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Role of *Diaspora* in facilitating Participation in *Global Knowledge Networks*: Lessons of Red Caldas in Colombia

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Table of Contents

1. THE CONTEXT WITHIN WHICH THE <i>RED CALDAS</i> EMERGED AND DEVELOPED	1
1.1. AN OVERVIEW OF THE EVOLUTION OF THE RED CALDAS	1
1.2. THE COLOMBIAN CONTEXT: DEVELOPMENT CHALLENGES AND THE ROLE OF KNOWLEDGE IN PROMOTING DEVELOPMENT	2
1.3. MAJOR CHALLENGES COLOMBIA FACES.....	3
<i>The Productivity and Innovation Challenge</i>	3
<i>Competitive Restructuring, New Technologies and Insertion into the Knowledge Economy</i>	3
<i>Coping with Social Consensus, Social Inclusion and Social Conflict</i>	4
1.4. HUMAN RESOURCES AND MIGRATION: THE EMERGENCE OF THE DIASPORA.....	5
2. NATURE, OBJECTIVES AND FUNCTIONS OF THE <i>RED CALDAS</i>.....	7
2.1. MISSION AND OBJECTIVES OF <i>RED CALDAS</i>	7
2.2. ORGANIZATIONAL STRUCTURE	10
2.3. MAIN ACTORS AND THE ROLE EACH ONE PLAYED	11
3. MAIN PHASES IN THE DEVELOPMENT OF <i>RED CALDAS</i>.....	12
3.1. FIRST PHASE: RESEARCH PARTNERSHIPS AND PROJECT-DEVELOPMENT LED BY THE NATIONAL NODES (1991-1997).....	12
3.2. SECOND PHASE: WEAKENING OF THE NODE STRUCTURE AND EMERGENCE OF THE SPECIALIZED RESEARCH AND KNOWLEDGE NETWORKS (1995-2001)	13
3.3. THIRD PHASE: IDENTITY CRISIS AND PROJECTING THE LESSONS LEARNED FROM THE <i>RED CALDAS</i> INTO THE FUTURE (2001-2004)	13
4. INNOVATIVE CASES IN DEVELOPING COLLABORATIVE RESEARCH: BUILDING-UP RESEARCH PARTNERSHIPS AND TAPING GLOBAL KNOWLEDGE NETWORKS	14
4.1. INNOVATIVE RESEARCH PARTNERSHIPS GENERATED BY THE INTERACTION BETWEEN NATIONAL NODES AND COLOMBIAN UNIVERSITIES (FIRST PHASE)	14
4.2. INNOVATIVE RESEARCH PARTNERSHIPS GENERATED BY THE SPECIALIZED RESEARCH AND KNOWLEDGE NETWORKS (SECOND PHASE).....	16
5. MAIN FACTORS THAT HAVE INFLUENCED THE EVOLUTION OF THE <i>RED CALDAS</i>	20
5.1. SUCCESS FACTORS THAT DYNAMIZED AND STRENGTHENED THE <i>RED CALDAS</i>	20
5.2. LIMITING FACTORS THAT LED TO INCREASING INEFFICIENCIES IN THE <i>RED CALDAS</i> BASED ON NATIONAL NODES AND ITS EVOLUTION TOWARDS SPECIALIZED RESEARCH AND KNOWLEDGE NETWORKS	21
6. LESSONS LEARNED: LOOKING TOWARDS THE FUTURE.....	23

1. The Context within which the *Red Caldas* Emerged and Developed

1.1. An Overview of the Evolution of the Red Caldas

The **Network of Colombian Researchers Abroad – Red Caldas**, was established in 1991 as part of an explicit policy of integrating the “*scientific diaspora*” (researchers abroad) with the Colombian scientific community and with the activities and programs of the National Scientific and Technological System. Two motivations are at the origin of this network. The first one was to strengthen the national research community with the participation of Colombian researchers studying and working in different countries, considering them as an “extension” of the former instead of looking at them as a loss to the country through a “brain-drain” process. The second motivation was that of using the Colombian scientific diaspora as a means of integrating national research groups into regional and global research and knowledge-intensive networks, given the increasingly important role these networks play in the knowledge economies of the turn of the century. It is important to point out that the emergence of Internet played a major role in making this network possible, since e-mail facilities went a long way in facilitating a continuous interaction with the various groups of Colombian researchers abroad.

One of the main aspects that will be analyzed in this chapter is the evolution that took place from the earlier days of the Red Caldas in the first half of the nineties, to the latter part of the development of this network when it evolved into a wide range of “*specialized research and knowledge networks*” that gradually replaced the traditional “*national nodes*” through which this network originally operated. This evolution reflects an important change in the perception of the role scientific diasporas play. While in the first half of its history the purpose of the Red Caldas was basically related to “*capacity building*” in S&T in Colombia through the linking of researchers abroad with local research groups in order to avoid losing their research capacity through the “brain-drain” process, in the second half of its history the purpose of the Red Caldas became more clearly related to a new strategic role: that of facilitating and strengthening the participation of national research groups in regional and global research and knowledge networks that are playing an increasingly important role in the generation and utilization of knowledge in the context of a globalized knowledge economy. The perspective significantly changed. In fact, some observers believe that the Red Caldas “*sensu strictu*” refers mainly to the first half of this evolution where the original motivation predominated, based on a network of “*national nodes*” of Colombian researchers in different countries. In the second half we witnessed a shift away from this model, maintaining a very loose network of a few nodes that survived, gradually being replaced by a much more flexible and dynamic range of specialized research and knowledge networks with a greater capacity for *taping knowledge flows* in topics of interest to the country.

The Red Caldas was formally launched in October of 1991 in Paris, where the first “*node of Colombian researchers abroad*” was constituted. Very rapidly other nodes emerged in the main cities of Europe and North America, where most Colombian researchers concentrated. Internet and e-mail facilities that were quickly developing in that moment greatly helped the interaction between the nodes, and between them and COLCIENCIAS, as coordinator of this emerging global network. In 1994 the *First Global Symposium of the Red Caldas Nodes* took place in Bogotá, with the purpose of facilitating interaction between researchers in Colombia and the researchers that constitute the various National Nodes around the world. When this Symposium took place the Red Caldas was constituted by 29 national nodes located in 27 countries with 874 researchers affiliated with them. Table 1 shows the distribution of Red Caldas nodes and members around the world, 50% of them concentrating in Europe, 45 % in the Americas and 5% in the rest of the world, mainly represented by Japan, Australia and Russia.

Table No. 1
Red Caldas: Distribución of its National Nodes and Members

	Europe	Americas	Other countries	Total
Nodes	14	10	5	29
%	48	35	17	100
Members	441	392	41	874
%	50	45	5	100

1.2. The Colombian Context: Development Challenges and the Role of Knowledge in Promoting Development

With 45 million inhabitants, Colombia has the third largest population in Latin America, right after Brazil and Mexico. Located at the midway point between North and South America, the country has a strategic location being the only country in South America with both Pacific Ocean and Caribbean coasts, and with easy access to North American, European, Latin American, African and Asian markets. It has a diversified population distribution with one city with more than 7 million inhabitants and three cities with more than 2 million. The adult literacy rate is one of the highest in Latin America, although the quality of education has suffered from the effort of extending coverage and the country faces a major challenge in assuring the development of the competencies (“*competencias*”) the new Knowledge-intensive Economy requires.

The recent evolution of the Colombian economy is full of contrasts, as it is the case with many developing countries. On the one hand, Colombia is one of the most stable economies in Latin America with a steady economic growth above the Latin American average. Until the late 1970’s the economy grew an average of 5 % per year, slowing to below 4% in the 1980’s. Despite this decline, Colombia’s gross domestic product (GDP) outperformed that of most other Latin American countries, where the debt crisis crippled output levels. While Latin American countries grew an average of 1.1 % in the 1980’s, Colombia’s average growth was 3.7 %. Liberalization of the economy in the early 1990’s laid the foundation for the economy to exceed its historic growth levels. As a result, between 1993 and 1995 the economy grew an average of 4.7 % per year.

This positive performance was mainly the result of the macroeconomic stability, a long standing democracy and a favorable foreign investment policy. Between 1990 and 2002 Colombia was among the top destinations for Foreign Direct Investment (FDI) in Latin America, reaching a yearly average of US\$ 2.0 billion, following Brazil, Mexico, Argentina, Chile, and Venezuela.

This performance drastically changed in the mid nineties. Real GDP growth declined from 5.2% in 1995 to 2.1% in 1996, due to a contraction in private sector investment and a slowdown in the growth of private sector consumption, and then recovered somewhat in 1997, growing by 3.4%. During 1998, as a consequence of sharply higher domestic interest rates, the effects of poor weather (*el Niño*) on the agricultural sector, the negative effects of the financial crises in Asia and Russia and the significant decline in international crude oil and other commodities prices, the Colombian economy suffered a severe slowdown, growing by just 0.5% during the year. The economy worsened in 1999, registering negative real growth of 4.5%, the deepest recession in Colombian economic history. In 2000 the economy began to rebound growing 2.9% in 2000, 1.5% in 2001, 1.8% in 2002, 3.9 in 2003 and 3.5 in 2004. Inflation, as measured by the consumer price index, averaged 17.9 % between 1994 and 1999, falling from 22.6 % on 1994 to 9.2 % in 1999 and reaching 6.5% in 2003.

1.3. Major Challenges Colombia Faces

The country faces three major challenges. The first one is the productivity and innovation challenge; the second one is that of the competitive restructuring of the economy, the adoption of the new technologies and the successful insertion into the globalized Knowledge-based economy of the XXIst century; and the third one is that of assuring a development model based on social inclusion and the high level of social conflict this situation has generated in the last two decades with the high social and economic cost this has. A brief description of each one follows.

The Productivity and Innovation Challenge

Industrial development in Colombia has been characterized by the development of light industry. The capital goods industry and heavy industry are characterized by a high proportion of import-utilization (“*tasa de penetración de importaciones*”). Competitiveness of Colombian industry concentrates in some consumer and intermediary goods. In the early nineties a major change in economic policy took place with the abandonment of the import-substitution strategy that had predominated in the previous thirty years. The liberalization of the economy had mixed effects. On the one hand, as pointed out above, it laid the foundation for the economy to exceed its historic growth levels. As a result, between 1993 and 1995 the economy grew an average of 4.7 % per year.

On the other hand, the weak incorporation of technology into Colombian enterprises and the lower costs of imports led to a serious limitation in the competitiveness of several industrial sectors leading to their disappearance.¹ Only a few industrial sectors have improved their competitiveness, measured by the proportion of the national production that is exported (“*tasa de apertura exportadora*”). Outstanding cases are those of clothing (“*confecciones*”) and leather goods (“*artículos de cuero*”). In these sectors Colombian enterprises have reached a competitive level globally, reflected by the fact that from 60 to 70 % of their production is exported.

The main problem the Colombian productive sector is confronting is that of the ***drastic fall in productivity*** that emerged in the mid nineties, as a consequence of the limited capacity to incorporate technology and to promote innovation in Colombian enterprises. From 1950 to 1995 there had been a gradual but steady increase in productivity (multifactorial productivity). The figures are quite eloquent. Using 1950 as the baseline, productivity increased to 110 in 1956, to 120 in 1964, to 130 in 1970, to 140 in 1974, to 150 in 1991 and to 153 in 1996. The most rapid increase in productivity took place between 1966 and 1975, when productivity jumped from 120 to 140 (using 1950 as the baseline of 100). Throughout the import-substitution period the annual increase in productivity was 1.43 %. By 1996 the impact of the liberalization of the economy and the lack of technological dynamism in several sectors caught up and the productivity trend changed drastically. Productivity levels decreased in most productive sectors leading to the gradual deterioration of the economy in the 1996-1999 period, specially to the major economic recession that took place in 1999.

Competitive Restructuring, New Technologies and Insertion into the Knowledge Economy

In this context three complementary problems have emerged: (a) how to cope with the challenge of competitive restructuring in order to evolve from the production structure that had emerged throughout the import-substitution strategy that was no longer competitive and sustainable in the open market

¹ See Luís Jorge Garay et al.: *Desempeño y Evolución de la Industria en Colombia 1967-1996*; Bogotá, Tercer Mundo Editores and COLCIENCIAS, 1998.

environment of the nineties; (b) how to incorporate the New Technologies that are transforming the production environment in most sectors (i.e. information and communication technologies – ICTs, biotechnology, new materials); and (c) how to manage the previous two processes in such a way as to be able to incorporate the national economy into the *globalized knowledge-intensive economy* that predominates in the XXIst century. With production systems becoming increasingly knowledge-based, not only in industry but also in agriculture, in natural resource management and in the service sector, the access to this knowledge through Knowledge Networks has become of strategic importance.

In Colombia some sectors have succeeded to integrate the new technologies, specially ICTs, being able to achieve a very significant increase in productivity. An outstanding case is that of maritime ports, where ports like Cartagena and Buenaventura have been able to increase by five their historical productivity level. The port wharf has basically not changed since it was constructed many years ago, being the main limitation to the number of ships and the volume of freight it could handle. With the full informatization of the port and of all its operations, coupled with the massive use of containers, the increase in productivity of ports has been one of the most outstanding ones in Colombia. There are interesting similar cases of informatization of specific enterprises, even in traditional production chains, such as the case of *Confecciones Leonisa* in women's clothing and *Grajales Hermanos* in fruit production. But in most industrial sectors this is not yet happening. This is particularly worrisome in light of the recent findings of research carried out by Nicolas Curien and Pierre-Alain Muet for the *Conseil d'Analyse Économique de France*, where it was found that in OECD countries from 0.35 to 0.95 % of economic growth in recent years is being generated by the massive adoption of the new ICTs technologies. This research has clearly shown that the so-called Robert Solow Paradigm of little impact on productivity by increased investments in ICTs no longer holds, but under the condition that the industry re-thinks its own business in order to really take advantage of the potential offered by the new technologies.² It is not a matter of simple technology adoption. If Colombian firms are not able to respond to this challenge they will loose competitiveness, even in those sectors where currently they are competitive.

The knowledge-intensive economy is introducing important changes in the innovation process itself. Traditionally the this process was basically dominated by *product and process innovation*, these being the two basic forms of technological change. In the new context, competitive enterprises are increasingly characterized by a third type which is that of *innovation based on knowledge-management* (i.e. market information, knowledge of customer requirements, knowledge on changes in the environment and their implications, identification of opportunities, etc.). Colombian firms and production chains are more acquainted with the product and process innovation, where most of the effort has concentrated. There s much less of a capacity in responding to the need to proactively introduce knowledge-management innovations. This again refers to a factor previously mentioned: the importance of being able to tap into regional and global knowledge networks that can provide a clear support to the development of knowledge management innovation capacities.

Coping with Social Consensus, Social Inclusion and Social Conflict

The development of social consensus in Colombian society has become one of the most serious challenges in its recent history. Despite government efforts, it has not been possible to reduce poverty levels, both in the urban and in the rural sectors. The proportion of the population below the poverty line (persons earning less than US\$ 2 per day) was that of 54.9 % in 1999, 54.8 on 2000 and 54.9 in 2001. The equivalent proportion of the population under the level of indigence (persons earning less than US\$ 1 per day) was that of 26.8 in 1999, 27.1 in 2000 and 27.6 in 2001. Food security has now become a

² See Nicolas Curien and Pierre-Alain Muet: *La Société de l'Information*; Paris, Conseil d'Analyse Economique (CAE), 2004.

problem in regions of the country that traditionally have been self-sufficient in food, increasingly relying on food imports. One of the most serious challenges the country faces is that of adopting policies that may assure a development pattern based on social inclusion, avoiding the social exclusion forces that have appeared in recent years and that have increasingly led to social conflict.

The immediate impact of this situation is the high level of internal strife and violence that Colombia has confronted in the last three decades, with much deeper historical origins. But besides the social exclusion factors, the Colombian conflict is generated by a complex mix of historical contention over land ownership, common criminality, narcotics-related crime and insurgency (FARC and ELN). Since the mid-1980s narcotics have totally transformed the conflict by providing larger amounts of funding.

The economic impact of this situation of social conflict is quite significant. “Violence annually costs an estimated 25% of growth in GDP. The average cost of violence for Latin America is 14.2 % of the region’s GDP, estimated at US 168 million annually and up to half of the private capital invested.”³ As can be seen in Table 2, El Salvador and Colombia are the two countries of the region with the highest economic impact of the internal strife. Violence is the principal cause of death and the greatest public health problem in the country.

Table No. 2 – Comparative Economic Costs of Violence as Percent of GDP

	El Salvador	Colombia	Venezuela	Brazil	Perú	México
Direct Costs	9.2	11.4	6.9	3.3	2.9	4.9
Loss of Wealth	4.3	5.0	0.3	1.9	1.5	1.3
Material Loss	4.9	6.4	6.6	1.4	1.4	3.8
Indirect Costs	11.7	8.9	4.8	5.6	1.6	4.6
Productivity, Investments	0.2	2.0	2.4	2.2	0.6	1.3
Work, Consumption	11.5	6.9	2.2	0.4	1.0	3.3
Transfers	4.0	4.4	0.3	1.6	0.6	2.8
TOTAL	24.9	24.7	11.8	10.5	5.1	12.3

Source: Gabriel Marcella: *The United States and Colombia: The Journey from Ambiguity to Strategic Clarity*; The North-South Institute of the University of Miami and the Strategic Studies Institute, May 2003, p. 21.

1.4. Human Resources and Migration: The Emergence of the Diaspora

According to Adela Pellegrino and Jorge Martinez by 1990 there were 11,030,840 migrants from Latin America and the Caribbean distributed throughout the world, of which 74.5% of this migration was concentrated in the United States. Nevertheless the *rate of increase* of this migration has been diminishing in the last forty years, as can be seen in Table 3. The rate of increase of this migratory movement has been higher in Colombia than in Latin America in general in the past (mainly in the sixties and in the eighties). It is interesting to point out that this rate of increase was lower in Colombia than in the region, despite the situation of internal conflict and economic recession that characterized this decade. Nevertheless, in terms of the size or volume of this migration Ecuador and Colombia represent the two

³ See Gabriel Marcella: *The United States and Colombia: The Journey from Ambiguity to Strategic Clarity*; The North-South Institute of the University of Miami and the Strategic Studies Institute, May 2003, pp. 19-22.

countries that have contributed the most to it, Ecuador representing 29.8 % of this population and Colombia representing 17.2 %.

Table No. 3 – Rate of Increase of Migration from Latin America and the Caribbean to the United States

Years:	Increase (%) of migration from Latin America & Caribbean	Increase (%) of migration from Colombia:
1960 – 1970	120.7	175.8
1970 - 1980	87.6	84.9
1980 – 1990	66.0	71.4
1990 – 2000	62.0	42.8

Source: Adela Pellegrino and Jorge Martinez: *“Una Aproximación al Diseño de Políticas sobre la Migración Internacional Calificada en América Latina”*; Santiago, CELADE-FNUA/CEPAL, Serie 23 Población y Desarrollo, 2001.

Table No. 4 – Educational Level of the Migration from Latin America: Proportion of Migrants with Tertiary Level Training

Country:	Migrants with Tertiary Level Training (%):	Country:	Migrants with Tertiary Level Training (%):
Brazil	54.6	Colombia	46.2
Perú	52.9	México	14.0

Source: Richard Adams: *“International Migration, Remittances and the Brain Drain: A study of 24 Labor Exporting Countries”*; Washington, The World Bank, PRMPR, Policy Research Working Paper 3069, June 2003.

A recent study done by Richard Adams for the World Bank (2003) shows that, if one takes into consideration only the population above 25 years with some level of education (primary, secondary and tertiary), there are two main patterns that emerge as can be seen in Table 4. In some countries close to 50% of the migrants have tertiary level training, thus with a heavy concentration on highly trained human resources. As can be seen in Table 4, 54.6 % of the migrants of Brazil, 52.9 % of the migrants of Perú and 46.2 % of the migrants of Colombia are in this category. In the case of countries like México a different pattern emerges in terms of educational level: only 14 have tertiary level training, with a higher concentration of migrants with primary and secondary levels only.

In a recent report prepared by Alejandro Gaviria on Colombian migration to the United States, some interesting characteristics of this population movement appear:⁴

- a) In terms of the total volume of this migration, estimates range widely from 500,000 to 700,000.
- b) Migrants have three years more of schooling than the average level of schooling in Colombia.
- c) The personal income level of migrants is double the average income level of residents in Colombia.
- d) The education level of migrants has been increasing over time. Before 1995 the average education level of migrants was 11.8 years of schooling; after 1995 it became 12.6 years of schooling and after 1998 12.8 years.

⁴ **Alejandro Gaviria:** *“Visa USA: Fortunas y Extravíos de los Inmigrantes Colombianos en los Estados Unidos”*; Bogotá, Universidad de los Andes, Documento CEDE 2004-17, marzo 2004.

This same study identifies the *changing reasons that have fueled migration* over the last decades, highlighting the following ones (see Gaviria 2004):

- From 1965 to 1975 migration was stimulated by the reform of migratory regulations in the US.
- From 1975 to 1985 migration was clearly fueled by the illicit drug business and persons related to it.
- From 1985 to 1995 Colombian migration to the US stabilizes (decrease in rate of growth) and it is stimulated by a combination of factors with a gradual predominance of factors related to the increasing internal conflict.
- After 1995 migration continues at a level below previous years, but clearly fueled by the situation of internal conflict and the economic crisis of the second half of the nineties.

These and other recent studies on migration from Colombia and from Latin America and the Caribbean corroborate the main hypothesis on which the *Red Caldas* was established in the early nineties. The increasing migration of highly trained human resources to developed countries due to the disparities of job opportunities, research facilities and income levels, poses a serious challenge to developing countries. They either consider this migration as a loss in terms of the investment they have made (through a “*brain drain*” process), or they seek to integrate this expatriate community as an extension of their own scientific and business communities, taking advantage of their capacity to facilitate access to knowledge through their participation in knowledge networks in which they participate.⁵ This leads to the evolution that is taking place in the concepts of *brain drain* to *brain exchange*, *brain circulation* and *brain gain*, leading to the increasingly important role the *scientific and business diasporas* can play. In the remainder of this chapter we will analyze how this is taking place in the case of Colombia.

2. Nature, Objectives and Functions of the *Red Caldas*

2.1. Mission and Objectives of *Red Caldas*

The general objective of the *Red Caldas* when it was established was to integrate the research potential of young Colombian researchers abroad, basically carrying out graduate studies in universities or linked to research labs, making them part of the Colombian scientific community and of national research programs. The purpose was clearly to strengthen national research capacities and to contribute to the internationalization of the Colombian scientific community through the contacts and collaborative research efforts with research groups in other countries facilitated by Colombian researchers abroad. Thus, the *Red Caldas* was explicitly aimed at integrating the scientific diaspora in order not to consider them as a loss to the country through the brain-drain.

The close relationship between the development of the *Red Caldas* and the concomitant development of a large Graduate Training Program supported by COLCIENCIAS that significantly increased the number of Colombian graduate students abroad, specially at the doctorate level, can be seen in Table 5. From 1992 to 1997 COLCIENCIAS sent abroad from 50 to 176 graduate students per year, gradually constructing a community of close to 850 graduate students located in the best universities of the world, most of them at the PhD level (totally funded with national funds). This community of Colombian graduate students

⁵ Besides the reports mentioned in Tables 3 and 4, see: Adela Pellegrino: “¿Drenaje o Éxodo? Reflexiones sobre la Migración Calificada”; Montevideo, Universidad de la República, Programa Población, marzo 2001. Adela Pellegrino: “La Migración Internacional en América Latina y el Caribe: Tendencias y Perfiles de los Migrantes”; Santiago, CEPAL, Serie 35 Población y Desarrollo, marzo 2003. Andrés Solimano: “Globalización y Migración Internacional: La Experiencia Latinoamericana”; Santiago, Revista de la CEPAL, No. 80, agosto 2003.

became the backbone of the Red Caldas. The years of expansion of this program (1992-1997) totally coincide with the years of strong development of the Caldas network. In 1998 this program almost disappeared, with practically no students being sent abroad in the following four years (1998 – 2001). The impact of this drastic reduction was immediately felt by the “National Nodes”, who found out that no new young Colombian researchers were arriving any more. This is one of the main “limiting factors” that the few nodes that have survived mentioned in an interview by the authors carried out in early 2004 in Brussels, leading to the weakening of the *Red Caldas*.

Table No. 5
No. of Students sent abroad for Graduate Training by COLCIENCIAS

Year	PhD:	Magister:	Total
1992	54	1	55
1993	84	5	89
1994	50	1	51
1995	118	3	121
1996	112	14	126
1997	136	40	176
1998	0	0	0
1999	0	0	0
2000	6	2	8
2001	6	3	9
2002	125	13	138
2003	73		73
Total	764	82	846

Source: COLCIENCIAS data on Graduate Training Program.

This explains an important characteristic of the Red Caldas. It is a network that brings together the *scientific diaspora*, basically based on university graduate students and young researchers in research labs, that were being integrated into the Colombian scientific community and in order to take advantage of the potential role they could play in helping to internationalize the latter. The main practical objective that was pursued was the development of “*collaborative research projects*” between Colombian research groups and research groups in the universities where these students were studying. It only very partially covers other development-related components of the Colombian diaspora, such as professionals in enterprises and in other types of organizations that could play an equally important role.

The activities of the Caldas Network were mainly organized around the following lines of action:

- a) **Identification of areas of potential scientific cooperation through *collaborative research projects*, between research groups in Colombia and their colleagues abroad.** This was done through the organization of workshops or symposia, either at the general level (such as the First Global Symposium of National Nodes that took place in 1994), or at the specialized level (such as the Workshop that was organized in 1997 on Research on Catalytic Cracking in Oil Production, as part of a process of formulating a joint research program in this area).
- b) **Support to Graduate Training Abroad and Reinsertion of Graduate Students (“*Retorno de Investigadores*”).** As pointed out above, the *Red Caldas* basically developed on the basis of the expansion of Colombian graduate students abroad that took place between 1992 and 1997 (see

Table 5). Thus, three important functions it played were: (a) to seek additional resources or facilities that could complement the COLCIENCIAS funds for graduate training in those countries; (b) facilitate the return of these students/researchers to Colombia in order to assure that high-level trained scientists would be incorporated into the Colombian scientific community; and (c) in the case of those researchers that remained abroad at the end of their graduate studies, provide a link between them and Colombian research groups in order to take advantage of their capacity in developing research projects of relevance to the country.

- c) **Visiting Fellows and Exchange of Researchers.** Through the *Red Caldas* COLCIENCIAS supported Visiting Fellows and Exchange of Researchers in both directions: Colombian researchers going to visit universities and labs abroad, or researchers from other countries coming to visit Colombian universities. This exchange of researchers played a strategic role in the development of joint research projects. It also led to collaboration agreements between universities in Colombia and in other countries. This exchange of researchers was often co-funded with institutions from those other countries (i.e. NSF in the US, DAAD in Germany, etc.).
- d) **Information and Dissemination Activities.** From the beginning, the Caldas Network developed strongly based on the use of Internet and e-mail, that were expanding very rapidly in the early nineties. One of the main functions assigned to the network was that of assuring a *flow of information* from Colombia to the network members in the various countries around the world, as well as from these members to researchers and research groups in Colombia (two-way flow of information). This information relates to scientific events, publications, research trends and research results, training opportunities, etc. This Information System led to the development of data bases on Colombian Researchers abroad, through the construction of mailing lists and related instruments. The coordination of this Information System was heavily centralized in COLCIENCIAS, becoming one of the main weaknesses of the *Red Caldas*, as will be argued in section 4 below. The real nature of the Internet as a *decentralized communication web* was not well understood at that time, except towards the end of the nineties when the evolution towards the specialized research networks took place (see sections 3.2 and 4.2).
- e) **Tapping into Specialized Knowledge Networks.** There is a fifth line of action that gradually developed in the second phase, when the Red Caldas evolved towards more *Specialized Research Networks*, not necessarily related to the National Node structure of the first phase. All the reports of the *Red Caldas* mention only the first four functions or lines of action described above. It is only in the second phase, towards the end of the nineties and the early 2000's, that the emphasis gradually shifted towards this fifth function (see section 3.2). By then it had been realized that in the Knowledge Societies of the XXIst century knowledge does not always flow freely as "pure public goods". Knowledge is increasingly being generated by "specialized communities and networks" that work in a given area or topic, and the access to this knowledge is increasingly dependent upon participation in such networks. This led to the realization that the diaspora could play an important role in facilitating access to these specialized knowledge communities or networks. In this perspective, the emphasis is no longer exclusively placed on generating "joint research projects" as was the case in the first phase.

The emergence of the fifth function or line of action requires a much more *strategic view of what is happening in science at the global level*: what are the main trends, what are the critical advances and breakthroughs being made, what are their implications, what opportunities are being generated for Colombia, what are the challenges of scientific and technological changes for the Colombian production structure (including potential negative impacts), etc. With this strategic view, one can then identify what are the strategic knowledge networks or communities in which it is critical to participate in order to be able to harness the potential of science and technology for the development of the country. The first

effort to move in this direction can be seen in the Hannover 2000 Program that will be described later, which is at the interphase of the evolution of the Node-based Red Caldas towards the more decentralized structure of the specialized research and knowledge networks of the second phase.

2.2. Organizational Structure

The organizational structure of the Red Caldas was quite simple and flexible. In the first phase (1992-1997) it basically had three components:

- a) *National Nodes* in the main countries of the world where there was a sufficient critical mass of Colombian graduate students and researchers to be able to constitute a formal or informal local association. By 1994 the Caldas Network had 29 nodes located in 27 countries, with 874 graduate students and/or researchers affiliated to them (in the larger countries, such as the US, there could be more than one Node). COLCIENCIAS provided some seed-money to support these nodes, allowing them to acquire a computer for their secretariat, hire a secretary or an assistant, get into Internet and construct a local database (mailing list) of Colombian researchers in that country. Quite often the secretariats of the nodes were located in the respective Colombian Embassy. An interesting evolution took place in some of them (i.e. Brussels), where the Node started bringing together not only Colombian researchers but also researchers from the host country interested in Colombia or in topics related to the development of the country (i.e. biodiversity and tropical agro-ecosystems). This led some of the Nodes to integrate the “*Colombianistas*” into the activities they carry out.
- b) A *Central Coordination Node* located in COLCIENCIAS, that managed the information and communication system that linked all the nodes in the Caldas Network, facilitated links with research groups in Colombia, provided information on Colombia, helped to organize workshops to formulate collaborative research projects and provided financial support for the projects that were finally approved through the peer review system. It will be argued below that this excessive concentration in COLCIENCIAS was a major weakness of the *Red Caldas*.
- c) The third organizational component was the *Information and Communication System* that linked the various nodes into a global network. As pointed out above, from the beginning the development of the Caldas Network was strongly based on the Internet and the extensive use of e-mail. Thus, databases of Colombian researchers and mailing lists to facilitate communication played an important role.

Although the National Nodes played a very important role, at the global level the network model adopted was too centralized and too heavily based on COLCIENCIAS support and initiatives. Despite the fact that the Internet was being used, the real nature of the Internet as a *decentralized web-based communication environment* was not well understood. The centralized model that emerged proved to be a fatal mistake. In *network models* there are two important types, among others, that are described in Figure 1. Figure 1-A graphically shows the *Centralized Radial Network* model that was adopted by Red Caldas, while Figure 1-B shows the *Decentralized Network* model that operated in the second phase, when a gradual shift took place towards the “*specialized research and knowledge networks*”, that basically operated as decentralized networks.

The fact that many of the key actors in *Red Caldas* insisted in making the system operate properly on the basis of the Centralized Radial Network Model led to the weakening of the system. It did not understand the opportunity that had emerged of evolving towards a “*Network of Networks*”, where the Caldas Network could have sustained and increased the momentum it had built up by abandoning the centralized model and becoming a federation of specialized networks, while at the same time retaining some of the

general information and support functions that the National Nodes could continue to provide. We will come back to this point in section 3.2 below.

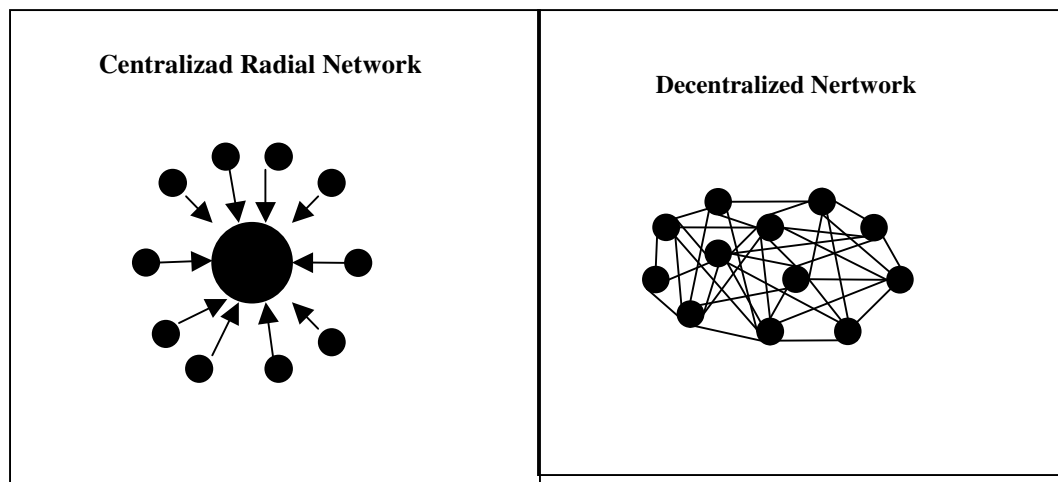


Figure 1-A – Centralized Radial Network

Figure 1-B – Decentralized Network

Figure 1 – Network Models

2.3. Main Actors and the Role each one Played

There are four types of actors that played a key role in the development of the Caldas Network.

- ☛ **Members of the Nodes, basically constituted by Colombian graduate students and researchers abroad:** This is the target population of the Caldas Network and the main actors behind most projects and activities carried out. In recent years the “*Colombianistas*” have been integrated into some of the nodes, generating a more proactive participation by the scientific community of the host country.
- ☛ **Colombian Embassies and Consulates:** They played a very important role in providing support to the Node by housing its Secretariat and by integrating the *Red Caldas* functions into the normal responsibilities a diplomatic mission carries out. Besides the immediate support, the most important impact of this “alliance” was that for the first time the Colombian Diplomatic Service formally introduced the topic of science and technology into the normal functions it performs. This led the basis for the more recent emergence of the “*Diplomacia Científica*” (Scientific Diplomacy) Program that the Ministry of Foreign Relations and COLCIENCIAS are currently developing.
- ☛ **COLCIENCIAS and the National Science and Technology System (NSTS):** These two actors are the main counterparts in Colombia of the diaspora members abroad. COLCIENCIAS is the main promoter and funding agency that supports the Red Caldas; the researchers and research groups that constitute the NSTS are the main partners that have developed the collaborative research projects that constitute the lifeblood of this network, specially during its first phase. The National Research Programs that exist in key areas of interest to the country played an important role in this process.

- ☛ **Scientific Leaders that play an Articulating or Catalytic Role (“Gatekeeper Role”):** All initiatives and projects that were formulated and developed within the framework of the Red Caldas always had a key person that played a leading role in establishing the contacts, in facilitating a dialogue among potential partners, in organizing the project-development workshops and in conceiving and orienting the collaborative research project that emerges. The most successful cases required two such persons: a scientific leader that is part of the diaspora located in a given country, and a scientific leader in Colombia that “teams-up” with him/her. When this type of leader did not emerge, the ideas and possibilities that were identified never crystallized into concrete projects or programs. This *Gatekeeper Role* played by outstanding researchers was essential for the functioning of the system.

3. Main Phases in the Development of *Red Caldas*

Three phases can be identified in the development of Red Caldas: (a) the first phase is characterized by the central role played by the National Nodes in developing collaborative research projects (1991-1996); (b) weakening of the Node structure and emergence of the specialized research and knowledge networks (1995-2001); and (c) identity crisis and projecting the lessons learned from the *Red Caldas* into the future (2001-2004). A brief description of each phase follows.

3.1. First Phase: Research Partnerships and Project-development led by the National Nodes (1991-1997)

The first phase of the development of the Caldas Network covers the first seven years of its existence. The first three years were dominated by the establishment of the National Nodes in the various countries where there was a critical mass of Colombian graduate students and researchers. Between 1991 and 1993 29 Nodes were established covering 27 countries and bringing together 874 researchers and graduate students located in those countries (see Table 1). In June 1994 COLCIENCIAS organized the *First Global Symposium of National Nodes of the Red Caldas*, with the purpose of identifying the main research areas that are both of importance to Colombia and of interest to research groups in the different countries where the network operates. On the basis of this “convergence of interest”, working groups were established to formulate joint research projects bringing together researchers in Colombia, Colombian researchers in the various counties (the Diaspora) and researchers from developed countries that were interested on these topics. The main results of this symposium were: (a) the establishment of a strategic framework for this program, (b) the formulation of a research agenda and the identification of potential projects to be carried out jointly by researchers in Colombia and abroad, and (c) the identification of specific research groups that were interested in the topics included in the research agenda.

In the next three years (1994-1997) a very important effort was made by the various social actors involved in formulating and developing specific projects that could be carried out through “*research partnerships*”. The *Red Caldas* did not establish a registry of such projects, and so it is difficult to determine how many projects were successfully formulated and implemented. In section 4 a few examples of such collaborative research partnerships and what they generally covered will be given.

This first phase culminated with the *Second Global Symposium of National Nodes* that was organized by COLCIENCIAS in May of 1997. Three main topics were covered in this Symposium. The first one was a review of some of the most successful projects that had been implemented in the last three years (1994-1997). Secondly, the Symposium analyzed the experience of the Red Caldas as a “new organizational mode” that allows scientific research communities in developing countries to internationalize themselves and to integrate their efforts with global science. Thirdly, attention was given to an analysis of the

limiting factors that were weakening the Caldas Network and eroding its effectiveness. Some of these factors will be mentioned in the next section. Two books were published with the cases and studies presented at this symposium.⁶

3.2. Second Phase: Weakening of the Node structure and Emergence of the Specialized Research and Knowledge Networks (1995-2001)

Parallel to the development of the *Red Caldas* there was a second process taking place throughout the nineties related to the increasing participation of Colombian researchers and research groups in specialized research and knowledge networks. These networks were being developed in different areas of science and technology, and with the participation not only of researchers but also of stakeholders and other end-users of knowledge.

In the second half of the nineties two complementary processes took place. The first one was a gradual weakening of the *Red Caldas* that started losing the momentum it had built up in the first half of that decade. The second one was the increasing importance of the specialized research and knowledge networks in achieving the objectives that had been established for this network. Among the factors that contributed to the weakening of the Caldas Network three aspects should be highlighted:

- a) The first one is related to the gradual loss of focus on the strategic objectives that initially had been developed in the 1994 Symposium of National Nodes, being replaced by other functions that gradually became more important in the day-to-day operation of the network, such as providing support to the information needs of Colombian students abroad and receiving complaints from them when something did not operate properly. There are some very good exceptions to this, such as the Catalytic Cracking Network and the Robotics Network that emerged from these efforts, analyzed below.
- b) The second one reflects the fact that the *specialized research and knowledge networks* proved to be more efficient both as tools for carrying out collaborative research projects, and as means for tapping knowledge that is being generated by “specialized research communities” that is important to the country.
- c) The third limiting factor was the insistence in the Centralized Radial Network model that the *Red Caldas* adopted, instead of using the Decentralized Network model that is more participatory and agile (see Figure 1). This centralization of functions in COLCIENCIAS, where the National Nodes interacted with the Central Node with relatively little interaction among them, led to inefficiencies in the system. With the growing importance of the specialized networks the Caldas Network could have evolved in the direction of a *Network of Networks*, which in fact was recommended by an external review carried out in 1998. But this recommendation was not accepted and an interesting opportunity of *organizational transformation* to keep up the momentum was lost.

3.3. Third Phase: Identity Crisis and Projecting the Lessons Learned from the *Red Caldas* into the future (2001-2004)

In this third phase most of the National Nodes lost their relevance and gradually started disappearing with some very interesting exceptions, such as the *Brussels Node* and the *Node in Switzerland* that continue to

⁶ See Jorge Charum and Jean-Baptiste Meyer (eds.): “*Hacer Ciencia en un Mundo Globalizado: La Diáspora Científica Colombiana en Perspectiva*”; Bogotá, Tercer Mundo Editores and COLCIENCIAS, 1998. And Jean Baptiste Meyer and Jorge Charum (eds.): “*El Nuevo Nomadismo Científico: La Perspectiva Latinoamericana*”; Bogotá, ESAP, 1998.

be quite active, until today. The disappearance of the Nodes is a consequence of the cumulative effect of the three factors mentioned in the previous section, with two additional important factors that should be mentioned. With the budget constraints that COLCIENCIAS confronted in the late nineties and the early 2000's the support to the National Nodes was discontinued. With a few exceptions (i.e. Brussels and Switzerland), the nodes had not been "appropriated" by the local community in the respective countries (constituted by Colombian researchers and other social actors). Thus, when the support "from the center" diminished the Nodes practically disappeared, since the role they played and their relevance had not really been internalized and appropriated by the local constituency or stakeholders. This is one of the implications of having adopted the Centralized Radial Network model. When the Decentralized Network model is used local stakeholders are much more involved given the greater degree of participation and of "local ownership".

Equally important was the negative impact of the practical disappearance of the COLCIENCIAS Graduate Training Program in 1998, 1999, 2000 and 2001 (see Table 5). This Program started operating again in 2002, although at a much more reduced level of funding, and thus of students. Given the fact that the *Red Caldas* was very dependent on the Colombian graduate student community abroad, the fact that this continuous supply of students was abruptly interrupted had a severe impact on the system. The impact was felt two or three years after the program collapsed when many of the leaders of the Nodes who were there as graduate students started returning to the country, without being replaced by new graduate students that were arriving each year.

4. Innovative Cases in Developing Collaborative Research: Building-up Research Partnerships and Taping Global Knowledge Networks

As pointed out above, the two overriding concerns of the *Red Caldas* were to promote the internationalization of the Colombian scientific community by integrating the diaspora to the former, and to facilitate and support research partnerships between Colombian research groups and research groups in other countries on topics of interest to the country. In this section we will look at examples on how these partnerships were built and how they operated. We will look at examples that emerged in the two main phases analyzed in sections 3.1 (*Research Partnerships and Project-development led by the National Nodes*) and 3.2 above (the *Specialized Research and Knowledge Networks*).

4.1. Innovative Research Partnerships Generated by the Interaction between National Nodes and Colombian Universities (First Phase)

The first phase of the *Red Caldas* was based on the activities carried out by the *National Nodes* that were established in 27 countries where there was a sufficient critical mass of Colombian graduate students and researchers to justify the establishment of an association, with a secretariat that was normally based in the Colombian Embassy or in a local institution. These National Nodes carried out five types of activities:

- a) formulation and implementation of collaborative research projects;
- b) promote collaborative projects between host-country universities and Colombian universities to support graduate training programs;
- c) promote institutional support projects aimed at strengthening research centers in Colombian universities;
- d) support exchange of researchers and university professors;
- e) develop general collaboration agreements between universities and/or research centers.

In those research areas that were considered to be of high importance to the country (i.e. identified in the 1994 Symposium or through the interaction between Colombian researchers and researchers abroad), a mix of two or three of these activities were organized and carried out, since they complement each other

quite well. In this section we will analyze two outstanding cases: the case of the Catalysis Network that was developed by the Belgium Node and the Environmental Impact Program that was developed by the Switzerland Node, in collaboration with others

The Case of the Catalysis Network and its Application to the Oil Industry

This research program was spearheaded by the Belgium Node, in collaboration with the France and Spain Nodes, working in collaboration with the *Colombian Catalysis Network*. This network emerged in the First National Symposium on this topic that was held in 1986, constituted by a group of Colombian Universities, the Colombian Oil Research Institute (ICP) and ECOPETROL (the Colombian Oil Company). A Latin American Network soon emerged, integrating universities and technological research institutes of Argentina, Brazil and Mexico. Catalysis has a wide range of applications, but one of its important applications is in the oil industry, where through this process (catalytic cracking and hydrotreating) heavy crude fractions can be converted into light gasoline and fractions which are easier to pump through oil pipelines, thus reducing operational costs and increasing efficiency in the oil transportation system. This was the reason for the clear interest that ECOPETROL and ICP expressed in research on these topics and provided support to the network as such.

There is a group of European universities that were working on similar topics, with similar applications. Here the Respective National Nodes and Colombian researchers in those countries (the diaspora) played a “bridge function”, placing in contact research groups in Colombia with their counterparts in Europe. These initial contacts led to the *Iberoamerican-European Symposium on Catalysis* that took place in Bogotá in 1995, organized by COLCIENCIAS, the Colombian Catalysis Network and the National Nodes of Belgium, France and Spain. Among the European universities researchers from the following universities participated: University of Louvain, the Petrochemical Research Institute of Gant, the University of Poitiers, the University of Nottingham and the CYTED Program of Spain. Two main products emerged from this symposium that provide a good example of the type of program that Red Caldas carried out: (a) a *Common Research Agenda* that served as a unifying platform for the network; (b) a *Training and Exchange Program* through which graduate students were sent to advanced training in the Universities of Louvain in Belgium and Poitiers and Marseille in France, as well as exchange of visiting professors among the participating universities; and (c) an *Information System* to allow participants to tap the knowledge basis of the centers of excellence that formed part of this network. In Colombia several universities participated, such as UIS, Universidad de Antioquia, Universidad del Valle, Universidad Nacional and others (as well as ICP and ECOPETROL).

The common research agenda was organized around the following topics:

- Environmental catalysis
- Computational catalysis (modeling)
- Catalytic valorization of natural products, such oil palm
- Catalytic cracking and hydrotreating of heavy crude fractions

In order to make the bridge between university research and production requirements ICP constructed a Pilot Plant to scale-up and test laboratory results. Besides various technological results that have been integrated into the oil industry of the participating countries, the network facilitated access to information and knowledge on various topics related to this field, not only to researchers but also to ICP and ECOPETROL, the Colombian Oil Company. When specialized knowledge was required for troubleshooting or other problems the network operated as a source of knowledge and of experts.

The Case of the Environmental Impact Analysis Program/Network

This program emerged with the support of Switzerland on the basis of a common research agenda that was initially developed by a group of Colombian and Swiss institutions. The Swiss Node played an important role in facilitating the articulation of this program. This collaborative research effort was coordinated by University del Valle in Colombia, in collaboration with Universidad Surcolombiana de Huila, local governments of the townships (“*municipios*”) that participated in this program in the Boyacá State in Colombia and ICP. The two main organizations from Switzerland that participated in this program are EPFL and ISTE.

The program basically consisted on a research partnership that was established between the participating organizations, both in Colombia and in Switzerland, around the topic of *environmental monitoring and impact assessment*. The program was carried out through seven projects on:

- ☛ Monitoring and control of air quality in Sogamoso, Boyacá.
- ☛ Environmental impact assessment in oil exploration and production
- ☛ Measuring and control of atmospheric pollution and development of impact indicators
- ☛ Treatment of toxic contaminants in industrial waters
- ☛ Analysis of chemical contaminants in water, air and soil
- ☛ Existing technologies for water treatment in small communities
- ☛ Use of Geographical Information Systems (GIS) in environmental impact assessment

These seven projects were all carried out in two regions of Colombia (Boyacá and Huila), combining the same three components mentioned in the previous case: a common research agenda carried out through research partnerships with the active participation of local government and stakeholders; advanced training in these specialized fields; and an information system to facilitate access to knowledge and to expertise, when required, to provide support both to the research process as well as to the environment management process in local communities. In itself, the participants in this program constituted a temporary network, but they also sought to facilitate the participation of the program members in other existing networks related to environment management and impact-assessment, thus integrating this group into the larger *knowledge community* that works on these topics.

From the two examples given in this section on the type of projects that *Red Caldas* developed we can see that the topics change from one case to the other, but the content and scope of these programs are quite similar. They basically comprise: (a) developing a research partnership in order to address specific development problems, involving both researchers and stakeholders; (b) an advanced training component at the graduate or post-doc level in order to build-up the capacity in Colombia in that particular field as an important by-product of each project; (c) developing an information system in order to facilitate the access to knowledge in databases and experts in advanced research centers that participate in each network. Quite often this led to the development of collaboration agreements between participating universities and/or research institutes. For an analysis of more cases that were developed in this first phase see the recent report on the *Red Caldas* and its research partnerships.⁷

4.2. Innovative Research Partnerships generated by the Specialized Research and Knowledge Networks (Second Phase)

The two cases mentioned in the previous section are good examples of the type of partnerships that the *Red Caldas* helped to establish, the approach and the instruments that were used and the type of development impact they generated. Parallel to these events a second process was unfolding of an increasing participation of Colombian researchers, firms and other stakeholders in *Specialized Research*

⁷ **Fernando Chaparro, Hernán Jaramillo and Vladimir Quintero: *Aprovechamiento de la Diáspora e Inserción de Colombia en Redes Globales de Conocimiento: El Caso de la Red Caldas*; Bogotá, Banco Mundial/Universidad del Rosario, 2004.**

and Knowledge Networks. With the gradual weakening of the National Nodes that took place in the second half of the nineties, these specialized research networks became much more important than the former in terms of the objectives pursued by the *Red Caldas*, such as: facilitating the internationalization of the Colombian scientific community through research partnerships with advanced research groups in key scientific fields; facilitating access to knowledge in areas related to development challenges of the country; assuring advanced training; and integrating the scientific diaspora in these efforts. In this section we will analyze three cases of the type of experience that was developed in this second phase.

Globalization and Research Partnerships in the Agricultural Sector

Given the fact that food security, rural poverty and sustainable development play a very prominent role in the global agenda, agricultural research is one of the most globalized scientific research areas. From the mid sixties a network of international research centers was established to carry out research aimed at developing appropriate technology for achieving food security, specially for the rural poor, and assuring sustainable agricultural production systems. This network, which is coordinated by the *Consultative Group on International Agricultural Research* (CGIAR), is one of the largest undertakings in Global Science related to development issues. Its first major contribution is the so-called *Green Revolution* that produced the new varieties of basic food crops that helped to avoid famine in the sixties and seventies in India and other developing countries. This was a major technological contribution to addressing the needs of development, although at the same time it generated serious questions with respect to the sustainability of the new varieties and mono-crop production systems.

In the nineties this global research network was responsible for the main advances in biotechnological research and in informatics applied to agricultural production and rural development problems. These research endeavors are carried out through specialized research networks that bring together researchers in the international research centers, the national agricultural research institutes of developing countries, universities of both developed and developing countries and stakeholders of agricultural research and production (producers, peasant organizations, etc.). Among developing countries, Colombia is the largest investor in this global research network. The Colombian Agricultural Research Corporation (CORPOICA) and other agricultural research centers in the country actively participate in the several research networks that have developed in the context of the CGIAR, such as the Rice Research Network, the Genetic Resources Research Networks, the Agricultural Biotechnology Research Network, the Participatory Research Network and others.

In the late nineties two parallel processes of regional/global agricultural research took place, both with a clear leadership coming from COLCIENCIAS and the Colombian scientific community. The first one was the establishment of the Regional Fund for Agricultural Research and Technological Development (FONTAGRO) and the second one was the emergence of the Global Forum on Agricultural Research for Development (GFAR). Both initiatives, one at the regional (Latin American and Caribbean) level and the other one at the global level, were aimed at strengthening both North/South as well as South/South research partnerships and networks around specific agricultural research and natural resource management problems. These networks bring together agricultural research institutes and universities, as well as NGOs and producer organizations (stakeholders), from both developed and developing countries in research partnerships around agricultural production and environmental management challenges. These networks basically have the same three components already mentioned in the case of the first phase of the *Red Caldas*: (a) a common research agenda that constitutes the basic platform that integrates the network; (b) a strong advanced training component at the graduate and post-doc levels; and (c) an information system closely related to an expert system around specific topics, that facilitates access to the information and knowledge produced by *specialized knowledge communities* that have emerged as part of today's *Global Science*. An additional important characteristic that these specialized networks have is the

very active participation of stakeholders, such as farmers and other end-users of knowledge, to a much greater extent than in the previous networks.

Hannover 2000: Constructing a National Agenda and a Global Agenda

In the late nineties there was an interesting convergence between two processes related to the construction of a “*Strategic Agenda*”. The first one was at the national level and it was aimed at proposing a *National Strategic Agenda* that could coalesce the efforts of all stakeholders in developing a capacity in the country to respond to the challenges of constructing a Knowledge Society in the globalized environment of the XXIst century.⁸ The second one was the process of formulating a Global Agenda on the same challenges through a consultation that was led by Germany, as part of the *Hannover 2000 Expo and Global Dialogue*. It is interesting to see that many common elements emerged in both agendas, such as biodiversity management; food security; the role of the new technologies in development (i.e. biotechnology and informatics); environment management; urbanization; social inclusion, consensus and conflict in contemporary societies. In both cases there was a very active participation of the Colombian scientific community and the Colombian diaspora in this process.

One of the important dimensions of this process was the formulation of a Scientific (Research) Agenda that emerged from the process of developing a National Strategic Agenda, structured around the topics mentioned in the previous paragraph. On the basis of this research agenda a *Colombian-German Program of Scientific and Technological Cooperation* was established organized in five main topics: (a) biodiversity and sustainable management of natural resources; (b) natural sciences; (c) social sciences; (d) innovation and technological development; and (e) biotechnology. Colombian and German coordinators were appointed for each research area and a formal mechanism was established for the identification of research partnerships bringing together research groups from both countries. It was agreed that the research projects that would be identified would be co-funded by Germany and Colombia. An important set of projects were identified and carried out from 1999 to 2002, becoming the most important bilateral program that Colombia has developed with an European country in science and technology.⁹ An interesting characteristic of this collaboration program is that it was considered in Germany to be part of their *international S&T collaboration programs*, not part of the “development-aid” program (the Overseas Development Assistance Program – ODA). This is an important policy change that COLCIENCIAS had been seeking for several years without success. One of the objectives that was being pursued through this strategy was to have access to the *German and European Research Networks* on the five topics of the research agenda that had been formulated (see above), being able to work with the best research groups in these fields.

The main obstacle that was confronted in developing and implementing these projects was the difficulty in coordinating the German and Colombian funding sources, in order to assure the co-funding of collaborative research projects. There were several cases where it was possible to assure this co-funding between the two sources (generally COLCIENCIAS for the Colombian component and the Volkswagen Foundation, the Alexander von Humboldt Foundation and DFG for the German component). In other cases it was not possible to do so; some projects were approved in Colombia and not in Germany, and others were approved in Germany but not in Colombia. The “*synchronization*” between the two funding mechanisms is of central importance in developing collaborative research projects.

⁸ **Fernando Chaparro:** *Conocimiento, Innovación y Construcción de Sociedad: Una Agenda para la Colombia del Siglo XXI*; Bogotá, Tercer Mundo Editores, 1998.

⁹ See “*Status in Germany of the Bilateral Projects within the Framework of the German-Colombian Scientific Agenda and Contact Information of the Counterparts in Germany*”; Bogotá and Berlin; COLCIENCIAS/ACAC/IB-BMBF, 2002.

The Hannover 2000 Program was quite successful in facilitating the participation of Colombian researchers in German and European research networks, especially in the areas of natural sciences, biodiversity management and biotechnology.

The Latin American Macroeconomics Network

The Latin American Macroeconomics Network was established in 1985 with the support of the International Development Research Centre (IDRC) of Canada, with the participation of FEDESARROLLO (Colombia), CEDES (Argentina), the Pontificia Universidad Católica de Rio de Janeiro (Brasil), and CIEPLAN (Chile). As associated members there were two additional groups: the Universidad Católica of Bolivia and the Consorcio de Investigación Económica of Perú. This network played a very important role in the region in advancing macroeconomics research on the main challenges the region confronted in the late eighties and nineties, with the mayor transition taking place from an *import-substitution strategy* to a *liberalized economy*. This network evolved, in the late nineties, to form the IDB Network of Socio-Economic Research Centers.

This network further developed the characteristics that we analyzed above in the Red Caldas Networks:

- a) A research agenda that was collectively developed around common problems faced by the countries in the region: (a) ahorro, investment and anti-inflationary policies and programs; (b) structural adjustment measures and their impact on stabilization policies; (c) structural reforms; and (d) impact of these reforms on employment and income distribution.
- b) Open network structure: besides the researchers who were the members of the network, the latter was open to the participation of key stakeholders, mainly economic policy-makers who were facing the challenges being studied by the network. The network insisted very much on the concept of *knowledge public goods* as the main product that the network produced. This allowed them to work closely with government policy-makers, insisting very much on the autonomy of the researchers vis-a-vis the policy positions of a given government.
- c) High-level training of researchers at the doctorate and post-doc levels was a high priority for the network through a variety of graduate programs that were organized or supported by this network.
- d) Socialization of research results and impact on policy-making in the region: One of the main characteristics of this network was its close interaction with senior policy-makers in the governments of the region and in the international Development Agencies that had an influence in economic policy-making, such as the World Bank, the Interamerican Development Bank, the International Monetary Fund and others. The annual meeting of this network became an important meeting place between researchers and policy-makers in the region, providing a neutral forum for the discussion of very polemical policy issues that were dividing the region and the world. The topic of each annual meeting addressed a major policy and research issue: the Buenos Aires meeting of 1988 was on Adjustment Policies and Processes (“Procesos de Ajuste”); the Santiago de Chile meeting of 1989 was on Structural Reform and Macroeconomic Policy; the Rio de Janeiro meeting of 1990 was on The New Economic Policies in Latin America; the 1991 and 1993 meetings in Cartagena (Colombia) were on Structural Reforms and Capital Flows (1991) and on Macroeconomic Stabilization (1993); the Washington meeting of 1992 was on The Reform of the State and Macroeconomic Stabilization; the Bogotá meeting of 1996 was on The Impact of Structural Reforms on Employment and Income Distribution in Latin America. These meetings brought together the main researchers from the region in this field along with senior policy-makers, and with senior researchers from Europe and North America. A very interesting interaction took

place with the African Macroeconomics Network that was facing similar challenges, being part of the developing world.

5. Main Factors that have Influenced the Evolution of the *Red Caldas*

This paper has analyzed both the way the Caldas Network operated and evolved, as well as concrete examples of the collaborative research projects it helped to establish. The objective of this section will be to summarize the main “*success factors*” that contributed to the most dynamic cases of collaboration, as well as the “*limiting factors*” that inhibited the effectiveness of the system.

5.1. Success Factors that Dynamized and Strengthened the *Red Caldas*

Among the “*success factors*” that led to the most dynamic National Nodes and to the most effective research partnerships the following can be mentioned:

- a) The most dynamic and sustainable Nodes were based on pre-existing associations of Colombian students or professionals in those countries or cities, thus providing a strong local basis for the operation of the *Red Caldas*. This is the case of ACIS in Switzerland and of PECK in New York, where these organizations already existed before the *Red Caldas* emerged, having been established by the local stakeholders.
- b) The most successful cases of research collaboration emerged in those cases where there was a very concrete and identifiable counterpart (stakeholder) in Colombia interested in that particular research topic. There are 12 *National Research Programs* that have been organized in the main areas of science that are of interest to the country. The most successful cases of research partnerships emerged in those research areas where the National Research Program in Colombia assigned a high priority to international collaboration, playing a proactive role in assuring a strong Colombian participation in research partnerships of interest to them. When the respective National Research Program did not show the same level of interest, the role of articulation of research partnerships was left in the hands of the *Red Caldas Liaison Office*. The latter did not have the same type of expertise to give an adequate support in the project-development phase.
- c) In contrast with other diaspora networks that are being analyzed in the World Bank Program, the *Red Caldas* exclusively concentrated on the *scientific diaspora*. Given this orientation, a great emphasis was placed on developing collaborative research projects to be carried out through concrete research partnerships. Other modes of collaboration and of knowledge dissemination were also used, as described in section 2.1 above. But the overriding concern was the development of collaborative research projects. A corollary of this was that the *funding of such projects* became a major concern of the participating researchers and of the Caldas Network in general. In fact, the effectiveness of the network was to a large extent evaluated on the basis of its capacity to mobilize the appropriate funding. The fact that COLCIENCIAS is a research-funding agency greatly helped in making this possible. Furthermore, in 1994-1996 the budget of COLCIENCIAS grew significantly, reflecting the highest level of public investment in S&T in recent Colombian history, thanks to a large loan from IDB for this purpose (the BID-3 Project). The main limitation that was confronted in the funding of research partnerships is that it proved to be very difficult to *coordinate funding agencies from different countries* in order to make research partnerships possible. For example, the coordination between COLCIENCIAS and the European Union proved to be almost impossible in the funding of research partnerships that involved groups in Europe and in Colombia, with a few exceptions where this coordination was achieved.

- d) One of the main motors behind the development of the Caldas Network was the great expansion of the COLCIENCIAS Program on Graduate Training Abroad through which 850 students were sent to top universities around the world, specially between 1992 and 1997 (see Table 5). This cohort of graduate students and young researchers became the backbone of this network.
- e) An important “factor of success” in the most active collaborative research projects that were developed was the presence of a *Scientific Leader* that played an articulating or catalytic role (“Gatekeeper Role”). It was thanks to his/her initiative that researchers from Colombia and from European or North American countries came together and formulated joint research projects. Furthermore, these scientific leaders also played an important role in linking these projects to other activities related to capacity-building, such as exchange of researchers, training of graduate students and the building-up of research networks around the topics being addressed. Although the projects carried out in the Red Caldas were basically research projects and not production-related or innovation projects, in certain cases the best scientific leaders did carry out a clear effort of linking those research activities to development issues and to innovation and production undertakings, including collaborative ventures with enterprises, either in Colombia or in the other countries (or both). It is important to point out that a “*dual leadership*” was a characteristic of the most dynamic and successful cases, since this quite often required a scientific leader in Colombia working shoulder-to-shoulder with a scientific leader in the other participating countries. This dual leadership can be seen in cases such as the Catalytic Cracking Network and the Robotics Network described in section 4.
- f) Internet obviously played a key role in the development of the *Red Caldas*. From the beginning it was e-mail interaction that made possible this network with an intensive use of mailing lists as an important communication instrument. At the same time, it reflected the limitations of the Internet technology at that time. The software that a few years later made possible effective real-time on-line interaction, and thus “dynamic electronic networks”, was still not available. It was simple e-mail interaction through the use of mailing lists that was used. This is one of the technological factors that led to the emergence of the Centralized Radial Network model, with interaction via a central Node instead of continuous dynamic interaction among all Nodes.
- g) The Decentralized Network model developed closely related to the *Specialized Research and Knowledge Networks* of the second phase. In the second half of the nineties and the early 2000’s the specialized networks became more important, parallel to the weakening of the National Nodes. The former proved to be a more effective means of *facilitating privileged access to knowledge on topics of interest to Colombia* that is generated by specialized knowledge networks and communities, on topics such as characterization of biodiversity, specific areas of biotechnology (in agriculture and in health) and robotics. The Hannover 2000 Program played a very important role in facilitating this process. The development of these specialized networks was at the same time a very important boost for achieving the objectives of the Red Caldas, while at the same time becoming a limiting factor, given the fact that the opportunity of evolving towards the role of “*Network of Networks*” was not well understood and thus it was not implemented.

5.2. Limiting Factors that led to Increasing Inefficiencies in the *Red Caldas* based on National Nodes and its Evolution towards Specialized Research and Knowledge Networks

Towards the end of the nineties the Red Caldas loses the impetus it had built up from 1991 to 1997. One of the expressions of this process can be seen in the fact that many of the National Nodes started losing relevance and most of them disappeared. Although the budget constraints that COLCIENCIAS confronted in those years contributed to this process, specially given its reduced capacity to fund

collaborative research projects that had become the core activity of this network, there were other limiting factors that contributed to this process. A brief description follows:

- a) One of the main limiting factors was the network model adopted. Although the web played a very important role in the development of this network, the real nature of the Internet as a *decentralized web-based communication environment* was not well understood. The Centralized Radial Network model that emerged proved to be a major limiting factor. It did not allow the effective utilization of the Internet and the possibility of “*dynamic networking*”. Furthermore, it made the network dependent on the capacity of the Central Node to function properly; when the latter was weakened the system of the National Nodes practically collapsed, being replaced by the parallel emergence of the specialized research networks.
- b) The limited interest shown by some National Research Programs on networking and on “going global” was one of the factors that led to little receptivity to the opportunities of collaborative research projects with colleagues around the world. When the National Research Program internalized this “world view” they integrated such criteria into the peer review system through which projects were selected, giving priority to the support of such projects.
- c) The great emphasis placed by the Red Caldas on the *development and funding of collaborative research projects* was at the same time a strength and a weakness of the system. It was a strength in the sense that it focused the attention of the network on this particular function and purpose. It was a weakness in the sense that it led the network to leave aside very important functions that the diaspora can play, such as *other ways of participating in knowledge networks* in order to have privileged access to the knowledge they generate and manage. There was little interest that was given to *innovation networks* and *industry-based knowledge networks*. With a few exceptions, most collaborative research projects were university-based.
- d) Given the importance given to collaborative research projects, the funding for them became of critical importance to the network. This became the overriding concern of the *Red Caldas*; many researchers looked at it as a funding mechanism. But the funding of collaborative research projects requires the mobilization of funds from at least two sources: a Colombian source to support the participation of the Colombian researchers in the project; and a foreign source in order to fund the participation of the researchers from that (or those) other country (ies). The Colombian source was basically COLCIENCIAS; two funding agencies played a mayor role in the case of foreign funding sources: NSF for US-based projects and the European Union for Europe-related projects. But it is not easy to coordinate funding sources from different countries in order to support international collaborative research projects, since the *peer review systems* of the two or more countries have to be synchronized and made compatible. This was the most important hurdle that was confronted for the operationalization of these projects. The COLCIENCIAS-NSF Agreement went a long way to developing an integrated project pipeline and review system, since both agencies agreed to use the same peer review systems in evaluating collaborative research projects. The agreement also defined who would fund what, and how to divide the “international costs” (coordination workshops, exchange of researchers, etc.). With the European Union it was impossible to develop a similar agreement. As part of this effort COLCIENCIAS tried to negotiate the participation of Colombian researchers in European Research Networks, with little success. The most successful case was the Hannover 2000 Program with Germany that came close to having an *integrated pipeline-and-review system* with German Foundations and government funding agencies. But the effective compatibility and integration of the two funding mechanisms plagued this program, not being possible to reach the integration that was achieved in the NSF Agreement.

- e) In its initial years the Red Caldas developed a strategic framework to orient its activities based on the identification of the development challenges the country faces, such as those described in section 1.2 in this paper. Nevertheless, overtime the network gradually lost focus on these strategic objectives, being replaced by other functions that gradually became more important in the *day-to-day operation of the network*, such as providing support to the information needs of Colombian students abroad and receiving complaints from them when something did not operate properly. This increasing flow of information related to personal problems and not to the strategic objectives of the network in terms of facilitating access to knowledge for development purposes, gradually eroded the effectiveness of the system and further placed pressure on the Central Node in terms of managing information flows that were not really contributing to the development objectives of the network. Obviously there are some very good exceptions to this, such as the success stories that are mentioned in section 4 above.

- f) With the weakening of the National Nodes that predominated in the first phase, the Specialized Research and Knowledge Networks gradually took over. Specialized knowledge networks have several advantages over “generic networks”. They are more focused, they have a more clearly defined membership and their products are better defined. Some of the specialized networks emerged from the Red Caldas itself (i.e. the Catalytic Cracking Network, the Robotics Network, etc.). But most specialized networks had their own dynamics and their emergence is not related to National Node initiatives. This is the case of the Macroeconomics Network, the agricultural research regional and global networks, the biotechnological networks, the biodiversity management networks and the few production-and-innovation related networks that emerged in industry and other production sectors. These specialized networks were to a large extent based on the Decentralized Network model described in Figure 1. This trend opened the possibility for the Red Caldas of becoming a *Network of Networks*, in order to provide a broad coordination framework for this growing range of specialized networks. This evolution would have given a very specific and clear function to the Central Node located in COLCIENCIAS, becoming a clearing house or “reference center” for the various networks that were operating. Additionally it could have reinvigorated the Caldas Network. But this opportunity was not well understood. The second phase developed to a large extent outside the “traditional Caldas system”.

- g) The significant budget cuts in government spending in Colombia that took place in 1997-2000, including COLCIENCIAS, drastically reduced the capacity of the latter to support the participation of the Colombian research groups in collaborative research projects. Given the importance that was attached to this particular function and the fact that many researchers had come to visualize the *Red Caldas* as a “funding mechanism”, this reduced capacity had a very negative impact since researchers lost interest on it once it could not provide funding for their research.

6. Lessons Learned: Looking Towards the Future

Knowledge Societies are characterized by the importance knowledge plays as a factor of production and as an organizing principle in contemporary societies (i.e. capacity to participate in their construction and in its benefits). In the context of the New Economy there are two contradictory processes that are taking place at the same time with respect to “*knowledge flows*” and “*access to knowledge*”. On the one hand, the rapid dissemination and adoption of information and communication technologies (ICTs) have facilitated knowledge flows between generators and users of knowledge, as well as among interested stakeholders, through the Internet and through a wide range of information dissemination facilities. At the same time, there has been an *increasing privatization of knowledge* due to the changing nature of knowledge itself and its increasing importance as a factor of production. This is reflected in the importance of industrial property rights (IPRs) and of other forms of “*knowledge appropriation*”. This

second process tends to limit knowledge flows, given the evolution of knowledge in many fields from being “*public goods*” to being “*proprietary technology*”. The dialectical tension between knowledge as public goods and proprietary technology is one of the characteristics of globalized Knowledge Societies.

But IPRs are not the only way of “protecting knowledge” and of regulating access to it. There are a variety of ways that have emerged in recent years that go from “industrial secret” to a wide range of knowledge generation-and-dissemination patterns, one of which is that of *Knowledge Networks* or *Knowledge Communities*. This reflects the fact that knowledge is increasingly being generated through specialized networks and communities of like-minded people or peers that work on a given topic. Knowledge is produced and shared among the members of these specialized networks and/or communities that bring together researchers, extension workers and end-users (stakeholders). Research and Innovation Networks function not only as mechanisms that generate knowledge; they are also becoming *organizational forms for accessing “protected knowledge”* that circulates freely within these communities, accessible only to its members.

Section 4 of this chapter presents several examples of the role these networks are playing as “*expert systems*” that provide support to decision-making in their area of competence (i.e. the Macroeconomics Research Network, the Catalysis Network, the Genetic Resources Network and others). This is what the South African study calls the “*Global Knowledge-Intensive Value Chains*”.¹⁰ One of the most important ways of joining these specialized networks is through developing collaborative research projects (research partnerships), which is the strategy followed by *Red Caldas*. For the researcher this is the most important function. But for the end-users of knowledge the possibility of accessing knowledge and expert advice is the most important value-added that these networks contribute (“knowledge-intensive value chains”).

Several conclusions emerge from this analysis.

- a) The first one is the role the scientific diaspora plays in facilitating access to these specialized knowledge networks, and through them, facilitating access to the “protected knowledge” that circulates within them.
- b) Secondly, there are different forms of participation in these networks that can be derived from the examples analyzed in section 4. Research partnerships is one modality, in some networks it is the main one, given the fact that *membership* in such networks is based on the *capacity of the members to contribute to the pool of knowledge shared by the community*, since they have to be accepted as “*peers*” by the other network members. These networks are generally open to participation, but they are highly selective in terms of the capacity of the individual to contribute to the knowledge-generation and management process. The quality of the research being done by the interested person is the main filter in order to obtain *acceptance by his/her peers in the network*. In some of these networks *obtaining acceptance* is a challenge. This is where the scientific diaspora can play an important role. But besides research there are other modes of participation in these networks, such as high-level training programs, scientific meetings and information management and extension systems (knowledge dissemination).
- c) In the cases analyzed in this paper, the success in formulating research partnerships and obtaining funding for them was heavily dependant on three factors. The first one was the presence of key scientific leaders that played an articulating or catalytic role (“gatekeeper role”) in the conception and development of the project. It was thanks to their leadership that the partnerships were

¹⁰ See Jonathan Marks: “*Expatriate Professionals as an Entry Point into Global Knowledge-Intensive Value-Chains: South Africa*”; Knowledge for Development Program, World Bank Institute, March 20004.

developed and the projects carried out. A second important success factor was the ability to synchronize the funding mechanisms in Colombia and in the other participating country (ies), since the absence of this coordination was quite often a major hurdle for collaborative research projects to take-off. The third success factor was obviously the quality of the proposal.

- d) An interesting new dimension is gradually taking shape with the widespread use of information and communication technologies (ICTs) and of the Internet. We are referring here to the increasing importance of *electronic networks* that operate through the web, using the more recent technologies that allow for *real-time on-line interaction among its members*. The new technologies go much beyond the simple use of mailing lists to more dynamic possibilities of on-line real-time interaction among network members. This is opening the possibility of collective work through the web that generates new opportunities for *e-learning* in decentralized and globalized knowledge communities, evolving towards new organizational forms of the scientific community such as *virtual research groups* and *virtual labs*. The Global Forum on Agricultural Research (GFAR), briefly analyzed in section 4, has sought to develop such networks among research groups in both developing and developed countries in the areas of natural resource management and of genetic resources and biotechnology.
- e) The *specialized research networks* that gradually replaced the system of National Nodes in the late nineties proved to be a more efficient mechanism than the *Centralized Radial Network* model that the *Red Caldas* developed in its first phase. These networks have a more focused agenda, a more clearly defined membership and better defined activities and responsibilities. They generally operate on the basis of the *Decentralized Network* model that is more efficient and participatory than the Centralized Radial Network model (see section 2.2). In looking towards the future, one of the challenges confronted is that of making a convergence between the experience gained in the first phase under the leadership of the National Nodes, on the one hand, and the approach developed in the second phase through the specialized research and knowledge networks, on the other. This could lead to the establishment of a “*network of networks*” that could function as a loose framework within which the specialized networks continue to play a central role. This was the recommendation that came from an external review of the *Red Caldas* carried out in 1998 that was not well understood at that moment.
- f) An important limitation of the *Red Caldas* was that it concentrated basically in the *scientific diaspora* found in universities and research centers abroad, but did not include other important components of this diaspora. We refer here to other social actors such as Colombian professionals working in firms and other organizations, including senior Colombian managers located in such firms. Given this orientation, a clear emphasis was placed on Scientific Networks more than Innovation Networks, although some of the networks analyzed combine both dimensions (i.e. the Catalysis Network). This aspect has to be strengthened in any future projection of this program.

At the present time the Foreign Relations Ministry of Colombia, COLCIENCIAS and the scientific community are in the process of developing a new *Program of Scientific and Technological Diplomacy*. In the conception and design of this program many of the ideas discussed in this paper are being incorporated, thus seeking to project the *Red Caldas* into the future but with a different structure and mode of operation. In organizing and implementing this program the lessons learned from the experiences analyzed in this paper are being integrated, in order to build on the strengths and avoid the weaknesses of the work done over the last twelve years.