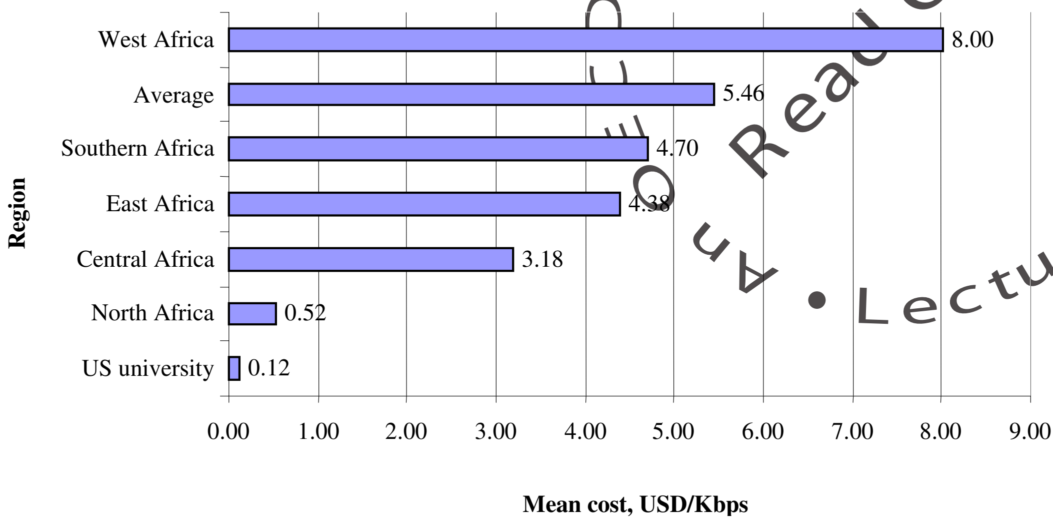
The study also reveals huge disparities within countries with regard to costs of connectivity. For instance, in Botswana, the Botswana College of Agriculture, while being part of the University of Botswana, pays a significantly higher amount for connectivity to the exact same Internet provider – the Botswana Telecommunications Corporation. The University of Botswana pays this provider USD 17 000 for a 1Mb/4Mb wire connection or about USD 3.32 per Kbps/month while the Botswana College of Agriculture pays USD 4 000 for a 128kps wire connection or about USD 15.63 per Kbps/month.

Also, VSAT costs on average tend to be more expensive than land-based connections. Land-based connectivity however ultimately gets access to the international Internet through VSAT and provides much lower levels of quality than the VSAT connections.

The study clearly supports the premise that the greater the volume of bandwidth purchased, the lower the marginal cost that is paid. This finding supports further development of consortia of universities such as the EUMED connect consortium formed in North Africa to aggregate demand and obtain lower costs for all institutions.

Figure 6.2.

Average bandwidth costs (USD per Kbps) by region



Source: ATICS 2004 *(www.atics.info).*

Bandwidth quality

Most of the institutions surveyed (66%) report that they either did not have a committed information rate (CIR) from their provider or did not know what it was. The CIR is a guarantee of a certain amount of bandwidth to the Internet at all times as opposed to sharing a connection with other users which will result in lower throughput when there is a large amount of demand on the provider's connection. The survey also reveals that where the respondent does not know if they have a CIR, they are also paying the most for their bandwidth – resulting in both high costs and low quality. This last point reveals the power of knowledge and information in negotiating for bandwidth quantities and costs.

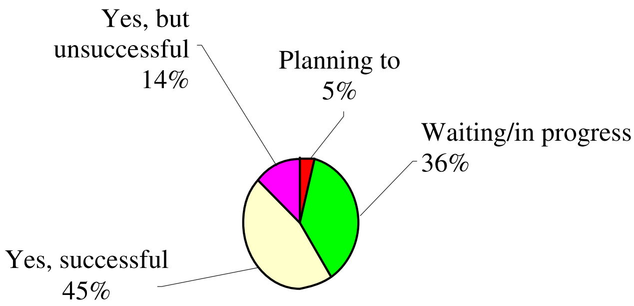
The regulatory environment

The study also investigates the environment under which universities obtain VSAT connectivity. By polling the end users, the study aimed to get a more candid assessment of the regulatory reality in each country. The study shows that only 14 of 52 countries have clearly defined competitive satellite regimes. In this environment, more than half of the universities sampled (55%) had not been able to get a proper VSAT license. However, a majority (58%) of those universities which did own a VSAT, were able to obtain free licenses usually through a waiver as an educational institution. That being said, the average cost of those who did pay for the license was USD 13 553, which is far higher than the EU average of USD 426.

Figure 6.3.

Attempts to obtain VSAT licenses

n=36



Source: ATICS 2004 *(www.atics.info)*.

Computer infrastructure

The survey also examines computer penetration at universities to determine the extent to which bandwidth could potentially be utilised. The survey shows large differences in the levels of computer access among the various institutions. For instance, the highest number of users per computer is 929, while the average across the sample is 55. This figure is still more than 10 times the average at US institutions which have about five users per computer.

The study also examined the level of bandwidth per networked computer. The Sudan University of Science and Technology has the lowest level of connectivity per computer with a miniscule 0.32 kbps average compared with the highest figure of about 37 kbps at the Universite de Bangui which is roughly the equivalent of a dial-up modem connection. It must be noted that the high rate of connectivity per computer in many of the institutions reflects a very low number of computers relative to bandwidth and not necessarily an optimal configuration of computers and connectivity. The average figure across the sample was 3.36 kbps.

Table 6.1. Rankings: Bits per networked computer

University	Country	Bits per networked computer
Top 10 universities		
Université de Bangui	Central African Republic	36 571
Université Catholique de Bukavu	DRC	15 360
University of Hargeisa	Somaliland	10 667
Université du Sahel	Senegal	10 240
Ashesi University	Ghana	10 105
University of Yaoundé II	Cameroon	9 600
Univeristé Libre de Tunis	Tunisia	9 600
Njala University College, University of Sierra Leone	Sierra Leone	8 000
Open University of Sudan	Sudan	7 680
African School of Architecture and Town Planning (West and Central Africa)	Togo	7 467
Bottom 10 universities		
Sokoine University of Agriculture	Tanzania	692
Moi University	Kenya	640
University of Port Elizabeth	South Africa	620
Gondar University	Ethiopia	533
University of Asmara	Eritrea	512
Egerton University	Kenya	512
Université du Benin	Togo	366
Eduardo Mondhlane University	Mozambique	346
University of Zambia	Zambia	320
Sudan University of Science and Technology	Sudan	320

Source: ATICS 2004 *(www.atics.info).*

Bandwidth management

Bandwidth management represents a major area where quick improvements through skills training can be made to improve the cost and quality of university bandwidth in Africa. The majority of the respondents surveyed (59%) report that they do not practice bandwidth management or seldom do. Moreover, while 41% of the respondents indicated that they do monitor bandwidth, only five of the universities could provide basic usage figures such as average bandwidth used which reveals sporadic monitoring at best. In evaluating the manpower needed to monitor and maintain a university network, it is also interesting to note that the survey reveals that VSATs have a higher failure rate with 10.63 hours per month down time than other type of links. Fibre for instance has the lowest rate of failure the only 0.15 hours per month reported.

Policies and strategies

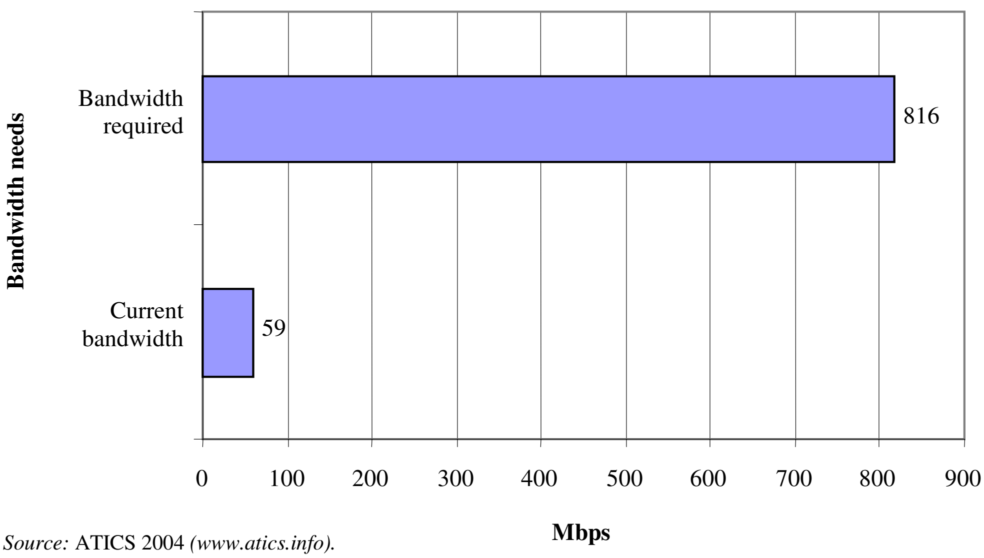
Most universities have not clearly articulated good strategic plans for use of their Internet connectivity. The survey illustrates that while 45% of universities have written an e-learning or ICT strategy for use of broadband connectivity, an almost equal amount or 42% have not. Also clearly lacking among African universities is a collaborative peering strategy with other institutions. Only eight countries in Africa currently have National Educational and Research Networks (NRENs) and only 22% of the institutions surveyed are members of these networks. While US universities are enjoying high speed connectivity at low costs through the collaborative Internet II consortium and European institutions have banded together to form GEANT, most African institutions remain isolated from one another.

Bandwidth requirements

Based on a formula[1] derived by the Partnership for Higher Education, an estimated bandwidth requirement was determined for African universities based on the number of available computers at an institution and an assumption that each computer handles around ten individuals per day. The calculation also estimates that each user would want to download around ten Mb of information per day with information defined as journal articles as opposed to more intensive information sources. With these assumptions, the survey compared current bandwidth with estimated requirements for 73 universities. The outcome calculates that average bandwidth requirements are at least ten times the current usage. This amount of additional bandwidth represents roughly the capacity of five to ten transponders if a VSAT solution were put in place.

Figure 6.4.

Estimated total bandwidth requirements
n=73



Source: ATICS 2004 *(www.atics.info).*

1. 10Mb/day * 8 bits *10 people * No. of networked computers ÷ seconds in 10hrs = Mbps required.

Recommendations

A number of recommendations emerged from this study for improving bandwidth quality, quantity and cost at African universities. The first recommendation is that universities in Africa need to do more to collaborate and form bandwidth buying consortia. It makes no sense for each university to negotiate its own bandwidth deals particularly as marginal costs decrease as volume increases. The study estimated that through the formation of consortia and the pooling of their demand, African universities could halve the cost of their Internet connectivity. Moreover, the formation of consortia could translate into other services where economies of scale could be exploited. For instance, subscriptions to journals available through digital libraries represent an area where one library servicing a large number of universities makes more sense than each university creating their own. The same logic applies to learning management systems and also to other forms of electronic content such as open courseware and learning objects. In order to define these benefits however, universities also need to develop clear policies and strategies for use and development of their Internet infrastuctrure.

As a first effort to address the high costs of connectivity in Africa, any new consortium of universities should also lobby for a more favourable regulatory environment for enhanced connectivity. This may take the form of waivers for VSAT licenses, concessionary pricing for access to fibre networks, clarity with regard to use of VOIP (voice over Internet protocol) or wireless spread spectrum licensing for connecting disparate campuses.

This form of collaboration could also lead to greater aggregation of expertise across African universities. Facilitating a means for the best African academics to collaborate to create African courses and content to be delivered to the rest of the world is a vision that should be embraced. Connectivity would foster the best minds in Africa to exchange ideas, data and solutions to Africa's challenges. From a practical perspective the aggregation of talent to manage the networks of a number of universities through centralised network management would allow for scarce talent to serve the greatest numbers. Moreover, the collaboration needs to extend beyond the institutions of higher learning to include the private sector, NGOs and other stakeholders.

Access to networked technologies also has the potential to reform teaching and learning in African universities. First, networked technologies are important in developing 21st century skills in learners. The information reasoning, teamwork, cultural understanding, and information literacy skills which are quickly becoming standard skills for participating in a global knowledge economy can be developed through effective use of ICTs. For instance teachers at schools with computer labs are 3.7 times more likely than other teachers to assign independent research and 45 times more likely to assign collaborative work.[2] Moreover, it is shown that the availability of computers and the Internet significantly increases the likelihood that teachers will assign work involving active learning.[3]

2. The Uganda VSAT Rural Connectivity Project Evaluation Report, July 2005.

3. Ibid.

In a world where most of the ideas, research and knowledge exist outside of the borders of a university campus, institutions of higher learning need to be connected and communicating with this outside world. Indeed, networked universities can play an increasingly critical role as engines for growth and development through the generation of ideas and innovations critical for economic development. Universities however need to have the basic infrastructure to facilitate this collaboration. In Africa, universities face a serious handicap with their poor quality and high cost connectivity.

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Chapter 7

DEVELOPING KNOWLEDGE INFRASTRUCTURE AND NETWORKS FOR SUSTAINABLE DEVELOPMENT

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Introduction

Science and technology have undoubtedly become indispensable inputs into a country's economic, social and environmental development and are acknowledged as among the chief drivers of the fast evolving globalisation process. Advances and innovation in science, technology and knowledge gained from these have had profound impacts on the society as a whole and on individual members of the society. Knowledge is a critical input for global change, especially at the national level and has certainly played a crucial role in a country's economic development, particularly so in developed countries.

Nevertheless, in most African countries there is an acute lack of the appreciation of the importance of knowledge to national development. In any case, the countries have limited access to scientific information and knowledge and limited capacity to analyse, process and disseminate information and knowledge. In effect, existing knowledge infrastructure networks in Africa are simply inadequate for the tasks before them. Selected knowledge infrastructures are discussed and suggestions made on how to develop or improve them to enable African countries to better utilise knowledge for sustainable development.

Knowledge infrastructures and networks

I shall take a broad view of knowledge infrastructures or networks and take them to include the following: *i)* schools, colleges, universities and research institutions; *ii)* computer and communications technologies; *iii)* journals and books; *iv)* the media – print, radio and television; and *v)* institutions for data collection and analysis and for information processing and dissemination.

Current situation in Africa

The current situation in Africa with regard to knowledge and information availability and flows is characterised by shortcomings and inherent limitations such as: *i)* limited access to scientific information and knowledge; *ii)* poor knowledge infrastructure and networks; *iii)* limited use of knowledge to help solve emerging problems and to achieve national sustainable development goals; *iv)* inadequate reservoir of expertise in science and technology and in knowledge-based development and management; *v)* limited capacity to analyse, process and disseminate information and knowledge, including the preparation of studies and reports; *vi)* inadequate awareness and appreciation of the importance of scientific knowledge; *vii)* lack of commitment; and *viii)* lack of knowledge policy.

The implications of the current dismal situation in Africa are stark. Developed countries are utilising the benefits of scientific and technological knowledge for their economic and social development. At the same time many developing countries are beginning to show increasing interest in developing and putting in place knowledge-based strategies for their development. Such, however, is not the case for most African countries: their economies are certainly not knowledge driven.

Developing knowledge infrastructures and networks

A number of required actions are discussed below as are other issues requiring attention.

Schools, colleges and universities and research institutions

Schools, colleges and universities and research institutions constitute a crucial knowledge infrastructure and network that must be developed and strengthened; there is also a need to develop in these institutions leadership in the promotion of knowledge management and to improve the knowledge base in the education system. The facilities should be upgraded and modernised so that the students and researchers can keep abreast of the latest developments in science and technology as well as in research and development in these areas.

Often, science is not taught well in schools; and laboratory assignments do not teach critical thinking; neither do they firm up the material taught in class. Many students frequently believe that science and technology are too difficult and are nothing but a database of facts; and that scientists' work is dull, uninteresting, monotonous and slow. Frequently, many students do not see the potential benefits of science or where a particular science or technology fits into the bigger picture. Of critical importance is the need to generate increased interest by students in science and technology so that they pursue the subjects in schools, colleges and universities and choose carriers in these areas. Students should be encouraged at an early stage to pursue studies and training in science and engineering; and to connect what they are studying to the real world. Once they opt for specific areas of study, the approach for instruction should be such as to stimulate and maintain their interest in the subjects.

Teachers are crucial link to achieving this objective. Yet many teachers feel that they are inadequately prepared to teach science. Teachers should be well trained in science and technology subjects and knowledge transfer; programmes for retraining teachers should be developed with the aim of ensuring genuine understanding of the science and technology subject matters; training material should be clearly understandable, reflecting real situations that the teachers are familiar with. At the same time, teachers should be encouraged to be innovative, and thereby to make acquisition of scientific and technical knowledge stimulating.

Journals and books

Learned *journals* have had and will continue to have a critical role to play in the flow of science and technology knowledge and as an invaluable vehicle for generating awareness of science and technology issues and problems. In general, the issue is not the paucity of journals in specific areas of science and technology but rather the message and content in many of them. In most African countries the issue of access is, however, not a trivial one. This is exemplified by the near or complete absence of these journals in the libraries even in the national universities. Many of these institutions also lack or have inadequate electronic access to the journals. Help in this area would be required in the form of additional resources, not only to improve access to journals and books, but also to train library personnel in the latest advances in library science.

Many *books* have been written on a staggering range of topics in science and technology, by the specialists themselves as well as by others knowledgeable on the subjects. Some of these books are aimed at a wide audience, the general reader, the experienced scientist in his chosen field who may not have the time to follow many of the developments in other areas. As is the case with journals, access to books in African countries is limited thus constraining the flow of knowledge to those who need it and stand to benefit the most from it. Here again, there is an urgent need for action to ensure the flow of knowledge through books.

Media (Print press, radio and television)

Many *newspapers* have over the years created sections on science and technology to provide information on the latest developments in these fields in a readable and stimulating manner. The information is widely disseminated and constitutes a valuable means of popularising science and technology and transfer of knowledge. This development has caught on in a number of newspapers in Africa, where local and international reporters have made praiseworthy contributions. The effort should be expanded: the quality of reportage in existing sections should be improved and more of such coverage provided on a regular basis.

Radio reaches far and wide and has spread to almost every corner of the countries in Africa. When used innovatively it can be an effective medium and tool in diffusing information and knowledge on a wide range of topics on science and technology. Nevertheless, not all schools are covered and more effort is required to reach that goal.

In the developed countries, *television* is the major medium for scientific and technological information and knowledge transfer. Many countries have good programmes on science and technology; some indeed have channels that are devoted to specific topics on science and technology; a few of these pieces are gradually finding their way to television programmes in African countries. But in Africa television is still a luxury; only a small fraction of inhabitants of large urban areas have access to it; those in many other areas are without it. In order for them to make the desired impact of generating public awareness on a wide scale, the number and frequency of television programmes in science and technology must be increased manifold.

Information and communications technologies

Telephones have for many years been a good medium of communication but whose infrastructure is still very poor in Africa. The availability of land lines has a direct impact on the development of the Internet: high availability portends good internet service and low availability leads to poor internet service. The landlines are inadequate for most purposes and have stagnated as a result of poor policy and lack of direction. All these shortcomings must be addressed to improve the quality of knowledge transfer.

Cell phones have transformed telecommunications beyond recognition. There is, however, need to increase connectivity between the different operators within a country; in a number of cases the charges for talking between the two operators is rendered unnecessarily expensive. The same is the case for connection between a cell phone provider and land lines.

Internet infrastructure in many African countries is meagre or absent; consequently, it takes a long time to send messages. Internet access is still unreliable and connectivity pitiable; in particular, access to international communication networks is poor and factor costs high. In many instances the problem is the unreliability or lack of electricity, inadequate number of skilled personnel to maintain the computers, lack of people with expertise to teach the use of computers. There is also the important issue of affordability. All these issues must be addressed in a concerted manner with the overall aim of strengthening or building all the relevant infrastructures to enhance knowledge transfer.

Other issues requiring attention

Enhanced awareness of science and technology

Ignorance of the importance of scientific and technology knowledge by policy and decision makers and the public at large in Africa is widespread. Moreover, the public at large is unconcerned about science and technology. It is of paramount importance that all are concerned. Enhanced awareness increases interest in the subject and leads to improved public support for government policies on, and activities in, these subjects.

Capacity development and institutional strengthening

The lack of or inadequate capacity to access, analyse, process and disseminate and put knowledge to productive use is a major obstacle to the successful development and application of science and technology and for facilitating knowledge and information flows in Africa. The building of capacity of African institutions at the national, sub-regional and regional levels in order to facilitate the implementation of desirable policies and realisation of sustainable development goals should be undertaken as matter of priority. Equally important is the development of human resources in the continent to ensure scientific and technological leadership.

Allocation of resources for scientific and technical research

This is closely related to the development and implementation of policies, discussed below. There is a strong need for governments to acquire and allocate adequate funds for education, research and development and related activities. Governments should institute and put in place required education reforms to improve science education, in primary and secondary schools, universities and other institutions of higher learning. Furthermore, governments should design and compile science and technology curricula and incorporate these into the syllabuses. Multinational corporations and national enterprises have the potential to make major contributions in this endeavour and their active participation should always be encouraged.

Once access to, and flow of, information and knowledge are assured, it is essential to properly manage them to ensure effective use. Studies should be undertaken to identify best knowledge management practices, and under what conditions and circumstances these may be modified to meet the conditions and requirements of different countries. An important dimension of knowledge management involves keeping abreast of the latest development in information and knowledge and constant updating of these. There are also pressing issues of the organisation and management of knowledge transfer between universities, research organisations, on the one hand and industries, on the other. This should be part of the general strategy for facilitating effective diffusion of scientific knowledge infrastructure.

International co-operation

International and multilateral organisations, as well as other bilateral and non-governmental organisations have, over the years, provided resources for capacity building and institutional strengthening and building, including training. They should continue with and expand their activities in these areas.

Co-operation at the regional and international levels should be further strengthened in order to support national efforts by promoting capacity-building and technology transfer investments to Africa. There are also many opportunities for private-public sector co-operation.

Funding and investment

There is a pressing need for massive investments in knowledge infrastructure and networks, including, in particular, those for science and technology as part of a policy framework and strategy. Of critical importance in this respect is the paramount need to create an environment that encourages both domestic and foreign investment. Foreign national organisations, and as noted, international as well as multinational ones have played a worthy role, but their contribution would be enhanced when the countries come up with good proposals.

Improving job opportunities for science and engineering graduates

It is sad to see many science and engineering graduates without jobs in their own countries partly because of the lack of appreciation of their training and worth. Consequently, invaluable resources are wasted and their potential unrealised. This bad experience also generates additional negative images about choosing science or engineering as a career. Strategies must thus be put in place for stimulating the economy of each country thereby creating job opportunities for the graduates so that they may in turn contribute to the country's well being. There should also be transparency in the hiring of qualified graduates.

Development and implementation of policy

At the core of the efforts to strengthen science and technology and facilitate information and knowledge flows is the presence of an effective policy framework. There is a compelling need for each country to formulate such policies which should have clear objectives and goals as part of overall national development strategy. In many cases the policy itself might be very good, but the bottleneck is usually at the implementation stage. The often quoted problems during implementation are inadequate institutions, human and financial resources; and lack of systematic monitoring and evaluation to keep things on track and to ensure that the stated goals and objectives are met.

Governments have a decisive role to play in the formulation and effective implementation of policies. Decision-makers in the private sector, too, have significant responsibilities. Developing and effectively implementing policies demand serious commitment at the political and decision making levels. A decisive ingredient in all this is the political will to take tough decisions for the good of the country. With a better understanding of the nature and extent of scientific and technological developments, of the issues that need to be addressed, of the constraints and of the challenges, a stage would be set for formulating and implementing the right and adequate policies appropriate to the situation at hand.

Conclusion

Science and technology play a key role in achieving sustainable development, and knowledge is a vital input to this end. But in Africa there is an acute lack of the appreciation of the importance of knowledge to national development; besides, existing knowledge infrastructures networks in the continent are largely inadequate.

Nevertheless, with the suggested development, strengthening and general improvement of the knowledge infrastructures and networks, African countries would be better placed to put knowledge to use in their economic and social development. But first and foremost, each country must establish a working and effective policy framework for further development and application the knowledge; such a policy must embrace clear objectives and goals as part of overall national development strategy.

Chapter 8

ASSESSING INTERNATIONAL S&T CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: TOWARDS EVIDENCE-BASED POLICY

by
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Summary

This paper reviews the process of indicator development in the area of science and technology; then, examines existing and proposed means of developing indicators of sustainable development. Suggestions follow for work leading to indicators of international science and technology co-operation for sustainable development which could support evidence-based policy.

Introduction

The Workshop on International Science and Technology Co-operation for Sustainable Development had two objectives. They were to: identify good practices in international science and technology co-operation between OECD and developing countries; and, to consider possible indicators of good practices in international science and technology co-operation for sustainable development and to evaluate international science and technology co-operation initiatives. This paper deals with the second objective.

The second objective has two components: to consider indicators; and, to evaluate initiatives. The paper focuses on the former, while raising some challenges in respect of the latter.

The principal objective of the paper, then, is 'to consider possible indicators of good practices in international S&T co-operation for sustainable development'. This is a complex undertaking as it involves the overlap of three areas: international co-operation; S&T; and not just 'development', but sustainable development. Each area has its own standards, conflicts, and literature, which make it difficult, if not impossible, to advance to the objective of considering possible indicators of good practice in the area of overlap.

1. This paper benefited from discussions with colleagues from the NESTI community and from Statistics Canada, especially Michael Bordt and Rob Smith. The work was supported, in part, by the Canadian International Development Research Centre (IDRC) and the Department of Science and Technology (DST) of the Government of the Republic of South Africa.

Implicit in the objective is an assumption that indicators are, in fact, desirable in order to describe good practice and then to permit evaluation. However, description and evaluation are two quite different uses for indicators.

The description of good practice, its outcome and its impacts, as well as its links to actors in the economic and social system, can inform the making of policy, and its implementation through agreements on trade, licensing, mobility of highly qualified people, or contracts for outsourcing and capacity building. Informing the making of policy and engaging in benchmarking and foresight require many indicators, at a relatively high level of aggregation, which can describe a country or a region and which support comparison across space and time. The need to be comparable over time is necessary if the policy being informed involves targets. An example is the Lisbon target of the measure of resources allocated to the performance of R&D, expressed as a percentage of the GDP.

Evaluation of an activity is more appropriately done at the project level and the process answers a different set of questions: "Are the project resources devoted to achieving the goals of the project?" and, "Are the resources being use effectively and efficiently?" Answering these questions requires an accounting framework, and standards, and it looks backwards in time, not forward, as in a foresight exercise or in benchmarking to determine a present position with a view to moving towards a set of targets in the future. The extensive literature on project evaluation is one of the reasons why it is not pursued here, but this leaves the major challenge of discussing indicators in support of policy development and the implicit assumption that this was a desirable end.

The implicit assumption was challenged in the course of discussion at the workshop with a suggestion that indicators were not needed to inform the policy process (intervention of Calestous Juma[2]). The suggestion was that policy makers where not used to dealing with quantitative measures and that they preferred to tell and to be told stories and, ideally, stories that conveyed powerful metaphors that would engage the audience and lead to action.

Story telling, to effect change, is discussed in the knowledge management literature (Denning, 2000) and it is a very powerful tool. The material for the story, in the context of the workshop, would come from a project involving successful international S&T co-operation for sustainable development with identifiable (not necessarily quantifiable) outcomes and impacts. This suggests that what may be important is the development of a collection of case studies illustrating both successes and failures from which inferences could be drawn, metaphors built and stories told.

Returning to indicators and their use, a central banker or a minister of finance expects to see measures of GDP, interest rates, trade in goods and services, employment rates, their change over time and their comparisons with the same measures in other economies. Stories are not the answer to informed monetary or fiscal policy. How does this picture differ from that being discussed in the papers from the workshop?

The indicators that are produced by the system of national accounts (SNA, 1993) have evolved over the last 70 or 80 years and have gradually entered popular discourse. The same cannot be said for indicators of, for example, sustainable development, or any other indicators with the possible exception of some R&D indicators which have been around for 40 years.

2. See Chapter 2.

In what follows there is a discussion of indicators related to science and technology, sustainable development, and international co-operation before returning to how to move towards the second objective of the workshop.

Indicators

Science and technology

Indicators of activity related to science and technology have been part of the on-going work of the OECD for more than 40 years, and which has given rise to the *Frascati* family of manuals, a list of which can be found in the most recent member, the *Oslo Manual* on innovation (OECD/Eurostat, 2005).

These manuals are overseen and updated by the OECD Working Party of National Experts on Science and Technology Indicators (NESTI) and they cover R&D, invention, innovation and diffusion of technologies and practices, and human resources related to S&T. NESTI works closely with Eurostat, the statistical office of the European Union and two manuals, one on innovation (OECD/Eurostat, 2005) and one on human resources (OECD/Eurostat, 1995) were joint undertakings. There is also co-operation with the UNESCO Institute of Statistics to minimize duplication and respondent burden. Other parts of the OECD, such as the Working Party of Indicators for the Information Society (WPIIS), produce guidelines on measuring the information society (OECD, 2005a) and there is a handbook on globalisation (OECD, 2005b).

Over the years the manuals have moved from measurement of activities, such as R&D and innovation, to measurement of linkages, such as sources of funds, ideas and technologies. This is a step towards measures of outcomes (for example, a change in employment level as a result of innovation), and impacts (behavioural change resulting from the use of mobile telephones is an example).

The on-going evolution of OECD manuals is an important point to make. They are not static, but part of a process. Manual development, or revision, brings together the understanding of data collection and interpretation, and the application of standards, in member countries. The process requires compromise, and commitment to applying the new or revised standards once they are agreed.

The African Union, through the New Partnership for Africa's Development (NEPAD) S&T Secretariat, and the African Conference of Ministers of Science and Technology (AMCOST), is proposing the development of science, technology and innovation indicators in the document, Africa's Science and Technology Consolidated Plan of Action (NEPAD, 2005). This is an important initiative as the indicators, and the Observatory proposed to produce them, will make comparison of science, technology and innovation activities across Africa possible and will allow the African Union and NEPAD to speak with one voice to the OECD, the UN and other organisations involved in indicator development.

Science and technology indicators have a well established approach, a formal means of providing coherence, comparability and quality, and this approach is being adopted by other organisations that have a need to reflect the different circumstances faced by developing countries in the collection and interpretation of data for indicators. For indicators of the activity of sustainable development, the approach is more diffuse.

Sustainable development

If the purpose of 'development' is to have an impact on the economy and society, then impact indicators are needed, but they are not yet well developed. Part of the reason, of course, is that 'impacts' do not just result from one activity at one time, but from many activities at many times and it is difficult, if not impossible, to tie activities and impacts together, except, perhaps, at the project level. If a project is established to improve the drinking water in the community and fewer people die as a result, that may be evidence of a social impact. However, it may also be evidence of better training in food preparation and personal hygiene, suggesting that the establishment of the causal link is not simple.

Indicators for "sustainable development" go beyond indicators of "development", and their uses are still evolving. There is no one organisation that takes the lead on the production of indicators and guidelines for their development and use, and there is a debate on how to approach the question. This debate can be simplified to a question of whether it is preferable to have lists of indicators under descriptive adjectives such as economic, environmental or social, the so called 'three pillar' approach, or whether a systems approach is preferable with environmental stocks and flows and the inclusion and measurement of natural capital as a particular stock.[3]

An example of lists of indicators under headings is provided by the UN Economic and Social Development Indicators[4] which uses four headings: social, environmental, economic, and institutional. Capacity building and the international co-operation of interest to the workshop appear under the Institutional heading while the other two subjects of the workshop, energy and water, appear under the economic and the environmental headings respectively. The lists of indicators can also be mapped to the Millennium Development Goals and to other initiatives, such as the Gates Foundation Grand Challenges for Global Health, in order to develop a more coherent view of their context and application.

There are also sustainable development indicator initiatives in the OECD (Stevens, 2005), Eurostat (2005), non-governmental organisations[5], governmental organisations[6] and, recently, there has been an initiative that may provide sustainable development indicators with the same means of development and acceptance as used for science and technology indicators. In 2003, the OECD Statistics Directorate convened a conference on Measuring Sustainable Development (OECD, 2004) which looked at integrated economic, environmental and social frameworks. This gave rise to the creation of a Working Group of the UN Economic Commission for Europe (ECE) Conference of European Statisticians (CES) which published terms of reference for a Working Group of Statistics for Sustainable Development in November 2005 (CES, 2005). The Working Group is to be jointly supported by the CES and by the Statistics Directorate of the OECD and it will report to the CES and the OECD Annual Meeting of Sustainable Development Experts at the end of its work. This Working Group, chaired by Robert Smith of Statistics Canada, will take on the task of bringing coherence to indicators of sustainable development.

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3. See, for example, the discussion in *Where is the Wealth of Nations?*, World Bank (2006).
4. See *www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/table_4.htm*
5. See *www.iisd.org/measure* as an example.
6. Two examples are Canada *www.ec.gc.ca/susdev_e.html* and the UK *www.sustainable-development.gov.uk*

While this Working Group is a joint CES-OECD initiative, it is an opportunity for OECD observer countries such as South Africa, which has been leading on the discussion of sustainable development practices and indicators, and other interested organisations, such as the NEPAD S&T Secretariat, to seek involvement in what should be a significant and far reaching exercise in consensus building and standard setting.

Co-operation

This paper, so far, has looked at the state of indicator production for science and technology and for sustainable development. The next stage is to look at what can be done to measure international S&T *co-operation* for sustainable development. As in the two previous discussions, the examination will concentrate on just "co-operation" before putting all of the components of the objective together and commenting on that. Co-operation, here, means an activity that involves people from more than one organisation. International co-operation implies either that the actors are separated by a national border, or borders, or that they belong to different international organisations.

The focus will be on measures of direct co-operation rather than attempting to discuss the effect that co-operation in one area may have in another. An indirect example is S&T co-operation to support universal primary education, an MDG, leading to a population better able to implement sustainable development practices. Such considerations are for the future.

Indicators of direct co-operation include measures of co-publication or co-patenting, of human resource mobility across borders, of grants and contracts, including trade in knowledge, technologies, goods and services, and foreign direct investment, both incoming and outgoing. There is much experience of measuring all of these linkage activities. What is missing is "science and technology" on one side and "sustainable development" on the other and that is what presents a serious problem to *the development of indicators of international science and technology co-operation for sustainable development.*

The difficulty of constructing indicators does not mean that the problems have not been studied, but from different aspects, and with different emphasis. Examples can be found in the work of Wagner *et al.* (2001), Maselli, Lys, and Schmid (2005) and Hoekman, Maskus and Saggi (2005).

A possible way to advance on the development of indicators of co-operation is to commit expertise and resources to supporting the CES-OECD initiative to build a consensus around indicators of sustainable development. As this work evolves, and as the indicators are used to support evidence based policy, the move could be made from measures of the activity of sustainable development to measuring linkages, such as international science and technology co-operation for sustainable development.

In parallel with such an initiative, there is a place for case studies, ideally standardised case studies, which can be used to test the concepts and definitions in the field and to provide input to the CES-OECD Working Group. Case studies would also provide, in the short term, the stories of success and best practice which could be used immediately by policy makers. To address the question of international science and technology co-operation for sustainable development, the case studies should include both sustainable development and science and technology perspectives.

These complementary undertakings are resource intensive and complex, as is illustrated in the next section.

Finding indicators

The background and issues paper for the workshop[7] focused on the practice of sustainable development in the areas of energy and water, and not on indicators. However it did include the objective noted at the start of this paper and also the following expected output:

> "Drawing up of possible indicators and criteria of good practices in international science and technology co-operation for sustainable development. Such indicators do not necessarily have to be quantitative, but should include indicators of levels of achievement that international co-operation initiatives should aim for."

To move towards the expected output, participants in the parallel sessions on energy and water were invited to identify a selection of indicators in their areas of expertise. None were found.

On the third day of the workshop a session was added on indicators and about 20 participants engaged in an exercise to design a project involving international science and technology co-operation and sustainable development and then to identify, as part of the design, what would be measured in order to provide quantitative or qualitative indicators which could be used for evaluation or policy development. The exercise, while appearing simple at the outset, proved to be quite difficult. No indicators were proposed.

The discussion in the parallel sessions and the exercise on 23 November 2005 made clear the complexity of the achieving the second objective of the workshop, a point also made by Michael Kahn[8] in these proceedings. The complexity of the task of developing indicators leads to the recommendations which follow in the conclusion.

Conclusion

This paper has looked at the objective of developing indicators *of international science and technology co-operation for sustainable development* by examining the state of indicators for science and technology, sustainable development and for international co-operation. While there is a case for pursuing this course, it should be seen as a long term objective that could form part of the work programme of the newly created Working Group of the Conference of European Statisticians, supported by the OECD.

The difficulty of the task of dealing with sustainable development and, implicitly, international S&T co-operation was noted in a speech made by Rob Adam, the Director General of the South African Department of Science and Technology, which was host to the workshop: "Sustainable development is hard – don't beat yourselves up. It is also complex and harder to reduce to a set of laws which embody the essence, meaning that it's less amenable to a classic physics approach" (Stilwell, 2005). The speech was made at a conference on Physics and Sustainable Development held in Durban just before the workshop.

The development of indicators of international science and technology co-operation for sustainable development would have to begin with work on definitions and classifications. As these developed, they could be tested in a parallel exercise of case studies,

7. See Chapter 1.

8. See Chapter 9.

conducted using an agreed set of questions. The findings from the case studies would then feed back into the more formal indicator development process. However, the case studies would also give rise to insights that could help policy makers in their efforts to propose policies that would reinforce best practices, in both the science and technology and the sustainable development domains.

As the definitions and classifications evolved and converged, guidelines could be produced to support countries and regional organisations in the production of indicators, and case study reports, related to international S&T co-operation for sustainable development. In time, this work would lead to the realisation of the second objective of the workshop.

An outcome of the workshop was to be a paper prepared by DST and tabled for comment at the first 2006 meeting of the OECD Committee for Scientific and Technological Policy before going to the UN Commission on Sustainable Development. This paper has proposed courses of action for consideration as part of that process.

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Chapter 9

ASSESSING INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: ART OF THE STATE

by
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Introduction

As with all other indicator schemes, indicators for international co-operation in science and technology (S&T) for sustainable development (SD), reside in a conceptual framework. A well-known framework takes into account social, technological, economic, environmental and political factors, under the mnemonic STEEP. These factors may be used in turn to examine the processes of change from a systems or other perspective. STEEP may also be supplemented with a factor for values, in which case one refers to STEEPV. Perhaps as we move into the knowledge economy one should leave STEEPV behind and introduce a framework organised under the mnemonic 'KEEP'. KEEP is a verbal noun whose meaning includes to pay due regard to; observe; stand by as well as to celebrate; guard; protect (Box 9.1). These meanings resonate appropriately with the goals of sustainable development.

Box 9.1. An environmental scanning tool for the knowledge economy

K – Knowledge (social, technological, indigenous, tacit)

E – Economic

E – Environment

P – Politics

We shall return to the KEEP factors when we consider the indicators themselves.

Sustainable development

Considerable effort has gone into building a consensus with respect to sustainable development so we shall assume awareness of the prior art including the Millennium Development Goals. To this prior art we may add some contemporary thinking from three sources, namely the *World Development Report* (World Bank, 2005a), *Where is the Wealth of Nations?* (World Bank, 2005b), and the Millennium Project Report (Juma and Yee-Cheong, 2005).

The *World Development Report* concerns itself with the concept of 'Investment Climate' and identifies four major factors that promote or restrict investment, namely:

- Stability and security.
- Regulation and taxation.
- Finance and infrastructure.
- Workers and labour markets.

These are also important in the implementation of interventions for sustainable development. The same report draws attention to the considerable size of the informal economy in low-income states, with a range between 25% and 75% of GDP being attributable to such activity. Were it not for barriers to finance and blockages arising from inefficient and ineffective regulation, the contribution could be even higher. (Of course with access to formal financial services, one might expect migration from the informal to the formal sector). The informal, or second economy is also important to sustainable development.

The second study *Where is the Wealth of Nations?* seeks to construct a single measure that accounts for all the sources of wealth of nations, natural capital, produced capital and intangible capital. As such this quest is of importance to these proceedings. Comparative data are provided for more than 100 nations that allow one to observe some of the different features between low and high-income countries. The low income countries differ from the high income countries in two critical aspects: in the former the share of natural capital stands at 26% while in the latter it is a mere 2%; on the other hand, intangible capital stands at 58% for the low income group and at 80% for the high income group. What this suggests is that the leading difference between these economic groups lies in their natural capital base. This observation must serve to concentrate the discussion on the importance of sustainability.

Finally we turn to the Millennium Project Report*: Innovation and Knowledge*, that seeks to build the intangibles of low–income countries. The five major recommendations of that report argue that emphasis must be given to

- Creation of an enabling policy environment that targets R&D.
- Exploitation of platform (generic) technologies.
- Improvement of infrastructure.
- Revitalisation of higher education in science, engineering, technology.
- Business activities in science, technology and innovation.

The above serve as a context within which to explore science and technology for sustainable development.

National systems of innovation

The construct known as the national system of innovation (NSI) has come to play a leading role in formulations of science and innovation policy (Freeman, 1981; Lundvall, 1985; Nelson, 1993). Since its introduction in the 1980s the 'free' exchange of goods, deregulation of financial markets together with the massive deployment of ICTs, in short the techno-economic paradigm loosely called 'globalisation' has led to significant changes in the way that financial, human, production and intellectual capital operate. This openness raises questions concerning the boundaries that apply to systems of innovation, with some authors questioning whether one can speak of a national system at all since values chains including that for R&D are increasingly distributed across borders. Nonetheless multinationals still conduct most of their R&D on home turf, so we shall in this contribution consider the NSI as a bounded and measurable entity.

In our conception the NSI is the broad collection of institutions for R&D, innovation, human resource development, scientific and technological services, and the legal, financial, intellectual property, cultural, and regulatory frameworks within which these activities occur. It is an interlocking and interacting set of systems, each with institutional norms and values, some of which are highly resistant to change. The aspects of the core institutions that may readily be measured are human resources for S&T and the inputs to R&D (*cf.* OECD *Frascati Manual*). However those charged with such measurement are well aware that even these simple aspects present considerable problems of definition. To take a case in point what counts as 'development' is constantly shifting (see *e.g.* Dodgson, Gann and Salter, 2005).

Since these discussions are being hosted on South African soil it is apposite to note aspects of the local economy (Box 9.2) and the national system of innovation (Box 9.3.)

Box 9.2. South Africa: Socio-economic profile

- 25% of African GDP; 30% SA GDP from Gauteng.
- GDP growth 4.8%; inflation 4.4%.
- GNP/capita PPP USD 11.5k.
- Services 62% of GDP.
- Large state sector; diversified private sector.
- 'Southern' multinationals: net exporter of FDI.
- Gini coefficient 0.59 – two linked economies.
- Unemployment ~ 25%; HIV infections ~ 20%.
- Steady rural-urban migration; 55% urbanised.

Box 9.3. South Africa: NSI profile (2003-2004)

- GERD:GDP = 0.81%; BERD = 56%.
- 55% Gauteng; Prov GERD/GGP ~ 1.3%.
- Catalysis; metallurgy; system development vaccines; telemetry; palaeontology; bioinformatics.
- Agricultural GERD/Agricultural GDP ~ 2.5%.
- 60% African science output; punching beyond weight class; volumes modest but in line with economic level.
- Brain drain, gain and circulation.
- 'Good' gender balance; diversity systemic issue.
- Indigenous Knowledge Systems law; patent law consistency.

What is important to note is the problem of the two (linked) economies – one wealthy and largely European, the other poor and largely African in character. Sustainable development seeks to eliminate if not reduce poverty and its associated negatives, so that the problem of the dual economy must be central to any solution in South Africa, and indeed so for countries that share the phenomenon of two economies in one (and they are many). As the Development Bank of SA notes (DBSA, 2005: 53):

> *So the poor remain poor, because they cannot borrow against future earnings to invest in inputs for production or the accumulation of assets for future production, including education. In the absence of opportunities for engaging in paid employment, they are unable or unwilling to enter into entrepreneurial activities because the costs of failure are too high, they are unable to insure themselves against risks, and they lack information about market opportunities. Finally, although significant improvements have been made in the provision of services, the poor remain deprived of many public goods necessary for entrepreneurial activities (such as property rights, public safety and infrastructure), and incur high costs in time and expense when trying to obtain these goods.*

Furthermore, (ibid. 69) that:

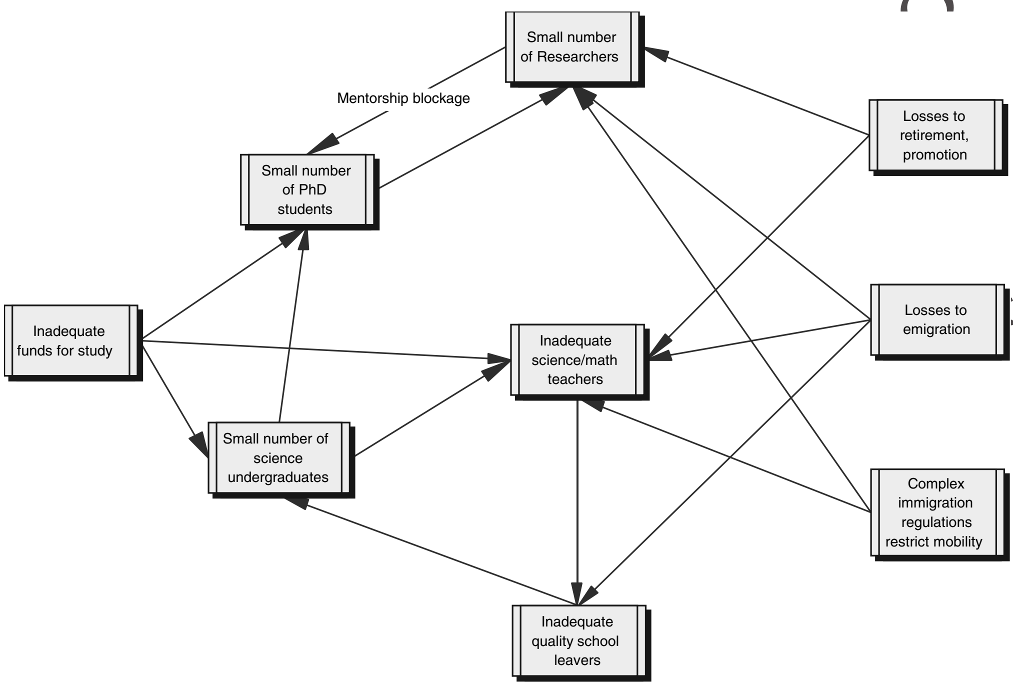
> *Studies also show that growing the agricultural sector is the primary channel for achieving household food security. However, unless agriculture reaches some degree of commercialisation, the impact of agricultural growth on food insecurity and poverty alleviation is limited.*

Two reasons why the experience with agricultural development in other parts of the developing world does not apply without qualification.

- The agricultural sector makes up such a small part of the total economy.
- Rural people generally migrate to urban areas in search of income and jobs, even when the chances of landing a permanent job and receiving a predictable income are minimal.

These perspectives provide a sober assessment of the *problematique* of development –while it is easy to think of grand theories of modernization or dependency, there is a domestic reality that must always be factored in. So a fortune may well exist at the bottom of the pyramid (Prahalad, 2004) but it is local architects that must do the building. And a shortage of such skill plagues all efforts at science-led development. We therefore conclude this section with a short discussion of the issue of high-level human resource development.

Figure 9.1. Human resource development constraints



This schematic summarises the way that a number of vicious cycles conspire together to limit the production of high-level skills for S&T (and R&D). This negative feedback is traceable down to school level where inadequate science (and mathematics) teaching for the majority of students restricts the number who might advance to quality science (and mathematics) teacher education. This in turn places limits on the number of quality school leavers and so on. Similarly in higher education falling numbers of S&T under-graduates translates into falling numbers of postgraduates. Matters are made worse by inappropriate mechanisms for staff retention or foreign recruitment. And it is often the case that government policies on education, remuneration and pensions, labour, and immigration operate at cross-purposes around HRST. Fundamentally the availability of the necessary skilled human resources is a critical success factor in allowing for S&T interventions locally and for there to be any prospect at all of international co-operation.

International co-operation implies the movement of personnel, and for equity reasons this must be multi-directional. Foreign personnel will travel to project sites; local personnel will engage in research and related development activities wherever this makes sense for the co-operative activity. This implies that the mobility of personnel will be an important component of co-operation, and that the risks of permanent migration must be factored in. Mobility in and of itself is necessary for ongoing science and technology development and must be managed, as opposed to being resisted.

International co-operation in science and technology implicitly assumes that national systems of innovation are functional and able not only to absorb S&T activity, but also shape it.

Criteria, assessment, indicators

So what criteria might apply to the construction of useful indicators that measure international co-operation in S&T for SD? For a start one must decide on which area of S&T the interventions are to focus on. In the case of this workshop these are to be Water and Energy. So far so good. Next one would have to specify what change the intervention is to bring about, and then to decide on what measurements are applicable. Before conducting the measurements it will be pertinent to ask whether the observed change arises because of the intervention or in spite of the intervention. In other words, one needs to think counterfactually. Impacts after all have many causes, some of which arise far from the intervention itself.

Even where one can demonstrate that the intervention has had the desired impact it should be a requirement to demonstrate that the intervention is cost-effective. There is always an opportunity cost in entering into agreements for co-operative funding and/or co-operative S&T.

The above discussion highlights some of the complexities that indicator development faces especially where calls are made for locally relevant indicators. It is tempting to argue for the development of locally specific indicators and there may well be certain proxy indicators that are valid in a particular context. These should be employed especially when they make the impact easily visible to decision makers. However internationally agreed definitions and standardization are desirable lest indicators become locked into their own narrow characterisations.

Lastly there must be the assurance that capacity for collection and maintenance of the indicators exists and that there is clarity regarding their dissemination and intended use. A future continental resource such as the African Observatory for Science, Technology and Innovation Indicators (AOSTII), that was given broad approval at the African Ministers Council on Science and Technology meeting in Dakar, Senegal in September 2005, might well fulfil both the role of capacity developer and disseminator.

Measuring KEEP

It was suggested that the components of 'KEEP' might serve as a useful organising scheme for indicator specification. Box 4 therefore provides a tentative list of possible areas for indicator development.

The 'Knowledge' dimension foregrounds human capability recognising another 'three Rs' namely the need to recruit, retain and retrain. These go to the heart of dealing with skills shortages. Indicators that encompass not only human capital but also structural and relational capital (Chatzkel, 2003) will be highly valuable.

Arguably for S&T to flourish there must be proximal capacity building in scientific and technological services as well as the basic amenities that enable economic activity. It is in the economic domain that one seeks evidence that interventions contribute to strengthening linkages between the two economies both by growing the first and removing blockages in the second.

Project specific indicators for energy and water would quite naturally have a strong environmental focus, though not exclusively so.

Last is the political domain where measures such as ethical compliance are a *sine qua non*. This includes symmetry of the relationships among the parties in order to avoid a 'me data gatherer' you 'research hunter' relationship between South and North, and appropriate indicators of collaboration will be needed. Even where the S&T agenda is demand-driven there will be a risk of this lopsided bias creeping in.

Box 9.4. Indicators for KEEP

Knowledge

- Capacity – External efficiency of schooling; further and higher education production; specific fields of expertise; Frascati measures; centres of excellence.
- Mobility.
- Social and cultural impact.
- Indigenous Knowledge Systems – extent; pharmacopeia.
- Networks, linkages and communities of practice.
- Public awareness of the initiatives.

Changes in intellectual capital (outputs *etc.*).

Economic

- Infrastructure (utilities, ICT) and Systems (financial, statistics, standards; S&T services).
- Formal and informal sectors – pre-competitive enablers and spillovers; start-ups.
- Technology t/f (Licensing, Patenting, Plant Breeders Rights, Innovation capability).

Changes in produced capital (Econometric, Oslo indicators *etc.*).

Environment

- Energy and water – conventional and frontier science.
- Biodiversity maintenance as the marker.
- Stakeholders and participatory research.

Changes in natural capital.

Political

- Governance and systems; ethical clearance.
- Regulatory frameworks especially business enablers, resource management and intellectual property rights.
- Exclusion: pockets and layers.
- Policy toward S&T generally, R&D in particular.

Progress with respect to the African Peer Review Mechanism of the African Union.

Indicator development entails an ongoing conversation with users and the parties that are being measured lest the indicators be deemed to be illegitimate. This sets out an agenda for measurement that is arguably broad. The KEEP measures relate not only to the confines of S&T, but the social and security domains as well.

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Part 3

SESSION ON WATER

Chapter 10

SUMMARY OF THE WATER BREAKOUT SESSION

by
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Introduction

In the water session, there were 13 presentations, illustrating many good practices in science and technology co-operation. They can be grouped into four categories:

- Demand-oriented practices.
- Ethical practices.
- Efficient practices.
- Sustainable practices.

Demand-oriented practices

In most presentations, it appeared that the research projects or programmes are demand-driven, leading to solution-focused research with clear goals. Some examples: Le Quang Minh and Joachim Clemens (Vietnam/Germany partnership) put forward their bottom-up approach. Colin Chartres, CSIRO, explains how his research project comes from the water scarcity situation in southern Australia. Shinichiro Ohgaki shows that mega-cities in Japan forced the issues of wastewater reserve systems and dual distribution systems.

Link public research/private industry

Science is all the more demand-oriented when it is linked with private companies. A good practice consists in designing institutional arrangements that allow for greater linkages between universities and private sector activities. That is what Wolfgang Fisher, Graz University, Austria, shows in his presentation. He explains economic relevance of links between research institutions and industry.

1. Teddie Muffels (Ministry of Foreign Affairs, Netherlands) also contributed as rapporteur. Rivka Kfir (Water Research Commission, South Africa) chaired the session.

Political commitment

Another way to take demand into account is to involve governments, in order to get political commitment. This is what Salif Diop and Jacques Boulègue expose in their presentations: the African Ministers' Council on Water (AMCOW) and African Ministerial Council on Science and Technology (AMCOST) play a major part in the project of creating the NEPAD centres of excellence in water science and technology.

Participation of local population

Taking demand into account, local populations should be encouraged to participate in knowledge production. Everything that makes collaboration easier between producers of knowledge and potential users makes up a good practice. It is necessary to involve users in evaluating needs and priorities. Eric De Deckere (Belgium) and Mbangiseni Nepfumbada (South Africa) put forward the necessity of public participation.

Implementation by local partners

To respect demand-side needs means letting local partners carry out the task, as says Harsha Ratnaweera (Norway). Donors must allow themselves a role of facilitator. That is what France/NEPAD co-operation, presented by Jacques Boulègue, is all about. France supports a network project which was initiated by NEPAD.

Focus on innovation

Taking demand into account means supporting the whole process of innovation, and not only research. It means building networks linking different types of organisations (universities, firms, government departments, local authorities, ONG, etc.), linking various competences. This is why Wolfgang Fisher uses the term "competence network" and not "science network". It has a broader meaning because organisations of different types are linked together. All partners must be included in a steering committee, or in co-management, as says Mbangiseni Nepfumbada.

Research focused on themes

Moreover, taking demand into account leads to scientific projects which are oriented toward themes. They are trans-disciplinary and system-focused. Most presentations agree on this view. They stipulate that water resources must be managed as ecosystems; and they put forward the need for integrated water resource management. Colin Chartres' approach effectively deals with the triple bottom line of environmental, economic and social issues, in a whole-of-system thinking. Eric De Deckere puts forward integrated water resource management as the key concept to tackle all the water challenges in a sustainable framework; his approach links the natural system to the socio-economic system. Jose Tundisi proposes an integrated and predictive approach based on the eco-systems of watersheds, and linking quantity and quality of water. Slavek Vasak, of the International Groundwater Resources Assessment Centre of the Netherlands, also uses the integrated water resource management concept, and Harsha Ratnaweera explains how integrated water resources management enables the achievement of water management related to millennium development goals.

Ethical practices

Speakers did not emphasize this, but some pointed out that practice must be in line with a code of ethics. There is no good practice of science and technology co-operation between north and south countries without a professional code of ethics.

Protection of vulnerable population

Protection of vulnerable populations, as well as natural resource and environment management and conservation, must include specific measures aiming at these in any programme likely to interfere with them. Shinichiro Ohgaki, pointing to real social issues, explains that in all the mega-cities of the world, the poor living environment in the economically developed urban areas is a current major problem. Eric De Deckere focused on preventing the population from the negative effects of droughts and floods; he clearly includes ethical aspects in his presentation.

Fair sharing of gains

Another good practice of scientific co-operation is the fair sharing of gains in scientific knowledge. Intellectual or economic use must be shared. No one should take out copyrights or patents to the detriment of developing countries. There should be a prior agreement on royalties. And all these decisions about sharing should be taken in accordance with both international and local laws.

Uwe Brekau, from Bayer, explained that all partners must be involved on the basis of equity. In a broader sense, ethical co-operation must be based on a strong mutual interest. Each partner must be convinced of a benefit to earn, as Le Quang Minh and Joachim Clemens explain. The perception of ownership must be shared by both sides.

Efficient practices

Good practice in science and technology co-operation means efficiency. The modes of collaboration and scientific production must be efficient. At the very beginning of a co-operation, it is necessary to make sure of good governance and good management. This means openness, monitoring, and communication.

Transparency

Openness of processes and of financial management is a necessity. All partners must be informed of the origin, the amount and the allocation of the funds devoted to the project. They all need free access to the records. These are a necessary prerequisite for establishing consensus. Responsibilities must be shared, particularly administrative responsibilities. Decisions must be taken jointly. Wolfgang Fisher underlines the role of transparency and trust. This idea of openness and responsibility sharing guided the setting up of NEPAD Water Task Force presented by Jacques Boulègue.

Strong monitoring

All along the implementation of co-operation, it is essential to carry out monitoring through periodic evaluations (in-house or external), or intermediate reports drawn up jointly. This implies setting up a timeframe and finding cost-saving solutions, as most speakers proposed. Mbangiseni Nepfumbada and Salif Diop stress the role of implementaion and strong monitoring. Wolfgang Fisher says increasing know-how has to be supervised and evaluated.

Internal communication

Internal communication between members of the network is a determining factor for its success. Geographically or culturally distant partners will only be able to actually co-operate if communication is effective. Wolfgang Fisher considers that good communication between research and business partners results in a higher added value from research and development investments. It takes time to familiarise with each other, as pointed out by Joachim Clemens, and also Jacques Boulègue who says all the partners must go at the same pace.

Budgets must be allowed for hardware, and particularly, as Slavek Vasak points out, for setting up meta-information systems and GIS-based applications, which are, through sustainable information sharing, key tools of efficiency. He emphasizes the importance of water information management. Mbansigeni Nepfumbada focuses on information needs for integrated water resources management.

Exchanging ideas between professionals, in order to develop a joint future vision for the project, is one of the main purposes of the Nile Basin Capacity Building Network for River Engineering, presented by Samir Ibrahim. Importance of information exchange is also highlighted by Felix Reinders, from the International Commission on Irrigation and Drainage.

Sustainable practices

The speakers did not only talk about sustainable development, but also the sustainable practice of co-operation. A good practice in co-operation must be sustainable, which means that it must create conditions so that scientific and technological research will go on in developing countries after the co-operation project finishes. According to our speakers, sustainable co-operation must be result oriented, build capacity and enhance human resources.

Focus on results

Scientific and technological co-operation should be result-oriented. Several speakers emphasized the importance of the dissemination of results (Joachim Clemens, Samir Ibrahim and others). One must be careful not to be misled by hopes aroused by field surveys with local populations. It is essential to communicate results. This requires collaboration with institutions on the same wavelength as the population (NGOs, local authorities, local firms).

It is important that the results are not just communicated but actually used. It is also important to avoid dead-end projects. Scientific dynamics should not stop after official closing of the co-operation project. Jose Tundisi (Brazil) shows clearly in his presentation how using the results of International Centres of Technology and Innovation in water resources develop new innovative perspectives in technology transfer and capacity building for water managers. Management should be fully integrated in research projects. Several presentations show very well those links between science and management system policy. The Australian experience, leading to the design of a National Water Initiative, presented by Colin Chartres, suggests that getting the policy and governance arrangements correct is a critical step in dealing with water issues. Shinichiro Ohgaki establishes the link between knowledge on water and innovation policy for sustainability of mega-cities. Eric De Deckere explains that a crucial phase in his scientific approach is translating the water system knowledge in a river basin management plan.

Capacity building

Most speakers noted that science and technology co-operation must promote capacity building. It has to support infrastructures and institutions, in order to strengthen the national scientific basis.

Enhancing human resources

Scientific and technological co-operation must enhance human resources. Training must be a priority at different levels: training young scientists (Masters, PhDs) as well as vocational training. Wolfgang Fisher presents a continuingly progressive build-up of competence through the network nodes of his projects; he explains how education and training programmes play an important role.

Spreading scientific culture in developing countries, especially among the young generation, is another way of enhancing human resources. Close relationships with the places where scientists work favour increasing participation in politics and society. Slavek Vasak emphasizes the importance of raising public awareness on water through information sharing.

Conclusion

Some good practices have been identified through the workshop session on water. Most of them are not specific to the water field, but are cross-thematic. They need to be formalised in order to become qualitative criteria, but it is not easy to obtain indicators from them.

Chapter 11

INTEGRATED WATER RESOURCES MANAGEMENT AND KNOWLEDGE TRANSFER

by
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Background

Integrated water resources management (IWRM) is an important tool in sustainable development, and was identified as one of the main issues of the World Summit on Sustainable Development (WSSD) in 2002. The importance of wise management of water can not be overemphasised, especially in a world where there are many areas with scarcities of water, and where water is a potential cause for international conflicts.

Though IWRM is a well-known and well-used concept, there are several definitions leading to slightly different interpretations. Among these, the definition provided by the Technical Advisory Committee of Global Water Partnership (GWP-TEC, 2002) seems to have been quoted the most. It says that "*IWRM is a process, which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"*. This definition links IWRM directly with sustainable development and meaningfully describes the extent of possibilities and limitations of the usage of resources.

However, the definition does not provide any guidance on how to achieve this objective. A set of actions involving human thinking and reasoning is needed, and can be efficiently put into practice with technology-oriented management. Different nations in the world have defined and achieved their IWRM goals and practice at various levels. This difference leads to the potential, and the need, for the transfer of knowledge between nations. Norway started to work with IWRM decades ago to meet its own challenges and has several competence areas to share with other nations, which are appreciated by the recipients. This paper presents some such activities where a fruitful transfer of knowledge on IWRM-related issues took place.

Norway as a country with IWRM experiences to share

With its extremely high renewable water resources per person (second only to Iceland), river and lake water quality that most other European countries can only dream about, and vast areas with no or few inhabitants or industries as potential polluters, Norway may appear to hardly ever have water problems, and not face any challenges in quality or quantity.

However, there are a few serious challenges, such as the heavy metal-containing lechates from old mines in central Norway, untreated sewage flowing into water courses in a few sparsely populated areas, agricultural runoff continuing to be a challenge with regards to nutrients, canals lacking edge plantation and leading to erosion, and impacts from heavily modified water courses to produce hydropower. To complicate the picture, Norway has a complex administrative structure to manage various aspects of water. Water quality is managed by the Ministry of Environment, while quantity is managed by the Ministry of Oil and Energy and drinking water quality is overseen by the Ministry of Health. All ministries have national-level directorates to cover these responsibilities, and each has decentralised regional and municipality-level responsibilities. It is unlikely that such a system would be readily suitable for another country, although it works relatively well for a small country like Norway where there are only short distances between and among the various stakeholders.

EU Water Framework Directive

The European Union (EU) has launched a harmonised water management practice and introduced the Water Framework Directive (WFD) for its member states. The WFD was quickly accepted as an important tool not only by the EU member states, but many associated states, states anticipating entry and neighbouring states, including Norway. It is clear that future water management in the whole of Europe will be based on, or heavily influenced by, the WFD. Compliance with WFD, its road map and time schedule is a challenge for many countries, including the well-developed ones.

Five main focal issues of the WFD are:

- Environmental objectives: good status for all water by 2015.
- Analysis of water status: pressures and impacts; economic analysis.
- River Basin Management Plan, with a programme of measures including existing directives: main instrument for planning and reporting.
- Water pricing policies operational by 2010: instrument supporting environmental objectives.
- Public participation: **not** just information.

Although WFD is a new tool in achieving the IWRM objectives, Norway had already started to work with similar concepts in the late 1970s. Examples include the extensive activities on river basin plans in all major basins and integrated coastal zone management plans in all coastal municipalities. Whereas compliance with the WFD road map is certainly a challenge for many countries with less experience, resources and knowledge, it is even a challenge for Norway. The Norwegian government has identified the need for and importance of this activity, and has supported it with a substantial part of the project costs. These activities are organised as bilateral projects, often with sister institutions and twinning between the authorities in the two countries.

Knowledge transfer issues

Knowledge transfer in typical projects can be characterised by all or some of the following activities:

- Scientific collaboration for compliance facilitation.
- Scientific collaboration to revitalise trans-boundary partnerships.
- Stakeholder participation.
- Local competence and capacity building.
- Securing political and administrative support.
- Use of modern tools and concepts.

An example of directive compliance

A project where the approaches to quantification of nutrient load in the Drim/Drini River Catchment is one such initiative. This catchment is shared by Albania, the former Yugoslav Republic of Macedonia (FYROM), Kosovo, Serbia and Montenegro, and Greece. It covers about 20 000 km^2 and has three large lakes, Prespa, Ohrid and Skadar. Quantification, consolidation and analysis of water quality and quantity data, pollution budgets and abatement plans will be addressed as a part of WFD compliance activities. Norwegian experience with simulation models and tools for water quality and quantity modelling are shared in this initiative.

This project was started as an extension of a similar project on Drim basin between Albania and FYROM. The Drimnet is to address the extended relationships between all riparian countries. It will bring managers and scientists from these five countries together in a dialogue over scientific and managerial issues concerning the Drim/Drini integrating the positive Norwegian experience on water quality and quantity modelling as well as the WFD-related activities.

An example of lake restoration

An another example of a project sharing some of the IWRM principles is the restoration of Lake Wuliangsuhai in Inner Mongolia in China. The project was funded by the Chinese, Swedish and Norwegian authorities and represented strong collaboration between the water and environment-related institutions in the three countries.

Lake Wuliangsuhai is the eighth largest lake in China and is the largest freshwater lake in the northwestern region of the country. Although it has a total area of about 300 km^2, only 170 km^2 is at present considered as open waters due to widespread reed vegetation. There are many conflicting interests between users of lake resources. Norway and Sweden had eutrophication problems in several lakes some years ago and successfully solved these using technological as well as participatory concepts. These concepts were considered for adoption in the case of Lake Wuiliangsuhai, and a collaboration project with the participation of Chinese, Swedish and Norwegian scientists. The project studied the lake status, trends and threats and proposed a set of management and control actions to secure the lake's existence as a lake.

Lake Wuliangsuhai serves as a source of income for several local stakeholder groups who have rights to harvest fish, reed and other natural resources. These groups together with local authorities have implemented some management measures to regulate their harvest, restore, and enhance natural resources. Pollution from various sources including agriculture, urban sewage and industry is a problem. Thus, loading of nutrients (phosphates and nitrogen), dissolved organic matter and mineral salts into the lake is an important issue to be addressed, as it affects a number of different sectors and could have many secondary effects.

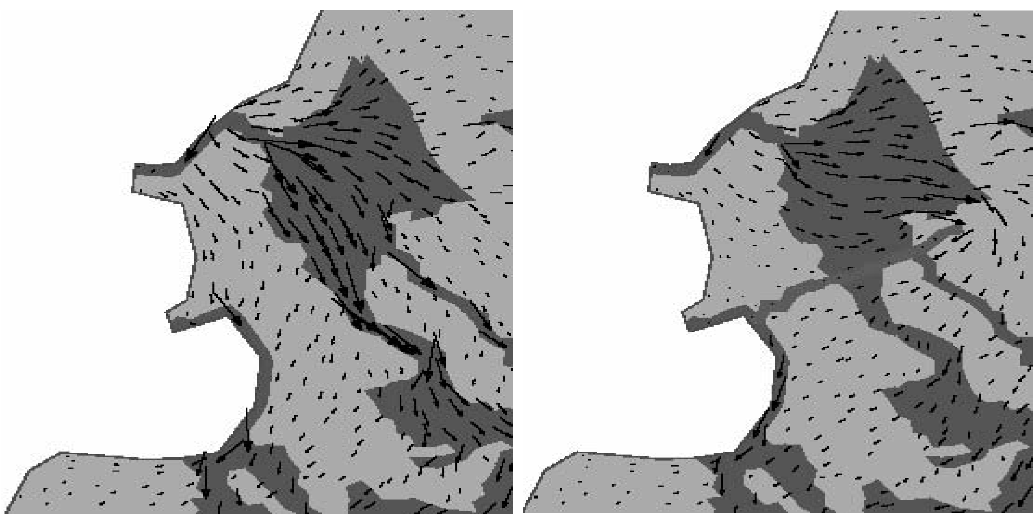
Overall, the exploitation, management, protection and restoration of Lake Wuliangsuhai pose unique challenges. One of these is to balance the competing demands of the various stakeholders on the lake's resources. This involves the need to satisfy the various user interests while at the same time sustaining or restoring both the lake's water quality and biodiversity. Scientific challenges include questions concerning the applicability of site-specific data to understand natural resource problems at the sub-basin, basin, or whole lake levels. Other challenges are the lack of long-term data collection programmes and the use and compatibility of data from various sources, and time periods to understand ecosystem health trend analyses.

Several technological solutions were proposed and analysed in this project. The hydrodynamic simulations with and without various actions to improve the water flow are examples, as shown in Figure 11.1.

Figure 11.1. The effects of establishing levees (barriers)

Left:
Present situation

Right: Effects of a levee (barrier) (red-k line)
improving flow conditions



Given the complex nature of the user conflicts and interests, it was important to have a participatory process in identifying and ranking them as future actions to meet the challenges. Workshops were held to identify suitable actions. A multi-criteria analysis (MCA) was then performed to rank the preference of the stakeholders and prioritise environmental, economic, social and institutional goals, and subsequently the actions. A ranking of actions according to cost-benefit rationales was also suggested.

In this project partners shared experiences in stakeholder involvement, especially regarding various decision-making traditions and complicated hierarchical relationships between stakeholders. One important role for Norwegian and Swedish partners was to convince all stakeholders of their involvement and support in the process.

The Chinese government has proposed to allocate up to USD 120 million in the 11th five-year plan for restoring the lake, an action which will use the outcomes and the knowledge base developed during this project.

This project focused on the following aspects from the previously mentioned list:

- Stakeholder participation.
- Local competence and capacity building.
- Securing political and administrative support.
- Use of modern tools and concepts.

An example of pollution reduction in a river

The rehabilitation of a river stretch in Serbia is another example of IWRM knowledge transfer. The Danube-Tisa-Danube Canal (Grand Canal) was built in the 18th century, partly for transport and water supply, but also with the purpose of draining the wet and fertile soils of the Backa district of Vojvodina.

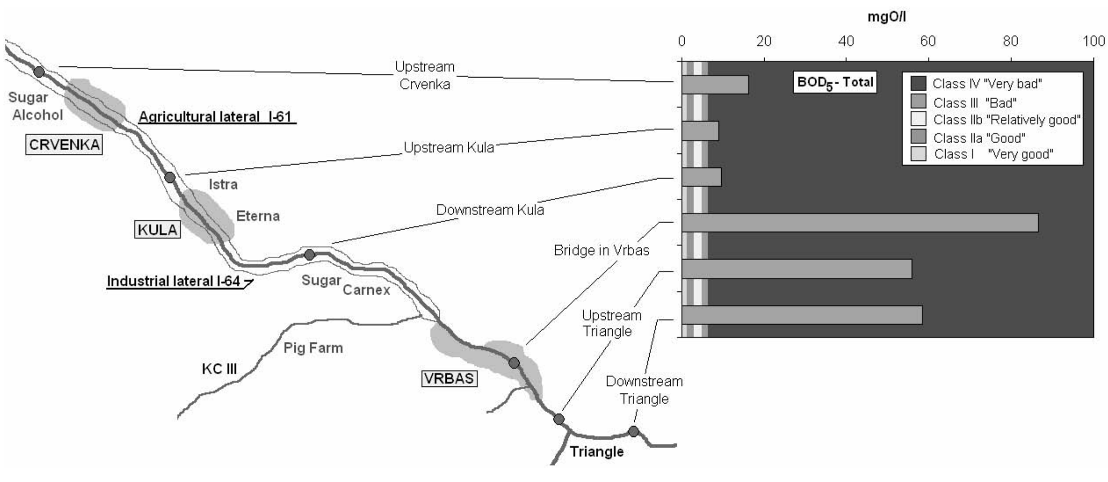
In the 20th century the area between Crvenka and Vrbas was heavily industrialised. This also resulted in increased settlement in the small towns along the canal. The canal became more and more polluted, and in the worst stretch around Vrbas, the canal is more or less filled with industrial sludge. Sugar beat processing factories, pig farms, slaughter-houses, food-oil factories and metal processing factories are the worst polluters in addition to untreated sewage from the towns. In addition to causing local problems, the pollution of the Grand Canal is a problem for the Tisa, and also constitutes a significant source of pollution for the Danube. Based on nutrient pollution, 70% of pollution comes from industrial sources, while 20% and 10% are from municipal and agricultural sources, respectively.

The environmental, aesthetic and hygienic needs, as well as public perception and demand, requires urgent action to reduce pollution and rehabilitate the Grand Canal. Frequent fish kills during the discharge from sugar processing, anaerobic conditions in many areas of the canal, 350 000 m^3 of decomposing anaerobic sediments, many stretches of water heavily polluted with nutrients, and oil and toxic matter demand urgent action. The following image shows a common situation in the river immediately after an industrial season, and Figure 11.2 shows that water in all sampling stations have the organic pollution categorising the river as “very bad” according to the national classification system.

Fish kills occur every year in the canal during the sugar campaign

Photo: P. Djuragin.

Figure 11.2. Organic pollution (BOD5) at different monitoring stations in the DTD canal in 2003-2004, as compared with Serbian water quality criteria



Norwegian specialists worked together with Serbian specialists in this project to identify the problems and solutions using advanced simulation software and methods which have proven to be efficient in northern Europe. The contributions were well received and scientists, administrators, industrialists and the general public were involved and pleased about the process. This project demanded an attitude change among many stakeholders. One main challenge was to convince the polluters that pollution reduction is not only a cost, but also a saving, as one can recover many valuable materials. The project has used substantial resources to convince stakeholders that it is vital to avoid a catastrophe with serious consequences.

In this process, building local competence and capacities was very important, as the country and the region have many similar challenges in other areas. Thus the local partners were encouraged and assigned to carry out the tasks by enhancing their competence, practice, attitude, capacities and resources, involving universities, authorities and local specialists.

This project addressed the following issues from the above mentioned list:

- Stakeholder participation.
- Local competence and capacity building.
- Securing political and administrative support.
- Use of modern tools and concepts.

Conclusion

There are many "capacity building" projects in various sectors, but unfortunately not all of them really build local capacities. Therefore, some local partners and recipients see these projects as unfair and selfish on the part of the industrialised countries, where the consultants are less willing to share knowledge and where the focus is on the implementation of tasks rather than on the transfer of knowledge. However, there are many projects where a true partnership and knowledge transfer are in focus, and receive much credit from the recipients. We can build up partnerships based on our success stories and share our knowledge for a sustainable future.

Chapter 12

EXPERIENCES FROM AN INTERDISCIPLINARY VIETNAMESE-GERMAN PROJECT ON DECENTRALISED WATER MANAGEMENT SYSTEMS

by
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Project description

This paper describes the experiences of an ongoing bilateral co-operation between the Universities of Can Tho, Vietnam, and Bonn, Germany.

The goal of the SANSED project, which is co-financed by Germany and Vietnam, is to develop decentralised water treatment systems. The systems should recycle as many nutrients as possible from waste water and the systems are regarded as “fertilizer factories”. Thus, not the technical philosophy, but the agro-ecological demands define the waste water treatment system (WWTS). For water supply every option such as rain, surface and ground water is tested before installation. All systems have to be socially acceptable, reliable and affordable.

The project is now in its second phase (2005-2008). In the first phase (2001-2004), the current water quality situation, treatment technologies and cultural habits related to waste water production and water use were evaluated. In German-Vietnamese tandem teams, groups in hygiene, socio-economy, hydrology, irrigation, agro-ecology and nutrient fluxes studied different aspects. The outcome of the first phase included suggestions for optimising the current situation with adapted technologies from Germany.

In the second phase, a variety of different treatment technologies are being realised or optimised on the campus of the University of Can Tho, such as biogas systems, urine diverting and composting systems, vertical soil filters, and different systems for drinking water supply. The systems are maintained by Vietnamese staff and are used to train Vietnamese and German students in the form of lectures, seminars, BSc., MSc. and PhD theses. After a test phase, the systems are presented to Vietnamese stakeholders to give them the chance to select the most suitable one for their own requirements.

In addition, for a peri-urban area with a high growth rate, centralised and decentralised water treatment concepts are compared for their relative benefits in terms of economy and ecology. In the Vietnamese-German water centre, training courses on water technologies are to be held. The water centre will also be a showroom for water technologies.

Key factors in a successful project

The project structure, perception of the project, the timeframe, additional activities developed around the project, and the people involved are all key to its success.

Key persons are convinced that both sides benefit from collaboration

An interdisciplinary and bilateral project needs strong support from the decision makers on both sides. As there are many regulations and possible organisational questions in terms of travel, export/import of scientific materials and distribution of workload, both sides need to have a powerful promoter in each organisation.

In the SANSED project, the German project leader has full power over the budget and the staff. The latter is contracted for the project. On the Vietnamese side, the rector of the university is the project leader.

The initiators need to motivate their staff. Questions to be addressed are the additional workload for the staff and the willingness of staff to travel to a foreign country. Perhaps the most difficult thing is to accept that the partners are from two different cultures, and both sides need to accept this when working together.

The benefits for the University of Can Tho are the opportunity for staff to receive an additional salary when working on the project and the possibility for students to graduate through SANSED and to gain access to equipment and pilot systems for their own research and training. The benefits for the University of Bonn are the research and degree opportunities for its students.

Structure

Ownership of the project

The partners in the developing country need to be sure that the project is their own, that it addresses their problems and that they can benefit from the project. The partners from the developed country are there to offer assistance (financial, technical, experience). They do not take over the work but work together with the developing country partners. However, for interdisciplinary projects, the presence of foreign scientists specialised in the research area is necessary. The partners have to understand their (perhaps different) perception of progress and project results. Students from both institutions graduating through the project are another important element of the partnership.

For the SANSED project, the Vietnamese partners provided their German counterparts with an office, where both the Vietnamese and Germans work together. At regular intervals, the tandem groups present their ongoing work to each other.

Different analytical methods have been introduced in the chemical laboratory of the College of Technology. They are used not for the project alone, but also for student training.

Vietnamese and German students were able to graduate with their experience in the project. On the Vietnamese side BSc. and MSc. degrees were awarded, and German students earned their MSc. or PhD through the project.

Need for planning workshops

Workshops with the participation of local authorities and representatives are one of the key measures in securing the project's success. Training of staff and stakeholders is also essential. Responsibilities should be well defined, and a long-term plan to clarify the vision, targets and aims of the project should be developed. This plan should be combined with an annual implementation plan.

At the beginning of both phases of SANSED, workshops were held and local authorities were invited to Can Tho. The results were implemented in the work plans. A steering committee of German and Vietnamese experts controls the project's progress. As a long-term plan, the systems installed are to be presented to stakeholders as soon as they are adapted and optimised. At the water centre, seminars on the maintenance of the treatment systems and new innovations in water treatment are to be presented.

Perception: need to combine different expectations

Each partner has its own expectations when collaborating on a project. These expectations need to be considered when implementing the project; for example, research can be defined at different levels according to such expectations, *e.g.* practically oriented and/or process-based.

In SANSED, the University of Can Tho wants to improve its knowledge about water treatment, and train its students and staff in this field. The research focus is on fast dissemination. The University of Bonn has a process-oriented research focus. As most of the research is done by PhD students, German students' involvement is also an important part. Both sides want to learn more about how to improve water quality for society.

Time

It takes time for the partners to learn about cultural differences, especially the different ways that scientific issues are discussed and the way knowledge is shared in each culture. Furthermore, it takes time to become familiar with each other in terms of working philosophy and different habits.

In addition, bilateral projects need to follow two national administrations and this sometimes leads to delays. In Phase I of SANSED, the collaboration was established. On both sides the partners were met with delays in their national administrations. These experiences were kept in mind in Phase II in order to find ways to minimise the delays caused by administrative procedures.

Additional activities

For bilateral projects, one project alone is not meant to be a reward in itself for both sides. The preparation and the contacts that are established can be used for other projects if the first project was a success. Thus, a project can be a sort of vehicle for additional activities. Moreover, both actors can use the project for their own specific interests.

Preparation for SANSED took over a year. After that, four additional projects in the field of water research were proposed much more rapidly. Two of the four proposals were successful. These projects are the basis for future collaboration until 2010.

The SANSED project led to a partnership between the two universities. This partner-ship supports Vietnamese students who study in Bonn. Additionally, a joint MSc. course in the field of agricultural resource management in the tropics and subtropics has been developed by the two institutions.

Conclusion

A successful bilateral project never stands on its own. Additional activities are developed around it, which is perhaps one of the most basic indicators of successful collaboration.

Chapter 13

NILE BASIN CAPACITY-BUILDING NETWORK FOR RIVER ENGINEERING

by
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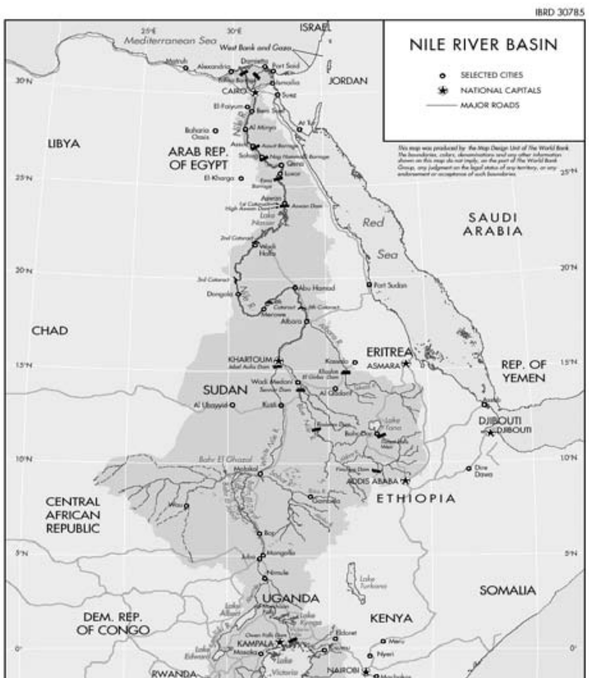
The Nile River and its challenges

The Nile River, the longest river in the world, traverses more than 6 700 kilometres from its farthest source at the headwaters of the Kagera River Basin in Rwanda and Burundi to its delta in Egypt on the Mediterranean Sea. Ten countries share the Nile: Burundi, Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The Nile River Basin covers three million km^2 – one tenth of Africa's total land mass.



It serves as home to world-class environmental assets, such as Lake Victoria (the second largest fresh water body by area in the world) and the vast wetlands of the Sudd. It also serves as home to an estimated 140 million people within the boundaries of the Basin, while more than twice that number – roughly 300 million – live in the ten countries that share the Nile waters.

Today, the Basin is characterised by poverty, instability, rapid population growth, and environmental degradation. Half of the ten Nile riparian countries are among the world's ten poorest. Population is expected to double within the next 25 years, placing additional strain on the scarce water and other natural resources. Yet the Nile holds significant opportunities for "win-win" development that could enhance energy availability, food production, transportation, industrial development, environmental conservation and other related development activities in the region. Co-operative water resources management should also serve as a catalyst for greater regional integration, both economic and political, with benefits far exceeding those derived from the river itself.

The need for capacity building

There is no doubt that there is any other continent than Africa that suffers more from the lack of capacity to carry out research and to establish policies for the region's development in general and for the water sector in particular. The lack of critical capacity in science and technology is one of the major obstacles to sustainable development. Many factors explain this:

- Disparities in income.
- Dependence on outside donors.
- Lack of access to post-graduate education. Lack of access to scientific literature.
- Lack of access to Internet.
- Poor participation on international conferences. Lack of scientific equipment.
- Decreasing public funding and budgets.
- Globalisation and privatisation have affected science development, reducing universities' activities.
- Very low participation of women.
- Aging of academic staff without new recruitments.
- The resulting brain drain process arising from these factors.

The above situation also holds for the water sector in most of the Nile basin countries. Co-operation at technical level has proved instrumental to improve the joint management of shared water resources and to mitigate and even prevent international conflicts. Informal and formal contacts at the professional level often formed the basis for agreements and effective international co-operation. It is in the interest of both powerful and less powerful riparian countries to "level the playing field" to share the same data, information and knowledge making it possible to analyse and interpret the consequences of certain measures at both the national and the river basin scale. Information and knowledge sharing is a critical issue in the development of trans-boundary rivers since it will build confidence and partnership among Ripanan states. Therefore the issue of capacity building has to be addressed in a way that it also encourages and facilitates Basin interchange. A long-term capacity-building programme is required to address the many gaps and variations among countries and should address in particular the following three sectoral issues.

The lack of capacity to manage water in an integrated manner

Most of the countries in the Basin are burdened by weak human and institutional capacity to manage water resources in an integrated manner. This situation applies not only to the management of international waters, but also to the management of national waters. Existing regional centres in the Nile Basin would be strengthened in the selected specialties of IWRM to provide training within the region.

Uneven distribution of capacity within the basin.

A central issue is that the water sector in the Basin is characterised by widely diverse institutional capacities in the countries. The availability of water professionals, for instance, varies from 100 in one country to over 3 000 in another. Senior managers, trainers, and researchers are even fewer. There is a great need for some of the countries in the Basin to develop a large cadre of trained professionals, while other countries already have such a group. Thus, it is important to have as many countries as possible represented in any training event. The more privileged countries will be invited to host and offer training to others. In addition, capacity building should encourage participation of women professionals.

Little interaction among water professionals in the Nile Basin

By its very nature, management of trans-boundary waters is a complex matter. In the case of the Nile, collective or joint development of the Nile waters is made even more difficult by the fact that there is limited trade and exchange among the riparian countries. Political, economic, social, and cultural (including language) differences among the countries pose a major challenge to such exchange.

The Hydraulics Research Institute

The Hydraulics Research Institute (HRI) is one of 12 research institutes within the National Water Research Center (NWRC) of the Ministry of Water Resources & Irrigation (MWRI). It was established in 1975 to take over and extend the work of the Hydraulic Research Experimental Station founded in 1949. The Institute is one of the oldest hydraulic institutes in the Middle East and Africa. HRI is located at the Nile River at a distance of about 26 km north of Cairo. Its area occupies more than ten acres of land. HRI was and still is one of the largest specialized institutes in the region in water-related research and river hydraulics studies. The Institute carries out studies for ministers, governmental and non-governmental bodies and consultant firms. Also, technical training and international co-operation in hydraulic research have been helpful to build institutional capacity and sustain technology transfer programmes.

HRI consists of four main departments: Physical Modelling; Numerical Modelling; Sedimentation and Field Measurements; and Calibration and Instrumentation. Research supporting services are also available, such as workshops, calibration flume for calibrating current meters, and sediment laboratory. Areas of specialization are river hydraulics and morphology; irrigation systems and hydraulic structures; river navigation (including locks); industrial hydraulics (water hammer and pipe networks); coastal hydraulics and marine structures; design and testing of cooling systems of power plants.

The Institute has many facilities. There are two main experimental halls used for construction of physical models. In addition, a third hall has been constructed for conducting coastal engineering studies. The hall is equipped with a wave generator and provided with necessary instruments and computer facilities. Software packages are used either solely or in conjunction with physical models to solve hydraulic problems as well as to assist in the design of hydraulic structures. Flume studies can be carried out in three flumes. There are also facilities to calibrate current meters. A 150 metre long, 2.0 metre deep and 2.0 metre wide flume is used to calibrate current meters used in prototype. There is also a circular tank with an outside diameter of 2.0 metre and inside diameter of

1.5 metre for calibrating miniature current meters. This tank is provided with digital timer counter and an arm which carries the current meters derived by AC motors.

A sediment laboratory is available for the analysis of bed and suspended sediment samples. Sieve analysis and pipette are used for determining grain size distribution for sediments. Also the laboratory is provided with other instruments. For hydraulic survey, HRI has three survey boots each of which is equipped with digital echo-sounding and positioning system so that while moving, the boot can record the water depth and its position with respect to fixed points. Modern equipments like differential geographic positioning system (DGPS), total stations, distomat (Range finder) are being used. HRI has also four rubber boats with different sizes to carry out the hydrographic survey in small water bodies. For storing and collecting field data, a data logger is available.

An instrumentation laboratory provides maintenance, repair and developed electronic and electrical equipment used for data collection and measurements either in the field or in the models. HRI has also computer centre helps in finalizing all the outputs of the technical and secretarial work. HRI has technical library containing a large collection of text books, periodicals, journals and scientific reports in the different fields of hydraulics, irrigation, hydrology, computer sciences, etc., to serve scientific research.

The HRI Regional Training Projects (1995-2004)

The HRI-Regional Training Project is a special example of capacity-building models for developing water sector training capability. Since 1996 FHU has been organising a three-month course and various short courses on Hydraulic Engineering in River Basins for professionals from the Nilotic States. The project activities are supported professionally, by the International Institute for Infrastructure, Hydraulic and Environmental Engineering (IRE), Delft and the International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, The Netherlands, with financial support of the Dutch Government. The main objective of the HRI project was to *"Strengthen the capacity of the Nilotic states to develop their research infrastructure required for a sound and proper management of the Nile and other river basins"*.

The first phase of the project (1995-1999) focused on the practical training of professionals active in the various (semi-) governmental authorities, institutes and projects dealing with water resources development in the region. Activities were tuned both to support HRI to become a regional training institution and to support training of professionals from the region and to provide a number of fellowships to enable participants to attend regular courses at HRI.

The training centre established at the HRI premises became in a short time a regional training centre well known not only within African Nilotic countries but also further in the African Continent and the Arab world. Training groups of young professionals coming from countries with different political background and culture fostered friendly relationships between them and actually turned out to be an excellent long term investment. They not only learned how to design hydraulic works but also how to solve practical problems in a technical and environmentally sustainable manner.

The above experiences seem worth elaborating further the concept and approach of the first phase through facilitating an even more intensive co-operation between professionals from the Nile region. The main concept on which the second phase of the project (2000-2004) is based is to create an environment in which professionals from the water sector sharing the same river basin would have the possibility to exchange ideas, best practices and lessons learned. Such an environment can best be established by fostering a network through which education, training, research and exchange of information for and by professionals can take place.

To this end, the Nile Basin Capacity-Building Network for River Engineering (NBCBN-RE) is to be established as a regional programme to build and strengthen capacity in the Nile riparian countries for an environmentally sound development and management of the Nile River Basin. The network is to be an open network of national and regional capacity-building institutions and professional organisations active in education, training and research. The ownership of the NBCBN-RE Network is an essential issue to be seriously addressed. It is envisaged that the network will be owned by a group of information and knowledge suppliers, capacity builders and end-users, all under the umbrella of a regional organisation. Such an organisation could best be the Nile Basin Initiative (NBI).

How to build a capacity-building network for the Nile Basin?

In the previous section, all kinds of building blocks have been brought up as essential components for building networks. In one way or another they all contribute to the concept and approach of building an Internet-based network. Communities of practice form one of the main building blocks for such a network. These are seen as the 'foundation' for every network, since the communities are the places where real value is produced through sharing ideas, insight, information, experience and tools.

The main concept behind the proposed establishment of a regional Nile Basin Capacity-Building Network is to support and strengthen the already existing communities, to promote and initiate an environment that stimulates the creation of new communities, and to generate additional value through making cross-links. The leading thought behind the regional network is that, in order to leverage knowledge, we should not focus on the knowledge itself, but on the communities that own the knowledge and the people that create and use it. In building the network and in supporting communities of practice it is therefore vital to identify, existing forms of communities and networks.

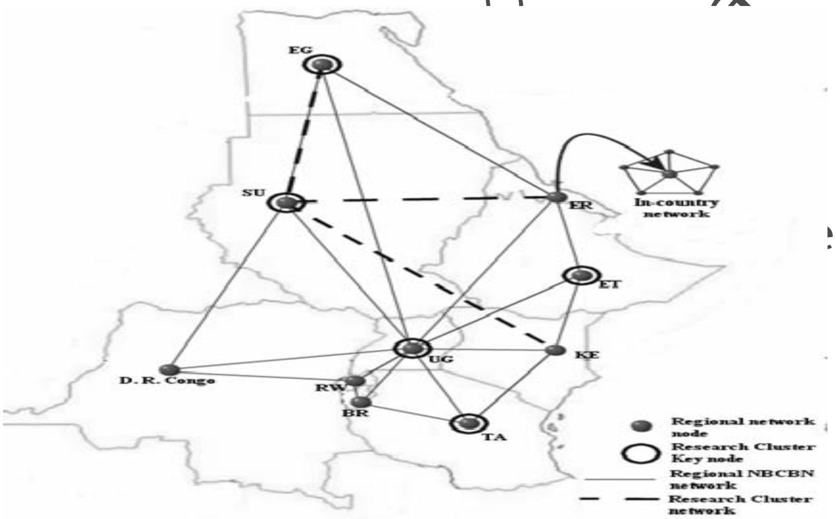
If communities of practice are such important building blocks for the development of capacity-building networks, the question arises: how to build and/or develop communities of practice? Communities of practice are living things and go through stages of development. Communities of practice typically start as loose networks that hold the potential of becoming more connected. In order to develop them one has to understand the structure. All communities of practice share a basic (social) knowledge structure, consisting of three fundamental elements for developing and sharing knowledge:

- A domain that creates the common ground and identity.
- The community that creates the social fabric of learning.
- The practice defined as the set of frameworks, ideas, tools, information, styles, language, stories and documents that community members share.

It is important for communities of practice to develop all three elements in parallel and in a balanced way.

NBCBN development approach and activities

The network development process is characterised by the establishment of network nodes in each Nile Basin country and the formation of research clusters that bring together representatives from the different nodes to implement regional joint research activities.



NBCBN node

The NBCBN has been designed as an open regional network with nodes in each of the Nile basin countries. Each Nilotic country is one node of NBCBN. A node itself is a (local) network of water sector professionals from a particular country. A node is an association of individual professionals supported by their organisations. Their activities are determined by the role the node plays in the different networks. The role of the node may slightly vary from country to country.

Role of the nodes

- *The node as in-country network.* The role is to develop and sustain a local capacity-building network for river engineering professionals within a country.
- *The node as the host of a research cluster.* The role is to develop and sustain a regional research capacity in a specific research domain in the field of river engineering.
- *The node as part of the regional network.* The role here is to participate in the overall network development and in sharing knowledge and information over the regional network.

Country	Hosting institution
Burundi	Université du Burundi
D.R. Congo	Ministry of Environment
Egypt	Hydraulics Research Institute
Eritrea	Ministry of Water Resources
Ethiopia	Addis Ababa University
Kenya	Nairobi University
Rwanda	Institut de Recherche Scientifique et Technologique
Sudan	UNESCO Chair in Water Resources
Tanzania	Dar Es Salaam University
Uganda	Makerere University

Node activities

- Co-ordination of river engineering capacity-building activities in country.
- Identification of the main river engineering challenges in the country.
- Inventory of professionals, organisations and resources that describe current capacity for meeting these challenges.
- Ensuring exchange of data and information for research.
- Preparing a node development and activity plan and a knowledge map.
- Identification of the training and research needs in the area of river engineering.
- Dissemination of the training activities initiated through NBCBN-RE
- Nomination of participants from the country to participate in the various training courses organised by NBCBN-RE.
- Identification of the top lecturers who could contribute to research cluster training courses, and other short and regular courses organised by NBCBN-RE.
- Involvement and support to the research cluster(s) that the country node will join and take part in.
- Communication and co-ordination of river engineering activities with other disciplines and organisations associated with the Nile Basin Initiative.
- Raising the public and water professional awareness in the country about NBCBN role and activities using the media whenever possible.
- Dissemination of NBCBN-RE publications such as newsletter, brochures, and scientific journals to the interested water professional and institutions in the country.

NBCBN cluster

A research cluster is a group of professionals coming from five – seven different Nile basin countries that carry out research activities to enhance their research skills and capacity in a particular sub-topic in river engineering. One country takes the leading role as a host of the research cluster, while the others are playing an active role as research cluster members.

So far six regional research clusters have been created, while six countries have taken the responsibility to host a particular research cluster. The GIS and Modelling research cluster is hosted by Egypt, River Structures cluster by Ethiopia, Flood Management cluster by Kenya, River Morphology cluster by Sudan, Hydropower Development cluster by Tanzania and Environmental Aspects by Uganda. Each regional research cluster has formed two to three smaller research groups that deal with different specialised topics.

Cluster host activities

- Organisation of research cluster workshops.
- Co-ordinating and contributing to research plan development.
- Co-ordinating and contributing to research cluster activities.
- Organisation of training courses needed by the research cluster.
- Communicating with the other research cluster members.
- Mobilising fund for sub-regional and regional research proposal in the area of cluster specialisation.

Cluster member activities

- Contribution to research plan development in the research clusters in which the country node is participating.
- Significant contribution to research clusters activities.
- Identification of the training needs by the research clusters.
- Communicating with the other research cluster members.
- Assisting the research cluster hosting in mobilising fund for sub-regional and regional research proposals in the area of cluster specialisation

The Cluster Host has been selected on the basis of its relative capacity and performance in this research area. While it is expected that cluster hosts may lead and co-ordinate these activities, all cluster members are supposed to take responsibility for some activities in the Research Cluster.

The lessons learned

1. Strategic partnerships as a basis for co-operation

The engagement of partners in a strategic partnership legitimates the co-operative framework and shows the commitment and ownership of the top management and decision-making level. It accelerates the process of co-operation and creates an enabling environment for institutions and professionals to start joint capacity-building activities. The NBCBN-RE has largely benefited from the partnership that was forged during the Cairo Kick-off meeting (Cairo Declaration).

2. Participation, approach creates ownership and commitment

In building partnerships, networks and communities a participatory approach through which all the participants have maximum involvement in the building process contributes largely to its success and secures commitment of the participants. Organisers and third parties should restrict themselves to optimal information provision and facilitation. In all its network and community building activities NBCBN has applied this approach successfully, which has proved to be a very effective methodology to maximise the outputs.

3. Joint research has a high potential in building capacity

In a region where the lack of capacity is greater than elsewhere in the world and where relations among member countries, institutions and people are tense the choice to concentrate initially on organising joint research has proven to be sensible. The main idea is that the research will lead to new, relevant and practical knowledge that can then be disseminated through special training courses and used for improvement of education curricula. NBCBN has indeed adopted joint research as the main driver for its capacity-building activities. It also has helped in identifying regional centres of excellence that has the capacity and willingness to take the hosting role for a specific research topic. It is also felt that this concept is the fastest way of levelling the playing field among the countries.

4. Capacity-building networks should involve all water sector institutions

To make capacity-building networks effective and to guarantee demand-responsiveness it should accommodate all the main stakeholders in the field: the water professionals active in both public and private water sector institutions (ministries, research institutions, water utilities, consultants and contractors) and local capacity builders (universities, polytechniques, professional organisations, research and study teams). The NBCBN-RE activities involve all the main players in the field of River Engineering in the Nile region.

5. Networks should be open and easy to access

Networks should be open and should stimulate relevant institutions and individuals to join. However, in order to secure the identity and value of the network, new incomers should express their commitment and willingness to actively participate. Networks should avoid discrimination and hierarchy among its members. The NBCBN-RE is an open network and can easily be accessed through its platform.

6. Networks require co-ordination

A network requires an active and good functioning co-coordinating body. It should stimulate the flow of information and knowledge between the nodes, coordinate the overall activities of the network, disseminate pro-actively relevant information to its members, maintain the knowledge base, develop, maintain and continuously improve the interactive network platform, and initiate new activities. The NBCBN-RE Network Secretariat fulfils a crucial role in the development of the network.

7. CoP's form the main building block of a knowledge network

Communities of practice are seen as one of the most important drivers for building capacity of both individuals and organisations. They are seen as the 'foundation' for every network, since the communities are the places where real value is produced through sharing ideas, insight, information, experience and tools. For this reason NBCBN has used this concept for building the network.

8. Networks should focus on already existing communities

The leading thinking behind a regional network is that, in order to leverage knowledge, it should not focus on the knowledge itself, but on the communities that own the knowledge and the people that create and use it. In building the network and in supporting communities of practice it is therefore vital to identify already existing forms of communities and networks. The network is to support and strengthen the existing communities and to promote and initiate an environment that stimulates the creation of new communities, and to generate additional value through making cross-links. NBCBN-RE is making the maximum use of existing contacts, local networks and professional communities.

9. Network and communities should clearly define its domain

A well-defined domain will inspire members to contribute and to participate. It provides the network and community members their common ground and identity. It should describe the key issues and problems that members jointly experience and really care about. It also triggers members to take leadership in promoting and developing that domain. NBCBN-RE has deliberately restricted itself to a specific area of water resources: river and hydraulic engineering. For the purpose of developing communities of practice the domain is even more confined to research activities in the fields of river morphology (reservoir sedimentation, river bed erosion and protection, watershed erosion and sediment transport), hydropower development (small hydropower for rural development, large hydropower), GIS and modelling (flood propagation, GIS for watershed management), river structures (diversion works and micro-dams).

10. Effective network and community co-ordinators are a key

The identification of effective network and community coordinators is a key factor for the successful development of any community. Effective co-ordinators are people who are well respected, knowledgeable about the domain, well connected to other members and good communicators. The most important factor is the time that they can make available for their community members. NBCBN has found these persons through the involvement of both scientific advisors from LTNESCO-IHE and ITC and through the proper selection of the key local players during the kick-off meeting (country co-ordinators) and research cluster launch events (research cluster co-ordinators).

11. Building distributed communities requires extra attention

Distributed communities of practice cannot rely on face-to-face meetings and interactions since they link people across time zones, countries, organisational units, languages and cultures. They rely heavily on technology. Since members have less contact it is more difficult to build trust and personal relationships. As the majority of the communities in the NBCBN are distributed, extra attention has been given to organise intensive participatory launch events and regular biannual or annual face to face meetings. Moreover, a great effort has been put in developing a user-friendly, dynamic and interactive website that can easily be accessed by all the members of the communities.

12. Critical success factors for network and community development

Being involved in the process of network and community development it is essential to understand the thoughts and feelings of the people participating. NBCBN has been asking participants in the kick-off and launch events to reveal their views on what they saw as the main critical success factors. The participants involved so far in those events have listed the following items as major success factors: commitment, transparency, trust, funding, co-ordination and co-operation.

13. Support to network development should lead to sustainability

In network development the central thinking behind all the externally supported activities should be on how they contribute to sustainability. Therefore NBCBN has focused its support to creating a support environment through which individuals and institutions are attracted and facilitated to co-operation and sharing information and knowledge. The main support components are: providing fellowships, organising and facilitating node launch events, supporting the establishment of an in-country network in all the 10 Nile Basin countries including the development of a proper ICT infrastructure, supporting staff development and exchange, supporting the applied research (no salaries, only small incentives), development of an information centre and a user-friendly interactive NBCBN website and establishing a network secretariat. NBCBN is actively creating awareness among the local and regional institutions to support its participating staff through making time available and financial support of their research.

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Chapter 14

INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION OF THE INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE IN THE FIELD OF IRRIGATION FOR SUSTAINABLE DEVELOPMENT

by
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Introduction

Water gives life and is crucial to development all over the world. It waters the fields and nurtures the crops and stock; it provides recreation; it supports mines, industry and electricity generation; and it sustains life for plants and animals that make up the eco-systems.

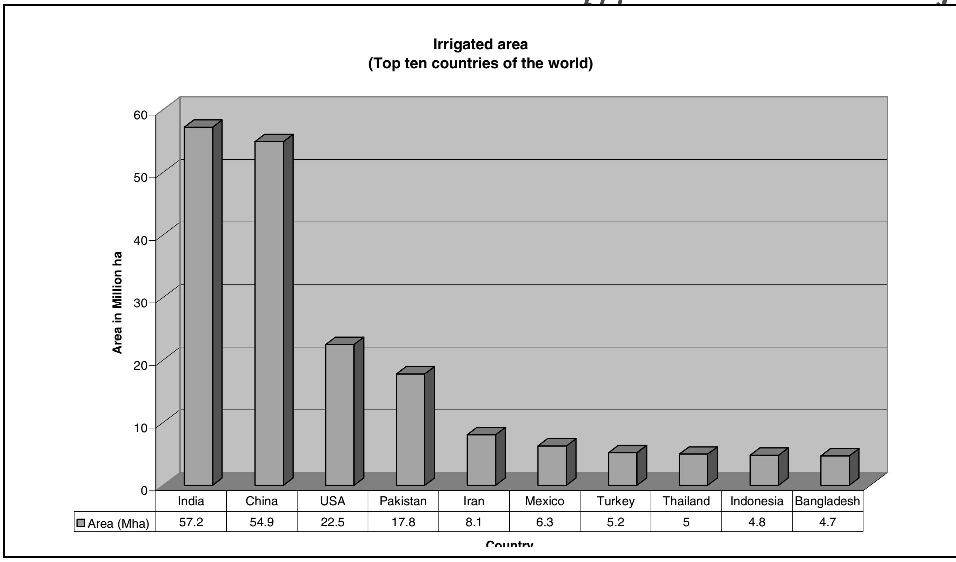
The world's population tripled in the 20th century, and the use of renewable water resources has grown sixfold. Substantial investments in the development of water resources in OECD countries and Asia have made major contributions to food security, electricity generation and economic growth in general.

It is within this context that the International Commission on Irrigation and Drainage (ICID) plays a vital role in enhancing world-wide supply of food and fibre for all people as one of the major international players in the field of scientific and technological co-operation for sustainable development.

Irrigated agriculture in the world

Irrigation is practiced on more than 277 million ha (ICID Survey, 2005). As can be seen in Figure 14.1, the top ten countries irrigate 67.3% of the world's total. Four countries – India, China, the United States and Pakistan – have the largest irrigated areas.

Figure 14.1. Irrigated areas in the world



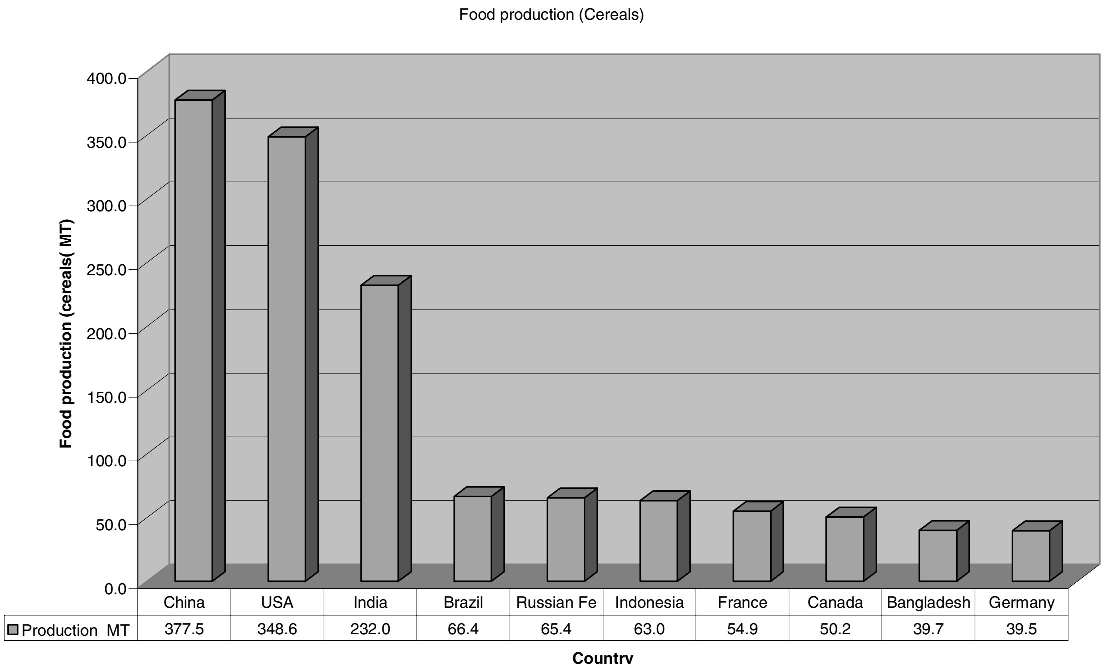
Irrigation is an age-old art and in the words of N.D. Gulhati of India: "Irrigation in many countries is an old art – as old as civilization – but for the whole world it is a modern science – the science of survival". Irrigation is of first importance in the more arid regions, but it is becoming increasingly important in humid regions. Although irrigation is one of the oldest known agricultural techniques, improvements are still being made in irrigation methods and practices.

Everyone involved in irrigation has a certain responsibility:

- The researcher, developer, and supplier for providing practical and useful technology.
- The designer, who must adapt the design so that it is technically and agriculturally appropriate.
- The producer, who must use the system properly and exercise sound irrigation practices.

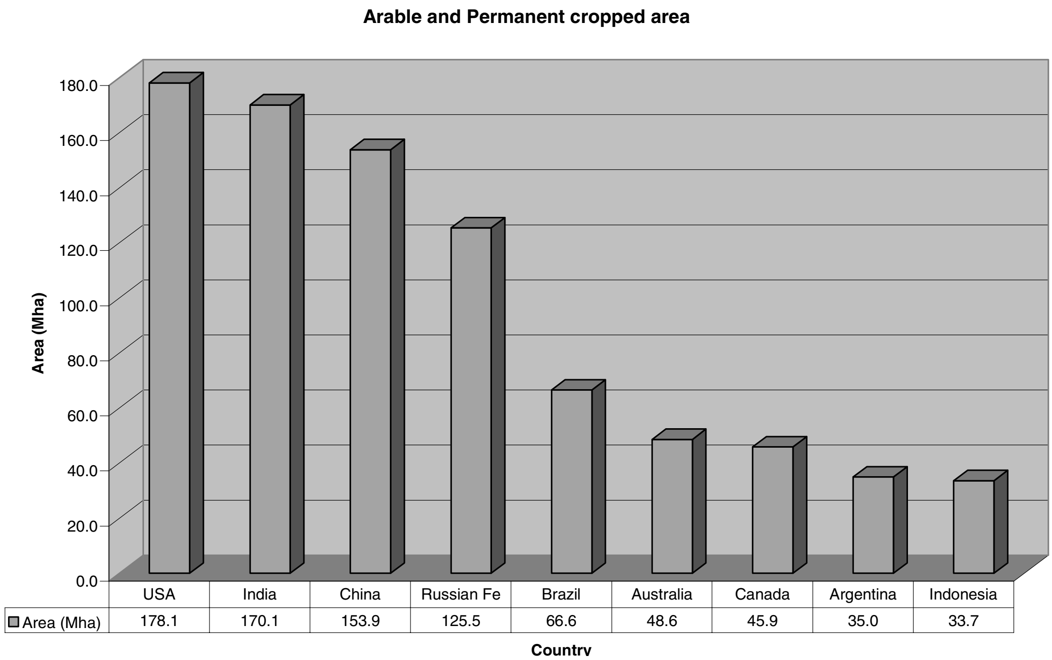
As the population of the world continues to increase, the demand for food and fibre for the people also increases. Food production (cereals) in the world is 2 075 million tons (FAO, 2003) (see Figure 14.2) and it is produced on an arable and permanently cropped area of 1 534 × 10^6 ha (see Figure 14.3).

Figure 14.2. Food production in the world



	China	USA	India	Brazil	Russian Fe	Indonesia	France	Canada	Bangladesh	Germany
Production MT	377.5	348.6	232.0	66.4	65.4	63.0	54.9	50.2	39.7	39.5

Figure 14.3. Arable and permanent cropped area

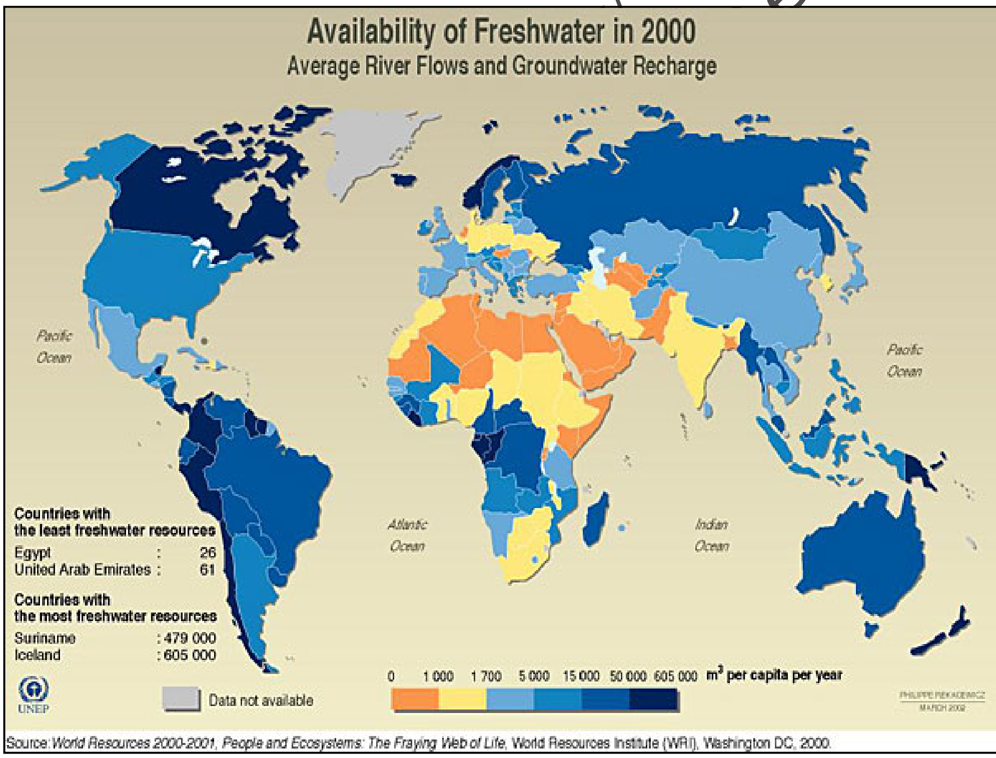


	USA	India	China	Russian Fe	Brazil	Australia	Canada	Argentina	Indonesia
Area (Mha)	178.1	170.1	153.9	125.5	66.6	48.6	45.9	35.0	33.7

Agricultural water usage

All life depends on water. The earth is covered with 70% water of which 97% is seawater, 2% the polar ice caps and only 1% is freshwater available for use. In Figure 14.4, the availability of freshwater in 2000 is shown in m³ per capita per year.

Figure 14.4. Availability of freshwater

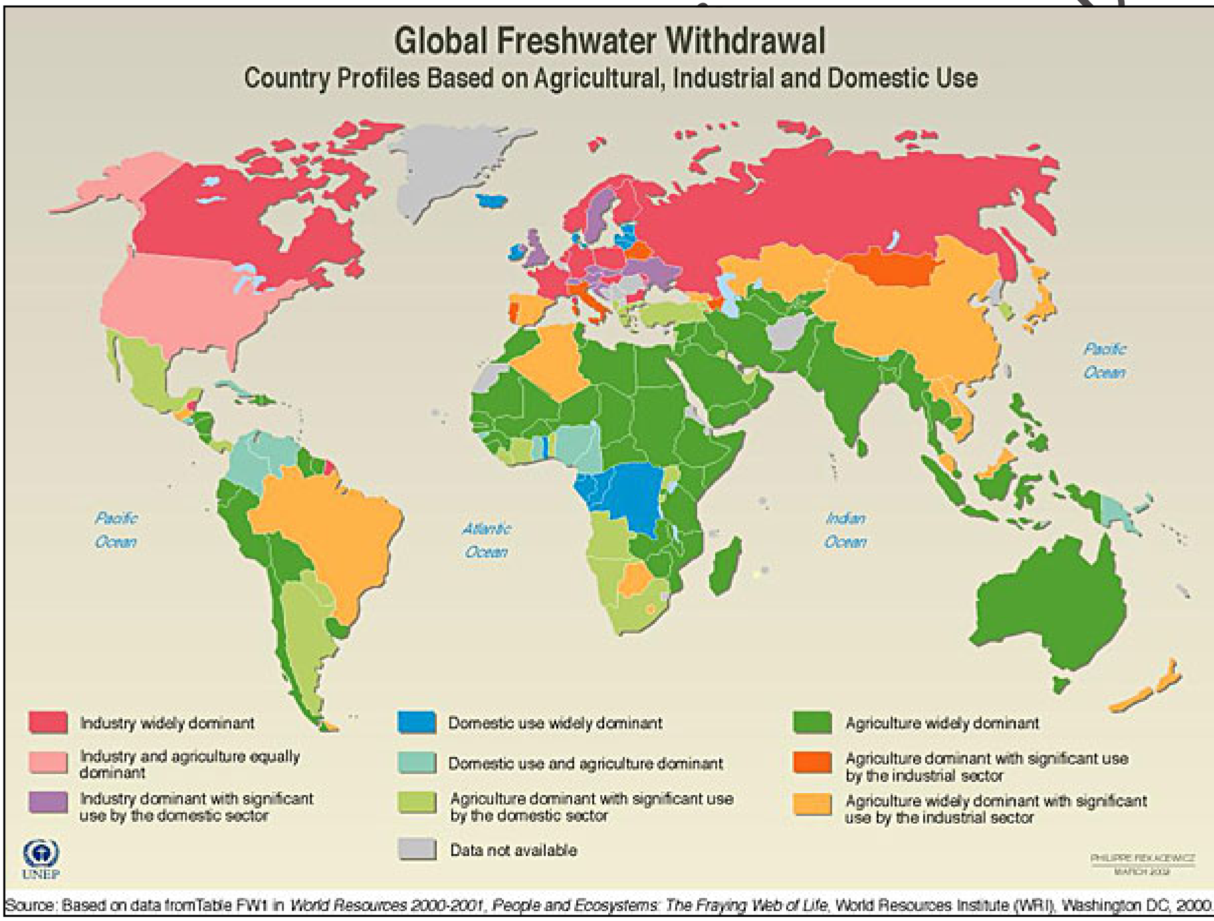


On a global scale, agriculture, industrial and domestic freshwater withdrawal is shown in Figure 14.5.

The agricultural sector is by far the biggest user of water (Cook, 2005):

- In 2000, agriculture accounted for 67% of the world's total water withdrawal, and 86% of consumption (UNESCO, 2000).
- In Africa and Asia, 85-90% of all the freshwater used is for agriculture (Shiklomanov, 1999).
- To satisfy global demand for food, by 2025, water requirements in agriculture are expected to **increase** by 1.2 times, (in industry, 1.5 times and domestic consumption by 1.8) (Shiklomanov, 1999).
- By 2000, 15% of the world's cultivated lands were irrigated, accounting for almost half of the value of global crop production (UNESCO, 1999).

Figure 14.5. Global freshwater withdrawal



Today 31 countries face chronic freshwater shortages. Among the countries likely to run short of water in the next 25 years are Ethiopia, India, Kenya, Nigeria and Peru. Parts of other large countries (*e.g.* China) already face chronic water problems (Hinrichsen *et al.*, 1998; Tibbetts, 2000).

International Commission of Irrigation and Drainage (ICID)

Within this water context, ICID plays a vital scientific and technological role. The International Commission on Irrigation and Drainage (ICID) was established in 1950 as a scientific, technical, professional, voluntary, not-for-profit, non-governmental international organisation (NGO), dedicated, *inter alia*, to enhancing the worldwide supply of food and fibre for all people by improving water and land management, and the productivity of irrigated and drained lands through the appropriate management of water, environment and the application of irrigation, drainage and flood control techniques.

Mission of ICID

The mission of the ICID is to stimulate and promote development of the arts, sciences and techniques of engineering, agriculture, economics, ecology and social science in managing water and land resources for irrigation, drainage, flood control including river training applications, and research and development, capacity building, adopting comprehensive approaches and up-to-date techniques for sustainable agriculture in the world.

Objectives of the ICID

The ICID reaches its objectives by giving attention to matters relating to:

- The planning, financing, economical and environmental impacts of irrigation and drainage for the reclamation and improvement of cultivated land, as well as the design, construction, operation, maintenance and management of related engineering works and engineering facilities.
- The planning, financing, economics and environmental impacts of schemes for river handling and action for flood control and protection of agricultural land against sea water penetration, as well as the design, construction and operation of related works, with the exception of matters regarding the design and construction of large dams, navigation and basic hydrology.

Modus operandi of the ICID

The objectives of the ICID are reached by means of:

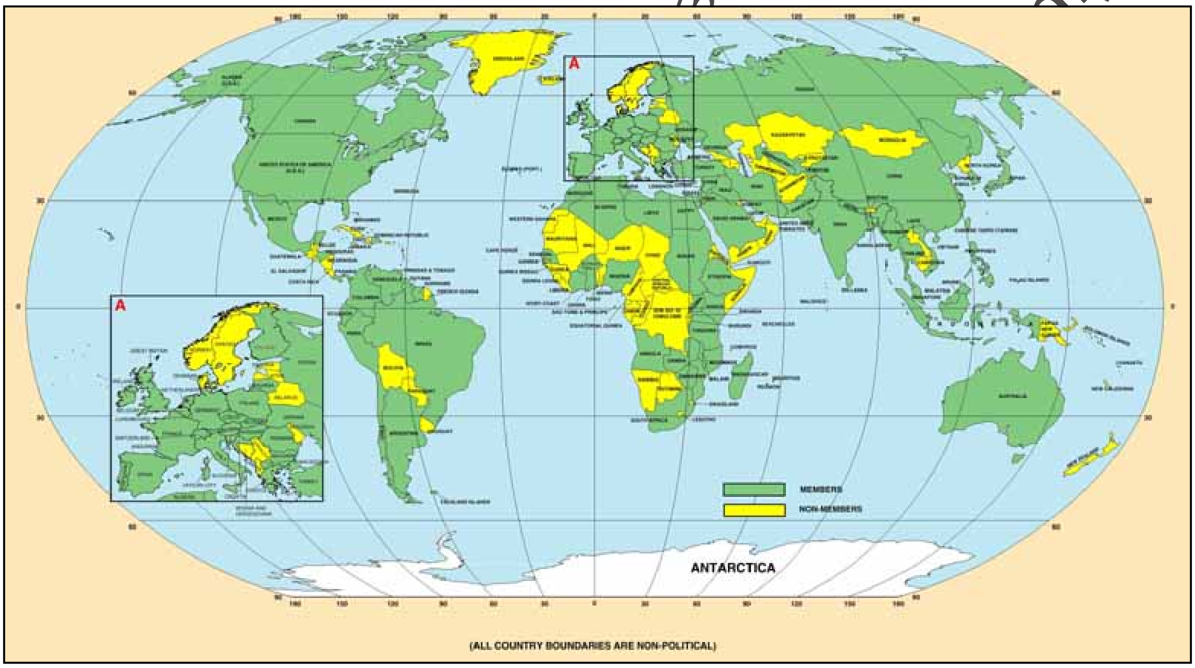
- Exchange of information between the national committees.
- Implementation of activities by committees, working groups and work teams on specific themes that are in the interest of member countries.
- Organising studies and experiments.
- Publishing dissertations, reports and documents.
- Co-ordinating with other international organisations with the same or related interests.

Internal organisation of the ICID

The vision and objectives of the ICID are determined by the International Executive Council (IEC), on which every national committee is represented. The IEC decides on all matters and policy that may be initiated by a member country. Committees and working groups are assigned to carry out its functions and implement policies and decisions.

The ICID's IEC meets each year and an International Congress is held every third year. The ICID was founded in 1950 with 11 countries and currently has 104 member countries (see Figure 14.6 for the membership network of ICID).

Figure 14.6. ICID membership network in August 2005



ICID events

ICID organises triennially World Irrigation and Drainage Congresses and annually, in rotation, one of the four regional conferences, namely, the African Regional Conference, Asian Regional Conference, European Regional Conference, and Pan-American Regional Conference to address and discuss important current, regional and global issues. Through the year 2005, 19 World Congresses, 21 European Regional Conferences, ten Afro-Asian Regional Conferences, four Pan American Regional Conferences, two Asian Regional Conferences, one African Regional Conference and eight international exhibitions have been held. Nine international drainage workshops have been organized. Symposia, seminars and special sessions are also held at the time of congresses and/or ICID's annual International Executive Council meetings and on various other occasions.

Information exchange

ICID's library houses more than 30 000 technical books and receives 150 periodicals. A Text Delivery Service (TDS) on irrigation, drainage and flood control is available on ICID's website *(www.icid.org/library.html)*. This includes access to the library holdings of publications, article references, grey literature etc., as well as information received from national committees. Quarterly newsletters and monthly news updates compiled by ICID provide current information on water-related activities of the Commission and other organisations. The ICID website (*www.icid.org* and *www.ciid-ciid.org*) provides all the information on ICID and its activities, including the quarterly newsletters, monthly news update, annual report and ICID directory.

Internal organisation of the ICID

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Collaboration with the United Nations and other international organisations

ICID has a consultative status with the United Nations Economic and Social Council (ECOSOC) and WNESCO since 1954. With the FAO, ICID has specialized consultative status since 1955. ICID, the World Bank and UNDP jointly sponsored the International Programme for Technology Research in Irrigation and Drainage (IPTRID) to enhance priority research and technology transfer, especially in developing countries. The World Bank is also a permanent observer in ICID's IEC. ICID has co-operative arrangements with non-governmental organisations, such as CIGR, IAHR, IAHS, IWRA, ICOLD, IWMI, WEC, INPIM, and consultative status with the International Standards Organisation (ISO).

Conclusion

International scientific and technological co-operation for sustainable development is of utmost importance and the International Commission on Irrigation and Drainage (ICID) is specifically focused and committed to the worldwide supply of food and fibre for all people by improving water and land management, and the productivity of irrigated and drained lands through appropriate management of water, environment and the application of irrigation, drainage and flood control techniques.

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Chapter 15

COUPLING SURFACE AND GROUND WATER RESEARCH: A NEW STEP FORWARD TOWARDS WATER MANAGEMENT

INTERNATIONAL CENTRES FOR INNOVATION, RESEARCH, DEVELOPMENT AND CAPACITY BUILDING IN WATER MANAGEMENT

by
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This paper describes and discusses the proposal of the IAP water programme to implement international centres of research, innovation and capacity building in water resources.

These centres, located on different continents, will have the task of developing an integrated, predictive ecosystem (watershed) approach in research and management. Capacity building will focus on the training of managers and technical staff, a critical issue in water management. The centres will be catalysts of scientific, technical and managerial activities.

A series of workshops in Brazil, South Africa, China, Poland, Kazakhstan and Jordan are programmed for 2006 in order to discuss the implementation of these centres and an operating network.

Introduction and background

At the beginning of the 21st century there is a water crisis, which is a consequence of a long history of excessive and inadequate use, pollution and contamination, and increasing demand. There are several demands and multiple uses of water with growing withdrawals of surface and ground water reserves. Increasing urbanisation has created rising demand for freshwater in very large quantities. In the next 20 years the rate of urbanisation will continue to grow, and by the year 2025, there will be 30 megacities with more than 8 million inhabitants and 500 cities of 1 million inhabitants. To supply clean and adequate water to these cities is a scientific, technological and managerial challenge (Jimenez *et al.*, 2004).

Water exists in the atmosphere, on the earth's surface and underground. However, at any given time, only 0.001% of the planet's water is located in the atmosphere. The overwhelming majority is located in both surface and ground water reserves. Hydrologically, wherever precipitation falls, the natural shape of the land directs the runoff into lakes, streams and rivers constituting the watersheds. Watersheds integrate the surface water run-off of an entire drainage basin and they are vital to human civilization, playing a critical role as sources of water, food, hydropower, recreational amenities, and transportation routes. Although great quantities of fresh surface water are present in many large watersheds, often extending across one or more international boundaries and providing the largest parcel of the water consumed in the world, the great majority of the earth's liquid fresh water is located beneath the surface.

Ground water has been used by humans since the beginning of civilization. However, until less than a century ago, consumption was limited only to near-surface water. With the fast advance in technology, deep ground water is now extracted on a large scale. Over the last decades, especially in arid and semi-arid areas and in big cities around the world, the aquifer over-abstraction has been causing rapid lowering of the potenciometric surfaces and water levels, increasing pumping costs and decreasing yields. Another problem resulting from ground water overexploitation is an irreversible dewatering and compaction of the sediments resulting in subsidence and other geotechnical problems, as are occurring in places such as Mexico City, Venice and Bangkok.

Multiple uses of both surface and ground water are increasing and many local and regional authorities now consider water as a basic asset for development (Gleick, 1993). On the other hand, degradation of water bodies by human activities may undermine their abilities to provide water ecosystem and economic services, potentially imposing enormous environmental and socio-economic losses (Wetzel, 1992).

Although the hydrological cycle provides all the water on the planet, traditionally surface and ground water have not been viewed or managed as integrated units. The disconnection between policies and practices regarding the two main water compartments in part is due to the failure of professionals (both scientists and managers) in considering them as integral units, thus recognising their interdependence. What happens in a watershed can have a profound impact in the aquifers, both qualitatively and quantitatively. Pollution, for example, is the most serious human impact on water today. An increasing variety of contaminants is finding its way into both surface and ground water supplies, especially in urban and industrialised areas. The chief pollutants – such as waste disposal sites (landfills, sewage treatment lagoons and disposal pits) and non-point sources (urban runoff and water from agricultural land treated with fertilizers and pesticides) contaminating surface and ground waters – have a common source. Effective management will depend on a deep understanding of the processes regarding water (*e.g.* water regime, aquifer recharge, water quality) and catchment issues (*e.g.* land uses, terrestrial inputs) (Foster *et al*., 2002).

The present dichotomy regarding surface and ground water issues can be treated advantageously by an integrated holistic approach considering that there is a common source of problems (pollution, over-extraction, over-commitment), although subsequently resulting on different processes (eutrophication, contamination) and symptoms (excessive production, toxicity, salinisation). Sustainable management on surface and ground water resources will not be possible unless scientists and managers can bridge professional and cultural gaps, gaining the best possible understanding and knowledge, in order to adequately manage the water cycle.

The IAP Water Programme can be a new paradigm by proposing that water cycle (atmospheric, surface and ground water) management be considered with an integrated predictive and ecosystemic (watershed) approach adapted as the basis for management (Likens, 2001).

Water resources and development

The basis for economic development and increased quality of life is good-quality water. The pressure for multiple uses increases with development. Therefore an adequate scientific and managerial approach is necessary to deal with this problem. Costs of water and water treatment will increase with development, therefore it is necessary to educate people in good practices, provide cheaper techniques for water treatment and promote conservation of clean natural sources. Irrigation will play an important role in the 21st century and quality control of irrigated water will be a basic need for many countries and regions.

Industrial development requires water, and to promote industrial growth, incentives for saving water and treating effluents are necessary. Management instruments such as the implementation of legal and institutional frameworks are necessary to protect water supplies and regulate their use (Meybeck *et al.*, 1990).

The medium-sized cities of several countries (towns of 50 000 to 200 000 inhabitants) are now facing a water crisis due to contamination of the supply sources and the discharge of untreated sewage downstream. This is also aggravated due to the disposition of solid waste, which is always located in the watersheds far away from the cities, affecting the water supply of other urban regions downstream (Lee, 1992; Rebouças *et al.*, 1999).

Water resources and the economies of urban and rural regions have strong linkages that need to be taken into account for management (Gleick, 1993).

Proposal

In order to cope with these problems it is necessary to improve programmes for water conservation, water management, wastewater treatment, control of eutrophication and contamination, and to develop a strong international scientific and technical capability based on research, development and innovation. Managerial capacity has to be improved, and research and development to enhance management is essential. As development progresses, there is a permanent need to improve and further increase capacity building, including in this process researchers, water resource managers and water technicians. A strong link has to be developed between researchers, technicians and managers in order to improve management programmes and to promote an integrated**,** predictive ecosystem approach, or in other words, a watershed approach. Agenda 21 is very clear on this need for capacity building, human resources development, innovation and institution building (IAC, 2003).

> *"Many governments will need to assign a high priority to their capacity-building efforts towards institution-building, legislation and human resources development. National efforts in this regard need to be supported by international, regional and national external support agencies, and by the non-governmental community, including the private sector."* (Agenda 21, United Nations, 1993)

The international centres for research, development, innovation and capacity building

As part of the framework for improving the development of human resources and the integration of innovation research and management, it is necessary to implement centres for development of these activities that will act as nuclei for development of new technologies, research, capacity-building and field facilities for these studies.

There centres will be linked through a network that will provide a facility for exchange of scientific data, research information and capacity building programmes. These centres will emphasise the integrated management of *atmospheric, surface* and *ground* waters. The exchange of regional scientific and technical information is essential in this effort as well innovative management procedures and tools, such as those proposed by Zalewski *et al.*, 2001.

The need for international centres

Capacity-building facilities for advanced training at the specialist level, integrated in a network of institutions, are scarce in many regions of the world although they are extremely necessary. Several programmes for training at MSc and PhD level emphasise local problems, but it is necessary to expand the scope of these programmes and place them into the context of a larger reality considered from a comparative perspective. An International Center in Water Resources Management will provide a forum for permanent discussion, preparation of case studies, and integration of research and management in a global perspective. Besides the regional context, the international centres will have visitors from many countries from industrialised regions, young PhDs and managers that will interact in a productive and creative atmosphere, stimulated by the international environment and the existing facilities for research, field work, and access to specialised literature. Such a concentrated facility should be enhanced by using existing facilities at present. There is a need or the articulation of researchers, laboratories and libraries to stimulate a programme of high-level teaching and research.

The existing local/regional infrastructure for water resources research and management will undoubtedly provide the necessary scholarly and applied atmosphere necessary for productive work.

International centres (ICs) will have the task of drawing attention to the water problems of the world with an integrated approach. They will place together scientists and managers that will address the pressing problems of water supply and, at the same time, will produce advanced scientific knowledge. They can stimulate publications and will enhance activities for public awareness. Managers and scientists will take part in specialised training modules, working in co-operation with local and regional universities. At the same time, suchan IC will be co-operating with other international centres worldwide, thus forming a network that will stimulate advanced scientific research of the highest quality. This programme will accelerate the development of partnerships between public and private institutions, integrating water resources development and management (Tundisi and Straskraba, 1995).

Objectives of the international centres

- To develop a focus on innovation, research and development, and capacity building in water resources and related issues; and on control, management and treatment of water, including technologies for watershed (surface and ground water) management and remediation and recovery.
- To promote and maintain a permanent advanced training activity in water resources management in order to improve regional standards of training and enhance the preparation of qualified human resources in these fields of expertise. This advanced capacity building programme will have a strong scientific and technological basis.
- To establish a network of collaborating institutions in the world, in order to utilise the best existing capacity and to provide the best quality training-based research on development and innovation for scientists, managers and technicians. This network will also be extremely useful and fundamental for exchange of scientists, managers and decision makers.
- To develop new approaches, mechanisms and techniques of capacity building at technical and scientific levels, integrating research approaches, and innovation in water resources;
- To prepare researchers, technicians and water resources managers with the best qualifications in order to meet the growing demands for human resources in scientific research and water resources management.
- To provide opportunities for a permanent exchange of qualified personnel.

It is clear that each IC will add more activities and emphasise regional/local priorities.

Training programmes will emphasise comparative studies, field work, practical lectures, intensive use of field facilities and demonstration of water management problems. Training modules will be designed in order to promote integration of science with management, providing the trainees with the best technological and scientific tools to develop research and management (Tundisi *et al*., 2000).

Staff will be recruited from local expertise and a number of invited visiting scientists will be involved in each training activity. This will enhance the quality of the programme and will stimulate the development of joint research projects with a network of profess-sionals, training fellows and institutions.

Focus of the international centres

Research and development in water management

In order to provide a solid scientific and technological background for the ICs, there must be a focus on research and innovation development. This focus will enhance the performance and the role of the IC and will promote the necessary systemic approach to the problem of research and water management. The systemic approach will enhance the watershed as a unit of research and management and can address problems of water quantity and quality integrating atmospheric, surface and ground waters (OECD, 2003).

For example, the prevention of eutrophication and the restoration of eutrophic lakes and aquifer contamination by nutrients require proper planning and management of associated watersheds. Therefore, sound management strategies for control of eutrophication require an understanding of the relationship between nutrient sources and degrees of contamination (IETC, 2000).

The watershed – a physical unit with a hydrologically integrated ecosystem – has been adopted as a unit for integrating research and monitoring and for managing and administering water resources. Integrated management should be adaptive, producing new ideas and tools, and this can only be achieved with local participation and political and managerial support. Education at all levels plays a fundamental role (Robarts and Wetzel, 2000).

> "Enhance national water resource assessment capabilities and measurement networks and establish water resource information systems that enable people to understand the options available for sustainable urban, industrial, domestic and agricultural development in combination with environmental conservation." (Agenda 21, United Nations, 1993)

Next steps

A series of workshops in 2006 to discuss local/regional problems in the implementation of the centres is planned in Brazil, China, Kazakhstan, Jordan, Poland and South Africa.

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Chapter 16

IMPLEMENTING THE NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT (NEPAD) INITIATIVE ON THE CREATION OF CENTRES OF EXCELLENCE ON WATER SCIENCE AND TECHNOLOGY

by
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Introduction

The approach which has been used in this initiative has been first to identify the issues/priorities that – among others – will assist African countries to meet targets related to "water for development", for example, the seventh Millenium Development Goal. The second element of the approach is to underline the process of co-operation between UNEP and NEPAD, which involved several steps:

- NEPAD/IRD/UNEP/AMCOW/UNESCO Workshop held in Nairobi in May 2005. One of the recommendations of the workshop was the recognition of the need to create a NEPAD water task team.
- The NEPAD water task team first met in Pretoria in July 2005. A series of terms of reference and project proposals related to water were developed, including factors to consider for the identification and designation of networks of centres of excellence on water sciences and technology.
- Specific recommendations have been made to ensure further meetings between AMCOW (African Ministers' Council on Water) and AMCOST (African Ministerial Council on Science and Technology) that will aim at *i)* reviewing the terms of reference and various project proposals; *ii)* adopting the terms of reference and identifying resources with NEPAD and its partners to begin implementation of a network of centres of excellence on water sciences and technology.

All heads of state and government representatives agreed on the following overall goal for water policy development:

> *"Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases."*

At their December 2003 conference in Addis Ababa, African Ministers addressed the fact that in the last three decades there has been no lack of declarations, recommendations, action plans and targets on the equitable and sustainable use of water resources. However, there has been a lack of political will, technical capacity and funds to implement those plans and start closing the growing gap between water management plans and the lack of safe water and sanitation for several hundred million poor people throughout Africa.

Key water policy priorities

The various national to regional water management plans over the last three decades essentially focused on the following eight key water policy challenges:

- The lack of adequate and accurate information for effective decision-making.
- The lack of safe water and improved sanitation for the majority of the poor.
- The lack of adequate and unpolluted water for efficient food production.
- The lack of proper laws, enforcement and projects to protect watersheds and ecosystems.
- The lack of preventative measures and contingency planning for floods and droughts.
- The lack of true and fair valuations, leading to the misuse and misallocation of water.
- The lack of stakeholder participation leading to poor policies, decisions and implementation.
- The lack of co-operation, leading to water mismanagement, unfair use and conflicts.

These eight key water policy challenges are largely the consequences of water policy failures that include:

- Water that has been poorly monitored has usually been poorly managed as well.
- Clean water has too often been subsidised for too few while being a luxury for the poor.
- Water has too often been too inefficiently and inadequately used to produce enough food.
- Development that has destroyed water ecosystems.
- Too many lives have been lost because of too little, too much or overly polluted water.
- Unfair allocation of water that has been unevenly distributed by nature
- Water has been a mismanaged public good because decision-making was too exclusive.
- Shared water has often not been shared fairly or wisely among communities and countries.

For at least the next decade, the eight key water management policy priorities from the community to continental level in Africa are:

- Ensuring the knowledge base.
- Meeting basic needs.
- Securing the food supply.
- Protecting ecosystems.
- Managing risks.
- Valuing and allocating water.
- Governing water wisely.
- Sharing water resources.

The last seven of these eight water management policy priorities were agreed and set out in the Ministerial Declaration on Water Security in the 21st Century in March 2000 in The Hague and marked "the emergence of an international consensus on the importance of water in sustainable development" (WWDR, 2003). The first priority of "ensuring the knowledge base" was added as it is so crucial for achieving the other seven water policy priorities. The World Water Development Report briefly described the eight priorities as follows WWDR, 2003, 19-20):

- **Ensuring the knowledge base**: reflecting that good water policies and management depend upon the quality of knowledge available to decision-makers.
- **Meeting basic needs**: recognizing that access to safe and sufficient water and sanitation are basic human needs and are essential to health and well-being and to empower people, especially women, through a participatory process of water management.
- **Securing the food supply**: enhancing food security, particularly of the poor and vulnerable, through the more efficient mobilization and use of water and the more equitable allocation of water for food production.
- **Protecting ecosystems**: ensuring the integrity of ecosystems through sustainable water resources management.
- **Managing risks**: providing security from floods, droughts, pollution and other water-related hazards.
- **Valuing and allocating water**: managing water in a way that reflects its economic, social, environmental and cultural values in all uses with a move towards pricing water services to reflect the cost of their provision. This approach should account for the need for equity and the basic needs of the poor and vulnerable.
- **Governing water wisely**: ensuring good governance so that the involvement of the public and the interests of all stakeholders are included in the management of water resources.
- **Sharing water resources**: promoting peaceful co-operation and developing synergies between different uses of water at all levels, whenever possible within and – in the case of boundary and trans-boundary water resources – between concerned states through sustainable river basin management or other appropriate approaches.

The World Water Development Report also added the following water policy priorities:

- **Water and cities**: acknowledging that urban areas are increasingly the focus of human settlements and economic activities and that they represent distinctive challenges to water managers.
- **Water and industry**: focusing on industry needs and the responsibility to respect water quality and take account of the needs of competing sectors.
- **Water and energy**: recognizing that water is vital for all forms of energy production and that there is a need to ensure that energy requirements are met in a sustainable manner.

Since the Ministerial Conference and Declaration in the Hague in March 2000, these water policy priorities have been reinforced by the launching of the African Ministerial Conference on Water and by the 2002 Accra Declaration on Water and Sustainable Development which called for "policies, strategies and real commitments to implementation in six key areas with all undertaken in a manner designed to protect the environment" (WWDR, 2003, 21). Reflecting the same water policy concerns and priorities agreed and incorporated in the earlier Hague Ministerial Declaration, the six key areas in the Accra Declaration are:

- Improved access to potable water services and sanitation.
- Water use to address food security and income generation.
- IWRM in national and shared water basins.
- Water-related disaster prevention, mitigation and management.
- Empowerment and capacity building focuses on improving equity and gender sensitivity.
- Water governance and policies to favour the poor.

In sum, a clear consensus has emerged in the last few years on the key water management policy challenges and priorities in Africa and especially on "the need for more integrated approaches, stronger partnerships and a more effective focus on poverty reduction and sustainable development in water policy processes" (WWDR, 2003, 21). What is now needed is an equally clear consensus on how to tackle those water policy priorities and targets immediately and effectively.

Now that those key water policy priorities within Africa have been clearly identified, it is opportune to discuss how the creation of an effective and efficient network of Centres of Excellence in water sciences and technology in Africa could assist African countries in meeting international goals related to water for sustainable development. A certain number of criteria have to be met, and these have been extensively discussed during the first NEPAD task team meeting. Implementation and timely action are key if we want to make progress.

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Chapter 17

WATERPOOL:
THE AUSTRIAN COMPETENCE NETWORK FOR WATER RESOURCES MANAGEMENT

by
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Introduction

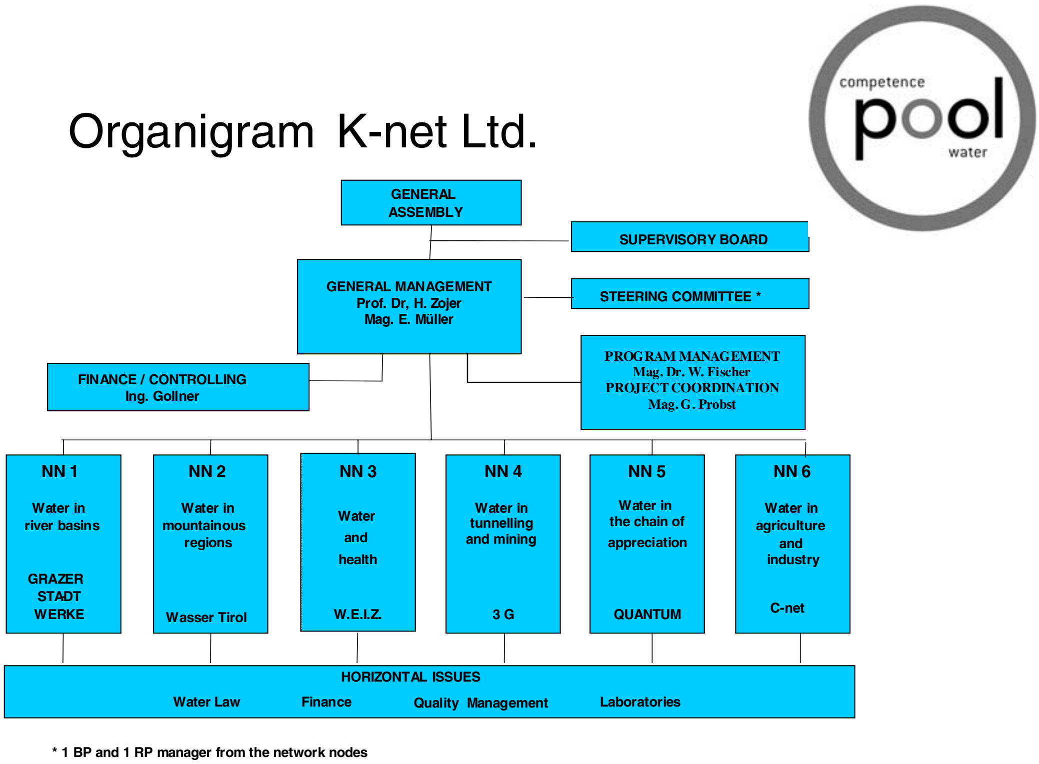
The Waterpool Competence Network was established in December 2003 to link water technology businesses, water-using industry and water research in Austria as well as in Central and Eastern Europe. It devises innovative and integrative approaches and solutions in order to optimise water resources management. Through transfer of know-how between partners and competence building, we can assist the development of the national water market and actively market Austrian know-how at the international level. The Competence Pool consists of about 75 partners from Austria, Slovenia, Croatia and Italy. The increasing number of partners and inquiries received is an indicator of the project's success. The programme is very close to EU strategies and very well received. The Austrian Federal Ministry of Economic Affairs and Labour finances about 40% of the programme. The Austrian federal states of Styria, Carinthia and Tyrol, the *Amministrazione Provinciale di Pordenone* in Italy, as well as Slovenia and Croatia together provide 20% of funding, and the remaining 40% is financed by about 35 business partners. According to the programme's funding guidelines, it is also possible to invite further foreign partners to participate. These are expected to be mainly those companies that could lead the way for Austrian business partners in their fields (*e.g.* irrigation, measurement and test engineering, engineering, tunnel construction). These companies can bring in a higher level of competence and this could lead to joint ventures with Austrian businesses.

Network structure

The network centre in Graz (Styria, Austria) (*www.waterpool.org*) is the recipient of the funding and, as K-net Ltd., is the body legally responsible for the competence network. The network centre is responsible for general scientific and economic management of the competence network. Its activities are restricted to research planning, co-ordination, controlling and evaluation. The actual research work is decentralised, according to the network philosophy.

Figure 17.1 illustrates the K-net structure. The network centre is the top level of research co-ordination. At the second level, the six competence nodes (or network hubs) are administratively managed by network partners (mainly business partners), and they are the units of knowledge transfer. The leaders of the research nodes are at the third level. A scientific project manager is appointed for each of the almost 45 projects or "work packages" at the fourth level of K-net. The managers are responsible to the network centre for the scientific and financial success of the projects. Individual module management can exist within the "work packages".

Figure 17.1. Organisation of K-net Ltd.



In addition to the vertical projects, there are also horizontal research fields, which connect to projects in individual topic areas. These horizontal research fields are run by the K-net management, which may appoint "key researchers" for them.

The competence nodes have a specific topic focus. Each competence node will work on its dedicated topics, and increase its competence and international competitiveness. As From spring 2006, a seventh net node (water for power plants) will be set up, one of many indicators of the success of Waterpool and its partners' co-operation.

Within the network, participating business and research partners are matched to competence nodes according to regional and thematic criteria to carry out the research projects, and in the case of business partners, to co-finance the network budget.

K-net Water was purposely established as an open network, so other partners can join and develop new network nodes. The choice of research areas can thus be expanded.

As project results are processed within the individual network nodes, an information network forms, through which know-how and information are shared. Improved knowledge and information are essential for future research assignments.

Value added for business and research

The added value of the water competence network for each company lies in the following:

- The implementation of the K-net Water funding programme allows stronger co-operation between business partners as well as between university and extra-university research institutions.
- Funding measures provide an incentive for highly innovative research projects in industry, tourism, and supply of drinking water and water for industrial purposes.
- A continuously progressive build-up of competence in business will take place through individual network nodes, which unify project and information networks. They are responsible for public relations, mobility and innovation management. Educational and training programmes thus play an important role.
- The focus on specialist competencies and the common presentation of several research and business partners result in a higher value added from R&D investments.
- The competitiveness of our business partners will increase because research results are directly generated within the company and/or through intensive co-operation with research partners. It is therefore not necessary to use resources to buy those results elsewhere (fairs, markets, etc.).
- In an international perspective, the market can be better prepared through additional know-how and this again increases our competitiveness.
- Accompanying network marketing serves as a way to track information, which brings advantages for positioning in the international market.
- Strategic business decisions can be better prepared through the network and can be made more easily with the establishment of field-related basic concepts.

Economic relevance

The economic importance of the programme is considered to be very high, especially due to the fact that business and research partners show, for the first time ever, their interest in building up common competences in the area of water resource management and in implementing these on the market. A great advantage for the business partners is that through co-operation of this kind, they will have contributed to the research results. Up to now, companies usually had to buy these results from research institutions. The increased competitiveness should be of importance on the international market as well.

The international water and energy industry

Austrian water suppliers together with research institutions have built up enormous knowledge in the structure and management of artificial ground water recharge which can be applied in dry regions (Southern Europe, but also in other semiarid and arid areas). The European Union shows an extraordinary interest in these technologies, which could revolutionise drinking water management in the Mediterranean area. They are aimed at using the large surplus quantities of winter underground water to guarantee a supply of drinking water and possibly water for irrigation in the dry summer period (artificial recharge and recovery, ARR). The importance of this question is underlined in a series of publications that recommend, along with the development of an early warning system and emergency plans, the development of strategies to meet water supply requirements during dry seasons and in dry/arid areas. Artificial recharge will take up a large part, depending on natural and socio-ecological conditions.

Large water suppliers that expand beyond their areas are of special economic relevance in the field of water service, as this results in the creation of affiliates. In this regard, K-net's role will be to support Austrian public water supplier "spin-offs" entering the international market.

"Water-relevant" tourism and health centres

This type of tourism can include holidays spent at thermal spas, as well as winter tourism (*i.e.* ski resorts, with their very high water consumption to produce artificial snow). Developments in this field include enlarging historic spa centres (some of which date back to the times of the Austro-Hungarian empire) and alpine skiing centres, which involve an environmental component and where individual business people already use research as part of their advertising strategies. There is also a medical component in the reputed therapeutic qualities of thermal waters.

Mining and tunnel engineering

Difficult situations in mining often result from water leakages which can often lead to dangerous conditions for workers. Construction companies are therefore interested in safety prognoses and information about incoming water quantities. Co-operation between tunnel construction companies and research institutions in this field is therefore very lucrative, especially when considering the international tunnel construction market.

Quality assurance of drinking water and in the beverage industry

The safety and quality of water reservoirs is not only of importance for present sites but is also a basis for risk estimation with investments in new segment markets or new positions.

Irrigation

Here the main concern is to understand the relationship between groundwater retention and water consumed by vegetation. Sensor companies find a wide spectrum of useful appliances such as in agricultural irrigation, irrigation of sporting areas, etc.

Measurement and data handling

Hydrologic measurement nets in alpine as well as in flat areas and in underground mining require specific methods of data collection, saving and transmission. Great efforts are therefore being undertaken in the area of measurement technology to register point, linear and special area data.

Relevance and intensity of co-operation as an indicator

The high degree of co-operation is one of the indicators for the success of a research network such as Waterpool. Altogether approximately 75 business and research partners are working on 40 "work packages" (projects). Some of the partners are involved in more than one project (which accounts for the totals in Table 17.1), which is another indicator for the dissemination of results and the transfer of know-how among the partners involved. It is therefore very important to build up a partnership structure within a given project to allow for co-operation between Austrian and foreign partner institutions.

Table 17.1. Number of work packages and partners involved

Net nodes	Work packages	Business partners	Research partners	Austrian partners	Foreign partners
Net node 1	4	7	8	10	5
Net node 2	8	8	7	12	3
Net node 3	12	11	11	17	5
Net node 4	6	7	9	13	3
Net node 5	7	8	7	15	0
Net node 6	3	4	5	1	8
Total	40	45	47	78	24

The content of the work packages and the results of investigations are further indicators of the deeper goals and strategies of the Pool. All six thematic fields of investigation (represented by the six net nodes) are very important for future improvement in the quality and quantity of water usage all over the world. After the first period of four-and-a-half years, another three years will allow new partners to join the Waterpool network in order to improve knowledge in regard to water-related themes. There are already many interested partners from developing countries. In addition to being the initiator of the Waterpool network, the Institute of Water Resources Management, a department of Joanneum Research in Austria, also organises summer universities with researchers in the field of water from all over the world. The training within these international groups creates contacts and transfer of know-how.

Adequate indicators have been defined for the many different work packages in the Waterpool, with the main goal of increasing knowledge and encouraging its transfer in order to improve the situation regarding usage of clean drinking water and in the implementation of guidelines for rational water management. The evaluation of the research work and results of all the work packages will underline the progress made by the partners involved.

Chapter 18

SHARING INFORMATION AND KNOWLEDGE ABOUT WATER: GROUNDWATER EXAMPLES

by
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Introduction

Data, information, knowledge and integrated water resources management

Integrated water resources management (IWRM) integrates science-based understanding of the natural controls on water quantity and quality with appropriate and effective human technologies and actions (USAID, 2005). The success of any IWRM largely depends on the availability of information and on the capability of its users to create knowledge for finding technical and socio-economic solutions.

Definitions of data, information and knowledge are subject to many discussions. Data usually refer to measured values such as discharge volumes, depths of groundwater or concentrations of chemical compounds in water. Information is obtained by interpretation of data and answering "who", "what" and "when" questions. We can speak about knowledge if we apply information to answer the "how" questions (Ackoff, 1989).

Demarcation of the terms is important for setting conditions in the process of acquisition, management and sharing of data, information and knowledge.

Acquisition of water-related data is costly and time-consuming. Design, installation and maintenance of monitoring networks and other data collection require large investments and long-term logistics. Large database systems have to be developed to store and manage data. Data sharing is subject to confidentiality or to a price. Information is obtained from data using interpretation skills and processing techniques. Geographical information systems are required to manage information in a spatial sense. Information is more easily exchangeable than data. Knowledge is based on the understanding of information and often uses analogies. Knowledge is disseminated through publications, papers, workshops, etc. There are usually no obstacles for exchange since almost everyone acknowledges the benefits of sharing knowledge.

Water specialists, decision makers and the general public require different types of information on water. The specialists prefer "raw" data in their discipline. They are also interested in information sources and techniques used in the interpretation of data. Specialists look for "quantitative" information and make their own statistics. Decision makers need information that combines various aspects of water in order to support regulatory and policy decisions. They prefer graphs and maps showing dependencies in space and/or time and other relationships. The general public is interested in easily understandable information without technical details. They usually look for information representing local conditions.

Information on water provides an important basis for the measures and recommendations resulting from the 13th session of the Commission on Sustainable Development (United Nations, 2005), such as access to basic water services and the adoption of integrated water resources management. Information is indispensable in assessing available water resources, to optimise their exploitation and to forecast temporal and spatial changes in water availability in the future. Data and information are also required to test new scientific theories in order to assess their applicability for sustainable development. Without adequate information, it is difficult to find appropriate technical and socio-economic solutions of water-related problems in the context of integrated water resources management.

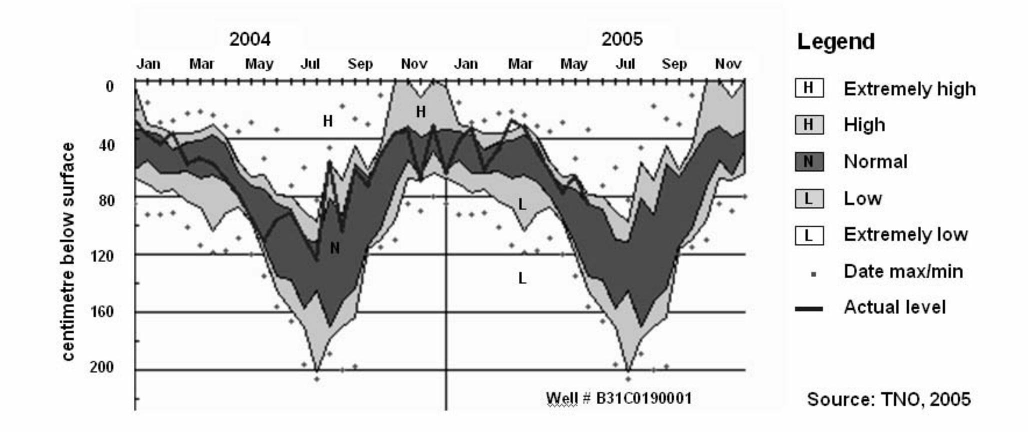
The "tulip case" in the Netherlands

Water-related problems are not limited to the arid and semi-arid parts of the world. They can also be found in regions with abundant water like the Netherlands. The country is situated in a delta and its lowland areas are prone to flooding from rivers and the sea. Not only surface water, but in the polders (land with artificial control of water levels) very shallow groundwater tables can hamper the production of agricultural crops. Several polders are used for the production of tulip bulbs, one of the main Dutch export products. The annual turnover of tulip and other flower bulbs represents EUR 1.5 billion. A small rise in groundwater of five centimetres may initiate a rotting process and reduce the production from the bulb fields by 10%. This implies potential damage to farmers of EUR 150 million. In this case, knowledge and understanding of the state of the groundwater level and of the impacts of different natural and anthropogenic factors are essential, and for this reason, groundwater levels are systematically monitored.

The Netherlands has an extensive monitoring network and groundwater level measurements are available from more than 20 000 monitoring points. Data are stored in a national groundwater archive that is operated by TNO-*Geological Survey of the Netherlands*. From the statistical analysis of time series, information can be obtained over ranges of fluctuation. This information can also be used to predict the groundwater levels a few months ahead.

Figure 18.1 shows an example of such analysis for one of the monitoring wells.

Figure 18.1. Actual groundwater levels in 2004 and 2005 against the historical regime graphs for last two decades in monitoring well B31C0190001



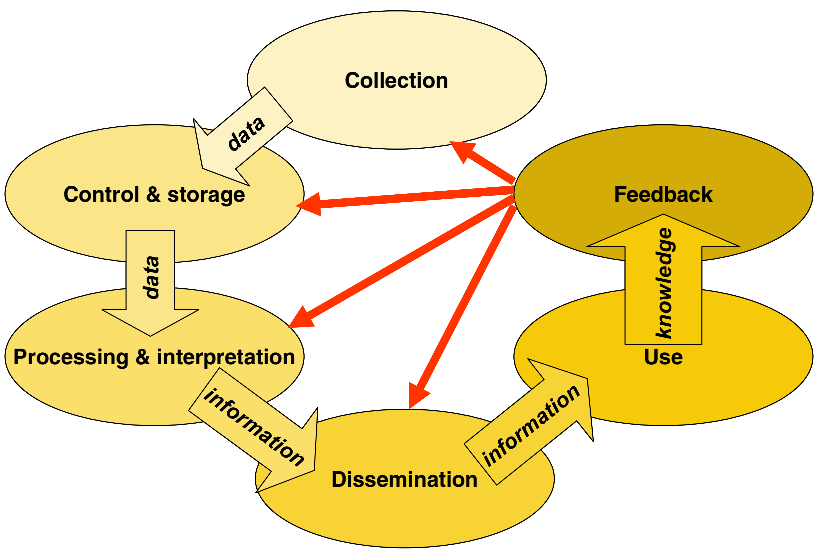
To explain the fluctuations of groundwater levels in the tulip regions, meteorological data are analyzed and combined with information on anthropogenic influences such as regulation of surface drainage, artificial recharge and changes in groundwater abstraction in nearby dune aquifers. To inform farmers on groundwater situation in their region, TNO-*Geological Survey of the Netherlands* has developed a website for selected monitoring wells. This site shows the actual groundwater levels in the context of historical long-term averages. It is periodically updated with new information.

Information management

Concept

The data and information flow from the "tulip case" is summarised in Figure 18.2.

Figure 18.2. Concept of data and information management



Groundwater level data recorded in field pass quality control and are stored in a database. Through processing and interpretation (for example, by statistical analysis) information about groundwater level trends is obtained. Information is then disseminated to the farmers in an easily understandable way. Use of information on groundwater trends in combination with information on natural and man-made factors results in knowledge on possible causes and impacts. Once the causes of groundwater level rise are fully understood, measures can be taken to mitigate the impacts. From the feedback of various stakeholders, the process of data and information management can be improved; for example, frequency of monitoring can be increased or better access to information can be established.

Management of water-related information

Management of water-related information is applied at local, national, regional and global levels. It is uncommon to find all water-related information of a certain spatial unit in one central place. In the Netherlands, for example, four different institutions centralise information related to water (Table 18.1). Information on precipitation and evaporation is managed at the Royal Meteorological Institute. Information about surface water is managed at two institutes linked with the Ministry of Transport, Public Works and Water Management. Management of information on groundwater and geology is under the responsibility of TNO-*Geological Survey of the Netherlands*.

Table 18.1. Institutions dealing with water information management in the Netherlands at national level

Theme	Database name	Administrator	Institutional status
Meteorology	KODAC	KNMI	Government
Surface water	DONAR	RIZA & RIKZ	Government
Groundwater	DINO	TNO	Non-government
Geology	DINO	TNO	Non-government

At the regional level, many institutions deal with water information related to different continents. The water sector coordinating unit of the Southern African Development Community (SADC) is an example of a regional initiative in Southern Africa for sharing data and information. At the global level there are several water-related information centres linked to the United Nations institutions. The Global Precipitation Climatology Centre (GPCC), hosted by Germany, provides global precipitation analyses for the World Climate Research Program established by the International Council for Science (ICSU) and the World Meteorological Organisation (WMO). Surface water information can be obtained from the Global Runoff Data Centre (GRDC). This centre operates under auspices of WMO and it is also hosted in Germany. The UNEP-based Global Environmental Monitoring System (GEMS)/Water Program, hosted in Canada, provides data and information on the state and trends of global inland water quality. AQUASTAT is a global information system on water and agriculture developed by the Land and Water Division of the Food and Agriculture Organisation (FAO). The International Groundwater Resources Assessment Centre (IGRAC), an initiative of UNESCO and WMO, deals with groundwater from a global perspective, and is based in the Netherlands.

The International Groundwater Resources Assessment Centre

Organisation and activities

Until recently, global centres involved in management of water-related information were focused mainly on surface water. In order to highlight the role of groundwater in global water development, IGRAC was established in 2003. The centre has a non-commercial profile. It receives financial support from the Dutch government and is hosted and staffed by Netherlands Organisation for Applied Scientific Research (TNO). IGRAC facilitates and promotes global sharing of information and knowledge required for sustainable groundwater resources development and management, including protection of ecosystems. It also supports the acquisition of groundwater data. The main activities of IGRAC include establishing a web-based global groundwater information system (GGIS) and producing/promoting guidelines and protocols on groundwater monitoring and data acquisition. IGRAC also cooperates in global programmes with groundwater component such as the World Water Assessment Program (WWAP), the World-wide Hydrogeological Mapping and Assessment Program (WHYMAP) and Internationally Shared Aquifer Resources Management (ISARM). IGRAC also aims to collect, systematise and make available more detailed information on groundwater topics, selected in response to the needs of the international community.

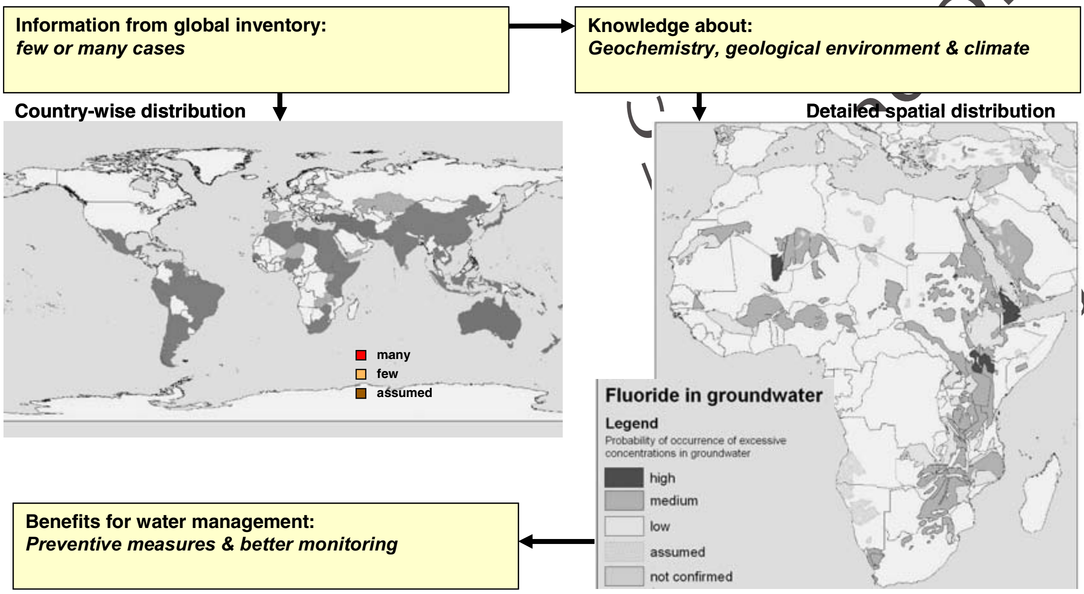
Examples of special projects

Mapping the occurrence of fluoride-rich groundwater and development of an information system on transboundary aquifers are two examples of IGRAC's special projects relevant to groundwater resources in Africa. Fluoride has a significant mitigating effect against dental caries if the concentration is approximately 1 mg/l. However, higher concentrations (in excess of 1.5 mg/l) can cause dental fluorosis and in extreme cases even skeletal fluorosis.

High fluoride concentrations in drinking water are critical in the developing countries, largely because of the lack of suitable infrastructure for treatment.

Many African countries report high fluoride concentrations in groundwater. Available reports on health and environment often refer to a number of cases, without paying much attention to mapping the variations. IGRAC's map on fluoride in groundwater is an example of mapping health risks in groundwater. For this map, IGRAC combined general information on fluoride occurrence with knowledge on geochemistry of fluorine and factors affecting the concentrations in groundwater. Since spatial information on geology and climate is available in digital maps, semi-detailed maps on the probability of fluoride-rich groundwater could be produced. Figure 18.3 schematizes the process of generating spatial information on fluoride occurrence in groundwater and shows the probability of occurrence of excessive concentrations in Africa.

Figure 18.3. Occurrence of fluoride-rich groundwater according to country-wise assessment (left) and a probability-based hydrochemical classification (right)



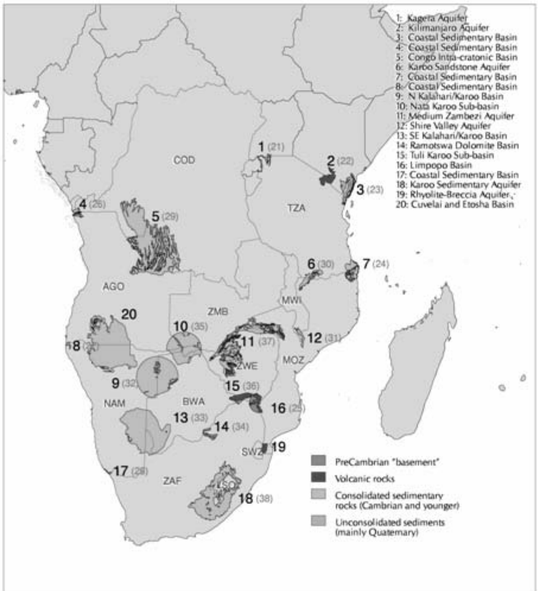
Source: IGRAC, 2005 & Brunt et al., 2004

The darkest shades on the map to the right indicate areas with the highest probability of containing fluoride-rich groundwater. This is the case in the East African Rift Valley where groundwater is enriched with fluoride from volcanic gases. Information obtained from the map can be used in the selection of new water supplies. This information can also help to optimize monitoring networks in order to collect more data on fluoride occurrence.

Trans-boundary aquifers cross boundaries between two or more countries. Management of trans-boundary aquifers is subject to bilateral agreements on abstraction, prevention of pollution and other relevant measures. A proper hydro-geological characterisation of a specific aquifer system, combined with understanding of legal, socioeconomic, institutional and environmental issues related to sharing the groundwater resources is crucial in this context. Information sharing is a first essential step in the management of trans-boundary aquifers. IGRAC participates in the ISARM programme on internationally shared aquifers as the partner responsible for information management.

To support the process of information sharing in the SADC region, IGRAC is developing a web-based information system on SADC trans-boundary aquifers. A map of trans-boundary aquifers is an essential part of this system. Delineation of aquifer geometry is sometimes very difficult because the lateral extent of aquifer formations and the lateral/vertical hydraulic continuity are poorly defined. IGRAC used publicly available information to produce a map with the preliminary delineation of 20 trans-boundary aquifers in the SADC region. The map, shown in Figure 18.4, serves as a geographical base for the information system. For each of the aquifers, information is collected on more than 80 attributes in various categories relevant to the management of trans-boundary aquifers. The system also allows managing data on organisations, people and documents related to the individual countries.

Figure 18.4. Trans-boundary aquifers of Southern Africa
(delineation and names are based on publicly available information)



No	Aquifer name	Countries
1	Kagera Aquifer	Tanzania, Uganda
2	Kilimanjaro Aquifer	Tanzania, Kenya
3	Coastal Sedimentary Basin I	Tanzania, Kenya
4	Coastal Sedimentary Basin II	DR of Congo, Angola
5	Congo Intra-cratonic Basin	DR of Congo, Angola
6	Karoo Sandstone Aquifer	Mozambique, Tanzania
7	Coastal Sedimentary Basin III	Mozambique, Tanzania
8	Coastal Sedimentary Basin IV	Angola, Namibia
9	Northern Kalahari/Karoo Basin	Namibia, Botswana
10	Nata Karoo Sub-basin	Angola, Namibia, Zambia, Botswana
11	Medium Zambezi Aquifer	Zambia, Zimbabwe, Mozambique
12	Shire Valley Alluvial Aquifer	Malawi, Mozambique
13	SE Kalahari/Karoo Basin	Namibia, Botswana, South Africa
14	Ramotswa Dolomite Basin	Botswana, South Africa
15	Tuli Karoo Sub-basin	Botswana, South Africa, Zimbabwe
16	Limpopo Basin	Zimbabwe, South Africa, Mozambique
17	Coastal Sedimentary Basin V	Namibia, South Africa
18	Karoo Sedimentary Aquifer	Lesotho, South Africa
19	Rhyolite-Breccia Aquifer	Mozambique, Swaziland
20	Cuvelai and Etosha Basin	Angola, Namibia

Elements of efficient and sustainable information sharing

Sharing information on water should be done in an efficient and sustainable manner. This is not an easy task. Data and information about groundwater are often scattered among various organisations and archives of data and information do not exist in many developing countries. Basic data appear in large numbers of technical reports or academic theses that are accessible to few potential users. Different data qualities may cause interpretation errors. These errors can propagate and yield incorrect conclusions. Information is usually disseminated on an ad hoc basis and is not imbedded in structured interactions.

The main elements of efficient and sustainable information sharing are:

- Inventory of availability of information.
- Improvement of access to information.
- Standardisation and quality control of data and information.
- Dissemination of information and knowledge through structured interactions.

Science and technology can significantly contribute to optimise the sharing process through development of modern tools, using web-technology.

IGRAC developed several tools to promote information sharing. The most important tools are:

- *Meta-information systems for inventory of availability.* Meta-information systems help to locate and understand data or information. Metadata describe the content, quality, form and other *a priori* specified characteristics of data and information. Web-based meta-information systems contribute to a systematic search for information sources and classify them according to their geographical position and the content.

The systems include information on persons and institutions and navigate users to information owners.

- *GIS-based applications for improvement of access to information.* On-line dedicated GIS-based applications are powerful tools for sharing information. Through a geographic interface and an extensive set of groundwater-related attributes, information can be seen in spatial context showing analogies and patterns. The above mentioned information system for trans-boundary aquifers in the SADC region is an example of such an application for sharing selected groundwater-related information on bilateral or multilateral scale.
- *Guidelines and protocols for monitoring and data collection.* IGRAC produces and promotes guidelines and protocols on groundwater monitoring and efficient, uniform and consistent data collection. Based on its worldwide inventory, IGRAC developed an on-line database on guidelines and protocols on these subjects. It also made an inventory on processing and presentation tools of groundwater data with focus on low cost, user friendly software tools.
- *Web-based discussion platforms for structured international interactions.* Joint publications, congresses and workshops are organised for structured international information and knowledge sharing. To complement this, IGRAC has developed a web-based discussion platform as a fast and cheap instrument for regular virtual meetings. Using state-of-the art means of communication, partners in international projects can share documents and make use of video-conferencing facilities.

Conclusions

The world's groundwater resources are a key to sustainable development. To make full benefit of these resources, information is needed to know what happens to water underground and what can be done to improve its availability and sustainable use. Dissemination of information is important for raising public awareness. The information provider should anticipate stakeholders' perceptions about water issues. Sharing information can save time in search for effective measures. All parties involved can benefit from analogies and do not need to duplicate the whole process of developing concepts, identifying problems and formulating solutions. The same applies also to reduction of costs if "lessons learned" are included in the sharing process.

Finally, a high concentration of information and knowledge can initiate important "breakthroughs" in knowledge and perception, leading to new views and better groundwater management approaches. Modern technology opens many possibilities for effective and efficient information sharing. Information sharing is a shortcut to proper understanding of issues in sustainable water resources management. In fact, nature itself "understands" the water-related issues very well. For example, the trees in the Kalahari Desert (Figure 18.5) adapt perfectly to the scarce water resources. They adjust during dry periods, store water to carry over from wet to dry seasons, or develop long roots that tap groundwater.

Figure 18.5. Water management in the Kalahari Desert

The baobab tree (left) only produces leaves during the wet season and the large trunk can store more than 100 m^3 of water. The acacia tree (right) develops long tap roots that can reach groundwater sources, up to 60 meters deep.

Adisonia digitata *Acacia*

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Chapter 19

WATER SCARCITY IMPACTS AND POLICY AND MANAGEMENT RESPONSES: EXAMPLES FROM AUSTRALIA

by

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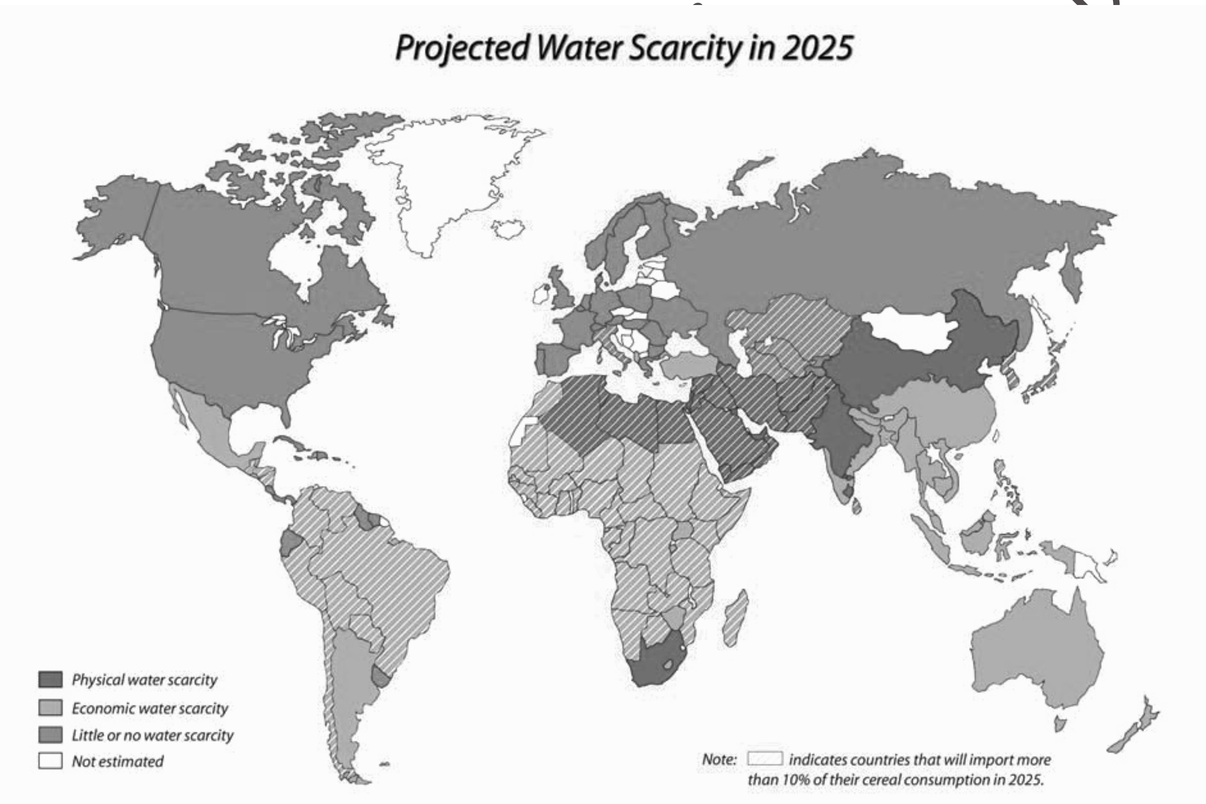
Water scarcity

Water scarcity is becoming an increasingly significant issue for many developed and developing countries. Rijsberman and Molden (2001) indicate that the fundamental fear of food shortages encourages ever greater use of water resources for agriculture, whilst at the same time pressures to divert water to other users are growing significantly. Given the finite nature of freshwater resources this presents the world with a major challenge we have to overcome if we are to feed everybody and sustain the economy and the environment. By 2025, the International Water Management Institute (IWMI) has estimated that 1.8 billion people will live in countries with absolute water scarcity. This currently includes most countries in the Middle East and Africa and by 2025, these countries will be joined by Pakistan, South Africa and large parts of India and China. The IWMI data (Seckler *et al.,* 1998) estimates scarcity based on criteria relating to the per cent increase in water withdrawals over the 1990-2025 period and water withdrawals in 2025 as a per cent of annual water resources of each country. However defined, the impact of scarcity is that countries affected will neither have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture, even at high levels of irrigation efficiency, nor to meet reasonable water needs for domestic, industrial and environmental purposes.

This will increase these countries' dependence on imported food. Pressures on water supplies will be further exacerbated by more people moving to and living in large cities; by 2025, 2 billion people will move to cities. Furthermore, currently 1 billion people lack clean drinking water and 2.4 billion lack adequate sanitation. In the face of all the above challenges, water will have to be transferred out of agriculture into other sectors.

1. I would like to acknowledge the contribution made by Dr John Williams with respect to some of the concepts discussed in this paper.

Figure 19.1. Projected water scarcity by 2025 (after IWMI)



IWMI's data (Seckler *et al.*, 1998, 1999) groups countries into three categories of water scarcity:

- *Physical water scarcity:* This is defined in terms of the magnitude of primary water supply (PWS) development with respect to potentially utilisable water resources (PUWR). Physical water scarce condition is reached if primary water supply of a country exceeds 60% of its PUWR. This means that even with highest feasible efficiency and productivity, PUWR of a country is not sufficient to meet the demand of agriculture, domestic, industrial sectors while satisfying its environmental needs. Countries in this category will have to transfer water from agriculture to other sectors and import food or invest in costly desalinisation plants.
- *Economic water scarcity*: Economic water scarce countries have sufficient water resources to meet their additional PWS needs, but need to increase their PWS through additional storage and conveyance facilities by more than 25%. Most of these countries face severe financial and development capacity problems for increasing PWS to those levels.
- The third category includes countries with *little or no water scarcity*. These countries are not physically water scarce and also need to develop less than 25% of additional PWS to meet their 2025 needs.

The IWMI data indicates that the remaining 118 countries included in their study will theoretically have enough water resources to meet their needs, but many will require significant investment to develop water supplies by 25% or more.

Australian water resources

Australia's water resources are highly variable (Table 19.1), and reflect the wide range of climatic conditions and terrain. In addition, the level of development in Australia's water resources ranges from heavily regulated rivers and groundwater resources, through to rivers and aquifers in almost pristine condition.

Table 19.1. Variability of flow in some of the world's major rivers compared with two Australian rivers

Country	River	Ratio between the maximum and the minimum annual flows
Switzerland	Rhine	1.9
China	Yangtze	2.0
Sudan	White Nile	2.4
United States	Potomac	3.9
South Africa	Orange	16.9
Australia	Murray	15.5
Australia	Hunter	54.3
Australia	Darling	4 705.2

About 65% of Australia's run-off (Figure 19.2) is in the three drainage divisions located in the sparsely populated tropical north. Australia has 385 923 gigalitres (GL) of mean annual run-off (NLWRA, 2001). The best estimate of how much water can be diverted and turned to human use is approximately 105 000 GL. At present, Australians extract about 70 000 GL and consume about 24 908 GL, of which 16 660 GL is used in agriculture (ABS, 2004). Whilst there is a net utilisation of about 24% of Australia's potentially divertible water resources, this figure masks the variation in distribution of use (NLWRA, 2001). For example, most large cities are situated in southern regions. Similarly, irrigated agriculture is concentrated in the Murray Darling Basin where only 6.1% of national run-off occurs

2.5 million hectares of Australia (<1% of the land surface) is irrigated and this generates about 50% of our profit from agriculture. Between the 1980s and 1996/97 the area under irrigation increased by 26% (NLWRA, 2001). Surface water consumption in irrigated agriculture increased by 59% over the same period. There was a further 22% increase in irrigated area between 1996-97 and 2000-01 (ABS, 2004). Given that agriculture consumes 70% of the water resource, Australian agriculture must learn how better to turn that scarce water into wealth and well-being for our communities.

Nearly 75% of irrigated agriculture occurs in the Murray-Darling Basin where water demand and levels of water extraction from rivers and groundwater are now unsustainable. About 75% of the mean annual flow in the basin is diverted with the result that the mouth of the Murray has often closed in recent years of lower rainfall. To cope with climate variability more than twice the average annual flow in the basin is held in storages.

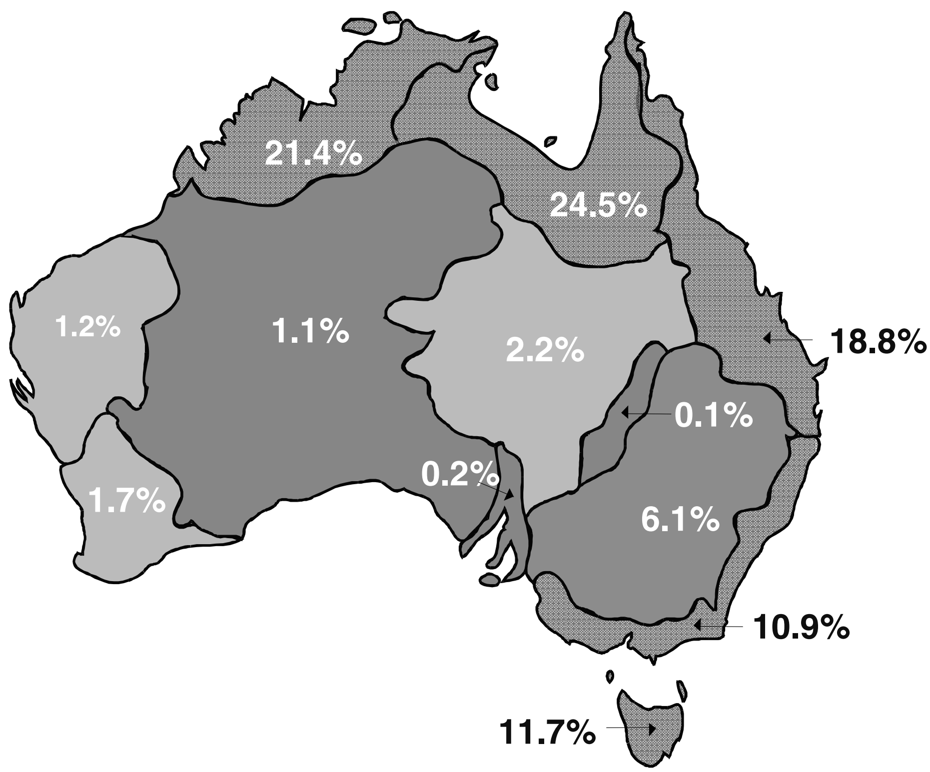
While IWMI (Figure 19.1) projects that Australia will suffer from economic water scarcity by 2025, some southern catchments are also already at, or approaching, the IWMI definition of physical water scarcity. Furthermore, the highly variable rainfall/run-off conditions experienced in Australia, coupled with the observation that many southern rivers are environmentally stressed suggest that the IWMI definition of physical scarcity is too generous for Australian conditions.

Table 19.2. Annual water availability/use in Australia 2000-2001 (NLWRA, 2001; ABS, 2004)

Mean annual run-off	385 923 GL
Water consumed	**24 908 GL**
• Agriculture	16 660 GL
• Forestry and fishing	27 GL
• Mining	401 GL
• Manufacturing	866 GL
• Electricity and gas	1 688 GL
• Water supply, sewerage and drainage	1 794 GL
• Household water	2 182 GL
• Other*	832 GL

* Includes service industry and recreational water uses, etc.

Figure 19.2. Australia's distribution of run-off



Source: NLWRA, 2002.

As has been demonstrated previously, Australia faces considerable water-related issues particularly in the south of the mainland where much of the population and irrigated agriculture occurs. Two challenges are perhaps paramount. These are:

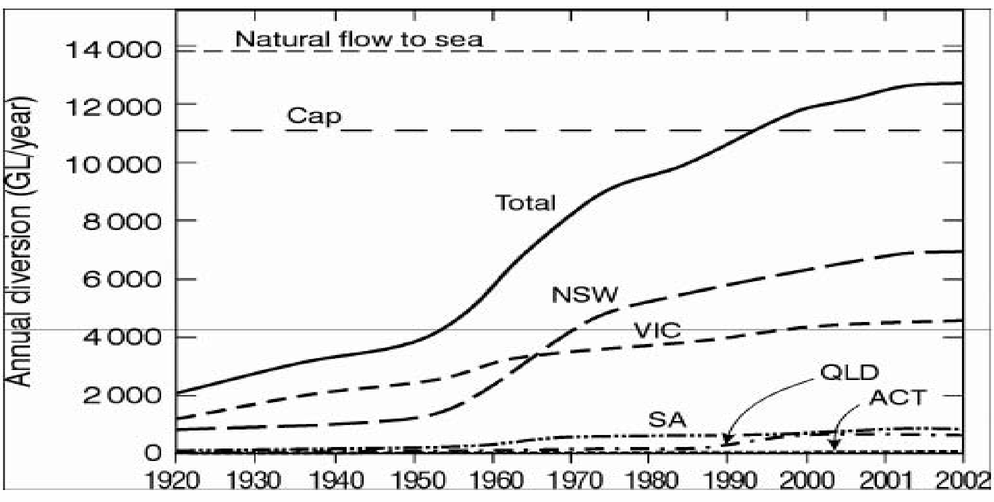
- Balancing water extractions for irrigation and other uses with provision of appropriate environmental flow to maintain healthy rivers and thus service the needs of all users of rivers and ground waters.
- Increasing the uptake and implementation of water recycling and reuse schemes in growing urban environments to minimise need for costly and environmentally detrimental new dams and energy intensive desalination schemes.

While returning increased flows to rivers in southern Australia is a major challenge, and absolutely critical to river system health, many other land management factors such as, drainage; nutrient and chemical pesticides loading are very important to the health and ecological function of rivers, ground waters, wetlands, floodplains and estuaries.

The water reform process in Australia

Water in Australia is vested in the state and territory governments which allow other parties to access and use water for a variety of purposes, including for irrigation, mining and other industrial uses, and servicing rural and urban communities. As demonstrated previously, by the second half of the last century, it was clear that the natural equilibrium essential to the healthy functioning of the natural resource base had been upset by over exploitation of our natural resources. In the Murray Darling Basin, the high levels of storage and extraction have very damaging impacts on the heath of the rivers, floodplains, wetlands and estuaries. Recognising this in the mid 1990s, jurisdictions agreed to cap their allocations for consumptive use from the system at 1994 levels (Figure 19.3). This was one of the first and most important policy decisions in the Murray-Darling, which recognised that the limits of sustainability had been overreached. Experience demonstrates, however, that if regulators place a cap on surface water, demand is transferred to groundwater. In reality, surface and groundwater need to be managed conjunctively.

Figure 19.3. Growth in water use in Murray-Darling Basin, 1920 to 2000



In 1994, all state and territory governments agreed on a package of reforms covering water prices, allocations and trading, environmental and water quality, and public education. In agreeing to the reforms, the governments formally acknowledged, for the first time, that Australian rivers, catchments and aquifers do not stop at state boundaries and that development activity in one state can have impacts in other states.

By the late 1990s the Australian government was sufficiently concerned by the range, breadth and cost of land and water degradation problems that it commissioned a nationwide National Land and Water Resources Audit (NLWRA, 2001) that showed that 26% of Australia's surface water management areas and some groundwater management units were either close to, or overused compared with their sustainable flow regimes.

More recently high levels of water extraction and few, if any, natural flood events have put further stress on the River Murray. In 2003 this was recognised with "The Living Murray" initiative aimed at returning 500 GL of water to the river for environmental flow purposes.

The Council of Australian Government's (CoAG) latest response to ongoing water issues has been to develop an intergovernmental agreement called the National Water Initiative (NWI). The NWI was signed in recognition of the continuing national imperative to increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and groundwater systems. The NWI is "A nationally-compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes."

It includes a comprehensive package of reforms related to water entitlements, trading and sustainable use. Critical to the above are:

- A wide range of governance and planning reforms;
- Definition of environmentally sustainable levels;
- Definition of water budgets and accounting systems that allow an indication of volumes of water available for use and trade under varying climatic conditions; and
- Ensuring that measurement and monitoring technologies are available to underpin robust accounting systems.

Policy and management strategies to deal with water scarcity

Southern Australia, at least, is faced with dealing with the ramifications of growing population, variable climate and increasing water scarcity. To cope with these the reform process has to include incentives that improve water use efficiency and productivity. Thus the NWI is stimulating and guiding the following developments in water management.

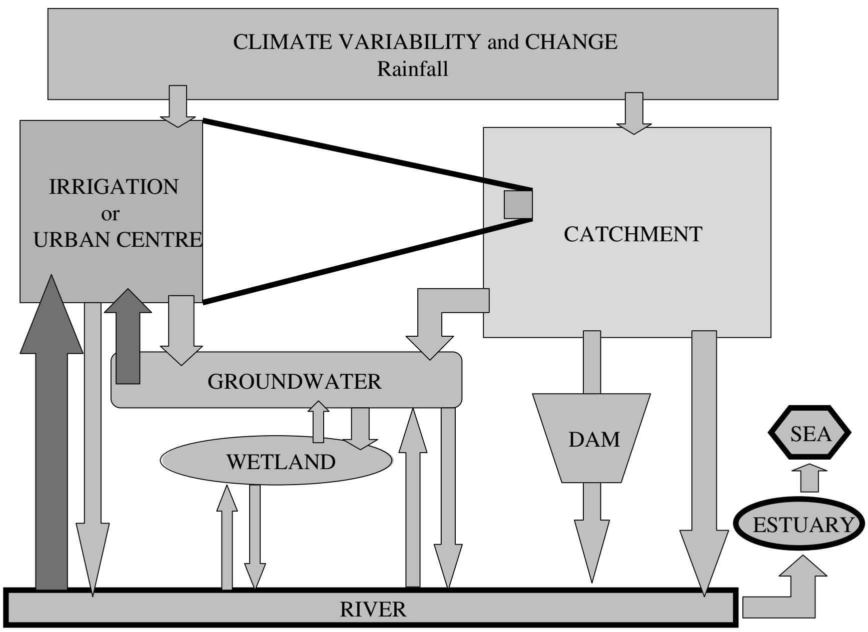
Whole-of-system thinking

Many water scarcities have developed because our management has failed to apply whole-of-system thinking to water supply, re-use, consumption and return of water to natural water bodies. Stream flow and groundwater are often managed as independent entities as are urban storm water and sewage treatment and effluent re-use. Progress in Australia has built on taking an integrated approach underpinned by the recognition of interactions in the water cycles (Figure 19.4). For example, rivers are stressed by being dammed and regulated, and by water extraction, when the pattern of flow is changed. Over-extraction of water can endanger native fish, increase salinity and the incidence of algal blooms, and damage vegetation in wetlands and floodplains. Changes in river flow regimes affect groundwater recharge and discharge patterns to and from wetlands, billabongs and flood plains. The death of Red River gums in the billabongs and flood-plains some distance from the Murray River is the result of declining and increasingly saline groundwater and lack of fresh water recharge. Integrated catchment management is now an operating principle for the implementation of CoAG's water reform initiatives and is central to the establishment of catchment management authorities in Victoria and New South Wales and similar structures in the other states. Regional management of catchments using many of the conceptual frameworks that have evolved from a whole-of-system approach are now established practice.

Technical innovation

Technical innovation in the water industry encompasses a wide range of possibilities including more effective and cheaper ways of treating waste and saline water for reuse, improved leak detection systems for urban and irrigation water conveyance systems, the use of solar energy to desalinate water, remote sensing technologies that improve our understanding of the distribution vertically and horizontally of fresh and saline water resources, improved modelling of water systems that facilitates adaptive management responses and engineering improvements that reduce the amounts of water required to process materials in mining, agriculture and manufacturing.

Figure 19.4. Water flows to be managed in irrigation within a whole of system approach

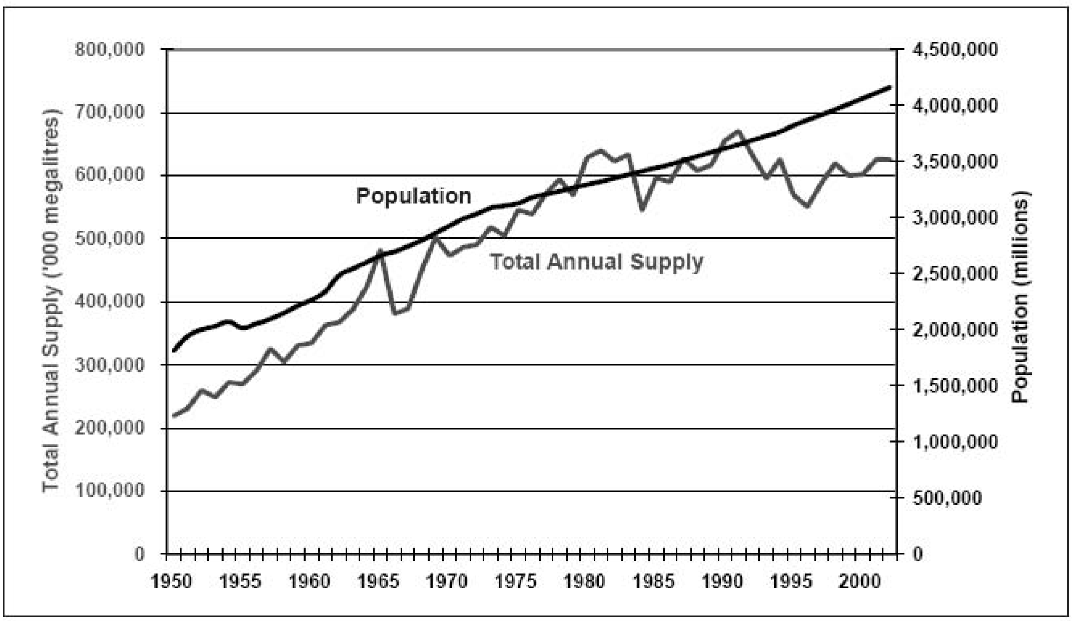


Urban systems

Limited sites for new dams and climate variability mean that Australian urban communities need to increasingly look at using water more efficiently and to conserve scarce supplies. In 2003, water usage in Australia's 22 largest cities was 2 065 GL of which 59% was residential and 28% was used for industrial, commercial, local government, parks and fire fighting. Nationwide about 9% of total effluent was reported as being recycled. In 2001/02, over 500 sewage treatment plants contributed to this recycling of less than 200 GL per year. Demand and price management have meant that Sydney, for example, has been able to accommodate population growth. Until 1985 population growth and water consumption increase were in parallel (Figure 19.5). However, subsequently consumption flattened off enabling the city to accommodate 700 000 additional inhabitants without growth in water demand.

A number of other initiatives that go under the headings of "integrated water system management" and "water sensitive urban design" include opportunities to incorporate third pipe "grey" water systems for toilet flushing and garden watering in new housing developments, increased treatment of effluent and its reuse for industry and irrigation, sewer mining and treatment for localised irrigation of parks and sports grounds and stormwater capture and treatment to substitute for potable water in a wide range of non-potable uses. However, non-potable reuse is still faced with considerable regulatory hurdles. Substitution of drinking water by treated effluent and stormwater for non potable uses has a lot of scope to alleviate the demand for new potable supplies. However, indirect potable reuse of treated sewage, will in some instances have to be considered.

Figure 19.5. Sydney's water supply in relation to its population growth



Source: After WSAA, 2005.

Water use efficiency and productivity gains

As elsewhere in the world, Australia's irrigation systems suffer from problems associated with losses in storage and conveyance, on-farm losses and variable water use efficiency. The Murray Darling Basin Commission has demonstrated that for the basin as a whole, 25% of diversions for irrigation are lost during conveyance in rivers, 15% are lost from canals and 24% lost on farm, meaning that only 36% of irrigation water is actually delivered to plants. Such losses are not atypical. The data for the Murrumbidgee Irrigation Area (MIA) (Table 19.3) do not include river conveyance losses and indicate on farm losses better than the overall MDB average. Simply increasing water use efficiency (WUE) is not the solution for a better use of irrigation water. Technically WUE tells us how much water is consumed by the crop and how much wasted. However, the real wastage comes from not being as productive as possible with the water that is consumed. Efficiency can be high with consequent detrimental environmental consequences, whilst productivity is low. Growing more food with less water alleviates scarcity, contributes to food security and puts less strain on nature. The most effective way to increase water productivity is to shift water use by trading from low value to high value crops. To facilitate this, water entitlements, trading regimes, market factors and other issues such as stranding of assets all have to be taken into account.

Over the last 60 years, Australian agricultural productivity in dry land and irrigated systems has increased on average by 3% per annum (Knopfke *et al.,* 2000). This has kept Australian farmers internationally competitive in the face of declining terms of trade for agricultural products and subsidies on agricultural production offered by some competitors.

Whilst many of these improvements have come from plant breeding, disease and pest management and soil and fertility management, improved use of available water has also been very important. For example, the productivity of Australian rice production has increased from about 0.4 g/Kg of water used to 0.8 g/Kg over the last 20 years with a concomitant reduction in water used from about 1 600 to 1 250 Ml/ha (Humphreys and Robinson, 2003).

Table 19.3. Surface water irrigation efficiency

Key indicators	Liuyuankou China	Rechna Doab Pakistan	MIA Australia
Area (ha)	40 724	2 970 000	156 605
Losses from supply system %	35	41	12
Field losses %	18	15	11
Net surface water available to crop %	46	32	77

Source: Personal communication, Shahbaz Khan.

Conclusions and lessons learned

Australia is at a crossroads in terms of its ability to cope with increasing water scarcity. The alternatives are to build more expensive dams and desalination plants with a high environmental cost, or to use water more efficiently through combination of increasing water productivity, technological innovation, recycling and demand management. However, coping with the major water challenges is as much a social and economic issue as a scientific problem. Scientific understanding and knowledge is not the major impediment to progress, but is vital in that it can demonstrate the problems, scenarios and potential solutions. Currently, knowledge gaps are being filled, but changes in thinking about social and economic value of water and governance are equally vital. Similarly it is critical that people from all levels of society understand the problem. What has been demonstrated so far is that effective solutions are founded in a triple bottom line approach (environmental, economic and social), backed up by a robust governance/institutional and policy reform process. It is clear from our experience that technical/economic fixes may not be acceptable without a social component (*e.g.* indirect potable reuse).

What is also clear is that effective water reform processes do involve trade-offs, winners and losers and that if environmental health is valued by society then it cannot always be the environment that loses. In recent years Australia has also focused attention on the real monetary value of water and is instigating water trading policy process aimed at moving water from low value to high value users, often with ancillary environmental benefits via improvements in water productivity and loss reduction. Whilst moving to systems that will ultimately charge all users the real value of water supplied may not yet be politically acceptable for some countries, the Australian experience is that it is certainly worth considering, at least for some sectors of the economy because of the ensuing economic and environmental benefits.

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Chapter 20

WATER RESOURCES MANAGEMENT IN MEGACITIES

by
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Approximately 60% of the total global population lives in urban areas and rapid economic growth is expected in these areas. Economically developed urban areas face excessive consumption of energy and materials to secure their comfortable life, while a poor living environment is a major problem in the economically developing urban areas. Such problems are intensifying, especially in the megacities all over the world.

The 13th Session of the United Nations Commission on Sustainable Development (CSD-13), which took place on 11-22 April 2005 at UN Headquarters in New York, aimed to facilitate the implementation of measures to improve the current problems related to water, sanitation and human settlements. On World Environment Day (5 June 2005) UN Secretary-General Kofi Annan said, "by 2030, more than 60% of the world's population will live in the cities. The growth poses huge problems, ranging from clean water supplies to trash collection"[1]. Urban and peri-urban areas are faced with many threats to water resources and the environment.

Comprehensive and well-organised water infrastructures are necessary for mega-cities. For good sanitation, sound public health and well-being, safe and stable provision of freshwater, efficient discharge and treatment of wastewater and the safety of the water environment are essential. Water issues are currently the most urgent and important topics for the sustainability of megacities.

Depending on the level of economic development, urban water environment issues in megacities are wide-ranging, from fundamental water supply/basic sanitation to advanced urban wastewater re-use/recycling systems. As a typical example, the socio-economic environment in the Asia-Pacific region presents a patchwork of factors including population density, climate (*e.g.* rainfall, temperature), sanitary conditions, protective measures against disasters (tsunamis, earthquakes, floods, drought). Cities and peri-urban areas in Asia-Pacific region are faced with various water threats.

Even in economically developed areas, cities are struggling with many problems that still remain unsolved. Japanese megacities have successfully implemented various innovative policies and technologies in wastewater re-use systems in the context of water resources management and water environment conservation. Reclaimed wastewater for toilet flushing with a dual distribution system is used in many office buildings, as is also the case in other Asian cities. Furthermore, stream restoration and flow augmentation using reclaimed wastewater for scenic purposes has a long history. A pilot study for the

1. *Bangkok Post*, 6 June 2005.

regeneration of seashore water quality for recreational bathing has been developed in Tokyo.

However, there are other issues associated with the water environment in Japan's urban areas:

- How to allocate future water resources in watersheds (rational and beneficial use/re-use of water).
- How to accommodate the multiple functions of "water" in urban areas (need for co-existence between human needs/use and ecosystems).
- How to maintain and upgrade the existing infrastructures (*e.g.* aging sewer systems, combined sewer overflow (CSOs) problems).

Singapore (an almost entirely urbanised country with a population of 4.2 million) is struggling with a water shortage which may worsen in the future. Singapore has ensured a diversified and sustainable supply of water for the country with the so-called "four national taps":

- Water from the country's own local catchment area.
- Imported water (from Malaysia).
- "NEWater" (reclaimed wastewater).
- Desalinated water (from seawater).

Megacities in the economically developing areas of the Asia-Pacific region are experiencing five major surges simultaneously:

- Increasing urban population.
- Rapid economic growth and centralisation.
- Unprecedented technological development.
- Social and cultural fragmentation.
- Economic globalisation.

Cities in other regions like Africa are likely to face similar situations.

We are far from achieving ideal, sustainable cities in either economically developing or developed regions. Water is one of the most complicated social issues, but to address them we have knowledge and tools and are gaining more, *e.g.:*

- Innovative science and technology (such as new biotechnology, nano-material technology, new information technology, satellite observation systems and others).
- New policy measures.
- New application and system management methods.

We need to exchange information and knowledge on water and establish innovative policies and technologies for the sustainability of the world's megacities. However, as the knowledge base is expanding very rapidly, we need to strengthen our professional network as no one can capture and apply all new knowledge and technology on water issues alone.

The project on sustainable freshwater resources management by the Institute for Global Environmental Strategies (IGES, Japan) is one example of international co-operation on water issues. Aware of the importance of water matters in the urban and peri-urban areas of Asia, its Freshwater Management Project carries out policy studies with the aim of proposing policy options to achieve sustainable water resource management. There is a special focus on urban areas in Asia.

The project promotes studies to propose integrated policy options for sustainable water resource management, looking into natural resources (environment), social infrastructures (water supply systems, sewer systems, etc.) and institutions (laws, regulations, administrative structure, etc.), in accordance with the diverse socio-economic and geographical conditions in the Asian countries.

In 2004, the project focused mainly on groundwater resource management, and expanded its scope to include surface water from 2005 onwards. The project studies water resource management, particularly in urban peri-urban areas, where water-related problems are considered extremely critical in the course of rapid economic and industrial growth. More specifically, the project plans to conduct historical overviews of water resource management and policies adopted in several representative cities (Tokyo, Osaka, Aichi) in Japan, and carry out case studies in Bangkok (Thailand), Ho Chi Minh City (Vietnam), Bandung (Indonesia), Tianjin (China) and Colombo/Kandy (Sri Lanka). The project promotes policy studies with the above-mentioned aims, in close collaboration with the following institutions: Asian Institute of Technology (AIT), Thailand; The Ho Chi Minh City University of Technology, Vietnam; The West Java EPA, Indonesia; Nankai University, China; and the University of Peradeniya, Sri Lanka.

For each case study, a meeting was organised to exchange ideas and information among local stakeholders from academia, governmental agencies, industry, water supply companies, NGOs and others, based on the research outcomes of the project. This dialogue with societal stakeholders contributes to international co-operation in research as it allows for better understanding of societies' specific water-related problems. We can learn from this project that we cannot discuss water issues merely on the basis of the size or level of development of a country, and should consider cities as areas with their own specificities. We should be careful to not misunderstand from country-wide data the real social issues in a specific city or area.

Possible indicators of good practices in international science and technology co-operation (especially water-related) could be to address questions such as:

- Does the co-operation have a clear target area?
- Is the output from the co-operation based on the facts and evidence?
- Does the outcome of the co-operation clarify and prioritise policy options?

Part 4

SESSION ON ENERGY

Chapter 21

SUMMARY OF THE ENERGY SESSION

by
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Introduction

The session on energy was organised in two parts, both of them dealing with energy efficiency: the first dealt with technologies and best practices and the second considered partnerships and collaborations to promote the deployment of renewable sources and the implementation of energy efficiency policies and measures.

In the first part, experiences in fostering energy efficiency in the United States, South Africa and Brazil were reported. The second part of the energy session was dedicated to multilateral and bilateral partnerships to promote renewable energy sources and environmentally sustainable industrial production in different regions of the world.

Energy efficiency technologies and best practices

In his presentation on "Energy Efficiency as a Critical Resource in Sustainable Development", Mark Levine, from Lawrence Berkeley Laboratory, described the five programmes launched in the United States on utility demand-side management and market transformation; standards and labels for appliances; building performance standards; promoting energy efficiency in the public sector; and voluntary agreements for industrial energy efficiency.

The effective implementation of the five programmes can reduce growth in energy use in buildings and industry a great deal, typically 2-5% per year based on US experience. Such programmes can have very large and favourable impacts, but their importance is not adequately recognised. As urban areas in Africa grow, it should be of very great benefit to have them in place.

South Africa's experience in energy efficiency was reported by Elsa Toit from the Department of Minerals and Energy in "An Overview of the Energy Efficiency Strategy of the Republic of South Africa", and by Ian Househam, International Institute for Energy Conservation South Africa, who discussed "Energy Efficiency Metrics".

1. Linda Manyuchi (Department of Science and Technology, South Africa) also acted as rapporteur. The session was chaired by Griffin Thompson, US State Department.

The Energy Efficiency Strategy, published in May 2005 after a long period of consultation, takes its mandate from the White Paper on Energy Policy published in 1998 and is part of the National Integrated Energy Plan approved in 2003. The Strategy sets sectoral and economy-wide energy efficiency targets to be achieved by 2015. Energy savings of at least 12% are foreseen by 2015. The enabling instruments to be used are economic and legislative means; information activities; energy labels and performance standards; energy audits and management and promotion of energy-efficient technologies.

The strategy aims at improving the health of the nation: creating jobs, alleviating energy poverty, reducing environmental pollution and CO_2 emissions, improving industrial competitiveness, enhancing energy security and reducing the necessity for additional power generation capacity.

To make the targets both challenging and achievable, they are to be revised every three years. To monitor the evolution of energy efficiency policies and measures, the government of South Africa has adopted an indicators-based top-down approach. The challenge is therefore to devise a way of decomposing the overall change in economic energy intensity in its component parts, one of which is the change in the actual energy efficiency. The indicators required for the decomposition analysis are energy consumption and activity-level indicators for every sector/sub-sector upon which the analysis is performed. By far the very poor availability of consistent and detailed data in some sub-sectors constitutes one of the major challenges in the South African context.

The Brazilian experience with a public benefit charge to support energy efficiency and research and development was reported by Gilberto Jannuzzi of the University of Campinas. Energy efficiency and energy research in Brazil has always relied on governmental support. In the 1990s, when the power sector began a restructuring process, there was a great deal of uncertainty about the future of the National Electricity Conservation Program and the funding of the Electricity Research Centre.

By 1998 the electricity regulator had taken the initiative to ensure support to energy efficiency and R&D from the recently privatised utilities. The compulsory investments in those activities were fixed at 1% of net annual revenues. To overcome the limitation of relying only on the utilities' decisions, a new national fund was created: CTEnerg, in charge of investing in energy efficiency programmes of public interest and energy R&D.

Energy efficiency and renewable energy partnerships and collaborations

From the standpoint of international co-operation, the partnerships that were reported covered a variety of regions: Africa, Asia and South and Central America were represented. While these initiatives vary in terms of number of partners and scope, there are certain factors that are common to all the partnerships presented. By pooling their skills and resources, these partnerships are working to develop knowledge networks and to enhance the scientific and technological base in order to contribute to the creation of an environment of informed decision making. Most partnerships reported progress within the broad categories of partnership building/coordination, capacity-building activities, information sharing and pilot projects.

The Mediterranean Renewable Energy Programme (MEDREP) is a multi-partner endeavour launched by the Italian government at the 2002 World Summit on Sustainable Development in Johannesburg, with projects in Algeria, Tunisia, Morocco and Egypt. MEDREP's mission follows the recommendation of the G8 Renewable Energy Task Force that countries should develop and demonstrate renewable energy projects where renewable energy is a least cost option on a life cycle basis and/or where renewable energy can protect the local/ global environment at a reasonable cost.

The two principal objectives of MEDREP are to provide sustainable energy services particularly to rural populations and to contribute to climate change mitigation by increasing the share of renewable energy in the energy mix of the region. Within these objectives, the programme aims to develop a sustainable renewable energy market system in the greater Mediterranean region through tailoring financial instruments and mechanisms; strengthening policy frameworks and overcoming barriers to renewable energy deployment; and building stronger private sector infrastructure, while considering the positive role of "tradable renewable certificates" and "certified emission reductions".

Within MEDREP framework, the Italian Ministry for the Environment and Territory, the Ministry for Industry, Energy and Small Medium Enterprises of Tunisia and the Tunisian National Agency for Energy Conservation, established a centre for training, information dissemination, networking and development of pilot projects in the field of renewable energies (MEDREC).

MEDREC, located in Tunis, is part of the Global Network on Energy for Sustainable Development (GNESD), a UNEP facilitated network of developing world centres of excellence and network partners working on energy, development and environment issues. MEDREC's main focus is development of the wind energy and solar energy sectors, although mini-hydro, geothermal, biomass and fuel cells are also considered.

The US-based non-governmental coalition Alliance to Save Energy is composed of prominent business, government, environmental and consumer leaders who promote the efficient and clean use of energy worldwide to benefit the environment, economy, and major stakeholders. The Alliance represents expertise in building, industrial, international, financing, utility, water and energy, policy, market development and education sectors and has over 70 associates. The Alliance runs programmes in many countries around the world including Brazil, Mexico, Ukraine, Bulgaria, India, Philippines and also, as of recently, in South Africa.

There is a strong relationship between water and energy, *e.g.* in many water supply systems (water and wastewater), energy represents the single biggest input cost in the final delivered product (up to 50%). As a response to this challenge, the Alliance has initiated the Watergy programme in various countries around the world. In South Africa, the United States Agency for International Development (USAID) has set aside funding for the implementation of a Watergy programme in four cities: Buffalo City, Mogale City, Sol Plaatje and Polokwane.

Having confronted the same issue in different countries, the solution proposed by the Alliance consists of comprehensively addressing efficiency both in terms of a supply-side and demand-side strategy. It has been proven that by adopting a holistic demand and supply-side strategy, it is possible to gain an even higher level of efficiency as a net positive benefit on one side that can lead to an unexpected (and sometimes unforeseen) benefit on the other side by exploiting synergies resulting from the water-energy co-management approach.

The Energy and Environment Partnership (EEP) with Central America promotes the use of renewable energy sources in seven Central American countries – Belize, Costa Rica, Guatemala, El Salvador, Honduras, Panama, and Nicaragua. By providing an innovative framework for project initiation and approval, the Partnership enables fruitful co-operation between government bodies, enterprises, investors and local civil society.

More than 50 projects have so far been granted funding, ranging from feasibility studies and pilot projects to networking, capacity building and the development of energy markets.

The Partnership was initiated by the Ministry of Foreign Affairs of Finland, the Central American System for Integration (SICA) and the Central American Commission on Environment and Development (CCAD) during the Johannesburg World Summit on Sustainable Development in 2002. The objective is to improve energy efficiency and promote the sustainable use of Central America's ample renewable natural resources.

A characteristic feature is the innovative model for project initiation in which any stakeholder is entitled to propose a project following a bottom-up approach. After the evaluation by both national representatives and a technical team, the amount of seed capital to be allocated to successful proposals is communicated to the stakeholders, enabling them to know, at an early stage, how much funding they can expect for their project. The EEP organises expert forums twice a year as part of its mission of making information available.

Energy and sustainable development in West Africa and, more specifically, in Mali, was reported by the Mali Folk Centre, which develops best practices on energy efficiency and renewables and supports the government in these policy areas. In Africa, electricity consumption per capita dropped from 431 kWh to 112 kWh from 1980 to 2000 and oil use has increased from 40 million tonnes in 1971 to 118 million tonnes in 2001, most of which is imported. The African countries are facing the problem of how to get out of this situation.

Taking the case of Mali, a wider use of renewable sources can be part of the solution. AREED (African Rural Energy Entreprise Development), a UNEP initiative supported by the UN Foundation, is devoted to strengthening Mali's private sector in order to play a major role in renewable energy adoption.

The Administrative Center for China's Agenda 21 of the Ministry of Science and Technology of the People's Republic of China presented two case studies on networks to promote environmentally sound technologies in the Asian region: the Asia-Pacific Economic Co-operation Virtual Centre for Environmentally Sound Technology Exchange (APEC-VC) and the Asian Regional Energy Database (RED) Project.

The APEC-VC is a strong and growing force in the Asian-Pacific region helping APEC economies, municipalities, corporations and environment-related institutions share, via the Internet, information on environmentally sound technologies. Much like an "environmental technology exhibition", APEC-VC disseminates a wide range of information in three main categories: global environmental conservation, local environmental conservation and environmental protection programmes.

The RED project, funded by UNESCO, Jakarta office (through a Japanese Fund In Trust Agreement) and coordinated by the Asian Institute of Technology with the support of UNESCAP, aims to enhance the capacity of the energy sector of developing countries in Asia and the Pacific region in policy formulation on energy for sustainable development. The project also aims to develop national databases in five pilot countries: Cambodia, Indonesia, China, Philippines and Vietnam. The database would present country profiles as a resource tool for the policy makers on the current status of renewable energy and energy efficiency in the country; research, development and dissemination programmes being undertaken and the key players involved in their promotion and utilisation.

The Austrian experiences on research for sustainable development constitute a good example of technology transfer through international co-operation in two areas: solar energy applications and bio-energy. The Austrian examples featured a façade integrated solar collector for water and space heating, the use of a cheap material such as straw for insulation, an ecological alpine refuge hut, combined heat and power plants, and the significant role of bio-energy in the Austrian energy system.

The success stories in international collaboration demonstrated how the technologies developed in Austria could be adapted and implemented in developing countries thanks to funding by the Austrian Development Agency. The "Clay Stove for Zimbabwe" project for cooking was developed in Zimbabwe and Bhutan with the R&D support of Austrian and local institutions.

Through the "Austria-Zimbabwe Solar Co-operation" project, 375 solar thermal systems and six solar dryers have been built. There has also been dissemination in Uganda and Iran.

Chapter 22

ENERGY EFFICIENCY METRICS

by
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Background

After a long period of consultation, South Africa's Energy Efficiency Strategy was published in May 2005. One of the most important parts of the strategy is the setting of energy efficiency targets at both the economy-wide and the sectoral levels, to be achieved by 2015. The targets are expressed as percentage reductions in final energy demand relative to a 'business as usual' scenario:

- Economy-wide: 12%.
- Industry and mining: 15%.
- Power generation (parasitic)[1]: 15%.
- Commercial/public: 15%.
- Residential: 10%.
- Transport: 9%.

Although not explicitly stated in the strategy, the targets are intended to be interpreted as percentage reductions in final energy demand *attributable to improvements in energy efficiency.*

Clearly, the setting of energy efficiency targets is useful only if progress towards achieving the targets can be monitored. The Energy Efficiency Strategy makes little mention of monitoring, and does not specify the methodology to be used. This paper explores some of the considerations taken in selecting a methodology, and describes in more detail the methodology selected as being the most appropriate for South Africa.

These discussions centre mainly around the quantitative aspects of energy efficiency monitoring, necessary for answering the question of *whether* the energy efficiency targets are being met. However, it is important not to overlook the more qualitative aspects of monitoring, through which an understanding can be gained of *why* targets are or are not being met. This has been characterised as a "Driving Force – State – Response" model. Under this model, the actual energy efficiency at any given time (and its rate and

1. In the Energy Efficiency Strategy, the term 'parasitic' was used to mean the consumption of energy by the electricity industry in all activities other than the direct generation, transmission and distribution of electricity. Examples include consumption by lighting and HVAC within power stations, and consumption within utility offices.

direction of change) represents the "state" of the system. The "driving forces" are the factors that have an impact on energy efficiency. These may be economic factors, or they may relate to the current regulatory environment, and they also include factors such as the awareness of, and attitudes to energy efficiency among energy users. These driving forces cause a change in the state of the system which, assuming it is observed and understood, elicit a response. This response may include policy measures or the introduction of energy efficiency programmes, which in turn become driving forces themselves.

These more qualitative and subjective variables are important not only in explaining the "why" of energy efficiency changes, but also in anticipating possible future problems. Future changes in energy efficiency are a function of investment decisions made today, which are in turn influenced by current attitudes and awareness. The importance of obtaining this complete picture is summarised by the consultants retained to develop an energy efficiency monitoring system for New Zealand:

> *"... for a rich picture of energy efficiency in New Zealand, [we] must monitor "driving forces" and "responses" as well. These will assist with answering the question of "why" energy efficiency changed as it did."*[2]

However, the New Zealand team also acknowledged that the "state" part of the model needs to receive the greatest attention in the initial stages of developing a system. The remainder of this paper therefore focuses on these more quantitative questions.

Approaches to monitoring energy efficiency

What is energy efficiency?

There are many possible definitions of energy efficiency, for example:

- Theoretical minimum energy requirement for performing task/energy actually used.
- Current best practice energy requirement for performing task/energy actually used.
- Useful output obtained/energy used.

The first of these definitions is the most "correct" from a technical perspective, but is of little use in practice, since the theoretical minimum energy requirement may have little relevance to technologies that are technically, economically and socially feasible.

The second definition is more useful, since it relates to technologies that are actually in use, and provides an indication of how much room for improvement realistically exists relative to the current level of energy efficiency. However, care must be taken in using international comparisons of best practice, since the appropriateness of a technology may be very specific to a given country's resource endowments.

The final definition is perhaps the most convenient and commonly used, along with its reciprocal which is usually referred to as energy intensity. Useful output – and hence energy intensity – may be defined either in physical units (*e.g.* tonnes of product, square metres of floor-space heated, etc.) or in economic units (amount of value added in appropriate currency units).

2. Lermit (2001).

Project-based versus indicators-based approaches

A number of different approaches to monitoring energy efficiency have been adopted at different times in various countries. These approaches can be categorised as either project-based or indicators-based.

Project-based approaches observe the impacts of individual energy efficiency policies, programmes and projects and infer that the aggregate change in energy efficiency is equal to the combined impacts of these policies, programmes and projects. A project-based approach is mandated in the EU by the Draft Directive on Energy End-Use Efficiency and Energy Services.

By definition, project-based approaches are bottom-up. By implication, these approaches measure improvements in energy efficiency relative to what would have happened in the absence of any specific energy-related interventions. Project-based approaches give little insight into the effects on energy efficiency of other factors that are not related to energy-specific policies, programmes and projects. This is unlikely to be a major problem in highly industrialised countries, where such policies, programmes and projects are collectively the most significant influence on energy efficiency.

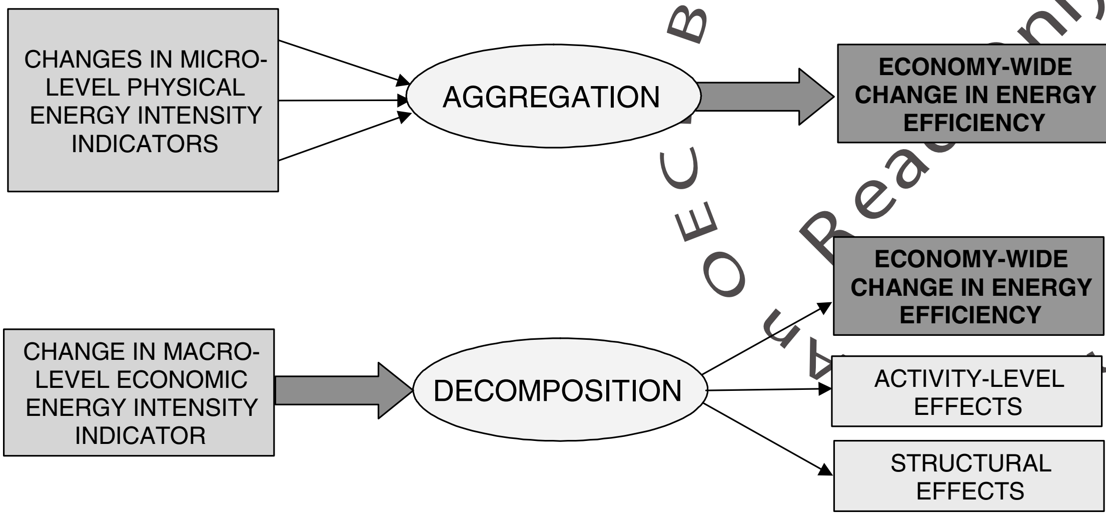
However, in developing countries there may be very few (if any) policies, programmes and projects specifically aimed at improving energy efficiency. Rather, energy efficiency is determined by a myriad of factors, including the extent of distortions in the markets for energy and energy-using technology, and the availability of information on energy efficiency options. Under these circumstances, a project-based approach to monitoring energy efficiency is unlikely to yield any useful insights.

Indicators-based approaches may be either top-down or bottom-up. Bottom-up approaches observe directly the changes in energy efficiency (the reciprocal of the *physical* energy intensity) at the level of individual firms, plants or even processes, and aggregate these together to derive sectoral or economy-wide changes in energy efficiency. The "Odex" indicators developed under the EU Odyssee Programme are an example of a bottom-up indicators-based approach. Odex indicators have been developed for all the major industrial, commercial, transport and residential sector energy-using activities, allowing detailed cross-country comparisons.

Conversely, top-down indicators-based approaches observe changes in *economic* energy intensity at the macro-level. This indicator is not the same thing as energy efficiency, but can be expected to mirror energy efficiency to a greater or lesser extent. A top-down approach then uses a process of '*decomposition'* to disaggregate changes in energy intensity into various components, one of which is the change in energy efficiency itself. A top-down indicators-based approach has been adopted in Canada, New Zealand and the Netherlands.

Figure 22.1 provides a summary of top-down versus bottom-up approaches. At the micro-level, physical energy intensity is a very good indicator of energy efficiency – one is simply the reciprocal of the other. However, the energy efficiency indicators from different activities will be in a diverse range of units (*e.g.* MJ per tonne of product, MJ per m^2 of floor space heated, MJ per passenger km travelled). The challenge with a bottom-up approach is to devise a meaningful way of aggregating indicators expressed in different units. Clearly this implies the use of a weighted mean, but the problem is choosing appropriate weightings to give the desired result.

Figure 22.1. Top-down vs. Bottom-up approaches to indicators-based monitoring



At the macro-level, economic energy intensity may be a very poor indicator of energy efficiency. Economic energy intensity is also affected by factors such as structural changes within the economy, price changes that affect the economic value of products and changes in population. The challenge with a top-down approach is therefore to devise a way of "decomposing" the overall change in economic energy intensity into its component parts, one of which is the change in actual energy efficiency.

In fact, from an arithmetical perspective, the processes of aggregation and decomposition are the inverse of one another. The weightings that are necessary for aggregating micro-level energy intensity changes in a bottom-up approach are also needed for performing a decomposition analysis. The data requirements of each approach are also similar, so the choice of process is one of convenience. Where detailed data is likely to prove unavailable, it makes more sense to use a top-down analysis, so this approach was identified as the most useful and practical for the South African context.

Top-down indicators-based energy efficiency monitoring – a closer look

The techniques used for decomposing changes in energy consumption into their constituent factors derive from the mathematically identical techniques derived in the late 19th and early 20th Centuries for analysing the underlying causes of differences in total factor productivity. The theory behind this methodology was developed by Laspeyres and Paasche in the 1870s, and refined by Fisher and Divisia in the 1920s.[3] From the 1980s, the methodology began to be applied to the specific problem of analysing the underlying reasons for changes in energy consumption and intensity.

The general approach of decomposition is to take the change in total energy consumption E and to express it as the sum of at least three factors, plus a residual term that results from some decomposition methods.[4] The basic decomposition is where:

3. For a historical and theoretical background, see Balk (2000) and Hoekstra (2000).

4. Some studies have preferred instead to decompose total energy intensity, rather than total energy consumption. In this form, two factors are sufficient – structural changes and changes in energy efficiency.

$$E = P + I + S + r$$

- P is the change in energy consumption that is attributable to the overall change in economic activity.
- I is the change in energy consumption that is attributable to changes in energy efficiency.
- S is the change in energy consumption that is attributable to changes in economic structure.
- r is a residual term that arises with some decomposition methods.

If E is expressed in absolute terms (*i.e.* in TJ, or some other energy unit) then so are the factors into which it is decomposed. Another possibility is to express E in relative terms (as a percentage), in which case the factors are also expressed as percentages. These two techniques are arithmetically equivalent, but the use of absolute terms is probably slightly easier to interpret, and will be used in this paper.

During the 1990s, a number of papers were published[5] illustrating that all the different decomposition methods previously used could be encompassed by a set of parametric frameworks equations. These equations are discussed in more detail in a review by Nanduri[6] and are represented mathematically below in a slightly modified form. Note that these equations can be applied at any level of decomposition. The equations given below assume that changes in economy-wide energy consumption are being decomposed, in which case data at the sectoral level is required. However, the same equations can be used to decompose changes in sectoral energy consumption using data from the sub-sectoral level.

The parametric framework equations are:

$$\Delta P = \ln\left(\frac{Y_t}{Y_0}\right) \times \sum_j F\left(E_{j,0}, E_{j,t}\right) \text{ .... (Equation 1a)}$$

$$\Delta I = \sum_j \left[F\left(E_{j,0}, E_{j,t}\right) \times \ln\left(\frac{I_{j,t}}{I_{j,0}}\right)\right] \text{ .... (Equation 1b)}$$

$$\Delta S = \sum_j \left[F\left(E_{j,0}, E_{j,t}\right) \times \ln\left(\frac{S_{j,t}}{S_{j,0}}\right)\right] \text{ .... (Equation 1c)}$$

where: subscripts 0, t refer to values at two points in time

Y is the total value-added for the economy

E_j is the energy consumption of the j^{th} sector

I_j is the energy intensity (energy consumption per unit of value-added) of the j^{th} sector

S_j is the share in total value-added of the j^{th} sector

5 See for example Liu (1992).

6 Nanduri (1998).

$F(E_{j,0},E_{j,t})$ is a 'weighting function', the choice of which defines which decomposition method is being used[7]. Table 22.1 describes some of the weighting functions commonly used, and the names that have been attached to the respective methods.

Although the Log-Mean Divisia method is arithmetically slightly more complex, this makes very little difference when data processing is computerised. Furthermore, this method has the big advantage that it does not lead to a residual term, which is a component of the change in total energy consumption that cannot be attributed to any of the factors under consideration. The residual term has no meaning in reality, and its existence is merely a result of the mathematics of the method chosen[8]. The Log-Mean Divisia method therefore appears to be the most effective decomposition method available, and it has been selected for use in South Africa.

Table 22.1. Weighting functions and their corresponding decomposition methods

Value of $F(E_{j,0},E_{j,t})$	Name of method
$E_{j,0}$	Laspeyres method
$E_{j,t}$	Paasche method
Arithmetic mean of $E_{j,0}$ & $E_{j,t}$ $\frac{(E_{j,0}+E_{j,t})}{2}$	Marshall-Edgeworth method
Geometric mean of $E_{j,0}$ & $E_{j,t}$ $\sqrt{(E_{j,0}\times E_{j,t})}$	Fisher Ideal method
Logarithmic mean[9] of $E_{j,0}$ & $E_{j,t}$ $(E_{j,t}-E_{j,0}) / \ln(E_{j,t}/E_{j,0})$	Log-Mean Divisia method

Data requirements for a decomposition analysis

Performing a decomposition analysis of changes in the observed level of energy consumption requires comprehensive data on both energy consumption and activity level, in both the base year and the year of analysis. This data must be available at a level of detail corresponding to the sub-divisions of the level at which the analysis is taking place. In other words, where energy efficiency targets have been set at the sectoral level, as in the case of South Africa, data on energy consumption and activity levels must be available at least at the level of the sub-sector.

7. The weighting function is needed because the process of decomposition results in the need to integrate a function the form of which is not known. The different choices of weighting function correspond to different assumptions about the shape of the function between the two integration limits.

8. Appendix 1 of Lermit (2001) provides a proof that the residual term disappears when the logarithmic mean of $E_{j,0}$ and $E_{j,t}$ is used as the weighting function.

9. Note that, when a = b, log-mean(a,b) = a = b.

Of course, a more precise picture is possible if data is available at a still greater level of detail. For example, an analysis conducted on the industrial sector will reveal how much of the change in sectoral energy consumption is due to structural changes between the main industrial sub-sectors, and how much is due to changes in average energy efficiency of the main industrial sub-sectors. However, part of this apparent change in energy efficiency is likely to be due to structual changes *within* the sub-sectors.

The aim of decomposition analysis is to identify the contributions to overall changes in energy consumption accounted for by: *i)* changes in energy efficiency; *ii)* changes in overall level of activity; *iii)* changes in other factors, which can usually be characterised collectively as "structural changes". Within the industrial sector, this does not present any major conceptual difficulties. In the transport sector, structural changes have a close parallel in "modal shifts", *i.e.* changes in the relative importance of different modes of transport.

The commercial sector presents a difficulty in that it is normally grouped together with the public sector, for which defining a uniform indicator for activity level is problematic. GDP or value-added is usually used as an indicator of activity level, but there are difficulties in measuring this meaningfully in the case of the public sector. Both number of employees and floor area in use have variously been suggested as activity level indicators, each of which has its merits and drawbacks.

Analysis of the residential sector presents particular difficulties. While population is a close parallel of 'activity level', there is no convenient and meaningful equivalent of the concept of "structural change". A wide range of factors, in addition to changes in energy efficiency and population, contribute to overall changes in residential sector energy consumption. These include income levels, ownership levels of energy-using appliances, social class, degree of electrification, degree of urbanisation. Perhaps the most useful methodology is to decompose changes in residential sector energy consumption into components attributable to: *i)* changes in the number of households; *ii)* changes in the ownership levels of key appliances; *iii)* changes in the average energy efficiency of the stock of each key appliance in use. However, although conceptually sound, this methodology presents some specific practical problems in the South African context.

Challenges in the South African context

By far the greatest challenge in the South African context is the very poor availability of consistent and detailed data. At best, data sets are sporadic through time, patchy in their coverage, or inconsistent in their units. At worst, data is entirely absent. In addition to the lack of good quality data, each sector presents its own specific practical challenges.

- **Industrial sector.** Although data for this sector is of a higher quality than in other sectors, it is still not sufficiently comprehensive and consistent to track energy efficiency changes on an annual basis. However, many industrial enterprises are now signatories to the Energy Efficiency Accord, under which they have made a commitment to improve their energy efficiency in line with the targets expressed in the Energy Efficiency Strategy. In fulfilling this commitment, signatories will need to implement some form of energy efficiency monitoring at the enterprise-level, or more likely at the industry-level through industry associations.
- **Commercial/public sector.** Energy consumption data disaggregated into sub-sectors is not currently collected in this sector. Data on the number of employees (which can serve as a proxy activity level indicator) is available for certain sub-

sectors, but is far from comprehensive. Lack of sub-sectoral data makes it impossible to separate out structural effects from genuine energy efficiency changes.

- **Transport sector.** Data availability is reasonable in this sector, but inconsistent. Data on energy consumption is disaggregated into rail versus road, but not into passenger versus freight. Data on activity levels is generally good, with the exception of the "minibus taxi" industry. Accounting for a huge fraction of total road passenger transportation, these vehicles cannot be ignored in an analysis of trends in energy efficiency. However, they are very poorly controlled or regulated, making it virtually impossible to collect reliable data on either activity levels or energy consumption.
- **Residential sector.** This sector presents the greatest challenges, both practically and conceptually. Data coverage and reliability is extremely poor. Some relatively comprehensive household surveys are conducted by various bodies (*e.g.* Statistics South Africa, South African Advertising Research Foundation), but these do not generally track the most useful variables for monitoring energy efficiency. However, given the availability of additional funding for monitoring energy efficiency, these surveys could be modified to track the required variables, at least in the case of higher-income households.

A particular problem is presented in lower-income households, where frequent switching of cooking fuels is common. It is not unusual for a household to possess and electric cooker as well as a paraffin stove and a coal stove. Any of these may serve as a water heater and a space heater in addition to being a cooking appliance. Householders will switch between them according to *i)* financial circumstances; *ii)* availability of fuel/electricity; *iii)* requirement for space heating. The design of a household energy survey that could capture this complexity presents a huge problem.

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Chapter 23

TAKING ADVANTAGE OF THE UNTAPPED WATER AND ENERGY EFFICIENCY OPPORTUNITIES IN MUNICIPAL WATER SYSTEMS

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Introduction

The Alliance to Save Energy is an NGO coalition of prominent business, government, environmental and consumer leaders who promote the efficient and clean use of energy worldwide to benefit the environment, economy, and major stakeholders. The Alliance represents expertise in building, industrial, international, financing, utility, water and energy, policy, market development and education sectors and has over 70 Alliance Associates. The Alliance runs programmes in many countries around the world including Brazil, Mexico, Ukraine, Bulgaria, India, Philippines and also, as of recent times, in South Africa.

The relationship between water and energy

Within municipal water supply systems around the world and considering the total water cycle (abstraction, purification, distribution, supply, collection and transportation of wastewater and wastewater treatment), energy in many cases represents the single biggest input cost in the final product. This cost, when quantified, can represent up to 50% of the total cost, although generally in South Africa it tends to be less than this amount.

Therefore, wasted water equals wasted energy. By addressing inefficiencies in systems, substantial water savings – and hence substantial energy savings – can be achieved. Within most municipal water systems, inefficiencies are common, and there exists huge opportunities to move towards more efficient systems. Analysis of these inefficiencies and definition of the aspects of water systems that can result in efficiencies will be discussed later on in this paper.

What the Alliance does to promote greater water efficiency

In response to the above challenge, the Alliance has initiated the Watergy Programme in various countries around the world. In South Africa the United States Agency for International Development (USAID) funds the implementation of Watergy Programme in four cities: Buffalo City, Mogale City, Sol Plaatje and Polokwane.

Amongst other initiatives, the Alliance assists in the establishment of efficiency management teams (cells) within municipalities such that a holistic and integrated approach is adopted in addressing inefficiencies. This approach often results in additional unexpected efficiency benefits, creating unforeseen cost-benefits that greatly enhance the case made for efficiency and effectiveness.

The Alliance also assists in accessing financial resources for the implementation of efficiency measures. This is possible due to international associations and a strong network with funding agencies, NGO's, financial institutions and government support programmes. Having established experience in the field of water management, the Alliance is able to disseminate best practice through documented case studies and the sharing of success stories.

Some of the intervention measures planned for selected cities in South Africa are:

- Leak reduction programmes.
- Pressure management programmes.
- Establishment of energy management cells.
- Utilisation of biogas.
- Water auditing and benchmarking.
- Monitoring and evaluation.

Amongst the challenges to this programme are the lack of available information (technical, billing, customer records), lack of capacity and lack of financial resources within the municipalities. These challenges will need to be proactively addressed and overcome in the quest for efficiency.

Context within South Africa

The municipal environment within South Africa has experienced much change in the last ten years. This has been precipitated mainly by the political transformation which has taken place, greatly influencing all aspects of local government and hence service delivery.

The majority would agree that this change was necessary so was the overall focus on service delivery extension and institutional restructuring at all levels. However because of this focus, very little attention has been paid to service delivery efficiency.

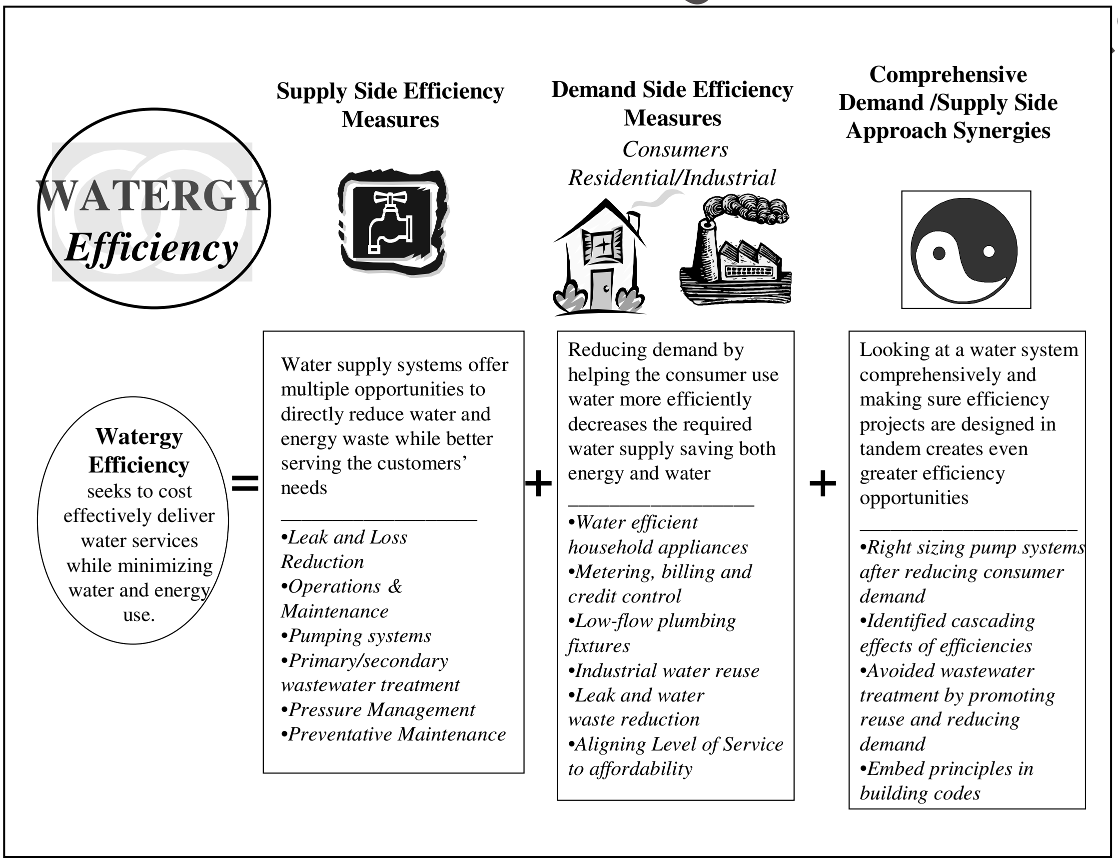
Further extension of service delivery to low income areas is critically needed, but the current constraint on resources makes this a difficult task to accomplish. A solution to this constraint is the creation of efficiencies within the existing supply system, ultimately freeing up operating expenditure that can then be utilised towards service delivery extension

The above statement in effect represents the fundamental relationship between sustainability, affordability and service delivery extension and reinforces the principle that efficiency within any system and extension of that same system are two sides of the same coin. This relationship is not unique to South Africa and manifests itself across the globe.

The Watergy efficiency solution

Having confronted the same issue in other countries, the solution proposed by the Alliance is one of comprehensively addressing efficiency both in terms of a supply side and demand side strategy. It has been proven that by adopting a holistic demand and supply side strategy it is possible to gain an even higher level of efficiency as a net positive benefit on one side that can lead to an unexpected (and sometimes unforeseen) benefit on the other side.

The following graphic illustrates this point:



Some of the synergies that can naturally result from this approach are:

- Reduced costs.
- Improved affordability and sustainability.
- Expanded service delivery.
- Reduced air pollution.
- Improved overall public health.
- Upgraded services.
- Minimised impact on the environment and natural resources.
- Reduced/postponed capital expenditure.

Activities that can be undertaken by municipalities towards efficiency

Although water efficiency within municipalities may be deemed to be a daunting task, there is much that can be done, even with limited resources. Even the smallest of interventions can result in significant savings. Perhaps the greatest need in the quest for efficiency is to ensure that at a decision-making level strategy is formulated to address efficiency. In so doing a framework is created and the way forward can be established. Some of the tried and tested intervention measures are discussed below and can be adopted individually although a more comprehensive and co-ordinated chronological sequence is recommended.

Creation of management infrastructure

The need for management infrastructure within municipalities relating to water efficiency is obvious. Indeed this is perhaps the single most important issue that will ultimately determine success in achieving efficiency. It is safe to state that to the extent that a municipality buys into efficiency and creates the necessary institutional infrastructure, efficiency results will ultimately be realised. Management infrastructure can be considered the single most important factor.

The issue of management infrastructure is both a competency and capacity (qualitative and quantitative) issue and no one size fits all for any municipality. Principles of efficiency are applicable across all municipalities. The principle of an integrated team or structure (horizontal linkage, breaking silo effect) that incorporates different line functions within an institution should be embodied in any such initiative. Also of critical importance is that the various levels of management are identified (vertical linkage) and that buy-in is obtained at all management levels. Actual implementation of efficiency activities (besides internal buy-in initiatives) can be assigned to the integrated efficiency cell or assigned to a dedicated team appointed to implement only specified activities.

Expand bulk water metering and monitoring systems

The age-old adage of ‘to measure is to know’ finds perfect application in efficiency initiatives. Without measurement, quantification of inefficiency is not possible and no relationship between initiatives and results (effectiveness) can be established. Measurement also allows the establishment of trends before intervention and also establishes areas of highest loss and therefore greatest cost-benefit.

Some monitoring systems are automatic, providing information in real time. Although these systems are extremely useful, they tend to be costly in terms of initial capital cost. Other manual systems involving the installation of simple measuring devices with a facility to log flows against time can suffice at this point and it is not always necessary to install complex systems.

No cost-benefit can be established without metering and monitoring systems and so some commitment to efficiency intervention (in terms of expenditure) is required from the municipality at this pre-feasibility stage. A commitment in terms of human resources is required to establish the procedures necessary to record all collated information.

Develop baselines and metrics

Once an initial metering and monitoring system has been established, baselines and metrics should be developed. This is a relatively easy step and requires as a minimum some historical metering and monitoring data. This activity also includes the setting of benchmarks and indicators as the means to establish the 'as-is' situation.

Conducting facility assessment

Based on the preceding steps, an audit of sort on the effectiveness of infrastructure facilities and especially those that form part of the service delivery chain (and hence having significant input costs) should be performed.

This audit will assist in quantifying inefficiencies in the system and assist in focusing effort on intervention measures.

Establish goals and record success

Having performed the above steps, it is possible to establish efficiency goals and start recording progress. Goals should be realistic and reflect the level of resource allocation to efficiency measures. A need exists at this stage for some form of cost-benefit exercise so as to establish the relationship between effort and results and in so doing ensure that efficiency is achievable. By recording success towards objectives and preset goals, the process can become entrenched in the institution resulting in a "success breeds success circle".

Develop a detailed action plan

Development of a detailed action plan is best done after progress has been made in the preceding steps. This will greatly assist in aligning intervention to identified need.

Some assessment of available resources (financial, capacity and competency) should be done before finalising the action plan. Thought should also be given to what is realistically achievable. Intervention measures can follow a project (externally recruited capacity of limited duration) or programme (internally recruited and ongoing activity) approach, and careful consideration should be given to which will be adopted for each specific intervention measure. Some form of internal buy-in at appropriate levels is critical at this stage.

The need for a scoping exercise is also crucial in quantifying required intervention and the action plan can either take into account the results of a previous quantification exercise (if relevant) or include as part of the plan, a quantification exercise. Detailed costs for each intervention measure should be the first outcome of this step or ideally should have been established prior to drawing up the action plan.

Seek outside assistance

Many municipalities and the operational divisions involved with service delivery (the division where efficiency initiatives are undertaken), find it very difficult to adopt an efficiency mindset. This can perhaps best be explained in terms of the contrast between reactive and proactive approaches. Most operational staff is reactive in terms of assigned duties whereas efficiency measures and tasks involve a proactive mindset. By seeking outside assistance this mindset can effectively be overcome.

The Alliance to Save Energy offers external assistance to South African municipalities in the form of free assistance, expertise, sharing of best practices, initiation of activities and access to alternative funding mechanisms. Best results can be achieved when municipalities allow for the transparent co-management of water operations by the Alliance working with operational staff.

Some efficiency initiatives are best implemented by adopting a project type approach involving the procurement of external consultants and contractors to perform various functions. Again this outside assistance, when managed properly, can be very useful in achieving specified efficiency objectives.

Mobilise community action

Community participation in end-user efficiency activities can greatly assist in ensuring buy-in and success of some initiatives. It is in this sphere that substantial opportunities for efficiency exist in the way water is used. This represents an education campaign relating to products and usage habits.

Another initiative that sits squarely in the community arena is the repair of plumbing fixtures on private properties. In many municipalities interventions of this nature is being undertaken as a type of once-off programme designed to empower the consumer to own water consumption beyond the meter. Such a programme is necessary in areas where a culture of non-payment (and hence also non-ownership of consumption) is the order of the day. The use of community plumbers to effect repairs is normally considered appropriate.

Informed communities are also able to assist in raising awareness at senior management level (decision-making and direction setting level) of the need for efficiency.

Supply and demand side intervention

Any integrated efficiency intervention plan should incorporate both supply and demand side interventions. It is only through such an approach that synergies are created and the full potential for an efficient water system realised. Here, an approach that can ensure success is presented.

It is noted that *all* components of the system should be considered, firstly in isolation to each other and secondly as part of the total water system. As such the process should be viewed as an iterative one, with quantified savings upstream inducing savings downstream and vice versa. A list of possible supply and demand side interventions is provided below.

Supply side interventions:

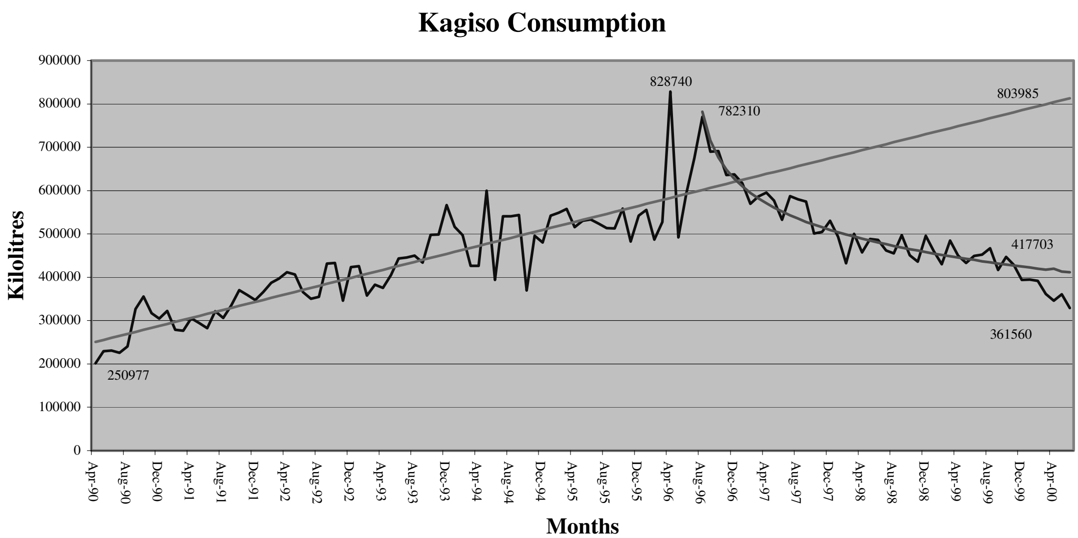
- Addressing leaks within the network.
- Installation of pipes with a low friction loss characteristic.
- Improvement in the network design.
- Reducing over-design of strategic components of the network.
- More appropriate selection of equipment.
- Replacement of redundant equipment.

- Implementation of preventative and proactive maintenance procedures.
- Improvement in reactive maintenance procedures.
- Replacement of inefficient pumps and correction of power factor.
- Installation of intelligent pressure management equipment.
- Shifting of load and pumping times to off-peak periods.

Demand side interventions:

- Focus on improved metering, billing and revenue collection procedures.
- Retrofitting of water efficient household plumbing fixtures.
- Industrial water re-use.
- Addressing leaks on private properties as a one-off exercise.
- Use of efficient wet household appliances.
- Matching service level provision to affordability.
- Promoting the use of water-efficient plants in landscape practices.
- Promoting the use of drip irrigation.
- Rebate installation programmes for consumers who install appropriate fixtures such as rainwater tanks.

Below is a graph representing the results of a co-ordinated and integrated supply and demand side approach to water services supplied to the residential area of Kagiso located in Mogale City over an extended time period.



The benefits and results accrued to the municipality are summarised as:

- Substantial water and energy savings.
- Creation of efficiencies.
- Reduced sewage flows.
- Reduced cost of sewage treatment due to concentrated sewage flows with a high Chemical Oxygen Demand (COD) value.
- Increased payment percentages for wet services (as opposed to payment amounts).
- Postponement of substantial CAPEX related to capacity expansion.

Overall the results represent a win-win situation for the municipality and the customers of Mogale City.

Efficiency attracts development

Efficient water services do ultimately attract development, although this is not an automatic outcome. Efficiencies result in reduction in operating expenditure and if this reduction is passed on to the consumer (especially industrial consumers) in the form of lower tariffs, then water intensive industries are often attracted to the municipality by the lower input costs. The attraction may not necessarily be in the form of new industries but rather expanded industries.

A case in point is SAB-Miller with breweries in multiple locations within Gauteng and also within Mogale City. The single biggest input cost into beer brewing is the water and effluent cost. This is because it takes almost five litres of water to produce one litre of beer. There is almost always an annual regional growth in consumption of beer and annual expansion in brewing capacity most often goes to the lowest cost producer in the region. With the creation of efficiencies it is quite possible that this increased production could be attracted to a city like Mogale, resulting not only in a substantial increase in industrial use of water but also in huge spin-offs to the local economy in the form of job creation and increased housing.

Case studies of successful and planned efficiency interventions

Many examples, both nationally and internationally, can be given of successful case studies involving efficiency interventions. Although they will not be discussed in detail some of these are mentioned below as a conclusion to this paper.

- The city of Austin, Texas developed an entirely independent piping system for recaptured water to be used in a large variety of industrial and irrigation purposes throughout the city, saving 150 million litres per day.
- California reuses over 160 billion gallons of water for irrigation and industries.
- Johannesburg Water is looking at a comprehensive intervention project for Soweto that is anticipated to save at least ZAR 180 million per year in water purchases alone.
- The city of Cape Town implemented a pressure management system for the area of Khayalitsha resulting in savings in water supply of 9 billion litres per annum.

- eThekwini municipality is investigating possibilities of optimising pumping activities during off-peak periods whilst still maintaining minimum storage capacities in all reservoirs.

Every water supply utility should adopt an approach that strongly considers efficiency before addressing shortages by increasing capacity. This principle holds true for water, sanitation, human and even financial resources.

Chapter 24

PUBLIC BENEFIT CHARGE TO SUPPORT ENERGY EFFICIENCY AND RESEARCH AND DEVELOPMENT: LESSONS FROM BRAZIL[1]

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Introduction

It has become common knowledge that in order to pursue a more sustainable development path we need to promote radical changes in the ways we produce and use energy. Developing countries face an enormous task to raise the material wealth of their populations, provide for clean water, sanitation, housing, health care and at the same time meet the challenge of sustainable development.

Energy efficiency and research and development are the very essential keys to help in this process (Herzog and Kammen, 2002; Turkenburg, 2002; Williams, 2001). Developing countries must also find ways to domestically finance these efforts and create the necessary institutional framework and human capacity in order to carry out the tasks related to energy and sustainable development. Countries like China, India, Brazil and South Africa are striving to promote their technology development in pace with concerns with climate change issues[2] and further co-operation with industrialised countries as part of their strategies to be able to compete fairly and participate meaningfully in the global economy.

Brazil has taken some steps to secure funding for energy efficiency and energy R&D and this paper discusses briefly some findings of its recent experiences. A more detailed analysis is developed in Jannuzzi (2005).

Public benefits charge

Traditional support to energy efficiency and energy research and development in Brazil has always relied on governmental support. During the 1990s, with the first moves towards power sector restructuring, there was a great deal of uncertainty about the future of the existing national electricity conservation programme (PROCEL) and the funding of the main electricity research centre (CEPEL), created in the 1970s and heavily dependent on contracts with the state-owned utilities.

1. For a more complete analysis, see Jannuzzi (2005).

2. See, for example, Chandler *et al.* (2002).

The Brazilian electricity sector has 92 GW of installed capacity, 75% of which is hydroelectric (2004). Electricity sales using data from total electricity consumption and national yearly average tariffs amounted to approximately USD 23 billion for that year. The industrial sector is the major consumer of electricity (54%) followed by the residential (26%) and commercial (16%) sectors. Public lighting is estimated to account for approximately 3% of total consumption.

By 1998 the electricity regulator took the initiative to ensure support to these activities from the recently privatized distributing companies. At that time the private electricity companies had the obligation to invest 1% of the net annual revenues in energy efficiency and R&D programmes. These programmes had to be submitted for the regulators' approval on an annual basis. In the beginning only privatised utilities were obliged to invest in EE and R&D programmes, but after the year 2000 all utilities were included, as their concession contracts were being renewed.

Law 9991, enacted in 2000, represented a landmark in this process because it demonstrated the limitation of the system existing at that time, which relied only on the utilities' decisions regarding investments in these programmes. Enough empirical evidence had accumulated suggesting that concentrating on certain types of programmes had not maximized social benefits.[3] The bill approved by the national congress maintained the "1% obligation" of electric utilities annual revenues, but created a new national fund, called CTEnerg, in charge of investing in public interest energy efficiency programmes and public interest energy research and development.[4]

This law also formalised the understanding that only end-use energy efficiency programmes should be considered under the regulated EE programmes.[5] The total amount collected from the utilities' revenues was split in shares varying from 0.25 to 0.5% for CTEnerg and the utilities' EE and R&D programmes.[6]

Between 2000 and 2005 electricity distribution utilities had to invest 0.5% of their annual revenues in end-use energy efficiency projects (note that only distribution utilities are obliged to invest in end-use EE programmes). Generation and transmission companies allocate 0.5% for their regulated R&D programme and collect the other 0.5% for the CTEnerg Fund – there is no contribution to EE programmes.

In 2004 another change occurred in the allocation of the funds collected from utilities' revenues. This was a result of Law 10.848/04 which had the main objective of setting up new rules for the power sector, and created a new entity (the Brazilian Company for Energy Planning or EPE[7]) at the expense of resources from the "1% obligation". Since

3. For example, in 1998/99 the total amount invested by utilities in supply-side efficiency projects amounted 0.72% of electricity revenues, the balance being end-use efficiency projects and R&D projects. Amongst these supply-side projects, a total of 0.54% of electricity revenues was destined to projects to reduce utilities' commercial and technical losses. In this period the amount of resources invested in marketing was the same as residential efficiency programs (Jannuzzi, 2000).

4. CTENERG has a document that defines the scope of its activities and the definition of public interest energy efficiency and R&D: *www6.prossiga.br/ctenerg/docs_base/Diretrizes_Estrategicas.pdf*.

5. Until then supply-side energy efficiency programmes could also be funded with the "1% obligation".

6. In this paper these programmes will be referred to as "regulated EE and R&D programmes". They are proposed and implemented by electric utilities under the approval and supervision of the regulator.

7. EPE is a company owned by the Ministry of Mines and Energy. It is mainly in charge of performing studies and energy inventories.

the law's approval, CTEnerg and the regulated EE and R&D programmes are each entitled to 40% of the funds collected from the "1% obligation" (instead of 50% as previously); the EPE receives the remaining 20%.[8] These percentages are applicable to generating and transmission utilities. In the case of distributing utilities currently 10% of their "1% obligation" goes to EPE and from 2006 onwards this will increase to 15%, according to current rules.

Impacts

The utilities' investments

The regulatory requirement introduced since 1998 has had a positive impact on the level of funding towards energy efficiency. It increased by several times the amount of investments in energy efficiency traditionally made by PROCEL. Whilst PROCEL invested an annual average of USD 14 million during 1994-2003, utilities investments averaged USD 57 million per year during 1998-2004.

The new inflow of financial resources has created an important source of income for some energy services companies (ESCOs) and engineering consulting firms. A recent survey conducted by ABESCO (Brazilian Association of ESCOs) concluded that ESCOs have rated the regulated EE programmes as one of their main funding sources[9]. Some of the largest utilities in the country are increasingly outsourcing the design of EE projects to ESCOs. These utilities decide the types of projects they have interest in and ESCOs compete for designing and implementing the projects. For example, in 2002, 117 contracts were signed with ESCOs, representing about 20% of the investments of the EE utilities' regulated programmes in that year. It is important to observe that in most cases performance contracts are signed between utilities and their clients, and not by the ESCO and the client. There is no information suggesting that the utilities' resources have been leveraged by ESCOs or other agents by taking credits with financial institutions.

In spite of the new level of funding, it is important to note that the evaluation of the savings incurred has not evolved to accurately monitor the progress being achieved. The regulator in fact has limited capacity in the area of energy efficiency monitoring and evaluation (which is not its primary role) and has not delegated the task to a more specialised agency.

Most of the investments in energy efficiency (about 55% during 1998-2003) have gone towards improving public lighting, although it represents only 3% of total electricity consumption. The predominance of public lighting becomes even more pronounced when we consider the governmental programme RELUZ administered by PROCEL and Eletrobrás. This programme began in 2000 with the target to improve the efficiency of 77% of the lighting points and to help expand lighting systems up to the year 2010. RELUZ can finance 75% of the capital costs of new lighting systems to utilities at highly

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8. It is important to register that prior to the approval of Law 10.848/04 a much more drastic re-allocation of the "1% obligation" was being proposed by the current government. Initial proposals would have reduced the allocation of funds to EE and R&D down to 0.25% for CTENERG and 0.25% for regulated EE and R&D programs. This triggered a concerted reaction from academics and utilities which were able to influence Congress to restore the levels of funding. The episode illustrates how fragile is the support to EE and R&D amongst government officials and politicians.

9. Personal communication with M. C. Amaral, ABESCO Executive Secretary, November 2005.

subsidised interest rates.[10] This partial grant helps explain the overwhelming preference for this type of measure by the utilities. Other reasons are the relatively low price paid by public lighting, despite its impact on peak load demand, and the poor payment history of many municipalities. From the utilities' perspective this was a way to minimise losses from their sales to municipalities. Utilities have also started to invest in R&D programmes contracting projects with universities and local research institutions. From 1998 to 2004 a total of USD 176.6 million was invested, a figure that is relevant by Brazilian standards.

The CTEnerg fund

According to the current CTEnerg guidelines, it is intended to provide funds for R&D and EE in areas considered socially desirable and consistent with national development plans and goals, but which are not being addressed by the market actors. The resources collected by CTEnerg can be transferred from year to year when not used in the current fiscal year, and they offer the possibility to invest in long-term projects with a higher degree of risk. This way, CTEnerg offers a more stable source of public support to energy R&D and EE for projects that do not attract interest from private investors but are considered important for society. If operated complementarily to the utilities' regulated programmes and other private investments, it has the potential to provide greater stability to the final commercialisation of R&D results in the future. CTEnerg projects are in general larger and have longer realisation periods compared to those implemented by utilities.

In 2001 CTEnerg invested USD 17.3 million in electricity-related programmes and USD 37.3 million in 2002. This was much less than the amount invested by utilities and less than the estimated amount accruing from the fund's share of resources from the "1% obligation". According to Law 9.991/00, the residual is being accumulated for future use. Current provisions in the legislation and formal procedures used to plan the national budget (annual expenditures under the CTEnerg Fund need to be approved by the national congress) have hampered the management of the resources and the fulfillment of its original objectives to provide a stable source for long term programmes. As the numbers in the following table show, the funds allocated for public interest EE and R&D have been consistently underspent. There has been a deliberate government policy to restrict the use of these funds, helping the Planning Ministry to claim these unspent resources as part of the annual targets for the public sector budget surplus. Although this procedure clearly contradicts the legislation that created CTEnerg, the practice has been maintained, compromising long-term research and EE programmes.[11]

10. The interest rate and payment conditions are very favorable considering existing market conditions in Brazil (5% interest per year, whilst market rates have varied 18-19% and the National Development Bank (BNDES) has an average rate of 15% per year).

11. In 2005 only 17% of the CTENERG annual budget was spent.

Table 24.1. Public R&D fund: budget allocation (2001-2005)

	Total budget	
	(USD millions)	% spent in R&D projects
2001	34.5	62%
2002	20.1	34%
2003	64.8	35%
2004	54.1	9%
2005	39.4	75% (official projection)

Source: Brazilian Ministry of Science and Technology.

Conclusions

It is very unlikely that after the power sector reforms, Brazilian utilities would have invested in energy efficiency or R&D projects. The regulatory and legislative efforts put in place were important instruments in not only securing support but also in moving the country to a higher level of activities in these areas.

However, it is becoming evident that these instruments are not sufficient to guarantee the advancement of energy efficiency and R&D and there is an increasing threat of political attacks on the mechanism, trying either to reduce the amount collected form the electricity sales or re-appropriation of the funds for purposes other than energy efficiency or energy R&D. The country has not implemented complementary public policies to take advantage of the higher levels of funding, nor has it succeeded in creating a more stable institutional framework to promote planning, monitoring and evaluation of the investments made.[12]

The country has moved very slowly in setting new technical standards that could drive R&D investments to meet higher levels of energy efficiency in equipments and buildings. There have not been any significant changes in tariff-setting procedures, or the regulatory incentives that address the decoupling of utility profits and increased electricity sales.

Several countries have now experimented with the implementation of public benefit charges by collecting resources from electricity sales to fund public purposes in the electricity sector. This is a strategy that can continue to support, in an equitable manner, activities that would be lost in a more competitive environment. The literature also points out the dangers of public benefit charges being captured for other purposes (Wiser *et al.*, 2003). This international experience and the recent Brazilian experience shows the importance of a broad energy policy that continuously supports the advancement of energy efficiency and investments in R&D aligned with objectives of sustainable development. Institutional capability has to be in place in order to secure proper allocation of the funds and avoid their appropriation by other agents and interests.

12. In 2002 the Brazilian Ministry of Science and Technology contracted an independent organisation to perform these activities. By 2004, with a new government and Minister these activities were interrupted and allocation of funds was under more political influence from government.

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Chapter 25

MEDITERRANEAN RENEWABLE ENERGY PROGRAMME

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Promoting renewable energy in the Mediterranean region

Renewable energy has advanced rapidly in the past two decades and offers a range of new, clean and sustainable energy services; however, the wider use of renewable energy is often hampered by a number of barriers, including higher initial costs and the lack of affordable finance. The Mediterranean Renewable Energy Programme (MEDREP), launched by Italy as a Type II Initiative at the 2002 World Summit on Sustainable Development in Johannesburg, has been developed to reduce the cost of renewable energy by expanding markets and creating a strong market environment for renewable energy. MEDREP's mission follows the recommendation of the G8 Renewable Energy Task Force that countries should develop and demonstrate renewable energy projects where renewable energy is a least cost option on a life cycle basis, and/or renewable energy can protect the local and/or global environment at a reasonable cost.

MEDREP objectives and activities

The two principal objectives of MEDREP are:

- To provide sustainable energy services particularly to rural populations; and
- To contribute to the climate change mitigation by increasing the share of renewable energy in the energy mix of the region.

Within these objectives, the programme aims to develop a sustainable renewable energy market system in the greater Mediterranean region through three main activities:

- Tailoring financial instruments and mechanisms to support renewable energy projects;
- Strengthening policy frameworks and overcoming barriers to renewable energy deployment; and
- Building stronger private sector infrastructure while considering the positive role of "tradable renewable certificates" and "certified emission reductions".

These activities also aim to strengthen existing networks while favouring the creation of new relations between stakeholders.

Strength through partnership

MEDREP incorporates the strengths and experience of a wide range of partners, including: the Italian Ministry for the Environment and Territory (IMET); the Ministry of Territory and Environment of Algeria; the New and Renewable Energy Authority of Egypt (NREA); the Environment General Authority of Libya (EGA); the Ministry for Resources and Infrastructure of Malta; the Centre for Renewable Energy Development (CDER) of Morocco; the Tunisian Ministry for Industry, Energy and SMEs (TMIESME); the Tunisian National Agency for Energy Conservation (ANME), the Ministry of Water and Environment of Yemen; the French Agency for Environment and Energy Management (ADEME); the International Energy Agency (IEA); the Interdisciplinary Institute for Environmental Research (DIPE); the International Solar Energy Society-Italy (ISES ITALY); the Mediterranean Association of the National Agencies for Energy Conservation (MEDENER); the Observatoire Méditerranéen de l'Energie (OME); the Regional Environmental Centre for Central and Eastern Europe (REC); the Renewable Energy and Energy Efficiency Partnership (REEEP); the United Nations Environment Programme (UNEP); and the World Bank.

Other partners will also shortly be involved in the partnership, as MEDREP is a co-operative programme with countries both on the north and south of the Mediterranean.

MEDREP is committed to developing and reinforcing potential synergies with other initiatives and partnerships in the sector of renewable energies, such as JREC (Joint Renewable Energy Coalition) and REEEP (Renewable Energy and Energy Efficiency Partnership).

Partners' tasks

Partner countries and national agencies of Southern and Eastern Mediterranean Region, identify and implement strategies, programmes and projects in the Region, in collaboration with international partners that, respectively, have the following tasks:

- IMET: promoter of the MEDREP initiative; it provides the funding at the starting stage and is responsible as the MEDREP Secretariat.
- ADEME: cooperates in the operational activities of the Mediterranean Renewable Energy Centre (MEDREC) particularly in the fields of renewable energy resource assessment, large scale integration of renewables in the building sector and on the electricity grids; it provides support through project financing on the basis of a project portfolio in close relation with project developers; support also given to other partners towards the regionalisation of MEDREP.
- IEA: identifies policies and institutional barriers to be overcome for the opening of markets, based on the review of feasibility studies of concrete projects. It also plays advisory role to the country-partners to evaluate and advise on appropriate policy frameworks in order to facilitate the diffusion of renewable energies, including tradable renewable certificates.

- ISES ITALY: facilitates communication and dissemination of information among potential Italian and international industrial partners and assists in the identification of Italian and international investors; also, serves as information centre and observatory for the renewable energy scene, focused on Italy, including development of programme monitoring and evaluation (M&E); provides technical support to MEDREP Secretariat; provides a web portal on renewable energy to serve as a clearing house mechanism in order to facilitate the participation of partners/investors in the implementation of projects in the Region.
- MEDENER: develops and finalises R&D activity, gives counselling for suitable policy frameworks in the host Countries and seeks and encourages regionalisation of the Programme.
- OME: submits proposals to European calls for funding in the area of the Sixth Framework Programme for R&D, MEDA II and SMAP Programmes; promotes capacity building, prepares pilot projects portfolio and identifies industrial partners and local implementing partners in the South Mediterranean region; contributes to the dissemination of results; co-operates with IEA on policy and institutional issues and with UNEP on capacity building aspects.
- REC: prepares pilot project portfolios and identifies industrial partners and local implementing partners in central and eastern European countries; serves as a training centre for central and eastern Europe and Turkey, in a similar manner to and in co-operation with MEDREC.
- REEEP: co-operates with MEDREP in creating a global network for the promotion of renewable energies and energy efficiency in the Mediterranean region by sharing best practices, tapping into global expertise and project financing opportunities and raising the profile of local/regional expertise and projects. MEDREP and REEEP co-operate on the basis of the exchange of relevant information, expertise and viewpoints in order to develop and reinforce potential synergies, enhance public dialogue and implementing common position.
- UNEP: identifies, develops and implements financial support mechanisms to positively influence finance flows to renewable energy companies and projects in the greater Mediterranean region countries. Based on a study on the availability of financing and possible investments, the opportunities for development of renewable energy projects in the region and the assessment of existing barriers to improve financial flows to renewable energy companies, UNEP develops project financing mechanisms that support renewables projects.
- The World Bank: provides assistance in project designing in order to facilitate their eligibility and evaluation of the possibility to co-finance the CDM-eligible projects through the Community Development Carbon Fund (CDCF) and the Italian Carbon Fund (ICF).

MEDREP structure

MEDREP is composed of a steering committee and a secretariat. The Steering Committee, chaired by the Italian Ministry for the Environment and Territory, is composed of one representative from each partner. The Steering Committee meets twice a year to provide strategic guidance for the Programme's work-plan and projects, oversees the Secretariat's activities, monitors and reviews the Programme work plan and project cycle implementation, and coordinates the activities of the multilateral partners.

The Mediterranean Renewable Energy Centre (MEDREC)

Within the MEDREP framework, the Italian Ministry for the Environment and Territory, the Tunisian Ministry for Industry, Energy and SMEs, and the Tunisian National Agency for Energy Conservation signed on 26 January 2004 a Memorandum of Understanding for establishing in Tunis a centre for training, information dissemination, networking and development of pilot projects in the field of renewable energies (MEDREC).

MEDREC is a part of the Global Network on Energy for Sustainable Development (GNESD), a UNEP facilitated network of centres of excellence in the developing countries and network partners working on energy, development and environment issues. MEDREC's main focus is the development of the wind energy and solar energy sectors, although mini-hydro, geothermal, biomass and fuel cells are also considered.

The objectives of the centre are to:

- Deploy sources of finance and options to support renewable energy projects;
- Develop regional competence in renewable energy;
- Disseminate information to different sectors; and
- Develop renewable energy pilot projects and transfer technology.

The centre is managed by a technical director designated by the Tunisian Ministry of Industry, Energy and SMEs who is assisted by a deputy director designated by IMET. The technical staff is composed of nine experts, one from each of the following countries of the Northern African Region: Algeria, Egypt, Libya, Morocco, and Tunisia; two experts from Italy and two experts from UNEP. MEDREC is already operational and is the reference point for the programmes carried out by the partners.

Current projects and activities

MEDREP renewable energy projects include those within bilateral agreements between IMET and Algeria, Egypt, Morocco and Tunisia.

Dounya Park (Algeria)

The project is about developing a 240-hectare urban park aimed at halting desertification and conserving biodiversity. The park will be powered by a photovoltaic wind system and includes a centre aimed at developing renewable energy study and training activities and managing energy production from renewable energy installations.

Timimoun (Algeria)

The project, developed in the framework of the Sahara Project, consists of waste water treatment in the Sahara oasis by using ultraviolet solar radiation and the recovery of the treated water for irrigation. Energy production with renewables brings about fewer greenhouse gas emissions that are responsible for climate change.

Use of solar thermal energy in resorts and new villages in reclaimed areas (Egypt)

The project uses solar thermal technologies to provide sustainable energy to tourist resorts and villages of the reclaimed lands. Particular attention is focused on providing heating and air conditioning to resorts, in order to decrease the total demand for electricity, and to provide cooling systems to conserve agricultural products in rural villages.

Photovoltaic rural electrification (Egypt)

The project aims at supplying electricity by photovoltaics to remote rural communities in the desert that suffer from the lack of energy services. Due to the dispersion of houses as well as rural communities, in addition to low demand, the extension of the grid is very non-economical, while the technical and economic feasibility for PV solar energy provision to those rural communities has been proven, in addition to its environmentally friendly performance.

Financial mechanisms for solar water heating (Morocco)

In the framework of the national solar water heaters programme in Morocco (PROMASOL), both the supply and demand-side financial supporting mechanisms (in particular, leasing) are being implemented to support the local market. In addition, with the involvement of the Office National de l'Electricité (ONE) and the United Nations Environment Programme, Division of Technology, Industry and Economics (UNEP/DTIE), financial tools for solar water heating are being further developed, specifically with regard to a leasing/credit facility developed for the hotel sector.

Renewable energies promotion by developing green certificates trading (Morocco)

The objective of the project is to promote renewable energies by setting up a framework of "green certificate trading" between Morocco and Italy, and by creating a legal and favourable environment for the transfer of these certificates between the two countries. The goal is then to create new concepts for promoting renewable energies and encouraging projects that generate green electricity.

Studies of wind energy integration into the national electric grid (Morocco)

Recent studies have confirmed the existence, in Morocco, of several regions with high wind energy potential. A 50 MW wind farm is already in operation and the installation of several wind parks is foreseen by 2010. In this context, this project has developed technical and economic feasibility studies for assessing the potential of wind energy exploitation.

Development and implementation of a control system for mini-hydraulic plants (MHP), rehabilitation of PV solar pumps in the region of Tensift Al Haouz, evaluation studies for the Souss-Massa biogas project (Morocco)

This set of projects addresses the problem of energy deficiency in some rural areas in Morocco by supporting actions intended to enhance energy services such as lighting, drinking water, health, education, agriculture, cooling, heating and cooking. Activities consist of identifying specific energy needs and necessary assistance to create economic, social and institutional conditions that will enable energy needs to be met, also involving the private sector and the civil society.

Renewable energy for water supply (Morocco)

This project consists of coupling wind and solar energy technologies to water desalination and water pumping installations in order to supply water to rural areas.

Energy efficiency in public hospitals (Morocco)

The project aims at promoting the improvement of energy efficiency and energy saving in public hospitals in Morocco. An assessment of energy demand and final energy use in Moroccan hospitals and feasibility studies will be carried out. On the basis of these feasibility studies, concrete implementation will take place for energy efficiency/energy saving actions and for high standard cogeneration plants.

Solar water heating system interest rate facility (Tunisia)

A financial support mechanism for a Tunisian solar water heating (SWH) interest rate facility is jointly implemented by UNEP/DTIE, the Tunisian National Agency for Energy Management (ANME) and the state utility, the Société Tunisienne de l'Electricité et de Gaz (STEG). Based on the Tunisian government's strategy and the assessment of the existing barriers, the 'ProSol' interest rate facility will support solar water heating market and provide training for local solar water heating suppliers.

The aim of the interest rate facility is to help local financial institutions build loan portfolios in the SWH area by providing an 'interest rate subsidy' that will effectively lower the interest rate for a ProSol loan, addressing, at least partially, the barrier of the higher initial cost for solar water heaters. STEG will help promote the facility and the use of solar water heating systems by recovering the monthly loan payment via a STEG customer's utility bill. This reduces the risk of a consumer defaulting on the loan, which lowers the bank's risk and contributes to the creation of a sustainable market for solar water heating systems.

The facility will be phased out over two to three years to allow a smooth transition with Tunisian government subsidies, leading to 20 000 to 30 000 solar water heating (SWH) system installations. This impact will increase as financial institutions build confidence and begin to expand retail lending to the SWH sector. The facility will promote a competitive market for SWH by offering an interest rate subsidy through a number of local banks for SWH credit loans, thus subsidising the borrower.

Future projects

At present, plans for enlargement of the area benefiting from MEDREP pilot projects to include all the other countries of the Northern African region are being implemented. A portfolio of potential projects to be developed in Algeria, Egypt, Libya, Morocco and Tunisia has been drafted by MEDREC experts, and other projects will be implemented in all the countries involved in the initiative.

The future projects aim at:

- Delivering electricity to isolated rural populations, based on village-scale mini-grids.
- Accelerating the integration of renewable energy on the national electricity grids with the objective of reaching grid stabilisation and meeting supply-demand balance.
- Addressing the global approach of renewable energy introduction (mainly solar but also geothermal energy) in the building sector in coherence with energy efficiency policy (by integrating the results of the MEDA/solar thermal technologies dissemination programme in the building sector).
- Desalinating sea water, in order to increase drinking water supply and water availability for irrigation.
- Increasing agricultural water pumping by solar, wind and biomass powered water pumps.
- Disseminating cooling systems for food conservation, powered by renewable, in farms and fisheries.
- Addressing, in the grid-connected urban and tourist areas, the household and the community demand for lighting, food and drugs cooling, access to communication networks, using solar home systems, small wind turbines, biogas and biomass power technologies.
- Creating joint ventures and other manufacturing, assembly and distribution/installation capabilities in partner countries, so that they gain the maximum economic benefit from the initiative; promoting certification/standardisation programmes for renewable energy equipments.

These innovative pilot projects will be a "catalogue" of best practices to be replicated, increasing the share of renewable energy options available through already feasible renewable energy power plants like wind farm, biomass co-combustion and hydro plants.

Chapter 26

ENERGY AND ENVIRONMENT PARTNERSHIP WITH CENTRAL AMERICA

by
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The Energy and Environment Partnership promotes the use of renewable energy sources in seven Central American countries. By providing an innovative framework for project initiation and approval, the partnership enables fruitful co-operation between government bodies, enterprises, investors and local civil society. More than 50 projects have so far been granted funding, ranging from feasibility studies and pilot projects to networking, capacity building and the development of energy markets.

Co-operation to promote renewable energy

The Partnership was initiated by the Ministry of Foreign Affairs of Finland, the Central American System for Integration (SICA) and the Central American Commission on Environment and Development (CCAD) during the Johannesburg World Summit on Sustainable Development in 2002. The objective is to improve energy efficiency and promote the sustainable use of Central America's ample renewable natural resources.

In order to reconcile the interests of business and administration, the Partnership involves concrete pilot projects as well as capacity building, the enhancement of regional co-operation and the development of administrative instruments. All stakeholders are encouraged to participate in projects from the very beginning. This approach has been welcomed enthusiastically, and attracted growing interest from international development funds. Current partners include enterprises, financiers, universities and research institutions from Central America and Finland.

An innovative model for project initiation

The Partnership organisation is co-ordinated by a high-level steering committee consisting of one member from each country's environment or energy ministry. A small technical evaluation team provides expert advice on project proposals.

Any stakeholder is entitled to propose a project using the Partnership's unique bottom-up procedure. Proposals are first evaluated by the national representatives of the Steering Committee, and then by the technical team. The Steering Committee decides on the amount of seed capital to be allocated for each successful proposal. This procedure enables stakeholders to know at an early stage how much Partnership funding they can expect for their project.

Concrete projects and expert forums

The Partnership has received more proposals than it is able to support, even though additional funding has also been provided by other stakeholders. So far, the 55 best projects have been accepted for support by the Steering Committee, covering all the main forms of renewable energy. Examples include:

- Belize: feasibility study of biomass fuel alternatives to bagasse for power production.
- El Salvador: planning a trust fund to promote small renewable energy projects.
- Guatemala: feasibility studies for two wind power projects; also, biodiesel production using Jatropa Curcas plants grown in plantations.
- Honduras: feasibility study on using methane from municipal waste to generate energy.
- Nicaragua: providing equipment for a small hydro project enabling connection to the grid.
- Panama: photovoltaic electrification of Kuna Indian island communities.

The latter project involves the Kuna Indians of Panama who live in small island communities in the Caribbean. Their indigenous cultures are among the best preserved in the Americas. As part of the Partnership, photovoltaic systems have been installed in the largest Kuna community on the island of Ustupo. Solar panels produced by Naps Systems now provide electricity for the community's hospital, school, council house and street lights. This successful pilot project can easily be replicated in the dozens of similar Kuna island communities.

Some of the projects involve several Central American countries, including the establishment of solar energy systems to heat water in hotels, pilot water pumping projects using photovoltaic systems, biomass tests in a Finnish laboratory container, and the installation of a pilot processing plants for biodiesel.

Making information available through publications is also a part of the Partnership. The Central American Carbon Finance Guide has been published within the Partnership to facilitate the application of the Clean Development Mechanism (CDM) of the Kyoto Protocol. CDM projects have so far been hindered by complex administrative procedures and lack of information. The new guide improves the situation by providing tools and valuable information on Central American countries' energy sectors and policies, business opportunities on the carbon markets, and risk management. The Guide is available on line at *www.sgsica.org/energia*.

The Partnership organises expert forums twice a year in connection with the Steering Committee meetings to facilitate networking and exchange of information. These popular and increasingly well-attended forums deal with themes such as financing, biomass, wind power, geothermal and small-scale hydropower.

Chapter 27

RESEARCH FOR SUSTAINABLE DEVELOPMENT: EXPERIENCES IN AUSTRIA

by
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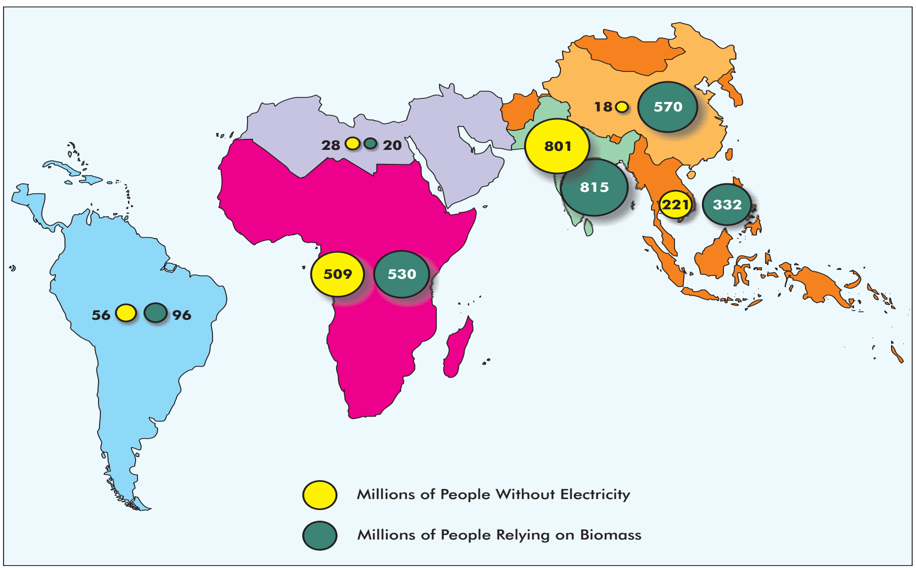
Introduction

Creating a sustainable energy system is one of the most challenging questions for the future worldwide. World energy demand is projected to grow rapidly this century, suggesting that the continuation of "business-as-usual" development will be unrealistic.

Figure 27.1 shows that, by far, not everyone has equal access to energy resources. 1.6 billion people worldwide are without electricity and 2.4 billion rely on traditional biomass.

Figure 27.1.



Source: IEA World Energy Outlook, 2002.

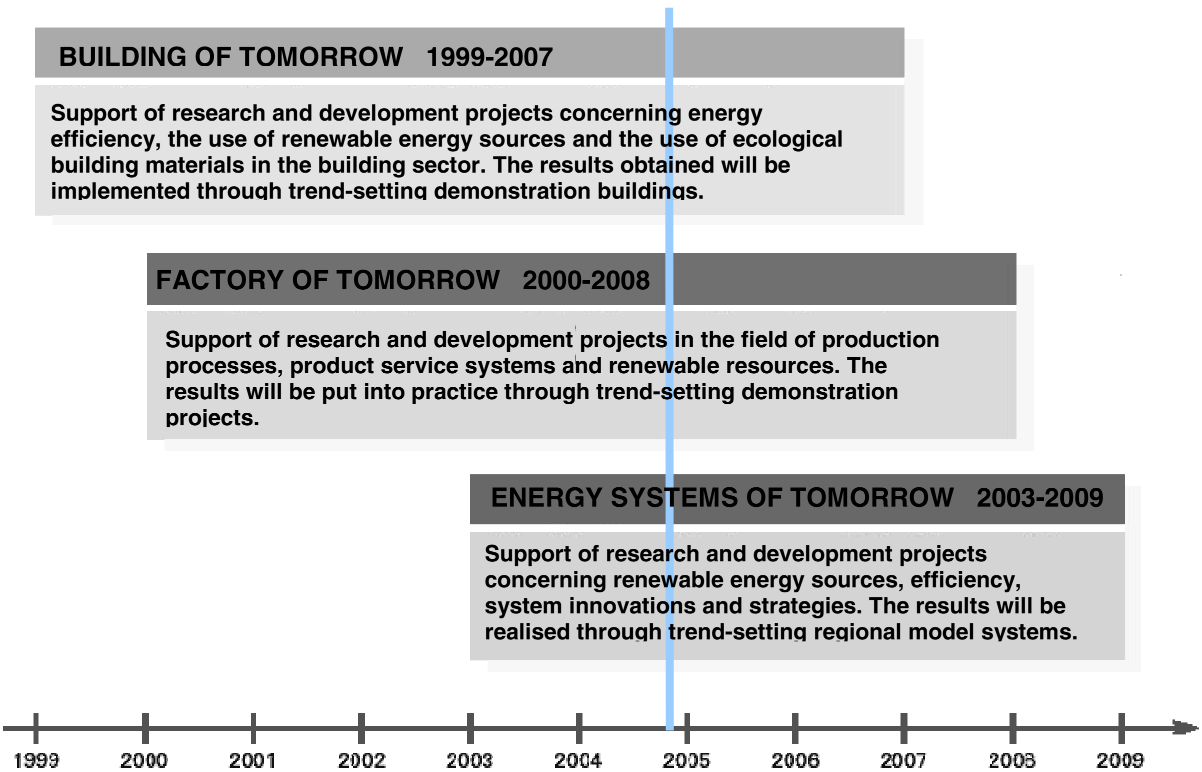
An equal distribution of opportunities and energy resources worldwide that respects sustainable development would demand enormous effort. According to expert calculations, every person in the developed countries would need to reduce energy demand to one-sixteenth of current levels to allow for equal development in poorer countries. Dedicated research, development and technology collaboration are crucial in working toward this goal.

Austria has a long tradition of research for sustainable development. Austrian energy-related R&D has two main priorities:

- First is increasing energy efficiency and reducing energy demand.
- Second is renewable energy development with a focus on R&D in bio-energy, solar energy and hydropower.

Socioeconomic aspects and concepts for successful technology diffusion are another important priority. The reasons for this are environmental concerns such as climate change and sustainable development, but also the long-term security of supply. When speaking about sustainability we think of environmental, social and economic issues.

Figure 27.2. Austrian programme on technologies for sustainable development



Austrian programme on technologies for sustainable development

One main R&D activity in the field of sustainable energy use is the Austrian programme on technologies for sustainable development. This programme started in 1995 and has the goal of fostering structural change to lead toward a sustainable economy through research, development and dissemination. Energy-related R&D topics include renewable energy, energy and resource efficiency, strategic questions and socioeconomic aspects**.** Figure 27.2 illustrates this programme's content and structure.

In addition to activities and programmes at the national level, there is an emphasis on international R&D collaboration. Austria is a founding member of the International Energy Agency (IEA) and is active in its technology programmes. Since joining the European Union, Austria has also been an active participant in the EU's R&D programmes.

With these R&D efforts at both the national and international level, Austria has obtained forward-looking results toward sustainable development. The following are some examples of demonstration projects resulting from R&D work in the field of sustainable development.

- *Example 1: Straw bale passive house building for office use.* This two-floor building is built with locally available renewable raw materials. It requires no external heating even in cold climate conditions. The concept combines modern architecture with the use of traditional raw materials.

- *Example 2: façade collector.* This construction is used for hot water generation and heating. Additionally it has an attractive design. Such façade collectors can be important components for passive house buildings.

- *Example 3: Schiestl house.* This is an alpine refuge hut for extreme climate conditions (2153 metres above sea level). To construct this house, an integrated ecological concept was developed. Electricity is generated by wind power and photovoltaics, and there are solar thermal systems for space heating and the production of hot water. Rain water is collected for water supply.

- *Example 4: combined heat and power gasification biomass plant.* This plant produces heat and power from a renewable energy source. The plant also generates liquid fuel, hydrogen and synthetic gas.

Adapting technology for developing countries

Based on these successful examples in implementing sustainable solutions in Austria, it has been demonstrated that the technologies can successfully be utilised in developing countries when they are adapted to specific situations in a particular region or country.

- *Example 5: the "Clay Stove for Zimbabwe" project.* In this bio-energy project a traditional Austrian stove concept has been adapted to the needs of a developing country, Zimbabwe. The first step was an assessment of local needs. Then, a prototype of a kitchen stove that can be built by local people with local materials was designed. With a thermal efficiency of 84%, these stoves allow significant reductions in fuel consumption.

The starting position for this project was the fact that 2.4 billion people worldwide rely on traditional biomass for cooking using stoves with very low combustion efficiency (10-20%), which causes severe health problems due to high emissions. Inefficient combustion creates high fuel demand and leads to deforestation and heavy work for women and children who must collect firewood.

The following two pictures show two stoves that have been developed in regions of Bhutan and Zimbabwe.

Source: AEE-Intec.

Example 6: "Austria-Zimbabwe Solar Energy Co-operation". Austria is a technology leader in the field of solar thermal applications. In this solar thermal energy project the technological knowledge is adapted to the needs of an African country. Through co-operation with local firms and the University of Zimbabwe a system for solar water heaters has been developed. These can be produced under local conditions. Another feature of this project is a qualification programme for manufacturers, technical personnel and students.

Through the project in Zimbabwe, 375 solar thermal systems and six solar dryers were built by August 2004. To promote further development, eight training courses with 179 participants have been held. Dissemination has also taken place in Uganda and Iran. Further development and dissemination is supported by the Austrian Development Agency.

The following picture shows a solar thermal system for water heating on the roof of a hotel in Uganda.

Source: AEE-Intec.

Chapter 28

INTERNATIONAL NETWORKS TO PROMOTE ENVIRONMENTALLY SUSTAINABLE INDUSTRIAL PRODUCTION

by
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Introduction

During the last two decades, China has experienced rapid economic growth as well as dramatic industrialisation and urbanisation. This galloping growth was based on a conventional development pattern with massive use of limited resources and energy consumption, which resulted in serious environmental damage. As one of the largest developing countries, China firmly expects to continuously improve people's living standards with the objective of quadrupling GDP by the year 2020 compared to 2000. Due to the three major challenges of a large population, shortage of resources and environmental pollution, pursuing economically, socially and environmentally sustainable development is the only solution.

In March 1994, the government of China published the White Paper, "China's 21st Century Population, Environment and Development", to guide the country towards sustainable development. After ten years of experience, the new government has adopted a practical strategy to implement a "new scientific development concept" and a "harmonious society" which calls for a "people-centred" outlook in ensuring sustainable development suited to China's current economic conditions.

The scientific development concept focuses on integrating humanism with harmony and sustainable development, while pushing forward the reforms and the development drive to co-ordinate and harmonise development between urban and rural areas, different regions, economy and society, man and nature, domestic development and the opening up to the outside world. A harmonious society aims at giving full scope to people's talent and creativity, enabling all people to share the social wealth of reform and development, and forging an ever closer relationship between the people and the government.

China's challenges in energy development

There are three major policies, which China is prioritising to implement sustainable industrial development:

- The development of a new development pattern of industrialisation.
- The development of a circular (recycling) economy.
- The development of a resource saving society.

China has set up specific objectives in the 11th Five-year Plan (2006-2010):

- Improve people's living standards with the objective of doubling GDP by 2010.
- Increase energy efficiency by reducing 20% of energy consumption per unit GDP in 2010. However, there are three main challenges for China's energy development:
- *Imbalance between demand and supply in energy:* China's energy demand in 2020 is predicted to be between 2.5-3.3 billion ton coal equivalent, which will be at least double the demand of 2000. According to energy data in 2002, China's energy consumption is 1.48 billion ton coal equivalent, but energy production is 1.387 billion ton coal equivalent.
- *Low efficiency of energy utilisation:* China's energy efficiency is 31.2%, 10% lower than the world average. Production of the main industrial products consumes 30% more energy per unit than in developed countries. There is great potential for energy saving and efficiency improvement.
- *Severe environmental pollution:* Energy exploitation and utilisation is the major cause of environmental pollution in China. Burning coal brings 70% of dust and CO_2 emissions and 90% of SO_2 emissions.In the coming 20 years, China will firmly follow the principle of ensuring energy supply, prioritising energy saving, and optimising structures to quadruple GDP growth and double energy supply. Main efforts will be made in technology development and innovation for energy saving and improving energy efficiency technologies. Energy demands in the building and transportation sectors will increase dramatically in the near future. These sectors should adopt energy saving and energy efficiency technologies as a priority.

Case studies on networks to promote environmentally sound technologies

Case 1: APEC Virtual Center for Environmentally Sound Technology Exchange

The APEC Virtual Center for Environmentally Sound Technology Exchange (APEC-VC) is a strong and growing force in the Asia-Pacific region working to address environment and technology issues. This project helps APEC economies, municipalities, corporations and environment-related institutions share, via the Internet, information on environmentally sound technologies. Much like an environmental technology exhibition, APEC-VC disseminates a wide range of information related to the protection of the earth's environment.

Each APEC-VC is a vast, diverse environmental technology exhibition. The web site contains links to a variety of documents, categorized by topic. For easier searching, information is classified by subject at three levels. The three main categories are global environmental conservation, local environmental conservation, and environmental protection programs.

Case 2: Asian Regional Energy Database (RED) Project

The Regional Energy Database (RED) project aims to enhance the capacity of the energy sector of developing countries in Asia and the Pacific region in policy formulation on energy for sustainable development. It contains analysis of good practices in support of enhanced utilisation of renewable energy and energy efficiency. This project is funded by UNESCO, Jakarta office (through a Japanese Fund In Trust Agreement) and co-ordinated by the Asian Institute of Technology (AIT) with the support of UNESCAP.

The project also aims to develop national databases in five pilot countries, namely Cambodia, Indonesia, China, the Philippines and Vietnam. The database will present country profiles as a resource tool for the policy makers on the current status of renewable energy and energy efficiency in the country; also, research, development and dissemination programs being undertaken, and the key players in their promotion and utilisation.

Detailed objectives of the RED project are:

- Developing a regional database/website where the above information would be accessible online.
- Developing national databases that would contain information on national energy policies that reflect the government's commitment towards energy efficiency and promoting renewable energy.
- Presenting examples of successful renewable energy development and energy efficiency implementation in Asia and the Pacific region.
- Developing an online directory of existing databases on renewable energy and energy efficiency worldwide with emphasis on Asia and the Pacific region.
- Training personnel in database development and maintenance to enhance capacity at the national level.

Proposal for an international OECD network to promote sustainable industrial development

It is proposed to establish an OECD Science and Technology Co-operation Network for Sustainable Development, in particular for sustainable industrial production. Network objectives could include:

- Setting up a multilateral platform to share information and promote S&T co-operation for sustainable industrial production between OECD members and developing countries, in particular to disseminate existing information in the OECD member countries.
- Promoting dialogue and partnerships among decision makers, industries, academics, consulting firms, etc., to promote sustainable industrial development between OECD and developing countries.

- Strengthening dissemination and application of knowledge related to sustainable development and technology innovation and transfer between OECD and developing countries.Information on research, policy, technologies, best practices and business opportunities could focus on the following four areas:
- Water.
- Energy.
- Raw materials.
- Biodiversity.

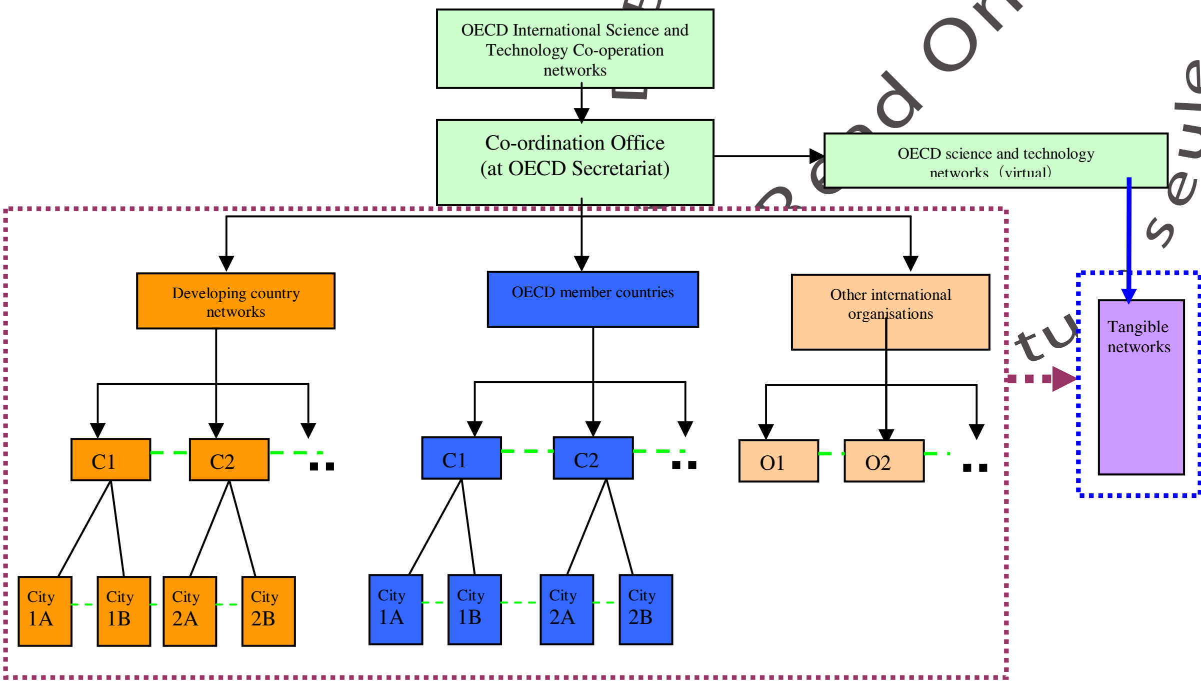
The framework of the OECD network (see Figure 28.1) could be as follows:

- Set up a network co-ordination office at the OECD Secretariat to build a co-operation platform between OECD member states, regions and cities.
- Liaison organisations in OECD member countries and associated developing countries would co-ordinate domestic and international co-operation as well as participation in international science and technology exchange activities.
- Build upon current national networks related to sustainable development, with a key core technology-providing organisation becoming the national centre for the OECD international co-operation network. National centres will form a platform to promote communication and exchange of information among centres at all levels.
- On that basis, build up a science and technology co-operation network for information exchange among OECD member countries and developing countries.

The following network activities can be suggested:

- Information sharing.
- Joint research and development programmes.
- Training and capacity-building programmes.
- Workshops.
- Technology transfer.

Figure 28.1.


OECD International Science and Technology Co-operation networks
Co-ordination Office (at OECD Secretariat)
OECD science and technology networks (virtual)
Developing country networks
OECD member countries
Other international organisations
Tangible networks
C1
C2
C1
C2
O1
O2
City 1A
City 1B
City 2A
City 2B
City 1A
City 1B
City 2A
City 2B

Chapter 29

ENERGY AND SUSTAINABLE DEVELOPMENT IN AFRICA: THE CASE OF MALI

by
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Current modern energy situation in Africa

Electricity is a catalyst for economic development. All countries do their best to increase access as it is essential to attain the UN Millennium Development Goals. Increase in access to modern energy services is based on oil products. African countries are the most dependent on oil as a source of energy (Figure 29.1) African oil use has increased from 40 million tonnes in 1971 to 118 million tonnes in 2001, and most countries import this oil. Electricity consumption per capita, on the other hand, has dropped from 431 kWh in 1980 to 112 kWh in 2000.

Figure 29.1. Energy supply in Africa

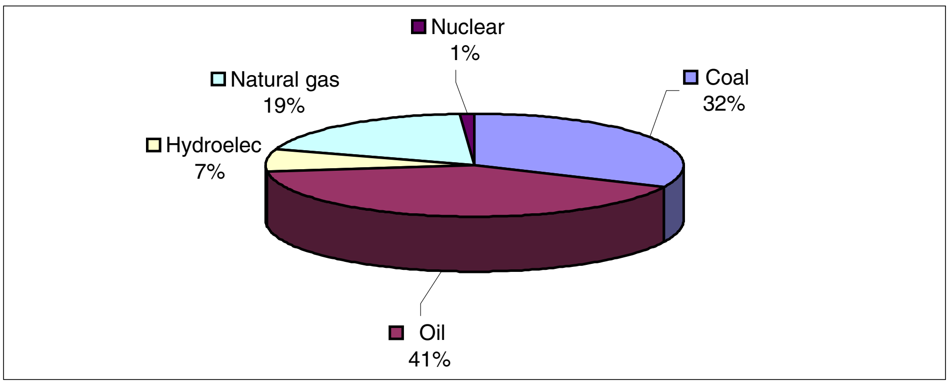
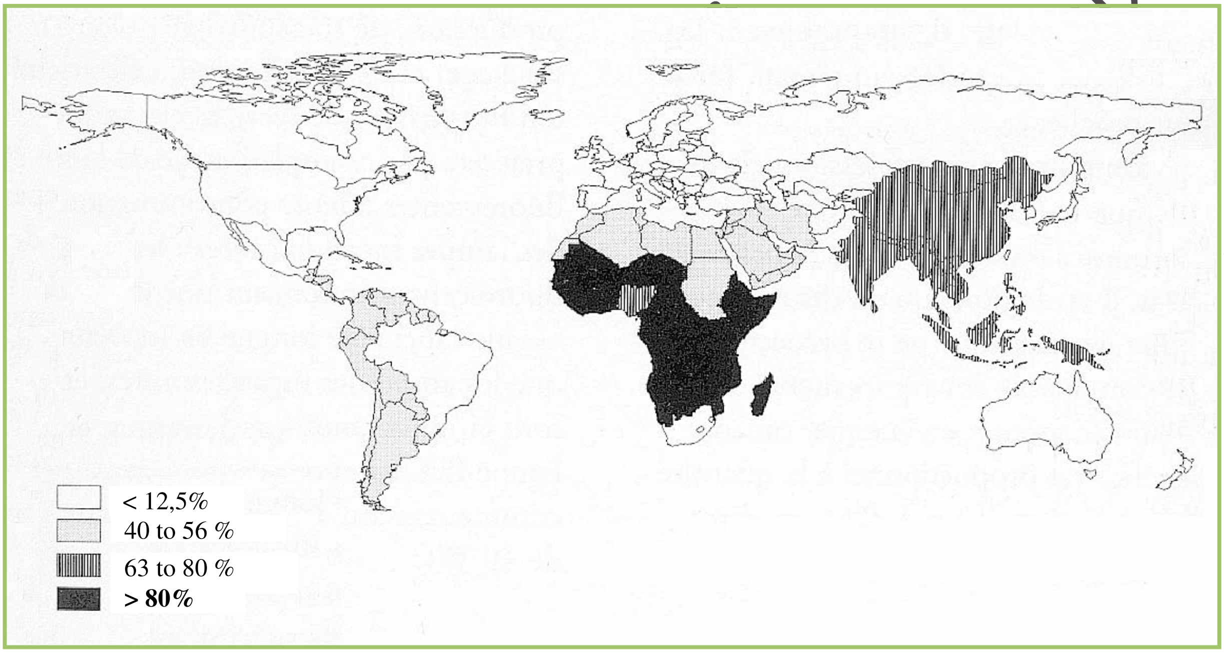
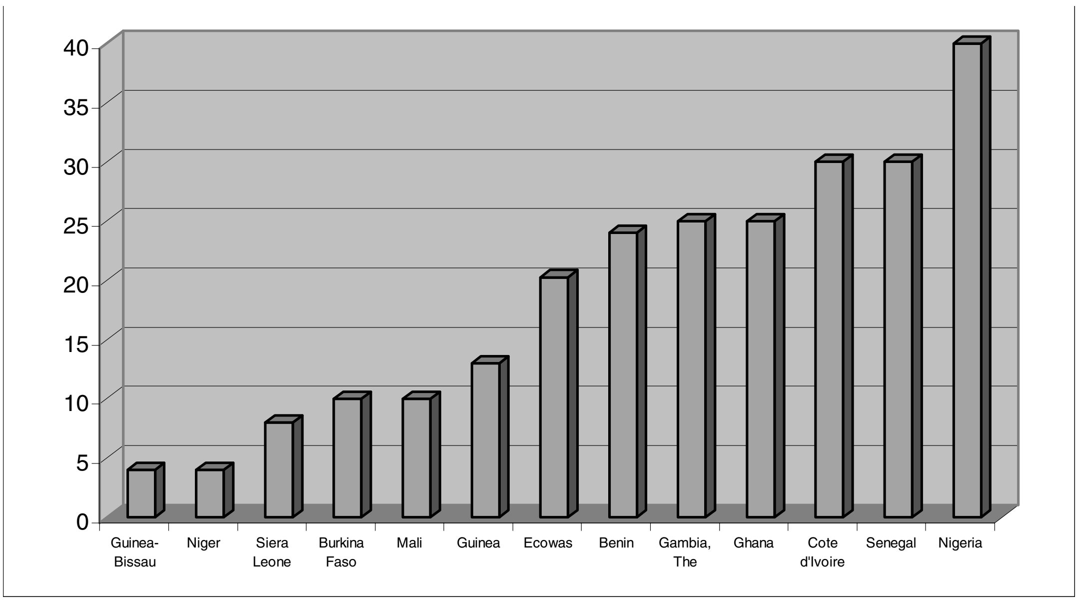


Figure 29.2. World population without electricity access



In fact, most of the people without access to electricity live in African countries (Figure 29.2). This situation makes development efforts very difficult. Electricity access in the Economic Community of West African States (ECOWAS) zone is 20%. This is why poverty reduction as policy is a major concern for ECOWAS.

Figure 29.3. Access to electricity (%)



Since independence, many of these countries have established special public institutions (and sometimes regional institutions, *e.g.* CRE) for the promotion of renewable energy, but very little action has been taken in the field of energy efficiency. Many attempts have been made by governments, with assistance from development partners, to create capacity and competence among local people for planning, designing and implementing energy projects, but still there is not enough capacity among local technicians to solve the problems Africa is facing. In addition, university and technical school programmes are not adapted to the realities of life in Africa and the needs of the market. Some successful results have been achieved; however, there have also been many failures. This has resulted in the unfavourable reputation of renewable energy technologies in particular, *e.g.* photovoltaics and biogas.

The cost of electricity – a financial burden on African economies

Efforts to develop the energy sector focus on petroleum products, which place a heavy financial burden on economies: in 2000 the value of Mali's petroleum imports was USD 100 million, compared with USD 75 million in 1998. Very few African countries are oil producers; therefore, most countries are subject to constant increases in oil price, over which they have no control. 70% of the African population relies on traditional biomass fuels, for Mali this represents 90% of total energy consumption, translating into a deforestation rate of 400 000 hectares per year. This situation makes sustainable development difficult to achieve for African countries and most of the developing world.

The high cost of electricity and modern energies is a barrier for industrialisation and development in many developing countries, especially in the western part of Africa, and Mali. The energy sector is characterised by difficulties in technology adaptation and poor quality of services. It is difficult to access sufficient energy and appropriate technologies to transform and develop agricultural products.

The question is how to get out of this situation.

Energy is essential for economic development; a country that masters its energy production masters its economic development. Considering Africa's poor level of economic development, it is essential to give priority to the use of indigenous natural resources for modern energy supply. Most African countries have huge potential for renewable and efficient use of existing energy sources. In the case of Mali as well as many other African countries, the country could provide for most of its energy needs from renewable sources and the efficient use of the existing potential.

Mali's energy supply today

In Mali, firewood and charcoal provide 92% of energy needs but in a very unsustainable way, leading to accelerated desertification. In terms of modern energy services, electricity supply characteristics are:

- About 70% from hydropower.
- The rest from thermal power plants mainly in urban centres.
- Car batteries and a few thousand PV installations supply some people in off-grid rural areas.

In 2000, electricity represented just 1% of the country's energy supply. The cost of fuel for thermal power plants and transportation to produce this electricity was high for the country at the cost of USD 100 million for the same period.

Renewable energy potential in Mali

Mali has good potential in renewable energy sources. These include:

- **Hydro**: 1 000 MW (<300 MW installed producing 70% of Mali's electricity). The remaining 30% generated by thermal power plants should not be difficult to replace with this source.
- **Wind**: 3-7 m/s in northern Mali. The GTZ TERNA programme is taking wind measurements in northern Mali for eventual installation of a wind farm.
- **Solar**: 2 500 hours annual sunshine with 5.7 kWh/m2/day. Solar home systems are a high quality and cost effective solution to domestic electricity needs particularly in rural areas.
- **Biomass:** cattle and agricultural waste:
  - Bagass from sugar cane industries in the Office du Niger (1 million ha of irrigated land) can be used for co-generation and the ethanol for transportation.
  - Cotton stalks 1 000 000 t/yr in southern Mali alone can be used in gasifiers or Stirling engines.
  - Cotton hull is used in steam turbines to produce electricity and hot water (oil mills in area of Koulikoro, Kita, Koutiala).
  - Rice balls can be used to produce electricity by existing steam turbines.
  - Sustainable use of fire wood.
  - Jatropha can supply vegetable oil for transport needs.
  - Just 2% of farm land in Mali could produce enough pure jatropha oil to run 1 million cars (700 million litres).

Such potential can be used to address energy needs in both rural and urban areas. What is crucial is the building of capacity in development, production and sustainable management of energy and other natural resources. Population density is low in many parts of Africa, including Mali, and the need is generally for small amounts of energy; therefore, decentralised renewable energy supply and increased energy efficiency are logical and sustainable solutions.

Mali Folkecenter and and other initiatives in the development of renewables

Mali Folkecenter (MFC) develops best practices in these fields in Mali and West Africa and supports governments in these areas. In solar and wind, MFC has realised over 50 installations with a 100% success rate and has trained technicians in rural training centres. Biogas has been revitalised in Mali through the creation of local competence and stimulating interest among local populations. Through its work, there has been renewed interest in jatropha, in south-south co-operation and building local capacity.

African Rural Energy Enterprise Development (AREED), a UNEP initiative supported by the UN Foundation, is playing a role in strengthening the Mali private sector to play a major role in renewable energy adoption. For example, there is a project to use an initial USD 50 000 investment to create a solar drying business employing eight permanent staff and 20 part-time staff with many other dealers selling the product. The initiative is lobbying for creation of an attractive political and legislative environment for investment in renewables.

An accumulation of such initiatives and actions can facilitate access to modern energy services for a majority of people in Mali and other developing countries, bringing about environmental benefits, foreign exchange savings, creation of income generating opportunities and jobs, and eventual poverty reduction. To achieve these results, there is a need for political will on the part of both developed and developing country governments as well as the development of partnerships for international exchange of scientific and technological know-how.

Annex

DEVELOPING COUNTRIES' PERSPECTIVE ON ENERGY AND WATER ISSUES

by
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Energy and climate change issues affecting developing countries

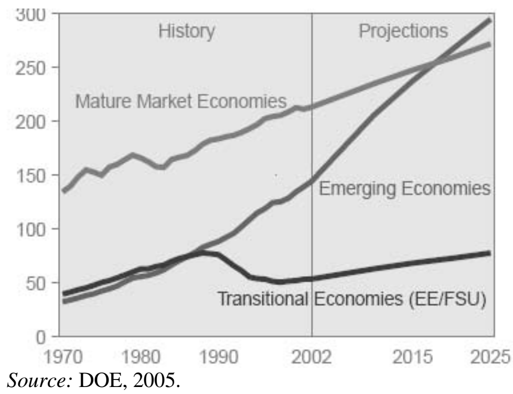
Introduction

Although developing countries (DCs) share some common development features, they are definitely not a homogenous entity. The heterogeneity is particularly significant as far as their energy supply and demand issues are concerned. The sub-Saharan Africa (SSA) region is considered the least developed region in the world. IMF projections show economic growth in all other DCs averaging 6% per year (2003-05) compared with 4% per year in SSA. Therefore, for this region to halve poverty levels by 2015, GDP growth must more than double from their current levels of 3% to 7% per year (Financial Mail, 2003; Melwana, 2005).

Common energy issues for developing countries

Recent estimates forecast that world energy consumption will increase by 57% between 2002 and 2025 (Figure 1). Much of this increase or growth is expected in DCs, especially in Asia (including China and India), where robust economic growth drives increases in energy use. The projected economic growth in DCs over this period is 5.1% per annum, compared to 2.5% per annum in the developed economies. More significantly, energy consumption in DCs will surpass that of mature economies reaching 250 quadrillion Btu in 2015. In order to sustain projected growth, DCs need adequate, affordable, acceptable and reliable energy sources. However, this remains a challenge, particularly in

Figure 1.
Historical and projected energy demand



Source: DOE, 2005.

1. Acknowledgements are due to Dr. Pete Ashton, of the Natural Resources and the Environment Division, CSIR, and Dr. Kevin Pietersen, of the Water Research Commission, for their valuable input in the water section of this paper.

SSA. A selection of critical energy issues and challenges is highlighted below.

Lack of adequate access to electricity

Of the 29% of the global population without electricity, more than 99% live in DCs. Lack of access to electricity is often equated with poverty. The situation is aggravated by high population growth and increasing rates of urbanisation. According to the IEA reference scenario, 1.4 billion people or 17% of the world population will be without electricity in 2030. In this scenario, 95% of population growth will occur in urban areas. Therefore, there is an urgent need to address this growing deficiency through robust urban electrification programmes (IEA, 2002).

The SSA region has the lowest rate of electrification in the world, with only 20-23% of the population served. More than 500 million people have no access to electricity. In South Asia (mostly India), the electricity network reaches 90% of the population, yet only 43% (or 580 million) is connected to the grid. The main factor for this situation is the high cost associated with electricity reticulation and use (IEA, 2002).

Dominance of "non-commercial" biomass energy

More than two billion people rely on traditional biomass (wood, cow dung, etc.), and this figure is likely to increase. Biomass energy sources meet about 80% of the residential energy needs, mainly cooking and heating. SSA and South Asia are the regions where the use of biomass is the highest. In SSA, more than 500 million people (or 89% of the population) depend on biomass as their major source of energy.

The use of "non-commercial" biomass (particularly fuel wood) impedes social and economic development, for the following reasons.

- In door air pollution. a key environmental and public health peril for countless of the world's poorest, most vulnerable people.
- Because of the low calorific value of these fuels, considerable time (one to five hours per day) is spent of gathering the fuel sources to meet the energy demand.
- Equity issues of both gender and class – poorer women put in more labour than women in rich households to meet the same energy demand. Women play a greater role than men in both cooking and energy management in households.

Table 1. Biomass usage in developing countries

Country or region	Millions	Percentage of population
China	706	56
Indonesia	155	74
Rest of East Asia	137	37
India	585	58
Rest of South Asia	128	41
Latin America	96	23
Middle East and North Africa	8	1
Sub-Saharan Africa	575	89
All developing countries	**2 390**	**52**

Source: IEA, 2002.

Exposure to emissions from transport

Transport is the leading economic sector responsible for increase in oil use over the past 30 years. In most countries, oil accounts for over 97% of transportation fuel (IEA, 2004). In SSA alone, the transport sector consumes some 55-60% of petroleum fuels, representing approximately 80% of commercial energy (Ogunlade). Increased fuel consumption in this sector has led to an equally large increase in atmospheric emissions from this sector. Atmospheric emissions from water, rail, air and road transport have been cited as being partly responsible for climate change, stratospheric ozone depletion, acid rain, tropospheric ozone production and urban air quality deterioration. The organic lead compounds that are still added to high-octane petrol in parts of Africa and Asia, to prevent premature combustion, also form particles (PM) in the exhaust.

Low R&D in renewable energy and energy efficiency

Renewable energy technologies (RETs) offer DCs the prospects of self-reliant energy supplies at national and local levels, with potential economic, ecological (little or no GHG emissions), social, and security benefits. Furthermore, they offer the opportunity to avoid many of the adverse effects caused by trade-offs between energy use, economic growth and environmental quality. Energy efficient (EE) projects reduce GHG emissions through energy conservation.

Developed nations by far lead DCs in RETs R&D. It is clear that DCs need to increase their R&D activities on RETs. This calls for a participative and collaborative approach from both developed and developing countries to develop innovative RET solutions to meet the DC's consumers and industrial needs. Community involvement and tapping into indigenous knowledge in the design and provision of the solutions to will greatly increase the acceptability of RETs in DCs.

Gap analysis: critical outstanding issues in DCs

Rural electrification vs. rural energisation

Conventional approaches to rural electrification are not succeeding in yielding desired outcomes in most DCs. Owing to geographical spread, centralised distribution networks are very costly. In addition, rural economies are not able to support centralised generation and distribution systems. While there is the *need* for energy services in rural areas, the *demand* for energy is very low. Here, energy demand is defined by the *ability* and *willingness* of the consumers to pay for the services. In many instances, the willingness to pay has not translated to the ability to pay. As a result, many rural electrification projects and programmes are not sustainable over the long-term, hence a new approach is needed. This approach should go beyond supplying energy hardware to focus instead on supplying energy services. The focus should shift from electrification to rural *energisation*.

Appropriate financing mechanisms

Credit in various forms can be used to purchase or use RETs, in order to overcome the market constraint of high capital costs and limited availability of financing. Micro-credit programmes have been active in RE recently. Community/NGO approaches have been demonstrated to be effective in local capacity building and development of micro-level institutions, and integration of energy programmes with the overall development process (Putti, 1998).

Realising reliable small-scale plants

Many utility companies consider the provision of electricity to rural areas to be uneconomical because of the low consumption and poor load factors. RETs, such as photovoltaics (PVs), wind and mini-hydro, are suitable for supplying small loads and are able to operate independently. Developments in technologies, constraints on the construction of new transmission lines, increased customer demand for highly reliable electricity, the electricity market liberalisation and concerns about climate change are other factors that are contributing to growth in distributed generation over centralised distribution systems.

Community participation in energy systems

One of the main limitations of rural electrification or energisation programmes has been the lack of involvement of the recipient communities in the solutions that have been proposed. resulting in a lukewarm acceptance of new technologies. There is now a growing realisation that the active involvement of rural communities in sustainable energy projects is pivotal to the successful deployment and acceptability of these technologies. The involvement of the primary stakeholders in the design, implementation and ownership of energy initiatives increases the likelihood of bringing sustained economic and social benefits to a larger number of people (Canadian Environmental Network, 2004)

Capacity building and technology transfer: north-south and south-south co-operation

Energy use concerns are global (*e.g.*, global warming), hence are better addressed through partnerships and collaborations. Over the last few decades, there has been a plethora of partnerships between countries in the north and in the south in addressing issues around sustainable energy systems. The Type II initiatives, established as the result of the WSSD in 2002, provide real opportunities for north-south and south-south collaborations in R&D and S&T. In the energy sector, the key North-South networks include:

- Intergovernmental Panel on Climate Change (IPCC).
- International Energy Agency (Committee on Energy Research and Technology).
- Renewable Energy and Energy Efficiency Partnership.
- European Union Energy Initiative.
- Global Village Energy Partnership (GVEP).

Other useful networks include:

- African Energy Policy Research Network
- ENERGIA
- HEDON Household Energy Network.

Most of the existing partnerships and networks are centered mostly on capacity building and technology transfer. Following areas also need further co-operation:

- **Assessment of generation and distribution systems.** Over the last two decades, electricity sectors in many countries have been restructured to introduce private capital and increase competition. This was accompanied by the introduction of new regulatory and fiscal regimes. The effectiveness of power sector reforms and their impact on rural electrification and poverty alleviation still need to be explored.
- **Assessment of large-scale growing of bio-fuel crops.** The use of bio-fuels is of importance to the current ecological and economic issues at both national and global scales. For successful deployment of energy crops in DCs, issues that need to be addressed include: competition for land use between food and energy crops, the future global water scarcity and the food security of poor countries that depend on cereal imports.
- **Capacity building on energy modelling.** DCs lack the capacity to utilise energy modelling tools; also, the capacity to use and develop appropriate indicators for the energy sector. Modelling is a cost-effective way to avoid policy mistakes whereas the information obtained from indicators is valuable in assessing the validity and effectiveness of tools (*e.g.* taxes, regulations or voluntary agreements) in meeting sustainability objectives.
- **Capacity building on CDM opportunities.** Clean development mechanisms (CDMs) assist DCs to achieve sustainable development, while helping developed economies to comply with their emission targets under the Kyoto Protocol, through the acquisition of certified emission reductions (CERs) accruing from project activities. There is a pressing need to engage and build capacity within the private sector, and the private

sector and government to formulate, shape and implement CDM projects in DCs. A similar need exists to inform various stakeholders on the rules and operational procedures of CDMs, in order to assist host countries in attracting private sector investment.

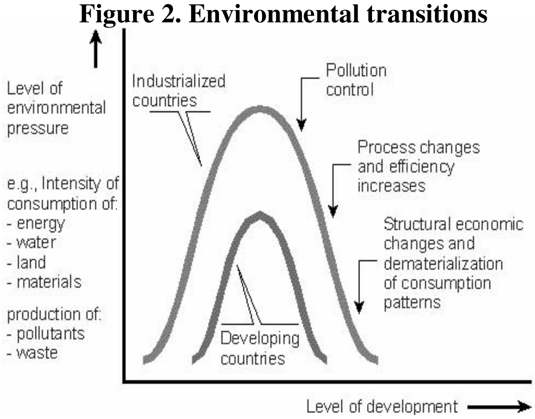
- **Innovative technology systems.** Industrialised countries dominate technology advances because they provide more support to technology oriented R&D efforts, and the "technology gap" between these countries and DCs is huge. Selecting the best way to enhance technology development in DCs is difficult. However there is no doubt that there is a need for international collaboration in advanced technology development and diffusion in conventional, RE, other emerging technologies (waste-to-energy, clean coal technologies, nuclear, photovoltaics and wind power, fuel cells, bio-fuels etc.), and related storage devices (flywheels, pumped hydroelectric energy storage, underground thermal energy storage, compressed air energy storage, superconducting magnetic energy storage, and super capacitors)
- **Energy use in transport sector.** There is potential for co-operation across all transport sectors. Due to its dominance in moving of both freight and passengers in most DCs, road transport initiatives are the most important. Typical areas of collaboration in road transport include: hybrid drives and batteries, fuel cell and renewables driven vehicles, efficiency improvements, CDMs in transport sector, regulatory and policy aspects facilitating efficient dependable public urban transport systems and effective communication systems where they present are cheaper options to physical movement.

Basic energy needs and climate change: managing the tensions

Economic growth and associated efforts to alleviate poverty are the major drivers of the energy consumption in DCs. Since most of the world's poor people live in DCs, the economic policies of these countries are geared towards rapid economic growth, which theoretically provides much needed job opportunities for the masses of unemployed people. Because of this overemphasis on economic growth, there is a bias towards energy intensive industries. Moreover, because of their Annex II status, DCs are not compelled to reduce their emission levels. On a world scale, current emissions from DCs (save for a few such as China and South Africa) are miniscule compared to the more developed economies. The economic growth policies of many governments are biased towards the use of fossil fuels (since these provide the engines for economic growth – in the transport and industrial sectors). Furthermore, many DCs are experiencing less environmental pollution and resource use compared to industrialized countries when they were at a similar economic development stage (Figure 2).

Policies that facilitate the mitigation of climate change impacts are not vehemently pursued. This largely explains why the use RETs and EE technologies have not received much enthusiasm in many DCs. A clear conflict or tension exists between the main agenda of most DCs (poverty alleviation through increased access to energy) and climate change concerns (emissions resulting from generation, distribution and consumption of energies). Successes of pro-climate change mitigation policies depend largely on the positive management of these tensions. The key question is *how* can DCs secure their energy supply needs without compromising the environment?

Figure 2. Environmental transitions



Conclusion

The primary development imperative of DCs is to alleviate the poverty of more than 2 billion people who live on less than USD 2 a day. Interventions that do not directly address access to basic necessities such as food security, employment, health and sanitation is likely to fail. Energy provision must also be within the context of this development agenda. This means that technological innovations should be appropriately contextualised, and address the real needs of communities. This new development agenda must also explicitly consider the environmental externalities caused by the generation, transportation, distribution and consumption of energy components. Therefore, S&T should be able to facilitate the fusion of the environmental agenda with the development agenda. Relentless pursuit of energy has obvious negative environmental impacts and should be avoided.

Sustainable development is about sustained social and economic development, which abates or mitigates climate change impacts. These impacts are trans-boundary; therefore, co-operation between nations and regions in capacity building and technology transfer is a cornerstone to address the energy needs of the present generation without harming the environment's ability to meet the needs of future generations.

Implementation in DCs of off-the-shelf technologies designed in developed countries, seldom works effectively or efficiently. International co-operation should be based on technology transfer coupled with the use of indigenous knowledge systems in the development and customisation of technologies. The DCs must be empowered to address their own development needs using their homemade, but internationally recognised S&T. Such co-operation should also be based on the sharing of knowledge between DCs.

Water issues affecting developing countries

Introduction

This section summarises the water issues in developing countries and highlights the potential contribution of international science and technology co-operation, poverty reduction, capacity building, and development of knowledge infrastructure and international networks to resolve these problems. Among the key questions being asked of developing countries is the extent to which Agenda 21 and the various environmental conventions have advanced these countries towards the goal of sustainable development. *Global Environmental Outlook* (GEO) (UNEP, 2002c) summarises the key environmental issues in different regions, and provides a starting point for discussions of regional water-related problems.

Table 2. Key environmental issues by GEO region for Developing Countries

Africa	• Variability of water resources • Water stress and scarcity • Access to safe water and sanitation • Deteriorating water quality • Wetlands loss
Asia and the pacific	• Water scarcity • Pollution
Latin America and the Caribbean	• Decreasing water available per capita • Water quality
West Asia	• Increasing water demand • Overexploitation of groundwater • Water quality

Source: UNEP, 2002c.

Water availability

Regional variation

Despite increasingly accurate remote-sensing technology, mapping capabilities, and computer models**,** great uncertainties still remain about water availability and its natural variations over time in the hydrological cycle. Global averages hide considerable variation in both spatial and temporal distribution of water. Similar variability is evident in the regional and annual distribution of runoff (Gleick, 2000).

Climate change

A growing number of scientists believe that some human-induced climatic changes are unavoidable, even if we act now to reduce our emissions of greenhouse gasses. According to Gleick (1998), the main possible hydrological effects of climate change include:

- Increased global precipitation.
- Changes in evaporation and transpiration.
- Changes in soil moisture.
- Changes in snowfall and melting.
- Higher storm frequency and intensity.
- Changes in runoff.

Science and technology can play an important role in the modelling and analysis needed to predict climatic change. Research and its outcomes need to be shared with developing countries.

Groundwater

About 2 billion people, approximately one-third of the world's population, depend on groundwater supplies, withdrawing about 20% of global water (600-700 km^3) annually (Edmunds, 2004). According to UNEP (2002b), groundwater issues have until recently received far less attention, particularly in some developing regions, than surface water, and data on groundwater stocks and flows are still not reliable. The main threats to groundwater are contamination and overuse, with subsequent saltwater intrusion in coastal areas.

Shared basins

Modern approaches to water resource management recognise that water resources can only be managed effectively and efficiently when the entire river basin or catchment is the basic management unit. This is particularly important in shared river basins where a country's water resource management strategies should be aligned with those of its neighbours, if conflicts are to be avoided (Ashton, 2002). Furthermore, because surface water and ground water are inextricably interlinked, they must be considered and managed as a single resource. These principles form the foundation for integrated water resource management (IWRM), which is rapidly gaining wider acceptance throughout the world.

The multilateral management of trans-boundary water resources started in 1966 with the Helsinki Rules which laid the international principles for shared watercourses. Various international efforts were based on these rules, including the work of the UN International Law Commission, which led in 1997 to the United Nations Convention on the Law of Watercourses. The 14-member Southern African Development Community (SADC) has adopted many of the principles in its revised protocol on shared watercourses. Also, Network of Basin Organisations (INBO) in 1996 and the International Conference on Water and Sustainable Development in 1998, were established (UNEP, 2002c).

Water storage

Clear understanding and thought is needed in building large dams, as these are often associated with negative ecological, social, and the economic impacts. During 1997, the World Bank and the World Conservation Union (IUCN) sponsored a meeting between champions and critics of large dams, leading to the formation of the World Commission on Dams (WCD, 2000).

The involvemnet of science and technology should focus around :

- Enhancement of efficiency in storing and harvesting natural waters.
- Data collection systems as well as the shortage of personnel and monetary funds.
- Adequate coverage of key areas and river/aquifer systems (UNICEF & WHO, 2005).

Water consumption

In developing countries most communities depend on river systems for water supply and waste disposal. Africa's 63 shared river basins, for example, contain approximately 61% of the area, 75% of the people on the continent, and 93% of the surface water, and are thus, particularly in drier regions, under severe pressure (Ashton, 2004). Agriculture accounts for 70% of the freshwater used in the world, and water efficiency and productivity in this sector remain low. At the same time, careless use of land ecosystems can disrupt natural water regulation, causing, amongst others, flooding and desertification (CSD, 2005).

Science and technology concerning water consumption could address opportunities, as identified by UNEP(2002*b*), to meet human needs with less water:

- Using existing technology (such as drip irrigation, low-flow toilets, and better industrial processes).
- Changing irrigation technology.
- Finding and stopping wasteful leaks.
- Changing wasteful practices.
- Charging proper prices for water.
- Changing human activities (shifting to more water-efficient crops, changing industrial processes away from water-intensive production).

Alternative water resources

Although structural solutions face increasing opposition on environmental and social grounds (WCD, 2000), and are also becoming progressively more expensive, their potential has not yet been exhausted. At the same time, a number of alternative ideas and options for water supply are being investigated. The role of science and technology is vital in establishing which of these approaches could be viable, against the relevant physical, social, cultural and economic background. The following, which are closely related to science and technology, have been identified by Smaktin *et al*. (2004):

- Reduction of evaporation.
- International water sharing.
- Deep groundwater extraction.
- Artificial recharge.
- Rainfall enhancement.
- Fog water collection.
- Iceberg water utilisation.
- Desalination.
- Direct seawater use.

Examples of institutions and structures for water management

The UN International Law Commission (ILC) developed the Convention on the Law of the Non-Navigational Uses of International Watercourses, adopted by the UN General Assembly in May 1997. As early as 1963, the United Nations Secretariat pioneered work on the consolidation of the then available water-related treaty record and on its dissemination. Following on from it, the Food and Agriculture Organisation of the United Nations (FAO) carried out systematic surveys of water-related treaties, which resulted in a series of publications between 1978 and 1997. The full texts of post-1980 water-related treaties are in FAOLEX, FAO's online legal database. UNEP's accumulated experience in the management of shared water resources is seen through its Environmentally Sound Management of International Water Resources, initiated in 1984 (UNEP, 2002b).

The thirteenth session of the UN Commission on Sustainable Development (CSD-13) in April 2005 drew up the following policies:

- Increasing access to clean drinking water.
- Decentralised water management.
- Private sector participation.
- Integrated water management.
- Efficiency in agriculture.
- Tariff reform and improved water financing (CSD, 2005).

Type two partnerships for water and sanitation

During the WSSD in 2002, alongside the formal intergovernmental agreements (type one agreements), a new kind of initiative emerged: the Type Two Partnerships (TTPs) involving multi-stakeholders. Type Two Partnerships have the potential to be an important supporting mechanism for countries to achieve the Millennium Development Goals (MDGs), if these partnerships are supported by the governments in developing countries (Stewart, 2004).

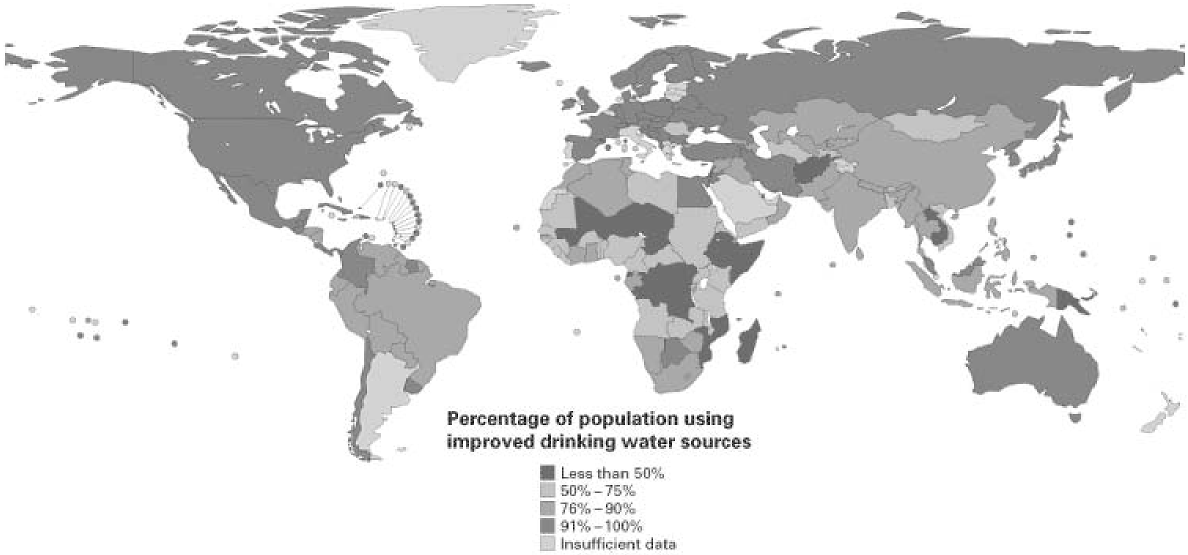
Water access

Higher per capita investment costs to reach the remaining few unserved communities follows the law of diminishing returns. Servicing urban slums, remote rural villages and arid areas requires a much greater effort than reaching a population that is located in more accessible or less arid regions. In addition, water treatment plants are becoming more complex due to polluted water sources and transmission that have to cross long distances (UNICEF & WHO, 2005).

Current state of the millennium development goals

Access to clean water and sanitation is either directly or indirectly related to the eight MDGs. In adopting these goals, the countries of the world pledged to reduce by half the proportion of people without access to safe drinking water and basic sanitation. If this is achieved, significant contribution to the achievement of other MDGs will also be made. The results so far are mixed. Drinking water coverage levels are the lowest in sub-Saharan Africa and in Eastern Asia. In contrast, several regions, including Northern Africa, Latin America and the Caribbean, and Western Asia, have achieved coverage levels of 90% or more. The greatest progress was made in South Asia, which increased coverage from 71 to 84% between 1990 and 2002. This was fuelled primarily by increased use of improved water sources in India. With 83% total coverage, the world is on track to meet the MDG target for drinking water, which means that there has been a gain in all regions since 1990 (UNICEF & WHO, 2005).

Figure 3. Improved drinking water sources in 2002



The approaches shown to be most effective involve decentralizing responsibility and ownership and providing a choice of service levels to communities, based on their ability and willingness to pay (UNEP, 2002a).

Investment needs

Meeting MDG targets on water and sanitation is estimated to avoid 470 000 deaths and result in an extra 320 million productive working days every year. A recent cost-benefit analysis by WHO found that achieving the MDG target in water and sanitation would bring substantial economic gains. Every USD 1 invested would yield an economic return of between USD 3 and USD 34, depending on the region. Globally, meeting the target would require an additional investment of around USD 11.3 billion per year, over current investments. Among the benefits would be an average 10% reduction worldwide in episodes of diarrhea and other water related diseases (UNICEF & WHO, 2005).

Sanitation

An estimated 2.6 billion people still lack improved sanitation facilities. If the 1990-2002 trend holds, the world will miss the 2015 sanitation target by half a billion people. Meeting the target will require that an additional 1 billion urban dwellers and almost 900 million people in rural communities are able to use improved sanitation services. Accomplishing this by 2015 will be an enormous undertaking (UNICEF and WHO, 2005). One international effort to improve access to drinking water was the United Nations International Drinking Water Supply and Sanitation Decade (1981-1990). Unfortunately, rapid population growth and the proliferation of unplanned settlements and urbanisation offset much of the progress made during this period (UNEP, 2002c).

Links to energy

Hydropower

Meeting the MDGs for electricity in developing countries has spurred calls for more effective energy use. Although hydropower is a clean, renewable source of power, the capital outlay is large and there are ongoing debates concerning the environmental and cultural effects of building large dams (National Hydropower Association, 2005).

Issues related to science and technology includes:

- Establish which dams and rivers could still be utilised and developed for hydro-electrical power.
- Apply and refine existing environmentally friendly turbines to reduce impacts on fish mortality.
- Develop new technology to meet both environment and energy needs by the power of water.

Cooling water

Heavy industries such as petrochemical refinery industry use substantial amounts of water for cooling. Once-through water cooling uses of massive volumes of water. A role for science and technology lies in changing existing once-through water-cooling systems, to so-called open re-circulating cooling systems, in which the benefits of water-cooling are preserved and the environmental disadvantages are reduced.

Special issues requiring attention

Gender

In the developing world, many girls do not receive primary education, since they are often taken out of school to attend to the chore of fetching water. It is difficult to exaggerate the impact that access to private, safe and sanitary toilets would have on the daily lives and long-term prospects of the 1.3 billion women and girls that do not currently have such access. Less discussed are the blows to health, productivity and dignity that result from poor sanitation (UNICEF and WHO, 2005). Demographic and social trends need to be investigated and priorities decided against this background.

Poverty

Naturally, water and sanitation coverage and the levels of service are higher among the rich than the poor. An analysis of 20 demographic and health surveys in the past five years shows that only about one in six households in the poorest 20% of the population uses improved sanitation facilities – compared to three out of four households in the richest 20%. Fewer than four in ten of the poorest households use an improved water source, whereas nearly nine out of ten of the richest households do (CSD, 2005).

Challenges lie in providing water for growing populations and expanding the economy so as to:

- Improve the quality of life.
- Redress disparities in service delivery.
- Improve food security.
- Attain conflict prevention and resolution where necessary.
- Sustain the ability of aquatic systems to deliver ecosystem goods and services.

Disparities in urban and rural water supplies

92% of the urban population and 70% of the rural population in developing countries use improved drinking water sources. That is, for every person without improved drinking water in urban centres, there are six people unserved in rural areas. Such disparities are the greatest in sub-Saharan Africa. Communities that have to rely on ground water supplies are particularly vulnerable to water shortages caused by droughts or over-exploitation, as well as contamination that arise from inappropriate land-use practices (Ashton, 2002).

Issues regarding water in rural communities such as the following should be taken into account when dealing with water accessibility (UNICEF & WHO, 2005):

- Subsistence agriculture.
- Access to resources.
- Water supply.
- Sanitation systems.

Disease

The way people secure their drinking water has a direct impact on their health and the economic status of households. Use of improved water and sanitation results in a significant reduction in diseases, especially diarrhoea, averted health-related costs, and time saving associated with having water and sanitation facilities located closer to home. Time saved may translate into higher productivity and school attendance, more leisure time and other, less tangible benefits, such as convenience and well-being, all of which can have an economic impact (UNICEF & WHO, 2005).

HIV and AIDS

Good access to safe and reliable sources of water is essential for people living with HIV and AIDS. Nearby latrines are necessary for weak patients who are unable to walk long distances. Clean water is needed in order to reduce the risk of infection, to take medication and make up formula feeds for bottle-fed babies (Kamminga and Wegelin-Schuringa, 2003).

Sub-Saharan Africa is the region with the highest HIV and AIDS prevalence rates in the world (UNAIDS & WHO, 2004). The age group between 15 and 49 years, the most economically productive group is regarded as being particularly vulnerable to infection (Keatimilwe and Setswe, 2005). As this is also one of the regions still lagging behind in terms of access to clean water and sanitation, the prevalence of HIV/AIDS could be an indicator in prioritizing regions for establishing services for clean water.

Pollution

Approximately 2 million tonnes of human waste, along with agricultural run-off and industrial effluent, are released untreated into our water resources around the world, causing contamination in surface and groundwater, and damaging ecosystems (CSD, 2005). During the past decade, several countries have started to address water quality problem by implementing large-scale programmes and action plans to rehabilitate degraded streams and depleted aquifers. These programmes are typically given legislative or statutory authority such as that provided by Thailand's National Water Quality Act, the Philippine Water Quality Code, India's Environment Protection Act, China's Water Law and the Republic of Korea's Water Quality Preservation Act (UNESCAP, 1999, in UNEP, 2002c).

Technology regarding water quality management should center around:

- Industrial effluents.
- Eutrophication.
- Arsenic waste from mining.
- Erosion and sedimentation (UNICEF & WHO, 2005).

Disaster management

There is a growing awareness amongst water resource managers of the need to collaborate more closely and to co-ordinate their activities. Greater collaboration will help to improve the approaches and technologies used for disaster management when dealing with floods and droughts. It is predicted that warmer temperatures will lead to a more vigorous hydrological cycle; translating into the possibility of more meteorological disasters, as well as more extreme rainfall effects (IPCC, 1996a in Gleick, 1998).

Sustaining ecosystems

Wetlands are an important ecosystem influencing not only species distribution and biodiversity in general, but also human settlements and activities. Significant impact on freshwater ecosystem were felt during the 20th century by eliminating marshes and wetlands, the removing water for other uses, altering flows, and contaminating water with industrial and human wastes. In many rivers and lakes, ecosystem functions have been lost or impaired (CSD, 1997).

More effective surveys

The Joint Monitoring Programme (JMP) database is the source for WHO and UNICEF's estimates on the use of drinking water and sanitation facilities. The database currently draws upon more than 350 nationally representative household surveys and census, double the amount of data that was available for the 2000 report. The surveys include the UNICEF-supported Multiple Indicator Cluster Surveys, the USAID-supported Demographic and Health Surveys, the World Bank's Living Standard Measurement Surveys and, most recently, WHO's World Health Surveys (UNICEF & WHO, 2005).

Conclusion

The challenge is to improve the water situation in the context of possible climate change, degraded environment, poverty and conflict that are experienced all over the world. The issues highlighted here are far from sufficient. A challenge for science and technology lies in finding more "hands on" solutions to address these issues. The water scenarios of developing countries across the world differ vastly. These countries should be empowered to address their own needs, with the support of the developed economies with advanced science and technology.

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OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(92 2007 01 1 P) ISBN 92-64-03209-5 – No. 55565 2007

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AN INTERNATIONAL PERSPECTIVE

Science and technology (S&T) can play an important role in making the economic, environmental and social dimensions of the development process more sustainable. Not only is S&T a key driver of economic growth, but it may also help provide answers for managing resources and reducing pollution, addressing climate change and preserving biodiversity, as well as reducing disease and safeguarding health and well-being, while maintaining the general quality of life.

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ISBN 978-92-64-03209-5
92 2007 01 1 P

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