Part B

Section B1 ANONYMOUS

Front Page

Proposal full title: Innovative management of *Acacia senegal* trees to improve resource productivity and gum-arabic production in arid and semi-arid sub-Saharan Africa.

Proposal acronym: ACACIAGUM

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Proposal summary page

Proposal full title: Innovative management of *Acacia senegal* trees to improve resource productivity and gum-arabic production in arid and semi-arid sub-Saharan Africa.

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Research objectives addressed: A.2. Rational use of natural resources / A.2.3 Managing arid and semi-arid ecosystems

Proposal abstract (anonymous):

In the arid and semi-arid regions of Africa, land degradation and soil fertility depletion are considered to be the major threats for natural resource conservation and food security. A potential solution to land degradation is to promote the utilization, regeneration and planting of a native under-utilized legume tree: *Acacia senegal*, the main species in the world producing the internationally traded gum-arabic. This tree is very important for the livelihoods of many rural populations and has potential for wider use. Its incorporation into farming systems will diversify agriculture, enhance income generation and contribute to land improvement, soil fertility replenishment and biodiversity preservation.
In order to mitigate land degradation and enhance sustainability of farming systems, the overall objective of the proposal is to provide tools to promote use and sustainable management of *A.senegal* tree resources. The goal is to combine high gum quality and increased gum production with sustainable tree management.
The project will use a multidisciplinary approach focusing on: the socio-economic viability of the gum-arabic commodity chain under different tree management and/or site conditions (climate and soil type) on (1) tree eco-physiology and gum production; (2) tree genetics and gum quality and production; (3) biological soil-tree interactions and tree-crop interactions.
In a broad range of ecological, cultural situations and farming systems, the proposal will provide insights in the interactions between technological choice and multiple market issues including (eco)labeling for gum-arabic produced in different socio-economic settings characterized by community's activities, resource access and control, market access and scale factors. The project will provide technical and institutional guidelines to enable investments in innovative management of *A.senegal* trees and gum for enhancing chain performance and reinforcing livelihoods of local producers.

B.1.1 Scientific and technological objectives of the project and state of the art

Overall objective: To enhance the sustainable management and use of natural *Acacia senegal* tree resources thereby supporting the environment and livelihoods in arid and semi-arid sub-Saharan Africa.

A. senegal improves soil fertility of degraded areas through its ability to fix atmospheric nitrogen in symbiosis with soil bacteria called Rhizobium. But it also produces the internationally-traded commodity 'gum-arabic' which as raw product is worth $US 0.5 per kg to the local community. As families can collect up to 10 kg per day, this yields a potential income of $US 150 per month – a substantial amount.
For this reason, we aim to obtain data which will promote gum-arabic production, while at the same time, promoting sustainable management of renewable natural tree resources, forest ecosystem restoration and conservation of bio-diversity.

***Specific objectives*:**

To gather information on local populations experience and constraints in *A. senegal* management in order to ascertain user priorities with respect to different activities (tree planting, tapping, gum picking, fodder harvest, crop associations, etc) and factors influencing their decisions, including exogenous factors (economic situation, market situation, forest policy, exploitation rights, etc…) as a function of site conditions.

To understand the inter-linkages between the institutional organization of supply chain networks with the dynamics of innovation regimes in gum-arabic production and their implications for rural livelihoods. This understanding will be developed in collaboration with chain parties and will catalyze enhanced chain performance and reinforce livelihood portfolios

To characterize the impact of the biophysical environment and tree management on gum yield and quality in multiple *A. senegal* based systems, and to investigate the consequences of tree management for associated crop production.

To characterize existing quantitative and neutral genetic variation and identify and understand the basis of variation in gum quality / yield.

To improve understanding of the relationship between soil microbial communities involved in the N cycle and the capacity of *A. senegal* trees (i) to produce gum-arabic in different environmental conditions and (ii) to rehabilitate degraded lands.

To ensure that information generated is properly packaged and availed to different stake holders in a form that is appropriate to each of them.

State-of-the-art (*To preserve anonymity, all references are listed in Section B2)*

Approximately 55% of Africa's land surface is arid and semi-arid (**1**), characterized by annual rainfalls between 100- 600 mm in a short season of 2-4 months. Annual crop productivity, especially in areas with less than 400 mm, is both poor and unpredictable. These conditions place an even greater value on perennial vegetation, especially multipurpose trees such as *Acacia* spp., which dominate the semi-arid ecosystems of tropical Africa. Because these ecosystems are important rangelands for the livestock industry, their loss would mean that herbivores would no longer be able to live through the dry season as food supplements are costly and impractical.
In general, the ecosystem represents a state of equilibrium between rainfall and regulating moisture and anthropogenic factors such as fire for clearance and hunting, grazing, cultivation, fuel-wood gathering, etc. However, it is generally accepted that the current use of trees for fuel wood exceeds incremental tree growth. The present trend of 2-3% increase in annual production and the concomitant increase in demands for more fuel and load for food have strained existing forest resources, especially in drier regions. This is because in most economies in Africa, an exponential population growth creates a demand that exceeds natural regeneration of the fuel source.

In the arid and semi-arid regions of Africa where land degradation is a problem, it is necessary to practice organic fertilization of soil to maintain the sustainability of cropping systems (**2**). Land degradation results from inappropriate land use: mainly unsustainable agricultural practices, overgrazing and deforestation. In the past, a long period of natural fallow was the general practice for maintaining soil fertility of cropping

systems. More recently, other alternatives have been considered. A potential solution to the declining fertility caused by shortened fallow period is using planted tree fallows shown to restore agricultural productivity more rapidly than natural fallows and at the same time provide tree products such as fodder, fuel, timber and gum (**3**, **4**, **5**).

Acacia senegal Willd is particularly interesting because it is the source of the multipurpose commodity gum-arabic which is traded on both local and international markets and is already used in several sub-Saharan African agricultural production systems. It is currently under utilized and has the potential for incorporation into agricultural systems throughout sub-Saharan Africa. The yield of gum appears best during conditions of water stress and thus volumes of saleable tree products may actually be maximized when income from crops and other farm outputs are low. Around 90% of the total gum produced worldwide comes from *A .senegal*. This species is used also to restore soil fertility in degraded soils in rotational systems such as in Sudan (**6**). Some authors (**7**) assessed the nutrient and organic-matter accumulation in *A. senegal* fallow over 18 years in Senegal, finding that current cycles of 12-15 years fallow and four years of cropping should be sustainable, at least in terms of N. Previous studies (**8**) demonstrated that during the fallow phase, N and other nutrients accumulate in the topsoil, refilling the system pool and providing resources for the cropping phase. They concluded that for the implementation of a rotational system, biogeochemical studies were essential to determine the optimal lengths of land use cycle phases. *A. senegal* also provides numerous other goods such as fodder for animals, medicinal products, fibres and fuel-wood. These products too provide sources of income for food purchase when crops fail. *A. senegal* trees can produce roots that can exploit water and nutrient resources that are located as deeply as 30 m below ground in certain type of soils (**9**), the tree is capable of surviving all but the most severe of droughts and so is very important in arid and semi-arid environments in sub-Saharan Africa.

In 1970 gum-arabic production peaked at about 70,000 tons but during the Sahel drought, production fell to 20,000 tons. Although drought and insect attack affected many trees, poor prices paid to local producers were believed to be the principal cause in diminishing the amounts of gum that were traded (**10**) Thus there is a need to ensure equitable returns to all stakeholders to ensure market stability. The European Community is the world's largest gum-arabic importer (**11**) (35,000 tons year^{-1}) and world imports have risen by 25% in the last 4 years. According to data available for the year 2002, the main gum producing and exporting countries were Sudan, Chad and Nigeria, accounting for 63% (34,162 MT), 20% (10,664 MT) and 12 % (6,556MT) of world production, respectively (**11**). Current international interest in gum-arabic can be gauged from the fact that the world market for gum-arabic was the subject of several recent commercial reviews (**12**) and the UNCTAD/WTO International Trade Centre reported that while production is stable, demand for natural ("green") products is increasing and that "the time is right" for gum arabic expansion with excellent prospects for Sub-Saharan Africa.(**13**) They also cite the case of Chad whose recent market share rose from 5% to nearly 30% within ten years, as evidence of how new competitors or small producers can successfully enter markets or expand market share. Furthermore, recent studies show that potential production of gum arabic from Kenya is about 3,000 MT/year (**11**, **14**). Even with the currently reported low production, export volumes have averaged 300-400 MT/year for Kenya, indicating that less than 10% of the production potential of gum arabic is exported, largely as a result of bottlenecks related to quality. Currently, the price per tonne is around US$ 4,500, having risen from US$ 1,500 in 2003. So all production can be sold immediately at a good rate. An important element of this project is to ensure that all stakeholders involved in the market chain benefit, especially the poorest.

Gum quality is compromised by collecting and mixing gums from different botanical sources and selling unprocessed material; there is also no organized tapping (**11, 14**). That both regional (provenance) and tree to tree variations in gum quality and productivity exist is well established. Gum of the highest quality currently comes from Sudan where quality control is exercised via laboratory tests and each export lot receives a certificate detailing analytical data such as optical rotation and moisture content. However, effective collection, cleaning, sorting and handling help maintain quality to the point of export and it is not clear whether there is also a genetic component involved in their gum quality. The pursuit of quality, and mapping of the supply chain to source, are hallmarks of the recent successful USAID gum-arabic initiative in Nigeria. Producing high quality gum is key to market expansion and penetration and currently most US orders for Nigerian gum are for the highest quality (**15**) but demand for high quality gum currently outstrips supply. There is a tendency for producers to use gums from other sources such as *Acacia seyal* when

supplies are limited. This seriously reduces batch quality and acceptability for food uses (**16**) and hence there is a need to develop a supply chain with guaranteed origins to maintain the reputation of the product for authenticity and high quality. Development of a certification system will enhance state of the art in marketing and ensure delivery of a quality product.

Detailed genetic information on *A .senegal* is very limited. Increasingly, neutral genetic data is being synthesized with traditional quantitative assessments to link variation in useful traits such as drought or pest tolerance or fast growth rates to understand the genetic basis of variation, identify differentially adapted varieties and isolate genetic markers to assist breeding programmes (**17**) Innovative linking of genetics with quality attributes of verified *A. senegal* trees will yield a tool to ensure that future tree plantings produce high quality gum.

Gum formation is regarded as a natural response of trees to store a strongly hydrophilic form of reserve carbohydrate when under dehydration stress and requires severe physiological stress from water depletion and heat (**18**). However, too much water stress results in tree mortality and relationships between gum production and water availability are poorly quantified. There is evidence that provenances originating from clay soils are more water-use efficient than those originating on sand (**19**) consequently water use *per se* and water use efficiency will be examined to determine whether this is simply a substrate effect or if a provenance (genetic) component is involved in water use, water-use efficiency and yield gum and quality. Such studies will advance the state of knowledge in tree/genetic/physiology/ environment interactions for this important tree species.

Where *A .senegal* trees are incorporated into agriculture, we can expect a positive effect on the soil fertility through its capacity to fix atmospheric nitrogen in symbiosis with soil bacteria called Rhizobium and through organic matter breakdown. But competition with crops can be expected and while crown pruning would reduce competition, it would also reduce gum yield (**20**). Consequently, root pruning which can substantially reduce competition (**21**) will be applied to control tree-crop competition. This innovative technique has been successful in sub-humid areas (**21**) but has never been tried in drier conditions. However, there is no information on the effects of types of tree management on the natural symbiotic associations, and it could pose an important constraint to growth. To increase symbiotic nitrogen fixation and growth of *A .senegal* trees, the inoculation of seedlings has to be practiced with selected microsymbionts by using the more efficient methods of inoculation described recently (**22**). Many factors can influence the success of the inoculation. For example, it was demonstrated that growth and nodulation of several provenances of *A .senegal* inoculated with the same rhizobial inoculum were significantly different (**22, 23**). Similar studies using mycorrhizal symbionts will be undertaken to ensure that nutrient uptake and growth of the trees are maximized. It is already known that dual, (*i.e.* mycorrhizal and rhizobial) rather than single inoculation stimulates the performance of N-fixing trees and that many naturally existing microsymbionts are either ineffective or have poor persistence in the field. Recently, some authors showed that the nodule occupancy by rhizobial strains inoculated to *A. senegal* seedlings was strongly dependent of the nature of soils (**24**). But sometimes, there are no effective or compatible native microsymbionts able to form a symbiosis with *A .senegal* in soil of plantations or natural fallows in arid environments (**25**). Further evidence to substantiate this is that rhizobial inoculation of adult trees stimulated gum production (**23, 26**). It seems that this positive effect of rhizobial inoculation on the gum-arabic production may be related to N mineralization (nitrification and ammonification) in the soil (**27**) suggesting that microsymbionts and heterotrophic microbial communities involved in the N cycle will interact in the rhizosphere of *A. senegal* trees. We will try to better understand the relationships between both communities and their manipulation (direct or indirect), which could be a way for a sustainable management of the gum-arabic production through an improvement of soil fertility.

In the Sahelian areas (less than 600 mm per year), the annual rainfall received in the season immediately preceding tapping positively affects the gum-arabic yield (**28**). It has been demonstrated that gum-arabic yield is related to the age of the tree. It increased from 5 year-old to reach its peak at 10-15 year-old of age and then decreases (**29**). Date of tapping is also an important factor affecting gum yield. For example in Western Sudan, late tapping reduces the gum yield by 40-50% (**28**). The same authors showed also how the effect of the tree management is important. They showed that the overall average yield at a research station is twice as high as that obtained in a gum garden managed by a farmer (**28**).

B.1.2 Relevance to the objectives of the INCO Specific Measures

The overall goal of ACACIAGUM is to promote the utilization of the gum-arabic tree, *A. senegal*, by local populations living in arid and semi arid sub-Saharan Africa, using sustainable management with respect to renewable natural tree resources, forest ecosystem restoration and conservation of bio-diversity. It is directly in accordance with the objectives of the INCO programme A2 "Rational use of natural resources" and more specifically A2.3 "Managing arid and semi-arid ecosystems". In Senegal, Cameroon, Niger and Kenya, the under-utilized native perennial tree *A. senegal* is present but usually poorly exploited for land improvement and gum-arabic production. It means that the potential of production is significantly higher than the real amount of gum-arabic produced in each country.
This situation justifies actions which will:

1. Define sustainable *A. senegal* tree management practices for maximising gum-arabic production. In accordance with the INCO call, ACACIAGUM proposes activities based on improving the economic productivity of *A. senegal* stands and plantations through a viable community-based management approach in order to optimise gum-arabic production. These will be used also for facilitating the sustainable land management practices, including monitoring systems such as indicators for sustainable forest management to improve and sustain the restoration of ecosystem stability

2. Improve the quality of the gum-arabic which is sold to International traders. To be able to ensure a good quality of gum-arabic on the International market through an "eco" or "green" label for the gum-arabic is a real necessity for the European traders who buy the bulk of gum produced around the world. The development of a certified market system should guarantee food safety, quality and source of outputs for local populations.

3. Integration of the tree into arable and sylvo-pastoral systems and subsequent sales of tree products and gum in particular, will diversify farm outputs, create employment opportunities and provide financial "insurance" when yields of annual crops are diminished through drought or pestilence. The dissemination of such resources in the region, through regional networks, will facilitate an improvement of the gum-arabic production, quality and market. The main beneficiaries will be the stakeholders of the gum-arabic sector and especially producers and collectors of gum. In executing the project, we will liaise with agencies of local governments, GOs and NGOs to help develop policy options that create an enabling environment for the production system and also which assist in marketing.

4. Existing and potential socio-economic effects of our activities and their developments will be examined. Particular attention will be given to gender issues and creation of employment opportunities for women because there are frequently gender related issues concerning "ownership" of products, particularly trees themselves. In particular, we shall seek to ensure that women benefit directly from our activities because although it is women who provide much of rural labour, they are often denied access to trees and tree ownership. We shall also strive to ensure that no sector in the gum producing chain fails to benefit from the introduction of the technology and that profits can be equitably shared. The rural poor have frequently failed to benefit from innovative initiatives when the richer sections in the production chain have sometimes benefited greatly.

The success of ACACIAGUM should enhance, directly or indirectly, the resource productivity and gum-arabic production in arid and semi-arid sub-Saharan Africa. The gradual accumulation of plant nutrients in the soil caused by tree presence will help maintain vitality of the soil, soil fertility and crop yield. Generation of fodder sources to help maintain animals in periods of water stress will also be of direct benefit to resource poor farmers and help prevent unplanned sales of their domestic animals into "buyer's markets" in times of water stress. Successful implementation of the project should catalyse wider uptake of gum production with concomitant enhancement of livelihoods, soil rehabilitation and protection from erosion.

The ACACIAGUM project's numerous activities contribute directly to the INCO specific measures. Through active collaboration with DC researchers, the ACACIAGUM project will enable access by European researchers to locally held scientific and indigenous knowledge to which Community scientists are not normally exposed. By establishing formal links with other groups such as NGOs who are locally based in DCs and who are already active in the areas targeted by the ACACIAGUM project, European researchers will obtain "front-line" access to ongoing "state of the art" development and extension activities. Such

access to ongoing work will enable the project activities to complement rather than duplicate, existing R & D activities and to become informed of current extension routes and their successes and failures. In this way, the European Research Area will be strengthened.

In this project for the ACP region, we shall have sufficient critical mass, finance and expertise to advance the biological and social sciences involved in gum-arabic production. A wide variety of data, results and innovative methodologies that derive from a diverse range of scientific disciplines will be obtained and synthesized to address the problem of rational use of natural resources in arid and semi-arid ecosystems. These results from innovative approaches in much of the Sahel and part of the Sudanian zone will be both novel and applicable in a wide range of other regional and global zones. The project will focus not only on the important topics of gum production, bio-safe food and quality, but will also address policy and the wider societal issues that will be impacted by the introduction/extension of gum production. The strong scientific partnership that we have assembled will enable us to address the specific problems of DCs and contribute to their sustainable economic, social, health, environmental and scientific development. The achievement of scientific excellence in the international arena will be brought about by the use of "state of the art" methods in modern well equipped laboratories and also by using properly designed and "controlled" field studies which are based on, and seek to advance, the current state of knowledge. Wherever possible existing trees and provenance trials will be integrated into our study/work plan. In this way, the period required to obtain results will be shortened. We have already identified a number of such trials in two of the participating DC countries.

The project will result in simple, sustainable, exploitable technological packages that are brought about by teams of European and developing country scientists working in partnership towards the common objectives of solving the specific problem of food insecurity faced by DCs. The project will strengthen research efforts in both European and developing countries and provide access to "state of the art" internationally used methods for developing country and young European researchers. These activities will promote informal training of researchers from DCs and provide reciprocal opportunities for European researchers to work in DCs and thus help integrate and strengthen the European Research Area. Strengthening, developing and consolidating the DC Partner country's research systems will reinforce synergy in accordance with Europe's external policies. In this way, long-term International co-operation between EU and developing country scientists will be enhanced and International co-operation will be promoted.

B.1.3 Potential impact

The ACACIAGUM project targets rural areas in sub-Saharan Africa and presents the opportunity for European and African scientists working in equitable partnership to combine their differing expertises to try to improve resource productivity and gum-arabic production in African arid and semi-arid ecosystems. The issue is complex and can only be properly addressed by a multidisciplinary approach to the differing subject areas.

Testable hypothesis:
The enhancement of both sustainable management and use of natural *Acacia senegal* tree resources will support the environment and livelihoods, and improvement of its gum production and quality

Solution of Third Country Problems.
There is no simple or single action solution to the problem of rational use of natural resources in arid and semi-arid ecosystems. Drylands communities depend more heavily on bio-diversity than in the wetter or higher potential areas. Woody plants and woodlands constitute the major sources of essential goods and services and also a major source of income, employment and capital. Therefore, it presents an important entry point for sustainable management and development in the drylands of sub-Saharan Africa, which naturally have fewer options due to harsh environmental conditions. When farmers diversify their crops into those produced by perennial trees, they are at much smaller risk of losing an entire year's production resulting simply from a poor rainy season. Tree products are affected much less than annual crops by drought. Such diversification into tree products can also make a significant impact on food security and the new products that arise can provide novel access to local as well as international markets.

Position of the European Community and reinforcing competitiveness
Increased production of high quality gum-arabic and its sale into the European market from sub-Saharan Africa will increase the competitiveness of both exporters and importers. Africa already produces most of the world's supply and the new marketing and certification schemes will strengthen Africa's hold in this market. Europe is the largest re-processor and exporter of processed gum–arabic and Europe's increased activity and market share will reinforce the competitivity of the European market. Our activities will produce results for the public domain which will initially be made available to local and European SMEs involved in the custody chains of the product. New methodologies will be developed to address many of the topics within this proposal, in particular, for the eco-physiology, genetics, microbiological, socio-economics and marketing studies. The focus on gum-arabic reinforces competitiveness by exposing European researchers to a new and sustainable source of a unique, multipurpose and valuable product which is currently available exclusively from DCs. With the current European focus on food safety, food hygiene, "green issues" (organic production systems) and sustainability of products, constructive links with, and access to, DC producers and market chains, offers a potential commercial advantage for European SMEs and larger commercial companies who will be kept informed of our activities and given the opportunity to comment and make suggestions as the project develops.

Impact and Societal Problems
Uptake and implementation of ACACIAGUM's results and recommendations will make a significant improvement to sustainable production of high quality gum, and hence food security, livelihoods, jobs and incomes. This approach will enable large groups of the rural poor to participate without the need to find investment capital. This is especially important to ensure equitable returns for the rural poor. They are frequently disenfranchised from politics and decisions and being the producers, are most vulnerable to fluctuations in market prices and demand. Their involvement will allow the "voices of the poor to be heard" and addressing their particular needs especially via innovative interventions like "Fair Trade gum" could have immediate impacts on rural food security. Women are increasingly assuming responsibility as heads of household because their husbands and young adult offspring migrate to cities in search of paid employment. A solution to the chronic local rural employment problem will help arrest migration driven family fragmentation and urbanisation and enhance family life. Urbanisation is an accelerating and serious societal problem which can only be addressed by creating non-urban employment and wealth.

Innovation
Numerous innovative approaches are planned:
1) Innovative approaches to the study of water-use and photosynthate allocation within trees are particularly apt for this study of an exudate-producing crop. Physiological measurement systems of tree water use (stem sapflow, leaf gas exchange, soil water content) will be conducted in conjunction with isotope techniques $^{18}O/^{16}O$ ratio of xylem sap and analysis of phloem sap ^{13}C.
2) Tree management (shoot and root) for optimization of gum-arabic production in relation to soil microbial populations present in the rhizosphere in differing environmental conditions has never been attempted and there are no data available concerning this important topic for improvement of the financial profits of the populations concerned in gum-arabic production.
3) Root pruning will be applied to control tree:crop competition. This innovative technique has been successful in combining trees and crops in sub-humid areas but has never been tried in drier conditions and the important topic concerning the possibility that severed roots may act as sinks for microsymbionts has never been examined.
4) The innovative linking of genetics with quality attributes of verified *A. senegal* trees will yield a tool to ensure that future tree plantings produce high quality gum.
5) An innovative and novel, certified marketing system that provides equitable returns to producers and rural populations and assures importers of the source, biosafety, hygiene and quality of the product will be developed and proposed to policy makers and commerce.
6) The relationship between soil fertility and sustainable gum-arabic production will be developed and quantified with the final objective to produce gum-arabic with a green label.

7) We will also use stable isotope techniques to provide a more integrated, longer-term analysis of provenance performance in different water availability environments and the analysis of the stable carbon isotope ratio ($^{13}C/^{12}C$) in phloem sap will be used to assess the degree of water stress experienced by the tree provenances under common environmental conditions. Stable isotope ratios also correlate well with proportions of sugar/protein in phloem sap, which are likely to be a key indicator for gum quality. This too will be an innovative approach to quality traits in gum-arabic. The impact of Ethephon, a promising plant hormone, on the gum production will be assessed.

Exploitation and Dissemination plans
The topic of dissemination of results and information has been granted particular importance and a work package has been dedicated to dissemination issues to try to maximize impact amongst end users. Dissemination plans will be developed for different audiences: to Government Departments in DC's countries involved in the proposal to national and international agencies involved in natural resource management, NGOs, all actors in the production/marketing chain from local populations through farmers, and the scientific community. The partners have strong existing links with these groups, are in constant contact with them, make regular visits and will keep them informed of developments and invite their comments on progress and implementation.
A CD-ROM describing methods for high quality, biosafe, gum-arabic production will be released to research institutes and libraries in DCs. A Website will be created describing the project and summarizing its main results. To encourage effective adoption of results and methodologies by end users, the final work package will try to integrate results into operational strategies which are of immediate use to end users.

Added value in carrying out the work at the European level
This ACACIAGUM partnership comprises a research team whose activities and expertise complement each other in differing disciplines with the fields of agroforestry, ecology, plant physiology, forestry, microbiology, socio-economics, sustainable livelihoods and marketing. The integration of researchers from the differing groups will permit generation and implementation of new insights and methods. The European partners possess a wide range of disciplines, expertise and experience which the DC researcher lack. The injection of this expertise with sufficient critical mass and funding (both from the European Commission) and contributions from the participating European organizations will provide significant European added value. The project will only achieve its overall goals if carried out by a multidisciplinary team at a level significantly above that which is possible by the national Partners acting in isolation. Such Community actions enhance local perceptions of Europe's role in DCs and foster good relationships between European and DC scientists, and provide the means for DC scientists from different countries to link together.

Other national and international research activities
Several initiatives concerning gum-arabic production are in progress. Some microbiological work is being undertaken in a west-African project under the aegis of a relevant research network and our planned microbiological activities will complement rather than duplicate actions in that project. ACACIAGUM overall objectives are wider, more ambitious and consider all aspects of gum production, management and marketing with a view to producing a sustainable, equitable, financially viable, employment and export generating agro-ecosystem.

Contribution to other EU policies
The Commission acknowledges that research, technology and environment are important areas supporting the main objective. The main strategy is to achieve poverty reduction via higher levels of export-led economic growth. Such issues are complex and their solution requires an integrated approach. EU policies which this proposal underpins are the EU Sustainable Development Strategy, the Green Diplomacy Network, the EU Trade and Environment Policy, the EU Environment Action Programme, the EU-ACP Cotonou and Lome agreements and EU policies in support of numbers 1, 3 and 7 of the UN's Millennium Development Goals (MDGs). That the EU and FAO have formed a joint Partnership to address the MDGs (September 2004) specifically focussing on food security, sustainable rural development, food safety and quality and natural resource management, dictates that this proposal directly supports both EU and FAO policies and development goals.

B.1.3.1. Contribution to standards

It is possible that ACACIAGUM's activities will make a contribution to standards in the field of gum-arabic quality. The gum physico-chemical studies that are planned could lead to a redefinition and revision of quality standards for gum-arabic. This will almost certainly be necessary if premium prices are to be obtained for gum of the highest quality. The standard could include details of provenance, soil type on which the gum is grown which is known to influence gum color as well as the normally applied chemical and rotation properties.

B.1.4 Detailed implementation plan

B.1.4.1.) *Implementation plan introduction*

ACACIAGUM will endeavour to provide tools to promote use and sustainable management of *A. senegal* tree resources. The goal is to combine high gum quality and increased gum production with sustainable tree management. Through this proposal, techniques to improve the growth, nutrient uptake, nitrogen fixation, quality and quantity of gum-arabic produced by *A. senegal* trees while ensuring bio-safe production methods, and equitable returns to all stakeholders by development of new marketing strategies will be also developed. The plan is to research the differing topics in separate yet complementary work packages which will provide a holistic approach to improving production, quality, equity and marketing, at both local and international levels.

There will be 6 work packages (WPs). Interlinking between the WPs and a schematic explanation of the proposed structure and routes to objectives can be seen in the diagrams presented on pages 14 and 15.

WP1 Traditional ecological knowledge

Local knowledge of management of *A. senegal* trees and gum can be used as a basis for sound inventory, monitoring and management of the resource. To collect such information from local populations, we will use in WP1, methods from the social sciences (participatory approaches, semi-structured interviews, market surveys, etc…).

The project is tackling a multi-dimensional, complex system in a broad range of geographical, cultural situations and farming systems. The sites/countries we are proposing to work in are at different stages of development in term of tree management, gum harvesting, utilization, marketing, etc. In some countries, gum is produced by nomadic communities from natural *A. senegal* stands with poor management whereas other countries have more advanced management (plantations), harvesting and marketing systems, involving nomadic or sedentary communities.

This WP will secure collaboration between local actors and outside experts in sharing knowledge and defining priorities and provide a sound base related to Traditional Ecological Knowledge to build our research hypothesis, and to ground the project on local realities. Highlighting the commodity chain, identifying the actors and understanding their representations, practices and traditional knowledge regarding the resource species will provide input for the other WPs:

- Stakeholders perception-based maps of gum production zones will feed other WPs and direct the sampling strategy,
- Commodity chain description and actors typology will form the base for economical assessment and prospective studies carried out in WP 2 (Market and livelihoods) and 6 (Knowledge transfer),

- Management practices will be analyzed and validated in WP 3 (Tree eco-physiology) and WP5 (Tree-soil interactions).
- Phenotypes with specific features (resistance, productivity, quality) identified by local actors will be analyzed in WP 4 (Genetic and gum quality) to describe their molecular bases and gum characteristics.

WP 2 Marketing networks

Rural households involved in gum-arabic production by *A. senegal* devote considerable land, labour and capital resources to tree management and gum production. Options for improving production systems or reinforcing sustainability of tree management regimes are strongly dependent on market conditions (access to information, outlet choice and relative prices) in particular related to the bargaining power of different agents within the supply chain and the trust and loyalty relationships established between network partners.
This WP will provide insight in the interactions between technology choice and multiple market configurations for gum-arabic produce in different socio-economic settings (characterized by market access and scale factors), focusing attention on the institutional arrangements that enable investments in innovative management of *A. senegal* trees by local producers for reinforcing their livelihoods
The research will rely on the agency characterization and stakeholder typology developed in WP1 and will deliver an operational framework for the socio-economic assessment of the feasibility of alternative management regimes (derived in WPs 3-5).

WP 3 Tree eco-physiology

Work package 3 on tree eco-physiology applies innovative approaches to the study of water-use and photosynthate allocation within trees, which are particularly apt for this study of an exudate-producing crop. Stable isotope techniques will be used to provide a more integrated, longer-term analysis of provenance performance in different water availability environments. The analysis of stable isotope ratios ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) in phloem sap and groundwater will be used to assess the degree of water stress experienced by the tree provenance under common environmental conditions in relation to the timing of photosynthate use in gum production. These isotope ratios also correlate well with proportions of sugar/protein in phloem sap, which are likely to be a key indicator for gum quality. Employing isotope techniques are particularly beneficial for gaining time series information about the physiological status of *A. senegal* in relation to changing climate conditions and water availability. More conventional measuring approaches require expensive and technically challenging equipment used in more time-consuming measurements, factors which often greatly limit the amount of information gained from monitoring campaigns. By contrast, frequent sampling for isotope work can be synchronised with other sampling events, such as monitoring for gum yield and quality, while isotope samples can be stored and analysed in bulk, allowing high sample frequency. Additionally, introducing isotope approaches offers the potential to train target country researchers in the use of nuclear techniques for monitoring long-term and complex processes in agricultural and agroforestry systems. The FAO are amongst a number of agencies which highlight nuclear techniques as providing a valuable tool for future development of integrated water and nutrient management practices in developing countries.

WP 4 Genetic and gum quality

A significant amount of progress has been made, through provenance trials, on assessment of quantitative genetic variation in *A. senegal*. For the purposes of improving the quality of gum production it will be essential to determine precisely the link between gum quality and genetic and environmental factors. WP4 has been specifically designed to evaluate the extent of natural variation in gum quality that exists within *A. senegal* and quantify linkages between this and patterns of genetic variation and environmental gradients. The end results will be an understanding of the biological basis for gum quality variation leading to progress on increasing gum quality production at the farm level.
Genetic structure, patterns of gene flow and evolutionary divergence within natural populations will be analyzed by a range-wide assessment of neutral genetic variation, using a suite of molecular markers and a hierarchically-structured sampling strategy. Genetic data will be integrated with a systematic assessment of variation in gum quality and yield. This synthesis will allow characterization of the existing genetic resources and, via linkage with existing provenance trials (Senegal, Cameroon), develop understanding of how divergent selection pressures across the species range have affected populations at a local level.

Comparative analysis of quantitative and neutral variation will allow characterization of the genetic and environmental components of gum quality / yield variation and identify intra-specific genetic units.

WP 5 Tree-soil interactions

Gum-arabic is produced by *A. senegal* trees under stress conditions such as drought, which occurs seasonally in this species' natural range. Gum production is not only governed by seasons and stress, but is also linked to plant maturity (age and size of tree). Hence, although stress is important and although there may be a strong genetic and environmental basis of gum production, it is probable that an essential prerequisite for gum production and successful fallow, will be a tree which is growing well. Nutrition is crucial, and soil microbial communities have the potential to play a significant and low-cost role in the promotion of growth of *A. senegal*.

Amongst the different parameters influencing yield, we hypothesise that N nutrition plays a key role as N is one of the major limiting nutrients in the soils where *A. senegal* grows. Therefore, this work package will focus on the role of the soil microbial communities involved in soil nitrogen cycle. Microbial communities (rhizobial and heterotrophic) responsible for symbiotic N_2-fixation and soil organic matter mineralization will be characterized *in situ* over the period of tree growth (rainy season) and gum production (dry season). Although arbuscular mycorrhizas are not directly involved in N cycling, they have an important role in enhancing the activity of rhizobia and will be included in these studies. Possibilities of enhancing N_2-fixation of mature acacia through rhizobia inoculation will be explored.

This WP will provide information on the impact of soil microbial communities involved in N cycle on the production of gum-arabic by *A. senegal* trees in relation to environmental conditions and tree management (WP3), and also with tree genetics (WP4). It will consist in an inventory of the natural biodiversity of rhizobia, mycorrhiza and heterotrophic bacterial communities associated with *A. senegal* in relation to environment and tree host, and the impact of inoculation on early growth and gum production of mature trees will be studied too.

WP 6 Dissemination and transfer of technologies

The success of the project will be measured by the number of technologies generated and effectiveness of availing the information generated to different beneficiaries. It is envisaged that important data sets will be generated related to biological aspects: improvement of productivity based on microsymbionts (WP5), genetics (WP4), eco-physiology and tree-crop interactions, (WP3) and socio-economic aspects (WP1 and 2) & improving livelihoods of rural communities through streamlining of the supply chain and development of the markets). Target beneficiaries include farmers, producers/collectors of gum-arabic, traders/merchants, policy makers and scientific community, among others. It will also be necessary to sensitize governments and politicians in the member countries on the importance of the sector in order to get their full support.

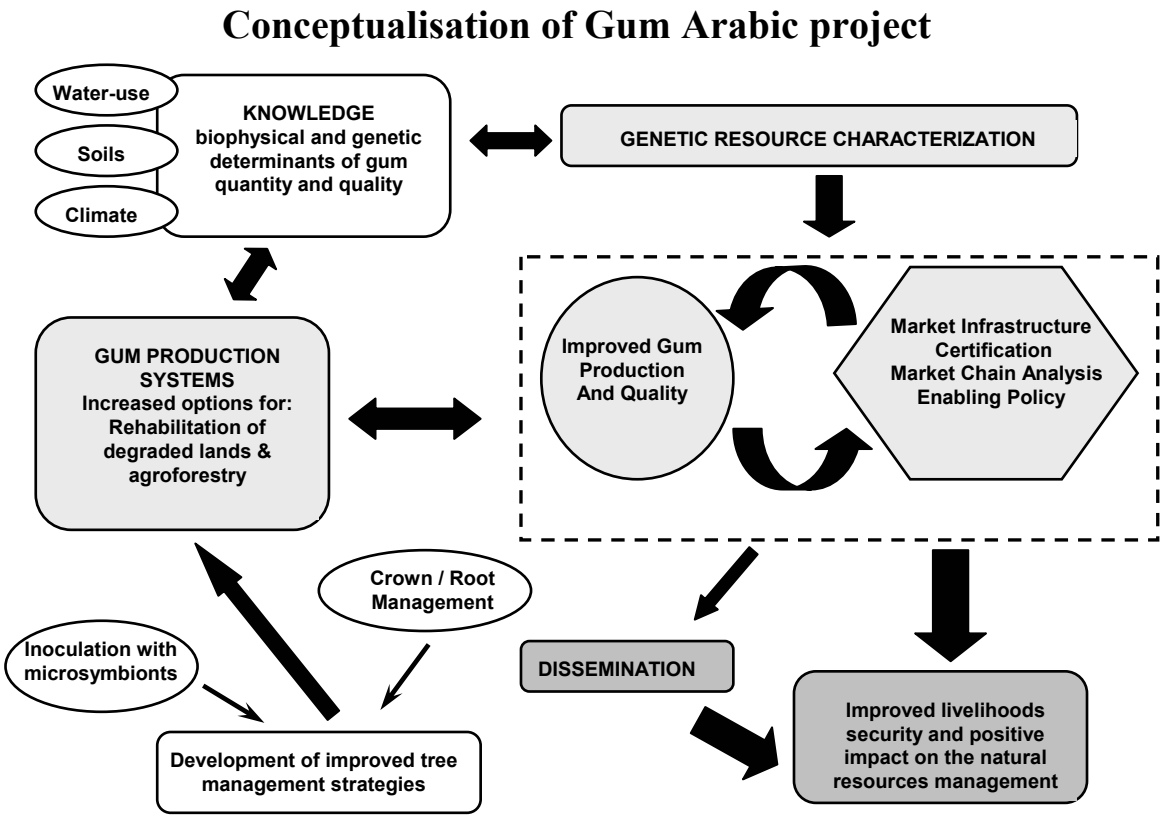
B.1.4.2.) *Work planning*

Gantt chart

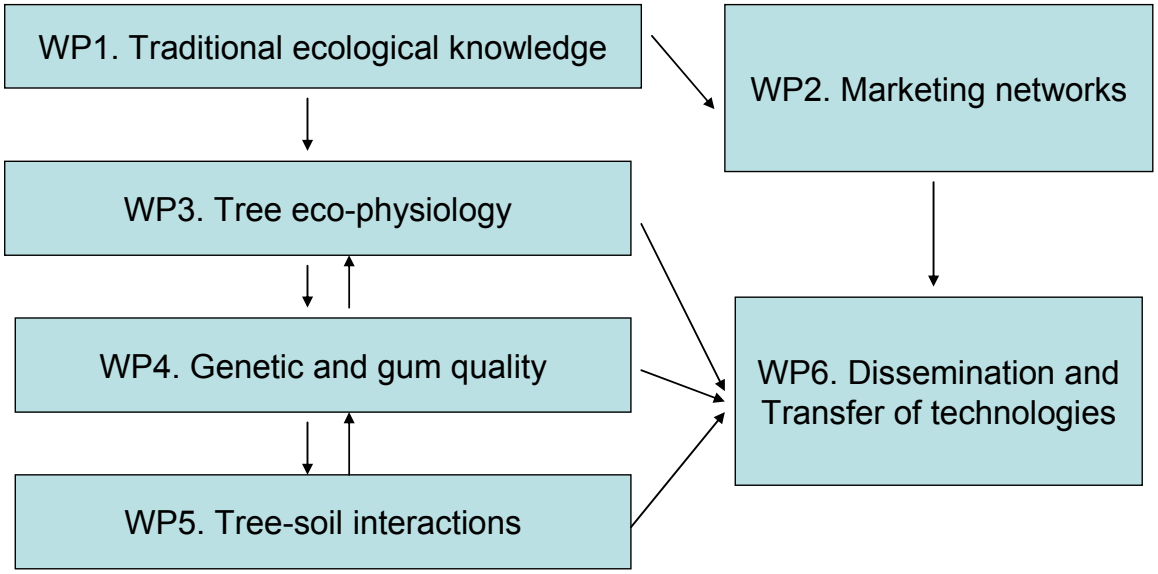
Activity WP	Year 1				Year 2				Year 3				Year 4			
WP 1																
Assessment of the current state of the art on *A. senegal* uses and gum-arabic production		■	■	■	■	■	■	■								
Description of the commodity chains				■	■	■	■	■								
Typology of the actors participating in the *A. senegal* resource management gum production and marketing				■	■	■	■	■	■	■	■	■				
Synthesis of the traditional agro-ecological knowledge							■	■	■	■	■	■	■	■	■	■
Identification of the constraints and factors limiting gum-arabic production and utilization of *A. senegal.*				■	■	■	■	■	■	■						
WP 2																
Surveys with farmers and other local populations		■	■	■	■	■	■	■								
Chain simulation					■	■	■	■	■	■	■	■	■	■		
Market trends analyses		■	■	■												
Study of local and international market chain			■	■	■	■	■	■								
Studies of market requirements and dynamics					■	■	■	■								
Consideration of certification issues and scheme									■	■	■	■	■	■	■	■

Activity WP	Year 1				Year 2				Year 3				Year 4			
WP3																
Investigation of the environmental impact on gum-arabic yield and quality, and growth of *A. senegal* trees																
Analysis of the provenance differences in water use																
Assessment of the relationship between eco-physiological characteristics of *A. senegal* and both tapping management and tree management strategies																
Study the outcome of number tree-crops systems with *A. senegal*																
Evaluation of the potential to enhance gum-arabic yield with Ethephon																
WP4																
Sampling gum-arabic, leaves, mycorrhiza and rhizobia																
Optimization and application of molecular markers for genetic analysis (lab works on AFLP & CpDNA variations)																
Utilization of morphological (leaves and fruits) and gum quality characters for quantitative analysis																
Synthesis to understand the genetic and environment components of gum-arabic yield and quality																
WP5																
Soil and root sampling																
Soil analyses and soils characterization																
Inoculation studies with mature trees																
Nodule fungi and root collections																
Microsymbiont effectiveness studies																
Gum production/quality studies & interactions																
Rhizosphere studies with microbes & microfauna																
WP6																
Assimilation of outputs from other WPs																
Internal working meetings																
Strategies elaboration																
Preparing and holding National Workshops																
Preparation of promotional booklets																
Preparation of multi-Partner scientific publications																

B.1.4.3.) *Graphical presentation of the components showing their interdependencies*



Schematic overview of WP relationships



We can show that WP1 and 2 are strongly linked because they concern socio-economic aspects. The WP3, 4 and 5 interact also together around the thematic "Tree – production of gum-arabic in relation with the global environment". All these WPs will provide data and information which will be disseminated through the WP6 and we expect to transfer several new technologies to the stakeholders involved in the gum-arabic production. In final, we assume that if people are convinced to get money through the utilization of *A. senegal* and gum-arabic production, the tree species will be protected, its utilization promoted and new

stands and plantations could be set up in Sahelian areas. In terms of rehabilitation of degraded lands, it will have a direct and positive environmental impact.

B.1.4.4.) *Detailed work description broken down into WPs*

Workpackage list (full duration of project). Section B1 - Anonymous

Work-package No[1]	Workpackage title	Lead contractor No[2]	Person-months [3]	Start month [4]	End month [5]	Deliv-erable No[6]
1	Traditional ecological knowledge	1	78	1	47	1-7
2	Marketing networks	3 & 9	90	8	38	8-14
3	Tree eco-physiology	5 & 7	125.2	1	47	15-20
4	Genetic and gum quality	5 & 1	123.7	1	47	21-24
5	Tree-soil interactions	8 & 2	174.1	1	47	25-32
6	Dissemination and transfer of technologies	2	78	8	47	33-39
	TOTAL		669			

Deliverables list (full duration of project).

Deliverable No[7]	Deliverable title	Delivery date [8]	Nature [9]	Dissemination level [10]

[1] Workpackage number: WP 1 – WP n.
[2] Number of the contractor leading the work in this workpackage.
[3] The total number of person-months allocated to each workpackage.
[4] Relative start date for the work in the specific workpackages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[5] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[6] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the workpackage: D1 - Dn.
[7] Deliverable numbers in order of delivery dates: D1 – Dn
[8] Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.
[9] Please indicate the nature of the deliverable using one of the following codes:
R = Report
P = Prototype
D = Demonstrator
O = Other
[10] Please indicate the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).

1	D.1.1 Information describing current research activities and results in the participating countries	2	O	PU
2	D.1.2 Flow charts detailing all the commodity chain and steps followed by the resource	8	O	PU
3	D.1.3 Checklist of tree management practices	12	O	PU
4	D.1.4 Stakeholders perception-based maps of gum production zones	12	O	PU
5	D.1.5 Checklist of possible problems to be solved to improve production and marketability	12	O	PU
6	D.1.6 Scientific report describing existing typologies and tree management	30	R	PU
7	D.1.7 Scientific papers of the issues, practices associated NFTP	36	R	PU
8	D.2.1 Methodology development and detailed research outline	6	O	PU
9	D.2.2 Data collection amongst chain agent	12	O	PU
10	D.2.3 Interactive chain-game simulations	20	O	PU
11	D.2.4 Multi-agency chain optimization model	28	O	PU
12	D.2.5 Experimental pilots for chain optimization	38	D	PU
13	D.2.6 Stakeholder workshop and policy report	42	R	PU
14	D.2.7 Delivery of four scientific papers	48	R	PU
15	D.3.1 Report and published scientific papers quantifying and attributing the effects of rainfall and edaphic conditions on the gum yield and quality of *A. senegal*, with detailed evaluation of the effect of seasonal climate variation, and the potential impacts of climate change on current and future gum production		R	PU
16	D.3.2 Report characterizing provenance variation in water-use, morphology and gum yield, leading to the definition of selection criteria for appropriate *A .senegal* provenances for a range of gum production systems, climate conditions and soil type.		R	PU

17	D.3.3 Report evaluating the use of various tree management strategies and gum tapping and timing techniques in different site conditions for enhanced gum yield and maintenance of crop production in tree-crop systems		R	PU
18	D.3.4 Report evaluating the efficacy of gum yield enhancement with the growth hormone Ethephon, and its potential for safe and widespread use in commercial gum production systems		R	PU
19	D.3.5 A range of publications aimed at farmers, plantation managers and policy-makers providing guidelines for managing *A. senegal* in different gum production systems, including optimized tapping protocols and tree management strategies for plantation, gum garden and agroforestry systems		R	PU
20	D.3.6 Report evaluating the potential for adoption of ethephon-induced gum enhancement in commercial gum production systems.		R	PU
21	D.4.1 Complete range-wide collections of tree tissue, gum and root samples		O	PU
22	D.4.2 Optimized molecular methods (cpDNA, AFLP, microsatellite): Analysis of range-wide AFLP, SSR variation; Analysis of local population genetic parameters, Hierarchical analysis of genetic structure and gene flow; Identification of intra-specific genetic units		O	PU
23	D.4.3 Methods to assess chemical components of gum-arabic; correlation of genetic, environmental factors with gum quality variation; Database of gum quality variation across the natural range		O	PU
24	D.4.4 Best practice guidelines for planting for increased yield / quality & scientific publications in International journals	48	R	PU
25	D.5.1 Data base on both global and specific microbial communities	38	O	PU
26	D.5.2 Data base of soil characteristics and other environmental conditions for gum producing areas	34	O	PU
27	D.5.3 Description of microbial diversity of rhizosphere micro-organisms	45	O	PU

28	D.5.4 Estimated of N_2-fixation by *A. senegal*	30	O	PU
29	D.5.5 Data describing the nitrification and denitrification potentials of soils under *A. senegal*	41	O	PU
30	D.5.6 Identification and establishment of effective microsymbionts germplasm suitable for inoculation of *A. senegal* in a range of environmental conditions	42	O	PU
31	D.5.7 Inoculation effects on mature trees	40	O	PU
32	D.5.8 Publications in International journals and locally for use by forest managers and gum-arabic producers, GOs and NGOs,…	47	R	PU
33	D.6.1 Internal project workshops with WP leaders and scientists on results generated		R	PU
34	D.6.2 Analysis and prioritization of results for different beneficiaries		O	PU
35	D.6.3 Evaluation of project sites to serve as demonstration sites		D	PU
36	D.6.4 Drafting of preliminary key points for each strategy document related to target groups		R	PU
37	D.6.5 Presentation and discussion of each strategy document at country level for improvement. This will assist in assessing the suitability of the documents to intended users		O	PU
38	D.6.6 Validation of the strategy documents		O	PU
39	D.6.7 Translation of extension		O	PU

Workpackage description (full duration of project).

Workpackage number 1 **Start date or starting event: 3**

Workpackage title ***Stakeholders and traditional ecological knowledge associated with Acacia senegal management and gum production***

Participant id	1	2	4	6	9
Person-months per participant:	8	10	10	10	40

General objective

To gather information on experience and constraints of local populations with *A. senegal* management in order to ascertain user priorities with respect to different activities (tree plantation, tapping, gum picking, fodder harvest, crop association, etc) and criteria of choice including exogenous factors (economic situation, market situation, forest policy, exploitation rights, etc…) as a function of site conditions.

Specific objectives

- To assess the current state of the art on *A. senegal* uses and gum production,
- To describe the commodity chains,
- To build a typology of the actors participating in the *A. senegal* resource management, gum production and marketing,
- To synthesize traditional agro-ecological knowledge applying to gum-arabic production, multi-purpose use of *A. senegal* and incorporation of gum trees into farming systems,
- To identify constraints and factors limiting gum production and utilization of Acacia trees

Description of work

Task 1.1 State of the art and on-going research

Information to inform participants of the current state of the art and of on-going research in the different countries will be shared amongst participants at the first co-ordination meeting. This information will guide research activities in WP1 and other WPs to ensure complementarity.

Qualitative and quantitative information about agro-ecological knowledge and socio economic constraints applying to *Acacia* management and gum-arabic production exists in a fragmented form (published and grey literature from past gum-tree experiments, on-farm research and socio-economical analysis) and will be put together for synthesis and cross-checking data.

Task 1.2 Commodity chain

In each country, in order to describe the complete gum channel we will detail the different steps leading from the plant to the final gum buyer (resource identification, harvesting, processing and marketing). We will start this phase with gum traders and market surveys. Each country will select the main gum traders, 2 city markets and 5 to 10 rural markets. Merging largely open key informant interviews and direct observations of product and prices will provide a good starting point for channel identification.

This step is not concerned with quantitative measures; it is only a qualitative phase, destined to identifydiverse and key actors. We are therefore not bothering with quantitative methods and statistical significance, since they will be covered in WP 2 (Market and livelihood).

Task 1.3 Stakeholders typology and livelihood patterns

In this task the identification of the different stakeholders will be complemented with an understanding of their logics and constraints. We will define a typology of the actors with a role in tree and gum management, with particular interest in gender and vulnerability issues (roles, constraints, access and control over resources, land tenure, wealth, distance from markets, connection to cities, social networks, decision-making and taboos, etc). Criteria by which gum producers, harvesters and traders judge their activity will be determined taking into account economic socio-cultural and policy issues. Respect to others activities, the importance of gum-arabic production or harvest will be considered in the different agro-ecological zones in relation to the socio economic and socio-cultural realities of the farmers. Data on costs (seedlings, labour, different inputs) and revenues will be collected as input for economic analysis (WP2), disaggregated and analized according to farmer typologies (*ie* Gender, class age, etc…).

We will conduct in-depth semi-structured interviews and participant observation with representatives of each type of actor identified. Depending on the complexity of the commodity chain, we expect to carry out 30 to 50 interviews per country.

Task 1.4 Indigenous ecological knowledge and practices

In depth, multiple, qualitative semi-structured interviews of gum producers, harvesters and those exploiting the tree for other purposes (charcoal, fodder, etc) will be conducted, focusing on management practices.

An evaluation will be made of the population's experiences with the respect to location of the resource, growth and dynamics of the trees, quantity and quality of gum as a function of site conditions (rainfall, temperature, soil type) and management interventions, measures to ensure hygienic collection of gum, integration of gum trees into crop land, effect of tree on soil rehabilitation and yields of associated crops. Tree management will be considered in a broad perspective from tree establishment, tapping methods including tools, schedules and regimes, pruning and coppicing to rejuvenate ageing trees, tree spacing and tree canopy structure for maximizing gum production and allowing intercropping. The degree of eco-friendly management of *A. senegal* trees will be evaluated. The multiple local uses of the gum as well as the *A. senegal* tree (fodder, fuel wood

and charcoal) in local communities will also be obtained.
Up to 20 interviews per country should provide a good overview of the indigenous management techniques associated with *A. senegal*. This task will identify management strategies to be studied in WP3.

Task 1.5 Limiting factors and obstacles
If the species shows potential for production improvement and better access to market, in order to generate revenue for the stakeholders, we have to address the question of why the species has been underutilized. The reasons may be symbolic (magical properties) technical (low response to tapping) or institutional (bad resource and market access, scattered resource, unorganized commodity chain…).

No specific field work is needed, since we will collate the data gathered on the other 3 tasks to answer this particular question. It is a specific point that will be incorporated in the interview frameworks.

Deliverables

D1.1. Information describing current research activities and results in the participating countries (Month 2)
D1.2. Flow charts detailing all the commodity chain and steps followed by the resource (Month 8)
D1.3. Checklist of tree management practices (Month 12)
D1.4. Stakeholders perception-based maps of gum production zones (Month 12)
D1.5. Checklist of possible problems to be solved to improve production and marketability (Month 12).
D1.6. Scientific report describing existing typologies and tree management (Month 30)
D1.7. scientific papers of the issues of uses, practices associated NTFP (Month 36).

Milestones[11] and expected results

Milestones
M1.1. All products and uses inventoried. Visits to market do not bring new information (Month 3)
M1.2. All actors identified, and their representations highlighted. Interviews are saturated (Month 8)
M1.3. All traditional techniques are well documented (Month 12)
M1.4. All the subsequent WPs (especially WPs 2, 3, 4) receive the needed information to build adapted sampling designs and formulate hypothesis (Month 12)
M1.5. Identification of the diversity of gum production systems with *A. senegal* in Sub Saharan Africa and validation through external sampling (Month 24, 30)
Expected results
E1.1 We have identified all the different stakeholders, and understand their main drives in the management of the resource. We can select specific groups to work with.
E1.2. We have identified relevant dimensions that shape the diversity in " Acacia related livelihoods"
E1.3. List of limiting factors and desired outcomes, developed together with the stakeholders.

Workpackage number 2	**Start date or starting event: 3**			
Workpackage title *Marketing networks and livelihood strategies of Acacia senegal farmers in Sub-Saharan Africa*				
Participant id	2	3	6	9
Person-months per participant:	8	20	2	60

General objective

[11] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

To understand the inter-linkages between the institutional organization of supply chain networks with the dynamics of innovation regimes in gum-arabic production, and their implications for rural livelihoods. This understanding will be developed in collaboration with chain parties and is meant to serve as a catalyst for enhancing chain performance and for reinforcing livelihood portfolios

Specific objectives

Which categories of farmers are typically involved in particular market outlets?

Which aspects influence bargaining power and value added distribution along the chain agents?

How do price and non-price aspects influence primary production decisions (scale, technology choice, input intensity, labour use, quality performance)?

Which processing techniques and logistics regimes offer best prospects for improving chain performance and for tailoring gum production towards market requirements?

How could market segmentation systems based on (eco)labelling or certification be helpful for enhancing process innovation and product upgrading?

How do insights regarding the functioning of the chain (including problems, opportunities and options for change) affect the dynamics of cooperation among chain parties?

To what extent do interventions contribute to learning and negotiation among chain parties, and which factors stimulate or hinder progress in the chain innovation process?

Description of work

Task 2.1 Socio-economic survey

The research is based on a detailed assessment of the distribution of value added along the supply chain and the underlying determinants of bargaining power. The study will start with a socio-economic survey amongst chain partners (input providers, producers, collectors, traders, processors and exporters) focusing on prices, costs, networks, information flows and other reasons and factors that shape the production practices and livelihoods of chain partners. Main attention is given to the role of reputation and trust in contractual arrangements. This tasks provides a follow up to the work conducted in WP1 (identification of key actors)

Task 2.2 Chain simulation

The survey is followed by a series of interactive chain-game simulations to identify the determinants of bargaining power and the options for supply chain improvement. A multiple agent supply chain optimization model will be developed as a benchmark. This procedure for chain simulation provides a stylized representation of the asset base and risk perceptions of different chain agents that underpin to their bargaining position in the supply chain. Major building blocks for the chain simulation is the presentation of alternative option sets to each of the agents regarding their willingness to invest in quality improvement, reliability and trust, or stability of economic returns.

Task 2.3 Experimental Pilots

Subsequently, chain partners are involved in experimental pilots that address critical (technical, information or social) bottlenecks in the supply chain. Empirical options for these pilots are derived from WP 3-5. The options for reaching win-win outcomes will be assessed in terms of revenue distribution and environmental benefits.

Task 2.4 Stakeholder workshop

Stakeholder workshops will be organized in order to monitor to what extent, how and why the experimental pilots (and the interventions by the research team therein) effectively contribute to chain innovation. The intermediate results of this study will be fed back to chain partners in order to contribute to an interactive change process.

Task 2.5 Synthesis

Summary of research findings focusing on (a) usefulness of the interactive simulation methodology for (co)innovation management and (b) strategic options for reinforcing livelihoods and strengthening value added

creations in a dynamic supply chain and network setting.

Deliverables

D2.1. Methodology development and detailed research outline (Month 6)
D2.2. Data collection amongst chain agents (Month 12)
D2.3. Interactive chain-game simulations (Month 20)
D2.4. Multi-agency chain optimization model (Month 28)
D2.5. Experimental pilots for chain optimization (Month 38)
D2.6. Stakeholder workshop and policy report (Month 42)
D2.7. Delivery of four scientific papers (Month 48).

Milestones[12] and expected results

Milestones

M2.1. Linking multiple purpose products with multiple market outlets
M2.2. Representative data collection amongst agents operating within supply chain (building on WP1)
M2.3. Chain simulation environment for interactive gaming and scenario exploration
M2.4. Experimental pilots for chain optimization (using inputs from WP 3-5)
M2.5. Exploration of market segmentation strategies

Expected results

E2.1. Identification of multiple market outlets for Arabic gum producers and the determinants of bargaining power between different supply chain agents;
E2.2. Delimitation of the opportunities and constraints for 'valuing' innovative management of *Acacia senegal* tree supply chains
E2.3. Simulation of the interactions between technical, managerial and socio-economic factors in innovation regimes for Acacia-based livelihoods

Workpackage number 3	**Start date or starting event: 3**						
Workpackage title *Tree eco-physiology and tree-crop interactions: consequences for gum-arabic production and yields of associated crops.*							
Participant id	1	2	4	5	6	7	9
Person-months per participant:	8	16	14.5	18.7	20	18	30

General objective

To characterize the impact of the biophysical environment and tree management on gum yield and quality in multiple *A. senegal* based systems, and to investigate the consequences of tree management for associated crop production.

Specific objectives

To investigate the impact of rainfall and soil conditions on the growth, gum yield and quality of *A. senegal* at a range of sites with contrasting climate/soil conditions in significant areas in the target countries, and to characterize water-use through seasonal time series to analyze the impact of water availability, current and historic, on gum yield and quality.
To analyze provenance differences in water-use and adaptation to edaphic conditions and to define selection criteria for *A. senegal* production systems.
To investigate the relationship between eco-physiological characteristics of *A. senegal* and both tapping

management and tree management strategies, in order to make recommendations for optimizing gum-arabic production.
To study the outcome of a number of tree-crop systems incorporating *A. senegal*, including variable density planting, crop species selection and tree management strategies such as crown and root pruning, in order to evaluate approaches for optimization of gum yield, crop productivity and soil condition.
To evaluate the potential to enhance gum yield with the use of a promising plant hormone (Ethephon).

Description of work

Task 3.1 Several target countries within the project have natural populations of *A. senegal* growing in a range of climatic and edaphic conditions, from 300mm to 1300mm annual rainfall and on sandy and clay soils. A selection of contrasting sites will be studied for assessment of growth, water-use and gum yield and quality along environmental gradients. Techniques employed will include physiological measurement systems of tree water-use (stem sapflow, leaf gas exchange, soil water measurements) in conjunction with stable isotope analysis, and morphological assessment of stems, canopy and root architecture and tree phenology. Climate monitoring systems will be established at a number of contrasting field sites and production systems where tree physiology, gum yield and quality will be intensively studied throughout seasonal time series. Isotope techniques employing $^{18}O/^{16}O$ ratio will be inform changes in water-use between rainfall and groundwater stores, and analysis of phloem sap ^{13}C will indicate patterns of photosynthate consumption during gum production, while also providing an indication of sugar : protein ratios which link strongly to gum quality. The task aims to improve understanding of the effect of climate variation and potential climate change on gum yield and quality.

Task 3.2 A number of target countries within the project have established *A. senegal* provenance trials that offer a valuable opportunity to examine provenance variation in key physiological and morphological traits influencing gum yield and quality. Physiological and morphological assessment of traits such as canopy and root architecture will be coupled with analysis of gum yield and quality amongst provenances (linked to WP4 on gum attributes). The quantitative data will then be analyzed for any associated marker variation detected by WP4, to derive maximum benefits from the characterization of heritable genetic traits that will inform selection criteria for gum-producing *A. senegal* for a range of production systems.

Task 3.3 A limited amount of information exists about tree management of *A. senegal*, aside from some studies on the effect of tapping date on gum yield in relation to site conditions. This task will study tapping management strategies identified by investigations of local knowledge in WP1, such as tapping method, timing, and number of cuts to branches. Much of this work will take place on indigenous tree populations selected for study in Task 3.1, and will aim to provide evidence of how eco-physiological characteristics (at the time of tapping) impact the yield and quality of gum-arabic, and how tree tapping affects tree physiology.

Task 3.4 Tree management will be assessed in plantation and small farm scale scenarios, looking at the impact of planting density, crown and root pruning on gum yield and associated crop production in tree-crop systems. Close collaboration on field trials rum by WP5 to investigate microsymbiont enhancement of *A. senegal* establishment and growth will evaluate effects of microsymbionts on water-use and nutrient capture of provenances and associated crops.

Task 3.5 New developments in the management of gum yield through stimulation of gum production by ethephon, a plant growth regulator, suggest that gum yield in *A. senegal* could be substantially enhanced by this inexpensive and non-toxic gum promoter. The plant hormone is used to enhance rubber yield in rubber trees, and to hasten ripening of fruits, and early trial results indicate a similar yield enhancement in gum-producing *Acacias*. Ethephon is state registered for horticultural use in at least one target country within the project, providing the opportunity to carry out trials on dose-response and application technique in controlled comparisons.

Deliverables

D3.1 Report and published scientific papers quantifying and attributing the effects of rainfall and edaphic conditions on the gum yield and quality of *A. senegal,* with detailed evaluation of the effect of seasonal climate variation, and the potential impacts of climate change on current and future gum production.
D3.2 Report characterizing provenance variation in water-use, morphology and gum yield, leading to the definition of selection criteria for appropriate *A. senegal* provenances for a range of gum production systems, climate conditions and soil type.
D3.3 Report evaluating the use of various tree management strategies and gum tapping and timing techniques in different site conditions for enhanced gum yield and maintenance of crop production in tree-crop systems.
D3.4 Report evaluating the efficacy of gum yield enhancement with the growth hormone Ethephon, and its potential for safe and widespread use in commercial gum production systems.
D3.5 A range of publications aimed at farmers, plantation managers, and policy-makers providing guidelines for managing *A. senegal* in different gum production systems, including optimized tapping protocols and tree management strategies for plantation, gum garden and agroforestry systems.
D3.6 Report evaluating the potential for adoption of Ethephon-induced gum enhancement in commercial gum production systems.

Milestones[13] and expected results

Milestones
M3.1 Review of methodologies; prioritization of field campaigns across target countries and gum production systems (month 6).
M3.2 Selection of marked trees in natural populations from field sites representing a range of climatic zones, edaphic conditions and gum production systems (month 9).
M3.4 Decision on key tapping strategies and tree management regimes that will be selected for study in controlled trials, and trials established in appropriate target countries (months 12).
M3.5 On-going review of data quality and methodological approaches (months 6-40).
M3.6 Dissemination strategy designed; booklets, dissemination material and papers for scientific journals written; final report produced (months 40-46)

Expected results
E3.1 Knowledge about the important climatic, edaphic and genetic determinants of gum-arabic production by *A. senegal*, disseminated to scientists, policy-makers, plantation managers and local farmers in target countries.
E3.2 Evidence-based provenance selection for optimized gum yield in a range of climate and edaphic conditions, and co-cultivation scenarios.
E3.3 Improved tapping management and tree management techniques adopted by workers and farmers in target countries, resulting in increased gum yields and improved management of associated crops.
E3.4 Evidence base for the evaluation of Ethephon-induced gum enhancement of *A. senegal*.

Workpackage number 4	**Start date or starting event: 4**					
Workpackage title *Genetic and environmental basis of gum quality and assessment of range-wide variation*						
Participant id	1	2	4	5	6	9
Person-months per participant:	12	28	20	9.7	4	50

General objective
To characterize existing quantitative and neutral genetic variation and identify and understand the basis of variation in gum quality / yield.

Specific objectives

[13] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

1 – To sample existing provenance / progeny trials and natural populations to achieve range-wide coverage
2 – To optimize molecular methods for analysis of *A. senegal*
3 – To optimize chemical methods for analysis of *A. senegal* gum quality
4 – To characterize range-wide genetic variation and structure and patterns of variation in gum quality
5 – To synthesize quantitative data (provenance trials) with new data for genetic and gum quality variation

Description of work

Task 4.1 Collection: preparation of samples from populations throughout the natural range (total of approx 25 populations of 25 trees).

4.1.1 Collection of samples (leaf, gum) from existing provenance trials. Identified trials: Senegal - provenances from Ethiopia, Sudan, Chad, Niger, Burkina Faso, Mali, Senegal, Mauritania, India, Pakistan; Cameroon – Sudan, Senegal, Cameroon.

4.1.2 Collection of samples (leaf, gum) from sites not covered by provenance collection and to ensure hierarchy (of population, region, range) and gradient (rainfall, soil type) is fulfilled, inc collection and mapping of trees and seed in a single population for analysis of fine-scale genetic structure. Currently identified populations: Kenya – Turkana (1 site), Isiolo-Marsabit (2 sites); Niger – 3 sites of contrasting environment (rainfall, soil type).

4.1.3 Distribution of samples to partners conducting genetic and chemical analysis

Task 4.2 Genetic analysis: optimization and application of molecular markers

4.2.1 DNA extraction using standardized methodologies.

4.2.2 Optimization of techniques for *A. senegal*. Chosen markers (Amplified Fragment Length Polymorphism – AFLP, micro-satellites, and universal chloroplast DNA markers) will be optimized for use with *A. senegal* by identification of regions with informative levels of variation. Standardized protocols will be produced for all partners involved in molecular analysis.

4.2.3 Genotyping of all samples using full suite of molecular markers:

4.2.3.1 Survey of chloroplast DNA variation across range: 5-10 trees / population in 25 populations (ca. 5 primer-enzyme combinations).

4.2.3.2 Survey of AFLP variation across range: 25 trees / pop. in 20 pop. (200 polymorphic AFLP markers).

4.2.3.3 Fine-scale population genetic structure: SSR analysis (5 loci) of mapped natural population (200 trees).

4.2.4 Data analyses and interpretation.

4.2.4.1 Elucidation of components of genetic structure at local (population), regional and range-wide scales

4.2.4.2 Identification of major gene flow disjunctions - i.e. identification of genetic units within the species

4.2.4.3 Relative contributions of seed and pollen dispersal to gene flow (cpDNA, AFLP comparison)

Task 4.3 Quantitative analysis: using morphological (leaves, fruits) and gum (morphology, chemistry, NIRS) characters

4.3.1 Optimization of techniques for *A. senegal*

4.3.2 Collation of existing quantitative data from provenance trials

4.3.3 Chemical analyses of gum samples: high-throughput methods (Near Infra Red Spectrometer) will be designed to analyze gum samples for chemical composition and nutritional characteristics. The analysis will use classical and industrial variables (mineral content such as N etc, and sugar composition to provide comparison with the classical methods to be applied in WP 1).

4.3.4 Data analysis and interpretation

Task 4.4 Synthesis: Understanding the genetic and environmental components of gum yield and quality

[14] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

4.4.1 Comparative analysis of quantitative vs genetic datasets
4.4.2 Correlation of quantitative and neutral datasets with both environmental and cultural factors.
4.4.3 Analysis of relationship between gum quality / yield variation with genetic, and environmental data.
4.4.4 Publication of results and proposals for certification scheme

Deliverables

D4.1 COLLECTION : Complete range-wide collections of tree tissue, gum and root (link to WP4) samples
D4.2 MOLECULAR OPTIMISATION : Optimized molecular methods (cpDNA, AFLP, microsatellite)
D4.2.1 CHLOROPLAST VARIATION : Analysis of range-wide chloroplast DNA variation
D4.2.2 WHOLE-GENOME VARIATION : Analysis of range-wide AFLP, SSR variation
D4.2.3 LOCAL SPATIAL GENETIC STRUCTURE : Analysis of local population genetic parameters
D4.2.4 RANGEWIDE GENETIC STRUCTURE : Hierarchical analysis of genetic structure and gene flow
D4.2.5 GENETIC UNIT ID : Identification of intra-specific genetic units
D4.3.1 GUM QUALITY ANALYSIS : Methods to assess chemical components of gum-arabic
D4.3.2 GUM QUALITY FACTORS : Correlation of genetic, environmental factors with gum quality variation
D4.3.3 DATABASE : Database of gum quality variation across the natural range
D4.4.1 GUIDELINES: Best practice guidelines for planting for increased yield / quality
D4.4.2 PUBLICATION : Publications in international journals

Milestones[14] and expected results

Milestones

M4.1 Existing provenance trials and new populations to be sampled identified, month 6
M4.2 Sampling from trials and across range completed, month 12
M4.3 Molecular methods and protocols for assessment of gum quality optimized, month 15
M4.4 Measurement of quantitative traits completed, month 24
M4.5 Genetic diversity lab analysis and variation of gum quality / yield completed, month 32
M4.6 Data analysis completed, month 34
M4.7 Scientific papers submitted and recommendations for certification scheme published (WP3) dissemination outputs transferred to WP 6, month 46

Expected result

E4.1 Assessment of the importance of genetic vs environmental factors in gum quality / yield variation
E4.2 Characterization of range-wide intra-specific genetic variation
E4.3 Geographic Units for *in-* and *ex-situ* conservation of genetic resources
E4.4 Identification of markers linked to genetic units
E4.5 Optimized provenance selection for target farm sites, maximizing gum production

Workpackage number 5 **Start date or starting event: 5**

Workpackage title *Relationships between Acacia senegal trees and soil microbial communities (symbiotic and heterotrophic): effects on soil fertility and the sustainability of gum-arabic production.*

Participant id	1	2	4	5	6	7	8
Person-months per participant:	10	30	24	15.1	6	40	49

General objectives

The overall aim of this work package is to improve understanding of the relationship between soil microbial communities involved in the N cycle and the capacity of *A. senegal* trees (i) to produce gum-arabic in different environmental conditions and (ii) to rehabilitate degraded lands.

Specific objectives

1) To characterise the soil in relation to edaphic conditions (Task 5.1)
2) To identify the natural diversity of rhizobia, mycorrhiza and heterotrophic communities associated with *A. senegal* occurring under various environmental conditions (*e.g.* rainfall gradient) and in the soil of the *A. senegal* stands which will be studied within other work packages. (Task 5.2)
3) To measure the impacts of inoculation with selected rhizobial and/or mycorrhizal inoculum in terms of microbial activity, seedling establishment and early growth, N_2-fixation, and gum-arabic production in mature trees. (Tasks 5.3)

Description of work

Task 5.1. Assessment of soil characteristics in association with A. senegal trees

This task will underpin studies in WP 3, 4 and 5. It will characterize edaphic conditions in plantations and natural populations of gum-producing *A. senegal* located in different eco-climatic regions identified in the participating countries. Spatio-temporal changes in soil characteristics according to reference degraded lands will be investigated. Main soil characteristics will be measured (*i.e.* pH, organic C, ECEC at soil pH, total N and P, micro-elements, etc.) to 1 m depth, as well as relevant environmental traits (slope, rainfall, etc...). A special focus will be paid for the assessment of phosphorus and potassium. Soil physical analysis will include soil particle size, bulk density and water holding capacity. All physical and chemical analyses will use standard procedures described for tropical soils, consistently across partner countries to enable comparability of data.

Task 5.2. Inventory of the natural diversity of microbial and arbuscular mycorrhizal fungus populations present in the rhizospheric area of A. senegal trees in relation to global environmental conditions and gum-arabic yield.

The aim of this task is to investigate relationships between the *A. senegal* trees and both microsymbionts (rhizobia and mycorrhiza) and heterotrophic microbial populations naturally associated with their root systems. It will examine inter and intra-specific geographical variation in both microsymbionts and heterotrophic communities associated with the trees across the range of *A. senegal* in the project partner countries using molecular tools and traditional taxonomic tools. Study sites will focus on those which are the targets of WP3 & 4. We will also examine the microbial communities in existing provenance trials to establish the relationships between the environmental conditions, and the composition of microsymbionts and microbial communities. In parallel, an *in situ* quantification of N_2-fixation by *A. senegal* will be carried out by using the $\partial^{15}N$ natural abundance method in order to link both microbial diversity and symbiotic nitrogen fixation efficiency.

Both traditional and molecular tools will be used to investigate mycorrhizal diversity in the range-wide survey and on existing provenance trials. The molecular studies will focus on a few key mycorrhizal spp.

Task 5.3. *How rhizobial inoculation of mature A. senegal trees can improve gum-arabic yield? Impact on the native soil microbial community and soil biological functioning.*

This task will aim: (i) to screen several representative novel rhizobial strains and mycorrhizal isolates originating from the natural stands of *A. senegal* in Task 5.2. Their effectiveness will be tested and compared with existing cultures on *A. senegal* under greenhouse conditions. In this task we will also aim to assess the impact of selected inoculants in a range of different soil types (sand, clay, acid, alkali or neutral) to determine the most suitable and adaptable in a range of conditions using *A. senegal* provenances or genotypes advised by WP4. We know from other studies of African legume (and non-legume) trees that many are highly responsive to mycorrhizal inoculation in terms of nodulation, N_2-fixation, nutrient uptake and growth. Those microsymbionts showing potential for improving nodulation, N_2-fixation and growth under glasshouse conditions will be selected as single and/or dual inoculants (rhizobia and mycorrhiza) and subsequently tested in nursery and field conditions in each target country; (ii) to assess the impact of the rhizobial inoculation on gum arabic production in existing gum producing mature trees in DC participating countries. Several soil functioning parameters will also be measured such as total microbial biomass, nitrogen mineralization, potentials of nitrification and denitrification; The structure and the diversity of soil heterotrophic microbial

community will be assessed in the rhizosphere of both inoculated and no-inoculated trees.

Deliverables

D5.1 Data on both global and specific microbial communities naturally associated to *A. senegal* trees in each country.(0-36 months)
D5.2 Data of soil characteristics and other environmental conditions for gum producing areas (0-20 months)
D5.3 Description of microbial biodiversity of rhizosphere microorganisms (0-20 months)
D5.4 Estimates of N_2-fixation by *A. Senegal* (20-40 months)
D5.5 Data describing the nitrification and denitrification potentials of soils under *A. Senegal* (20-46 months)
D5.6 Identification and establishment of effective microsymbiont germplasm suitable for inoculation of *A. senegal* in a range of environmental conditions (0-20 months)
D5.7 : Quantification of the effects of inoculation on seedling growth and survival, and gum-arabic stimulation in mature trees (20-40 months)
D5.8 Publications in international journals and locally for use by forest managers and gum-arabic producers, GOs and NGOs etc (36-46 months).

Milestones[15] and expected results

Milestones

M 5.1 Site stratification established; temporary plots established and characterized; corresponding soil and roots samples collected and soil analyses initiated; collecting nodules, fungi and roots, prior to isolation of rhizobial and mycorrhizal strains; collecting of tree leaf samples for determination of ^{15}N natural abundance. Assessment and quantification of gum arabic production by experimental trees under field conditions (months 0 to 20).
M 5.2 Characterization of total microbial abundance and total microfauna ; nitrification bacteria quantified; potential N mineralization *in situ* assessed; ^{15}N tree sample analyses completed; microsymbiont populations assessed; denitrification bacteria enumerated and potential N denitrification assessed; structure and diversity of microbial communities investigated and determined; training of students and project staff in molecular biology and ecology (DNA fingerprinting, sequencing of microbial strains) (months 20 to 40).
M 5.3 Processing and analyses of various data sets completed (months 20 to 46).
M 5.4 Writing up of booklets and scientific papers in high impact factor international journals on indicators of forest restoration (months 32 to 48).

Expected results

E 5.1 Knowledge of the state of *A. senegal* natural stands/plantations in terms soil characteristics and soil functioning
E 5.2 Use of soil bio-indicators as management tools to maintain a sustainable gum arabic production
E 5.3 Farmers routinely use microsymbiont inoculants to establish new plantations, and mature trees to stimulate tree vigour and gum-arabic production
E 5.4 Best microsymbiont inoculants readily available for inoculation of *A. senegal*.

Workpackage number 6	**Start date or starting event: 6**			
Workpackage title *Information Dissemination and Transfer of Technologies of Project Results*				
Participant id	2	4	6	7
Person-months per participant:	54	5	10	9

Generall objective

To ensure that information generated is properly packaged and availed to different stake-holders in a form that is appropriate to each of them.

[15] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Specific objectives:
Evaluation and integration of results generated from different work packages into coherent outputs for dissemination and technology transfer
Preparation of specific dissemination/technology transfer packages
Development of suitable dissemination/technology transfer pathways.

Description of work

Task 6.1 Evaluation and integration of results generated from different work packages into coherent outputs for dissemination and technology transfer
Varied results will be generated from different work packages. Consultative meetings will be held among the project implementers to analyze the results generated and agree on suitable dissemination pathways. The first level of dissemination will therefore be sharing results among the implementing scientists in internal workshops. This will involve an analysis of the results and prioritizing them on the basis of suitable beneficiaries. Hard scientific data will be prepared for publication in journals for the benefit of the scientific community. It is expected that most of the results from WP1 to WP5 will be of this nature. However, useful information for the policy makers, service providers, farmers and traders/merchants will also be generated and it will be necessary to extract such information from the scientific results. There will therefore be need to review and prioritize the information for different categories of stakeholders.

Task 6.2 Preparation of specific dissemination/technology transfer packages
This task will mostly concern four categories of beneficiaries; policy makers, service providers, farmers and traders/merchants who will need to be informed on particular outcomes relevant to them. For policy makers, specific briefs will be prepared supported by concrete results while for farmers and traders, suitable outreach materials will be prepared. It will be necessary to discuss exhaustively among the WP Leaders as well as with other experts in the area of information dissemination on relevant key results that should go into production of each document. Further discussions will be held with decision makers in each country to inform them of the project results and involve them in promotion strategy.
Methods and deliverables:

- Drafting of preliminary key points for each strategy document related to the target groups,
- Presentation and discussion of each strategy document at country level for improvement. This will assist in assessing the suitability of the documents to intended users, and
- Validation of the strategy documents,
- Translation of extension documents into local languages for use by service providers, farmers and traders/merchants.

Task 6.3 Development and implementation of suitable dissemination/technology transfer pathways
There are generally different dissemination pathways depending on the nature of information and audience. Dissemination through publications in scientific journals is straightforward for the scientists. However, the greatest impact of the project will be dissemination to and adoption by farmers, traders/merchants and support by the policy makers. Success in dissemination will depend a lot on development of effective instruments and pathways. For policy makers and service providers, the following instruments and pathways are proposed;

- Policy briefs and extension materials (pamphlets and technical manuals) presented and discussed in workshops organized in the beneficiary countries,
- Training of service providers on the use and application of training manuals
- Internet through email (list serves) and websites
- Field visits of representatives to the trial sites

For the Farmers and traders/merchants;

- Training based on extension materials including information on marketing,
- Field visits of representatives to the trial sites

[16] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

- Radio and TV programs in suitable local languages
- Videos on key results

It is possible that some of the scientific results may not be published in journals but are useful sources of information. Such information could be compiled into technical reports. Additionally key outputs from the project can be compiled into a book.

Deliverables

D6.1 Internal project workshops with WP Leaders and scientists on results generated.
D6.2 Analysis and prioritization of results for different beneficiaries.
D6.3 Evaluation of project sites to serve as demonstration sites
D6.4 Drafting of preliminary key points for each strategy document related to the target groups.
D6.5 Presentation and discussion of each strategy document at country level for improvement. This will assist in assessing the suitability of the documents to intended users.
D6.6 Validation of the strategy documents.
D6.7 Translation of extension.

Milestones[16] and expected results

Milestones

M6.1 Consultative meetings to review, prioritize and extract relevant information for different stakeholders (months 10, 20, 30 and 40),
M6.2 Draft documents for policy makers, service providers, farmers and traders/merchants (months 12, 22, 32 and 42)
M6.3 Discussion of the draft documents with the stakeholders (months 14, 24, 34 and 44)
Validation of the documents incorporating suggestions from stakeholders (months 16, 18, 26 and 46)
M6.4 Suitable extension materials to stakeholders, training (different instruments) to stakeholders (months 17, 19, 27 and 47)

Expected results

E6.1 Coherent outputs for dissemination and technology transfer from different work packages evaluated and prioritized.
E6.2 Specific dissemination/technology transfer packages prepared.
E6.3 Suitable dissemination/technology transfer pathways developed and implemented.

B.1.5 Others issues

B.1.5.1 Ethical issues

Table A. Proposers are requested to fill in the following table

Does your proposed research raise sensitive ethical questions related to:	**YES**	**NO**
Human beings		X
Human biological samples		X
Personal data (whether identified by name or not)		X
Genetic information		X

Animals		X

There will be no negative environmental, ethical or gender effects resulting directly from this project. The activities proposed in ACACIAGUM do not include research on human cloning, human genetics or human embryos and no genetic transformations, or work with GMOs or releases of GMOs are planned. Neither will ACACIAGUM's activities contravene the policies and directives outlined in the "Ethical Rules for FP6 Projects" as presented in the "Guide for Proposers" and with the recommendations concerning microbial research covered by the "Elaboration and diffusion of a Code of Conduct for the access to and sustainable use of microbial resources within the framework of the convention on biological diversity" (EU Concerted Action Contract No BIO4-CT97-2206 (DGXII-SSMI). Within the context of this proposal, microsymbionts originating in developing countries will remain the "property" of their countries of origin and non-indigenous proposers will not attempt, or encourage, their commercial exploitation without the approval and/or participation of representatives of the relevant country of origin. Any subsequent exploitation will be in accordance with the rules of this programme and will conform with EU and DC ethics concerning IPR.

Investigation of new gum tapping methods using Ethephon, a plant growth regulator and registered pesticide, introduce issues related to authorization for use and regulation of this substance to safeguard the health of project workers and the local environment. Ethephon has widespread use in the horticulture industry in Europe and the US for accelerated ripening, however only one target country in the project has Ethephon registered for use. The activities involving study of the effects of Ethephon on gum yield will be restricted to this target country and no further applications for registrations will be made to expand project activities. The chemical is not listed as a UNEP Persistent Organic Pollutant, and has a WHO Acute Hazard Ranking of U (unlikely to be hazardous). Toxicological information provided by the PAN Pesticides Database, and regulatory information guiding its use in European partner countries, will be used to develop safe systems of work for its deployment within the project. Protocols for safe use in controlled applications will be authorized by health and safety officers within the European partner institutes, and a mechanism for evaluation of field practices will be instigated with the appropriate regulatory body in the target country.

Table B. Proposers are requested to confirm that the proposed research does not involve:

- Research activity aimed at human cloning for reproductive purposes,
- Research activity intended to modify the genetic heritage of human beings which could make such changes heritable[17]
- Research activity intended to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

	YES	**NO**
Confirmation : the proposed research involves none of the issues listed in Table B	X	

B.1.5.2 Gender issues

Wealth and opportunity is unequally distributed amongst poor populations in DCs. This generates hierarchical, power and privilege differences between men and women. Women are frequently prohibited access to trees and denied involvement in tree management. However, this situation is changing and women are increasingly becoming heads of household because of increasing migration of men to cities in search of work. In ACACIAGUM, we shall endeavour to ensure that women are not disenfranchised from decision and tree management issues. Their targeting in socio-economic surveys will be essential because the spending patterns of men and women differ. Women tend to use more of their money on household needs than men and their empowerment will have direct benefits on the livelihoods of their dependents. For too

[17] Research relating to cancer treatment of the gonads can be financed

long, women have been confined to activities such as gathering gum and have been denied the capacity to participate in management and comment on opportunities.

WPs 1 and 2 will provide guidance as to the level of gender differences within the study areas, and among specific social/ethnic groupings, and provide guidance on how to tackle these differences in the differing work packages. During the evolution of the ACACIAGUM proposal we have been at pains to involve women and to ensure that female participants will carry out leadership roles and have equal responsibility with men. However, in this respect, equality of opportunity for responsible roles was hampered because of the over-representation of male researchers in several of the participating institutions and in the DCs in particular. Nevertheless female DC researchers have also been given responsible roles in many of the tasks and will share responsibility for WP co-ordination with other participants. In this way we hope to encourage woman into science and further their career development.

B.1.5.3 Policy issues

In promoting gum production using a scientific knowledge-based biological, economical and sociological strategy, ACACIAGUM will contribute directly to EU development policies by empowering civil society in development of enabling policy guidelines, increasing production, biosafety and quality of exportable commodities, improvement of marketing, diversification of farmers' income sources to provide "insurance" against total loss of income in periods of crisis, increasing financial stability, providing local opportunities for employment and ensuring that women will benefit. EU policy contains elements of good governance and involvement of civil society and while the project will not be in a position to influence governments directly, we shall make policy recommendations to GOs NGOs and local organisations so that potential impact can be maximised. The European proposers all have substantial experience of working in developing countries. This is particularly important in the business domain where negotiations typically take a long time to progress and where trying to enforce European methods and standards in business, can easily cause offence.

Opinion will be sought on whether planned studies are perceived as being in the interests of the local population, participants and beneficiaries. Only activities in which the local populations have confidence will be conducted on their properties. The researchers will be obliged to obtain permission to work on experimental sites/farms before commencing studies and any risks to the local populations will be explained to them in full, if necessary by local associates using local languages, before studies commence. In all of these matters, liaison with local DC researchers will be an essential prerequisite for avoiding infringement of ethics.

Part B / Section B2

Front Page

Proposal full title: Innovative management of *Acacia senegal* trees to improve resource productivity and gum-arabic production in arid and semi-arid sub-Saharan Africa

Proposal acronym: ACACIAGUM

Date of preparation: August 2005

Type of Instrument: Specific Targeted Research Project (STREP)

List of participants

Participant no.	Participant organization name	Participant org. short name
1	Coordinator : Dr Didier LESUEUR Coordinator organization : Departement Foret du Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement, Montpellier, France **Co-ordinator email:** d.lesueur@cgiar.org **Co-ordinator fax:** +254 20.722.4763/64	CIRAD
2	Kenyan Forestry Research Institute, Nairobi, Kenya	KEFRI
3	Wageningen University, Wageningen, The Netherlands	WU
4	Universite Abdou Moumouni, Niamey, Niger	UNIAMEY
5	Natural Environment Research Council, Centre for Ecology and Hydrology, Edinburgh, UK	CEH
6	Pôle de Recherches Appliquées au Développement des Savanes d'Afrique Centrale/ Institute of Agricultural Research for Development, North Centre, Agroforestry and Forestry Program Maroua., Cameroon	PRASAC/IRAD
7	Universite Cheikh Anta Diop de Dakar, Dakar, Senegal	UCAD
8	Institut de Recherche pour le Developpement, Paris, France	IRD
9	Institut Senegalais de Recherche Agricole, Dakar, Senegal	ISRA

B.2.1 The consortium and project resources

B.2.1.Consortium quality

This is a high quality consortium comprising scientists with long and relevant experience in the areas that will be researched in this contract. The participating scientists from France, the United Kingdom and Netherlands have many years experience of work in tropical countries and are familiar with the problems

being addressed. All participants are experienced in working in multidisciplinary projects and will interact positively with colleagues from other scientific disciplines. All of the Partners have worked previously with at least some of the other Partners and we foresee no difficulties in establishing rapport and collaboration within this broader assemblage of researchers.

Both European and African scientists are conversant with work within the European context and scientists from both continents are currently operating in co-ordination roles in EU INCO research contracts. Thus their experience and expertise is already established.

All DC Partners from 4 sub-Saharan African countries including 2 from West Africa (Senegal and Niger), 1 from Central Africa (Cameroon) and one from East Africa (Kenya). have already worked with European organisations and several from both East, Central and West Africa undertook their PhDs in European and north American universities and institutions. They also have substantial publication records and dissemination capabilities.

B.2.1.2. Commitment

The topics contained within this proposal form part of the core activities of each of the participants and hence both the organizations and their staff are already committed to the planned activities. The DC partners are also determined to learn new skills as evidenced by the planned exchange visits. (KEFRI to IRD and CEH; UNIVAMOUM to IRD; ISRA to CEH for example). The commitment is also evidenced by the requests to extend project management meetings to include not only plenary sessions but sessions devoted to specific WPs to ensure proper communication, progress and development. This fuller consideration of progress, needs, and potential new research methods will help ensure success.

The European participants will conduct research activities in the DCs. That DC partners will participate in all of the WPs demonstrates their strong commitment to the project. The larger consortium will widen the experience of each Partner and reinforce synergy and commitment of all participants. Airline links between the four DCs and Europe are largely easy and inexpensive which will facilitate exchange visits and participation at meetings at reasonable cost.

Although much of the actual work will be undertaken in DCs, researchers from DCs will undertake some of their tasks in European laboratories and will thus benefit from exposure to state of the art methods and software, in molecular biology, biometrics, modelling and genetics.

So far as is practicable given the range of expertise in modern techniques, the WPs and tasks within them are being led by European and DC partners in a more or less balanced way. Opportunities to involve women scientists have been exploited where their expertise and knowledge of the subject areas would enable them to do so.

B.2.1.3. Complementarity between participants

There is strong complementarity between the research teams. In Europe each of the four research teams presents strong experience in specific fields. CEH has extensive experience in studies in plant genetics, plant physiology, mycology, tree:crop interactions and manipulation of coarse root systems. IRD is particularly experienced in soil functioning and microbiology. CIRAD is skilled in tree management, microbiology and genetics. IRD will focus on soil functioning and their bacterial activities will complement those of CIRAD, and WU is more concerned by socio-economics aspects in connection with CIRAD. Because of the size of the task, CEH and CIRAD will collaborate closely on genetics and share the tasks in a complementary fashion. Thus there is strong complementarity between the northern Universities and the research institutions. However, it is less easy and less desirable to enforce complementarity among DC partners. Due to the nature of the work and the regional dimension, some studies need to be replicated by the local Partners in DCs so that the data sets for each country can be collected and compared. On this basis, the DC Partners were selected on the basis of potential to produce biosafe, high quality gum-arabic as well as for their skills range and experience. The latter is key to conducting high quality multidisciplinary research and is a prerequisite for achieving the wider objectives of ACACIAGUM. There will of course be multiple European/DC studies particularly in fieldwork where complementary approaches and skills will enable the work to proceed smoothly.

B.2.1.4. Involvement of SMEs

Although the interests of SMEs have been taken into account in ACACIAGUM and some of the fieldwork will be carried out in plantations belonging to SMEs involved in the gum trade, we elected to have indirect

involvement of SMEs because of the wide ranging surveys that need to be conducted amongst SMEs at all stages of the gum production chain. Given the context of the study, direct involvement of only a few SMEs would not have provided sufficient sample size for collection of the ideas and information required at all stages in the production chain. Nevertheless, SMEs in both Africa and Europe will be kept informed of our activities and progress and will be invited to attend local project meetings and final workshops. In that way, as well as during socio-economic surveys, SMEs will play an important part in the development of strategies and there will be a two-way flow of information upon which the relevant strategies can be developed and built. SMEs will of course receive the final outputs and recommendations from the project.

B.2.1.5. Adequacy of funding

The financial planning of this project was based on sound financial principles using realistic estimates of the time required to execute tasks and allowing for inflation whilst costing personnel. The need for labour, both scientific and in support roles has also been properly estimated and accounted in both European and DCs. All foreseeable expenditure and costs have been allowed for and verified in budgets. With travel, airfares and costs for subsistence in the various venues were properly estimated and taken into consideration. As the sites in Niger and Kenya are located quite fare from the laboratories and offices, we have to strengthen the travel budget of these two partners KEFRI and UNIAMEY. Thus travel budgets are based upon needs. We have elected to hold longer co-ordination meetings than normal with time allocated to both Plenary and WP sessions. This strategy will minimize the money that is consumed in travel. Modern systems of communication apply in all of the DCs and thus frequent contact and communication can take place at costs that are much smaller than those incurred in holding "extra" meetings. Contact between researchers and the local population and visits to research sites also requires local travel funds and this too has been included in estimates. The FC and FF funded Partners have already agreed and underwritten their commitments to total costs. The European Partners are equipped to undertake most of the studies allocated to them and thus needs for equipment are limited. However running costs for consumables, especially for molecular studies, will be quite large and the contribution from Europe will be invaluable in funding their purchase. Consumable costs too, have been properly estimated and entered into budgets. For effective participation in some WPs it will be necessary for the DC Partners to obtain some durable scientific and computing equipment with the European funding. This equipment and training in its use and subsequent experience, will help with capacity building in the DCs. The CEH's overhead rates are negotiated by their parent organization - the UK Natural Environment Research Council, with the EU and they are applied, where appropriate, to all contracts with the EU. Within the last 12 months, NERC has submitted its overhead calculations to the EU for scrutiny and they have been passed by the EU. The CEH's overheads are calculated as 105% of staff costs only. Other costs are excluded

Detail budget breakdown of ACACIAGUM project :

	ACACIAGUM BUDGET			**details of budget in euros**							
RTD activities											
Country		**Organisation**	**model**	**travel & subsistence**	**consumables**	**staff cost**	**Others**	**equipment**	**overheads**	**total**	**requested grant**
France	1	CIRAD	FCF	89710	50000	293480	2000		87038	522228	261114
Kenya	2	KEFRI	AC	105930	89500	34594	25226	58920	62834	377004	377004
Belgium	3	WU	AC	53970	22500	105460	3935		37173	223038	223038
Niger	4	UNIAMEY	AC	75735	20000	15549	9146	54611	35008	210049	210049
U.K.	5	CEH	FC	38786	54286	211724		15714	227157	547667	277834
Chad	6	PRASAD-IRAD	AC	30040	38200	35330		53000	31314	187884	187884
Senegal	7	UCAD	AC	51448	33841	34299	5845	19284	28943	173660	173660
France	8	IRD	FC	64834	65100	141150	4000		55017	330101	165050
Senegal	9	ISRA	AC	64166	30000	35000	2000	20400	30313	181879	181879
TOTAL				**574619**	**403427**	**906586**	**52152**	**221929**	**594798**	**2753511**	**2057513**

Management activities					
Country		**Organisation**	**model**	**total**	**requested grant**
France	1	CIRAD	FCF	108000	108000
Kenya	2	KEFRI	AC	4000	4000
Belgium	3	WU	AC	4000	4000
Niger	4	UNIAMEY	AC	4000	4000
U.K.	5	CEH	FC	4000	4000
Chad	6	PRASAD-IRAD	AC	4000	4000
Senegal	7	UCAD	AC	4000	4000
France	8	IRD	FC	4000	4000
Senegal	9	ISRA	AC	4000	4000
TOTAL				**140000**	**140000**

Description of the partners.

Coordinator and participant 1: Departement Foret du Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD-Foret).

CIRAD is the French Agricultural Research Centre for International Development. Its mission is to contribute to the social and economic development of the tropical and subtropical regions through research on agriculture, environment and rural areas, along with training, capacity building and dissemination of scientific and technical results. It employs 1 850 people, including 950 senior staff, working in over 50 different countries. CIRAD is operating though partnership and networking activities, with all concerned stakeholders as it is routinely working with NARIs, Education and Training Centers, ARIs, International and Regional Centers, Organizations of Producers, Development Projects, Extension Services, NGOs and Private sector. Hence, CIRAD mission and objectives perfectly match the mandate of the Sub Saharan Africa Challenge Program that is building sustainable livelihoods through Integrated Agricultural Research for Development.

The Forest Dept of CIRAD will coordinate the whole project and will participate mainly in WPs 1, 3, 4 and 5.

Staff involved in the project:

Dr Didier Lesueur is a soil microbiologist of Forest Dept of CIRAD since 1991. He is based in Africa during 9 years (Senegal, 8 years and now in Kenya). He will act as project coordinator and will also lead CIRAD-Foret activities in WP5. He has a background in tree legumes nutrition in relation with microsymbionts, but also recently soil functioning microbiology (microbial communities involved in the N cycle and P solubilization). He has leaded a succession of projects in sub-Saharan West Africa on the utilization of inoculated native and exotic tree species to improve degraded lands. During these last ten years, he has coordinated an INCO project during 4 years (IC18-CT97-0194/ diversity of microsymbionts associated to *Calliandra calothyrsus* / 1997-2001) and he is participating in two others INCO project leaded by KEFRI (ICA4-CT-2001-10093 / SAFSYS / 2001-2005) and CIRAD-Foret (FOREAIM which started on 1st June 2005 for four years). Through these several projects, he is working in Kenya since 1997 and has a strong collaboration with some national partners such as KEFRI, University of Niamey and also international partners such as CEH.

Dr. Jean-Michel Harmand is an agro-forester at CIRAD since 1985. His main research topics are: 1) rehabilitation of degraded land, 2) water use, nutrient cycling and soil fertility in agroforestry systems and forest plantations. During the years 1993-1998, he worked in close collaboration with IRAD in Northern Cameroon developing a research expertise on *Acacia senegal* management for gum-arabic production.

Dr Nicole Sibelet, agronomist and sociologist, has been working since 1987 on the sociology of rural innovation and on the relations between society and tree. She analyzes representations, practices and motivations of the stakeholders in the evolution of their systems facing crisis, especially with dynamics concerning trees. She has lived ten years aboard. Since 2001, she is used to go in North-Cameroon regularly, on tree issues.
She has always worked with foresters, particularly since 1997 when she started teaching sociology in a foresters'school (Ecole Nationale du Génie Rural des Eaux et des Forêts). Her methods come from Research-Action with parternship, for the knowledge and the action, to improve stakeholder's situations.

Msc Regis Peltier is an agro-forester of CTFT and CIRAD-Forêt since 1978. His main research topics are: 1) farm-trees plantations and forest local management in tropical area, 2) rehabilitation of degraded lands. During the period 1981-1988, he worked with IRAD in North-Cameroon, developing a research program on local species plantation, including *Acacia senega.l* He set up around ten field-trials on Acacia species and provenances, in a wide range of soils and rainfall. After that, he is continuing to collaborate with development project in North-Cameroon (DPGT-ESA) to support farmer's gum-trees plantations

Dr Jean-Marc Bouvet has 20 years of experience in general forestry issues and specifically in quantitative and population genetics and in the coordination of projects and research activities. He is the coordinator of the INCO DEV project FOREAIM (Bridging restoration and multi-functionality in degraded forest landscape of Eastern Africa and Indian Ocean Islands). He will lead CIRAD-Foret activities in WP4.

Relevant publications:

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Reyniers F.N., **Sibelet N.** and Torquebiau E. 2002. How farmers use agrobiodiversity to cope with climatic variability and community change. Fifth international Farming System Association European Symposium, Florence, Italy, April 8-11, 2002. 10 p.

Rouxel C., Barbier J., Niang A., Kaya A B. et **Sibelet, N**. 2005. Biodiversité spécifique ligneuse des terroirs : quelles relations ? Le cas de trois villages de la région de Ségou (Mali). Bois et Forêts des Tropiques. 283 : 33-49.

Saïd M. et **Sibelet N.** 2004. Pour que la terre ne cache plus l'arbre : le foncier de l'arbre. In : Agricultures. 13 (6) : 510-515.

Sanou H., Lovett P.N. and **Bouvet J.M.** 2005. comparison of quantitative and molecular variation in agroforestry populations of the shea tree *(Vitellaria paradoxa* C.F Gaertn) in Mali, *Molecular Ecology*. 14: 2601-2610.

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Sarr A., Neyra M., Oihabi A., Houeibib M.A., Ndoye I. and **Lesueur D.** Characterization of native rhizobial populations presents in soils from natural forests of *Acacia senegal* and *Acacia nilotica* in Trarza and Gorgol regions from Mauritania. *Microbial Ecology* (in press).

Participant 2:Kenyan Forestry Research Institute, Nairobi, Kenya (KEFRI)

KEFRI's mandate is to conduct research in forestry, co-operate with other research bodies within and outside Kenya carrying out similar research, liaise with other organisations and institutions of higher learning in training and on matters of forestry research, and disseminate research findings. Its mission is to enhance the social and economic welfare of Kenyans through user-oriented research for sustainable development of forests and allied natural resources. The institute has over 1200 employees, including 80 Assistant and Senior Scientists undertaking research in five regional centres representing various ecological zones. It is a regional centre for African Forestry Research Network (AFORNET), Forestry Research Network for Sub-Saharan

Africa (FORNESA), Association of Forestry Research Institutions in Eastern Africa (AFREA), International Forestry Resources and Institutions (IFRI, a global network on the study of institutions and natural forests).

KEFRI is also hosting the **Network for Natural Gums and Resins in Africa (NGARA),** which is the most pertinent to the ACACIAGUM project. NGARA is a regional network being hosted in Kenya at KEFRI and whose goal is to assist African countries and partners formulate a coordinated strategy in sustainable development of their natural gum and resin resources for improving rural livelihood and environmental conservation. NGARA was established with the mission to position African producer countries and partners as major global players in the production, processing and marketing of gums and resins.
The objectives of the NGARA Network are to:

- promote exchange of information on production, marketing, processing and quality control among producer countries as well as with partners;
- facilitate access to technological development and training;
- support relevant research in the key areas of the sector; and to
- promote the links between the primary producer, processor and end user.

NGARA has 14 members from countries in sub-Saharan Africa producing the commodities and organizations involved in the development of the resources and/or commodities.
The Regional Coordinator of Network for Natural Gums and Resins in Africa (NGARA) is also a key scientist in the ACACIAGUM Project.

The KEFRI will participate in WPs with greatest emphasis on 1, 2, 3, 4 and 5 and NGARA on WP 6

Staff involved in the project:

KEFRI

Dr David ODEE, more than 15 years experience in microsymbiont work and tree domestication in tropical forestry and agroforestry. He is the coordinator of the INCO DEV project SAFSYS (Symbionts in agroforestery Systems: what are the long-term impact of inoculation of *Calliandra calothyrsys* and its intercrops? Ref No ICA4-CT-2001-10093)

Mr Charles Kirinya, more than 20 years in forest silvilculture

Mr Norman Gachathi, more than 20 years of experience in plant taxonomy and ecology with emphasis on woody species; currently leading studies on survey and inventory of gum and resin producing species in ASALs

James Maua, ecologist, also responsible for seed germplasm collection, storage, and seed technology, currently leading collection and storage of *A. senegal* seeds

Joseph Machua, experience in soil fertility, microbiology and soil mapping

Mr Albert Luvanda, wide experience in market research especially of farm forestry products and cost benefit analysis.

Mr David Langat, forest resource economist specialised in socio-economic surveys, institutional analysis & participatory approaches

Mr Joseph Lelon, experience in analytical chemistry including soil nutrient-plant relationships and soil physico-chemical analyses; currently also involved in gum quality assessment in relation to soil conditions

Stephen Indieka, microbiology (rhizobia/mycorrhiza) and vegetative propagation

NGARA

Enrico Casadei has 35 years of postgraduate experience; 20 of them in the area of projects development and supervision in the area of commodities, quality control, market development and sustainable use of resources.

Chidume Okoro has 26 years of post graduate experience; 15 of them spent in the area of commodity trade including market development (rural, national and international), supply chain mapping, establishment of commodity cooperatives, Associations and Networks.

Ben Chikamai has over 22 years of experience as a researcher with about 18 years of research in gum-arabic production, quality and marketing. Also involved in networking where dissemination is a key component.

Sheila Mbiru has over 14 years experience as a researcher; Nine years in the area of non-wood forest products and the last five years in scientific information management and dissemination. This involves scientific writing and editing, desktop publishing, database development and management and website design and management.

Relevant publications:

Chikamai B.N. and Odera J.A. [Eds]. 2002. Commercial Plant Gums and Gum Resins in Kenya: Sources of Alternative Livelihood and Economic Development in the Drylands. Executive Printers Ltd., Nairobi.

Chikamai B.N.; Mbiru S.S. and **Casadei E.** 2000. Report of the Network for Natural Gums and Resins in Africa. Foundation Press Ltd., Nairobi. 50p.

FAO/**NGARA**/AIDGUM. 2004. Gum Trees and Gum Arabic: Field manual. Executive Printers, Nairobi.

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Machua J., Harrier L.A., Macdonald A., Ingleby K. and Wilson J. 2002 Using molecular approaches to monitor persistence and spread of *Calliandra calothyrsus* Meissn. arbuscular mycorrhizal inoculants in tropical agroforestry. *Poster abstract at the 14th Symposium of The Scottish Microbiology Society and British Society for Plant Pathology joint meeting "Plant microbe interactions" University of Paisley, Glasgow, September 4Th 2002*

McInroy S.G., Campbell C.D., Haukka K.E., **Odee D.W.,** Sprent J.I., Wang W.J., Young J.P.W. and Suntherland J.M. 1999. Characterization of rhizobia from African Acacias and other tropical woody legumes using BiologTM and partial 16S rRNA sequencing. *FEMS Microbiology Letters*. 170:111-117.

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Odee D.W., Haukka K., McInroy S.G., Sprent J.I., Sutherland J.M, and Young J.P.W. 2002. Genetic and symbiotic characterization of rhizobia isolated from tree & herbaceous legumes grown in soils from ecologically diverse sites in Kenya. *Soil Biology & Biochemistry*. 34: 801-811

Odee D.W., Indieka S.A. and Lesueur D. 2002. Evaluation of inoculation procedures for *Calliandra calothyrsus* Meisn. grown in tree nurseries. *Biology and Fertility of Soils*. 36: 124-128.

Odee D.W., Ingleby K, Lebonvallet S., Sylvester-Bradley R., Machua J. and Lesueur D. 2003 Selection of multi-origin microsymbionts (rhizobia and arbuscular mycorrhiza) of *Calliandra calothyrsus* Meisn. for field inoculation trials, pp22-41 *In* (Eds A J Pottinger & D Lesueur), Evaluation and use of the microsymbionts of *Calliandra calothyrsus* to optimise fodder production within small-scale farming systems in the humid zone.

Sutherland J.M., **Odee D.W.,** Muluvi G.M., McInroy S.G. and Patel A. 2000. Single and multi-strain rhizobial inoculation of African Acacias in nursery conditions. *Soil Biology and Biochemistry.* 32:323-333.

Participant 3: Wageningen University, Wageningen, The Netherlands (WAGU)

Wageningen University and Research Centre (Wageningen UR) is a leading international knowledge institute in the fields of nutrition and health, sustainable agricultural systems, environmental quality and processes of social change. The path-breaking research of the university and innovative education form a vital contribution to the quality of life.
The research institutes and university work together closely in five areas of expertise: Agrotechnology & Food, Animal, Environmental, Plant and Social Sciences.
All personnel participating in this project have experience with regional and international collaborative research projects. WU will participate mainly in WPs 1 and 2

Staff involved in the project:

Dr. R. Ruben – DEC: Senior lecturer/associate professor in agrarian economic, specialized in farm household economics and rural institutions. He has worked extensively in Central America (Nicaragua, Honduras, Costa Rica) on issues of land reform, cooperative development, rural credit and integrated rural development programmes. After his appointment at Wageningen UR (1993) he is in charge of the research programme "sustainable land use and food security in developing countries" (DLV). He is involved in research on bio-economic models to analyze farm household responses to agrarian policy instruments (Mali, Burkina Faso, Costa Rica, China), agrarian institutions and land markets (Central America, Bolivia), climate change (West Africa) and rural off-farm employment (India,

Honduras). His current research interests focus on the economic appraisal of high and low-input agriculture, farm household entitlements to food security, and the impact of social capital on rural incomes and agricultural productivity.

Prof. Dr. Rr. C. Leeuwis – CIS : Professor of Communication and Innovation Studies and chairman of the MSc programme Management of Agro-ecological Knowledge and Social Change (MAKS). He regards innovations as a balanced whole of technical devices, mental models and organizational arrangements, resulting in coordinated action in a network of stakeholders. His research focuses on (a) the value of new interactive and cross-disciplinary approaches to bringing about coherent innovations, (b) the analysis of social learning and conflict management in networks, (c) changing dynamics and arrangements in the knowledge infrastructure due to a.o. privatization of research and extension, and (d) the reflexive monitoring and evaluation of innovation support strategies and trajectories.
He is currently involved in several research projects in Africa, including a large trans-disciplinary PhD research program in Ghana and Bénin (Convergence of Sciences). He has played a coordinating role in the Zimbabwe program on Women Extension Sociology and Irrigation (ZIMWESI) from 1994 to 1998. Other PhD research projects take place in the Netherlands, South Africa, Uganda and Ethiopia.

Prof. Dr. K.E. Giller – PPS: Professor of Plant Production Systems since 2001. Projects involved collaboration with scientists in many countries in East and Southern Africa, South America and South and South-east Asia. In these projects resources for production of crops and livestock are studied, with special emphasis on the temporal and spatial dynamics of resources within farming systems (including common property) and their interactions. Resource utilization efficiency is studied as a function of capture (interception and absorption) and conversion efficiencies. Moreover, development of principles for enhancing efficient use of scarce resources are considered within complex dynamics of interacting temporal and spatial scales. The unit of analysis for research is extended beyond the farm boundary to the livelihood of the farming household.

Relevant publications:

Ruben R. and J. Pender. 2004. Rural Diversity and heterogeneity in less-favoured areas: the quest for policy targeting. *Food Policy* 29:303 - 320.

Ruben R.; Kruijssen F. and Saenz F. 2004. Exports contracts for non-traditional products: quality and loyalty in Chayote chains from Costa Rica. In: *Dynamics in Chains and Networks*. - Wageningen : Wageningen Academic Publishers, 2004 - p. 493 - 500.

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Moll H.A.J., **Leeuwis C**, Manzungu E and Vincent L.F. (Eds.) 2004. *Agrarian institutions between policies and local action: Experiences from Zimbabwe*. Harare: Weaver Press, 320 pp.

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Dormon E.N.A, van Huis A., **Leeuwis C.,** Obeng-Ofori D. and Sakyi–Dawson O. 2004. Causes of low productivity of cocoa in Ghana: Farmers' perspectives and insights from research and the socio-political establishment. *NJAS - Wageningen Journal of Life Sciences*, 52 (3-4): 237-259.

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Mafongoya P.L., **Giller K.E.,** Odee D.W., Gathumbi S., Ndufa S.K. and Sitompul S.M. 2004. Benefiting from N2-Fixation and Managing Rhizobia. In M. van Noordwijk, G. Cadisch, & C.K. Ong (Eds.), *Below-ground Interactions in Tropical Agroecosystems* (pp. 227-242). Wallingford: CABI.

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Giller K.E. 2001. *Nitrogen Fixation in Tropical Cropping Systems*, 2nd/Ed. CAB International, Wallingford, 423 pp.

Participant 4: Universite Abdou Moumouni, Niamey, Niger (UNIAMEY)

UNIAMEY is the main training and research institution in Niger. UNIAMEY has carried out several research in biodiversity and ecology of plants and microorganisms for more than 20 years. UNIAMEY has a wide experience in collaborative research and in conducting research within consortia in both Africa, Europe or for the European Commission. UNIAMEY has also a large experience in the dissemination of scientific results through training sessions and collaborations with NGOs.
All personnel participating in this project have experience of regional and international collaborative research projects. The UNIAMEY team is multi-disciplinary in nature embracing agroforesty, microbiology,

silviculture, physiology, bio-technology and soil science. UNIAMEY will participate mainly in WPs 1, 3, 4 and 5

Staff involved in the project:

Pr. Saadou M., more than 34 years experience in Biology, Ecology and Biodiversity. Prof Saadou is the responsible of the Laboratory of Biology and Ecology "Garba Mounkaïla". The Prof Saadou will coordinate the UNIAMEY activities and he will lead the UNIAMEY activities in the WPs3 and 6.

Dr Alzouma M., more than 8 years experience in soil microbiology, biotechnology. Dr ALZOUMA will be responsible for the UNIAMEY in the WP5 concerning microsymbionts such as rhizobia, characterization and ecological study and training of students and researches on rhizobia and a good experimental experience with PCR/RFLP technique studies.

Mme Marafat D., more than 17 years experience in soil microbiology, Dr MARAFA will take in charge for UNIAMEY the activities concerning the mycorrhizal studies in WP5.

Dr Atta S., more than 12 years experience in physiology who have previously worked in legume physiology will conduct the physiology impact and using ^{15}N techniques to assess N fixation in WPs3 and 5.

Dr Mahamane A., more than 10 years of experience in agroforestry and silviculture research and gum production and cost benefit analysis in WP1. He will be also co-leader for activities for improvement of the production out of gum within WP3.

Dr Bakasso Y., more than 14 years of experience works in genetic and plants improvement spontaneous as cultivated. He has good experience of biodiversity analysis and morphologic traits characterization and environmental basis in WP4.

Dr Ichaou A., more than 30 years of experience in agroforestry and silviculture. He will be responsible for UNIAMEY activities carries out in the WP 1. He will be also co-leader for activities for improvement of the production of gum within WP4.

Relevant publications:

Alzouma Mayaki Z., 1997a. Etude de l'influence du champignon *Fusarium Sp* AF-967 sur les bactéries des rhizosphères de certaines plantes. Revue scientifique de l'Académie des sciences agricoles de Moscou IZVESTIA N°4,110-116. Académie Timiriazev, Moscou.

Alzouma Mayaki Z., 1997b. Propriétés biologiques et technologiques du champignon *Fusarium sp* AF-967- antagoniste des agents de la pourriture des racines de certaines plantes agricoles. Thèse pour l'obtention du Ph.D en protection biologique des plantes et microbiologie. Académie Timiriazev, Moscou

Atta S., Maltese S., Marget P., Cousin R., 2004. $^{15}NO_3$ assimilation by field pea *Pisum sativum* L., *Agronomie* 24 (2): 85-92.

Bakasso Y. and Zongo J.D. 2000a. Astudy of genetic variability in *Sesbania pachycarpa* DC. In Burkina Faso. *Agronomie* 20 INERA, EDP Sciences 2000, pp 431-438.

Bakasso Y. and Zongo J.D. 2000b. Heterosis and combining ability in half-diallel cross of *Sesbania paychycarpa* DC. *Agronomie* 20, INERA, EDP Sciences 2000, pp 927-932

Ichaou A. 2000. Dynamique et productivité des structures forestières contractées des plateaux de l'Ouest Nigérien. Thèse de Doctorat de l'Université Paul Sabatier de Toulouse III. Spécialité : Ecologie Végétale Tropicale : 231 p.

Ichaou A. et d'Herbès J.M. 1995. Productivité comparée des formations structurées et non structurées dans le sahel nigérien. Conséquence pour la gestion forestière. *in* Fonctionnement et gestion des écosystèmes forestiers contractés sahéliens. JM d'Herbès, JMK Ambouta et R. Peltier : 119 – 130.

Mahamane A., Barbier N., Dulieu D., Lejoly J., De Deblauwe V. and **Saadou M. 2004**. Diversity and dynamics of plant communities in the Niger valley (Regional Park W). Symposium Exploitation and restoration of Tropical aquatic ecosystem, **necov**. **Mahamane A., 2001**. Etude de l'évolution à long terme dans le Département de Maradi : Usage des terres agricoles et évolution végétale basée sur les données de photographies aériennes et d'images satellitaires de 1950 à 1999. Drylands Research / Overseas Development Institute (ODI), London. 44 p.

Saadou M., 2005. Suivi écologique de la végétation ligneuse des jachères dans le terroir de Magou, Sud – ouest du Niger. Annales de Botanique de l'Afrique de l'Ouest.

Saadou M. et Mahamane A., 2003. - Ecologie, chorologie et rôle de *Boscia senegalensis* (Pers.) Lam. Ex Poir dans les écosystèmes sahéliens et sahélo-sahariens du Niger. AETFAT, Addis-Abeba.

Participant 5: Natural Environment Research Council, Centre for Ecology and Hydrology, Edinburgh, UK

The Centre for Ecology and Hydrology (CEH) is the UK's Centre of Excellence for research in the terrestrial and freshwater environmental sciences. Our parent organisation is the UK Natural Environment Research Council. CEH's staff has specialist skills in a wide range of environmental disciplines, ranging in scale from the gene to whole Earth systems. CEH Edinburgh, has been involved in tropical research since the early 1980's. It is a component member of the Edinburgh Centre for Tropical Forests.

CEH will participate mainly in WPs 3, 4 and 5

Staff involved in the project:

Dr Julia Wilson is leader of the Biosystems Management Section at CEH, a core member of CEH's Sustainable Economies Programme and will also lead CEH activities in WP 5. She has a background in plant physiology, genetic diversity and mycorrhizas and recently has led a succession of projects focussed on improving understanding of below-ground tree-crop interactions in projects in Kenya and Uganda, funded by the UK Department for International Development. She has coordinated or contributed to numerous EU projects, including TS3*-CT94-0316, ERBIC 18C18CT970149, IC18-CT97-0194 and ICA4-CT-2001-10093 (SAFSYS).

Dr. Stephen Cavers will lead WP4. He has nearly 10 years experience of tropical field work and extensive experience of using molecular tools to answer questions in conservation and population genetics. His most recent research examined regional and landscape genetic variation within the forest tree species *Cedrela odorata, Swietenia macrophylla* and *Vochysia ferruginea* in Central America. He is currently coordinator of the FP5 project GENEO-TROPECO: Sustainable management of Neotropical tree genetic resources (ICA4-CT-2001-10101), leading contract negotiations on a new FP6 project (SEEDSOURCE) and collaborating on FP5 projects TEAKDIV (ICA4-CT-2001-10094) and OAKFLOW (QLK5-CT-2000-00960).

Dr. Nicola Hall is a terrestrial ecologist with a background in plant physiological ecology gained during her recent PhD. She will contribute to WP3. She has worked on the physiology of drought tolerance using gas exchange and fluorescence techniques combined with stable isotope methods, as well as the genetic control of quantitative traits with QTL analysis. She now works on a number of projects in the Biosystem Management section involving field work in West Africa, applying plant and soil studies combined with carbon modelling techniques to the study of carbon sequestration, land-use management and ecosystem sustainability. Her current research interests lie in studying soil microbial communities that indicate and regulate soil condition in agro-ecosystems.

Mr Kevin Ingleby is a microbiologist with special expertise in mycorrhizas, he has spent the last 30 years conducting research on mycorrhizas including research and training on arbuscular mycorrhizas in the tropics since the mid 1980s, and has skills in taxonomy, culturing, inoculation and identification through molecular approaches. He will contribute to WP5. He has extensive research experience in Africa through numerous EU projects including ERBIC 18C18CT970149, ICA4-CT-2001-10093 (SAFSYS).

Mr RC Munro has about 15 years experience of working in Africa and has particular experience in root systems and mycorrhizas. He has worked extensively in both West and East Africa, and will contribute to WP3.

Relevant publications:

Lowe A.J., Jourde B., Breyne P., Colpaert N., Navarro C.**, Wilson J., and Cavers S.** 2003. Fine scale genetic structure and gene flow within Costa of Rican populations of Mahogany (*Swietenia macrophylla*). *Heredity*. 90: 268-275.

Cavers S., Navarro C. and Lowe A.J. 2004. Targeting genetic resource conservation in widespread species: a case study of Cedrela odorata L. *Forest Ecology and Management*. 197: 285-294.

Odhiambo H.O., Ong C.K., Deans J.D., **Wilson J.,** Khan A.A.H. and Sprent, J.I. 2001. Roots, soil water and crop yield: tree crop interactions in a semi-arid agroforestry system in Kenya. *Plant and Soil* 235: 221-233

Ong C.K., **Wilson J.**, Deans J.D., Mulatya J., Raussen,. T., and Wajja-Musukwe N. 2002. Tree-crop interactions: manipulation of water use and root function. *Agricultural Water Management* 53: 171 – 186

Mulatya J.M., **Wilson J.,** Ong C.K., Deans J.D., Sprent J.I., and Raussen T. 2002. Root architecture of provenances, seedlings and cuttings of *Melia volkensii*: implications for crop yield in dryland agroforestry. *Agroforestry Systems*, 56:65 – 72

Hall N.M., Griffiths H., Corlett J.A., Jones H.G., Farquhar G.D., Lynn J. and King G.K. 2005. Relationships Between Water-Use Traits and Photosynthesis In *Brassica oleracea* L. Resolved By Quantitative Genetic Analysis. Plant Cell & Environment (in press).

Hall N.M., Kaya B., Dick J., Skiba U., Niang A. and Tabo D. 2004. Effect of improved fallow on crop productivity, soil fertility and climate-forcing gas emissions. Submitted to *Journal of Arid Environments*.

Ingleby, K., Diagne, O., Deans, J.D., Lindley, D.K., Neyra, M. & Ducousso, M. (1997). Distribution of roots, arbuscular mycorrhizal (AM) colonisation and spores around fast-growing tree species in Senegal. Forest Ecology. & Management. **90,** 19-27.

Diagne, O., **Ingleby, K.,** Deans, J.D., Lindley, D.K. & Neyra, M. (2001). Mycorrhizal inoculum potential of soils from alley-cropping plots in Senegal. Forest Ecology. & Management.,146: 35-43.

Lesueur D., **Ingleby K.,** Odee D.W., Chamberlain J., **Wilson J.,** Manga T.T., Sarrailh J.M. and Pottinger A. 2001. Improvement of forage production in *Calliandra calothyrsus*: methodology for the identification of an effective inoculum containing *Rhizobium* strains and arbuscular mycorrhizal isolates. *Journal of Biotechnology*. 91: 269-282.

Deans J.D., Diagne O., Nizinski J., Lindley D.K., Seck M., **Ingleby K.** and **Munro R.C**. 2003. Comparative growth, biomass production, nutrient use and soil amelioration by nitrogen fixing tree species in semi-arid Senegal. *Forest. Ecology & Management*. 176: 253-264.

Participant 6: Pôle de Recherches Appliquées au Développement des Savanes d'Afrique Centrale. Institute of Agricultural Research for Development, North Centre, Agroforestry and Forestry Program Maroua., Cameroon (PRASAC/IRAD)

PRASAC (Pôle de Recherches Appliquées au Développement des Savanes d'Afrique Centrale) is a regional organisation (specialised institution of UEAC: Union Economique et Monétaire de l'Afrique Centrale) created in 1998 with the mission of carrying out and coordinating the scientific and technical cooperation between the national institutions involved in agricultural and environment research in the savannah area of Central Africa (Chad, Cameroon, Central Africa Republic). Prasac is also affiliated to CORAF. IRAD (Institute of Agricultural Research for Development) of Cameroon is member of PRASAC.
IRAD is the main agricultural (agriculture, forestry, agroforestry, economics) research organisation in Cameroon. IRAD collaborates with governmental (ANAFOR, SODECOTON, Water and Forest Department, …) private and non governmental organisations and with many development projects (DPGT, ESA,…). All personnel participating in this project have experience of regional and international collaborative research projects. The IRAD team will participate mainly in WPs 1, 3 and 5

Staff involved in the project:

Dr Mama NTOUPKA. more than 15 years experience in ecology, forestry and agroforestry research including gum production. Dr NTOUPKA will be responsible for IRAD's activities and will be involved within WP3 and WP 4.

Dr Clement NJITI-FORKONG. more than 15 years experience in agroforestry research, including soil microbiology and *Acacia senegal* management. He will be involved within WP5.

Mr Oumarou PALOU. young researcher, with 3 years experience in agroforestry research, will gather information on experience and constraints about *Acacia senegal* management, gum production and contribution to the household revenues within WP1.

Relevant publications:

Harmand J.M., Mathieu B., **Njiti C.F. et Ntoupka** M. 1998. Possibilités de production de gomme arabique par *Acacia senegal* dans différentes situations pédo-climatiques du Nord Cameroun. Rapport final. IRAD Maroua.

Njiti C.F. et Lelong F. 2000. Production par saignée artificielle de gomme arabique d'*Acacia seyal* au Nord Cameroun. Rapport Technique. IRAD Garoua.14 pp +Annexes.

Njiti C.F. and Galiana A. 1996. Symbiotic Properties and *Rhizobium* Requirements for Effective Nodulation of Five Dry Zone Tropical Acacias. *Agroforestry Systems*. 34:265-275.

Ntoupka M. 1999. Impact of human disturbances (browsing by livestock, fire and wood-cuttings) on the dynamics of a Sudano-Sahelian tree savanna site in northern Cameroon. Thèse Dr d'Université. Spécialité : Biologie des Populations. Montpellier : Université Paul Valéry, 260 p.

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Harmand J.M., Ndonfack P. and **Njiti C.F.** 2003. Tree-root systems and herbaceous species characteristics under tree species introduced into grazing lands in sub-humid Cameroon. *Agroforestry Systems*. 59: 131-140, 2003.

Harmand J.M. et **Njiti C.F.** 1998. Effet des jachères agroforestières sur les propriétés d'un sol ferrugineux et sur la production céréalière. *Agriculture et Développement.* 18: 21-29.

Harmand J.M., **Njiti C.F.** et **Ntoupka M.** 1996. Gestion de l'arbre et des formations naturelles de savane en zone soudanienne. In: Agriculture des savanes du Nord-Cameroun. pp. 49-65. Proceedings. IRAD, BP 415 Garoua.

Participant 7: Universite Cheikh Anta Diop de Dakar, Dakar, Senegal (UCAD)

UCAD is the main higher education and research organisation in Senegal, working in multi-disciplinary scientific areas (Biology, Physiology, Botanic, Biotechnology, Ecology and Biodiversity, …). All personnel participating in this project have experience of regional and international collaborative research projects. The UCAD team is multi-disciplinary in nature embracing agroforesty, microbiology, silviculture, physiology, bio-technology and soil science.The UCAD partner is member of the Laboratoire Commun de Microbiologie IRD/UCAD/ISRA (LCM). LCM conducts research on soil microbiology, symbiosis and forestry since more than 30 years. With its wide experience LCM is a privileged partner of many universities and research organisations in Africa and around the world and participates and coordinates numerous research contracts (FNRAA, IFS, AAS, CORAF, AIEA and the European Commission). All personnel participating in this project have experience of regional and international collaborative research projects. The UCAD team is multi-disciplinary in nature embracing agroforesty, microbiology, silviculture, physiology, bio-technology and soil science.

Staff involved in the project:

Dr Diegane Diouf. more than 12 years experience in microbiology, physiology and biotechnology. Dr DIOUF will be responsible for UCAD's activities and will be co-leader for rhizobial studies within WP3 and WP5.

Mr Aliou Faye. assistant researcher will be involved to supervise field trials and co-leader of the WP3. **He** has 17 years experience on *A. senegal* agroforestry and silviculture research and gum production and cost benefit analysis.

Dr Aboubacry Kane. more than 12 years experience in mycorrhizal research. **He** will carry out research on mycorrhizas characterization and ecological study and training of students and researches on mycorrhizal characterization and eco-physiological studies in WP5.

Dr Samba Sylla. more than 15 years of experience microbiosymbionts work and molecular characterization of rhizobium. He will be involved in agronomic topics in relation to inoculant impact and using ^{15}N techniques to assess N fixation in WP3 and WP5.

Relevant publications:

Bâ A.M., Samba R., **Sylla S.**, Le Roux C., Neyra M., Rousteau A., Imbert D. et Toribio A. 2002. Caractérisation de la diversité des microorganismes symbiotiques de P*terocarpus officinalis* dans des forêts marécageuses de Guadeloupe et Martinique. *Revue d'Écologie Terre et Vie*, 59 : 163-190.

Campa C., **Diouf D.**, NDoye I. and Dreyfus B. 2000. Differences in nitrogen metabolism of *Faidherbia albida* and others N_2-fixing tropical woody acacias reflect habitat water availability. *New Phytology*, 147:571-578.

Diouf D., Forestier S., Neyra M. and Lesueur D. 2003. Optimisation of inoculation of *Leucaena leucocephala* and *Acacia mangium* with rhizobium under greenhouse conditions. *Annal of Forest Sciences*, 60: 379-384.

Diouf D., Neyra M., Sougoufara B. and Lesueur D. 2001. Le Plan d'Action Forestier du Sénégal : Bilan et perspectives des six premières années. *Bois et Forêt des Tropiques*, 270: 5-13.

Diouf D., Sougoufara B., Neyra M. and Lesueur D. 2002. Le reboisement au Sénégal / Bilan des réalisations de 1993 à 1998. *Revue Forestière Française*, 54 (3) : 227-238.

Mbaye M.S., Noba K., Sarr R.S., **Kane A**., Sambou J.M. et BA A.T. 2001. Caractères spécifiques d'identification au stade jeune plant d'adventices sénégalaises du genre *Corchorus* L. (TILIACEAE) – Annales Botaniques Africaines (1) : 35-42

Ndiaye A., **Sylla S.N**., Gueye M., de Lajudie P. et Ndoye I. 2002. Utilisation de la Technique d'électrophorèse des protéines totales sur Gel de polyacrylamide-SDS (SDS-PAGE) pour l'étude de la diversité des rhizobiums d'*Acacia tortilis* (Forsk.) Hayne Subsp. *raddiana* (Savi) Brenan. *African Journal of science and technology* (AJST) vol : 3, n°1, pp. 33-43.

Samba R.T., **Sylla S.N.**, Neyra M., Gueye M., Dreyfus B. and Ndoye I. 2002. Biological nitrogen fixation in *Crotalaria* species estimated using isotpic ^{15}N dilution technique. *African Jounal of Biotechnology*. Vol. 1, (1) pp. 17-22.

Sylla S. N., Samba R. T., Neyra M., Ndoye I., Giraud E., Willems A., de Lajudie P. and Dreyfus B. 2002. Phenotypic and genotypic diversity of rhizobia nodulating *Pterocarpus erinaceus* and *P. lucens* in Senegal. *Systematic Applied Microbiology*. 25: 572-583.

Sylla S.N., Ndoye I., Gueye M., Ba A.T. and Dreyfus B. 2002. Estimates of biological nitrogen fixation by *Pterocarpus lucens* in a semi arid natural forest park in Senegal using 15N natural abundance method. *African Jounal of Biotechnology*. 1 (2):50-56.

Participant 8: Institut de Recherche pour le Developpement, Paris, France (IRD)

IRD is a French public science and technology research institute. It conducts scientific programs contributing to the sustainable development of the countries of the South with an emphasis on the relationships between man and environment. The Institute employs 2187 persons, including 831 researchers. About 40% of permanent staff is posted overseas, mainly in Africa, the DOM-TOMs and Latin American research institutes. IRD is established in 23 tropical countries where it develops joint project with local Institutes. IRD will participate mainly in WP5

Staff involved in the project:

Dr Komi Assigbetse has great expertise in molecular techniques aimed at describing the soil microbial community. He has 10 years experience in molecular methodology dedicated to microbial communities.

Dr Jean-Luc Chotte is Director of the Research Unit « Seqbio » of IRD. He is soil scientist, specializing in soil biological functioning. He has long experience in the field of tropical soil science and in the field of microbiology in relation to flows of nutrients. Dr. Chotte has more than 17 years experience in soil functioning and nutrient cycles.

Dr Alain Brauman has 17 years experience in Microbial Ecology, in Soil Microbiology and genetic techniques.

Relevant publications:

Diallo M.D., Guissé A., Badiane-Niane A., Sall S. and **Chotte J.L**. 2005. *In situ* effect of some tropical litters on N mineralization. *Arid land research and management* 19: 173-181

Assigbetsé K., Gueye M., Thioulouse J. and Duponnois R. 2005. Analysis of the ectomycorrhizosphere microbial diversity with special reference to actinomycete and fluorescent *pseudomonad* communities. *Microbial Ecology* (in press)

Djigal D., Brauman A., Diop T.A., **Chotte J.L.** and Villenave C. 2004. Influence of some bacterial-feeding nematods (Cephalobidae) on soil microbial community during mays growth. *Soil Biology and Biochemistry*. 36:323-331

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Fall S., Nazaret S., **Chotte J.L.** and **Brauman A.** 2004. Cell Density and Genetic Structure of Microbial Community at the microenvironment level in a Soil Feeding (*Cubitermes niokoloensis*) Termite's Mound as Determined by Enumeration and Automated Ribosomal Intergenic Spacer Analysis Fingerprints. *Microbial Ecology*. 48 :2, 191-199.

Gros R., Jocteur Monrozier L., Bartoli F., **Chotte J.L.** and Faivre P. 2004. Relationships between soil physico-chemical properties and microbial activity along a chronosequence of restored ski runs. *Applied Soil Ecology*. 27:1, 7-22

Masse D., Manlay R.J., Diatta M., Pontanier R. and **Chotte J.L.** 2004. Soil properties and plant production after experimental modification of the vegetation in short-term fallows in Senegal. *Soil Use Management.* 20 : 1-4.

Duponnois R., Diedhou S., **Chotte J.L.** and Sy M.O. 2003. Relative importance of the endomycorrhizal and / or ectomycorrhizal associations in *Allocasuarina* and *Casuarina* genera. *Canadian Journal of Microbiology*. 49 (4) : 281-287.

Delannoy E., Jalloul A., **Assigbetse K.,** Marmey P., Geiger J.P., Lherminier J., Daniel J.F., Martinez C. and Nicole M. 2003. Activity of class III peroxidases during defense of cotton to bacterial blight. *Molecular Plant-Microbe Interactions.* 16 : (11) 1030-1038.

Founoune H., Duponnois R., Meyer J.M., Ba A.M., **Chotte J.L.** and Neyra, M. 2002. Interactions between ectomycorrhizal symbiosis and fluorescent *Pseudomonads* on *Acacia holosericea*: isolation of Mycorrhization Helper Bacteria (MHB) from a Soudano-Sahelian soil. *FEMS Microbiology Ecology*. 41 :37-46

Sall S., **Brauman A.** Rouland C. Niambi E. and **Chotte J.L.** 2002. Variation in the distribution of monosacharides in soil fractions in the mounds of termites with different feeding habits (Senegal). *Biology and Fertility of Soil*. 36:232-239.

Participant 9: Institut Senegalais de Recherche Agricole, **Dakar, Senegal**

ISRA is the main agricultural (agriculture, forestry, animal production, fishery, economics) research organization in Senegal. It will participate to researches in 4 work packages in Senegal: Tree Management knowledge (WP1), Improving humain livelihoods (WP2), Tree ecophysiology and tree-crop interactions (WP3), Genetics and environmental basis (WP4). ISRA is well qualified to carry out the tasks allocated to it in the project. ISRA is performing research on many of these aspects through several departments located throughout the country. WP2 will be conducted by the Office of Macroeconomics analysis (BAME) which represents the ISRA department of economics. A part of WP3 will be carried out by CERAAS another department of ISRA which has a sub - regional dimension and which works on plant adaptation to drought. ISRA also has a long history of working collaboratively with African, European and American organizations and has a Memorandum of Understanding with many of these Partners including the co-ordinating Partner.

Staff involved in the project:

Dr Abibou Gaye (the director of the forestry division) will have overall responsibility for the project,
Dr Samba A.N. Samba, (silviculture / agroforestry),
Dr. Ismaïla. Diallo, (genetics),
Dr. Macoumba. Diouf (Physiology) and
Mrs M. Faye (economics) will conduct the studies.
The ISRA team leader will be Dr Samba A.N. Samba. Three technicians will also work on the contract.

Relevant publications:

Bakhoum C., **Samba S A.N**., Ndour B., 2001. *Sterculia setigera* Del. : effet sur les cultures. Annals of. Forest Sciences, 58 (2001) 207 – 215.

Dione, P., S. Ndiaye, **S.A.N. Samba,** I. Thomas and P. Sall. 1999. Estimation et Évaluation des Arbres Hors Forêts: première partie de la contribution au projet FRA 2000 et à l'identification des thèmes - Étude spéciale pour la région soudano - sahélienne, Ministère de l'Environnement et de la Protection de la Nature, Direction des Eaux, Forêts, Chasse et Conservation des Eaux, Dakar - Hann, Sénégal. pp. 78.

Fall S.T., **Samba S A.N**., Taoré E. 2000. Exploitation des arbres à usages multiples dans les systèmes d'élevage en zone soudanienne et sahélienne. In : La production et l'utilisation des arbustes fourragers à usages multiples en Asie de l'Est, Afrique du Nord et Sahel. Actes du séminaire tenu du 16 au- 22 février 1999 à Rabat (Maroc). G. Gintzburger et M. Bounejmate, Editeurs scientifiques. P 47 - 58. ISBN 92 - 9217 - 095 - 04.

Samba. S A.N. 1997. Influence de *Cordyla pinnata* sur la fertilité d'un sol ferrugineux tropical et sur le mil et l'arachide dans un système agroforestier traditionnel au Sénégal. Thèse de PhD, Département des Sciences du bois et de la forêt - Faculté de Foresterie et de Géomatique, Université Laval, Québec, Canada, 186 p.

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Samba.S A.N., Camiré C., Margolis H. 2001. Allometry and rainfall interception of *Cordyla pinnata* in a semi-arid agroforestry parkland, Senegal. Forest Ecology and Management, 154 (1-2): 277-288.

Sarr B., Diouf O., **Diouf M**., Roy-Macauley H., Ndjendole S.. 1999. Suivi de l'état hydrique du sol et de la température du couvert de maïs au Sénégal. Cahiers sécheresse, vol. 10, n. 2.

Sarr B, Diouf O, **Diouf M**, Roy-Macauley H, Brou C, 2001. Utilisation de paramètres agronomiques comme critères de résistance à la sécheresse chez trois variétés de niébé cultivées au Sénégal et au Niger. Science et changements planétaires / Sécheresse. Volume 12, Numéro 4, 259-66, Décembre, Notes de recherche

Diallo I. (1992) "Etude de la diversité génétique de populations de *Acacia senegal* au Sénégal par électrophorèse enzymatique", Mém. DEA, UCAD de Dakar – Sénégal, 65p.

Chevallier M-H., Brizard J-P., **Diallo I**. et LeBlanc J-M. (1994) "Etude de la diversité génétique dans le complexe *Acacia senegal*", Bois et Forêts des Tropiques

Diallo I. (2002) "Etude de la biologie de la reproduction et évaluation de la variabilité génétique chez le jujubier (*Ziziphus mauritiana*)" Thèse Troisième Cycle UCAD, Dakar -Sénégal, 100p

B.2.2 Project management

ACACIAGUM, with a duration of four years, relies on efficient coordination and management activities. This will be achieved through the *Project Coordinator* and a *Steering Committee*, consisting of the work package leaders.

B.2.2.1. Stakeholders' roles and responsibilities

The *Project Co-ordinator* (CIRAD) will be responsible for the overall management/co-ordination of the project. CIRAD will be responsible for undertaking two groups of activities:

1) Overall coordination/management tasks including consolidation of the project planning, progress reports, milestone reports, cost statements, audit certificates and budgetary overviews, etc.
2) Promoting dissemination activities within the consortium.

Under the direction of a *Steering Committee*, CIRAD will:

- co-ordinate the work carried out, keeping strictly to the predefined schedule of events
- provide the interface between the partners and the desk officer of the Commission;
- provide overall management of financial, contractual and administrative issues;
- control and review the financial and technical progress;
- discuss and approve the detailed plan for successive periods of activities
- promote and stimulate the establishment of contacts with other relevant EU/international projects;
- Ensure that reports and TIP plans are submitted on time to the scientific coordinator in Brussels

Dr Didier Lesueur (CIRAD) will co-ordinate the project with the support of CIRAD central administration who are specialists in financial and administrative/contractual issues. Dr Lesueur has previous experience in managing international and EU projects, including FP5 RTD projects, and CIRAD administration understand the financial and administrative / contractual issues.

WP leaders have been nominated for the detailed co-ordination, planning, monitoring and reporting of the WP under their responsibilities. WPs are being led by both European and DC partners. Each WP leader will be responsible for information flow amongst WP participants to ensure planning and exchange of information and that research work is implemented smoothly. WP leaders are also responsible for liaison with other WP leaders and the project coordinator. WP Groups will hold separate meetings during annual co-ordination meetings under the chairmanship of its WP leader.

The *Steering Committee* will provide technical, financial, planning and control measures. Membership of the steering committee will comprise the WP leaders or their deputies. Every Project steering committee member has the empowerment from his organization to commit the staff and other resources required by the project. The steering committee will meet at a minimum of once each year. For cost-efficiency, the majority of steering committee meetings will take place during the annual project meetings. Efficient email, fax and telephone systems should be adequate to address issues which arise at other times. New opportunities for free telephone connections utilizing broadband computer systems are being explored. Partners may request extra steering committee meeting, however, due to limitations imposed by budgets, the frequency of extra meetings will of necessity be restricted and limited to matters of urgency. The project co-ordinator (CIRAD) will chair the steering committee.

B.2.2.2. Implementation of activities

Meetings, workshops and conferences are vital components of the project management and delivery. They are planned to take place as indicated below. However, locations and timing may change if there are good operational reasons.

Theme of the meeting	**Country**	**Participants**	**Month**	**Duration (days)**
Start-up meeting of ACACIAGUM	Senegal	Steering Committee	2	1
Workshops: planning and design. (Separate and combined meetings as necessary)	Senegal	WP leaders and senior representatives of participants	2	4
First annual meeting, presentation of results and future plans in all WPs	Kenya	WP leaders, WP participants and senior representatives of participants	14	4
First evaluation of ACACIAGUM progress	Kenya	Steering Committee	14	1
Second annual meeting, presentation of results and future plans in all WPs	UK	WP leaders, WP participants and senior representatives of participants	26	4
Second evaluation of ACACIAGUM	UK	Steering Committee	26	1

progress				
Third annual meeting, presentation of results and future plans in all WPs	Niger	WP leaders, WP participants and senior representatives of participants	38	4
Third evaluation of ACACIAGUM progress	Niger	Steering Committee	38	1
Fourth annual meeting, presentation of results	France	WP leaders, WP participants and senior representatives of participants	46	4
Final evaluation of ACACIAGUM progress. Scientific synthesis, preparation of dissemination and country conferences	France	Steering Committee	46	4
ACACIAGUM Dissemination conferences/ workshops	Senegal, Cameroon, Kenya, Niger	All ACACIAGUM researchers from the country, representatives of the gum arabic user community, SMEs GOs, NGOs, policy makers, government agents, media etc	47	1 day each

In addition to the meetings' timetable, work-package leaders are expected to be active in their leadership, be in regular touch with the participants in their work-package and inform the co-ordinator of progress. If delays arise in any work-package which impinges on other work-packages, they will be expected to inform the relevant WP leaders and the co-ordinator. They will be responsible for coordinating the preparation of material for reports to the EU and for TIP plans and the timely submission of deliverables to the co-ordinator.

Milestone reviews
WP leaders will be responsible for milestone reviews, at which the progress of the project and the outlook for exploitation of the results will be critically reviewed and compared to the planning and schedules shown in the work-programme. Depending on the progress and the results achieved, a change in the work-programme to focus on more promising/productive areas of research, may be proposed, agreed and implemented, given the agreement of the desk officer of the European Commission.
These milestone reviews will substitute for a single formal "mid-term" project review, because it seems that a review at a fixed period in time is inappropriate, given the differing start and finish times for the various WP activities.

Communication flow within the consortium
Good communication flow is a prerequisite to success. Information flow will be both "top down" and "bottom up", to ensure maximum transparency for all parties involved and maximization of synergy between Partners over the duration of the project. Interactive management and technical meetings play an important role in the communication strategy. All information (e.g. minutes of meetings, mission reports, WP reports, relevant publications etc.) will be communicated to the project co-ordinator who shall mount the information on the project website. Communication with parties outside the consortium (e.g. local authorities, European/international organisations active in the field etc) is also foreseen through partners' local contacts and via the web site.

Consortium agreement
A consortium agreement between all partners will be concluded in order to lay down the framework for cooperation in this project.

Monitoring and reporting progress
Each Partner will provide their WP leaders with reports detailing progress as follows and conforming with the requirements laid out in the Model Contract :-

- Work carried out, results obtained
- Future plans
- Developing problems or required alterations to schedules as referenced to the work plan.

Because actions in most WPs are dependent on successful outcomes from other WPs, where problems arise, they may impact several other WPs and could jeopardise the overall schedule of activities. Consequently, Partners who experience problems must immediately inform the WP leader and jointly, in collaboration with the co-ordinator will devise remedial actions to keep the contract as close to the planned schedule as is practicable.

Work package leaders will collate the reports received and integrate the information provided, according to the reporting requirements of the EU. They will submit reports in English to the Project coordinator, so that she can submit the scientific reports on time to the EU.

The co-ordinator will summarise the overall project status and co-ordinate the preparation of project reports. All items will be in English and provided to the Commission as well as to the Partners. These deliverables will encompass:

- full periodic reports.
- special technical reports if required

The senior scientist of each project partner will be responsible for ensuring that cost statements are prepared and submitted on time to the Project coordinator.

The *modi operandi* will apply to every researcher involved in ACACIAGUM such that each contributes to conveying a feeling of joint ownership of the research and its results to the local populations. Similarly, Intellectual Property Rights issues arising from the project will be dealt with in a sensitive manner during plenary sessions at project meetings. Although our intention is to produce information for the public domain, all proposers and other stakeholders associated with the project will be encouraged to exploit IPR and where appropriate, will be granted the right to seek intellectual property protection.

Full duration of project
(insert person-months for activities in which partners are involved)

Project acronym –ACACIAGUM

	CIRAD	KEFRI	WU	UNIAMEY	CEH	PRASAC /IRAD	UCAD	IRD	ISRA	Total partners
Research/innovation activities										
WP 1 Traditional ecological knowledge	6.8	8.5		8.5		8.5			34	66.3
WP 2 Marketing networks		6.8	17			1.7			51	76.5
WP 3 Tree eco-physiology	6.8	13.6		12.2	15.9	17	15.3		25.5	106.3
WP 4 Genetic and gum quality	8.510.2	23.8		17	8.2	3.4			42.5	105.1
WP 5 Tree - soil interactions	8.5	25.5		20.4	12.8	5.1	34	41.7		148
WP 6 Dissemination and transfer of technologies		45.9		4.3		8.5	7.7			66.4
Total research/innovation	32.3	124.1	17	62.4	36.9	44.2	57	41.7	153	568.6

Dissemination/exploitation activities										
WP 1 Traditional ecological knowledge	0.8	1		1		1		4	7.8	
WP 2 Marketing networks		0.8	2			0.2		6	9	
WP 3 Tree eco-physiology	0.8	1.6		1.5	1.9	2		3	12.6	
WP 4 Genetic and gum quality	1.2	2.8		2	1	0.4		5	12.4	
WP 5 Tree - soil interactions	1	3		2.4	1.5	0.6	4.8		17.3	
WP 6 Dissemination and transfer of technologies		5.4		0.5		1			7.7	
Total dissemination/exploitation	3.8	14.6	2	7.4	4.4	5.2	4.8	18	66.8	

Management activities										

WP 1 Traditional ecological knowledge	0.4*	0.5		0.5		0.5			2	3.9
WP 2 Marketing networks		0.4	1			0.1			3	4.5
WP 3 Tree eco-physiology	0.4*	0.8		0.7	0.9	1	0.9		1.5	6.2
WP 4 Genetic and gum quality	0.6*	1.4		1	0.5	0.2			2.5	6.2
WP 5 Tree - soil interactions	0.5*	1.5		1.2	0.8	0.3	2	2.5		8.8
WP 6 Dissemination and transfer of technologies		2.7		0.3		0.5	0.5			4
Total management	1.9*	7.3	1	3.7	2.2	2.6	3.4	2.5	9	33.6
TOTAL ACTIVITIES	38	146	20	73.5	43.5	52	67	49	180	669

* The STREP Effort Form details CIRAD's management activities in the specific WPs but does not cover CIRAD's overarching obligations to co-ordinate the entire contract. Person months associated with this latter activity are supplementary to those shown against the individual WPs in the STREP Effort Form and are accounted in budgets.

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In bold, are the names of the participants to the ACACIAGUM proposal