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# NETWORKING RESEARCH, DEVELOPMENT AND INNOVATION IN ARAB COUNTRIES

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**ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA**

# NETWORKING RESEARCH, DEVELOPMENT AND INNOVATION IN ARAB COUNTRIES

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## ABBREVIATIONS AND EXPLANATORY NOTES

| | |
|---|---|
| $ | United States dollar (unless otherwise stated) |
| € | euro |
| AGREN | Agricultural Research and Extension Network |
| ALI | Association of Lebanese Industrialists |
| ASARECA | Association for Strengthening Agricultural Research in Eastern and Central Africa |
| ATM | asynchronous transfer mode |
| BIOS | Biological Innovation for Open Society |
| BioTekNet | Regional Competence Centre on Industrial Biotechnologies |
| CANARIE | Canadian Network for the Advancement of Research, Industry and Education |
| CBN | Cassava Biotechnology Network |
| CGIAR | Consultative Group on International Agricultural Research |
| CORAF | Conference of the agricultural research leaders in West and Central Africa |
| CORDIS | Community Research and Development Information Service |
| COST | European Cooperation in the field of Scientific and Technical Research |
| DWDM | dense wavelength division multiplexing |
| ERA | European Research Area |
| ESCWA | Economic and Social Commission for Western Asia |
| ETFRN | European Tropical Forestry Research Network |
| EU | European Union |
| FES | Friedrich Ebert Stiftung |
| FP5 | Fifth Framework Programme |
| FP6 | Sixth Framework Programme |
| GARR | Italian Academic and Research Network |
| Gbps | gigabits per second |
| GCC | Gulf Cooperation Council |
| GDP | gross domestic product |
| GigaPoP | gigabit capacity point of presence |
| GIS | geographical information system |
| GNP | gross national product |
| ICT | information and communication technology |
| IDRC | International Development Research Centre |
| IEEE | Institute of Electrical and Electronics Engineers |
| IPR | intellectual property right |
| IPv4 | Internet Protocol version 4 |
| IPv6 | Internet Protocol version 6 |
| KBT | knowledge-based theory |
| KISTI | Korea Institute of Science and Technology Information |
| KOSEN | Global Network of Korean Scientists and Engineers |
| KREONET | Korea Research Environment Open NETwork |
| LIRA | Lebanese Industrial Research Achievements Programme |
| MAIN | Membrane Academic Industry Network |
| MAN | metropolitan area network |
| Mbps | megabits per second |
| MBS | Managed Bandwidth Services |
| MOST | Ministry of Science and Technology in the Republic of Korea |
| MPLS | multi-protocol label switching |
| NARI | National Agricultural Research Institute |
| NCSR | National Council for Scientific Research in Lebanon |
| NGI | Next Generation Internet |
| NGO | non-governmental organization |
| NIS | national innovation system |
| NorNet | Northern Environmental Research Network |
| NOSSTIA | Network of Syrian Scientists, Technologists and Innovators Abroad |
| NREN | National Research and Educational Network |

| | |
|---|---|
| OECD | Organization for Economic Cooperation and Development |
| PAPP | Programme of Assistance to the Palestinian People |
| PoP | point of presence |
| QoS | Quality of Service |
| R and D | research and development |
| RBT | resource-based theory |
| RBV | resource-based value |
| RDFN | Rural Development Forestry Network |
| RDI | research, development and innovation |
| RRC | Regional Research Centre |
| RTD | research and technological development |
| SDH | Synchronous Digital Hierarchy |
| SERC | Semiconductor Equipment Research Centre |
| STI | science, technology and innovation |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TCT | transaction cost theory |
| Tekes | National Technology Agency of Finland |
| TI | Telecom Italia |
| TOKTEN | Transfer of Knowledge Through Expatriate Nationals |
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| UNV | United Nations Volunteers |
| VC | virtual circuit |
| VPN | virtual private network |
| WDM | wave division multiplexing |
| WIPO | World Intellectual Property Organization |

## Introduction

Innovation is central to the development of successful economies. Less-favoured countries and regions are often those that lack the capacity to innovate and, consequently, that lack the ability to improve their positions in today's competitive global market. Capacity to innovate helps countries and regional groupings achieve advantageous positions in key industrial and service sectors.

Research, development and innovation (RDI) networks designed to promote innovative inputs can secure competencies in areas of expertise unattainable by individual countries and institutions. Furthermore, RDI networks play a significant role in securing a critical mass of both human and financial resources, particularly given the increased importance of multidisciplinary approaches and demand for higher resource levels linked to tangible impacts. Indeed, increasing sophistication of the research and development (R and D) enterprise is reflected in the cost of equipment and consumables, which renders R and D activities an expensive business whose costs are better shared among as many concerned partners as possible.

In addition, ready access to information and the ability to engage in effective cooperation with relevant organizations and individual experts are two crucial prerequisites for success in RDI endeavours as well as human resource development. Research institutes, universities and other organizations involved in innovative and educational activities cannot survive and contribute to socio-economic development without the ability to exchange information with their counterparts on timely bases.

This study is ultimately intended to encourage research, development and innovation (RDI) networking in Arab countries. To that end, chapter I discusses the theoretical background, including recent institutional theories, which advocate the comparative advantage of networks over other institutional arrangements. This is followed, in chapter II, by an overview of major RDI network types and characteristics.

Chapter III discusses selected RDI networking experiences in Europe and East Asia, summarizing lessons learnt with respect to network successes. Attention is drawn in chapter IV to the situation in Arab countries, briefly characterizing research and development (R and D) activity and describing selected networking initiatives in the region, with focus on their characteristics and modes of operation. In the light of this overview, an attempt is made to identify research areas seen as offering great potential for growth in the region; and to propose general guidelines for establishing viable regional R and D networking projects. Additionally, chapter IV discusses future prospects in RDI networking of major importance for Arab countries, namely, open source R and D and the protection of intellectual property rights (IPRs).

Chapter V highlights institutional, technical and legal issues that must be taken into account to ensure the success of RDI networks. The intention is to offer guidance through a number of basic and practical steps for the establishment of RDI networks with a view to carrying out collaborative R and D activities in selected research areas. This information is complemented, in the annexes to the study, with information on the physical infrastructure requirements for RDI networks, in addition to models of major documents that need to be prepared during the process of establishing networks.

The final chapter of the study provides a number of concluding remarks that highlight important aspects of RDI networking and implications for Arab countries from a policy perspective.

## I. RDI NETWORKING: THE THEORETICAL CONTEXT

The world is undergoing fundamental and rapid changes. The globalization of firms and markets constitutes one of the main forces behind several sweeping transformations, fuelled in no small measure by technological development. The emergence of a knowledge-based economy, whereby knowledge is the utmost strategic resource to achieve growth, is shaping a new era in development and growth.[1]

Changes in numerous domains and sectors pose serious challenges for the Arab region. With knowledge and innovation at the root of competitive advantage in the global economy, the capacity to innovate is coveted by most nations as an optimal response to both current and future challenges.[2]

Despite significant improvements in their capacity to conduct relevant research and development, national RDI systems in Arab countries suffer considerable shortcomings. Some of the most glaring handicaps are related to disjointedness and fragmentation of RDI efforts. Meagre resources constitute another important stumbling block. Both these obstacles can be attenuated through appropriate RDI networking. As a means of collaborative knowledge creation and dissemination, RDI networking can significantly help countries and institutions to overcome knowledge gaps and resource scarcities.

RDI networks are presently recognized as increasingly important instruments for enhancing capacity-building in science, technology and innovation (STI), thereby providing numerous benefits at regional, national, institutional and enterprise levels (see box 1). Well-coordinated research and development efforts by STI actors operating within dedicated RDI networks have been proven effective in a wide range of sectors and domains, including agriculture and health. Many international and regional organizations, including the United Nations, have come to recognize this and have accordingly adopted networking approaches in their work.[3]

### A. GLOBALIZATION, COMPETITIVENESS AND RDI NETWORKING

An important implication of globalization is intensified price and cost competition, which arises as national monopolies or oligopolies are eroded. Globalization has also induced new bases for competition, including enhanced emphasis on quality, timely market entry and efficient distribution networks. In order to operate successfully on the current global market, a firm or country must be able to produce high-quality products at low costs, sell them at reasonable prices, and possess the ability for timely delivery wherever these products are required. More importantly, while meeting the above competition criteria can be enough to attain short-term benefits, competitiveness, in the longer term, has become increasingly dependent upon a firm's capability to innovate continually in terms of new products and processes. Consequently, the ability to innovate is an important attribute that, in addition to being relative to productive efficiency and cost reductions, is set to gain more importance as demand becomes increasingly individualized and product life cycles continue to shrink.[4]

In order to achieve greater competitiveness in a global economy, international firms have resorted to networking of a variety of functions, including scientific research, technological development, and product and process innovation. They have been at the forefront in exploiting a range of technologies, including

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[1] The World Bank, "Knowledge economies in the Middle East and North Africa: toward new development strategies" (the International Bank for Reconstruction and Development/the World Bank, 2003).

[2] The term "innovation" is used in this document to indicate concrete application of knowledge in the form of new and improved technologies within products and processes. Within that context, innovation is considered as the driving force for past, current and future development and growth.

[3] See, for example, "A Common Vision for the Future of Science and Technology for Development", which was adopted by the United Nations Commission on Science and Technology for Development (UNCSTD) in 1996, and which addresses research networks.

[4] T. Hamalainen and G. Schienstock, "Innovation networks and network policies" (Organization for Economic Cooperation and Development (OECD), 2000), which is available at: www.oecd.org/dataoecd/35/8/2100869.pdf.

information and communications technologies (ICTs), to support their transnational activities in many spheres.

**Box 1. Some of the salient benefits of RDI networking arrangements**

Research and development (R and D) networking schemes have been shown to provide several benefits, including the following that are particularly relevant to developing countries:

(a) Sustain and strengthen capacities of individuals and institutions through peer learning, and build a critical mass of researchers and expertise in specific fields. This in turn allows developing countries to respond to critical development challenges;

(b) Promote multidisciplinary and cross-sectoral approaches through collaboration and coordination, which yields to the development of a "research community". Achieving R and D complementarity has in fact become a prerequisite to innovation;

(c) Improve research quantity and quality in terms of comprehensiveness, relevance and usefulness to end-users;

(d) Avoid duplication of R and D efforts and allow a better utilization of financial, infrastructural and human resources, which are particularly limited in developing countries. Consequently, higher returns are achieved from investments in science and technology;

(e) Share costs and risks of R and D, especially in high-tech areas. Moreover, networking can reduce the time span required to attain tangible R and D results;

(f) Disseminate and expand the utilization of research findings. Networks can help to transfer the results of successful research to other areas and improve this research to achieve a better impact.

Through the engagement of different stakeholders, a network can effectively lead to the adoption and local ownership of a research agenda that is relevant to the priorities and needs of the country or region. Furthermore, when policy community is involved in a network, research becomes responsive to national policies; and in turn research results can influence public policy and decision making and improve the policy development process.

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*Source*: Adapted from A. Adamo, "A review of IDRC documentation on the intended results of IDRC's support of networks (1995-2004)" (International Development Research Centre (IDRC), November 2004).

By examining specifically the implications of globalization for STI policy, it is possible to draw on resource-based value (RBV) and competency-based perspectives. Such perspectives are equally valuable in the formulation of strategies for research networking and cluster development.[5] Moreover, these approaches can be used to analyse the role performed by foreign direct investment, mainly by transnational corporations, in creating networks that lead to technology transfer and diffusion (see box 2).

A number of conclusions drawn from resource-based value and competency-based approaches remain valid whether a corporate strategy or national technology policy is at stake. Consequently, within the framework of both perspectives, while decision-makers at institutional or national levels cannot always predict the outcomes of a given competitive approach, they can certainly influence predominant trends, facilitate direct communication between users and producers of know-how, and catalyse preferred modes of institutional and national learning.

[5] This study adopts the modern concept of clusters to refer to linked industries and entities, including, among others, suppliers of specialized inputs and infrastructure, governmental institutions, universities, standards-setting agencies, think tanks, providers of vocational training, and trade associations. Using this conceptual definition, geographical concentration is not a requirement.

Additionally, both the resource-based value and competency-based perspectives share an important regional dimension and, furthermore, recognize the importance of commitment to attaining and retaining competitive advantage. Within that context, it has been suggested that transactions involving dissimilar and complementary assets, such as the variety of technological competencies essential for the development and marketing of a given product or process, could be better managed through inter-firm alliances and networks, rather than on the basis of governance and vertical integration within a given firm or institution.[6]

**Box 2. Competency-based versus resource-based value perspectives**

From an evolutionary perspective, core competencies are viewed as mechanisms that guarantee coordination of production skills in diverse situations and catalyse integration across assemblages of technologies. From this perspective, competencies constitute the core of competitiveness, evolving much more slowly than products upon which actual competitiveness is ultimately decided. Indeed, competencies can find expression in a variety of products. Competencies are also the result of collective learning processes within the organization and in its immediate environs. Moreover, they can be enhanced through application and shared utilization.

By contrast, resource heterogeneity, uniqueness and immobility are at the core of the resource-based value (RBV) perspective. The existence of ex ante and ex post barriers to competition is central to RBV analyses. The former are viewed as essentially due to positive information and transaction costs, while the latter are manifested in constraints over ability of rivals to imitate, substitute or completely replace extant combinations of resources.

Advocates of an evolutionary perspective are generally averse to the notion of grand strategies, with customary focus on top-down approaches and goal convergence. Rather, attention is paid to issues of process, unrestricted interactions, flexibility, receptiveness and local autonomy; and emphasis is made on the importance of disseminating knowledge within the organization.

*Sources*: Adapted from C. Lawson (1999), as cited in R. Green and J. Juniper, "Globalization and innovation: the implications of the Irish miracle", *Global Business Regulation: Some Research Perspectives*, K. Thorne and G. Turner eds. (Prentice Hall, Australia, 2001).

Increasingly, policymakers in developed countries and in countries undergoing transition to a market economy are attempting to avoid generic, broad-brush policies, including tax relief and wide-ranging subsidies, and are leaning instead towards policies of network and cluster development. The main objective of such an approach is to link the science and technology sector more closely with its constituency in industry and services and, perhaps more crucially, to bring closer parties engaged in the development, use, purchase and dissemination of a given technology.

Case studies of a number of countries, including Ireland during the 1990s, demonstrate that policy interventions of this kind possess many advantages. One of the more evident advantages is that otherwise mobile firms become tightly embedded into the local economy, and tend to be less willing to move away to locations that can appear more attractive in the short term.

## B. The knowledge-based economy and RDI networking

Networks and networking arrangements are set to play a crucial part in the knowledge-based economy (see box 3). Indeed, the knowledge-based economy is often termed an economy of networks at a variety of hierarchical levels. The role of networks in the knowledge-based economy is essentially linked to the fact that innovation will be a permanent feature of this economy, thereby permeating institutions and their relationships, both within and across national boundaries. The rapid tempo of change within the competitive and increasingly globalizing and liberalizing world economy equally constitutes a strong case for more effective networking with emphasis on selected innovations and their dissemination.

[6] G.B. Richardson (1972) and N.J. Foss (1999), as cited in R. Green and J. Juniper, "Globalization and innovation: the implications of the Irish miracle", *Global Business Regulation: Some Research Perspectives*, K. Thorne and G. Turner eds. (Prentice Hall, Australia, 2001).

**Box 3. Characteristics of the knowledge-based economy**

The knowledge-based economy can be defined in terms of the following characteristics:

(a) Rapid innovation is a permanent and central feature of the knowledge-based economy, differentiating it from previous forms of organization;

(b) The knowledge-based economy is essentially an economy of networks operating at different hierarchical levels and involving numerous forms of cooperation and interactions between the public and private sectors;

(c) Human capital plays a decisive role in the knowledge-based economy. Capacity to learn outweighs the level of static knowledge attained and, consequently, the higher degrees become essential qualifications for a labour force engaged in the knowledge economy. The ability to learn and to achieve lifelong training are essential;

(d) Information-related activities proliferate in all sectors of the knowledge-based economy and tacit knowledge is constantly codified and disseminated.

All of the above have imperative consequences on ways of conducting business, given that knowledge becomes a key factor of production, perhaps even more important than financial and physical assets, which therefore requires the adoption by firms of new strategies and management techniques.

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*Sources*: The World Bank, "Knowledge economies in the Middle East and North Africa: toward new development strategies" (the International Bank for Reconstruction and Development/the World Bank, 2003); and T. Stewart, *The wealth of knowledge: intellectual capital and the twenty-first century organization* (Utopia Limited, 2001).

In effect, all new forms of organization, including RDI networks, require novel modes of cooperation between a variety of partners in the public as well as the private sectors. Human capital performs a decisive role as an essential element of the new organizational forms, which is directly and indirectly influenced by education, training and other forms of information and knowledge exchange inherent of cooperative activity. The capacity for learning and human capital accumulation imparted by a given network generally outweighs the level of knowledge at which it can operate.

Some of the more important ways in which new institutional forms, particularly RDI networks, can contribute to human capital and knowledge accumulation become evident through the following: (a) rendering lifelong learning and on-the-job training more accessible; (b) helping to codify and disseminate tacit knowledge; and (c) facilitating the proliferation of information-related development into all sectors of a national economy.

New institutional forms, including RDI networks, invigorate knowledge-based socio-economic development, thereby posing challenges to traditional economic theories and practices. This can largely be attributed to the fact that, in the knowledge-based economy, growth is essentially based on many levels of learning. It is through learning that endogenous development of resources is attained and value added. Given the higher levels of competition in the global economy, the stock of knowledge is of far lesser importance than the ability to renew it continually through scientific research and technological development (RTD). Additionally, knowledge renewal generates externalities and raises outputs. However, while knowledge is an unlimited and renewable resource, it is inherently difficult to evaluate since its tacit component can be as important as its formal and tangible manifestations.

Knowledge ownership is non-exclusive and its use by a given individual or institution does not exclude or diminish possibilities for its use by others. These facts constitute essential arguments for research networks as vital ingredients in knowledge economies.

A key feature of innovation systems pertains to collaboration between firms in industry and what are sometimes broadly referred to as knowledge institutions. The past few decades have witnessed considerable evolution in the perception of innovation systems and processes, with set objectives and tangible achievements. Consequently, there is general agreement that technological innovation is the result of an elaborate interaction between research, design, production and marketing, which is undertaken on the basis of a web of relations. Moreover, interactive learning is involved with a variety of actors at all levels of the economy and performs more or less active roles. Multiple sources of information and pluralistic patterns of collaboration seem to be the rule rather than the exception.[7]

### C. Framework for the analysis of the comparative advantages of networks

In general, the comparative advantages of different organizational arrangements are highly susceptible to various influences, including technological, political and cultural. These in turn vary according to type of industry, location and time. Such influences inevitably affect value-adding activities in production and services. For example, the "high-trust culture" in Japan is supposed to have favoured networking arrangements; other countries and cultures could favour hierarchical organizations.[8]

When attempting to analyse the comparative advantages of networks, it is important to keep in mind the knowledge flow mechanisms and the learning competencies required to manage knowledge flow in learning organizations. Within that context, the following four learning competencies have been identified: (a) absorption of knowledge from outside; (b) diffusion of knowledge; (c) generation of knowledge; and (d) exploitation of knowledge in products and services. Networks have been identified as instruments for growing at least two of these learning competencies, namely, absorption and diffusion of knowledge.[9]

A relatively new branch of economics, termed "new institutional economics", focuses attention on the comparative advantages of markets, hierarchies and networks. In this context, the transaction cost theory (TCT) is used to argue that economic activities are organized according to their transaction cost characteristics.[10] It is suggested that economic activities characterized by low transaction costs can be efficiently organized by markets, while hierarchies are better at dealing with high transaction cost activities, with networks presenting a comparative organizational advantage in tackling intermediate transaction cost activities.[11] More recently, however, TCT has suffered from the following criticisms:

(a) Vague definitions of "transaction" and "transaction cost";

(b) Disproportionate attention to transactions in comparison to production and coordination issues;

(c) Neglect, through focus on the individual transaction as the basic unit of analysis, of the fact that costs and benefits in a particular transaction can influence other parts of an interdependent production system;

(d) Inadequate attention to the dynamics of technological and organizational innovation;

(e) Disregard for economic uncertainties and their organizational implications.

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7 J. Christensen, A. Schibany and A. Vinding, "Collaboration between manufacturing firms and knowledge institutions on product development: evidence from harmonized surveys in Australia, Denmark, Austria, Norway and Spain" (OECD, September 2000).

8 M. Aoki, "Toward an economic model of the Japanese firm", *Journal of Economic Literature*, vol. XXVIII (March 1990), pp. 1-27.

9 S. Have et al., *Key management models: the management tools and practices that will improve your business*, (Financial Times Prentice Hall, Pearson Education Limited, 2003).

10 R. Coase, *The nature of the firm* (Economica 4, November 1937), pp. 386-404; O. Williamson, *Markets and hierarchies: analysis and antitrust implications* (New York: Free Press, 1975); and O. Williamson, *The economic institutions of capitalism* (New York: Free Press, 1985).

11 O. Williamson, "Comparative economic organization: the analysis of discrete structural alternatives", *Administrative Science Quarterly*, No. 36 (June 1991), pp. 269-296.

In essence, criticism of TCT relates to the notion that, despite the importance of transaction costs, organizational choices are made with reference to a variety of gains and losses embodied in alternative solutions, rather than on cost considerations alone. Consequently, even when transaction costs are an important factor, organizational decisions could still take into account other factors, including synergies relating to production activities and resources, coordination costs and consequences for innovative aspects of organizational alternatives.

TCT does not by itself adequately explain the current preference for networking arrangements. This preference is best supported by a richer framework that involves multiple key characteristics of value-adding systems, only one of which is embodied in transaction costs. A recent paper on the subject of innovation networks refers to three additional "organizational determinants" to transaction cost, namely: (a) resource similarities; (b) coordination costs; and (c) innovation activity.[12] These additional determinants, which are reviewed below, can promote divergent outcomes in terms of organizational arrangements and can influence comparative advantages of networks in value-adding activities.

1. *Resource similarities*

Regardless of their sizes and orientations, all institutions concerned with generating and using innovative output possess their own organizational strengths and weaknesses, thereby resulting in specific advantages and disadvantages. Recent research aimed at analysing how the resources and capabilities of firms shape the organizational structure of value-adding systems revealed that firms target activities and maintain organizational arrangements only when they correspond closely to prominent firm-specific resources.

In institutional economics, the resource-based theory (RBT) gained popularity among business strategy researchers during the 1980s and 1990s.[13] This theory highlights the need for the resources and capabilities of an institution to be used in implementing closely related activities. RBT views institutions, essentially firms, in terms of their unique resource bundles on the basis of which they tend to build their competitive advantage. These include the following: (a) attributes due to geographical location; (b) proprietary technology and know-how, implicit as well as explicit; (c) good reputation among peers, customers and suppliers; and (d) superior organizational culture and management routine.

Owing to increasing specialization, peripheral and complementary activities are therefore best farmed out or subcontracted to other institutions, which are in possession of optimal expertise and resource bases. While this can apply to commercial activities undertaken with regard to innovation, both in terms of products and processes, the more recent knowledge-based theory (KBT) of the organization of firms considers innovation as a central determinant in organizational analysis (see subsection 3 below).

2. *Coordination costs*

The level of interdependence among value-adding activities is a major determinant of coordination mechanisms and associated costs. In other words, when important information exchange and links exist between different value-adding activities in a firm, there is a need for powerful coordination mechanisms. In a dynamic industry, reciprocal interdependence between activities is highly common, with multiple feedback loops within and between teams.

Applying this concept to interdependent value activities that are undertaken by different firms, it is seen that firms need to cooperate through networks in order to achieve a qualitative coordination, including the development of shared understanding, values and visions.

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[12] T. Hamalainen and G. Schienstock, "Innovation networks and network policies" (OECD, 2000), which is available at: www.oecd.org/dataoecd/35/8/2100869.pdf.

[13] Ibid.

However, the cost of such high-communication coordination between firms could be prohibitive due to different cultures and clashing ideologies and values. The high coordination cost can be greater than the resource advantages achieved by linking with related firms. This could hinder the creation of networks and favour the extension of corporate hierarchies, therefore ensuring a homogenous culture. One important factor which could counter this effect and decrease coordination costs is the availability of a high inter-firm trust, such as exists in Japan. This factor has in fact been reported as a major success factor of cooperative modes between Japanese firms.

### 3. *Innovation activity*

According innovation a central position in organizational and networking analysis is particularly relevant in today's competitive world. In essence, innovation can play a greater or smaller role in organizational and networking arrangements, in response to the particularities of the industry or sector under consideration. Consequently, innovation could well be expected to perform a more prominent role in the organization and networking of new knowledge-based production and service activities. On the other hand, resource and transaction cost considerations could be expected to acquire greater importance in mature and less dynamic production and service activities.

Among other considerations, the above issues are at the core of the knowledge based theory (KBT) of institutional organization. This theory addresses the implications of tacit and codified knowledge for competitiveness, communication, information systems and organizational arrangements. Essentially, KBT proposes that sustainable competitive advantage can best be attained through the dynamic interaction between the tacit and codified knowledge bases of an organization for the development of new knowledge.[14] The importance of direct and informal communication modes is also emphasized in highly complex, uncertain and dynamic situations.[15]

In essence, KBT emphasizes four organizational factors which influence the innovativeness of firms, namely: diversity of knowledge; required communication intensity; social capital; and the availability of complementary assets.

New knowledge can be created when different types of extant knowledge are combined or when elements inherent in knowledge already at hand are brought together in a new manner. This latter combination was often undertaken by "hero inventors", working often in isolation and inspired or facilitated by a varied background and which, when coupled with training, provided an ability to merge different types of knowledge or to create novel ideas from amalgamated old knowledge.[16] The fact that individual bases of knowledge have become highly specialized means that, in many instances, the combinations of different sets of specialized knowledge that yield major innovations require a pooling of experts rather than an individual "hero inventor".[17] Naturally, while the resulting knowledge base becomes more or less partially shared, it can never be fully shared.

In practice, different sets of knowledge possessed by individuals may not be readily shared and, subsequently, combined in order to produce tangible collective advantages. Effective knowledge sharing and later amalgamation require that a shared language as well as overlapping knowledge and cognitive frameworks be available from the very outset. Another essential prerequisite is the recognition by experts engaged in knowledge sharing of their respective knowledge domains. In general, these attributes imply that experts engaged in sharing knowledge need to possess tacit knowledge, which is essentially difficult to communicate. Nevertheless, once a given shared knowledge base is created, individual experts need to be

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[14] I. Nonaka and H. Takeuchi (1995), as cited in T. Hamalainen and G. Schienstock, op. cit.

[15] R. Daft and R. Lengel (1986) , as cited in T. Hamalainen and G. Schienstock, op. cit.

[16] Cultural diversity is accorded a high degree of importance in major scientific breakthroughs. Such diversity can be facilitated by an education system that induces familiarity with a variety of disciplines and perspectives. R. Hollingsworth (2000), as cited in T. Hamalainen and G. Schienstock, op. cit.

[17] R. Grant (1996) , as cited in T. Hamalainen and G. Schienstock, op. cit.

able to share and combine aspects of knowledge that are not necessarily common to them, and, in the process, to formulate new insights that would not otherwise have materialized.

It is generally recognized that effective communication capabilities are required in order for disparate knowledge sets to evolve into a shared knowledge base. Additionally, such required communication grows more difficult as the initial knowledge sets become more dissimilar. Communication and the creation of new knowledge become impossible when the initial knowledge bases are entirely different. Conversely, communication and the creation of knowledge are facilitated when the initial knowledge sets are very similar. However, learning and invention receive little impetus by their very similarity.

A corollary to the above argument is that the relationship between knowledge diversity and possibilities for invention and learning is best represented by an inverted U-curve.[18] Combining different knowledge sets is possible and could provide rich soil for innovation and learning under conditions of intermediate knowledge diversity. Moreover, it can be supposed that the resulting innovations tend to be more radical as initial knowledge sets are more diverse.

The third determinant of innovation is social capital, which can be defined in terms of the network of actual and potential relationships available to an individual or social unit. Social capital is, therefore, the sum total of the actual network available to an individual or unit and other links that can be mustered through that network.[19]

Social capital achieves its impact through structural, cognitive and relational dimensions.[20] The structural dimension involves the extent and configuration of existing or prior network links possessed by a given social unit. Such links strongly impact the diversity of available knowledge.

The second cognitive dimension comprises shared language and frames of knowledge creation and application, and governs the efficiency and intensity of communication between knowledge sets. The third relational dimension of social capital is concerned with behavioural and social norms, which translate into the prevailing level of trust among network members, thereby influencing access to complementary knowledge and motivating exchange of knowledge and extension of network linkages. In this sense, social capital performs an essential role in shaping the outcome of innovation by influencing the diversity of available knowledge sources and the extent to which initial networking capabilities are enhanced.

In order to become effective innovations, inventions must be combined with a variety of complementary assets, resulting in successful introduction into the market. This necessitates the adoption of systemic practices whereby missing links in the chain separating an invention from an innovation are attained, and activities resulting in adding value to the new invention are undertaken. The latter activities can involve any part of the value-adding system, including sourcing, technology, production and marketing; while systemic innovation focuses on other, complementary components of the system.

Underscoring the role played by hierarchical organization in the above process, some analysts have argued that new innovations cannot be created purely through market mechanisms, which are essentially unable to support the requisite rich communication flows.[21] Others have noted that new knowledge is typically created in closely interacting "communities of practice" with shared frames, professional code and knowledge bases.

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[18] J. Nahapiet and S. Ghoshal (1998), and R. Hollingsworth (2000), as cited in T. Hamalainen and G. Schienstock, op. cit.

[19] Ibid.

[20] Ibid.

[21] Ibid.

## D. CONCLUDING REMARKS

As a new institutional form, RDI networking helps firms and countries to achieve greater competitiveness, thereby mitigating the challenges posed by globalization and the shift towards knowledge-based economies. Essentially, competitiveness is enhanced due to faster knowledge accumulation and renewal, in addition to a greater capability to innovate.

Several economic theories were discussed in an attempt to discern the comparative advantage of networks over other institutional arrangements. The main conclusion from this discussion is that only a rich and complex framework, as adopted by evolutionary economic theories, can explain the comparative advantage of networks. Consequently, in addition to including an analysis of resources, transaction and coordination costs, the most adequate framework needs to incorporate the prominent determinants of innovation, namely, knowledge creation mechanisms and social capital.

## II. REVIEW OF RDI NETWORKING ARRANGEMENTS

The concept of "networking" has become popular during the past decade to the extent that little consensus exists with regard to a precise definition. This is equally a reflection of the fact that networks can take various forms. The term "research and development network" has been used in a general sense to refer to a variety of cooperative activities involved in conducting R and D activities, including disseminating information, sharing knowledge and training manpower. For the purposes of this study, R and D networks are defined as cooperative arrangements adopted by a variety of actors, including individual researchers, research centres, academic research groups and firms. These actors share more or less common objectives and tasks, sometimes use common resources, and work on mutually agreed research agenda with well-defined goals.

While R and D networks have become more visible since the 1970s and 1980s,[22] they have existed in one form or another well before those decades, often on the basis of informal arrangements. Indeed, it can be argued that many of the valuable results achieved during the nineteenth and twentieth centuries, particularly in the area of atomic and theoretical physics, were the outcome of largely informal as well as formal networking among laboratories and experts in developed countries.

Networks can be viewed from a variety of perspectives in line with research interests and desired outcomes. Aspects relating to network formation, field of operation, coordination modalities, configuration and geographical distribution are often considered in network taxonomies. Degree of formality and inter-institutional linkages can also be used as bases for network classification. This chapter outlines some of the more salient issues pertaining to network types and characterization, emphasizing points relating to both design and operational issues. Within that context, the discussions below apply to networks in general, whether these comprise academic institutions, research centres, governmental departments, non-governmental organizations (NGOs) or private enterprises.

Furthermore, advances in ICTs have introduced dynamism and vitality into networking, freeing it from dependence on physical proximity and drastically reducing the time needed for the exchange of information. As a result, traditional networks can now be supported by virtual networks based on novel forms of interaction, including, among others, exchange of documents in electronic format, video and Internet conferencing and ad hoc online chat rooms. While greatly facilitating interaction among network members, ICTs have also introduced issues that require close attention in relation to information security and authentication. However, solutions are rapidly being developed to tackle such issues, some of which are already commercially available for implementation. Annex I provides case studies on the ICT infrastructure requirements to support RDI networking activities.

### A. INNOVATION NETWORKING VERSUS R AND D NETWORKING

Product and process innovation encompass activities of considerably broader scope than corresponding R and D endeavours. Consequently, networking aimed at innovative products and processes are correspondingly broader and more protracted than networking involving purely R and D activities.

An important distinction between innovation networking and R and D networking resides in the constitution of partnering teams and institutions. While R and D networking can be properly handled on the basis of partner institutions, including university research laboratories and public sector research centres,[23] a broader range of institutions need to be involved in innovation networking. An innovation network, whether aimed at a new product or process, will most likely require partnerships between and among technical institutions, enterprises, selected suppliers and providers of technical services, as well as institutions that tackle testing, standardization and certification issues. In addition, linkages among actors in innovation

[22] See "Making North-South research networks work: a contribution to A Common Vision for the Future of Science and Technology for Development" (European Centre for Development Policy Management, 6 May 1999), which was presented to the fourth session of the Commission on Science and Technology for Development (Geneva, 17 May 1999).

[23] Within that context, public sector enterprises sometimes make their own R and D contributions.

networks can take several forms, depending on stage of competition, type of cooperation and number of partners (see table 1).

TABLE 1. TAXONOMY OF LINKAGES IN INNOVATION NETWORKS

| Stage | Type of cooperation | | Number of partners |
|---|---|---|---|
| Pre-competitive stage | R and D cooperation | University based cooperation research financed by associated firms (with or without public support) | Many partners |
| | | Government-industry cooperative R and D projects with universities and public research institute involvement | |
| | | R and D corporations on a private joint venture basis | Several partners |
| Competitive stage | Technological cooperation | Corporate venture capital in small high-tech firms (by one or by several firms that are otherwise competitors) | Few or very few partners |
| | | Non-equity cooperative R and D agreements between two firms in selected areas | |
| | | Technical agreements between firms concerning completed technology, including, inter alia, the following: technology sharing agreements; second-sourcing agreements; complex two-way licensing; cross-licensing in separate product markets | |
| | Manufacturing and/or marketing cooperation | Industrial joint venture firms and comprehensive R and D, manufacturing and marketing consortia | Few or very few partners |
| | | Customer-supplier agreements, notably partnerships | |
| | | One-way licensing and/or marketing agreements (including original equipment manufacturer sales agreements) | |

*Source*: Adapted from D. Chudnovsky and A. López, "Enterprise dynamics: key research issues within an innovation systems approach" (Centro de Investigationes para la Transformación (CENIT), Argentina, June 1997).

## B. COMMUNITIES OF PRACTICE

Communities of practice have generated considerable interest during the past decade. A community of practice can be defined as a group of people undertaking activities within a shared practice such that opportunities for situational learning develop, and knowledge-based abilities are reproduced, through common collective efforts. They can therefore be viewed as informal networking arrangements designed to promote knowledge sharing and to disseminate innovative practices within given institutional or disciplinary frameworks.

The concept of a community of practice stems from the relationships between knowledge and activity and, on the other hand, between activity and organizational groups. Consequently, "knowledge is not produced by passively perceiving individuals, but by interacting social groups engaged in particular activities. And it is evaluated communally and not by isolated, individual judgments".[24]

From a socio-technical perspective, implementing technological innovations essentially involves blending new knowledge and related artefacts with existing organizational structures, operational practices and underlying knowledge and artefacts. As the literature indicates, communities of practice in a given organizational or disciplinary setting shape the structure of the knowledge base in the institution or discipline in question, and help to maintain stores of organizational and disciplinary knowledge. They have the potential to play an important role in the implementation of technological innovations.

Activity is firmly embedded in current definitions of communities of practice, underlining the knowledge and collaboration aspects of interactions among individuals working within a given context or tackling related or similar issues. The main characteristics of communities of practice are as follows: (a) participation in a group of workers in possession of a stock of knowledge that they are willing to share; (b) the availability of shared values and attitudes towards subject matter and the sharing of related knowledge; and (c) possession of a common group identity.

The link between communities of practice and innovations is of special interest, particularly given that communities of practice tend to influence processes involved in the implementation and dissemination of innovation within and by a given organization. Integration and adaptation of knowledge lies at the focus of such processes. Customization of novel knowledge inputs and their incorporation within extant structures, practices and knowledge lie at the heart of innovative practices. An essential attribute of a successful innovating organization is therefore its effectiveness in tending, nurturing and utilizing its communities of practice.

The relationship between innovation processes taking place in an organization and its communities of practice is far from unidirectional. Indeed, it is essentially a two-way relationship. Under normal conditions, a community of practice will not only contribute to the innovation processes of an organization, it will also be shaped by whatever innovative input it incorporates into its surroundings. Communities of practice can well bear the brunt of change, and associated discontinuity, arising from whatever technological innovations they can introduce.

Addressing questions relating to innovation in an organization through the framework provided by the concept of a community of practice usually enhances understanding of the dynamics of innovation. In effect, the concept of a community of practice provides an additional dimension through which it is possible to characterize and enhance innovation dynamics processes in an organization.

Research carried out over the past decade has resulted in a number of general conclusions with regard to the make up and modalities adopted by communities of practice in organizations known to have succeeded in exploiting this organizational format.[25] A striking common feature is the fragmented nature of the knowledge bases available to successful communities of practice. This goes to support the notion that, in order to be implemented successfully, an innovation needs to be considered from many aspects by experts from a variety of pertinent disciplines. An additional lesson brought forth by recent research is that organizations, which have proved successful in creating and supporting such communities of practice, were in possession of a considerable number of viable and distinct communities of practice.

Clearly this poses a particular challenge for most small and medium-sized enterprises, such as exist in the developing countries of the Arab region. Innovative solutions are needed in order to overcome such difficulties. The establishment of communities of practice across sectors or sub-sectors can provide such a solution. Consequently, it can well be advantageous to create a community of practice that deals with cross-

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[24] B. Barnes, *Interests and the growth of knowledge* (London: Routledge and Kegan Paul, 1977), p. 2, as cited in D. Hislop, "The complex relations between communities of practice and the implementation of technological innovations", *International Journal of Innovation Management*, vol. 7, No. 2 (Imperial College Press, June 2003) pp. 163-188.

[25] D. Hislop, op. cit.

cutting innovations in the agro-food industry for the benefit of a syndicate of agro-food producers. Problems that can be tackled by such a community of practice can span a wide range of issues, including, for example, issues related to packaging or compliance with specific environmental legislation, health or export quality regimes.

### C. Vertical versus horizontal networks

In general terms, there are two major network categories, namely, the vertical and the horizontal classes of networks. This classification is based on the part played by the network in question with regard to the value-adding chain or sequence. With the objectives of the present study in mind, value adding can be taken as extending beyond financial profit or material wealth in general to encompass knowledge accumulation and the creation of new knowledge.

Vertical networks connect institutions along a particular value-adding, or knowledge accumulation/creation, chain.[26] Horizontal networks, on the other hand, connect individuals and organizations involved in such specific functional areas as research, production, services, logistics and marketing. Networks of both the horizontal and vertical types can be created between private and public sector institutions.

### D. Formal versus open networks

Other parameters that can be used to characterize networks include level of formality and openness. Clearly, the formality, or informality, adopted in a particular network could vary enormously, ranging from situations where personal relations are paramount to more rigid networks where elaborate protocols can be involved. With specific regard to R and D networks, it is possible to have networking arrangements evolving as a project progresses from a more informal stance, at the outset of a project, to one in which more formality is introduced, thereby taking into account credits for parts of the work undertaken by the various network partners and allowing for joint ownership of any intellectual property rights that could ensue as a result.

The issue of formality is closely linked to a network's boundaries. It is possible to have networks opening up to wide membership, on the one hand, and others that are confined to a restricted membership. Consequently, networks can have distinct or blurred boundaries. In the latter situation, traffic across the network boundary allows new members to join, while past members leave or assume a lower profile due to programmatic, institutional or other reasons. Literature reports point to varying degrees of network openness. This variation can sometimes reach a degree at which it becomes difficult to decide whether a specific individual or organization belongs to a particular network or not. Nevertheless, it is more common for networks to have few constraints restricting entry of institutions concerned with its subject matter. However, conditions can be set later with regard to ownership of the results of collaboration and to contributions made by parties cooperating towards a given goal.

Furthermore, it is logical to assume that the degree of openness adopted by a given network varies in relation to the types of organizations involved and activities under consideration. Equally, it is quite possible to have varying degrees of openness featured in a given network according to the stage of activity. Within that context, networks can move from a complete openness at the start of a given activity to a more restrictive stance as the particular project progresses to a stage when issues regarding intellectual property and credits for authorship arise.

### E. Network duration and stability

Looking at the duration of networking as a parameter, it is possible to have networks focusing on a particular project or group of projects. In such cases, the network's lifetime is necessarily limited to that of the project or projects in question. Network members are then committed to a particular short-term goal. Alternatively, a network fostering a long-term relationship can target collaborative activities in a particular domain, including implementation of projects in a variety of allied areas. It is quite possible for this latter

[26] Traditionally, these institutions are firms engaged in production or services activities.

type of network to form bases for strategic alliances to which members could be committed in the long term. Within this type of arrangement, it can be possible to construct teams targeting more specific outcomes as in the former type of network.

Stability is another parameter to consider in network characterization. In general, network stability can vary considerably and is largely linked to continuing resource availability and constancy of individual institutional arrangements. While it can be unwise to hardwire stability at inception, it can be advisable and even desirable to promote certain measures of interdependency and trust among members with a view to greater network stability.

### F. Network structure and organization

The organization of a network is another important consideration to address at the outset. Networks can differ in terms of the centrality and distributed nature of their operations. In essence, networks are an association of autonomous actors sharing broad interest and more or less well-defined specific objectives. While they generally comprise members in possession of equal rights and duties, several forms of dependence and asymmetry can sometimes be excluded from the network structure. In fact, a situation whereby a given network partner or group of partners assumes a leading role is more likely to arise in practice. Indeed, it is likely that one or more “flagship” partners can take up leading status within a network, with more or less control of the network’s activities and possibly its partners.

A recent review revealed three main types of active networks whose operations target common goals while being largely dependent on the pattern of relationships between network members.[27] These are as follows:

(a) Enclave networks, which are characterized by a flat structure whereby every member has the same level and can build relationships with all other members. The network is governed by persuasion, consensus-building and “bottom-up” legitimacy and trust, rather than control. This type is commonly found in information dissemination networks, as well as local academic networks of researchers;

(b) Hierarchical networks, which are centred on an organizational core that has the authority to regulate activities of other members. They resemble the structure of individual organizations whereby control is exerted through direct authority, steering and regulating. These networks are best suited for the coordination of collective action over the longer term to achieve pre-defined objectives. Division of labour is usually clear;

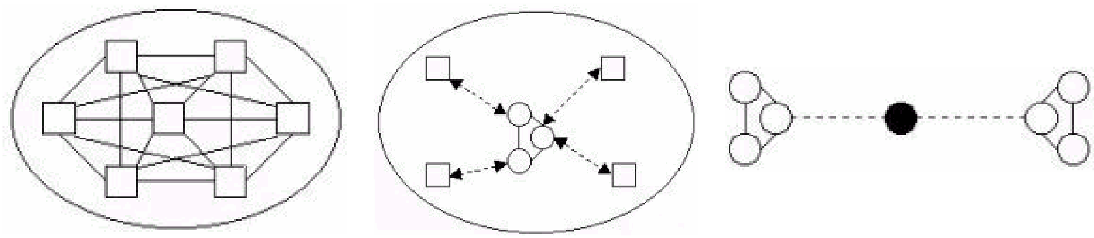
(c) Individualistic networks, which are single organizations that develop an association of affiliates to work on specific tasks, including, for example, the procurement of one or more networks of service providers through contracts and agreements.

Figure I provides a schematic representation of these three types of networks. In many cases, existing networks are hybrid forms between these types and exhibit a mix of characteristics. Table 2 presents the main strengths and weaknesses of each type.

A trend towards networks with enclave structure has been observed as an effective mechanism to promote the transfer of knowledge, particularly tacit knowledge. It is worth noting that the network structure is greatly affected by already existing linkage patterns between member organizations.

[27] The review was conducted by N. Goodwin et al., entitled “Managing across diverse networks: lessons from other sectors” (Service Development and Organization Programme, January 2004).

**Figure I. Schematic representation of enclave, hierarchical and individualistic networks**



(a) Enclave network (b) Hierarchical network (c) Individualistic network

*Source*: N. Goodwin et al., "Managing across diverse networks: lessons from other sectors" (Service Development and Organization Programme, January 2004).

TABLE 2. STRENGTHS AND WEAKNESSES OF DIFFERENT TYPES OF NETWORKS

| Type of network | Strengths | Weaknesses |
|---|---|---|
| Enclave networks | ▸ Equality between members stimulates commitment, trust and integrity<br>▸ Sharing of information and ideas is stimulated | ▸ Chance of failure in case of a clash in principles or a lack of motivation<br>▸ Insufficient institutionalization |
| Hierarchical networks | ▸ Ability to coordinate and control a pre-defined task<br>▸ Better use of shared resources over the long term | ▸ Bureaucracy<br>▸ Demotivation of members<br>▸ Innovation can be limited |
| Individualistic networks | ▸ Innovation is stimulated<br>▸ Flexibility<br>▸ Fluid membership | ▸ High levels of transaction costs<br>▸ Competition and conflicts between affiliates are possible |

*Source*: N. Goodwin et al., "Managing across diverse networks: lessons from other sectors" (Service Development and Organization Programme, January 2004).

## G. NETWORK GOAL

The following three types of research networks can be identified based on specific goals:[28]

(a) Information exchange networks, with such examples as the Agricultural Research and Extension Network (AGREN) and the Rural Development Forestry Network (RDFN);[29]

(b) Research coordination networks, where members conduct their experiments independently, while based on a common research agenda. Research results are then exchanged between members for comparative analysis. Examples of this type include the Cassava Biotechnology Network (CBN) and the networks of the Conference of the agricultural research leaders in West and Central Africa (CORAF);[30]

[28] See "Making North-South research networks work: a contribution to A Common Vision for the Future of Science and Technology for Development" (European Centre for Development Policy Management, 6 May 1999), which was presented to the fourth session of the Commission on Science and Technology for Development (Geneva, 17 May 1999).

[29] While information exchange is a general characteristic of networks, what is referred to here are networks that undertake only this type of activity. The examples provided are available at: www.odi.org.uk/agren/; and www.odifpeg.org.uk/.

[30] The examples provided are available at: www.ciat.cgiar.org/biotechnology/cbn/; and www.coraf.org/reseau.php.

(c) Research policy consultation networks, where advocacy and research policy are the main goals. Examples include the European Tropical Forestry Research Network (ETFRN) and the Consultative Group on International Agricultural Research (CGIAR),[31] which bring together 15 research institutes in an advocacy group called Future Harvest.[32] Moreover, a "network of networks" can be classified within this type of networks, which typically comprises a regional network whose members are national networks. An example of this type of network of networks is the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).[33]

It is common for a network to evolve as its focus changes. For example, a network can start as an information exchange network and develop into a coordination or policy consultation network.

## H. Network life cycle

Networks evolve from their creation, through to maturity and until they achieve their objectives or otherwise become inactive. Their membership base, governance structure, activities and the coordination of their work change as they move from an informal entity to a well-established independent structure.[34] This process depends largely on the availability of funds and the influence of donor agencies. The typical life cycle of a network is depicted in table 3.

TABLE 3. CHARACTERISTICS OF RESEARCH NETWORKS FROM INITIATION TO MATURITY

| Characteristic | At initiation | At maturity |
|---|---|---|
| Membership | Small | Broad |
| Governance | Informal | A formal governing body, including, for example, a management committee and a scientific advisory to set and oversee the implementation of a policy agenda |
| Activities and products | Minimal or limited | Range of regular activities and products, including, inter alia, the following: databases, publications, training and joint research projects |
| Coordination | Voluntary or by staff members of key network institutions | Permanent professional and administrative staff |

*Source*: Adapted from "Making North-South research networks work: a contribution to A Common Vision for the Future of Science and Technology for Development" (European Centre for Development Policy Management, 6 May 1999), which was presented to the fourth session of the Commission on Science and Technology for Development (Geneva, 17 May 1999).

[31] The examples provided are available at: www.etfrn.org; and www.cgiar.org/.

[32] The advocacy group is available at: www.futureharvest.org.

[33] More information on the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is available at: www.asareca.org.

[34] See "Making North-South research networks work: a contribution to A Common Vision for the Future of Science and Technology for Development" (European Centre for Development Policy Management, 6 May 1999), which was presented to the fourth session of the Commission on Science and Technology for Development (Geneva, 17 May 1999).

## III. RDI NETWORKING EXPERIENCES IN SELECTED COUNTRIES AND REGIONS

Globally, there are many networking experiences. This chapter focuses on the more successful efforts aimed at building RDI networks in selected countries and regions across the world. Whenever relevant information is available, a brief look at the national science, technology and innovation system is presented, followed by an overview of some existing networking experiences.

It is important to note that "innovation" aspects can be more or less explicit in the networking arrangements enacted by the countries under review. The degree to which they are apparent varies according to the extent of participation in the networking arrangements by enterprises and enterprise associations, and to the level to which programmes adopted by networks respond to enterprise priorities.

Important lessons that could be learned from these experiences are summarized at the end of the chapter. Additional case studies are presented in annex II.

### A. THE CASE OF FINLAND[35]

Finland is one of the few countries that was able to transform its traditional resource-based economy into an innovation driven economy. It is a country that ranks highly in terms of global competitiveness, with considerable prospects for future growth in high-tech exports. The Finnish informational economy is based on its strong role as a producer of ICT. Specifically, in 2000, the ICT cluster employed a modest 3-4 per cent of total labour force and yet accounted for one-third of total exports and approximately 45 per cent of gross domestic product (GDP).[36]

The Nokia experience is often quoted in discussions concerning Finland's success story. In less than a decade, Nokia was able to move from its original position as a national mobile telephone equipment company to the rank of a super multinational producer of mobile telephones, acquiring, in the process, a global market share of 35 per cent in 2002. The Finnish national innovation system is often credited with playing a major role in Nokia's success, with a good deal of credit going to networking and clustering approaches promoted by the National Technology Agency of Finland (Tekes). Box 4 provides a summary of R and D activities undertaken by Nokia.

**Box 4. The Nokia experience in research and development**

Nokia invests highly in research and development (R and D). Its R and D spending reached €3.76 billion in 2003, representing 12.8 per cent of net sales. Approximately 39 per cent of employees work in the different branches of the corporate Nokia Research Center, which are located in 11 countries.

One of the main strategies at Nokia is to monitor and influence technological developments through global contacts, including active participation in standardization and pre-competitive R and D projects in cooperation with universities, research institutes and other companies in Europe, Asia and the Pacific, and North America. In addition, Nokia conducts continual external networking with business communities, customers, product users and a range of other stakeholders.

The Nokia Research Center undertakes both basic long-term industry research and short-term product development to serve Nokia's business groups. Funding for the Center is ensured by selling contracted research directly to Nokia's business groups.

*Source*: Nokia Research Center, which is available at: www.nokia.com/nokia/0,,50249,00.html.

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[35] This section is based on E.Y. Park, "Cluster approach for promoting innovation: Comparison of Finland and Korea" (Handong Global University, October 2003).

[36] M. Castells and P. Himanen, *The Information Society and the Welfare State: The Finnish Model* (Oxford University Press, 2002).

Finland's science and technology policy was given new direction in the 1980s, with emphasis on the strategic technology development and innovation (see box 5). Within that context, the new concept of national innovation system (NIS) was adopted in official policy discussions and relevant documents.[37]

**Box 5. Major changes in Finland's innovation system**

Changes in funding modalities include the following:

(a) Shifting from line-item budgeting to lump-sum budgeting, essentially in support of university research;

(b) Channelling funding increasingly through specialized funding agencies and enhancing coordination among these agencies;

(c) Emphasizing funding based on competition and specific programmes with clear targets;

(d) Budgeting projects over a number of years.

Formulation and development of research activities aim at the following:

(a) Establishing research, technology and "cluster" programmes;
(b) Promoting internationalization of research;
(c) Promoting networking and collaboration.

Institutional changes are aimed at the following:

(a) Establishing post-graduate schools and advancing "professional research careers";
(b) Establishing centres of excellence;
(c) Setting up liaison and support organizations, including, for example, liaison offices within the European Union;
(d) Encouraging structural development and profiling of universities.

National policy and regulatory arrangements aim at the following:

(a) Formulating and adopting a national innovation system;
(b) Shifting from detailed regulation to performance-based management;
(c) Adopting result-oriented evaluation of research and technology activities;
(d) Emphasizing conformity with intellectual property right (IPR) regimes;
(e) Introducing accountability systems.

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*Source*: E. Park, "Cluster approach for promoting innovation: Comparison of Finland and Korea" (Handong Global University, October 2003).

Additionally, Finland established Tekes, the National Technology Agency, to provide a key tool for channelling official support for STI. Through this Agency, the Government was able to use R and D funding in its approach to build an innovation driven economy. Another important element in this national strategy was the promotion of regional science parks as hubs of technology-based regional clusters. Crucially, this strategy was supported by increased resources, which translated as increases in R and D funding from 1.2 per cent of GDP in 1982 to 2.2 per cent by 1990.

Key actors in the national innovation system, namely, universities, private sector firms and public research institutions, were encouraged to collaborate closely through more funding allocated to joint research projects. Multidisciplinary projects and those with components addressing international cooperation were equally targeted for special funding support by Tekes.

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[37] Despite this shift in focus, Finland continued to allocate significant support for research in the basic sciences.

In the following subsections, a closer look is taken at the role of Tekes in supporting R and D networking, and an example is given of an existing R and D network in Finland, namely, the Northern Environmental Research Network (NorNet).

### 1. *The National Technology Agency*

The National Technology Agency (Tekes) is the main public funding organization for R and D in Finland. Tekes supports innovative, risk-intensive projects in both industrial enterprises and research organizations. In addition, Tekes links Finnish researchers with industrial enterprises in Finland, on one hand, and with researchers from abroad, on the other, thereby acting as an effective instrument for cooperation and networking for companies and the research sector.

Tekes funds projects through research programmes in specific sectors of technology or industry. The programmes are prepared by Tekes jointly with companies and research organizations through workgroups and seminars. This exercise is even more important given that the costs of projects are usually shared equally between Tekes and participating companies. Small and medium-sized companies are equally involved in the process.

The budget of research programmes in 2003 amounted to €180 million; and in 2004, a total of 23 extensive national technology programmes were ongoing.

Each technology programme is managed by a steering group, a coordinator and a responsible person at Tekes. Moreover, the duration of programmes ranges from between three to five years; and programme assessment is performed by foreign evaluators.

### 2. *The Northern Environmental Research Network*

The Northern Environmental Research Network (NorNet) groups together researchers working cooperatively in the field of northern Finnish environment. The network aims to support, integrate and profile northern research, expert and laboratory services, as well as education.

Established in 1999, NorNet members now include the University of Oulu, Finnish Environmental Administration, Finnish Environment Institute, North Ostrobothnia Regional Environment Centre, Kainuu Regional Environment Centre, Lapland Regional Environment Centre, Finnish Game and Fisheries Research Institute, Finnish Forest Research Institute, Agrifood Research Finland, and Geological Survey of Finland. Partners in NorNet collaborate with each other in their research projects and, moreover, cooperate with users of research findings, business enterprises and regional development organizations.

Activities of NorNet are multidisciplinary in nature and tap the strengths of its members in the fields of land-use and river basin management, sustainable use of natural resources, environmentally friendly production, environmental monitoring, industrial ecology, green chemistry, geoinformatics, global change, rural development and environmental sociology. In addition, competencies in economics, social and health sciences, and cultural history are sought when deemed necessary.

## B. THE CASE OF THE REPUBLIC OF KOREA[38]

During the latter part of the twentieth century, the Republic of Korea succeeded in transforming its traditional agricultural economy into an industry-driven economy. However, the country is currently suffering from weaker collaboration among key players in its national innovation system, namely, universities, private sector firms, R and D centres and concerned governmental departments. Innovation clusters are not considered to be well-developed in the Republic of Korea and, despite the large size of its tertiary education sector and relatively large R and D funding contributions from gross national product

[38] This section is based on E. Park, "Cluster approach for promoting innovation: Comparison of Finland and Korea" (Handong Global University, October 2003).

(GNP), national innovation output does not rate high enough in quality terms. Consequently, its international competitiveness and future growth potential are often questioned.

Rapid growth took place in the tertiary education system during the past four decades of the twentieth century. It is reported that more than 70 per cent of high school graduates attend tertiary courses of study in the country's colleges and universities. However, numerical expansion of tertiary education does not appear to have been accompanied by commensurate development in terms of quality. Many Arab countries are in a similar situation.

The following factors have been quoted with regard to some of the main shortcomings suffered by higher education and research in the Republic of Korea:

(a) Public funding remained inadequate for a considerable length of time. Specifically, public expenditure on tertiary education in the Republic of Korea was estimated at 0.6 per cent of GDP, compared to an average of 1.2 per cent in the countries of the Organization for Economic Cooperation and Development (OECD), and well below 2.1 per cent of GDP in Finland;

(b) Lack of Government support for education and research in the country's private universities, which constitute almost two thirds of the total number of national tertiary educational institutions;

(c) Inadequate incentive schemes to motivate and guide professors and research staff in the national university system;

(d) Inefficient management of R and D public funding to universities whereby several ministries provide funding but without adequate coordination, monitoring and feedback mechanisms.

As a result of these shortcomings, the output of higher education and research institutions has tended to fall below expectations; and research undertaken by national institutions has had a minimal impact on the development of innovative regional clusters. However, recent changes in the country's university system could produce positive developments. Innovative output could benefit from new provisions for university-private sector collaboration, particularly in aspects relating to venture capital investment in innovative enterprises and start-up schemes. Additionally, improvements have been made in the design and implementation of more objective project evaluation, monitoring and feedback schemes. Furthermore, the gradual adoption of competition and incentive systems in the appointment and promotion of professors and staff are set to improve the quality of higher education.

In the following subsections, a closer look is taken at the role of the Regional Research Centres (RRCs), which constitute a major networking initiative by the Government of the Republic of Korea in supporting R and D networking, and an example is given of an existing R and D network, namely, the Global Network of Korean Scientists and Engineers.

### 1. *The Regional Research Centre Programme*[39]

In 1995, the Government of the Republic of Korea launched the Regional Research Centre (RRC) Programme with the aim of establishing a regional network among researchers in priority areas and of building their technological capacity. Subsequently, the Programme was given a new spin and was used as a policy tool for developing research networks between production clusters and R and D clusters. These networks were seen as a catalyser for production and R and D clusters to evolve into innovation clusters.

Generally located in universities with a potential cluster, RRCs act as central network agents that catalyse innovation by selecting and distributing knowledge among user firms, supplier firms, regional universities and public research institutes.

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[39] This subsection is based on K. Lee, "Promoting innovative clusters through the RRC (Regional Research Center) Policy Program in Korea" (Science and Technology Policy Institute, 2002).

Moreover, RRCs were established using a bottom-up approach whereby a given university establishes relationships with local firms, governmental and public research institutes, and then submits a research proposal to the Ministry of Science and Technology (MOST). Once the proposal is accepted, MOST provides approximately one third of the budget necessary to undertake research over the first five years, while the remaining two-thirds are divided between private firms, universities and local government.[40]

In 1999, a total of 37 major RRCs were established in 15 provinces and in such diverse fields of R and D activities as environmental technologies, electronics and biotechnology. Moreover, by 1999, more than 100 universities had participated in the Programme, including many that lacked the resources to undertake research activities independently. Upon evaluation, the Programme was found to have assisted the establishment of local science and technology communities, the integration of production and R and D clusters, and the improvement of innovative performance. Box 6 provides an overview of one of the earliest and more successful RRCs, namely, the Semiconductor Equipment Research Centre (SERC).

**Box 6. The Semiconductor Equipment Research Centre**

Until the early 1990s, the semiconductor equipment industry in the Republic of Korea depended greatly upon foreign suppliers, and approximately 85 per cent of components were imported from such countries as Japan and the United States of America. This dependency prevented local manufacturers from competing internationally owing to high costs. Local development activities, even those conducted in leading national universities, had failed to build national capacities in the design and manufacture of sophisticated semiconductor equipment.

Following the launch of the Regional Research Centre (RRC) Programme in 1995, Hoseo University became a regional research centre for semiconductor equipment and established the Semiconductor Equipment Research Centre (SERC) in 1996. In its first four years of operation and with a modest budget, SERC registered three patents, transferred 22 technologies to private firms, undertook 34 training courses and offered some 100 consultancies to small and medium enterprises.

Prior to becoming an RRC, Hoseo University did not possess a strong knowledge base in semiconductor equipment. This field of research was selected, however, in view of the large demand for such research from semiconductor manufacturing companies in the region surrounding the University. Indeed, the success of SERC relied heavily on the support of several private firms, including Samsung Electronics, which showed great interest in the programme.

A total of five other local universities and two public research institutes were also involved in SERC research, which was divided between basic research and research targeting firm-specific technological problems. In the first three years of operation, SERC undertook 35 projects and served 19 private firms. Specifically, technological research was undertaken in the following areas: software, control, test equipment, plasma simulation and component design.

By virtue of these activities, SERC has become the centre of semiconductor research networks in the Cheonan-Asan region, which has led to the formation of an innovation cluster in the region. Through SERC, previously fragmented knowledge is shared among partner firms, and the level of trust with universities and research institutes has risen, thereby yielding to more cooperation and interaction.

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*Source*: K. Lee, "Promoting innovative clusters through the RRC (Regional Research Center) Policy Program in Korea" (Science and Technology Policy Institute, 2002).

### 2. *The Global Network of Korean Scientists and Engineers*

The Global Network of Korean Scientists and Engineers (KOSEN) is a web portal aimed at promoting information exchange among Korean scientists and engineers all across the world for the development of the national science and technology system.[41] Managed by the Korea Institute of Science and Technology Information (KISTI) and funded by MOST, KOSEN maintains on its website useful information and

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[40] Private firms and universities bear approximately one quarter of the expenses each, and local government provides the remaining 16 per cent.

[41] The Global Network of Korean Scientists and Engineers (KOSEN) website is available at: www.kosen21.org/english/.

materials, including expert reviews, and conference and technology reports. Additional services offered include assistance to members in promoting their research projects.

In order to encourage expatriate Koreans to join the network and actively participate in its activities, KOSEN compensates its members by rewarding them with mileage points, which are accumulated as a function of the number of information items they post on the website.[42]

### C. The case of the European Union

The European Union (EU) claims to produce almost one third of the world's scientific knowledge.[43] However, Europe's economic growth and competitiveness have been lagging behind such countries as Japan and the United States of America, due in part to the following weaknesses in the EU innovation system: (a) lack of investment in innovative research; (b) fragmented nature of research activities due to loose cooperation; and (c) difficulties in converting research achievements and innovations into commercial technologies owing to stringent product regulations and standards.[44]

At the European Summit of March 2000, which was held in Lisbon, European leaders called for the EU to become the most competitive economy in the world by 2010. Targets set at the Summit and subsequent plans of action aimed at the following:

(a) Increasing R and D spending by more than 50 per cent before 2010 in order to reach 3 per cent of GDP, and raising the share of private sector funding in R and D from half to two thirds of total expenditure;

(b) Creating the European Research Area (ERA) to consolidate research activities undertaken by individuals and research organizations into programmes that are integrated across borders and across disciplines. A budget of €20 billion was allocated for 2002-2006 under the Sixth Framework Programme (FP6) for the purpose of building EU-wide platforms of excellence working in the following seven priority areas: (i) genomics and biotechnology for health; (ii) information society technologies; (iii) nanotechnologies, intelligent materials and new production processes; (iv) aeronautics and space; (v) food safety and health risks; (vi) sustainable development; and (vii) economic and social sciences;

(c) Improving the innovation framework, including regulatory aspects targeting the diffusion of existing technology to small and medium-sized enterprises in the hope of bridging the gap between research work and downstream commercial applications. The plan also aims to foster organizational innovation such as new business models and innovation management techniques in order to increase competitiveness and promote the full exploitation of technological innovation.

In line with the above objectives and in order to be eligible for funding, FP6 projects must be integrated and involve a critical mass of partners through cross-border networking among centres of excellence in universities, research bodies and business enterprises. Additionally, these projects must target significant products, processes or service applications.

#### 1. *European Cooperation in the field of Scientific and Technical Research*

The European Cooperation in the field of Scientific and Technical Research (COST) is an intergovernmental framework that was established in 1971 to cover basic and pre-competitive research as well as activities of public and cross-border utility, including environmental research. Through the years, this long-running initiative has developed into a valuable mechanism for coordinating national research activities in Europe.

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[42] These items can include relevant events, jobs, projects and reports. Equally, mileage points are awarded whenever a member recommends other members to join the network.

[43] See "Overviews of the European Union activities: research and innovation", which is available at: www.eu.int/pol/rd/overview_en.htm.

[44] For example, companies in the EU apply for some 170 patents each year per million inhabitants, compared to 400 patents by their American counterparts. In addition, it costs five times more to register a patent in the EU than it does in the United States of America.

In addition to its 34 European members, 12 non-European countries[45] and a number of individual NGOs are involved in COST projects, making it possible to tackle research areas with a global outreach. In 2004, the number of new and ongoing groups of projects, which are referred to as "actions", was approximately 200 and involved more than 300,000 scientists. The duration of an action is typically four years and the average fund available for an action is €80,000.

One of the major characteristics and advantages of COST is the flexibility in defining, launching and joining projects. Projects are defined using a bottom-up approach by the European science and technology community, and participation by members is on an à la carte basis.

At the end of 2002, efforts were made to achieve closer links between COST and other European cooperation initiatives, including the Framework Programmes, with the aim of creating synergies and benefiting from complementarities. In particular, actions were taken at three levels, namely: (a) exchange of information and best practices between partners; (b) partnership at the project level; and (c) partnership at the programme and policy level.[46]

### 2. *The RTD framework programmes*

The European Union has acknowledged the role that research and technological development (RTD) can play in coping with increasing industrial competition in a global context and in ensuring a better quality of life for its citizens. The research priorities of the EU are reflected in the five-year framework programmes. For example, the Fifth Framework Programme (FP5), which covered the period 1998-2002 and was allocated a budget of €13.7 billion, responded particularly to major socio-economic challenges facing Europe, namely: (a) to achieve a better quality of life; (b) to manage living resources; (c) to build an information society; (d) to promote competitive and sustainable growth; and (e) to protect the environment.

In selecting focus research areas, key players in research are systematically consulted. Moreover, in order to maximize possibilities for cooperation in R and D projects, an online database was established to provide the profiles of companies, research institutions and universities from across Europe and the world. This database includes a free online tool, which was designed by the Community Research and Development Information Service (CORDIS) to help organizations locate suitable partners for participation in FP5 or other international collaborations.[47]

Once a given project is completed, partners are obliged by contract to submit information on the results of the project and on plans to exploit those results. This information, referred to as a technological implementation plan, is included in a free online database, called the Technology Marketplace. Additionally, this online forum features offers of technology and business opportunities resulting from R and D projects funded by the EU and other entities, and provides relevant news and information services.

Both public and private organizations can submit research results, which are subsequently assessed and published in an attractive format by CORDIS as technology offers. These technology offers are categorized according to level of development with regard to marketability, as follows: (a) business, whereby the offer is close to exploitation, has developed a prototype and is ready to be marketed; (b) science, whereby the offer is at the R and D stage, is highly scientific in nature and has exploitable potential to a very selective market; and (c) society, whereby the offer is mostly involved with issues that affect society at large. Offers are further categorized by technology domains, including biology/medicine, energy, environment, ICT sector and industrial technologies.

A brief assessment is provided below of the involvement of ESCWA members in FP5 projects.

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[45] Of these non-European countries, none are from the ESCWA region; and only one Arab country, namely, Algeria, is a member of COST.

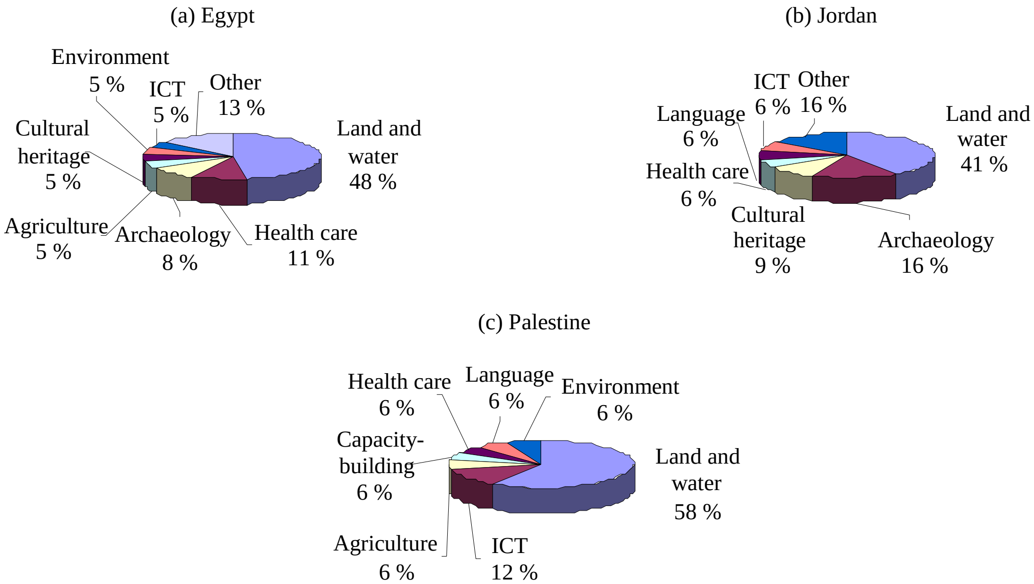
[46] See the discussion paper from the European Commission, entitled "Towards a new partnership between COST and the Commission" (European Commission, September 2004).

[47] The database is available at: www.cordis.lu/fp5/partner.htm.

*FP5 projects involving partners from ESCWA members*

Within the framework of FP5, ESCWA members were involved in a total of 54 projects, of which 23 were related to water and land management, 6 in archaeology and a modest 3 projects were related to ICTs.[48] These projects involved partners, particularly national universities and major R and D institutes, in Egypt, Jordan, Lebanon and Palestine. Figure II shows the percentage distribution by sector for three of these participating ESCWA members.[49]

**Figure II. Distribution by sector of R and D projects funded by the EU under FP5 and involving partners from the ESCWA region**




*Source*: Community Research and Development Information Service (CORDIS), "Fifth Framework Programme", which is available at: www.cordis.lu/fp5/.

*Note*: These charts are based on projects available in the CORDIS RTD projects database as of January 2005.

## D. LESSONS LEARNT IN RDI NETWORKING

This section outlines lessons learnt from practical experiences in RDI networks of diverse types, sizes and mechanisms. Two main issues are discussed, namely, network sustainability, and network governance and coordination. Factors are identified that affect these issues and lead to the success or failure of networks.

### 1. *Network sustainability*[50]

Sustainability is often one of the goals of a network, whether declared formally or informally.[51] Even in those cases where permanency is not a goal, networks need to remain active until they achieve their objectives. In other words, they need to come to a completion point, rather than dissolve. Some degree of

[48] A complete list of these projects and their durations has been compiled and can be obtained by contacting ESCWA.

[49] Lebanon is a partner in only two FP5 projects: one in the area of environment and one in the ICT sector.

[50] This subsection is based on T. Wind, "Document review on network sustainability for IDRC's Evaluation Unit and the Network Working Group (International Development Research Centre (IDRC), November 2004).

[51] In this context, sustainability refers to the functioning of a given network as a mechanism, rather than the sustainability of its impacts.

sustainability is therefore always required. Sustainability in the context of a network is viewed through the following four dimensions: (a) lifespan; (b) financial sufficiency; (c) relational sustainability, including membership and relationships between members; and (d) structural sustainability, including methodologies, products and governance structure.

Looking at the experiences of different existing networks, the following factors affecting the sustainability of networks in its four dimensions can be identified:

(a) Lifespan, which is dependent upon the objectives of the network and can vary from a few years to several decades. In some cases, a time limit is set for the operation of a network, while in others lifespan is left open-ended depending on how the network is expected to evolve. Typically, networks require five to seven years before they start to produce tangible results. Moreover, networks that are built incrementally usually span a longer timeframe as their scopes broaden and objectives change. When striving for network sustainability, an R and D network is not an aim by itself, but rather a means to an end. A network is expected to dissolve when it no longer serves its purpose;[52]

(b) Internal relations, which include the following issues: (i) shared ownership and mutual trust; (ii) interactions between members whereby equality of relations can be preferred in knowledge-sharing networks, including communities of practice, while levels of participation can be clarified in more formal networks; and (iii) membership policy whereby networks can opt for either an open or closed membership, which in turn can be open to institutions rather than individuals;[53]

(c) External relations, including relationships with stakeholders;

(d) Continuing relevance to members and stakeholders. In order to remain relevant, a network must continually evaluate its work, shift its focus and modify its structure and processes in accordance with the results of this evaluation. Flexibility is key to ensuring relevance of the network;

(e) Availability of long-term financial commitment from donors. To increase this possibility, networks need to diversify their funding sources, which can include the following: (i) donor agencies;[54] (ii) private sector organizations, which can be willing to contribute, albeit partially, towards the financing of specific network activities or research projects; (iii) membership fees and selling advisory and consulting services;[55] and (iv) commercializing research results. Costs incurred by a network usually include such overhead charges as telephone lines, travel, and staffing costs, which minimally include a coordinating secretary, in addition to expenses arising from such outputs as publications and meetings;

(f) Network housing and independent status. It is important to house a network in a host institution that will improve relationships with members and keep it relevant to its context. In addition, networks that are housed and formally managed by an independent and stable institution with long-term interests in research have better chances of sustainability. Giving the network an independent status can help the network to generate and manage its own revenues;

(g) It is important for networks to foster a flexible structure that can easily adapt to internal and external change. Network focus, activities and organizational management structure could have to be modified to ensure sustainability.

[52] Ecotec Research and Consulting, "A practical guide to cluster development: a report to the Department of Trade and Industry and the English RDAs by Ecotec Research and Consulting", which is available at: www.dti.gov.uk/clusters/ecotec-report/download.html.

[53] In all cases, the sustainability of relationships built through the lifespan of a network need not imply a static network membership. In effect, changes in network membership can be needed as a network matures and as its focus evolves.

[54] While donor agencies are a major source of network funding, the continual decline in their budgets means that funding from this source cannot be secured over the long term; and network coordinators are compelled to seek alternative funding sources.

[55] In order to be able to generate such revenues, network activities and services must be demand-driven.

### 2. *Network governance and coordination*[56]

The network governance and coordination styles relate to such issues as membership criteria, member roles, organizational structure, communication channels, as well as mechanisms for decision-making, consensus-building and collaboration. The following paragraphs highlight the governance and coordination styles that best suit different research networks, and underscore the challenges associated with each of these styles.

A survey of literature on research networks indicates that there is no single "good" governance style. Rather, governance style depends on established goals, membership base and context. The importance of governance style relative to the success of a network must not be underestimated. This is due to the fact that governance style shapes ownership of a network, thereby enhancing or decreasing the relevance of its agenda and outputs to members and stakeholders at large. For example, in an international research network involving members from both developed and developing countries, a governing body composed mainly of representatives from the developed countries can reduce the relevance of the research agenda to the developing countries. This can lead to diminished interest and contributions by the partners from these developing countries, who feel they are not well-represented.

Adopting a formal governance style can prevent small groups from dominating the research agenda and contorting it in ways that suit their individual needs. Moreover, formal procedures are beneficial in resolving conflict situations relating to important policy issues. Equally, transparency in decision-making is key to the success of a network, given that it ensures that members work within the network and not for the network.

Another important factor for the success of a network is the coordination style. A coordination secretary often assumes the role of a mediator between members and ensures good relationships with donor agencies. The secretary must demonstrate wisdom and diplomacy in reconciling the sometimes conflicting interests between members and donors.

In addition, a successful coordination secretary must seek to encourage members to contribute to the network. Given that contributions to a network by members are voluntary in nature, it is important to maintain a climate of enthusiasm through, for example, public relations efforts; to acknowledge individual and collective efforts; and to ensure that all or the majority of members benefit from the activities of the network. Creating a "win-win" situation for individual network members increases commitments in terms of contributing time and resources, and avoids abrupt withdrawals from a network by disaffected members.

Equally vital in terms of strengthening the commitment of members is the quality of the network's output, particularly given that quality reflects on the image of all network members. It is therefore essential for the management of the network to focus on and promote the quality of its activities.

### 3. *Defining a shared focus area*[57]

A network's success is highly contingent on the voluntary contribution of members who find interest in the goals that the network serves. It is therefore essential for a network to focus on specific and well-defined problems or goals that are shared among institutions and individuals in different locations and in order to stimulate the exchange of information. This does not mean, however, that the established goals need to be cast in stone. Leeway must be given to principal members of the network to fine-tune these goals, while ensuring that the goals do not conflict with the interests and aims of the donor agency.

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[56] This subsection is based on a paper, entitled "Making North-South research networks work: a contribution to A Common Vision for the Future of Science and Technology for Development" (European Centre for Development Policy Management, 6 May 1999), which was presented to the fourth session of the Commission on Science and Technology for Development (Geneva, 17 May 1999).

[57] Ibid.

### 4. *Establishing criteria of achievement*[58]

Establishing criteria of achievement at the outset within a network's initiating process ensures that all involved parties are aware beforehand of the indicators that will be used to evaluate the network project during mid-term assessment. This prevents unnecessary deviations from the established goals. A terms of reference of the planned evaluation can serve for this purpose.

### 5. *Establishing clear strategies*[59]

As is the case with any project, establishing strategies, work plans and budgets to achieve set goals all contribute towards ensuring proper channelling of efforts, providing means of evaluating implementation and identifying deviations. In the case of R and D networks, clear strategies ensure that members at large, rather than a select few, benefit from the activities of the network. However, care must be taken such that established strategies and plans do not eliminate the culture of informality, which is an essential characteristic of networks and a major factor of success.

### 6. *Concluding remarks*

Networks and systems of relationships essential for their operation take a comparatively long period of time to establish and mature. However, once they are established on the basis of optimized designs and furnished with adequate coordination modalities, networks can often foster interdependence, high levels of mutual trust and reciprocity.

Conflict and power-asymmetries can never be totally absent in networking arrangements. Consequently, there is a strong need to clarify and elucidate the objectives, and to define the coordination modalities and arrangements, thereby ensuring that all parties enjoy the fruits of collaboration.

Moreover, rather than concentrating merely on resource and institutional aspects of networks, there is a need to maintain focus on relationships in the context of promoting effective interaction among network members. Personal linkages can perform a crucial part in reinforcing the non-economic bases for exchanging information and sharing knowledge. Contracts designed to commit institutions to cooperation are equally indispensable. However, banking solely on personal linkages or contracts can lead to highly unpredictable outcomes, which underscores the need to emphasize active commitment to common goals expressed in shared and tangible benefits. Table 4 presents a list of important success factors and risks for R and D networks.

TABLE 4. SUCCESS AND RISK FACTORS SURROUNDING R AND D NETWORKS

| Success factors | Risk factors |
|---|---|
| Member ownership, responsiveness and cooperation | Loss of control |
| Increasing learning capacity though diversity | High requirement of time and energy to achieve tangible results |
| Creating a shared agreement | Broad focus |
| Ability to manage change | Overemphasis of certain research sectors of others that are considered marginal |
| Professional satisfaction of members | Conservatism |

*Source*: Adapted from A. Bernard, "IDRC networks: an ethnographic perspective" (IDRC, 1998), which is available at: web.idrc.ca/en/ev-26858-201-1-DO_TOPIC.html.

[58] Ibid.

[59] Ibid.

# IV. SELECTED RDI NETWORKING INITIATIVES IN ARAB COUNTRIES: PRESENT STATUS AND FUTURE PROSPECTS

This chapter begins with a brief characterization of R and D activity in the Arab region, followed by an overview of selected networking initiatives in Arab countries with focus on their characteristics and modes of operation. In the light of this overview, the final section identifies research areas seen as offering significant potential for growth in the region, and proposes general guidelines for establishing viable regional R and D networking projects.

## A. RESEARCH AND DEVELOPMENT ACTIVITY IN THE ARAB REGION

Research and development, particularly as performed by central R and D institutions, is considered the main source of technological innovation in the Arab region. R and D activities in the Arab countries have been popular and effective in the more traditional disciplines. Indeed, the prevalence of research organizations that specialize in agriculture and related subjects, including forestry, water and irrigation research, is noteworthy. Equally significant are the research organizations that specialize in health and related disciplines, as well as education, management and economics. However, research organizations in the field of engineering, including computer engineering, microelectronics and energy technologies have a lesser share of R and D activity.[60] Moreover, there is modest R and D capacity in such areas as oil and gas, and water desalination in the countries of the Gulf Cooperation Council (GCC), even though these sectors constitute a major proportion of GNP in those countries.

Egypt leads the Arab countries with regard to the total number of research organizations, followed by Saudi Arabia and Kuwait. Within the context of affiliations of R and D organizations in the Arab region, the majority of institutes are Government-funded, followed by university institutes and, trailing far behind, private R and D institutes.

An analysis of R and D expenditure in Arab countries reveals that the resource levels allocated to R and D are meagre, particularly in non-GCC countries.[61] A point that is not revealed by available statistics is the fact that a substantial proportion of R and D expenditure is allocated to salaries and wages for researchers and support staff.[62]

R and D activity in the region is very fragmented. There is a clear need to coordinate and streamline science and technology activities in order to reduce duplication and conserve R and D resources. These issues are expressed in almost all policy documents and related pronouncements. In some countries, coordination committees have been set up for this purpose, and efforts have been made to undertake joint R and D at national and regional levels. However, these efforts remain insufficient.

Technology alliances with technology holders from outside the region are evident in some member countries but have remained the exclusive preserve of the larger enterprises. Furthermore, they appear to generate little or no spin-off for national innovation systems. Several industrial concerns in the GCC have concluded technology alliances, particularly in the petrochemical industry and, more recently, in the pharmaceuticals industry. It is significant that these alliances do not always stipulate the supply of modified or renovated manufacturing technologies as they become available to the original technology holder.

[60] ESCWA, "Science and technology policies for the twenty-first century" (United Nations, 1999), E/ESCWA/TECH/ 1999/4.

[61] According to available data, which is not homogeneous across Arab countries.

[62] ESCWA, "Science and technology policies for the twenty-first century" (United Nations, 1999), E/ESCWA/TECH/ 1999/4.

## B. EXISTING RDI NETWORKS IN ARAB COUNTRIES

### 1. *The Transfer of Knowledge Through Expatriate Nationals Programme*[63]

The Transfer of Knowledge Through Expatriate Nationals (TOKTEN) Programme was introduced by the United Nations Development Programme (UNDP) in 1977 with the aim of transferring the know-how of expatriate specialists to their countries of origin and in an attempt to reverse the brain drain from the Arab region. Since 1994, TOKTEN has come under the umbrella of the United Nations Volunteers (UNV) and is currently being implemented in more than 25 developing countries.

The TOKTEN Programme, which is essentially broad based, deals with a variety of knowledge transfer and capacity-building issues that often transcend mere R and D activities. Consultants taking part in TOKTEN are selected on the basis of a solid academic background and professional track record.[64] Furthermore, consultants chosen to participate must be committed to return to their countries of origin, albeit for a short term, in order to engage in activities that will result in knowledge transfer.[65] Typically, these terms range from approximately three weeks to three months, depending on the needs of the recipient institution and the availability of the specialist.

Host institutions benefit from the expertise contributed by TOKTEN consultants at relatively low cost, and the implementation phase is typically short. These host institutions can include ministries and public institutions, NGOs, universities, research centres and private sector institutions.

TOKTEN consultancies cover a wide range of specialized technical fields, depending on the needs of participating developing countries and the availability of consultants. The scope encompasses most if not all sectors and, moreover, includes all development specializations with the proviso that a professional expatriate is available for the consultative task. Key sectors and fields include the following: agriculture; coordination and management of aid; arts; aviation; children’s rights; civic education; cultural preservation; democratic elections; development and strategic planning; education; environment; film-making; financial management; geographic information systems; globalization; governance; health; human rights; ICT sector; management information systems; public administration; remote sensing; and sports.

Some of the advantages of TOKTEN over traditional technical assistance include the following:

(a) Cultural affinity and linguistic background of TOKTEN consultants, which provide optimum conditions for their work, and foster acceptance and cooperation among local staff, thereby leading to the transfer of know-how in a coherent manner;

(b) Lower costs, given that consultants are motivated by the desire to serve their countries of origin rather than by financial remuneration;

(c) Shorter lead time to identify and place TOKTEN consultants, given that there is less need for a period of learning, adapting and adjusting to local conditions, or for establishing credibility.[66]

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[63] This subsection is based on a presentation, entitled “Transfer of Knowledge Through Expatriate Nationals (TOKTEN): ten years of brain gain”, which was made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004).

[64] Within the context of the latter, this entails a minimum of eight years of work experience in a relevant field.

[65] While permanent returns are not envisaged, repeated missions aimed at enhancing the sustainability of projects are possible.

[66] Typically, the lead time is just a few weeks.

*The TOKTEN Palestinian Programme*[67]

The harsh living conditions in Palestine have led to a severe brain drain. More than 4.5 million Palestinians reside abroad, of which an estimated 70 per cent have specialized skills and higher education qualifications. In response to these challenges, UNDP launched the Programme of Assistance to the Palestinian People (PAPP) and began field operations in 1980. Subsequently, in 1994, UNDP/PAPP initiated the TOKTEN Palestinian Programme aimed at the following:

(a) Benefiting from the acquired knowledge and skills of expatriates, along with their familiarity of local culture and language in serving human development in Palestine;

(b) Enhancing national affinity across borders, which in some cases could result in expatriate nationals returning to their homeland;

(c) Contributing towards public and private sector development in Palestine;

(d) Building knowledge networks to connect Palestinian consultants worldwide;

(e) Transferring advanced knowledge and skills in cost-effective ways through a practical, effective and demand-driven scheme.

The Ministry of Foreign Affairs was delegated with the responsibility of acting as the national counterpart for the TOKTEN Palestinian Programme; and a working committee was established with representatives from that Ministry, UNDP, UNV, other United Nations entities, other relevant ministries, leading civil society institutions and private sector representatives. Moreover, the TOKTEN Palestinian Programme has been integrated within the National Development Plan for the periods 1997-2000 and 2002-2003.

In the first ten years since its launch, until 2004, the TOKTEN Palestinian Programme impacted positively on the fabric of Palestinian society. Specifically, during that decade a total of 490 TOKTEN consultants served in advisory and planning positions in various key Palestinian institutions, including the Office of the Prime Minister, 13 line ministries, 34 leading NGOs and civil society institutions, 9 private sector firms, 5 universities and 6 research centres.[68]

Some of the accomplishments achieved with the assistance of TOKTEN consultants include improving the treatment of kidney disease, establishing cardiology units, developing macroeconomic frameworks and plans, developing geographic information systems, updating university curricula, promoting academic networking, upgrading film and television capacities, reforming democratic elections, and establishing a five-year strategy for the Ministry of Women's Affairs. Additionally, TOKTEN consultants have lectured and researched at major universities; and through their work in such issues and areas as youth, sports, communications and the media, they have acted as good advocates for transparency, accountability and integrity.

The TOKTEN Palestinian Programme was recognized as a model for successful TOKTEN implementation at the Sixth International TOKTEN Conference (Beijing, 8 May 2000); and its modalities have been adopted by other UNDP country offices, including Afghanistan, Lebanon, Syrian Arab Republic, Vietnam and, more recently, Iraq.

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[67] This subsection is based on a presentation, entitled "Transfer of Knowledge Through Expatriate Nationals (TOKTEN): ten years of brain gain", which was made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004).

[68] Out of that total, 56 consultants subsequently chose to relocate permanently to Palestine.

### 2. *The Network of Syrian Scientists, Technologists and Innovators Abroad*[69]

The Network of Syrian Scientists, Technologists and Innovators Abroad (NOSSTIA) is a non-governmental organization that groups high-level expatriate Syrian scientists and innovators in all fields of technology. Founded in 2001, its board of trustees and chairman were elected in the same year, and its charter and bylaws were elaborated. Specifically, members must be of Syrian origin, reside permanently abroad, have gained doctorate degrees or masters degrees with a minimum of five years of relevant experience. Alternatively, they can be self-taught innovators or industrial creators. NOSSTIA is funded through membership fees, donations and activity sponsors.

Three main organizational entities are responsible for the definition of NOSSTIA's role, the execution of its activities and the evaluation of its performance, namely: a general committee, a board of trustees and an executive office.

The first two years following establishment involved considerable preparatory activities aimed at creating contacts with all the ministries, identifying national needs and priorities, and developing an implementation strategy. Consequently, modest results have been realized in terms of studies and projects.

During its first general assembly, which was held in Damascus in June 2003, a decision was made to focus on selected areas, including water, ICT and education, and to instigate academic cooperation between the Syrian Arab Republic and foreign institutions in developed countries. Moreover, the following activities were planned: (a) the implementation of two pilot projects in water recycling and desalination, and in new irrigation technologies; (b) organizing, with the cooperation with the Ministry of Information, a workshop on open source software, which was held in Damascus in March 2003 and which resulted in the establishment of an open source software design and industry centre; and (c) co-organizing with the Institute of Electrical and Electronics Engineers (IEEE) the First International Conference on Information and Communication Technologies: From Theory to Applications (Damascus, 19-23 April 2004), which provided a valuable forum for discussing issues related to ICTs, data processing, image processing, e-business, e-learning, knowledge management and data mining.[70]

In the short term, one of the network's principal objectives is to build permanent relations between Syrian and European institutions, thereby leading to the creation of common curricula, projects and research programmes, and to the exchange of students and professors. Box 7 provides a list of working groups established within NOSSTIA.

**Box 7. Working groups established within the Network of Syrian Scientists, Technologists and Innovators Abroad**

The following working groups have been established within the Network of Syrian Scientists, Technologists and Innovators Abroad (NOSSTIA):

(a) International academic cooperation;
(b) Industrial liaison;
(c) Information and communication technology;
(d) Banking and finance;
(e) Water resources;
(f) Energy.

*Source*: Adapted from a presentation made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004), which was entitled "Network of Syrian Scientists, Technologists and Innovators Abroad (NOSSTIA)".

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[69] This subsection is based on a presentation, entitled "Network of Syrian Scientists, Technologists and Innovators Abroad (NOSSTIA)", which was made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004).

[70] A total of 450 researchers from 45 countries attended the Conference, and 350 papers were presented.

From its experience, NOSSTIA has learned that it cannot on its own transfer the knowledge of expatriates to the Syrian Arab Republic. The cooperation of related ministries, institutions and private sector is essential. The cooperation mechanisms need to be flexible and adapted as needed in different projects.

### 3. *The Scientific Research Cooperation Programme between Lebanon and the Syrian Arab Republic*[71]

This Programme was launched in 2001 with the aim of promoting scientific cooperation between Lebanese researchers and their Syrian counterparts. Moreover, it is aimed at supporting scientific research projects implemented jointly by researchers and specialized teams in both countries with specific focus on the following: basic sciences, applied sciences, technology, medical sciences and public health, environmental sciences, and history of Arab sciences.

Beneficiaries include universities and institutions of higher education in the Syrian Arab Republic, which encompasses five public universities; research centres of the National Council for Scientific Research (NCSR) in Lebanon; and the Lebanese University.

The Programme is managed by a joint committee from NCSR, the Lebanese University and eminent figures from Syrian universities and the High Council for Sciences in the Syrian Arab Republic. The committee is responsible for reviewing joint projects, budget allocations, periodical financial and scientific monitoring of ongoing projects; and for ensuring that contracts signed by researchers or their institutions conform with rules and regulations in both countries.

Funding, which is calculated on the basis of an annual balance, is divided between the Lebanese and Syrian partners, as follows: the components of the Programme that are implemented in Lebanon are financed through equal contributions by the Lebanese University and NCSR; and the components of the Programme that are implemented in the Syrian Arab Republic are funded by the High Council for Sciences. Researchers from both countries share infrastructural facilities, including laboratories and equipment, and benefit from support staff available at the cooperating institutions.

In order to be eligible for the Programme, research projects must involve participation by researchers and institutions from both countries; and a special committee, which screens project proposals, accepts submissions only from professionals with doctorate degrees. Moreover, participating institutions must consent to the shared use of their equipment as required for activities pertaining to research projects.[72] Expenses covered by the Programme include the following: (a) running or operational expenses; (b) transportation costs between the two countries; (c) compensations for field visits; (d) expenses arising from the exchange of information, scientific publications and software; (e) expenditures on consumer products; and (f) expenditures on complementary equipment.

The duration of a project adopted by the Programme is generally two years with the possibility of a single extension of an additional two years. A joint scientific seminar is organized at the end of the period and project results are made public and evaluated. Researchers agree to publish their results in specialized peer-reviewed international or regional scientific journals with specific reference to the Programme. Any inventions or discoveries resulting from these projects are subject to regulations prevailing in Lebanon and the Syrian Arab Republic. Figure III provides a summary view of the Programme and corresponding funding during 2001-2004.

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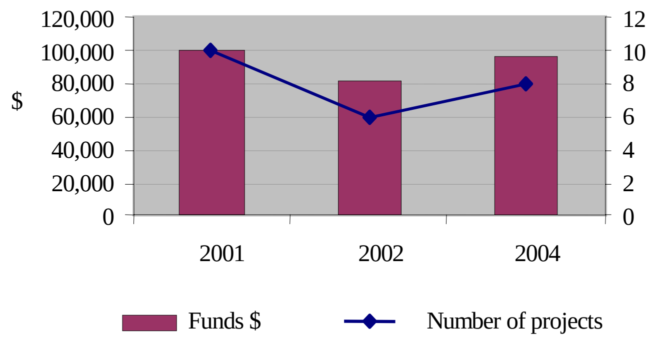
[71] This subsection is based on a presentation, entitled "Scientific Research Cooperation Programme between Lebanon and Syria", which was made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004).

[72] The Programme does not finance the acquisition of heavy and precision equipment. Consequently, these have to be provided by the institutions in which the financed research project is carried out.

**Figure III. Overview of the Scientific Research Cooperation Programme between Lebanon and the Syrian Arab Republic for the period 2001-2004**




*Source*: Adapted from a presentation, entitled "Scientific Research Cooperation Programme between Lebanon and Syria", which was made during the second meeting of the ESCWA Consultative Committee on Scientific and Technological Development and Technological Innovation (Damascus, 24 November 2004).

### 4. *The Lebanese Industrial Research Achievements Programme*

The Lebanese Industrial Research Achievements (LIRA) Programme was initiated in 1997 by NCSR, the Association of Lebanese Industrialists (ALI) and the Ministry of Industry in Lebanon, and in cooperation with Friedrich Ebert Stiftung (FES) and ESCWA.[73] The main objective of LIRA is to foster university-industry cooperation, thereby bridging the gap between academic research and industrial needs. Moreover, the Programme aims to promote the exploitation of innovative academic projects by the industry. LIRA can be considered an innovation network since it links together universities and technical schools, research centres, industrial enterprises, as well as NGOs and funding agencies.

Academic projects are submitted to LIRA on an annual basis, which are subsequently evaluated according to different criteria, including quality, creativity, value-added estimates, multidisciplinary components, marketability and manufacturability.

Since 1997, LIRA has led to the upgrading of several production lines in industry, the creation of new start-up firms and the improvement of university programmes and curricula, particularly in the fields of engineering and sciences. In addition, new jobs were created, and a number of machines, equipment and software programs were designed, manufactured and implemented in industrial settings both in Lebanon and abroad.

### 5. *The national centre for biotechnology in Jordan*

In December 2003, the Higher Council for Science and Technology in Jordan approved a decision to establish a national centre for biotechnology in coordination with local universities and research centres. The "virtual" centre is set to pool local capabilities in the field of biotechnology, develop and fund these entities. Additionally, the centre is aimed at the following: (a) creating a knowledge map in specific areas of biotechnology; (b) building an online database of available human resources and expertise in Jordan; (c) organizing brainstorming meetings to stimulate cooperation; (d) helping to finance cooperative R and D projects; (e) developing feasibility studies and business plans to suggested projects; (f) helping to finance the start-up of feasible projects; (g) assisting in terms of registering patents internationally; (h) linking academic centres with industry; and (i) encouraging the exploitation of expensive facilities and technical equipment to benefit a large number of researchers.

[73] The Lebanese Industrial Research Achievements (LIRA) Programme is available at: www.liraprogram.com/.

## C. PROPOSED RDI NETWORK INITIATIVES FOR ARAB COUNTRIES

Prior to the formulation of any networking project, and in order to ensure its future success and sustainability, focus areas must be identified that are expected to stir interest in the research community. One of the major incentives for researchers and research institutions to participate in networking arrangements is to achieve return in knowledge. Consequently, it is crucial for the proposed networking arrangement to ensure an effective knowledge transfer between potential members of a network by striking a balance between the following two conditions:[74]

(a) Complementarity of expertise and resources, which is a major motivation for members to participate in joint R and D endeavours, given that individual members rarely possess all the competences and resources required to undertake an R and D project in the most efficient and effective way;

(b) Sufficient science and technology overlap, whereby individual network members need to be on an equal footing with regard to a level of understanding of the relevant science or technology before new knowledge can be absorbed.

Furthermore, network members must be complementary enough and similar enough for them to maximize reciprocal benefits from an R and D networking arrangement. Consequently, care must be taken when choosing focus areas for a networking project in order to benefit from existing capacities and resources, both in terms of complementarity and overlap, thereby producing the best synergy.

### 1. *Potential areas for RDI networking in the Arab region*

This subsection attempts to identify potential areas for RDI networking in the region involving both mature and new technologies.[75] The research areas discussed below, namely, agriculture, agro-food technologies, water desalination and new materials technologies, are only a subset of the potential areas for networking. Other equally important areas include, among others, biotechnology, particularly agricultural biotechnology; and ICT-based educational systems.

#### (a) *Agriculture*

A recent survey was undertaken by ESCWA to assess and identify areas of complementarity and overlap in agricultural R and D projects in major universities of three member countries, namely, Jordan, Lebanon and the Syrian Arab Republic.[76] This in turn will allow the identification of potential focus areas that are ripe for networking endeavours at national and regional levels. Agriculture was chosen for its relevance to the Arab region as a major economic sector.

Results of the survey have indicated that a level of duplication in agricultural research exists between the universities in Jordan, Lebanon and the Syrian Arab Republic, in the fields of animal science, plant science, natural resource management and food science research. Despite these duplications, no substantial attempts to collaborate in research projects have been reported. This can be attributed to the physical distance between the universities, the lack of information on the projects being implemented by each university, or simply the lack of incentive or motivation to establish partnerships and create networks.

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[74] L. Zirulia, "R and D networks in an artificial industry" (CESPRI-Bocconi University, January 2003).

[75] This subsection takes into account the resolutions and recommendations that emanated from various expert group meetings, as well as from the twenty-second session of the Commission (Beirut, 14-17 April 2003).

[76] H. Chahal, "Survey of agricultural research and development activities in Lebanon, Syria and Jordan" (2004). The survey, which can be obtained from ESCWA, characterized human, physical and financial resources used in agricultural R and D, as well as research output in each of the countries covered over the period 2000-2003. For every university, an attempt was made to rank lines of agricultural research and identify specific interest topics for each of these research lines, with the aim of identifying topics suitable for networking endeavours at both national and regional levels.

Research networking creates synergies, reduces duplication in efforts and provides a better use of scarce financial resources. In addition, complementarity in competences, as well as in equipment and laboratories could be used to the advantage of collaborating parties to raise the quality of research results.

(b) *Agro-food technologies*[77]

Modern agro-food technologies play an important part in achieving food security and sustainable development. Moreover, they contribute towards creating employment and ensure that the agro-food industry complies with environmental standards, and attains higher competitiveness and profitability.

Cooperation between enterprises and technology institutions in Arab countries and regions in Europe is becoming more compelling given both the ever dwindling resources that Governments and donors are providing for industrial development, and the need to make the best of internal resources and modern technologies.

The complex and varied challenges posed by the development of the agro-food industry, which remains essentially a relatively new and employment-generating field in many Arab countries, are also important reasons for instituting collaborative approaches to technology acquisition and dissemination. It is through such technology inputs that efficient use of resources can be made and constraints overcome.

Benefits attained by improving modern technology inputs to the agro-food industry in Arab countries will exceed their boundaries, thereby limiting the migration of unskilled and semi-skilled labour, and allowing wider opportunities for productive trade and exchange of expertise between these countries and their European neighbours.

Arab universities and industries possess potential capabilities in terms of manpower, as well as scope for market development and technology dissemination, with substantial opportunities for socio-economic returns.

(c) *Water desalination*[78]

Water desalination technologies play a crucial role in socio-economic development in a number of Arab countries. Desalinated water is an essential and often only source of freshwater in several of these countries. In addition, rising living standards and high population growth have created a substantial market for desalinated water.

Large-scale thermal desalination technologies have been in use in the region since the 1950s. In 2001, Arab countries were home to some 1,750 desalination plants, incorporating a range of capacities and a number of technologies. Significant funds have gone into erecting, refurbishing and running these plants over the past 50 years. Given that many of these plants are currently nearing the end of their useful life, there is therefore a growing need for the wider dissemination and further R and D of desalination technologies.

Current desalination research in the region tends to focus on achieving a better understanding of existing processes and interactions between process parameters. While this is of intrinsic value, research geared towards the development of innovative designs is needed. A certain amount of such research has to be conducted in areas closer to basic science than to applied science, thereby necessitating closer cooperation at international and regional levels. Well-formulated research programmes in this domain can provide bases for future technology development and could be supported by concerned stakeholders, whose participation could improve their position with respect to the acquisition of future technologies.

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[77] This subsection is based on a paper, entitled "Network on agro-food technologies: a virtual ESCWA/Campania research and development network", which was presented during the Forum on Capacity-Building through Technology Transfer and Networking (Beirut, 11-12 March 2004).

[78] See ESCWA, "Water desalination technologies in the ESCWA member countries" (United Nations, 2001), E/ESCWA/TECH/2001/3.

There is no evidence to suggest that sufficient capabilities have been acquired for the manufacture and development of desalination technology equipment and instrumentation. This lack comes despite indicators of growing involvement by the region's scientists and engineers in research activities relating to different areas of desalination technology. There have been a number of credible claims regarding new processes and significant modifications to existing processes originated by local researchers. However, there is little to indicate any substantial or widespread contributions by local scientists and engineers to desalination technology. Evidence of tangible technology contributions from local business institutions is even harder to uncover. This situation prevails despite both the rapidly growing demand for freshwater, and the fact that endogenous capacity building in desalination technologies is a critical necessity for the countries of the region.

Success can be achieved in terms of reducing desalination costs and disseminating appropriate technologies by building R and D capabilities, and by reinforcing and expanding research efforts through networking with universities, research centres, companies and other sources of technology in both developed and developing countries outside the region.

(d) *New materials technologies*[79]

The plastics industries in some Arab countries date back to the early 1960s. Given the versatility and relatively low cost of raw materials for the plastics industry, a large base for manufacturing plastics has developed in most Arab countries, some as joint ventures with foreign companies. This base covers local and regional needs, with a few firms capable of competing on the international market. Some of these industries cover special applications for the region, including, for example, the membrane manufacturing for desalination filters in Saudi Arabia.

The plastics processing technology has evolved considerably in the past two decades, with changes introduced in raw materials and processes that have forced established firms to modernize their equipment in order to remain competitive.

One of the difficulties faced in this area is the missing link between R and D establishments and plastics industries in Arab countries. Specifically, whenever they are carried out at universities and research centres, R and D activities do not typically relate to the needs of local industries. Another significant challenge is that higher education and training of technical personnel in new material technologies, particularly in plastics, is virtually non-existent. Greater efforts are required in the region to enhance technical and postgraduate curricula by incorporating new materials subjects, establishing related specializations and promoting university-industry linkages.

Regional integration of the operations of national industries can solve many of the problems faced by emerging as well as established operators in Arab countries. Concerned governmental departments, aided by national and regional associations and chambers of industry and commerce, could facilitate such integration through appropriate legislation, tariff structures and support for enterprise activities. The role of major manufacturers in facilitating such integration cannot be overemphasized. Moreover, new institutional structures, including R and D networks, technology parks, technology incubation schemes and high-technology industrial clusters, are often more effective when conceived as part of industrial free zones. Additionally, such structures stand to play a significant and growing role in the acquisition and dissemination of new materials technologies.

### 2. *Guidelines for viable RDI networks in the Arab region*

The guidelines for establishing viable regional RDI networks in the Arab region are outlined below.[80]

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[79] See ESCWA, "Review of science and technology in ESCWA member countries", Issue no. 4 (United Nations, 2001), E/ESCWA/TECH/2001/5.

[80] These guidelines take into account the particularities of the Arab region and represent a summary of the components required for establishing viable RDI networks. For a more comprehensive analysis see chapter V.

(a) *Development objectives*

An Arab regional RDI network will need to support multidisciplinary and multi-institutional approaches as bases for effective promotion of the targeted sector in member countries. Moreover, a regional network must promote cooperation and resource sharing in the acquisition and dissemination of modern technologies among member institutions, including academia, centres of applied research and private enterprises. Using practical and cost-effective modalities and without compromising the independence and profitability of the partners, the network must strive to achieve the following development objectives:

(i) Capacity-building for the design of collaborative schemes in R and D in the targeted sector;

(ii) Disseminating information on current product and process technologies, related trends, and R and D needs of the sector;

(iii) Networking concerned institutions to facilitate the creation of virtual R and D communities;

(iv) Paving the way towards the establishment of virtual centres of excellence to service priority areas for partner institutions in Arab countries.

(b) *Immediate objectives*

Through collaborative efforts, the regional network must essentially be aimed at identifying and solving common problems faced by Arab countries. Additionally, it needs to strive to acquire and disseminate modern and sustainable capabilities in the network members, thereby contributing to enterprise growth and development.

Within that context, the regional network must be designed to allow implementation of conferences, awareness campaigns and other forms of interactions directed at specialists and members of the public. Moreover, it needs to undertake activities aimed at delivering education and training relevant to the targeted area.

Furthermore, the work programmes of this network must highlight issues of common interest, including new and emerging technologies and their applications in product and process development.[81] Specifically, ICTs can be used to facilitate the network's activities and conserve resources. However, ICTs must be used as cost-effective means to complement rather than replace traditional means of coordination, information delivery, education and training. Consequently, ICTs could be used to enhance information systems, including databases that support specific projects, as well as specific and generic information packages.

The Arab regional network must strive to become the following: (a) a one-stop interactive shop for the acquisition and exchange of generic pre-competitive information, as well as joint development of specific information packages; (b) a gateway to a wide spectrum of sources of information; and (c) a forum for interactions aimed at identifying and resolving issues of common interest to its members.

With the above in mind, a network portal can be designed to host a variety of databases and electronic publications in the areas of science and technology of special relevance to academic and enterprise development. Moreover, the portal needs to host information and facilities that allow secure and effective networking and cooperation among scientists and technologists in Arab countries, as well as between Arab scientists and technologists and their counterparts in developed countries. In order to facilitate such exchanges, the portal could be linked to satellite facilities on the Internet and maintain mirror utilities in selected Arab countries.

[81] The work programmes need to be developed in consultation with all the partners, approved by the network's steering committee, and implemented by its management committee.

(c) *Project stages*

The regional network could be launched and developed through the following activities:[82]

(i) Finalization of the conceptual design;

(ii) Convening of a small expert panel to discuss policy, operational strategy and plans of action, in addition to issues relating to management and commitments by partners;

(iii) Conducting a feasibility study and business plan;

(iv) Undertaking substantive and administrative activities aimed at specific objectives, including: (1) management, upkeep and periodic performance evaluation methodologies; (2) sharing in research activities and their outcomes; and (3) future development and expansion of the network;

(v) Identifying and purchasing equipment and software; and securing staffing needs for pilot sites;

(vi) Establishing partnerships and concluding related contractual arrangements for future expansion.

(d) *Cooperating institutions*

Within the context of the Arab region, it is advisable for the founding institutions of the network to comprise a regional organization, such as ESCWA, and national ministries concerned with scientific research. Subsequently, upon application and ratification by the steering committee, membership could extend to include chambers of industry and commerce, private enterprises, NGOs, university departments, and R and D centres in Arab countries.

(e) *Ownership and management*

The Arab regional network must be owned by its partners; and its activities need to be implemented by the members themselves in a cooperative and coordinated manner, building on indigenous capabilities in partner institutions. Within that framework, the network partners must strive for the following: (a) commit resources to implement the network and its programmes, at least during the formative phase of the network's activities; and (b) implement as fully as possible results achieved through the network's efforts in their respective development policies and work programmes.

The network's activities and performance need to be overseen by the steering committee, thereby ensuring that the programmes and projects address the priority issues and needs as stipulated at the outset and as approved subsequently through relevant amendments. Additionally, the needs and priorities must be translated into plans of action by the management committee.

(f) *Financial resources*

Budget estimates for setting up the regional network must be determined through a feasibility study and business plan. In order to ensure sustainability, the network must aim to become a self-sustaining independent entity after one or two years following its establishment.

Given those prerequisites, the network must seek to achieve the following: (a) become self-sustaining in order to finance such core functions as technical advice, information exchange and overall network activities coordination and secretarial services; (b) generate revenue by providing services against payments; (c) develop programmes and projects for collaborative assistance of donors and development agencies; and (d) forge partnerships and work with other institutions in areas of common interests.

[82] Some overlaps in these activities are possible as dictated by specific priorities and availability of resources.

## D. FUTURE PROSPECTS IN RDI NETWORKING

The open source model in R and D creates a number of opportunities for both developed and developing countries. Indeed, a large number of developed countries have already embraced this model, as witnessed by the proliferation of open source development in industries beyond software, particularly in such emerging technological fields as biotechnology. However, many developing countries, including Arab countries, have been slow to emulate this trend.

This section is divided as follows: (a) applying the open source model in RDI networks, which reviews the philosophy and benefits of the open source model and discusses its current and potential applications, particularly for R and D networks in the Arab region; and (b) intellectual property rights (IPRs) for cooperative R and D, which provides a brief overview of IPRs in developing countries and discusses cooperative research agreements as a tool for clarifying the many aspects related to IPRs.

### 1. *Applying the open source model in RDI networks*

The open source model emerged out of the software industry, where programmers share the source code of their programs and contribute freely to its future development.[83] Developments in ICTs, particularly the Internet, have greatly enhanced opportunities of applying the open source model. This can largely be attributed to the increased ease and reduced cost of communication, the creation of virtual communities and the duplication of information.

The open source model challenges economists in several respects, including as follows:

(a) Individual incentives, which motivate researchers to make their work freely available;[84]

(b) Corporate strategies, which motivate commercial companies to allocate resources and take part in open source projects;

(c) Organizational behaviour, whereby the apparently anarchistic process of open source production seems to possess the potential for creating a new model of business organization;

(d) Innovative process, whereby the new innovation model presented by open sourcing appears to contradict the "innovation process driven by intellectual property rights".[85]

Indeed, the potential to make large profits from IPRs usually drives universities and businesses to adopt closed approaches in conducting research. However, an open source approach can provide the basis for profitable business strategies. For example, open source research can make information and software available to both start-up companies and existing businesses in a way that could enable them to develop commercial products or services based on the technology being developed.[86] This must be seen as an incentive for businesses, particularly large enterprises, to finance and participate in joint open research endeavours. Moreover, this need not prevent businesses from adopting a mixed strategy whereby an open source approach is applied in some cases and a proprietary approach is chosen for others. In brief, firms and research institutions will opt for an open source strategy when access to open R and D is important and outweighs revenues generated from the exploitation of proprietary intellectual property, as can be seen in the examples provided below.

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[83] Typically, open source refers to any program whose source code is made available for use or modification as users or other developers see fit.

[84] This appears to contradict the "self-interested-economic-agent paradigm" of traditional economics. See J. Lerner and J. Tirole, "The open source movement: Key research questions", *European Economic Review*, vol. 45 (Elsevier Science B.V., 2001), pp. 819-826.

[85] Such IPRs include patents, copyrights and trade secrets. Ibid.

[86] B. Bruns, "Open sourcing nanotechnology research and development: issues and opportunities", *Nanotechnology: Science and Technology of Nanostructures* (2000).

(a) *Successful open source R and D endeavours*

The open source model in R and D has been particularly successful in the following cases:

(i) Developing general-purpose application software, whereby developers are the users themselves and do not intend to commercialize the product. The best known and successful examples of software applications developed through such efforts are the Linux operating system and the Apache web server;[87]

(ii) Biotechnology and bio-informatics, whereby collaborative research was undertaken in a decentralized form and results made available in the public domain. The most successful example in this case is the human genome sequencing project, which was conducted through a top-down approach involving governmental departments and enterprises.[88] Box 8 provides an example of an open source network in the field of biotechnology and bio-informatics;

(iii) Developing and exchanging pre-competitive research tools and platform technologies, whereby the benefits of using open knowledge outweighs the potential gains from monopoly and exclusive patents. In such cases, the development of research tools or platforms is not in itself the target of the exercise and will not provide the developer with a distinct marketable advantage. Rather the developed product is merely the foundation for generating valuable closed source and further open source knowledge;

(iv) The early stages of medical research, equally referred to as "upstream" research, whereby only computational work is undertaken involving little or no laboratory work.

**Box 8. The Biological Innovation for Open Society**

The Biological Innovation for Open Society (BIOS) is a non-profit organization based in Australia, whose efforts are geared towards giving momentum to open source biotechnology. BIOS promotes the creative use of living systems and their environment through the implementation of open source principles and development methods in the field of bio-informatics. One of the initiatives of BIOS, namely, BioForge, is a mechanism by which researchers can collaborate with optimum effectiveness, thereby solving problems and creating technologies under an open-access regime. This creative process is further improved and accelerated by making a dynamic, protected commons of enabling technologies available to innovators from across the world.

BioForge offers the following services:

(a) Portfolios of key enabling technologies for biological innovation are available to prospective users through licences rather than royalties, which impose conditions to maintain the technology available for further innovation;

(b) An Internet-based platform for the development, deposit and use of new research tools and enabling technologies, which are available through licences to the inventors, developers and users;

(c) A forum for the global biotechnology community;

(d) Patent tools, which allow innovators to survey the technological possibilities and intellectual property constraints with regard to potential inventions.

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*Source*: The Biological Innovation for Open Society (BIOS), which is available at: www.bios.net.

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[87] C. Schweik and J. Morgan Grove, "Fostering open-source research via a World Wide Web system", *Public Administration and Management: An Interactive Journal*, vol. 5, No. 4 (2000), pp. 161-189.

[88] This represents a departure from the more typical, bottom-up approach of open source projects as seen in the software industry. See "An open-source shot in the arm?", *The Economist* (10 June 2004).

(b) *Potential areas for open research*

Research areas with potential for the application of the open source model include the development of drugs for diseases that affect the poor, who are typically unable to pay for patented drugs, as well as diseases that affect a minority of people.[89] Within the context of the latter, the existing customer base is too small to justify expenditures by pharmaceutical companies, which, consequently, are unwilling to invest in development research and the necessary regulatory approval to produce and market drugs for that minority.

An alternative scenario based on an open source model could involve a website whereby medical biologists and chemists study shared databases and undertake joint experiments. The results of these experiments could then be made available to a laboratory with the highest bid and under the proviso that the final drug be made available to generic drug manufacturers. A similar model could be applied for research aimed at improving and expanding the use of existing non-patentable drugs.[90]

Another area suitable for open source research is the modelling of complex systems involving human-environment interactions in a broad geographic region. Multidisciplinary data sets are required to produce accurate models for such interactions, and different participants can contribute a data set that could enhance evolving models.[91] One example is the modelling of land cover of a particular geographic area, which is a complex phenomenon that is dependent on a multitude of environmental change processes, including, among others, urbanization, adoption of environmental protocols and timber activity.

(c) *Adopting an open source approach*

The experience of the software industry in applying the open source model provides various general steps and requirements for the successful adoption of an open source approach in R and D, including the following:[92]

(a) Existence of a common research problem that interests a large number of stakeholders;

(b) An open source initiator, usually a credible research institute, that is capable of establishing an initial core of interested organizations and individuals on the basis of discussions concerning the goal of the intended collaboration and the essential "rules of engagement";

(c) An initial R and D project concept that others can identify with and build upon;

(d) Developing a large and active virtual community, whether physical or Internet-based or a hybrid form of both.[93] This requires the following: (i) promoting collaboration among members by taking into account such individual motivations as personal satisfaction, recognition among peers and the inherent desire to see the technology advance; and (ii) building social capital, including mutual trust and reciprocity;

(e) Establishing standards and rules, including licensing rules, that govern the use and improvement of open research efforts.[94]

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[89] Ibid.

[90] Ibid.

[91] C. Schweik and J. Morgan Grove, "Fostering open-source research via a World Wide Web system", *Public Administration and Management: An Interactive Journal*, vol. 5, No. 4 (2000), pp. 161-189.

[92] Ibid.

[93] The Linux virtual community, which currently comprises more than 27 million programmers and users from across the world, represents the best example of an Internet-based virtual community.

[94] In open source software development, for example, documenting code and the commitment to a modular architecture are two important standards that ensure that other programmers can understand the code and add to it.

(d) *Benefits and drawbacks of an open source strategy in R and D*[95]

The benefits of an open source strategy are clear in the software industry. These have their parallels in R and D strategies, as follows: (a) creating shared intellectual property that is accessible and can be customized; (b) increasing the reliability of research results owing to a broad peer review; (c) lowering R and D costs and associated risks; (d) increasing innovation;[96] and (e) accelerating the rate of development.

While it can be tempting to identify and consider only the benefits of open sourcing, such a strategy cannot be applied in all cases. Specifically, the following two drawbacks of an open source strategy in R and D have been identified: (a) an excessively fragmented intellectual property claim can restrict the use of associated patents owing to the need to negotiate agreements among a multitude of owners;[97] and (b) a lack of incentives to contribute to the development of the network.[98]

(e) *Concluding remarks*

In software development, the open source model has emerged as a viable alternative source of innovation to the "private investment" model, whereby returns result from private goods and efficient regimes of intellectual property protection. Indeed, while this "collective action" model seems non-intuitive, it proves to be sound when compared to academic research, where researchers publish their findings in journals and books for other academicians to build upon. The economic model in both cases is mainly based on giving away knowledge in return for mutual benefit and recognition among peers.

However, it is claimed that globalization has changed the nature of knowledge from a "public good" to a "market commodity", particularly in such strategic areas and disciplines as biotechnologies.[99] This modified perception of knowledge, especially in the West, has led to the development and anchoring of IPR regimes that are fed by an ever regenerating capitalism. This has affected university laws, which are changing towards defining science and knowledge as a proprietary good that must be protected. Such laws restrict circulation of, access to, and use of research findings, thereby hindering collaborative and distributed research work. The closer connections of academic research with commercial applications reinforce this approach. For these reasons, the extension of the open source model to R and D, whether in academic or industrial settings, deserves further investigation.

### 2. *Intellectual property rights for cooperative R and D*

(a) *Intellectual property rights: importance for Arab countries*

There is a general consensus that strong and effective IPRs facilitate the operation of markets and promote technology transfer. Indeed, IPRs allow both private and public enterprises to transfer technology through various means, including voluntary licensing, direct investment, technology sales and dissemination, and cooperative ventures. Collaboration, such as public-private partnerships, are in fact not possible without IPRs, which constitute a bridging mechanism.[100]

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[95] B. Bruns, "Open sourcing nanotechnology research and development: issues and opportunities", *Nanotechnology: Science and Technology of Nanostructures* (2000).

[96] Counter arguments to this point of view claim that open source approaches in software development have mainly led to the creation of software programs that match their proprietary counterparts, albeit sometimes with improved quality.

[97] This creates a phenomenon, referred to as "micro-monopolies", whereby any one of numerous owners can block access to different parts of the intellectual property.

[98] This is especially true in large networks where users, sometimes referred to as "free riders", exploit open knowledge without contributing to its development. This can be overcome by licensing rules, which can make information accessible only to those who accept and abide by core principles, including the obligation to acknowledge the originator and disclose modifications to the original work.

[99] M. Nieminen and E. Kaukonen, "Universities and R and D networking in a knowledge-based economy: A glance at Finnish developments", *Sitra Reports series 11* (Sitra, 2001).

[100] See "Intellectual Property Rights" (OECD, January 2005).

One example where IPRs have played an important role is in the ICT industry by helping multiple firms to solve, through joint pre-competitive research, industry-wide problems and to create and improve industry standards. Intellectual property regimes in developing countries, including Arab countries, remain inadequate for accommodating structural innovations that are based on knowledge networks and markets, such as public-private partnerships.

Moreover, it is often difficult for researchers in developing countries, including those in the Arab region, to protect, own and exploit the results of their research for several reasons, including the following:[101] (a) lack of resources; (b) lack of training in drafting patents and licensing contracts, as well as in research marketing skills; (c) unavailability of professional services, including legal and marketing services; and (d) absence of a regional body consolidating all IPR processes in all member countries, thereby streamlining IPR procedures at a regional level.

As a result, research results remain largely untapped given that researchers do not own the knowledge they have generated. Funding agencies could even be discouraged to invest in research activities that are not set to yield any economic or social return.

Aware of these difficulties, the World Intellectual Property Organization (WIPO) launched an initiative in 2004 to help scientists and researchers protect their work and commercialise their results. Box 9 provides an overview of the WIPO initiative.

**Box 9. The WIPO project on research networks and intellectual property**

In September 2004, the World Intellectual Property Organization (WIPO) launched, in collaboration with a number of partner institutions in Central Africa, Columbia and Switzerland, a project to support researchers in R and D networks in developing countries; and to protect and commercialize the results of their work. The project mainly targets research in the health sector in order to promote the development of drugs against diseases that are widespread in developing countries.

Project components include training of research personnel in patent drafting and licensing contracts, in addition to the establishment of two intellectual property (IP) hubs, namely, in Central Africa and in Columbia. The IP hubs offer legal and advisory services, and help researchers to exploit their research results. The project is expected to materialize by September 2006.

In conducting this project, WIPO is adopting a multidisciplinary approach to develop a feasible and effective model, thereby involving professionals in research management, marketing, economics, law and policymaking.

*Source*: World Intellectual Property Organization (WIPO), which is available at: www.wipo.int.

(b) *Cooperative research agreements*

Research institutes must carefully consider their intellectual property management strategies prior to embarking on R and D projects, whether collaborative or otherwise. A formal agreement between all relevant parties on IPRs is key to the positive outcome of the endeavour. Specifically, a number of questions need to be answered during the early stages of formulation, including the following:[102] (a) what happens if a major innovation occurs; (b) who will bear the royalties; and (c) what is the percentage of contribution between R and D institutes. Setting the "rules of the game" through cooperative research agreements can provide answers and guidelines to similar questions.

Indeed, an essential step during the establishment of a R and D network is the cooperative research agreement that covers the legal details governing operation in joint research projects, and that predicates from the outset the handling of IPRs between all the relevant parties.

[101] World Intellectual Property Organization (WIPO), *Research Networks and Intellectual Property* (WIPO, 2004).

[102] F.H. Erbish, *Basic Workbook in Intellectual Property Management* (Agricultural Biotechnology Support Project, Institute of International Agriculture, Michigan State University, June 2004).

Annex III provides a generic model of a cooperative research agreement, which must be modified to become fully compliant with national laws and in accordance with the agendas of the participating institutions. Box 10 provides a list of the main items typically included in a cooperative research agreement.[103]

**Box 10. Items typically included in a cooperative research agreement**

During the formulation of cooperative research agreements, special attention needs to be given to the following terms and conditions, which are common to most agreements:

(a) *Parties*: A careful wording of the names and contact details of the participating institutes will provide the base for any communication flow;

(b) *Definitions*: Special or well-established meanings of certain words or phrases must be explicitly understood, including, for example, such terms as “joint ownership” and “joint project”;

(c) *Handling of intellectual properties*: The supervisor(s) of issues relating to intellectual properties, including protection and licences, must be assigned and made explicit;

(d) *Finance*: Expenses and royalties are among the first to be formally clarified to avoid any misunderstanding or disagreement;

(e) *Governing law*: The relevant parties must be formally aware of the prevailing laws and regulations under which they operate;

(f) *Effective date*: Calendar dates, particularly launch dates, must be made explicit to all relevant parties.

*Source*: F.H. Erbish, Basic Workbook in Intellectual Property Management (Agricultural Biotechnology Support Project, Institute of International Agriculture, Michigan State University, June 2004).

In devising a cooperative research agreement, it is possible to draw on the experience of the European Commission in handling IPR-related issues in projects under FP6 (see box 11).

**Box 11. Handling of intellectual property rights under the Sixth Framework Programme**

According to the recent guide to intellectual property rights (IPRs) under the Sixth Framework Programme (FP6), knowledge that results from a joint project is owned by the party that generated it. Consequently, joint ownership is only necessary in the case when a single knowledge generator cannot be identified, in other words, when knowledge cannot be distinguishably separated between the cooperating parties. In such a case, it is strongly advisable to agree on the allocation and terms of using the ownership of the knowledge. Terms include, for example, cost sharing of patent filing and renewal fees. Care must be taken to ensure the agreement takes into account prevailing co-ownership regimes in the countries of the concerned parties.

When the resulting knowledge can be commercially exploited, the guide recommends registering the intellectual property. However, the guide also warns of the risks of premature filing of patent application, such as rejection of case. It is advisable to keep accurate records of the discoveries made, including dated laboratory workbooks, in order to prove ownership. In addition, dissemination of publication through different means, including publication, conferences or any formal or informal correspondence, needs to be avoided until a decision has been reached to protect legally the specific piece of knowledge. Where a decision has been reached not to protect generated knowledge, the European Commission is required to disseminate such information within two years following the end of the project, thereby benefiting and creating synergies with other projects.

[103] More information on these items is available at: www.upov.int; www.wipo.int; and www.wto.org.

**Box 11** (*continued*)

Moreover, one of the evaluation criteria for FP6 projects addresses directly the plan quality in terms of use and dissemination of knowledge, potential for promoting innovation, and management of intellectual property.

Intellectual property protection is not the only provision for exploiting a project's results. Other, more advanced strategies have been used, including the following: (a) the creation of patent pools, or groups of related patents, to be used by the project participants or jointly licensed to third parties; and (b) the establishment of a spin-off company that owns and exploits the joint intellectual property generated by the project.

In the area of access rights, the Framework Programmes were modified to encompass more stringent provisions. Consequently, under FP6, the following currently apply:

(a) A participant is now allowed to deny access rights of pre-existing know-how to other participants in the project. This pre-existing know-how, which is defined as information developed prior to the conclusion of the contract with the Commission, needs to be specific and clearly defined in the contract if it is to be excluded;

(b) A participant in a project needs to request access rights to use such project information that has been generated by other participants in the project. These rights can be granted only if needed to undertake the project or for generating knowledge for the project;

(c) Requests by participants in a project to access rights from participants in different projects within the same specific programme are now not allowed.

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*Source*: "Guide to Intellectual Property Rights for FP6 projects", Version 1 (European Commission, March 2004).

## V. ESTABLISHING AND MANAGING RDI NETWORKS

This chapter presents a number of institutional, technical and legal issues that must be taken into account to ensure the success of an RDI network. The first section focuses on regional R and D networks and highlights preparatory activities that need to be undertaken prior to the launch of a network project, including the evaluation of the region's assets, the establishment of priorities and the groundwork preparations. Moreover, this section provides guidelines for establishing a regional R and D network, complemented by models of major documents that need to be prepared during the set-up process, with a view to carrying out collaborative R and D activities in selected research areas.

The second section of this chapter reviews inter-firm innovation networks and provides basic practical steps to guide managers in the establishment of such networks. Throughout this chapter, it is assumed that an adequate physical ICT infrastructure exists in the countries in question to support the establishment of RDI networks (see annex I on the physical infrastructure for RDI networking).

### A. STEPS FOR ESTABLISHING REGIONAL R AND D NETWORKS[104]

Requirements for setting up R and D networking projects vary naturally according to their objectives, domain of activity, partnering organizations and the needs of beneficiaries. However, a successful networking project will always need to be predicated upon an evaluation of assets, a definition of strategic networking priorities, and consensus building between concerned parties. Once these requirements have been secured, operational and project evaluation modalities can be established.

In its initial stages, it can be advisable for a given network to take on the format of a "project" with clear objectives and operational modalities. This format can be particularly useful in cases where additional resources are required and where institutions behind the networking initiative in question need to monitor progress in order to decide on further support or even expansion of scope or realm of activities.

Naturally, an alternative modality that can be adopted is to grant the network in question the status of a free-standing non-profit institution, and to embed the network within a suitable existing institution, preferably also non-profit, thereby ensuring that the host institution has and is able to implement adequate measures for performance evaluation and enhancement.

The core steps required to establish a viable R and D network are outlined below. Additional steps could be required depending on the nature and objectives of the network in question.

#### 1. *Evaluating assets for innovation*

At a national or regional level, the main assets that require evaluation can be categorized as follows: (a) the state of technologies applied in leading sectors of economic activity in the country or region in question; (b) policies that govern technology acquisition in these sectors and their capacity to take up innovative inputs; (c) characteristics of key firms and institutions within the region, particularly of a managerial and technological nature, relevant to innovation capacity building; and (d) the orientations and experiences of existing innovation support agencies in the region.

In particular, it is vital to identify the specific characteristics and capabilities of national R and D and support institutions. This needs to be undertaken with reference to the following points: (a) institutional needs and development objectives as outlined in published plans and mission statements; (b) existing and proven capabilities of the R and D centres or institutions in question;[105] and (c) motivating factors for a

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[104] This section is based on the following: *A guide to regional innovation strategies* (DG Regio, DG Enterprise, October 1999); *Green Paper on Innovation*, Supplement 5/95 (European Commission, 1996); and "Reinforcing cohesion and competitiveness through research, technological development and innovation" (European Commission, May 1998).

[105] These capabilities must be assessed in a manner that allows evaluation of output produced by scientific staff in terms of, for example, number of patents, publications and bibliometric analysis.

given national R and D institution to innovate and take part in networking, as well as barriers that hinder innovation and innovative approaches.

Moreover, the attitudes of researchers and research managers towards innovative cooperation modalities and networking arrangements need to be explored. Within that context, there is need to understand value-chain relationships of the R and D institutions in question and the extent and nature of existing inter-institutional collaboration and ongoing networking.

In conducting a thorough evaluation of assets, it is of particular importance to answer the following questions:

(a) How can the networking activity in question be adapted to national and regional particularities;

(b) How are existing "traditional" activities aimed at R and D cooperation affected by new technological advances and possibilities offered by the network in question;

(c) How can global trends be taken up in the network's design, its establishment and operation;

(d) Who are the main R and D actors in the country or region in question; and what are their sizes and institutional structures;

(e) What special skills and technological processes are being successfully applied in the country or region in question;

(f) What were the important innovations made in the region that influenced regional development;

(g) What are the main market and technological factors affecting the sector in the region.

In order to answer the above questions, reviews of several sources of information are needed, including reports on related activities undertaken in the sector(s) under consideration at national, regional and/or global levels, as well as national output and employment statistics, and surveys of firms concerned with the network in question.

### 2. *Establishing strategic priorities for networking*

A strategic framework for the operations of a proposed network must be established by taking into account, as far as possible, stated needs and mission statements of concerned R and D institutions. Moreover, this strategic framework needs to stem from the analysis and assessment work outlined in the section above; and address national and regional trends, as well as strengths and weaknesses of national and regional R and D institutions. Consistency with existing regional socio-economic policies and priorities need to be observed in order to avoid duplications in the supply of technology and innovation support within the region. Equally crucial to the success of the proposed network is a consensus on the adequate forms of support among the main actors, including the national and regional institutions, and the private companies.

Specifically, a strategic framework document usually addresses the following issues: (a) the principal "barriers" and "drivers" in RTD within the region; (b) the main trends in key regional sectors and technology areas;[106] and (c) alternative development scenarios.

Moreover, a strategic framework is likely to involve a combination of actions, including as follows: (a) promoting awareness and disseminating information; (b) providing support advice to economic sectors, thereby encouraging innovation; (c) enhancing support for R and D and technology adaptation activities; (d) ensuring availability of adequate specialist support services; (e) encouraging/facilitating adequate

[106] This could include a survey of existing research capabilities and focus areas; see, for example, H. Chahal, "Survey of agricultural research and development activities in Lebanon, Syria and Jordan" (2004), which can be obtained from ESCWA.

technology transfer; (f) developing skills and a capable human resource base; and (g) improving access to and reducing costs of financing.

Once strategic priorities have been outlined, a public debate needs to be launched in order to challenge, verify and achieve consensus with regard to these priorities. This is accomplished by drafting and publishing a consultative report, which includes the strategic framework, possibly during a conference organized for this purpose. Subsequently, the report needs to be presented at seminars within the region and comments requested within a defined consultative period. Interaction among network partners is a cornerstone of networking approaches, given that it facilitates the analysis of existing assets and factors that influence innovation in their environment. Key actors in the region will each have a valuable perception of the strengths and weaknesses of these assets; and the results of these analyses and the pointers for policy priorities can be tested against the views and perspectives of these actors.

### 3. *Building consensus and raising awareness*

Building consensus and raising awareness are two essential tasks during the initial phase of network creation. A letter of intent, signed by all the concerned parties, can constitute a good instrument in achieving consensus and triggering interest in the intended network. Annex IV provides, by way of example, a sample letter of intent on cooperation between R and D institutes and ESCWA aimed at establishing an R and D network in an area of mutual interest.

Promoting awareness of the network and its objectives can be achieved through the following:

(a) A project launch event, including a regional seminar, forum or conference;

(b) A series of presentations across the region to industry groups, local or community meetings and/or existing meetings of regional actors;

(c) Publicity campaigns via national and regional media, including radio, television and newspapers;

(d) Preparation, publication and distribution during relevant national and international events of a brochure describing the network and its objectives;

(e) Establishing a website for the network with mutual links to other relevant networks and concerned institutions.

### 4. *Formulating a project document*

Following the above preparatory activities, the first operational step in establishing a network involves drawing up a project document with essential details of its overall objectives and a framework for its intended activities. The overall objectives and framework can be further developed and revisited as the network evolves and as opportunities arise for its expansion once new institutions are added to its membership. Structures and processes outlined in the project document need to embody a good deal of flexibility in order to provide for effective responses to realities and expectations.

An essential aim of a networking project is to support national, regional or international R and D capacity by providing critical mass and by enabling access to expertise and technical services that cannot be available to some member institutions. More specific objectives often include enhancing innovation in the country, region or discipline in question by targeting and strengthening capacity in specific R and D areas; and by fostering a collaborative culture, involving research centres and enterprises, with knowledge and possible substantive and development contributions in the area under consideration.

With particular reference to the situation in Arab countries, it is essential that networking arrangements be aimed at strengthening the national/regional innovation system by increasing inter-firm and public-private cooperation and networking.

In order to prepare a network project document, project promoters proceed through a series of activities, including as follows:

(a) Interviewing and consulting key actors at national and regional levels, particularly members of Government, enterprises, professional associations and civil society (see box 12). These interviews can significantly help to compile and formulate a list of main objectives for the proposed network, thereby elucidating more specific objectives that can be more relevant to individual member institutions or subgroups; and emphasizing certain aspects of the overall objectives, including, for example, product development, environmental amelioration and continuous education;

(b) Compiling an inventory of existing studies relating to the domain of interest with specific reference to the region in which networking is intended to take place. Case studies of networks with similar objectives, preferably also working in comparable settings, can be of great value in outlining both the main and detailed objectives.

Formulating the draft project document and circulating it to a group of founding members or institutions ensures initial feedback and support by prospective partners. Within that context, an ad hoc workshop is often necessary to discuss and finalize the project document and to create awareness of the proposed network. Furthermore, this document paves the way for identifying a steering committee and a management group.

**Box 12. Technology and innovation actors**

Technology and innovation actors include the following:

(a) National research and development centres;
(b) Research departments in national universities and colleges;
(c) Business and innovation centres;
(d) Professional associations;
(e) Concerned regional and local authorities;
(f) Public sector laboratories;
(g) Selected vocational training institutions;
(h) Public sector funding agencies/councils;
(i) Venture capital organizations and other institutions providing private capital;
(j) Regional development bodies;
(k) Science and technology parks and related institutions;
(l) Industrial and service enterprise federations and chambers of commerce;
(m) National “think-tanks” and concerned consulting firms;
(n) Regional and multinational firms.

*Source*: Adapted from A guide to regional innovation strategies (DG Regio, DG Enterprise, October 1999).
*Note*: Some of these actors are weak or nonexistent in the Arab region.

### 5. *Selecting members of the steering committee and the management group*

During the initial phase of network creation, consideration needs to be given to arrangements for directing and managing the proposed network project. It is typically at this point that a steering committee and a management group are established.

The steering committee is responsible for providing guidance with regard to the network’s scope of activities, objectives, evaluation criteria and overall progress monitoring. The main tasks of the steering committee generally include the following: (a) formulating detailed objectives and implementation strategies, as well as approving work plans, rules of procedure, progress reports and monitoring modalities; (b) selecting the members of the management group; (c) supervising progress with regard to the implementation of work plans; (d) providing political and institutional support with emphasis on funding and widening the scope of activities; and (e) liasing with relevant regional and international bodies.

The management group is responsible for implementing the project under the guidance of the steering committee. Its tasks include the following: (a) undertaking contacts with members of the network and initiating activities in a manner that is consistent with the rules of procedure; (b) formulating work plans within the framework of the main objectives and strategies formulated/approved by the steering committee; (c) establishing relations with regional and international bodies and seeking their support; (d) performing the functions of a secretariat to the steering committee, including organizing its meetings, both physical and virtual, and drafting briefing papers and agendas; (e) launching and coordinating preparatory activities, including the assessment of priority areas and optimal operational modalities;[107] (f) facilitating the development of regional consensus and collaboration with regard to the project through publicity campaigns, meetings, workshops conferences and seminars; and (g) acting as a focal point and clearing-house for linkages with other regions, including study visits to draw on the experiences of other R and D networks and collaborative initiatives.

Particular attention needs to be paid when selecting members of the steering committee. Specifically, a balance must be struck between the need to provide credibility and authority, with the requirement that members of the steering committee will be able to dedicate adequate time to oversee the project. This applies equally to the selection of the members of the management group. Moreover, this group needs to be established in consultation with all participants; and its leader, or coordinator, would preferably be chosen from the staff of the principal host institution or the network's hub.

The organizational structure of the proposed network varies depending on national and regional circumstances. Within that context, both the steering committee and the management group must be carefully selected in line with internationally-acknowledged criteria and domestic particularities.

### 6. *Securing financial resources*

The next most important step in establishing the proposed R and D network is securing financial resources in order to ensure smooth coordination of networking arrangements and continuous output, including publications, both in hardcopy and in electronic formats.

Funding by relevant national, regional and international authorities must be actively sought as early as possible. Other sources of funding can include private sector institutions and their federations, national and regional development agencies and NGOs, as well as individual academic institutions, and central and local authorities expected to benefit from intended networking arrangements. Contributions by private enterprises and their federations is generally facilitated if the objectives include activities that benefit overall competitiveness of industrial or service sectors with which they are concerned. Consequently, it is advisable to include activities that feed into pre-competitive R and D, and benefit large segments of enterprises. For example, activities for an agro-food network could include research on the use of modern packaging techniques and materials for traditional food products, and research on technologies for treatment of wastewater produced by specific food production processes such as olive oil extraction.

### 7. *Monitoring and evaluating network activities*

A monitoring and evaluation system needs to be established, based on a well-articulated definition of objectives against which progress can be assessed. Additionally, the following tasks need to be undertaken: (a) formulating indicators pertinent to the implementation of both the overall objectives and the strategic framework, referred to as interim output indicators; (b) evaluating ex ante the extent to which progress is likely to be achieved and the factors that can influence such progress; (c) developing and agreeing on the methodology to be applied in collecting information on the established indicators; and (d) defining benchmarks, thereby providing realistic targets for the achievement of the strategic framework.

[107] Members of the management group can themselves undertake some of the research work required in fulfilling this task.

## B. STEPS FOR ESTABLISHING INTER-FIRM INNOVATION NETWORKS

In the following paragraphs, guidelines are provided for assessing the need for inter-firm innovation networks. Once this need—hence, opportunity—has been established, identifying partners and creating networks can ensue.

### 1. *Assessing the need for inter-firm innovation networks*

Inter-firm innovation networks have been chosen as the organizational form for R and D in some industries more than in others. In attempting to assess the need for such networks, three inter-related dimensions must be examined, namely:[108]

(a) The extent to which R and D in the industry in question is driven by "technology push" or "market pull", which in turn is affected by such industry characteristics as the emphasis on science versus technology, the role of suppliers and the type of product;

(b) The extent to which R and D in the industry is centralized or decentralized, which results in the following two opposing forces: (i) advantages of scale; and (ii) the need to develop a diversity of products closer to their respective markets;[109]

(c) The extent to which sources of knowledge acquisition are principally internal or external. Networking is sought more when external knowledge acquisition is critical or, in other words, when acquiring knowledge internally is significantly difficult and expensive.

Indeed, a cornerstone for establishing an inter-firm innovation network is the availability of a clearly defined business need or opportunity that cannot be met by a single firm, but rather through collaboration with other firms. Often, this business need translates into improved competitiveness and performance, which can be seen from different angles, including, among others, knowledge accumulation, cost saving, critical mass, increased efficiency, developing new business and responding to market changes.

Inter-firm networks feed on matches in technology, capital equipment, labour supplies and materials, as well as similarities in problems or difficulties faced. The fact that these firms most often compete with each other in the market place does not hinder network formation.

### 2. *Partner identification and assessment*[110]

While identifying network partners could be evident for some companies, other firms, particularly small enterprises, find difficulty in searching for potential business partners. Personal contacts can play a role in this regard. More formal approaches for identifying partners include, among others, reviewing public databases and directories of firms, chambers of commerce and business support agencies.

Partner identification is best undertaken by the network manager or broker who must have a clear understanding of the goal of the network. Based on that goal, partner criteria are established and potential partners are identified and assessed based on the following compatibilities: (a) expectations in terms of time, commitment, costs and outcomes; (b) corporate values, and management style and culture; and (c) expertise and resources.

This assessment needs to evaluate both the issue of complementarities and of similarities with regard to competences. Moreover, while geographical proximity can be a criterion, it is never a requirement.

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[108] V. Gilsing and H. Erken, "Trends in corporate R and D" (Ministry of Economic Affairs in the Netherlands, Directorate-General for Innovation, December 2002).

[109] A decentralized R and D increases the possibility of collaborations among parties in different countries. Ibid.

[110] This subsection is based on "Network formation", *Skillnets Network Series*, No. 2, which is available at: www.skillnets.com/images/ContentBuilder/Network_Formation.pdf.

Once potential partners have been assessed, initial contact can be made to ensure willingness of the firm to enter into and commit to a networking arrangement. Meetings are arranged to gather further information on the candidate's business strategy, organization, resources and existing partnerships. It is important to be able to sell the network idea to candidate partners by pinpointing likely benefits from network participation.

One success criterion that must not be overlooked is the availability of a senior-level manager who will be willing to represent the company in the network. The manager must be enthusiastic and flexible to the idea and, moreover, must possess an open management style. Additionally, the ideal manager needs to be able to sell the idea internally to the network staff, thereby ensuring commitment and implementation. Finally, personal chemistry plays an important role in reducing tension and building trust between network partners.

### 3. *Forming the network*

One of the initial steps during network formation involves the analysis of the current situation of each network partner. Strengths, weaknesses, opportunities and threats must be disclosed in order to identify how competitive advantages and core expertise can best be used. Equally, there is a need to assess the industrial sector where partners operate, to evaluate the competitive situation and to clarify networking expectations.

Following this exercise, specific objectives and expectations of the network must be set, potential risks and barriers need to be identified, and evaluation mechanisms must be established, including the use of such financial tools as the use of real options to identify and organize RDI network strategy around valuable growth opportunities. Organizational issues must equally be established, including network structure and management, funding, staffing and membership policy. It is at this stage that network responsibilities and relationships are clarified, particularly conflict resolution.

Two documents are required to formalize results of preparatory meetings with network partners, namely: (a) the network agreement; and (b) the network plan.

(a) *The network agreement document*

At a minimum, the network agreement specifies the goals, actions, measurable results, structures, and procedures of the network. A typical network agreement includes the items listed in box 13.

**Box 13. Items typically included in a network agreement**

The following are typically included in a network agreement:

(a) Names of the members;

(b) Aims and objectives of the network;

(c) Structure of the network, including, for example, management committee;

(d) Arrangements with regard to staffing;

(e) Specific responsibilities of network members;

(f) Decision-making procedures;

(g) Conditions regarding confidentiality of information, knowledge, equipment or technology shared within the network;

**Box 13** (*continued*)

(h) Conditions regarding joint ownership of any products or services developed jointly by or for the network;

(i) Procedures for resolving disputes between network members;

(j) Procedures for accepting new members;

(k) Procedures for the termination of the network.

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*Source*: Adapted from "Network formation", Skillnets Network Series, No. 2, which is available at: www.skillnets.com/images/ContentBuilder/Network..Formation.pdf.

(b) *The network plan*

The network plan is normally produced on an annual or biennial basis. Depending on the network's sphere of activity and objectives, the network plan can stretch over many years. Typically, however, network plans do not cover more than four years. The network plan needs to specify priorities, targets, evaluation indicators, activities and budget adopted for the period in question. Moreover, the plan needs to be formulated and disseminated well in advance and, preferably, on the basis of consultations involving a wide range of actors, stakeholders and partners.

Depending upon the type of network in question, target accomplishments need to be spelled out and modalities for monitoring their attainment laid down during the planning exercise.

## VI. CONCLUDING REMARKS

More than ever before, RDI activity must be based upon multidisciplinary contributions that are hard to come by within the confines of a single institution. This is a consequence of the change in the modes of knowledge production and application from linear to a networked, multidisciplinary and interactive mode.[111] Given this change, there is currently a greater impetus for companies, universities and research centres to collaborate in order to create and transfer discoveries into applications.

Collaboration between R and D institutions can be greatly facilitated by computer networks. Indeed, the genesis of the Internet owes a great deal to the possibilities offered by research and university collaboration. However, demands made by current R and D and educational activities are increasingly difficult to meet on the basis of the Internet. This has necessitated moves to set up high performance networks that have been especially designed to satisfy the needs of researchers and educators.

Clearly, networks need not always be the best modality for solving all organizational and resource problems. However, their comparative advantages have become more apparent in the light of recent developments in ICTs and of the apparent need for multidisciplinary approaches and inter-institutional collaboration, particularly in R and D and innovation-related activities.

As indicated above, some of the main advantages posed by networks reside in their ability to provide multidisciplinary approaches and facilitate inter-institutional collaboration, with subsequent benefits in terms of reduced cost and more holistic outcomes. Moreover, networks can be viewed as tools for information and knowledge sharing, which is an essential prerequisite in approaching information and knowledge societies.

Compared to developed countries, and even some developing countries, the institutions that need to generate and use innovative inputs in Arab countries are essentially small and medium-sized enterprises. Their main source of strength can reside in close links to their markets and in a certain level of internal cohesiveness, brought about by their size, predominant ownership patterns and comparatively limited ranges of activity. However, their main disadvantage is weak or absent relations to sources of innovation, and a general inability to internalize innovation.

The question of how Arab institutions can improve their access to innovation is central to national competitiveness and, indeed, to the viability of socio-economic development in the global knowledge-based economy. Networking for more effective access to innovation is particularly relevant in this context and can be of particular importance for institutions active in new knowledge-based production and service activities. Clearly, such activities are not always confined to new high-technology sectors. New knowledge is beneficial in traditional sectors, including agriculture, mining and even artisanal industries. Networking arrangements can be particularly valuable by bringing the benefits of modern biotechnologies and ICTs into traditional areas of activity.

Emphasis can be placed in such activities on networking and cooperative approaches for which concerned enterprises and organizations could be expected to be well equipped. It is in such cases that the creation of networks of communities of practice comprising a variety of institutions can be expected to be most fruitful. A host of institutions of many types could be involved in such networking; and new institutional forms could be created. Consequently, technology incubators and research parks can be established to achieve coherence and continuity in new knowledge creation, adaptation and delivery. Specific national or sectoral initiatives can also be launched, including enterprise-university partnerships. Such partnerships are expected to be particularly fruitful in Arab countries, where there is little evidence of interaction both between institutions of higher learning and research, and between enterprises and their associations.

Additionally, activities in various resource-based and resource-linked sectors, including agro-food, gas and oil, water treatment and desalination, can only gain from accessing and incorporating innovative inputs. Indeed, the future of some mature and resource-based sectors in the region can well hinge upon the

[111] See “Intellectual Property Rights” (OECD, January 2005).

availability of innovative inputs. While new institutional forms and specialized initiatives can be fruitful, there is a fundamental need for broad training and retraining activities to make such collaboration schemes a success.

Within that context, ICTs need to play a prominent role through a number of modalities, particularly by facilitating networking among experts and practitioners, and by reducing transaction costs. However, in order to reap the full benefits of new ICTs, there is need to institute changes at a number of levels, including organizational arrangements, information sharing and decision-making processes.

Turning institutions, whether in the public or private sector, into knowledge-based organizations is another issue that needs to be addressed in the medium and long term. While substantial changes are required at the national level, particularly with regard to legislation and regulatory issues as well as institutional and management practices, much of this transformation and reform can be facilitated by new technology inputs.

Specifically, ICTs could facilitate such a transformation by promoting dynamic interaction between the tacit and codified knowledge bases of an organization, thereby leading to the development of new knowledge. However, such knowledge cannot be generated in a void. The accumulation of social capital and complementary assets can only be accomplished through a supportive organizational culture and practices, and through open channels of communication and information sharing.

In conclusion, prerequisites for effective networking with a view to introducing innovative inputs, whether at institutional or national levels, cannot come about spontaneously. Well-defined national and sector-based initiatives are needed to initiate change. Detailed consideration of modalities and directions clearly depend upon the particular setting under consideration. The choice of partners must be broad, even exhaustive. Additionally, given their wide-ranging implications, such initiatives need to be subjected to comprehensive discussions at all levels and, moreover, be launched where possible with the political support from the highest national authority.[112]

Government and corporate policies are crucial for promoting R and D cooperation and networking aimed at enhancing sectoral and national competitiveness. Typically, R and D firms in the Arab region are modest as are, consequently, the resources available to drive R and D cooperation and networking. Given this state of national R and D capabilities in many Arab countries, the role of industry federations and chambers is of the utmost importance. Equally, however, little can be achieved without the full cooperation of academic and specialized research centres and of professional associations. While such cooperation at a national level can help improve intra-national R and D cooperation and networking, possibly focusing on pre-competitive research, there is a need for policies that specifically target international cooperation. It is in this latter case that a good deal of serious policy work is needed to ensure maximum benefits.

Operating collectively with other Arab countries and individually, Arab countries have formulated national programmes aimed at building information and knowledge societies. In this sense, they are driven by the need to face the challenges posed by globalization and liberalization. Within the framework of national priorities, building networking capabilities must therefore be linked to efforts aimed at building social capital, which, as indicated above, is often defined in terms of the network of actual and potential relationships available to individuals or social units. However, given that social capital achieves its impact through structural, cognitive and relational dimensions, there is clear need for assigning top priority to institutional reform.

Acting on the cognitive dimension requires considerable efforts in terms of raising awareness and education. The main purpose of such efforts need to centre on disseminating a shared language, creating adaptable frames of knowledge and applying values that govern quality, particularly in products, processes, and efficiency and level of communication between partners involved in creating and using knowledge.

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[112] This support could take the form of a presidential or royal patronage.

Moreover, behavioural and social norms have to be dealt with in order to tackle the relational dimension of social capital. As indicated above, action at this level translates into enhancing the level of trust between networks and among network members.

Ultimately, there is need for a formal recognition that networks and networking practices are valuable tools for promoting national and sectoral STI policies. With that context, there is an essential need for further research in this field, particularly in order to emphasize open source models aimed at establishing modalities that ensure viable outcomes and equitable distribution of benefits. To that end, Arab countries are advised to include networks and networking on the agenda of their STI policy bodies and, furthermore, are encouraged to initiate research programmes aimed at monitoring RDI networks and networking practices, and at building national capacities in this domain.

Annex I

## PHYSICAL INFRASTRUCTURE FOR RDI NETWORKING

Currently, all innovative activities, including R and D, have to be based upon multidisciplinary efforts that have become increasingly difficult to organize within a single institutional entity. Collaboration between institutions and individuals involved in a given R and D activity can be greatly facilitated with the help of computer networks. Despite the enormous benefits that can still be available through traditional Internet capabilities, demands made by research and teaching organizations in dynamic situations are often difficult to meet using the Internet. This has prompted moves to set up the high performance networks that are emerging today in developed countries, with the specific purpose of satisfying the needs of researchers and educators.

Sufficient international bandwidth is essential for R and D and educational networks. A network dedicated to R and D must ultimately deliver efficient, fast and reliable connectivity. Consequently, it needs to be based upon viable new technologies and be able to support the development and deployment of new services and cooperation protocols, as well as be capable of creating linkages to new network members and to other related networks.

Moreover, planning R and D network infrastructures development must be based upon close consideration of a number of factors, including available technology and prospects for its future development, business and administrative models, and the nature of application and services supported by the network. There are a number of questions and challenges relating to the future of R and D networking. This uncertainty favours experimental and pilot approaches, which have been created to allow for dynamic planning with regard to hardware and software requirements.

Two major case studies are reviewed below, namely: (a) the Italian Academic and Research Network; and (b) the GÉANT project. These provide a guide to strategies for establishing hardware and software requirements for networking research and academic activities. Additional case studies are briefly discussed in section C.

### A. THE ITALIAN ACADEMIC AND RESEARCH NETWORK[113]

#### 1. *Current status*

The Italian Academic and Research Network (GARR) dates back to the late 1980s. It was created on the basis of independent academic and research networks, which were established in Italy during the 1970s. GARR has had a comparatively long tradition of innovation with regard to networking techniques and protocols. Examples of innovative ventures undertaken by GARR include introducing Transmission Control Protocol/Internet Protocol (TCP/IP) in Italy, setting up the first 2 megabits per second (Mbps) backbone in Europe, and participating in the experimental development of Internet Protocol version 6 (IPv6).[114] Moreover, GARR is focusing on innovative gigabit speed technologies and relevant applications in the hope that these technologies could prove beneficial in the long term.

The present GARR backbone is based on the available asynchronous transfer mode (ATM) infrastructure, which operates at 155 Mbps.[115] This allows interconnection of four fully-meshed core nodes.

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[113] This section is based on C. Allocchio et al., "The Italian academic network GARR: evolution in the Gigabit era" (Elsevier Science B.V., 2002).

[114] Internet Protocol version 6 (IPv6) is as an evolutionary set of improvements to the current Internet Protocol (Ipv4). In IPv6, addresses are lengthened from 32 bits to 128 bits, thereby providing relief for what was perceived as an impending shortage of network addresses.

[115] Asynchronous transfer mode (ATM) is a dedicated connection switching technology that is implemented by hardware (as opposed to software), thereby allowing faster processing and switch speeds.

Additionally, GARR has 16 access points of presence (PoPs),[116] which are connected to the backbone with speeds in the range of 34-155 Mbps.[117]

### 2. *Network infrastructure management and evolution*

Network infrastructure management is an important consideration in R and D networking. In the case of GARR, infrastructure is managed by Telecom Italia (TI), which provides leased lines; the ATM backbone; PoP connections to core nodes; and the majority of access circuits connecting users to PoPs, which are also 'hosted' within TI facilities. Additionally, TI manages the configuration of ATM virtual circuits (VCs) on the base of set requirements.

Network infrastructure evolution is often directed towards two main objectives, namely: (a) rapidly increasing bandwidth in order to accommodate the needs of the general Internet user;[118] and (b) providing significantly high broadband dedicated to scientific application services, which is particularly relevant where computing grids are the object of networking. In any case, there is often the need for the creation of broadband virtual private networks (VPNs) with specific objectives for specific user communities.[119]

With regard to GARR, the former objective can be perceived as an attempt to increase connectivity in southern Italy in order to meet rising demand for connectivity in other countries across the Mediterranean. Specifically, the province of Palermo, located in Sicily is considered an important node in the strategy for further developing the GARR network. Consequently, Palermo is a major concentration point for all the fibre optic cables connected with the Mediterranean region and beyond.

In addition to the physical infrastructure, steps are being made by GARR to prepare for smooth migration into the gigabit era. To that end, major changes in network design are projected, which could institute transformations of a significant number of PoPs across Italy, particularly in the south. Moreover, redundant circuits towards PoPs could be needed to help extend the mesh more widely; and the physical location of those PoPs could well relocate from carrier premises to selected user facilities.

Furthermore, the evolution of the present network structure could include the following issues: (a) significant costs for entry into the gigabit range; (b) adequate model aimed at increasing infrastructure, with its corollary model of pricing the cost-per-megabit;[120] (c) facilitating the creation of local loops between circuits operated by competing carriers; (d) interconnection with high-bandwidth metropolitan area networks (MANs); and (e) implementation of typical ATM services within a traditional Internet Protocol version 4 (IPv4) architecture, particularly Quality of Service (QoS) and Managed Bandwidth Services (MBS).[121]

### 3. *Long term traffic requirements*

Statistics gathered by GARR indicate that user request for IP 'best effort' traffic bandwidth is currently growing by a factor of 2.2 per annum. Plans for long-term traffic must therefore include the almost

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[116] A point of presence (PoP) is an access point from one place to the rest of the Internet, which usually includes routers, digital/analogue call aggregators, servers and, frequently, frame relays or ATM switches. The number of PoPs denotes the size and growth of a network.

[117] Some 300 access circuits operating at speeds of 2-155 Mbps are used to connect user sites to PoPs. Technologies used in these circuits include Direct Numeric Circuits (CDNs) and ATM. Currently, GARR provides "IP best effort" service for general Internet use on the basis of IPv4 protocols and a Managed Bandwidth Service (MBS).

[118] Within that context, increasing bandwidth is set to become a major objective in the case of almost all Arab countries.

[119] Virtual private networks (VPNs) use a public telecommunication infrastructure, such as the Internet, to provide remote offices or individual users with secure access to their organization's network. This provides an affordable solution, particularly by contrast with other systems of owned or leased lines that can only be used by one organization.

[120] Upgrading the backbone to reach the 622 Mbps mark using ATM is on offer by many carriers.

[121] Quality of Service (QoS) allows a company or user to pre-select a level of quality in terms of transmission rates, error rates, and other characteristics; and Managed Bandwidth Service (MBS) allows users to request a dedicated end-to-end connectivity at guaranteed bandwidth.

certain expansion in demand generated by new participants seeking connectivity, including, among others, libraries, technical institutes and governmental departments. These considerations highlight the need for exploring new technologies beyond ATM. Limitation of ATM technology to a bandwidth of 622 Mbps is expected to be an essential impediment. Alternative solutions include Wave Division Multiplexing (WDM).[122]

#### 4. *Pilot network models*

It is not uncommon for networks to adopt pilot approaches in seeking to identify technology options. Within that context, GARR is engaged in piloting entry into the gigabit range through arrangements aimed at examining possibilities for coexistence and interoperability among different carriers. This is essential given that different operators can utilize different technologies, or at least different variants of a given technology.

### B. THE GÉANT PROJECT

The GÉANT Project, which was launched in 2000, is the fourth generation of pan-European research networks.[123] The Project is aimed at linking services delivered by the 28 National Research and Educational Networks (NRENs) in Europe. It was intended that such services be provided to NRENs from the 32 countries qualifying for membership of the Fifth Framework Programme (FP5). GÉANT was designed to support activities of the research and educational community in Europe, serving more than 3,500 research and education institutions, in addition to catering for the development and exploitation of new networking capabilities.

Services offered by GÉANT are categorized as follows: (a) in terms of connectivity services, including a standard IP service, a premium IP service and a guaranteed capacity service; and (b) in terms of network-based, value-added services, designed to target VPNs, a multicast service and new services embodying network-based intelligence, including, among others, security and video-conferencing.

GÉANT allows researchers to collaborate on cutting-edge research projects in real-time, and to transfer rapidly large quantities of data at rates up to 10 gigabits per second (Gbps).[124] Distributed or "grid" computing, possible through GÉANT, allows the exploitation of the resources of many computers in a network at the same time to solve a single problem.

From the outset, GÉANT was designed to incorporate advanced technologies targeting high capacity, performance and reliability. Its innovative nature is largely due to the manner in which commercial components are brought together in support of network services, which are inherently novel and target the following three main areas of network innovation: data transmission, QoS technology and operational quality management across multiple networks (see annex box).

**Annex box. Areas of network innovation targeted by GÉANT**

*Data transmission*: Dense Wavelength Division Multiplexing (DWDM) and optical switching technologies offer the potential for very high transmission rates at acceptable costs. Additionally, direct access to dedicated fibre links can offer higher capacities by up to one or two orders of magnitude.

There are currently two avenues for equipment suppliers to enhance capacity available from single fibre links, namely: (a) increasing the number of wavelengths used on a single fibre; and (b) increasing transmission capacity on a single wavelength.

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[122] Wavelength Division Multiplexing (WDM) is a method of transmitting data from different sources over the same fiber optic link at the same time whereby each data channel is carried on its own unique wavelength.

[123] The four consecutive generations are as follows: EuropaNET, TEN-34, TEN-155 and GÉANT.

[124] One example is in gene sequencing, where the transfer of substantial amounts of data is needed to speed up the notoriously slow process of developing new drugs and therapies.

**Annex box** (*continued*)

When combined, these two possibilities could well lead to capacities in the hundred Gbps range. DWDM is able to offer logically separate transmission paths using the same fibre link. This is especially valuable for supporting large-scale virtual private network (VPN) services, envisaged for use by computing "grids" dedicated to specific applications.

*Quality of service mechanisms*: Multi-Protocol Label Switching (MPLS) is envisaged for network traffic flow management. This will enable best use of network topology and will contribute to implementing effective "leased line equivalent" and VPN services. MPLS will constitute an evolutionary step from ATM technology in current use. Additionally, MPLS enables automatic re-routing of traffic upon circuit failure, obviating the need for automatic recovery by Synchronous Digital Hierarchy (SDH) technology and facilitating effective management of network resilience. This is particularly useful when circuits based on DWDM or other optical transmission technologies are inducted into the network.

Queue management techniques are set to constitute the basis for a premium IP service. Techniques will be selected to offer priority over normal traffic, or ability for meeting specific performance criteria.

*Quality of service management*: Not only are component technologies envisaged for the programme innovative in their own right, the manner in which they will be implemented will also incorporate innovative notions, designed mainly to ensure seamless operation and user friendliness of end-to-end services. While the same selection of services will be made available to all users, regardless of geographical location, different technology platforms could sometimes be used to accommodate specific sets of conditions. Naturally, new operating procedures will be needed to handle exchange of information and to handle the interface between national services and those provided by GÉANT. Bandwidth brokers and other distributed network intelligence mechanisms will be installed in support of such exchange and interfacing.

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*Source*: Adapted from the GÉANT website, which is available at: www.geant.net.

*The GÉANT test programme*

GÉANT also provides a platform for research into networking itself. The GÉANT test programme is designed to accept additional services, based on new techniques, as R and D activities demonstrate a requirement for them and as their feasibility is established.

Validating a given additional service is envisaged as consisting of the following three phases: (a) full understanding of the new technologies and related equipment; (b) detailed specification of new services required on the basis of knowledge gained in previous testing; and (c) pilot activities designed to confirm that a service can be made available on a realistic scale before being expanded to cover a wider range of end-users.

## C. OTHER R AND D NETWORKS

### 1. *The Canadian Network for the Advancement of Research, Industry and Education*[125]

The Canadian Network for the Advancement of Research, Industry and Education (CANARIE) launched CA*net 3 in the late 1990s. Exponential growth in network traffic coupled to expectations of new high bandwidth applications prompted the Government of Canada to commit $110 million (Canadian dollars) for the design, deployment, and operation of a successor, namely, CA*net 4. In line with the objectives of its predecessor, CA*net 4 is set to interconnect provincial research networks in universities, research centres, public research laboratories and schools. Additionally, CA*net 4 will foster linkages to international peer networks. Through a series of point-to-point optical interconnections, mostly provisioned at speeds of 10 Gbps, CA*net 4 will provide an initial network capacity four- to eight-fold that of its predecessor.

[125] More information on the Canadian Network for the Advancement of Research, Industry and Education (CANARIE) is available at: www.canarie.ca/.

CA*net 4 embodies the "customer-empowered network" concept. This concept provides a greater role for end-users in allocating network resources, and contributes significantly to innovation on the basis of network-based applications. For the most part, these applications are based upon the rapid expansion in the use of computers and computer networks as platforms for R and D activity in a variety of fields. Applications essential for national and international collaboration are available on CA*net 4, thereby facilitating, among others, data access and analysis, distributed computing and remote control of instrumentation.

### 2. *The Korea Research Environment Open NETwork*

The Korea Research Environment Open NETwork (KREONET) is a national R and D network that was established in 1988 to provide high-performance network and supercomputing services to the research community for science and technology information exchange and collaboration.[126] Members in KREONET exceed 230 organizations, including governmental research institutes, universities and industrial research laboratories.

KREONET has five gigabit capacity points of presence (GigaPoP) nodes covering the national territory. These GigaPoPs are linked to each other with a bandwidth of 45/155/622 Mbps and 15 local access PoPs at bandwidth of 45/155 Mbps. Moreover, in order to encourage international research collaboration and remote education, this two-layer backbone is connected to international networks in various regions and countries, including, the European Union, Japan, Singapore and the United States.[127]

Technologies used include Multicast, QoS, IPv6, Traffic Measurement, Globus Middleware, and Web Cashing. Continuous efforts are made to enlarge and modernize KREONET, which is being upgraded to the KREONet2 using Next Generation Internet (NGI) and Grid technologies. Through these technologies, the network is projected to allow the processing of large data on supercomputers, as well as other world-class collaborative applied services.

[126] The Korea Research Environment Open NETwork (KREONET) is managed by the Korea Institute of Science and Technology Information (KISTI) and funded by the Ministry of Science and Technology in the Republic of Korea. More information is available at: www.kreonet2.net/.

[127] Within that context, plans are underway to establish connections with China.

Annex II

# SELECTED NETWORK CASE STUDIES

## A. THE MEMBRANE ACADEMIC INDUSTRY NETWORK[128]

### 1. *Objectives*

Triggered by an increased demand by the water industry in the United Kingdom of Great Britain and Northern Ireland for information that addresses membrane technology for wastewater treatment, the Membrane Academic Industry Network (MAIN) was established to disseminate the results of R and D projects conducted at national and global levels. Conversely, the network will help provide feedback to researchers on the specific needs of the water industrial sector.

More specifically, the objectives of MAIN are as follows: (a) to establish a knowledge-based centre for research expertise in this area, which is set to comprise a dedicated relational database that incorporates academic expertise, suppliers information and user experience; (b) to advance the level of understanding of emerging membrane process principles; (c) to identify future research requirements by the industry; and (d) to focus on critical membrane applications, including removing arsenic and suppressing the formation of halogenated organics.

### 2. *Communication and dissemination mechanisms*

The following mechanisms are planned to promote the dissemination of information: (a) organizing workshops and conferences on specific subjects; (b) launching a relevant website; (c) generating a database; (d) providing technical classes; and (e) producing newsletters, articles and/or features in existing trade association and relevant publications.

## B. THE ASSOCIATION FOR STRENGTHENING AGRICULTURAL RESEARCH IN EASTERN AND CENTRAL AFRICA

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is a non-profit organization of the National Agricultural Research Institutes (NARIs) aimed at increasing the efficiency of agricultural research in the region, thereby facilitating economic growth, food security and export competitiveness through productive and sustainable agriculture.[129]

ASARECA was established within the Framework for Action on Agricultural Research in Eastern and Central Africa of November 1993, and comprises ten member countries, namely: Burundi, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda.

The strategic objective of ASARECA and its regional programmes is "to promote regional economic growth by developing, introducing and disseminating agricultural technologies that respond to the markets and to the prevailing and future economic opportunities for new technologies as well as maintaining the long term sustainability of the agricultural resource base".[130]

ASARECA carries out its activities through a number of regional research networks, programmes and projects (see annex table).

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[128] This section is based on S. Judd, "A network in membrane technology for the water industry: the Membrane Academic Industry Network (MAIN), which is available at: www.cranfield.ac.uk/sims/water/mem-net/netw00.pdf.

[129] More information on the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is available at: www.asareca.org/.

[130] Ibid.

ANNEX TABLE. ASARECA ACTIVITIES BY NETWORK AND AREA OF SPECIALIZATION

| Network name | Area of Specialization |
|---|---|
| Trees on Farm Network | Agro-forestry |
| Regional Potato and Sweet Potato | Potato and sweet potato |
| Rootcrops Research Network | Rootcrops |
| Africa Bean Research Network | Bean |
| Banana Research Network | Bananas |
| Animal Agriculture Research Network | Livestock |
| Maize and Wheat Research Network | Maize and wheat |
| Coffee Research Network | Coffee |
| Plant Genetic Resources Network | Plant genetic research |
| Regional Sorghum and Millet Network | Sorghum and millet |
| Biotechnology and Biosafety | Biotechnology/biosafety |
| Soil and Water Management Network | Soil and water |
| Regional Agriculture Information Network | Information and communication |

## C. THE REGIONAL COMPETENCE CENTRE ON INDUSTRIAL BIOTECHNOLOGIES[131]

### 1. *Objectives*

The Regional Competence Centre on Industrial Biotechnologies (BioTekNet**)** is aimed at rendering the relevant biotechnological competences existing in the Campania region of Italy accessible to the productive world by developing industrial processes and technologies that employ biological systems or their components.

Particular attention is awarded to the following research areas: (a) new fermentative processes; (b) innovative biosensors; (c) bio-systems for the depuration of water; (d) advanced biological applications for food industry; and (e) industrial enzymology.

Additionally, the primary aims of BioTekNet are as follows: (a) creating an integrated network of scientific, technological, instrumental, economical and managerial resources, thereby ensuring an efficient transfer of knowledge to the industrial apparatus; (b) implementing R and D activities to meet the needs of the productive system; (c) involving enterprises in the innovation creation process; (d) creating favourable conditions in the Campania region of Italy in order to attract industrial investments in emerging high-tech fields; (e) incubating knowledge-based industries; (f) creating infrastructures that favour the growth of industrial and/or university spin-offs; and (g) improving the quality of technological advice available for enterprises.

### 2. *Scientific competences*

The technical-scientific competences were organized in the following five thematic departments:

(a) Bio-computer science, Biomathematics and Modelling, which deals with scientific and technological competences related to the implementation, development and management of computational instruments pertaining to modern bio-computer science and modelling techniques;

(b) Structural and Functional Proteomics and Genomics, which deals with competences in the fields of proteomics and genomics, particularly those necessary to identify, characterize, modify, engineer, immobilize and produce proteins of interest using most advanced methodologies;

[131] This section is based on A. Donato, “Centre of technologies and industrial applications of biomolecules and biosystems: a model for technology transfer and networking”, which was presented during the Forum on Capacity Building through Technology Transfer and Networking (Beirut, 11-12 March 2004). More information is available at: www.bioteknet.com.

(c) Biosensors, Micro-arrays and Biochips, which deals with competences in biosensorial research to determine analytics that are highly relevant in such industrial fields as chemico-clinical, chemico-pharmaceutical, environmental and agro-food;

(d) Metabolic Engineering and Biomass Productive Processes, which deals with competences in the fields of industrial and medical microbiology, metabolic engineering, fermentative processes, cell cultures and their application in the bio-medical field;

(e) Industrial Enzymology, Bioreactors and Bioprocesses, which deals with competences in molecular biology, chemical biotechnologies, industrial biotechnology and biotechnological processing.

### 3. *Organizational structure*

BioTekNet is managed by the Management and Development Department, which is divided into four managerial units, namely: (a) the Project Leader, which represents the University of Naples and heads the organizational structure; (b) the Scientific Council, which is a consulting advisory body that helps the scientific structures to compare activities and focus on the plans of action; (c) the Scientific Advisory Board, which comprises eminent international scientists of the biotechnological world, proposes highly innovative research strategies and acts as referee on the formulated proposals; and (d) the Management Committee, which supports the Project Leader in the areas of strategy, organization, legal issues, administration and management.

Annex III

## GENERIC MODEL OF A COOPERATIVE RESEARCH AGREEMENT[132]

This Agreement is entered into by .......................................... a research organization established under.......................... laws (hereinafter referred to as INSTITUTE), having its main office at ......................................................................................................................................; and ...................................................................... a ............................... organized under the laws of ..................................................... (hereinafter referred to as PARTNER INSTITUTION I), having its main office at .....................................; and ................................................................. a ....................................... organized under the laws of ..................................................... (hereinafter referred to as PARTNER INSTITUTION II), having its main office at ............................................................................

WHEREAS, researchers at INSTITUTE, PARTNER INSTITUTION I and PARTNER INSTITUTION II are collaborating and continue to collaborate on research pertaining to .............................. and,

WHEREAS, certain intellectual property, including patents and patent applications and .............................., may be derived from this collaborative research effort; and,

WHEREAS, the researchers have agreed that the Joint Project (as defined below in Article I) would be a joint effort and that the intellectual property or any other benefits that could be derived from the collaboration would be commonly owned by the researchers and their respective institutions; and,

WHEREAS, INSTITUTE, PARTNER INSTITUTION I and PARTNER INSTITUTION II wish to provide for the handling and division of the patenting costs and the monies received from any option to license or license under said patent rights,

NOW THEREFORE, in consideration of the mutual benefits to be derived hereunder, the Parties agree as follows:

**Article I - Definitions**

1.1. “Intellectual Property” shall mean patents, copyrights, trademarks, .......................................... and any other forms of intellectual property that is protected under .............................. law.

1.2. “Joint Ownership” shall mean two or more of the Parties have employees that are co-inventors to Intellectual Property.

1.3. “Joint Project” shall mean a collaborative research programme between Parties involving researchers ........................................................., …...................................., ..........................................., and ........................................... and such other researchers who may participate in this project, titled..............................................................

1.4. “Party” shall mean INSTITUTE, PARTNER INSTITUTION I and PARTNER INSTITUTION II individually. Collectively, they shall be referred to as “Parties”.

**Article II - Proprietary rights**

2.1. Title to Intellectual Property will be with the originating Party unless there is Joint Ownership.

2.2. Handling of Intellectual Property:

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[132] Adapted from F.H. Erbish, *Basic Workbook in Intellectual Property Management* (Agricultural Biotechnology Support Project, Institute of International Agriculture, Michigan State University, June 2004).

(a) INSTITUTE will be responsible for the patenting and licensing of Intellectual Property with Joint Ownership. There will be joint assignment to Intellectual Property with Joint Ownership to the contributing Parties;

(b) Intellectual Property made solely by one Party will be owned and controlled by that Party. Controlled means said Party will be in control of all decisions concerning patenting and licensing, and said Party will retain all royalties resulting from the licensing;

(c) In all instances, the counsel chosen to prosecute patent applications shall be made aware of the nature of the Joint Project and shall be charged with determining Inventorship in accordance with the law, soliciting facts, if any, from each Party.

2.3. Licensing and Use:

(a) Licensing of jointly developed invention shall only be by mutual agreement of Parties. INSTITUTE shall take the lead in identifying potential licensees and negotiating license agreement(s) following consultations with the other two Parties;

(b) Inventions developed by individual Parties under the Joint Project shall be available to the other two institutions through a non-exclusive, royalty-free licence to use such inventions for internal, non-commercial purposes.

2.4. Other institutions or parties may be added to the Joint Project via a subcontract or some other mechanism for the purpose of facilitating the research. INSTITUTE, PARTNER INSTITUTION I and PARTNER INSTITUTION II will remain the primary Parties for the determination of patenting and Intellectual Property ownership and the other institutions which may be added to the Joint Project shall be secondary in the decision-making process pertaining to proprietary rights.

**Article III - Protection expenses**

3.1. Foreign patent applications for Joint Ownership shall be filed, prosecuted and enforced as mutually agreed upon between the Parties and enforced as mutually agreed upon between the Parties. The Parties will share the expenses thereof as provided in Article III 3.2 hereof.

3.2. Unless agreed otherwise, all legal costs and fees incurred after the Effective Date of this Agreement will be shared equally by the institutions contributing to an invention of a new ............................., except that if any Party objects to the filing or continued prosecution of an application or enforcement of a patent or certificate in a particular country (or countries), the other Party (Parties) may proceed at its (their) own expense. If any Party (Parties) proceeds on its (their) own, the Party declining to proceed shall have no rights or interest in any patent rights for said country (countries) in which it declines to proceed.

**Article IV - Income distribution**

For Joint Ownership Intellectual Property the Parties agree to share equally all income received from licensing and commercialization of the Intellectual Property or any other technology that could result from the present and future collaboration on the Joint Project. In the event gross royalties do not cover the accrued legal costs expended by any Party with respect to jointly developed Intellectual Property, no Party shall be held responsible for reimbursing the other Party (Parties).

**Article V - Assignability**

None of the Parties shall assign or transfer any of the rights under this Agreement without the prior written approval of the other Parties which such approval shall not be unreasonably withheld.

**Article VI - Future issues**

6.1. If any disagreements arise, the Parties will use best efforts to negotiate and resolve all differences. The collaboration of Parties and their researchers is paramount.

6.2. This Agreement shall terminate with the expiration of the last to expire patents developed under this Joint Project, or on abandonment of all patent applications developed under this Joint Project, provided such abandonment is by mutual consent.

6.3. This Agreement may be amended by mutual agreement of the Parties. Such amendments shall not be binding unless they are in writing and signed by authorized representatives of each party.

**Article VII - Miscellaneous**

7.1. The construction, validity, performance and effect of this entire Agreement shall be governed by the laws of ................................

7.2. This Agreement sets forth the entire agreement and understanding between the Parties as to the subject matter thereof and merges all prior discussions between them.

7.3. If any provision of this Agreement shall be held to be invalid, such invalidity shall not affect any other provisions of this Agreement, but the remainder hereof shall be effective as though such invalid provisions had not been contained herein.

7.4. Each Party shall require all of its researchers conducting research under the Joint Project to assign their rights to Intellectual Property conceived during the term of the Joint Project to the appropriate Party.

7.5. The researchers of each Party shall continue to be employees of that Party and shall not be considered to be employees of any other Party.

7.6. This Agreement may be executed in any number of counterparts, any one of which shall be deemed to be the original without the production of the others. In witness whereof, the Parties hereto have caused the Agreement to be executed in triplicate by their duly authorized representatives.

The Effective Date of this Agreement is .........................................., 20 .......

INSTITUTE

By: ................................................................<br>
Name: ..........................................................<br>
Title: ............................................................

| PARTNER INSTITUTION I | PARTNER INSTITUTION II |
|---|---|
| By: ................................................................ | By: ..................................................................... |
| Name: .......................................................... | Name: .................................................................... |
| Title: ............................................................ | Title: ..................................................................... |

Annex IV

# SAMPLE LETTER OF INTENT

Letter of Intent on Cooperation Between

………………………………………………………………..

and

The Economic and Social Commission for Western Asia,

on

The Establishment of a Research and Development Network on

…………………………………………………….

This Letter of Intent provides a framework for mutual collaboration between the following parties: ………….., ………………., ………….. and the United Nations Economic and Social Commission for Western Asia (hereinafter referred to as ESCWA) with emphasis on activities targeting planning, designing and implementing the Research and Development Network on ……………………………...…………………………..

Cognizant of the benefits posed by selected new technologies for sustainable development;

Attentive to the possibilities presented by promoting the concept and operation of networking by research and development institutes in order to achieve greater productivity, reduced operational costs, hence improved contributions to local and national sustainable development;

Aware of the need to customize interventions and combine capabilities targeting knowledge production and innovation promotion to national and local settings;

Hoping that cooperation modalities described herein constitute the bases for implementing similar joint activities in other regions and/or research fields of Arab countries.

The Parties have agreed on the following:

Phase I:

All parties signatory to this letter of intent agree *in principle* on the need to establish cooperation in conducting R and D activities through networks, and express their willingness to participate in activities designed for the implementation of such networks. With this in mind, signatories to this letter declare their intention to collaborate in establishing the Network on ………………………………………………

Phase II:

All parties signatory to this Letter of Intent also agree to cooperate in the following activities leading to the establishment of the Network on ……………………………….:

(a) Set-up an advisory board and a management team to oversee and coordinate the activities of the network, respectively;

(b) Identify a hub for the Network;

(c) Commission a preliminary study on the plan of action and implementation modalities of the Network;

(d) Agree on issues related to Intellectual Property Rights, including, inter alia, patents, inventions, new/original designs and trademarks;

(e) Agree on a common protocol of communication governing the flow of information between them.