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'Increased Food Security Control and Management of Prosopis'

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Frontispiece Photograph: Prosopis juliflora invading an irrigation canal in Zeibad Eastern Sudan with vines stretched more than two metres across the surface water and eventually engulfing the canal. Removal and rehabilitation costs are high. Credit: A.G.T.Babiker, Sudan University of Science and Technology, Shamat, Sudan.

Photographs in text: Generally attributable to author(s) of papers. Other contributions gratefully received courtesy of Jan Breithaupt, Peter Steele, Ricardo Labrada and A.G.T. Babiker

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Abbreviations and Acronyms

AGPP	Plant Production and Protection Service *(of FAO)*
AMPAH	Academic Model for Providing Access to Healthcare
ANRS	Afar National Regional State
AU	African Union
CMA	Charcoal Making Association *(of Afar)*
EC	European Commission
ECA	Economic Commission for Africa
EIAR	Ethiopian Institute of Agricultural Research
ER	Equivalence ratio
EREDPC	Ethiopian Rural Energy Development and Promotion Center
FAO	Food and Agriculture Organization of the United Nations
FARM	Food and Agriculture Research Management
FFS	Farmers field school
FDRE	Federal Democratic Republic of Ethiopia
FOMC	Forest Conservation Service *(of FAO)*
GDDRD	Global Donor Platform for Rural Development
GDP	Gross Domestic Product
GFR	Gas flow rate
HDRA	Henry Doubleday Research Association *(a registered charity in the UK)*
HV	Heating value
HVF	Heating value of fuel
LHV	Low heating value
KEFRI	Kenya Forestry Research Institute
KFPRC	Kenya Forest Products Research Centre
MC	Moisture content
NGO	Non-Governmental Organizations
NRM	Natural Resource Management
PARD	Pastoralist, Agriculture and Rural Development *(Bureau of the ANRS)*
PandC	Prevention and Controlling (committee)
QF	Heat energy *(available in fuel)*
RandD	Research and development
RET	Renewable Energy Technology *(commercial firm)*
SFE	Sub-Regional Office for Eastern Africa *(of FAO)*
SGPR	Specific gas production rate
SGR	Specific gasification rate
spp	Species
STP	Storage node through plate *(i.e. unit of volume/volume occupied by gas)*
TE	Thermal efficiency
TPI	Tropical Products Institute
USA	United States of America
WFU	Weight of fuel used *(in the gasifier)*

Measurement Units

Abbr.	Unit
Cal	calorie
g	gram
h	hour
ha	hectare
kCal	kilocalorie
kJ	kilojoules
km/km^2	kilometre/squared
kW/kWh	kilowatt/kilowatthour
m/m^3	metre/cubed
mg	milligram
mm	millimetre
MJ	Megajoules
N	Newton
t	tonne
y	year

Executive Summary

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Expert Consultation '*Prosopis*'

The regional expert consultation '*Prosopis*' was held 15-19 October 2007 at the Buffet Aouache Restaurant Hotel in Awash Township in Eastern Ethiopia. The three-day meeting provided an opportunity for scrutinizing regional experience for the many issues and opportunities that currently prevail for people living with *Prosopis*. Considered highly successful by delegates, the debate lead directly to the preparation of a conceptual framework for developing model strategies that will apply for control, management and utilization of *Prosopis* spp. in the region during the next period.

There was consensus that priority effort should shift to control and improved use of productive lands that were cleared; and that this should be done on the basis of appropriate eradication technologies that could be used by local communities. Where possible control/eradication/land-use should be linked into the exploitation of *Prosopis* products as the basis for creating employment and income, and boosting the well being of local communities. Herein is the basis for raising the economic security of people, but it remains essential for local communities to take '*ownership*' of the many opportunities that prevail. It is not sufficient for people to wait for others to take charge (and this notwithstanding the need for external assistance if invaded communities are to be able to do so).

Why *Prosopis* remains a threat to food security

The expert consultation highlighted the risks associated with loss of productive lands. Many of the countries affected have declared *Prosopis* a national priority issue and threat to food security. The tree is highly invasive and occupies significant area of land previously used for grazing and crop production. A sustainable control and management strategy implemented in *Prosopis*-affected countries will help contribute to the alternative livelihoods required and, by so doing, boost the confidence and resilience of local communities.

Prosopis and the environment

The expert consultation quickly covered the debate of *'why Prosopis'*. The story is a well-known one. For all the best of reasons – many now considered mis-guided – *Prosopis* was planted across large areas of land as a means of stabilizing country that was at risk of desertification. Towns were encircled with green belts and, for more inaccessible lands, seeds were distributed by air. Much of this has been recent, but some original plantings were made more than 70 years ago. Such is the vigour and competitiveness of the plant, *Prosopis* has become a formidable invader of farmlands and ponds, rivers, lakes and swamps. It creates dense and impenetrable thorny thickets that are replacing native tree species and taking over ground cover, making it difficult for grasses to grow. Such has been the extent of invasion on 'protected lands' that livestock and crop farmers have been displaced over large areas.

Controlling the plant

The magnitude of distribution and mass of material produced across complete tracts of land makes *Prosopis* virtually impossible to eradicate once established. Control becomes an approach that has to be shared within the whole community that people understand the many complex issues for containment, for use of lands that remain vulnerable to encroachment and for intensive management of lands that have been cleared. Given the extent of current knowledge within most rural communities, pragmatism suggests that the tree will continue to extend into new lands during the next period.

Using the plant

Large-scale mechanized and smaller-scale labour gangs have been widely used as a means of eradication, but such has been the resilience of the plant that it can quickly return to lands where there is little in the way of follow-up cleaning. Small-scale localized use of the plant has been a major focus of control; encouraging people for their ability to adapt and develop new products. Equipment, technologies, information and training have been provided, and people have learned to harvest and process seedpods, collect timber for fuelwood and charcoal making and to explore the novelty of high quality timber, more efficient energy production and similar. In the Republic of Yemen, for example, a high quality honey is harvested.

Long-term strategies

Small-scale eradication and/or utilization, however, has limitations for the extent of support received from the public sector, an issue exacerbated by the isolation of most *Prosopis* invaded lands. Once initial investments and/or interest have declined, people revert to earlier coping methods, which typically results in re-invasion. The expert consultation highlighted the need for strategic development with public-sector investment based on control - and encouragement for the private sector to establish a host of agro-enterprises (with on-going support from government and others). The need for continuity of investment – from all sources – was emphasised so that the issues became better understood, so that markets for *Prosopis*-derived products could be developed and so that people were better able to eradicate, control and/or live alongside a plant that will gain dominance the moment that efforts and investments decline. Paradoxically, such is the demand for *Prosopis*-derived products in traditional areas of Latin America where the plant is a native, that is has to be protected from over-exploitation. This, long-term, will be the aim for affected communities in Eastern Africa.

The challenge facing delegates at the expert consultation and those they represented back home was one of imagination and tenacity - mobilizing the resources to provide the technical and financial assistance that regional people will be provided with the information, technologies, equipment and funds to shift from a defensive position to one where they take full charge of their natural resources. A proposal was devised in outline for a four-year investment with estimated US$6.5 million donor and government funds with which to continue to explore many of the key issues for control, management and utilization of *Prosopis* and products within the region. This centred upon a group of core countries networked into more than 15 others in the region, and based on the novelty of shared responsibility for boosting food and economic security of *Prosopis* affected communities.

Foreword to the Proceedings

Value of proceedings

Proceedings are an important part of all workshops, technical meetings and expert consultations, and provide a record of the presentations made and debate undertaken at the time. Expert consultations and the proceedings that follow comprise one small part of the repository of the intellectual wealth of a community, industry or country.

Continuity of investment

Proceedings provides a measure of continuity within the sector, and enables others to take note and advantage of the information provided. This helps with choices that may follow, with the promotion of investment opportunities and provides for wealth creation – financial, technical and intellectual – in the host community. In this case, the proceedings from the Awash expert consultation will help to highlight the challenges facing people living with *Prosopis juliflora;* coming to terms with a highly invasive plant on land that just a few years earlier was open to grazing or cropping. Findings and recommendations that followed the debate have provided opportunities and choices for those responsible for decision-making in support of those regions, areas and communities, which have been seriously affected by plant invasion.

Strategic proposals have to be made that will benefit from further interest by, and investment from, the partnership groups that can be assembled representing public and private sector people, institutions, Non-Governmental Organizations (NGOs) and companies. The European Commission/FAO project may have provided small investment funds – sufficient to organize the expert consultation and to invited regional delegates - but it will be follow-on investments that will help reveal the extent of the challenges facing people living on lands invaded by *Prosopis*.

Challenge of living with an invader

The expert consultation was held in Ethiopia, but issues of invasion from *Prosopis* affect all countries in the region – and further a field. Ethiopia faces enormous challenges into the next period (of which *Prosopis* invasion can, by comparison, be considered relatively benign). Herein are complex issues for the high expectations of the people (population more than 74 million and growing more than 2.5 percent annually; more than 60 percent under 15 years.), for the traditional nature of agricultural production (more than 85 percent subsistence, but producing more than 50 percent of Gross Domestic Product (GDP) and more than 90 percent of export earnings), from land fragmentation (area 1.20 Mkm^2 of which less than 15 percent suitable for cropping, etc.) and levels of poverty that are amongst the highest in Africa (per capita income US$110/year). People are poor, with the majority unable to break free from domestic poverty. Loss of productive land simply exacerbates regional issues and people migrate in search of a better life.

'Control, management and utilization' comprised the title of the expert consultation; and it is herein with better understanding of the complexity of the investment issues that people will be able to make change. Small communities struggle to make a difference in their locality with neither the resources nor information nor leadership available. Understand the plant and its characteristics and more can be done to eradicate, ring-fence, and/or utilize it. The reality is that the plant may never be completely eradicated and that communities will need to learn

how to adapt, to exploit and to control. The expert consultation provided a host of ideas for exploitation with energy, foods, livestock feed and services providing the basis for new livelihoods.

There was, however, little information on the strategic planning and investment required of central authorities. Loss of land becomes a national issue. If your neighbor has invaded and stolen land, you would quickly seek redress from the law and claim it back. And the reality of *Prosopis* invasion is exactly the same, but national response has been and remains ambivalent. The plant has excellent qualities of environmental protection, but it does so at the expense of people and their livelihoods and this is neither logical nor acceptable.

Investment into the next period

In a region of the world that is rapidly changing for a host of reasons and not least as a result of fluctuations in climate, rising populations and rising expectations from people, time becomes a constraint – making every investment euro, dollar, shilling or birr count, but also every litre of water. People occupy deserts and drylands, and take advantage of ruminants that can live on foods that people cannot eat. Unfortunately, only the seedpods of *Prosopis* are edible to ruminants (and people alike), which raises issues of what to do with the rest of the plant. Here will be the energy, construction and forage industries that will evolve. Utilization alone will not reduce invasion; leastways this has been the experience of small-scale exploitation thus far. Large-scale and/or industrial use for energy production could change this view. This will be for the people and their children to decide.

Future options

Ethiopia is a large country by standards elsewhere and has enormous potential for shifting into the commercial diversification that a range of climatic, topographical and natural resources offers. Geographical location also brings advantages that are rarely explored and, although the internal infrastructure of roads, rail, markets, processing centres, etc. are strictly limited, they are improving – and, meanwhile, can be exploited more effectively. *Prosopis* for large-scale foods and energy feedstock should become part of this new future; and the models devised should spread across all *Prosopis*-affected countries

1. Introduction to the Expert Consultation 'Investing in Change'

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Summary

Expert Consultations provide opportunities for sharing experience and decision-making. Here it is that *"information can be reviewed and debated and, importantly, channelled into the next phase of investment. Gain the confidence of everyone attending and there will be ownership with decisions taken. Everyone has a role and a responsibility to become involved."*

Prosopis invasion of the Horn of Africa region has been severe and rural people face challenges with adapting to land cover that has changed; making a living from the exploitation of new methods, technologies and products. This will require assistance from outside the community. The Expert Consultation provides a means of recommending and redirecting investment.

The Expert Consultation has brought together experts and others from three countries in the region – Ethiopia, Kenya and Sudan, and from the international community. Other countries not represented face similar issues of *Prosopis* invasion. Experts are people who are skilled and knowledgeable with *Prosopis* management, control and/or utilization; and who are prepared to share information and to work one-with-the-other.

A key objective of the meeting will be the preparation of an investment document that will attract the attention of an interested donor; to contain design, objectives, outputs and activities that will further extend understanding of the role of this aggressive plant within local ecosystem. This is about empowering people to combat invasion and/or adapting to take advantages of the new opportunities that present themselves.

1.1 People taking charge

The whole idea of our meeting is based on the assertion that people are responsible for development – regardless of the scale involved. People dominate most ecosystems worldwide. Typically, we place development in human context and considered what impact it will have on us and on our families. Expert Consultation such as this one provide us with an opportunity to address the many development issues involved; they bring together people with varied experience, backgrounds and interests, and challenge them to explore the sometimes conflicting issues and opportunities available. This results in shared knowledge, an exchange of views and, importantly, provides direction into the next period. Everyone gains a measure of ownership from participation. Equally important, there is justification in the investment made by those providing the resources and those taking the time to become involved. Expert Consultations provide the intellectual basis for decision-making and development.

At the end of our four-day consultation we can expect two major outcomes. First, regardless of the different opinions that will be shared in the course of the meeting, we have to keep in

mind objectivity for what will be (or should be) our next move. Secondly, and as a final outcome, we will be obliged to prepare jointly an investment document that will attract the interest and funds of an appropriate donor. Clearly, these investment proposals need to be pragmatic, attainable and well designed and which will meet the needs of the recipient communities (and countries) and match the investment resources of the donor. This comes as the result of dialogue between recipients and donors that a common position can be found for investment into the next period.

1.2 Background Expert Consultation

As part of the consultation process papers will be presented, challenged and debated. Informed discussion is the basis for reaching consensus on the different views that may prevail, for example, for the advantages and constraints of *prosopis* spp[1]. Presenters and participants will be expected to share successful experience (and also constraints and/or failures) that will assist others in the core group and within the wider development community with whom they/we work in the region. Here it is that the best practices can be shared, modified and/or introduced[2].

A word for the value of failures as a means of making change; failure is an intrinsic part of human experience and helps with the learning process. People take decisions, make note of results and modify findings into the next period. It takes skills, resilience and effort to learn; and this helps build confidence (for people, communities and countries) for renewed decision-making.

Environmental issues are of urgent concern to all countries in the Horn of Africa; and, moreover, they extend more than 2,500 km across the geographically similar terrain of the Sahel region to Senegal in West Africa. More than a dozen countries share much the same constraints for boosting development within a region that is dry and impoverished, and challenged by limited infrastructure and the demands of its people. Any attempt to boost socio-economic development and enhance the livelihoods of people in this region cannot ignore environmental change. The Horn of Africa has become increasingly dry during living memory; and not least because of what has come to be considered global climatic change, but also from the direct impact of the people and grazing livestock living in the region.

There is a measure of urgency with need to act in timely manner to meet the expectations of people, but also to provide for sustainability of resources into the next period. Decisions taken now will continue to impact 50 years into the future and directly affect people who have yet to come into being. Thus it is that *'environment friendly'* development will be essential for the food security of future generations. Herein will be need to explore, for example, what people are doing adjacent to the coastal areas, in the deserts and in locations where water and quality soils are in limited supply; and to learn from what is being done - to begin to adopt practices from elsewhere that may have value.

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[1] *Prosopis* spp. The Consultation is concerned with the impact of *Prosopis* spp on agricultural development in Eastern Africa. It is not seeking to explore, for example, the implications of invasion on a global scale, which raises issues of the different plant species and geographic location. Note, however, that there are 44 known species within the family of which *Prosopis juliflora* typically dominates within the region. Differences with the structure of the flower or fruit help determine species, but may have little direct bearing on control and management issues.

[2] Technical information. There is a wealth of information available to describe people living with *Prosopis*. Papers available to the Consultation courtesy of FAO include Laxen, J. (2007), FAO (2006), Habit, M.A, *et al,* (1981) and Grados, N. (1999). The list of recipes available from Grados (1999) and others provides a useful starting point for a regional East Africa recipe book for use by local communities.

The spread of *Prosopis* spp. is one indicator of a dynamically changing environment. Introduced mainly by people in an effort to provide resources, the plant has rapidly adapted and spread into new lands. It is exceedingly difficult to eradicate from lands in which it is not required, which realistically, leads to the compromise of *adaptation*, with people adapting their lives around the plant and exploiting it for community well-being. This too, is not always easy. Local people, for example, may lack the technical abilities and financial resources to do this without external assistance. They may be unable to take priority decisions. Control, management and/or eradication thus becomes a shared venture with partners - central government, local governments, donors, technical advisors and other stakeholders. This Expert Consultation represents one such partnership – taking the combined experience of the many experts available, consolidating their respective views and recommendations, and channeling these into an appropriate investment proposal for making changes.

1.3 Opportunities

People reach consensus from debate – the best solutions to problems come mainly from people working together and rarely (but this is not always so) from the effort of individuals working alone. This applies for countries as well as for people sharing common regional interests. We can confidently expect this to be the case with the Expert Consultation; which has brought together groups of experts from three key countries in the Horn of Africa region and a handful of international counterparts. For the four-days duration of the Consultation, this group of people represents the most technically influential group for *Prosopis* control, management and/or eradication anywhere in the world. Existing political boundaries have little or no value in a modern world; natural ecosystems do not recognize or respect them (and neither do business people). Only governments see value in national boundaries.

Notwithstanding the basis for people living in formal communities since the earliest times of agricultural production, much has changed with the socio-political development of people in the past 50 years as the result of technological innovation (and particularly telecommunications). Previously isolated people are now in direct contact with others; people are better informed, able to make comparisons with those elsewhere and, importantly, have begun to demand more. The implications of this are largely beyond the debate of the *Prosopis* Consultation, but in-as-far as this exchange of information has raised issues and expectations and provided opportunities – all linked to the technologies of *Prosopis* management and/or utilization – so the debate and recommendations of the Consultation should recognize the pragmatism of what can reasonably achieved into the next period.

As a meeting we will begin by sharing what we know of *Prosopis* within the group; and invite others to join in the exchange. At the end of the meeting a proceedings will be prepared that the papers, debate and findings can be shared outside the meeting. Sharing represents a form of *'technologies transfer'* - that others may gain benefit from the effort and investments made.

Prosopis invades and occupies lands that may then become unavailable and unproductive (see Figure 1). This is unacceptable to a region which has limited resources of productive lands and, at the same time, faces populations expanding at more than 2.5 percent annually. Therein will be competition for natural resources between people and communities and, in a worse case scenario, between neighboring countries. This is neither a new development nor is it likely to become less tangible into the next period. Environmental degradation of local resources threatens livelihoods, employment and income and, ultimately, the security of all.

Conflict can be considered simply a manifestation of environmental mismanagement - with too many people living in unsustainable manner.

1.4 Livelihoods

Notwithstanding its invasive and aggressive nature, *Prosopis* has a number of popular uses in rural communities, much of which depend upon the technical resources of the community and their ability to manage. Consider, for example, the potential of *Prosopis* as a source of fodder for livestock and food for people. Experience in Latin America, South Africa and, more recently, in Kenya has demonstrated the value of seedpods as food for people and livestock. Recent experience from Kenya will be explored within the Consultation, but suffice to note the potential that exists where, just a short time earlier, none had been foreseen.

Markets exist for a number of different products; for which specific care and preparatory effort may be required by the community. For example, the introduction of biological control methods may result in damage to flowers, fruits and seeds that are typically caused, for example, by *lepidoptera* spp., *aphie* spp. and/or *coleoptera* spp. A recent request for seedpods free of insect damage from buyers in South Africa to suppliers in Kenya highlighted markets that cannot be exploited by domestic South African suppliers given the earlier release of beetle predators in that country.

For the production of timber *Prosopis* (for fuel or for construction) has to be managed to produce individual trees that develop a firm trunk and separate canopy. This assists with access, harvesting, extraction and so on; and provides marketable products that can be exploited, for example, for charcoal production. Small quantities of raw timber have also been successfully manufactured into furniture or house fittings in Kenya. The dense undergrowth of tangled vines that typically represents weed invasion of grazing pastures is of value to no one; and land becomes lost. Exploitation by tree control/management requires that skills be taught that people are able to plan into the next period. Here it is that the livestock producer and the community at large may need to reach harmony on the extent of resource utilization.

Figure 1: Prosopis growing naturally.Dense thicket that is impossible for people or cattle to penetrate. Vine-like runners provide fine ground cover and protect land, but at the expense of productivity – native vegetation is smothered and traditional crops can no longer be grown

Charcoal is the most widely used biofuel in the countries of the Horn of Africa (Figure 2). Charcoal is particularly popular in local towns. Production of charcoal has mixed value for the resilience of land cover, and large areas of vegetation have become lost alongside the main highways in areas adjacent to the main urban centres. Lattice networks of roads and denuded county highlight the exploitive nature of the charcoal industry. In many places restrictions apply for shipment of charcoal by road – in an effort to protect indigenous tree cover. Notwithstanding the illegalities of transforming native trees into charcoal in many areas (and then paying off those responsible for control), such restrictions may also impede the manufacture and shipment of *Prosopis* charcoal. There is scope for re-visiting local legislation (but continuing issues of how to check the source of the charcoal once bagged and shipped.).

Figure 2: Traditional Charcoal making. Simple, low-cost and requiring few resources these, however, are inefficient and wasteful of Prosopis timber. They also result in considerable contamination of charcoal with soil (used to cover the timber and restrict the flow of air into the fire).

Traditional charcoal production can also be inefficient; and people may need access to improved technologies and equipment to exploit their natural resources more effectively – to produce more saleable products with improved burning properties in less time. *Prosopis* as a source of energy will be explored further within the Expert Consultation – this is a logical opportunity for large-scale clearing of land – but with more effective and efficient methods of conversion (as shown in Figure 3).

1.5 Shared resources

Three countries are represented at the Expert Consultation - Ethiopia, Kenya and Sudan. However, estimated 10-12 countries across the region face similar issues with the unchecked spread of *Prosopis* into previously unaffected lands (much of which has been typically open and communal grazing). A dozen countries covering estimated 30 percent of the continent and

the value of sharing information and resources cannot be over-emphasized. Therein is a 'win-win' situation for sharing resources with no easy-to-see disadvantages.

The first day of the Consultation represents an open debate for what will eventually be promoted for investment post-Consultation, but delegates may like to begin considering the value of focusing upon a few core countries and others that may link into a network of shared information. Clearly, those countries represented at the Consultation would comprise part of the 'core' group, with others invited to participate – as appropriate. Delegates will need to determine the extent of existing investments that focus upon the same countries and the same sectors. We can expect to learn more of network investments as the Consultation develops – the reality of *'who is doing what and where'*.

Figure 3: Efficient charcoal making. Improved carbonization is practical with the use of equipment that provides better control of air. The Tropical Products Institute (TPI)-designed charcoal kiln can be seen in proportion to the people; it is small and compact. Picture shows delegates from the Expert Consultation being introduced to the work of the Food and Agriculture Research Management (FARM)-Africa field programme.

Design of the post-Consultation investment can be expected to contain reference to core and network countries/groups and the different national priorities that may prevail. For example, the investment should not be limited to *Prosopis* management/eradication, but explore opportunities for exploitation within existing development priorities. This may need to take note of regional developments, of issues of infrastructure, gender, livelihoods, education and similar; that is, sectors that may only be indirectly linked to land management. *Prosopis* control, management, eradication and/or utilization may result in a complex matrix of options and choices that cross international boundaries and national priorities.

Governments vary in their ability to manage natural resources; and to marshal the people, skills and investments required. Some measure of equality may need to be built into design that will take account of existing programmes and those that have yet to be started. Similarly,

there will be differences between technically advanced programmes and those that are rudimentary or simple. For example, the introduction of biological control methods within one country will eventually spill over into a neighbouring state. How to accommodate the diverging requirements and/or interests that may arise?

One consultation *'does not a programme make'*, but it does help point the way into the next period. For the current Consultation, a logical starting point is one of information sharing; that everyone here from the three core countries provides the same baseline information. It also behooves delegates to aim for some form of information exchange that each group is able to share equally within the debate. This brings ownership of the results of the Consultation and is likely to help further with any subsequent investment long-term. Everyone benefits.

1.6 Ongoing activities

It always helps to know what everyone is doing as a normal starting point with any initiative – and the proposed investment post-Consultation will be no exception. Shared knowledge avoids repetition of work that may have already been completed or which is currently underway. It also enables development elsewhere to be further explored and/or changed to suit local conditions. Start with taking an inventory of work programmes from those countries represented at the Consultation. This should list and summarize the *'what, where, who and when'* of any Research and Development (RandD) and extension programmes. Include all known activities and not simply those that may be funded by government, but also those that may involved the NGOs, commercial companies, the universities and so on.

There is considerable experience within delegates attending the Consultation. Many of you are well-known in your respective fields of study; some of the work that you have done in recent years has been well-reported. For example, the work undertaken within the auspices of the Government of Kenya/FAO project at Baringo in North-West Kenya during the period 2004-2006 has been widely reported. Such was the success of the project that it was able to reposition the *Prosopis* tree within the collective mind of local communities - and shift it from pest to valuable resource and one, moreover, that could provide employment and income to local people.

Experience of the Baringo project is worth replicating elsewhere; that others may benefit. Some findings can be transferred/copied immediately, for example, with adaptation of recipes for livestock feed or for food for people, the introduction of appropriate conversion equipment (for milling, mixing and similar – as shown in Figure 4) and crop/land management techniques that enable the tree to be grown for timber production. This is a case of following that well-known principle of *'learning from the mistakes/successes of others'*. Everyone attending the Consultation can learn from the experience and success of the Kenyan RandD workers at Baringo. (Note, in particular, the value of the recipes for food for people that have been developed at Baringo – and elsewhere – as described in Annex 6).

Figure 4: Milling dry Prosopis seedpods. Equipment supplied by the FARM-Africa field programme being demonstrated to delegates from the Expert Consultation. Note the mask that protects the operator from inhaling dust.

1.7 Classic project investment

There is always competition for investment funds – be it from a local bank or from an international donor - and the basis for requesting funds are much the same. You need to gather high quality information, collate and review it, and present it well. It is here that the international people represented at the Consultation may be able to assist; to share their experience and network of contacts when preparing the documentation required of new investment. Depending on the target donor, investment documents normally have to be prepared in pre-designated and formal manner that will meet the requirements of the donor agency concerned. Different donors/agencies have different requirements for presentation (and for procedures for presentation).

Most investment documents contain a number of standard sections including background, justification, objectives, outputs, activities, budget and supporting information (such as the equipment that will be purchased, the people employed, the work program required and so on). The document will also have to meet the needs of the host government(s) (that is, *'the recipient'*) and ensure that the key people concerned (in both administrative and technical sectors) are happy with what has been said on their behalf. Investment documents represent a request from the host government(s) to the donor government; and protocols need to be

known and followed. Note that at all times it is the national government that retains ownership of documents and contents.

1.8 Wealth creation

Irrespective of the investment sector '*development'* is all about people improving their lives. Wealth is created as the result of assets that are earned/collated, kids that are educated, lives lived longer and to the full, improved health and a host of similar socio-economic factors – within the family, community and/or country. This remains the same regardless of where people may live. Development is all about meeting the aspirations of people and their families. Much of this is '*perceived'* as the result of improved communications that have become available in recent years including access to satellite television, modern telecommunications, and the Internet. People around the world are able to talk with each other, to compare and to copy.

The world seems to have become smaller in recent times and the '*perceived'* wealth of others quickly becomes known (no matter the inequalities involved – at home or elsewhere). The implications of this for people in the low-income countries can be profound; and issues arise that are way beyond the mandate of a technical consultation. The basis of well-being within any community is typically a reliable livelihood that will provide employment and income with which to grow the family. Where deficiencies may apply, it behooves the community to agitate, marshal the resources and create that additional employment and income; to create the wealth required. Control, management and/or exploitation of *Prosopis* should be seen as simple one means of doing this.

1.9 Project investment

For the first day of the Consultation we cannot be certain how our presentations and debate will develop and what choices we may take. What is important is the measure of cohesion that may evolve as people get to know each other better; and how this may lead to a shared vision of what to do post-Consultation. Will this shared vision meet the demands of an appropriate investment that can be placed before the donor community? And too, will it attract investment from the private sector? Can ideas be channelled into products that can be sold commercially? In a best-case scenario, ideas and proposals will meet the demands of investors (i.e. donor agencies, but also the private sector), comply with the development objectives of the donor, help fulfil the commitments of the host government towards people in the areas in which the project will be based and provide for long-term socio-economic development. Ideas need to be explored within the many (and sometimes contradictory, confusing and complex) opportunities that arise for people/communities, agronomy/forestry, RandD investigations, environment, land/livestock production, marketing and added value investments.

1.10 Challenge

Opening the debate on the first day of the Consultation and representing the international management team – we confirm that each and every one of you has a responsibility to make a contribution. You are presented with a challenge that is well within your ability – to explore the many issues involved with *Prosopis* development in regional communities that we will collectively be able to boost understanding of prevailing issues and, importantly, prepare a suitable investment document that will attract donor funding into the next period.

It has been a pleasure to formally open our four-day Consultation. You cannot let this invasive tree take away your lands; as people you have the ability and the will to manage land for the good of your respective communities. Collectively, we have everything to gain; and nothing to lose by working together. On behalf of the FAO Director-General we wish you well with your debate.

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2. Increased Food Security through Prosopis Control, Management and Utilization

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Summary

Much is known about *Prosopis* – constraints, opportunities, control, etc. and local knowledge can be found in all countries in which the plant has been introduced; large numbers of people are familiar with it. Introduced for all the best reasons – for land control and protection – the plant has long outstripped its original function in many places and has become an invasive weed crop. Local people are frequently overwhelmed with their limited ability to cope. The Consultation is expected to explore options and to exchange information, and to develop a suitable post-Consultation investment. This will further enable the collective experience, skills and enthusiasm of the national experts represented at the Consultation to be channelled into a regional venture that will boost local understanding of improved management, control, eradication and utilization of the *Prosopis* tree and its products. Herein is considerable potential to be realized.

2.1 Objective of the Expert Consultation

The main objective of current project investment (and, it follows, for the Expert Consultation) is to formulate a sub-regional project document, which can be expected to lead into implementation of a management programme for *Prosopis* in affected countries. Further, the new medium-term project proposed should target participating countries and help people to reclaim land lost to the plant. Importantly, the project should help communities make use of the large quantities of biomass that results from land clearing. This will further promote additional income generating opportunities for farmers, pastoralists and others in rural communities.

2.2 Outputs

If the Consultation works as planned, sufficient information will be presented and shared that will enable the FAO Consultant to formulate an appropriate project document. This will focus upon issues of control, management and utilization of *Prosopis* on lands that have been invaded and lost. The immediate objectives of the new project will be to forge consensus among key national partners for the action required. This will help achieve:

- reduction of the invasive plant in affected areas;

- removal and utilization of biomass materials - for livelihood development and for income generation;
- boost in exchange of information and collaboration between key national institutions within countries and, equally, between countries.

A key activity will be one of sensitising government officials on the need to implement the action plan proposed for investment; for improved integration of land clearing, management of cover and use of the products of *Prosopis* as an essential component of national food security. It follows, because invasive plants do not recognise national boundaries that regional strategic planning will better assist neighbouring countries that face similar issues of land lost from *Prosopis* invasion. There is more to be gained by groups of countries working within a regional mandate than by remaining within their respective portfolios of national interests.

2.3 Country presentations

Country presentations will comprise the basis of our debate during the next few days. The strategies followed by each participating country for *Prosopis* management (and, it follows, for the similarities and differences that may apply between practices and approaches) will be introduced, examined and debated at the Consultation.

At the end of the Consultation, a proceedings will be drafted that will record the papers presented and the debate that followed. The proceedings will also explore requirements (including institutional arrangements) for the execution of the proposed project at national and sub-regional levels. Elaborate on the requirements for regional investment and we can expect to gain some understanding of the interaction and collaboration that will be required between the different national groups; and the network required for coordinating technical and managerial decision-making across the region.

Regional initiatives are always more of a challenge with need to work in harmony across national boundaries. It is early days yet – given that the Consultation is just beginning – but we envisage the development of project design that will identify the international collaboration and assistance required, the complementary role of donors, governments and the international agencies, budgets describing inputs of people, technologies and equipment and a work plan that may span four years of activities. Your contribution to design will be essential.

2.4 Integrated Prosopis management

Prosopis (mesquite) is a declared invader of riverbanks and hence seriously affects fisheries – productivity is lost. The plant has the capacity to withstand heat and drought and has high tolerance to salinity. However, when used correctly, it has potential as a valuable source of fodder for livestock and food for people. Additionally, it can be used as fuel wood, charcoal, construction timber including fence poles (where it is remarkably resistant to pest attack) and for agro-forestry, reforestation and shade tree cover. Notwithstanding issues of control, the tree continues to provide excellent cover for land that is at risk of environmental damage (see Figure 5*).*

Whilst strategic planning and action is required on national scale, it is the development of regional and/or sub-regional planning that offers the best potential for making changes (and for attracting funds for investment). As the result of the huge areas of land already lost to the plant and continued expansion into new lands, the introduction of an integrated sub-regional programme for controlling the plant using various strategies will be essential. A programme

of this kind should include a portfolio of approaches for management, control, eradication and utilization; to include:

- removal of plants in areas where food can be produced (where land will be continually cultivated) with use of manual and mechanical methods;
- utilization of biomass removed for different purposes (e.g. biofuels, construction materials, composting, mulching, etc.).

Management of existing stands - for livestock feed (e.g. seedpods and leaf), for food for people (e.g. mill mixes), for construction timber, for fuelwoods, for forage for bees (and production of wax and honey) and other novel uses (most of which remain RandD such as tannings, medicines, gums and extracts).

Figure 5: Prosopis cover. Land previously available to livestock has become lost as trees propagate without management or control. Stands of this kind help protect land, but remain largely unproductive to people.

2.5 Key components and accepted management tactics for control

The various measures that may help contribute to integrated *Prosopis* management can be classified as: prevention, mechanical eradication, chemical eradication and utilization. Prevention refers to the restriction of cattle from grazing on creeping mesquite infested areas when pods are present on the trees. Mechanical eradication programmes may be suitable for certain areas (e.g. in areas of agricultural production). *Prosopis* demonstrates strong vegetative reproduction from root buds. The removal of the creeping root system is essential to prevent re-growth, although this is generally not feasible with dense infestations where is will be difficult to gain access and hence, chaining or ploughing (with the use of heavy tractors) is recommended – but expensive. Manual control is more suited to the low-income countries - with people clearing and re-clearing infested lands to eradicate unwanted growth. See Figure 6.

Figure 6: Re-growth. Prosopis can quickly cover ground with lateral runners that may grow more than 1m per month. Mature shrubs can access water at more than 20m depth providing resilience and making it difficult to eradicate the plant in a single cultivation.

Chemical control methods have been widely explored and reported but, for low-income countries, they have not generally been found successful. Quality of application, follow-up and low-levels of technical ability frequently lead to inadequate control. It is exceedingly difficult to gain access to dense cover for people with hand sprayers or equipment-mounted spray equipment and to adequately apply foliar herbicides. Manual cutting combined with chemical treatment of stumps has, however, proven robust and low-cost. One practical option is to treat stumps with kerosene or waste motor oil and then burn the stump (using cut waste timber heaped around the stump). This will normally prevent further growth and ensure eradication. That said, follow-up is essential to ensure that the stumps have been completely killed. See Figure 7.

Biological control of *Prosopis* is practical and low-cost - introducing predators from the countries of origin and releasing them on to new growth. The issues are many and wide-reaching, and have been well reported. The plant has two natural enemies - seed beetles *Algarobius bottimeri* and *Algarobius prosopis*. The larvae of these beetles destroy the seeds in the mature pods both on the tree and on the ground. Each larva lives in a single seed and develops into a beetle after 6-10 weeks. This method is sound; it prevents the spread of the plant without actually killing it. This is important and particularly where local people continue to exploit the plant. Damage to seeds/pods will reduce the seed load in the soil, but may also reduce their value for processing into feed/livestock or food/people.

Figure 7: Burning techniques. Land cleared of Prosopis cover as the result of extensive cut back and burning of stumps that remained. Note that a poor burn will enable trees to recover and grow again – and follow up is essential.

Utilizing the plant represents indirect control (and thus managed eradication of unwanted growth/cover). It provides for long-term added value of selected products and, in the short-term, may provide an outlet for large quantities of biomass (for example, for conversion into charcoal). Commercial exploitation is a logical means of boosting utilization and raising incomes for *Prosopis* products from sale of fuelwoods, construction timber and similar. Sawn timber has found outlets, for example, as high quality flooring and, more modestly, as pallets.

2.6 End note

The Consultation provides an opportunity of sharing information, ideas and enthusiasm for the control and/or use of *Prosopis* on invaded lands. Consultations provide a measure of continuity with the development and progress of the one team, community or country shared with the next. Here it is that a measure of pooling can be made that the best options from the one investigation can be modified for use elsewhere. Mistakes made can be rectified as part of the new investment. A well-reasoned and well-prepared investment document will attract the attention of an interested donor, and should result in further investigation across the region. Regain access to land lost to *Prosopis* and it can be re-used to produce food and other commercial crops. This represents a logical step when planning regional food security.

3. Problems posed by the introduction of Prosopis plants

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Summary

Prosopis spp. are typically native to the Americas but have, during the past 200 years, been widely introduced into Africa, India and Australia as plants capable of protecting vulnerable lands and soils. Inadequate management and lack of good husbandry practices have seen the plant escape from areas of introduction to invade lands previously used for crop production and/or for grazing livestock. *Prosopis juliflora* is generally credited as the most noxious of invaders with characteristics that make it a highly successful competitor for land and water. A prolific seeder and with seeds that are highly palatable to livestock, plants can be spread by ingestion and excretion. Similarly, plants have been quick to colonize previously uncontaminated waterways on productive lands.

Numerous methods have been explored and used for eradication and for preventing infestation of new lands. A key logical feature for control is prevention; with restriction on planting into new areas. Similarly, eradication effort has to be prompt and enduring to prevent newly established plants from taking over. In the low-income countries control is typically a mix of manual clearing and burning. Where additional resources are available, larger-scale mechanical clearing with use of heavy equipment may have a role; and followed by chemical treatment to kill re-growth. Utilization of *Prosopis* and products is not generally a method of control, but more one of management tolerance. Communities typically need to be shown how to grow productive stands of *Prosopis* for the extraction of commercial goods, and to promptly eradicate unwanted growth.

3.1 Introduction

Poor husbandry practices and abusive management of natural resources have helped accelerate the rate of land degradation and erosion in arid and semi-arid areas worldwide. It is for this reason that several plants - most of them trees - have long been used for conservation of land, soils and water in damaged areas. Massed planting of trees has helped reduce the rate of degradation and conserved the natural resources remaining. In many cases land has quickly returned to productivity. One of these plants has been *Prosopis* spp. (popularly called *'mesquite'*). It is a deciduous, thorny shrub or small tree native to the tropical or subtropical regions of the mainly Western Hemisphere, but also for some species native to Africa, India and the Middle East.

Most *Prosopis* spp. in North America are small trees that rarely exceed 15 m in height. The plant is a source of fuelwood and charcoal, and timber can also be used for fence posts, crossties, house construction and furniture. Mesquite provides high-quality forage for livestock and wildlife, and the seeds were once widely used by Native American peoples in what is today the southwest United States (USA) (Davis, *et al,* 1975; Martin and Alexander, 1974; and Vines, 1960). Mesquite flowers provide popular forage for bees and excellent

honey can be produced - especially in Hawaii (Skolmen, 1990). The crude protein contents of honey and velvet mesquite seeds are 31 percent and 24 percent, respectively, according to Becker and Grosjean (1980). The seedpods of honey mesquite are high in carbohydrates (Harden and Zolfaghari, 1988). In addition, the tree is a robust nitrogen-fixer and has been widely planted for erosion control in Hawaii, as well as for highway landscaping and for reclaiming land spoiled by mining in the southwest USA (Day and Ludeke, 1980).

There are numerous species of *Prosopis* most of which are native to North America (see Table 1). *Prosopis juliflora* has been widely introduced as ground cover in Africa and Asia, and it is this species that has generally become widely known internationally as an aggressive invader of lands.

Table 1: Selected species of Prosopis

Item	Scientific name	Common names and synonyms	Occurrence
1.	*Proposis. glandulosa* (Torr.)	Honey mesquite	East Texas and Oklahoma to Utah
	Proposis chilensis var. *glandulosa* (Torr.)	Standl	Northern Mexico and Southern California
	Proposis juliflora var. *glandulosa* (Torr.)	Cockerell	Northern Mexico and Southern California
2.	*Proposis juliflora* (Sw.) DC.	Mesquite	Mexico and Hawaii
3.	*Proposis pubescens* Benth	Screwbean mesquite, screwbean and tornillo	Trans-Pecos Texas to Southern California and Utah
4.	*Proposis velutina* Woot	Velvet mesquite	Central Arizona and New Mexico
5.	*Proposis pallida* (Humb. and Bonpl. ex Willd.) Kinth		Peru
6.	*Proposis juliflora* (Sw.) DC		Mexico through Central America to northern South America and to the Galapagos Islands.
7.	*Proposis cinerea*		India, Iran, Pakistan, Afghanistan and Arabia
8.	*Proposis juliflora*		Australia, La Reunión, Mauritius and Papua New Guinea

Note: *Proposis juliflora* is included in the Hawaii State exclusion list and *Proposis pallida* is included in the USA exclusion list.

3.2 *Prosopis julifora* characteristics

The leguminous shrub *Prosopis julifora* was introduced into the countries of East and Southern Africa, Australia, India and the Middle East for improving the environment in arid and semi-arid zones. *Proposis juliflora* is an evergreen shrub/tree up to 15 m high, very

thorny (or thorn-less), sensitive to cold weather and highly tolerant of heat, salinity and alkalinity. The plant is a prolific producer of seeds, which can be transported by floodwaters or ingested by animals and spread in their manure. Once established *Proposis juliflora* inhibits the germination of seeds of other species, thereby enabling the tree to spread unopposed. It is an opportunistic plant since it will seed and grow wherever sufficient moisture is available.

3.3 Problems caused by *Prosopis juliflora*

Due to lack of understanding, mis-management and/or insufficient exploitation and/or eradication, *Proposis juliflora* has invaded both natural lands and farmed habitats. This has included watercourses, floodplains, highways, degraded lands, abandoned lands and irrigated areas. Due to severe invasiveness *Proposis juliflora* plants have replaced native *Acacia* spp. in many lands. The plant canopy easily takes over and provides dense ground cover, making it difficult for other grasses and plants to establish and flourish. Thorns 70-100 mm long grow along the tendrils and inflict injury to people (and especially children) when they step on them. Thorns injure animals and cause punctures in bicycle tyres.

As livestock feed the plant has mixed value. Seedpods have high sugar content, which causes severe teeth decay in animals ingesting them. Further, seeds pass easily through the digestive tract without harming the animals, thereby encouraging further spread of the plant and resulting in dense stands covering many fertile areas previously available for grazing. Above 1m in height, it is impossible for people or livestock to push easily through a stand. The total area affected by *Prosopis* in Kenya and Sudan is estimated at more than 1 200 000 ha (i.e. 120 km^2).

Table 2 illustrates annual household losses caused by *Prosopis* in affected communities in rural Kenya. It is clear that the presence of this tree presents a serious challenge for both farmers and pastoralists, and much land is abandoned as the plant takes over. Most rural people are unable to cope with the adverse effect of the plant, and suffer losses to crops and livestock as well as personal injury.

3.4 *Prosopis* management and control

Planting where/when required. *Prosopis* plants should be kept only where they are wanted. Further, there is no sense with introducing the plant without providing adequate management. In fact, the major problem has been leaving the plant to spread unchecked, and not removing/using it for various purposes – including the original reasons for its introduction. This creates issues for those following, for people only really notice the invasive nature of the plant when it has already spread into new areas and formed densely crowed and impenetrable thickets.

Table 2: Contribution of Prosopis spp. *to annual household losses among rural communities in Kenya*

Loss per household by category	Annual value of loss per household (US$)*
Thorns *(people)*	30
Thorns *(bicycles)*	52
Labour to remove plants *(farmed areas)*	48
Livestock deaths *(due to teeth decay)*	650
Crop losses *(due to invasion)*	125
Fishing losses	675
Total losses	**1,580**

Source: Choge and Nguijiri (2006).
* Note: US$1 = Ksh71 at time of assessment (2004).

A key feature of management is to remove the plant from those areas where it has become a barrier to agricultural and animal production; and to do this when the plant is easy to manage/control. Once farmers or pastoralists have started to remove unwanted stands of *Prosopis* the large quantities of biomass available can be used for different purposes.

Control. Mechanical or manual control strategies are essential to remove dense stands of *Prosopis*. For manual removal chainsaws or other tools may help, while for mechanical control heavy machinery will be required. Manual removal of unwanted trees is hard work and requires much labour. Mechanical removal requires access to heavy machinery, skilled operators and management and to the fuels, replacement parts and other consumables required of mechanization practices. These are resources that are not typical of small-scale landowners, and normally available from the state. Any removal programme based on the use of large-scale mechanization should be evaluated and budgeted prior to beginning – that sufficient resources are available to see the programme through to conclusion. See Figure 8.

Land clearance. Mechanical land clearance has been undertaken in Australia with '*chaining'* land clear of scrub. Chaining is dragging heavy chain stretched between two bulldozers/tractors with a change of direction to ensure that the monotypic woodland stands of *Prosopis* land cover have been destroyed in two directions (Meadly, 1962). Up to 40 ha can be cleared daily according to Rentz (1993), but this has to be followed up with herbicide treatment to prevent re-growth of suckers. Methods such as this may be effective in some regions but it cannot be recommended more widely, because of the risk of re-invasion by alien plants. Further, there is considerable environmental damage to flora, fauna and to the soils, which are then exposed to the elements. Chaining as a technology for land clearing has fallen out of favour in recent times.

In Yemen, it was found that ploughing killed a high proportion of *Prosopis* roots. However, some re-growth may follow which will then need to be removed and/or treated chemically. Light ploughing with farm equipment can only handle low-growing shrubbery and then there

is the likelihood of damage to tyres and plant. Manual land clearance is a well proven if difficult task, but highly practical where plant infestation is light to moderate. Even here it is more productive to spray auxyn-like herbicides directly on to the plant to hasten the likelihood of kill. Issues of legislation may arise with the use of use of herbicides in some areas.

Figure 8: Mechanical removal of Prosopis. Systems are practical but expensive and require access to plant and people with experience. Re-invasion can typically occur when there is failure to follow-up with eradication of re-growth from rootstock that remains in buried.

Burning. Fresh stumps can be treated either with an appropriate herbicide or other means to avoid re-growth. In Kenya, for example, the stump is burned with a mixture of goat manure, twigs and firewood, while in Yemen the application of kerosene over the stump followed by burning has shown to provide good suppression of the plant.

Biological control. To avoid the spread of the plant biological control can be used. The most effective agent and method available is the use of insect seed feeders (such as *Algarobius prosopis*). In principle, the insect will damage the seeds of the plant – and reduce germination potential - but it will not control it (and, it follows, it will not eradicate the plant from an area).

Chemical control. Basal bark treatment with an herbicide sprayed around the base of the lower stem(s) of the plant is a practice used in the USA. The herbicides commonly used for this purpose are 2,4 D, picloram, triclopyr or mixtures. Methods of this kind may not be feasible in countries where herbicide application is severely restricted; and it may not be practical where people have neither access to the chemicals and equipment required nor to the funds with which to purchase them. Treatments of this kind can only be practised in areas far from other broad leaf crops (that may be susceptible to spray drift) or where there are crops that are generally not affected by the herbicide formulations used.

Replacement crops/cover. It is extremely important not to leave land uncovered after clearing it of unwanted *Prosopis* stands. If there is no natural regeneration then an appropriate forage grass or similar fast-growing crop should be planted across exposed lands. This will help prevent issues of soil erosion and provide competition from regenerated *Prosopis* suckers and runners. Controlled grazing will further limit re-growth.

Good housekeeping. There are other preventative measures available with which to avoid future problems of *Prosopis* infestation. One logical approach is to strictly prevent the introduction of new *Prosopis* plants into the area – deliberately or inadvertently. Ensure that any livestock moving in from infested areas are corralled and given time to excrete any ingested seeds prior to relocation on cleared and/or non-infested lands. This is simply good land husbandry practice.

Monitoring risk. It is sensible to undertake regular weed risk assessments to evaluate any future problems that may arise from the introduction of exotic plants into new habitats (FAO, 2005). This is normally undertaken with the guidance of specialists from the Ministry of Agriculture - with experienced people able to reject or approve the propriety of newly introduced species (whether *Prosopis* or other invasive species).

Utilization. Utilization of *Prosopis* is an important component of management, but it is *not* a control method. Removal of *Prosopis* on mass will stimulate use among affected communities, but people may need access to technical advice and/or specialized equipment if they are to use the tree and its products in an effective manner long-term. Utilization also requires that people will be taught to plan and establish suitable gardens of plants and to train them in the correct manner (for the production, for example, of timber).

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4. Prosopis Situation in Ethiopia

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Summary

Prosopis juniflora has become one of the most serious invaders of agricultural lands in Ethiopia since its introduction during the early 1990s. Estimated more than 16 000 ha of reasonable productive lands have been lost to the plant in the Afar and Somalia Regions of Eastern and SE Ethiopia. This is predominately livestock grazing country but the plant has, in addition, successfully occupied cropping lands and infrastructure such as irrigation canals, roads and village areas. The plant is found with moderate level infestation elsewhere in Central and Northern Ethiopia. *Prosopis* is resilient and adaptable and cannot easily be eradicated by local communities without external assistance.

Therein is the dilemma of national decision-makers; whether to encourage control, management and/or utilization or whether to attempt eradication. There are well-developed advantages and well-known constraints for both courses of action. The reality is likely to be one of acceptance where people are capable of managing existing stands in productive manner – harvesting a range of products for use in the home or for sale. Where the plant is not required – it should be eradicated if possible. Eradication requires considerable investment over long-periods and is expensive in effort, labour and other resources. It may not be practical. Quarantine methods will be required for movement of livestock and plant materials.

Long-term there is need for strategic planning that is best undertaken by central authority that sufficient resources are allocated for understanding the extent of the issues, providing dialogue with local communities, providing training, funds, technologies and equipment for control, management and/or utilization and for encouraging local people to become involved and to take ownership.

4.1 Introduction

Many different types of invasive and noxious weeds have been introduced into Ethiopia at various times. The five main invasive economic plants of today are: *Parthenium hystrophros, Prosopis juliflora, Eichhornia crassipes, Lantana camara* and *Orobanche* spp. This paper has been prepared for the Expert Consultation and focuses specifically upon *Prosopis juliflora*. However, many of the principles involved for enhanced understanding of invasiveness and how people come to terms with unwanted plants on large-scale apply equally to the many different ecosystems that have faced invasion from alien species; and of how people react to changing socio-economic opportunities.

Prosopis juliflora is a native of Central and North America and exotic to Ethiopia. More specifically, it is a thorny evergreen/semi-evergreen tree, which produces a large green crown

and develops a deep and well-developed lateral root system. It reaches a height of 10 m depending on the type of soil, topography and climate where it is found.

Key characteristics of *Prosopis juliflora* are those of drought resistance, tolerance to mild frosts and an ability to withstand adverse growing conditions better than most native competitors. Further, *Prosopis* is unique insofar as it thrives in, and adapts to, almost all types of soil and widely varying climatic conditions. It easily invades new regions over great distances (given the ease with which seeds are transported) and grows well on both arable and pasture lands. Extreme versatility represents one of the greatest dangers associated with the plant.

The *Prosopis* tree is highly prolific, adaptable and resilient, and produces more than 35 000 seeds annually. Moreover, seeds have prolonged dormancy and are capable of surviving long periods of drought (secure within a protective seedpod). Quick to adapt and highly competitive within a host of ecosystems, the plant is invasive and difficult to eradicate easily once established. People farming with low productivity systems in the low-income countries quickly come to terms with the plant and either accept that invaded lands have become lost to previous use, and/or struggle to adapt and make use of the few *Prosopis* products available. Many people abandon invaded lands.

4.2 Status in Ethiopia

Prosopis juliflora is an exotic tree (more of a shrub really) in Ethiopia and was widely distributed as a biological soil and water conservation agent during the early 1990s. Sixteen years later it is now considered a major threat because of its invasive nature. The exact dates and means of introduction in the country predate this period and have not been recorded, although speculation exists. What is not disputed are the areas into which the plant was first introduced. According to many local people, *Prosopis juliflora* was introduced deliberately to provide shade as well as for soil conservation purpose. *Prosopis* seeds were planted in a number of places with the consent of the traditional authorities who were advised about its benefits. The tree was widely distributed in the Middle and Upper Valley of the Awash River and within the area of the Dire Dawa Council in Eastern Ethiopia.

Although originally planted for all the best of reasons, the unintended consequence of its introduction quickly became known. *Prosopis juliflora* has invaded important pasture lands, dry lands, irrigated lands, irrigation canals, roadsides and riverbanks alike throughout eastern and north-eastern parts of the country. It has invaded large-scale farms and small-scale holdings without discrimination; where both modern production technologies and equipment and subsistence methods are used. Given innate aggressive and invasive characteristics that can easily dominate the local ecosystem, the plant has quickly overrun native species of trees and ground cover and occupied cropping lands, rangelands and forest country alike.

4.3 The *Prosopis* dilemma

A dilemma exists for the different stakeholders working with *Prosopis;* whether to encourage eradication as a prohibited weed or whether the possibilities of utilization should take prominence. Exploitation may help with food security of local communities with the tree producing a range of products for use in the home or sold into commercial markets. Those who promote utilization cite benefits that include:

- land ameliorating capabilities - improving the chemical and physical properties of the soil;

- potential for use as feed for livestock - as stand alone or in feed mixtures;
- potential for use as food for people. See Figure 9;
- potential for fuel wood development and/or conversion of timber into charcoal;
- potential of timber as construction materials.

Figure 9: Drying seedpods. Collect undamaged seedpods from the tree and dry them in the sun on tables above ground contamination. Mill them and produce a flour that can substitute up to 25 percent *wheat, maize or cassava flour in traditional recipes for breads and cakes. Herein is a measure of additional food security for local communities.*

There is sufficient experience within the country to demonstrate the value of these advantages and/or products and for encouraging exploitation. On the other hand, however, it is possible to match the equally compelling arguments of those who advocate the eradication of *Prosopis*. This includes:

- reduced productivity of pastoral lands from loss of grass cover, contamination of valuable water recourses and restricted access to livestock;
- extensive injury caused to livestock – hooves, skin, eyes, etc. and damage to tyres of vehicles and bicycles;
- the excessive consumption of seedpods in livestock feed leads to poisoning and/or loss of teeth of grazing animals; livestock thereby become unproductive during their middle years;
- adverse environmental impact due to land/soil erosion from the loss of native grasses and shrubs that are better-suited and more productive for local growing conditions (for cropping/livestock and for native flora and fauna);

- existing stands of *Prosopis* (whether well-managed or remaining wild) continue to act as sources of contamination of lands (close by and at a distance) from the prolific distribution of seeds.

4.4 Challenges for producers

Problems associated with *Prosopis juliflora* are mainly due to its thorny, dense and poisonous characteristics, which prevent animal passage and restrict browsing on other endemic bush species. Ripened seedpods fall to the ground and are eaten by grazing livestock, and this results in digestive disorders and, ultimately, to teeth decay. Further, stock pushing into the lands covered in long trailing *Prosopis* vines can be damaged by thorns. Stock become lame from damage to hooves, and cuts and abrasions of the skin lowers the quality of the leathers that can be produced by tanneries. This lowers prices for hides and skins at time of slaughter. *Prosopis* domination of dry land areas lowers the productivity of livestock.

Much the same happens with invasion of cropping land. Neither wild flora nor agricultural crops can compete. Further, *Prosopis* will invade and occupy infrastructure required of cropping, for example, hindering the free movement of irrigation water in canals, making farm roads impassable and causing damage to farm equipment and road transport. Considerable effort and resources are required to combat invasion and keep roads, land and irrigation channels free of the plant. See Figure 10.

4.5 Lands invaded

In terms of coverage, the areas most adversely affected nationally include the Afar and Somali Regions in the east and southeast of the country and the area around Dire Dawa City. There are also moderately affected areas in Amhara, Oromia, Southern Nations Nationalities and Peoples (SNNP) and Tigray Regions – that is, in the mainly dry lands of Central, East and North Ethiopia.

Relevant data showing the extent of land invaded in the most seriously affected areas have been gathered through preliminary surveys. These show of the order 16 730 ha pasture, villages, cropping and irrigated lands affected in nine districts in Afar Region. Further, in villages in three districts of Somali Region more than 4 000 ha of pasture and irrigated lands are estimated to have been lost. Losses in the moderately affected lands raise issues for continued invasion – and potential for increased severity particularly where areas are adjacent to Afar and Somali Regions. These are relatively isolated and impoverished areas that lack reliable infrastructure, and home to communities that may be outside the mainstream of development opportunities. Invasion takes place over many years and may go unnoticed and remain unreported until crisis point is reached – when people are forced to abandon their lands.

Figure 10: Invaded surface water. Open water invaded by Prosopis restricts access by both livestock and people. Loss of income from fishing can result. Travel by boat is restricted. Seedpods are highly mobile in water and can successfully travel many hundreds of km from the mother tree.

The tree spreads easily from one location to the next as the result of people transporting seeds inadvertently, but also purposely for propagation (for environmental control, etc.). Livestock consume the nutritious seedpods and excrete scarified and viable seeds in their manure, thereby providing ideal nursery conditions for the new plant in what may be an alien environment. Seeds/seedpods are also easily spread by water – and can be carried great distances along creeks, rivers and canals during times of rain and flood.

4.6 Combating the plant

Much effort has been done to come to terms with the spread of *Prosopis juliflora*, to determine the many complex issues involved, to determine the extent of invasion and danger to agricultural production systems and to curb unwanted and unexpected side effects. A Task Force to counter *Prosopis* was established by the Ministry of Agriculture in 2004, although it was neither as effective as required nor was it able to do more than highlight the many issues involved. It was, however, able to prioritise the severity of the extent of the invasion and to stimulate government to take further action.

Field and situation analysis surveys have been undertaken in Afar and Somali Regions and in Dire Dawa; questionnaires have been developed and interviews conducted with local pastoral communities. Further, eradiation campaigns have been organized and implemented in the Afar Region (for clearing road, road sides and villages). Charcoal production has been encouraged with the formation of producer associations throughout affected areas. Training has been provided to people – decision-makers in local communities and to landholders – for the complex nature of plant invasion; and choices that need to be made for eradication, control and/or management that will suit local conditions in Afar and Somali Regions. See Figure 11.

Figure 11: Training. Dense Prosopis scrubland in the background and, directly in front of the camera, a group of local people receive instruction on the value of clearing land and then keeping it clear with intensive cultivation. (Picture taken during the Expert Consultation.)

Despite current and past efforts, however, continuity of investment will be essential that more people are trained to recognise invasion and become capable of handling the many issues involved. Eradication from current lands may be difficult (if not impossible), but practical action to prevent further spread of *Prosopis juliflora* is possible. This requires better internal quarantine systems that will restrict/monitor the movement of livestock and road transport; it means no planting of new areas without permission from the appropriate authorities (which is, given the nature of the currently invasion, highly unlikely) and; where harvesting of *Prosopis* products is practical it requires the use of well-established control methods to ensure that the plant does not spread.

Exploitation of the plant, for example, for charcoal production by definition will *not* result in plant eradication. It will result in the development of managed stands of trees that will have larger trunks and main branches that can be harvested on a rotational basis for carbonisation (i.e. larger timber sections make better charcoal). Herein there is need for technical assistance with the introduction of improved production systems, the use of modern charcoal equipment (that provide more efficient conversion of timber to charcoal) and for traders and others to become involved with the production and marketing of high quality goods. See Figure 12.

The dry country of Eastern and North-East Ethiopia is traditionally the land of the pastoralist, but it also has considerable potential long-term for adventure tourism with the return/establishment of wildlife conservation areas. The Awash National Park is one example of what can be achieved with imaginative planning and investment but the park is, even now, in danger of being invaded by *Prosopis* (and will thus become alien to local fauna, flora and to tourists alike).

Figure 12: Managed gardens. Surrounded by a wasteland of Prosopis scrub, a small garden has been developed with intensive forage and a handful of single Prosopis trees that will eventually be harvested for timber.

4.7 Conclusions

Conclusions are logical and can be summarized relatively simply:

- eradicate the plant in areas where it is unwanted;
- prevent the plant from spreading to new areas;
- exploit the plant and its products where people have both the ability of manage it and to harvest, use and trade the few products available.

Management through careful and well-informed utilization should be given top priority. The environmental, social and economical impact of the plant needs to be thoroughly investigated when designing any area-specific management strategy.

A word of caution. It will not be sufficient to apply generalized principles for either eradication or utilization of *Prosopis* region-wide. Local people and their capabilities may have to be into account. Communities and their ability to cope will depend largely upon the support received from outside (whether from governments, NGOs or others) and from any markets that can be exploited for a range of products. Initially this is likely to be for charcoal and/or livestock feed and, subsequently, for honey, wax, timber and other more valuable products.

Quarantine effort will be required in order to minimize the dispersal of seed by grazing livestock. Plants growing in watercourses should be removed as a priority to prevent the further distribution of seeds by water.

Implicit and *de facto* strategic planning is required on the part of the Federal and/or State Governments that sufficient investment is made in RandD, investigation, training, products and markets development for use of *Prosopis* products. Equally important, state assistance will be required for control and/or management of existing stands that local people are better able to understand the principles that underlie invasion and how to cope with it. It is not

sufficient to remain with the status quo – there are simply too many unknowns involved for the future.

5. Impact of Prosopis Invasion and Experience with Control in Afar National Regional State

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Summary

The valley of the Awash River in Afar National Regional State represents the most extensively invaded *Prosopis* area in the country with estimated 70 000 ha of land occupied. A programme in support of affected communities has been undertaken by FARM-Africa during more than five years. This has enabled people to better understand the impact of invasion and how to come to terms with changing resources. Grazing and croplands have been lost, but charcoal makers in communities have gained from the large quantities of additional biomass available. The establishment of cooperative societies and unions has provided a channel for investment and training that people are better able to cope with changing lifestyles.

Survey undertaken by FARM-Africa in 2006 is important for the value of how local communities may consider the impact of pro-*Prosopis* interventions - to provide better understanding of the principles involved with control and/or utilization. Firm gender roles emerged with women generally more in favour of exploitation than their menfolk. Charcoal makers represent a sector of the community in favour of exploitation.

A key regulation introduced by the Government of the ANRS in January 2007 provided guidance for the control, management and utilization of *Prosopis*. The regulation has potential for sharing further within the country and the region.

5.1 Background of Afar National Regional State

The Afar National Regional State (ANRS) is located in the northeastern part of Ethiopia. (see Figure 13). With area estimated at 96 707 km² the region covers 10 percent of total land and 29 percent of lowlands in the country. It lies in the Great Rift Valley of East Africa and is characterized by patches of scattered dry forest, acacia woodland, bush lands and wooded savannah. About 64 percent of land in the region is degraded and bare of vegetation. The mean annual rainfall is 564 mm with annual evapo-transpiration rates 1 400-2 200 mm. The region has bi-modal rainfall distribution pattern extending from July-August and from February-April annually.

The economic base of the region is transhumance pastoralism with cattle, camel, goats and sheep as dominant animals. Local people are engaged mainly in agro-pastoral activities. A significant number also earn their living as daily labourers on large estates and private farms. The region is extremely drought-prone with underdeveloped socio-economic services and limited physical and human infrastructure. These are some of the most isolated and impoverished parts of the country with high levels of illiteracy and high levels of human and livestock disease.

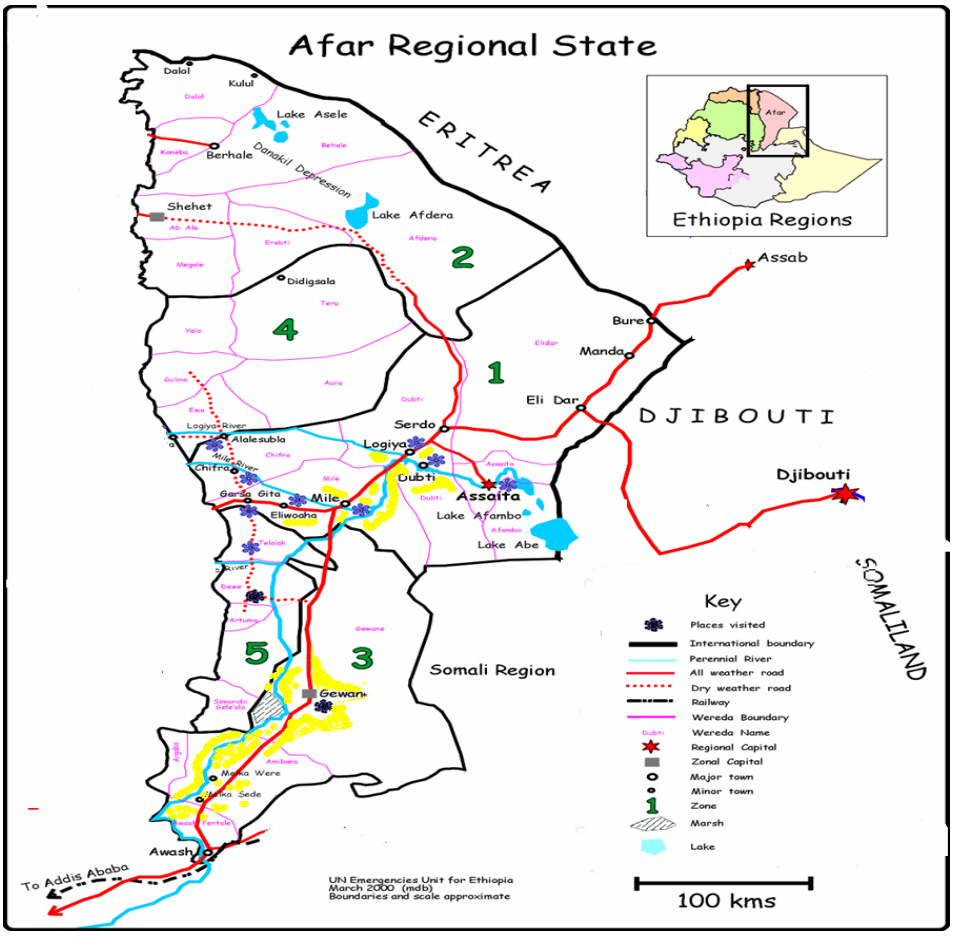

Figure 13: ANRS and Prosopis invasion in the state

5.2 Losses and benefits from *Prosopis* invasion in ANRS

Prosopis is generally thought to have been introduced into Ethiopia from India in the 1970s for conservation purposes by the Ministry of Agriculture. According to recent surveys more than 700 000 ha in ANRS have already been invaded or remains at risk from *Prosopis* invasion (as shown shaded in yellow in Figure 13). Major negative effects of *Prosopis* in ANRS are loss of pasture and loss of indigenous trees. Table 3 describes major grasses and fodder tree species threatened by the spread of *Prosopis*. Other negative effects are increased predator attack and rising risk of raiding and livestock theft (as people compete for scarcer resources).

The proliferation of *Prosopis* canopy blocks access to lands, roads and watering points, causes mechanical injury to livestock and people and, increasingly, results in more malaria infection due to water ponding under the trees (and offering more breeding grounds for mosquitoes). Invaded lands provide host for crop pests - attracting insects such as grasshoppers. More strategically for local people, invasion of lands adjacent to the Awash River has contributed to a shift in the watercourse along stretches of the river. This disrupts communal areas for habitation, cropping and grazing and watering livestock.

Table 3: Major grass and fodder species threatened from Prosopis *invasion in Gewane and Amibara District*

Scientific name	Vernacular name	Remarks
Acacia tortilis	Eebto	Multi-purpose tree
Acacia senegal	Adebo	Multi-purpose tree
Acacia nilotica	Keselto	Multi-purpose tree
Dobera gelabera	Gersaito	Multi-purpose tree
Chrysopogon plumulosus	Durfu	Grass
Cenchrus ciliaris	Serdoitas	Grass
Seataria acromelaena	Mussa	Grass

Source: FARM-Africa. (2006).

Livestock are further disadvantaged from risk of diarrhoea from eating immature seedpods/seeds and from internal obstruction (called locally *'armeko'*) and from loss of teeth (given the high sugar content of seedpods/seeds). See Figure 14 and note Table 4; and particularly the high carbohydrate content for all parts of the plant.

Table 4: Nutrient composition of Prosopis parts

Parts	Ingredients in 100g						
	Protein (g)	Fat (g)	CHO (g)	Fibre (g)	Ash (g)	Ca (mg)	P (mg)
Flower	21.0	3.2	65.8	15.5	10.0	1310.0	400.0
Leaves	19.0	2.9	69.6	21.6	8.5	2080.0	220.0
Fruits	13.9	3.0	78.3	27.7	4.8		
Seed	65.2	7.8	21.8	2.8	5.2		

Source: FARM-Africa. (2006).

Notwithstanding well-documented constraints, *Prosopis* has many advantages. On the ecological side it serves as a windbreak, improves soil fertility, reduces soil erosion and helps with reclaiming saline lands. From an economic point of view, *Proposis* can be used for the production of fuelwood and charcoal for home use and sold to help raise household incomes. Timber can be used for construction materials in fenced settlement camps, for live fences, shade, livestock fences and local houses.

Figure 14: Sick animal. Feeding exclusively on Prosopis seedpods for long periods

Table 5 provides a comparison of the different socio-economic groups within the community and makes an assessment of their gains and losses from land invasion. Not surprisingly, established livestock and cropping people complain of lost assets, land, etc., and those such as charcoal makers reap the benefits from the exploitation of new opportunities. Surveys show that livestock producers have been slow to shift to off-farm enterprises; placing more emphasis on grazing livestock at a greater distance from the homestead. Crop producers and labourers working for others showed more versatility and many embraced the new opportunities.

5.3 FARM-Africa pilot control interventions and outcome

During the past five years, FARM-Africa has worked closely with local communities living in invaded lands, and done much to explore control and management of *Prosopis*. Intervention strategies placed people-participation at the centre of control. This included mobilizing communities for land eradication of seedlings and mature plants, and helping establish exploratory enterprises for a host of quasi-commercial products including livestock feed, food for people, fuelwood, charcoal and timber. Seedpods have been collected, crushed in hammer mills provided to local communities by FARM-Africa and livestock rations have been developed. Mixed with other ingredients the crushed seedpods have been baked into breads for people. Traditional charcoal production techniques have been upgraded with improved equipment (boosting efficiency of production 2-3 fold).

Pilot interventions of this kind are undertaken with the agreement of the regional administration. Cooperative societies were organized and licensed, and by-laws developed and introduced to encourage people to work in well-defined places (i.e. those in areas invaded by the plant) with recommended working practices that focus on control (e.g. cutting the plant 100-300 mm below ground level)[3].

[3] Recommended practices. Extensive experience of management, control and/or eradication of *Prosopis* within the state led the ANRS Government to implement the first *Prosopis*-specific legislation in Ethiopia in January 2007. Given the importance of this development for local people and for the environmental stability of natural resources within the state (and for the country at large), this regulation is described further in an annex attached to the paper.

Table 5: Comparison of benefits and losses from Prosopis by community groups

Occupation	Benefits and losses (%)		
	More benefits	More losses	Balanced
Pastoralists	5	90	5
Agro-pastoralists	5	95	0
Charcoal makers	78	22	0
Total	26	72	2

Source: FARM-Africa. (2006).

Priorities apply that focus on eradication/utilization for cropland and pasturelands in the mainly small communities that have been seriously affected by invasion and loss of land. In addition, households and communities have been provided with seed money, hand tools, pod-crushing machines, metal kilns, technical information and agro-business support for the production and marketing of a range of products (but mainly for charcoal). Community support has been channeled into promoting the role of cooperative societies (i.e. refurbishing and/or redirecting those already available and, where non exist, helping to establish them). A brief overview of the economic benefits that have accrued during the period 2004/2005 is explored in Table 6.

Table 6: Economic benefits for cooperatives from charcoal marketing (Oct 2004 - Sept 2005)

Name cooperative	No. m'bers	Bags Ch'coal sold	Gross revenue	Payment to m'bers	Payment to labour	Total expenses	Profits	Area cleared (ha)
Serkamo	63	151 363	4 994 979	531 284	2 259 093	2 790 377	2 204 602	250
Sedhafagae	87	24 291	801 603	370 681	-	370 681	430 922	100
Geliladura	29	12 621	416 493	36 601	76 004	112 605	303 888	46
Be'eda	28	7 674	155 694	94 360	-	94 360	61 334	10
Total	207	195 949	6 368 769	1 032 926	2,335 097	3 368 023	3 000 746	406

Source: FARM-Africa. (2006). Note: Currency at time of the survey US$ 1=ETB 8.5.

Training was given to community members (within and outside cooperative societies) and to local development agents to help with improved charcoal production (undertaken jointly with the Ethiopian Rural Energy Development and Promotion Center - EREDPC)*;* for fodder and crop production on cleared land (undertaken jointly with the Ethiopian Institute of Agricultural Research - EIAR and Afar National Regional State –ANRS - Pastoralist, Agriculture and Rural Development Office - PARDO); for cooperative management and agro-business skills; and for operation and maintenance of pod crushing and feed mixing equipment.

The prime activity of the programme of work undertaken by FARM-Africa in local communities has been support for charcoal production and marketing. A simply analysis of cash flow within the charcoal trade is shown in Table 7 (note the similarities across different areas and cooperative societies with costs/prices). Members of cooperative societies were able to accumulate sufficient assets such as tractors and equipment and trucks, which could then be used for other commercial activities in the community. Such was the buoyancy of the charcoal enterprises that cooperative members were able to earn average monthly payment of ETB 750/US$ 88 (Serkamo); with dividend distribution per member for one-year operation of ETB 1 257/US$ 150 (Sedhafagae) and ETB 1 500/US$ 176 (Serkamo). FARM-Africa's

community effort created job opportunities for daily labourers totalling more than 233 500 work/days per year (and earning estimated US$ 675 000 for local communities).

Table 7: Income distribution from charcoal (ETB)

Description	Serkamo	Sedhafagae	Gelaladura	Average
Cooperatives selling price to wholesalers/bag	37.95	36.01	35	36.32
Profit to the cooperative/bag	8.61	6.77	4.59	6.90
Wholesalers selling price/bag	50	50	50	50.00
Wholesalers gross margin/bag	12.05	13.99	15	13.68
Retailers price/bag	66	66	66	66
Retailers gross margin/bag	16	16	16	16

Source: FARM-Africa (2006). Note: currency conversion US$1 = ETB8.5.

Socio-economic benefits in the community were also enjoyed outside the local cooperative society. Everyone gained access to open lands, and roads and pathways were once again available for movement on foot and on bicycle. Money earned by those directly involved was re-invested into the community for purchase of normal services, labour and goods typically available; a measure of wealth always arises when money circulates within a community. Issues of copying also arose; with neighbouring communities exploring the models demonstrated, requesting technical assistance from FARM-Africa advisors and by simply comparing themselves with their neighbours; others cleared land of *Prosopis*, opened the land to new cultivation/crops and sold and/or converted the wood obtained into charcoal.[4] Some additional findings for the socio-economic changes that resulted from the FARM-Africa pro-*Prosopis* investment are described in the annex attached to the paper.

One direct benefit that had not been considered earlier was the reduction of illegal tree cutting for charcoal production that resulted. This provided a welcome remise for local cover as people shifted to *Prosopis* as feedstock. More legal charcoal resulted in more openness of production, and higher taxes earned by local governments. There was no need for people to work illegally. More winners than losers resulted for production of *Prosopis* charcoal.[5]

The other key result of FARM-Africa intervention schemes was the success of seedpod crushing for livestock feed – given the high value and palatability of seedpods and the willingness with which livestock will eat them (See Table 4). Here it was the producers were shown how to prepare a balance feed and one, moreover, which would limit the danger of a diet exclusively based on seedpods. (See Figure 14). Livestock feed production became a lucrative source of income for the cooperative societies.

[4] Community reaction to *Prosopis* management. With more than five years experience of *Prosopis* management within the ANRS, FARM-Africa has developed a considerable portfolio of survey information; much of it based on practical feedback from the implementation of planning, investment and management of village/district enterprises linked to *Prosopis* management. Findings are explored further – but briefly - within an annex to this paper.

[5] Charcoal production. Local governments taxed charcoal production at the rate of ETB 0.4/bag (i.e. about US$ 0.05/bag). Charcoal production was not all successes, however, with failure to encourage local producers to adopt technologies/equipment that produced more charcoal per charge of timber. Issues arose with units of production when the equipment introduced could only accommodate small charges at a time. Producers were less interested in efficiency of conversion where large quantities of raw timber were available (and preferred to go for bulk production whatever the levels of waste that resulted).

Collect and crush seedpods and the plant can no longer invade new lands by passing through the gut of the animal; the seeds have been killed before ingestion. Prevent invasion of new lands and the community can focus upon eradication of existing lands. Cleared and cultivated areas were reclaimed by the FARM-Africa programmes and provided immediate benefits to local people. Indigenous trees, shrubs and grasses emerged immediately after *Prosopis* had been removed. (See Figure 15.) Indigenous trees that had previously been choked for resources were effectively rescued.[6]

A number of limitations were noted including conflicts on boundaries and land tenure issues; misuse of pass permits; a focus on income and not on *Prosopis* control; many of the cooperatives established were weak administratively and provided few real services; lack of proper bag or identification system for *Prosopis* charcoal; approval for investors to engage in charcoal production including endogenous trees; lack of coordination and information sharing; indiscriminate banning of cooperatives; and buying charcoal outside working areas thus threatened endogenous trees.

5.4 Lessons learned

There is much that can be done in local communities to raise issues and to promote control, management and eradiation of *Prosopis*; but there are also risks and contradictions with choice of options. Ultimately, decisions have to be taken with the agreement of the local community; and on the basis of the wider techno-economic issues that may apply to district and/or regional planning. Herein, is value for those who may be privy to senior decision-makers. The potential of the one argument or demand may have to be tempered or balanced with the risks of the other; and local people may not be sufficiently well informed to understand the wider picture.

Figure 15: Acacia tortilis. Seedlings re-growing after clearing land of Prosopis

Prosopis may spread further into uncontaminated farmlands and pasturelands where products utilization is promoted within communities who have neither understanding of risk nor the resources to provide the management required of stands that are contained and isolated from the surrounding country. Issues of quarantine may need to be implemented, that neither seeds

[6] Land clearance. Notwithstanding the quality of the first clearing undertaken with the support and supervision of FARM-Africa, the local community in this case was slow to follow-up and take care to remove remaining stumps and rootstock and, as a consequence, reclaimed pastureland was re-invaded during the next few months.

nor planting materials can escape existing stands/areas. By promoting utilization within the community/area, others at a distance who will not benefit directly may be put at risk. There is economic benefit if planning and regulation are carefully devised and implemented. Here it is that local governments have a role with ensuring that communities are aware of the risks/opportunities and direct/participate within the policies and guidelines required of management. Some of these will be legal requirements. It is not sufficient to motivated and exploit new products and markets, but to ensure that the natural resource base of the community/area is sufficiently protected for everyone. The implications of this are considered further in the annex attached to the paper.

If conditions of this kind cannot be met within the local community then *Prosopis* production should not be encouraged – but the plant eradicated. Eradication brings severe challenge and the reality of low-production systems is one where it may *never* be possible to clear land completely once invaded. People will need to become part of community/government led programmes that will continue to eradicate, with opportunistic exploitation of the materials removed as a best-choice second level option.

References cited

FARM-Africa. 2006. Survey of communities at risk from *Prosopis* invasion in the Afar National Regional State and impact of development. Internal report. FARM-Africa, Addis Ababa, Ethiopia. (Unpublished).

Annexes to paper: Invasion and experiences ANR State/ Dubale Admasu

Annex A: Evaluation of Community response to *Prosopis* Eradication and Use

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A1. Summary

The community survey undertaken by FARM-Africa in 2006 showed, as expected, mixed responses to *Prosopis* invasion and utilization with generally favourable opinions where more goods, materials and products were available for specific purposes – most of which were linked to gender responsibilities in households. Women, in general, were more likely to be in favour of *Prosopis* exploitation (given the value of *Prosopis* products to their traditional activities). Apart from charcoal producers, menfolk were less enthusiastic for *Prosopis* exploitation. Opinion was divided evenly for the contribution of charcoal making to the spread or reduction of *Prosopis*.

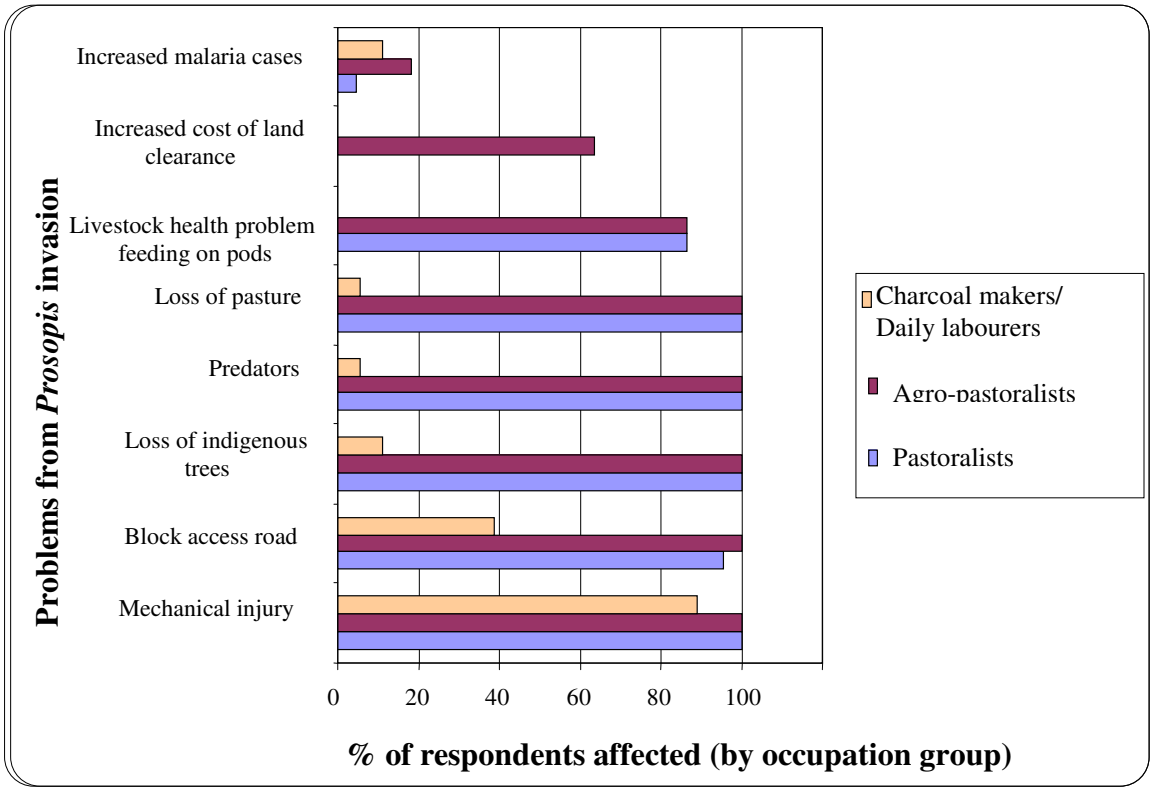
A1.1 Introduction

FARM-Africa undertook a survey of communities within the valley of the River Awash during 2005-2006 (FARM-Africa, 2006). The survey helped to determine the impact of *Prosopis* invasion upon what had been traditional livelihoods (i.e. livestock grazing, cropping, etc.) the changes that had taken place and how these were perceived by local people. A brief review of findings is of value to the paper given the differences that arose between those in the community who were directly affected (e.g. with loss of livelihoods) the relevance of gender within the different role models that are typical of households and/or communities and, importantly, for new opportunities presented to people with exploitation of *Prosopis* and derivative products. Changes and findings are illustrated in Tables A1.1-A1.4 and briefly described below.

A1.2 Impact on residents

Table A1.1 provides a matrix of eight impact/effects upon people within three categories of occupation, viz. two traditionalist producers (i.e. of 1. Livestock, and 2. Crops/livestock) and one off-farm service/producer (i.e. charcoal maker). Direct loss of grazing and/or lands have adversely affected traditional activities but, with the abundance of additional cover available for exploitation, *Prosopis* invasion has had direct benefit for charcoal (and fuelwood) producers. The entire community has been adversely affected by loss of infrastructure and lack of access and by secondary effects such as injury and ill health (of which additional malarial cases have been a relatively small part). Not unexpected, land clearance issues predominate with crop producers – keeping land open for cultivation. Charcoal makers have gained additional biomass and, typically, have only been disadvantaged with issues of access and injury. Summarizing, it follows that communities dependent upon crop and livestock production stand to lose by invasion; those producing charcoal/fuelwood normally gain.

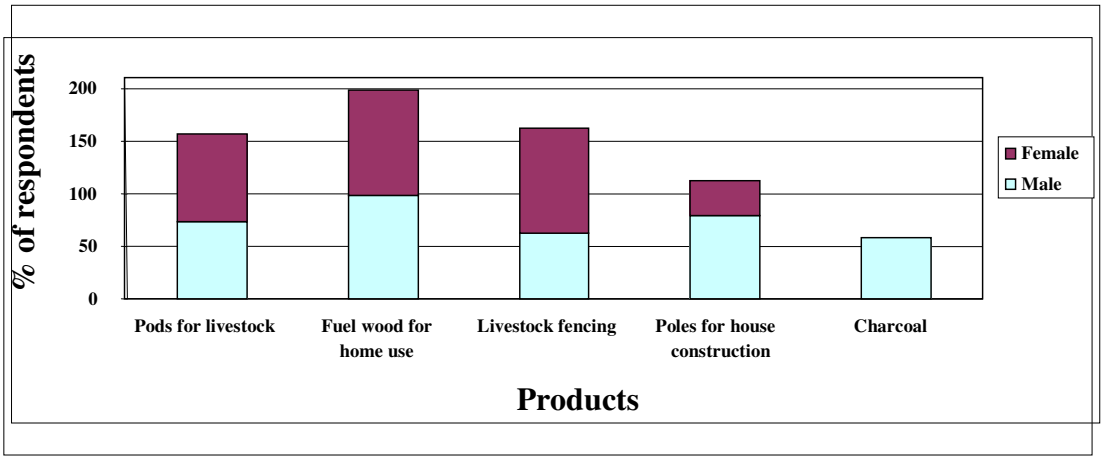
Table A1 1: Proportion of residents affected by the different problems caused by Prosopis



A1.3 Prosopis and gender

The information in Table A1.2 follows from Table A1.1 and provides an impact assessment of *Prosopis* on gender differences within the community; these link directly to shared responsibilities in the household – comparing *'women's work'* and *'men's work'*. With much of livestock care, feed and management vested in the women and children in the community, the provision of feed and fencing has dominated with women more affected from *Prosopis* invasion. Clearly this will be both positive (for more feed and posts available) and negative (for issues of land access, injuries, etc.). Menfolk in the community have gained more from increased quantities of timber available for both house construction and charcoal making.

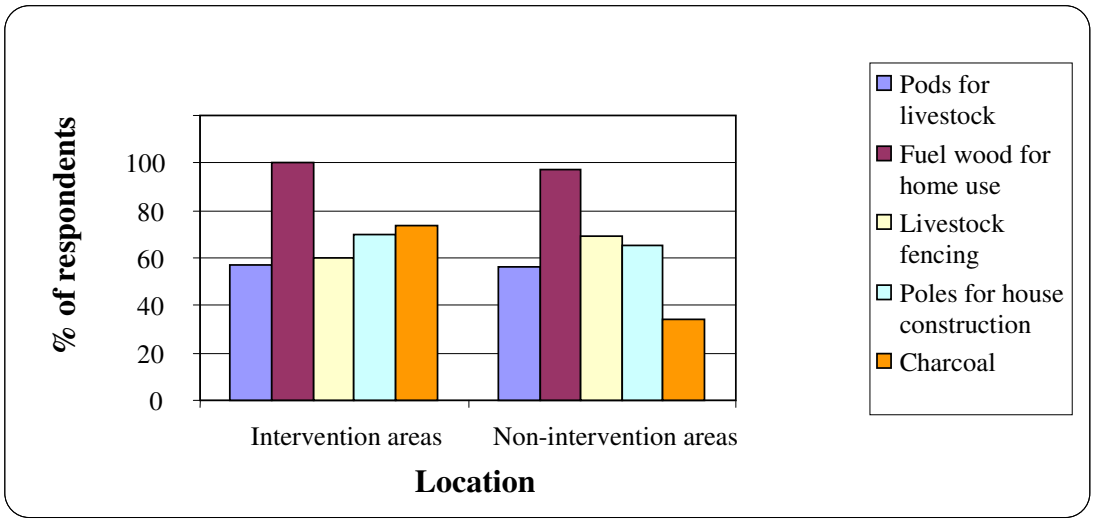
Table A1. 2: Prosopis uses and gender issues



A1.4 Increasing trends of Prosopis use

There are similarities between communities in areas of intervention (in support of *Prosopis* intervention) and those in non-intervention areas (as shown in Table A1.3). Here again, there are direct links between issues of gender and the value of *Prosopis* products that come within the different household duties of men and women (as described in Table A1.2). Differences are strictly limited where feed for livestock, timber for construction and fuelwood are compared, but markedly different where timber is converted to charcoal. The advantages for charcoal makers in the intervention areas are greater (given the emphasis upon wood harvested and then converted to charcoal). Equally significant, but not shown in Table A1.3, are benefits to natural cover (with greater protection available) and the reduction in illegal charcoal trading. Greater production of legal charcoal results in higher taxation earnings for local government.

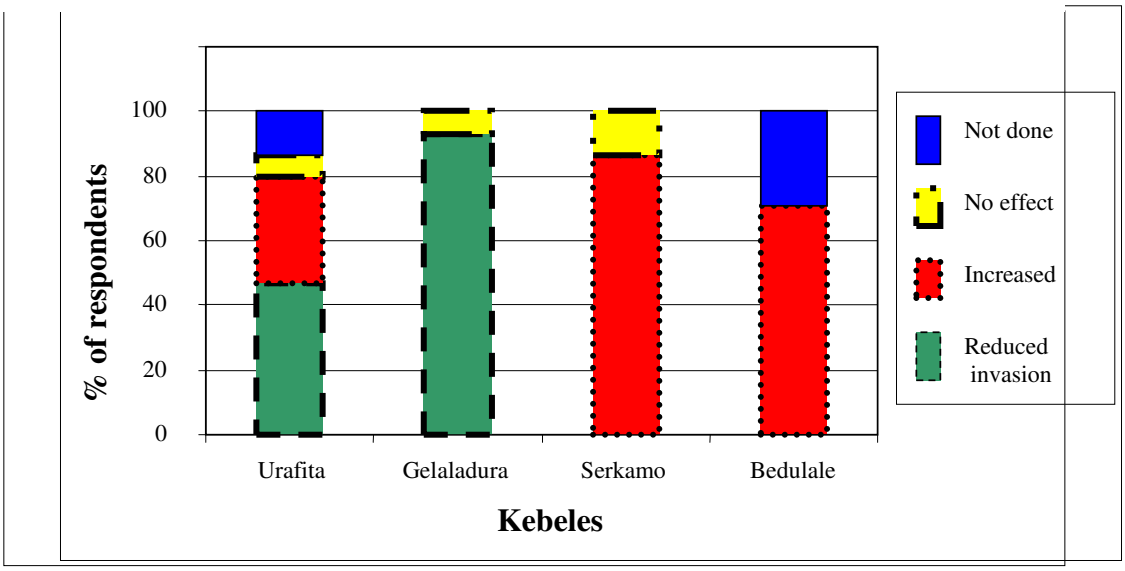
Table A1 3: Proportion of respondents agree on increasing trends of Prosopis use



A1.5 Charcoal making and reduced Prosopis invasion

Opinions can sometimes be of limited value – and are always subjective – but the general consensus of opinion from charcoal makers and those who monitored them was that charcoal making had mixed impact on *Prosopis* invasion in the areas in which FARM-Africa was working. Table A1.4 provides a comparison of four village communities from a survey of opinions of the people involved. Notwithstanding differences in the capabilities of people, the extent of invasion and the products harvested (i.e. seedpods, fuelwood, timber and charcoal) two villages showed increased invasion and two showed the direct opposite. Note the equally mixed reaction in Urafita Village where respondents were divided equally between those who assessed *increased* invasion and those who assessed *reduced* invasion. Minority views prevailed for no 'change in impact' across the four villages.

Table A1 4: Opinion of respondents on the contribution of charcoal production to reduce Prosopis invasion



Annex A2. State initiatives for *Prosopis* management in ANR State

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A2. Summary

In an effort to regulate and guide the control, management and/or eradiation of *Prosopis* on agricultural lands and to promote the use of *Prosopis* products within the state, the ANRS Government issued a special regulation in January 2007 comprising six separate but inter-related sections. The regulation helped with understanding the strategic approach required of land management that recommended practices were adopted and followed (for example, that land would be used effectively once cleared and would not be re-invaded). It further identified the people and community groups responsible for implementation and management of the regulation – based on village and district committees and the technical advice of the state and district PARD offices.

Procedures for encouraging the licit production of a range of products were established and also procedures for discouraging illegal activities that would be counter-productive to market development. District and village committees provide management jurisdiction over activities within their administrative areas, with market exploitation dependent upon the technical expertise of PARD and unions (i.e. groups of cooperative societies and others responsible for land clearance, and production and marketing of goods).

A2.1 Introduction

In an attempt to limit the negative impact of *Prosopis* invasion and to maximize the benefits of *Prosopis* exploitation, the PARD Bureau of the ANRS Government issued a key regulation in January 2007. The regulation provided general strategies for prevention and control of *Prosopis* from farmlands, grazing lands and homesteads, and promoted opportunities for production, marketing and income from sale of *Prosopis* goods. Importantly, the regulation provided guidelines for those responsible within local, regional and federal governments – describing the institutions, ministries and councils responsible and their respective duties. A brief description of the regulation follows.

A2.2 Regulation

The regulation comprises six sections.

Section 1. Strategies. This section covers general and major strategies for prevention and control of *Prosopis* invasion. These are strategies that have been closely followed in the FARM-Africa programme, viz:

- uprooting mass seedlings, cuttings and roots; digging out trees/roots to minimum150mm below ground level; and crushing seedpods;
- feeding mixtures to livestock (i.e. seedpods and roughage);
- use of timber for different products; controlled charcoal production with due care for fire control to reduce further land degradation;
- use of biological control methods based on sound RandD, the planning and release of vectors, and monitoring and evaluation of control;

- community awareness raising that people understand the risks and opportunities available; that people follow the law and treat the plant with respect for its resilience and danger including quarantine and control of livestock movement as required.

Section 2. Responsibilities. The section places responsibility on local people to adopt recommended practices. There is need to follow established preventive/control methods to eradicate *Prosopis* from cultivable areas by cutting the trees, removing the roots and using the wood for different purposes. Greater onus is placed on landowners who regularly use the same land – these people are responsible for eradicating existing stands and preventing seed recharge. Growers using communal areas around farmland such as canals, access roads, village compounds and similar have the same responsibilities for these areas.

Management of control will be vested in the community with committees established at village (kebelle) and district (woreda) levels, and led by traditional leaders with the advice and participation of government experts. Committees are required to prepare and implement plans for invaded areas, and to guide local eradication/management practices on the basis of these agreed plans. Clan leaders and councils are expected to mobilize the community and facilitate the work required. Prevention and control thus becomes a community responsibility - from local leadership to land user to local government.

Section 3. Licensed Products. Section three considers licensed products of *Prosopis* - production and marketing. Those responsible are identified and their responsibilities described. Licensing becomes the domain of the different committees established. For the district council this is expected to be the council head (chairperson), PARD forestry expert (secretary), and committee members comprising the cooperative desk head, district advisor and the security office head. Others may include local NGO representatives and private investors - and others as required. For the village committee similar arrangements apply, viz. village chair (chairperson), government development agent (secretary) and members comprising clan leaders, women's representative, forest guards, religious leaders and others as required.

A number of protocols described under section 3 have to be followed when land is cleared. These include:

- land selected for clearing has to be assessed for its agricultural potential; this is undertaken with the assistance of district government experts;
- a plan is developed that will determine the programme of activities to be followed. Implementation responsibilities rest with the village committee. The plan determines the land to be cleared and the uses for the wood that is harvested;
- the local government selects and authorizes cooperative societies, private companies and others to clear land and to use the wood harvested.

Authorization to clear land and to use the wood harvested carries responsibilities. The village committee is responsible for following progress with land clearing. This includes:

- checking that the groups/people clearing and harvesting wood are the people authorized to do so, and are following recommended practices – removing *Prosopis* stumps to the correct depth, removing seedlings and vines, leaving indigenous trees/shrubs in place, etc.;

- checking that land has been cleared and providing permission for wood to be transported off site; with reference to quantity, type, use, packaging, etc. and providing any documents/serial numbers that may apply (this helps prevent the movement of illegal goods – mainly charcoal produced from native timber).

Further authorization is required when goods are transported out of district. This includes:

- issuing the appropriate pass showing type of produce, date issued, places produced, serial numbers, etc.;
- authorizing documentation should also carry the ANRS logo and contain a description of the producer's name(s) (e.g. cooperative society or other), contents of goods, source, dates of travel, route/destination and information to describe the truck and driver.

Section 4. Markets. Section four deals with the promotion of markets. It stipulates that cooperative societies producing *Prosopis* goods should work within unions (of cooperative societies) that maximum benefit will accrue to producers. The unions are responsible for the organization of markets - that supply is controlled such that market prices remain as stable as may be practical. As appropriate, studies should be undertaken to determine markets including export markets. Producers should be kept informed of market opportunities.

For specialized *Prosopis* products the unions will be responsible for supplying the appropriate packaging materials that will enhance market appeal. Labelling may be required and should contain the appropriate names, messages, serial numbers, weights, etc. Where required for high value niche markets, unions will be responsible for acquiring and using the proper equipment for production, packaging, shipping, etc.

Section 5. Illegalities. Section five is concerned with illegal activities and penalties that may apply. These include:

- unauthorized clearance of land. Clearing land and using timber harvested without due authority – with the licenses and passes required (i.e. unauthorized clearance);
- management and control. Failure on the part of the designated authority (i.e. the cooperative society, NGO or private company) to manage the work/activities required/agreed including poor time management;
- selection of land. Failure to clear the land selected for development and planned for re-use for agricultural production;
- land clearing. Failure to cut trees 150 mm below ground level and failure to remove branches, immature trees and seedlings while clearing the mature trees (and thus leaving opportunity for re-invasion);
- use of land post-clearing. Failure to use the land after clearing for designated purposes (and thereby leaving it open for re-invasion);
- mis-representation of timber harvested. Trading *Prosopis* products from outside the designated lands, mixing harvested timber with bought-in timber, mixing *Prosopis* timber/products with similar products from indigenous trees (e.g. cut illegally on site or outside);
- additional control measures. Failure to follow other preventative measures as may be required, for example for biological control, seedpod crushing for livestock feed, etc.

Section 6. Groups Responsible. Section six identifies the government and community groups involved and describes their respective responsibilities. This includes:

- Regional/State PARD Bureau. Facilitates endorsement of the regulation; and provides revision when necessary; and provides guidelines for implementation. Further, prints and distributes legal documents including permits and licenses (and follows proper use). Bureau provides technical support to district councils for *Prosopis* invasion, controls, etc. of work, and monitors activities of NGOs, government offices, etc. Encourages shared RandD, new technologies, extension, etc. for new innovation, novel methods for control, etc.;
- District Council. Responsible for organizing *Prosopis 'prevention and controlling (PandC)'* committees in districts and villages. Leads PandC district committee and assists village committees with land use planning/development for invaded areas and lands at risk. Monitors proper implementation of PandC activities, and ensures proper administration of law and penalties for illegal activities;
- District Council PARD Office. Helps with the establishment of village *Prosopis* PandC committees. Leads land use planning required of invaded areas and areas at risk, and provides a direct link to the regional PARD office for licensing and recommendations required for cooperative societies, NGOs and/or private companies. Additional functions include monitoring performance of licensees (that they keep to agreements, follow recommended practices, etc.). Issues permits for processing and/or movement of products following approval of village and district committees. Reports to the regional PARD office monthly and quarterly;
- Village Council. Responsible for local work activities. Prepares land use plans for invaded lands and lands at risk with technical assistance of district council and experts. Leads village PandC committee and ensures compliance with agreed plans and recommended practices. Provides support for local people, cooperative societies, etc. with request to PARD office for licensing; and provides follow-up reporting on the implementation of land cleared and follow-up effort (as agreed in the original plan). Monitors performance of licensees to ensure compliance with the law. Reports directly to the district PARD office and district committee.

6. Design and Manufacture of Down-Draft Gasifier Plant for use Prosopis Juliflora as Feedstock: Analysis and Evaluation of Performance

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Summary

An RandD programme for exploring the energy potential of *Prosopis* by gasification was undertaken by the EREDPC during a two-year period 2005-2006. A down-draft gasifier was designed and constructed to match local technologies, and tested for gas production from *Prosopis* fuelwood.

The gasification system functioned well and within the limitations of design. *Prosopis* wood produced of the order more than 2.20 Nm3/kg with lower heating value of more than 5 500 kJ/Nm3 for an air/biomass ratio of the order 3.0/Nm3/kg. Testing showed gas produced had energy equivalent of 2.7 kWh/kg of air-dry wood at more than 65 percent conversion efficiency. This was of the order 10 percent below theoretical values, with differences attributable to experimental error. Average energy output for a fully-operational gasifier was more than 133 MJ/h, which was equivalent to a 37 kW diesel engine operating in dual fuel mode.

The gasification of *Prosopis* biomass has considerable economic/energy potential for Ethiopia; and for the investment partnerships available from those countries with similar invasive experience of *Prosopis* and exploitation of energy potential with gasification technologies. India has been highlighted as a logical partner for both the RandD and commercial phases. This would comprise the next period of national investment in cooperation with the Government of Ethiopia and the international agencies.

6.1 Introduction

Shortages of fuelwood prompted the introduction of *Prosopis Juliflora* into the most arid parts of the world. This included Ethiopia and *Prosopis Juliflora* was planted in the area of the Awash Basin of the Afar Region. In a study undertaken around Melakaworer, the spread and impact of this plant has been devastating (Shiferaw, 2002). Invasion, however, can be seen as a valuable opportunity for the production of renewable energy sources through gasification. As little as 1-1.25 kg of solid wood (at 20 percent moisture content – MC) will produce 1 kWh of energy. Herein is a logical route for exploitation of the extensive resources of fuelwood available – convert it into much needed energy supply. It is important, however, to design and manufacture the appropriate equipment required. In this case - *and the subject of the paper/presentation* - this has been a down-draft gasifier for the production of producer gas. Designed for use with *Prosopis* and other fuels grown in Afar Region, the equipment was designed for 40-50 kWh output. The pilot plant was built and RandD activities undertaken on site in Amibara District.

6.2 *Prosopis* as a source of energy

Fuelwood from *Prosopis* represents an excellent source of energy, which has heat value of about 20 920 KJ/kg. *Prosopis* can also be used to make high quality charcoal. Preliminary surveys highlighted the higher efficiency of energy conversion that comes from controlled gas production; converting wood into gas for the production of electrical power. Gasification is a thermal process converting dry biomass feedstock into a mixture of gases that can be burnt in an internal combustion engine and/or gas turbine plant (thus conversion to heat and/or mechanical energy and/or electrical energy is relative easy - a well-developed technology).

6.3 Gasifier design

Preliminary investigations helped to establish the most suitable design of gasifier plant for the production of synagas from *Prosopis*. This eventually comprised a final design RandD plant based on a mix of conventional and locally available manufacturing technologies. Testing and evaluation of the plant provided the basis for establishing the performance of the gasifier and energy produced from a range of biomass feedstock. A programme of five test runs was made.

According to typical gasification practices, the considerable potential of biomass can be '*modernized'* – shifting from burning in an open fire to controlled conversion in a gasifier and producing a range of gases and/or liquids and/or electricity before distribution and utilization. This contrasts to more traditional practices of direct burning and/or carbonising to produce charcoal (which are typical of Ethiopian practices). Gasification methods, equipment and technologies are widely used in power industries worldwide as a means of providing more efficient (and thus more cost-effective) means of conversion. Higher efficiency comes from increased fuel density and decrease in emissions and loss of heat that represent loss of potential. That said, technologies and equipment for small-scale gasification energy conversion in the low-income countries are rare. The EREDPC RandD programme set out to demonstrate the viability of locally designed and manufactured systems, and its suitability for practical use.

Gasification has been promoted as the most efficient method of converting *Prosopis juliflora* wood energy to electrical energy. Approximately 1 kg of *Prosopis* biomass generates 2.5 m^3 of gas, which can supply 12 552 KJ of thermal energy. Gasification replaces direct combustion and thus complies with current national efforts to promote *'cleaner energy production'* with corresponding reduction of emissions to the atmosphere. With some gasifier feedstocks, for example, emissions can be virtually zero.

Choice of design (and design parameters) influences the gas generation process, and links to choice(s) of the different fuels that will be used and, importantly, to energy output. Choice of design required priority choices to be made to meet specifications (as shown in Figures 16 and 17). Choices for design of equipment manufactured for the EREDPC programme included:

- grate. Selection of stationary or mobile down-draft type with revolving grate assembly;
- output. Required within the range 40-50 kWh;
- fuel/fuel source *Prosopis juriflora* supplied in small wooden blocks of the order 200 cm^3 (i.e. about fist-size);

- store/hopper capacity. Sufficient to provide for continuous operation over a period of four hours without refilling;
- store/hopper form. With sloping sides that minimize risks of bridging (and thus disrupted feed to the gasifier);
- manufacture. All components/parts capable of being manufactured locally and from locally available materials;
- plant layout. Providing sufficient space such that wood could easily be reduced to feed-size blocks and stacked for drying to meet MC specifications prior to firing;
- safety. Plant layout, equipment manufacture, materials handling and management of plant such that safety and security of people remained a top priority.

Figure 16 shows the gasifier 99 in cross-section with key identifiers as gasifier 12 and gas scrubber and cooling apparatus 14. The gasifier 99 is vertically-oriented and cylindrical in shape. It contains a hopper 2 and drying chamber 3, which represents the first chamber of the gasifier reactor. An intermediate chamber 4 comprising the fire zone is positioned beneath with the second gasification/lower chamber 5 further down the cylinder. An end cap 18 forms the bottom most portion of the gasifier and provides a collection chamber for ash waste. It also seals the bottom of the gasifier from the outside environment. The gasifier is supported on legs.

Figure 16: Down-draft gasifier. RandD unit shown after manufacture and prior to installation in the gasifier plant. Note the three-part unit, widely-spaced legs for stability and ladder used by the operator to charge the hopper. Commercial unit would be modified to provide for easier charging.

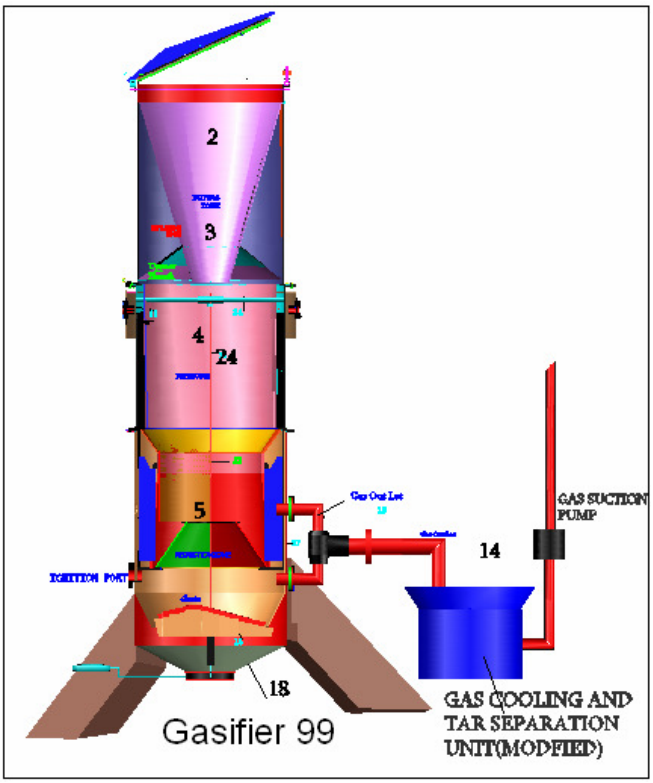

Figure 17: Diagram down-draft gasifier. Showing cross-section and internal components.

6.4 Methods of exploratory testing

Some basic knowledge is required of the theoretical background of the EREDPC RandD work to boost understanding of the information collated and the analysis made for the performance of the gasifier. This helps provide for clarity and, for the layman, helps with choice of materials and methods into the next phase of development (i.e. practical and/or commercial use). Findings were based on five test runs of the gasification plant.

Temperature monitoring remained an important part of the testing process. A number of thermocouples were used to provide continuous measurement of the temperature of the gases as they exhausted the gasifier. The outer temperature of the gasifier was also monitored. Heat energy input is the amount of heat energy available in the fuel. This can be found from the simply relationship:

$$QF = WFU \times HVF$$

Where:

QF is the heat energy available in the fuel (measured in kCal)
WFU is the weight of fuel used in the gasifier (kg)
HVF is the heating value of fuel (kCal/kg).

For gas analysis cool and dry gas was analyzed using Test 350 for carbon monoxide, carbon dioxide, hydrogen, oxygen and gas compositions. To determine the gas flow rate (GFR) a calibrated orifice meter was connected into the gas line, and the amount of producer gas obtained was recorded.

A gas chromatographer was used to analyse the heating value (HV) of the producer gas. After firing, a small quantity (about 1 kg) of *Prosopis* wood was added to the reactor. When the fire

reached the top layer of the fuelwood in the reactor, the weighed amount of *Prosopis* wood required for the run was added. This was taken as the starting time for the run. Towards the end of the run when no more combustible gas was produced the run was concluded. The difference in time between start and finish was taken as the net operating time.

The equivalence ratio (ER) of the text run can be defined as follows:

$$\frac{\text{Actual air used}}{\text{Amount of stoichiometric air}}$$

The flow rate of the air was measured using a rotameter. The stoichiometric air requirement was estimated as 20-30 percent M.C. For dry *Prosopis* this was 3.3468 m^3/kg. Thus the ER for each run was the amount of air used in a run divided by the amount of stoichiometric air in the run. The specific gasification rate (SGR) was calculated using the weight of dry wood gasified for each run, the net operating period and the cross-sectional area of the reactor. By way of contrast, the specific gas production rate (SGPR) is the rate of producer gas generation at standard temperature and pressure (STP) per unit cross-sectional area of the gasifier.

Gasification efficiency is the percentage energy of wood converted into cold producer gas (free from tar), and can be found from the following equation:

$$\eta = \left[\frac{Amount\ of\ gas\ produced\ x\ LCV\ of\ gas}{Quantity\ of\ Husk\ used\ x\ LCV\ of\ husk} \right] x\ 100$$

Power Output is the amount of energy released by the gasifier and can be found from the equation:

$$Po = FCR \times HVF \times TE$$

Where:

Po is the power output (measured in kW)
FCR is the fuel consumption rate (kg/h)
HVF is the heating value of fuel (kCal/kg)
TE is thermal efficiency.

Additional information assessed during the tests included frequency of attendance, smoke emission, portability, maintenance, cleaning and presence of fly ash and other residues.

6.5 Test results

Test runs were undertaken after a period of familiarization with the plant and its operating characteristics, to enable the monitoring team to gain some practical experience of the new technologies and instrumentation. This was followed by test runs to investigate the energy potential of *Prosopis* by gasification. Further, the extent of the variation in parameters during the learning phase helped determine the accuracy of testing and test results found. Measurements taken for gas flow rate, temperature, etc. provided the basis for calculating the air fuel ratio, equivalence ratio, specific gasification rate, specific gas production rate, lower heating value of producer gas, the air/biomass ratio on gas composition and energy transformation and gasification efficiency for each run was tested and computed. These are shown in Table 8.

Table 8: Test parameters and results

Item	Run #1	Run #2	Run #3	Run #4	Run #5
Temperature (degC)					
Reactor outer body temperature (degC)	43.3	53.4	39.6	47.3	39.8
Gas outlet flame temp. (degC)	860	870	870	880	890
Air/wood (Nm3/kg)	2.325	2.07	3.557	3.793	3.155
Gas produced from wood (Nm3/kg)	5.989	7.651	7.966	7.768	7.788
Energy input LHV (kCal/kg)	3,500	3,500	3,500	3,500	3,500
Gas composition (%)					
H2	9.27	12.22	12.81	8.23	9.73
CO	14.3	15.12	17.7	15.08	14.52
CH4					
CO2	14.28	14.49	12.29	16.57	13.47
Total combustible fuel gases (%)	23.57	27.34	30.51	23.31	24.25
Total combustible fuel gases (Nm3/kg)	1.67	2.15	2.97	2.08	2.19
Heating value of gas produced (kJ/kg)	6,762	10,384.5	11,592	8,694	98,694
Efficiency of gasification (%)	62.9	64.8	68.2	65.5	65.1
Gas flow rate	9.53	10.87	12.87	11.24	11.55
ER	0.33	0.35	0.38	0.4	0.44
SGR (kg h-1m-2)	158.7	171.77	187.35	173.26	174.78
SGPR (m3 h-1m-2)	62.67	72.46	85.7	74.95	75.12
Heating value of gas produced (kJ/Nm3)	5,978.4	6,049.4	5,211.5	4,908.4	5,472.3
Total operating time (h)	6.5	5.4	4.35	5.2	5.3

Prosopis wood was used as feedstock with MC within the range 16.3-19.7 percent. Trials found that with increasing gas flow in a single run, the air fuel ratio, equivalence ratio and specific gasification rate increased linearly for all tests. Concerning the performance of the gasifier, efficiency increased with increase in the specific gasification rate (SGR) and then started decreasing. An optimum SGR was found at 173.14 kg/hr-1 m-2. This resulted in average efficiency of 65.3 percent and, importantly, provided an indication of the maximum output of the gasification process (as shown in Chart 1).

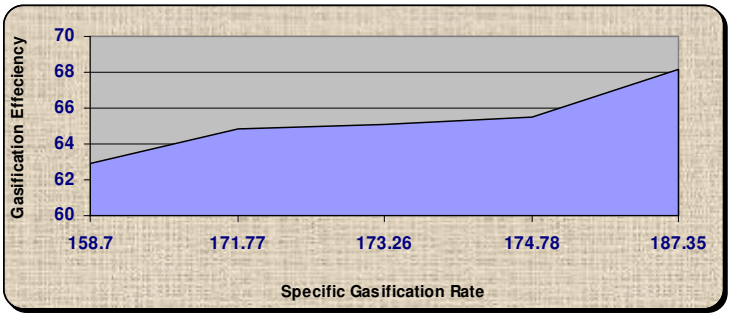

Chart 1: Gasification efficiency vs SGR for the five test runs

As expected, the specific gas production rate (SGPR) increased linearly with increasing specific gasification rate (SGR). Like the SGR, the optimum value of SGPR that corresponds to maximum gasification efficiency falls within the narrow range 75.12 to 79.4 m^3 h-1m-2. Average value was 74.18 m^3 hr-1m-2 and may be taken as an optimum efficiency for the down-draft gasifier with *Prosopis* feedstock. SGRP and SGR are compared in Chart 2. Maximum efficiency of the gasifier corresponds to an equivalence ratio (ER) 0.38, which can then be used to determine the amount of air needed for effective gasification.

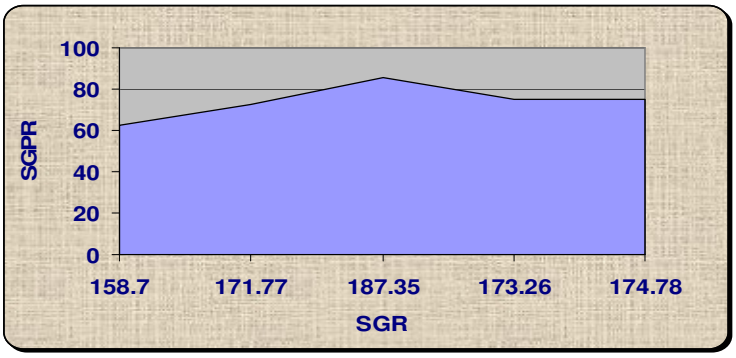

Chart 2: Specific gas production rate (SGPR) vs specific gasification rate (SGR)

In terms of fuel gas composition, yield and low heating value (LHV) given fuel gas composition at an air/biomass ratio of 2.325N m^3/kg, the total combustible fuel gas (H2+CO) composition was 30.47 percent. Fuel gas production was 2.97N m^3/kg. The variation of LHV of fuel gas produced is shown in Chart 3. As the air/biomass ratio increased, the corresponding heating value of the fuel gas decreased.

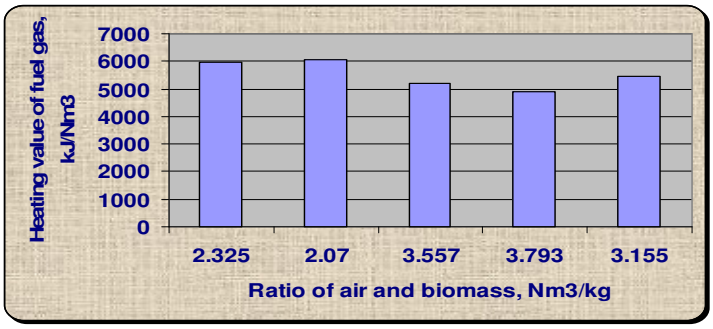

Chart 3: Variation of low heating value of fuel gas produced with air/biomass ratio

Total combustible composition and individual combustible composition in fuel gases reached a maximum at a lower air/biomass ratio - 2.5N m^3/kg for the current study. It seems that this air/biomass ratio represented a transformation point for production and consumption of combustible compositions within the fuel gases. After increasing the air input more fuel gases are produced as shown in Chart 4.

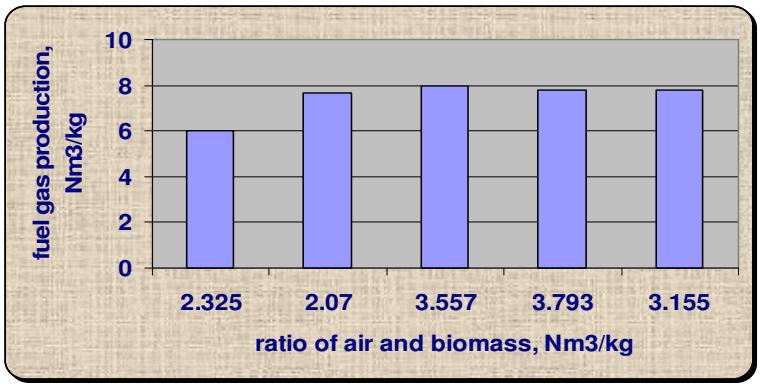

Chart 4: Variation of low heating value of fuel gases produced with air/biomass ratio

The air/biomass ratio increased, as expected, leading to increased efficiency of gasification. Average value of gasification efficiency was of the order 65 percent. Note, however, that 10 percent measurement error was estimated earlier from pre-test experimentation, and this may have led to an efficiency level that was generally lower than expected. Efficiency should have been more than 70 percent.

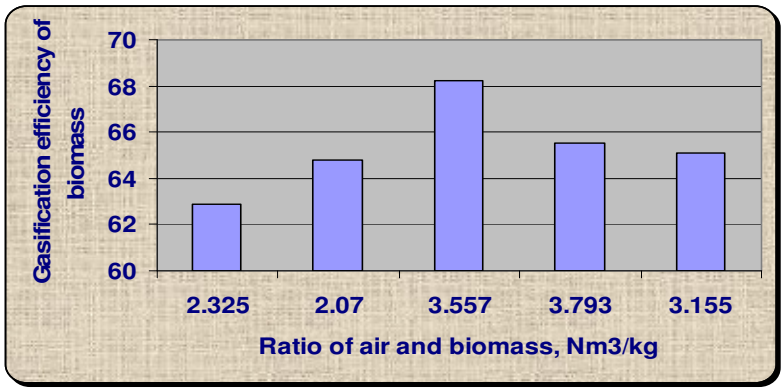

Chart 5: Variation of the gasification efficiency with air/biomass ratio

According to energy modelling provided by Messrs RET® Screen *(Renewable Energy Technology, 2007*) the medium heat value of *Prosopies* with 20 percent MC is 14,448 MJ/t when the biomass is fired. If this heating value is applied to a single-stage boiler rated at 300 kW and 75 percent efficiency, then the biomass energy delivered to the system will be 516 MWh at 78 percent peak heating load and 58 percent total heating energy demand.

The gasification system functioned well during the operational phase - five-test runs. Fuel gas production was firm - with gas production of fuelwood 2.21N m^3/kg and lower heating value (LHV) at 5,524 kJ/Nm^3 when the air/biomass ratio was maintained at 2.98N m^3/kg. Average quantity of combustible fuel gases of 2.21N m^3/kg is equivalent to 2.66 kWh/kg of air-dry wood at 65.3 percent conversion efficiency. The average energy output for a fully operational gasifier was calculated at 133.43 MJ/h, which corresponds to an energy requirement of 37kW diesel engine operating in dual fuel mode.

6.6 Conclusions and Recommendations

Current response to the invasion of *Prosopis* in the Afar Region has been to direct investment into eradication programmes. Efforts to eradicate *Prosopis* are overly expensive and likely to be ineffective long-term. *Prosopis* is an invidious propagator that cannot be eradicated by

small-scale or village-level interventions. It does, however, provide opportunities for large- or community-scale exploitation as a fuelwood – boosting the efficiency of energy capture by means of relatively low-cost gasification processes.

The gasification of *Prosopis* biomass has considerable economic/energy potential, and much can be learned from work elsewhere and the effort/investment made to exploit that potential. Ethiopia has much to gain, and a logical RandD and/or commercial partner would be India - a country that has much larger areas of land invaded by *Prosopis*. India has sufficient experience of the manufacture and use of gasifiers and with use of *Prosopis* as feedstock (and the management/utilization programmes that have been implemented for invaded lands). The plant may currently be a menace, but this need not be the case long-term. India has demonstrated the commercial potential for exploiting *Prosopis* energy by gasification.

Operational results from the gasification of *Prosopis* fuelwood have come within theoretical expectations; and the practicalities of the system and the processes involved have shown merit. The establishment of post-RandD installations are practical. Units could be established and run with a measure of technical backup/services. This represents the key findings and recommendation of the EREDPC programme. A next development stage is to encourage the use of these technologies in communities that may gain socio-economic value from investment. The challenge will be to source the partners and the investment funds with which to do so. Here it is that the Government of Ethiopia working in cooperation with the international agencies may be a logical starting point.

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7. Utilizing Prosopis for Charcoal Production in Ethiopia

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Summary

Charcoal production in Afar State remains traditional with charcoal makers exploiting native flora (and particularly *Acacia* spp.). Charcoal production is no longer legal given the extensive degradation of land cover. The Ethiopian Rural Energy Development and Promotion Center (EREDPC) undertook an RandD programme during the past five years in support of charcoal and briquette production in an effort to boost understanding of key issues of people skills, equipment, charcoal production technologies, charcoal properties and similar.

Findings have illustrated the extent of the inefficiencies of traditional practices and of opportunities that may apply with the introduction of new practices, technologies and equipment. With the demise of natural cover, charcoal production using wood from the invasive tree *Prosopis* has merit. This is feasible within land clearance/eradication programmes or within some form of continuity of wood harvesting. Much depends upon community mobilization and people taking charge/responsibility.

There are opportunities for follow-on investment with the wider introduction of equipment, information, skills and technologies promoted by the EREDPC RandD programme. This should come as the result of collectivization of charcoal makers into regional/area groups that can exploit incoming investment and markets that can be developed for high quality charcoal – to include the production of briquettes from fines, fragments, etc. from kilns and for small timber. *Prosopis* charcoal production will need to be legalized.

7.1 Introduction

In Ethiopia 90 percent of energy needs are met by utilizing biomass in the form of fuelwood and charcoal. For traditional charcoal kilns, the average conversion ratio is 10–15 percent. According to FAO (2007), Ethiopia has the second highest charcoal consumption in Africa at more than 400 000 t/y. In commercial terms this represents 10 million bags of charcoal sold annually at estimated value US$77 million and, alarmingly, estimated 3.3 m of wood consumed each year (from a country that has less than 2 percent forest cover).

Lump charcoal and charcoal briquettes can be produced from *Prosopis*. The plant has the potential to replace unreliable supplies of long-rotational wood from scarce natural land cover, which will help provide for increasing energy demand from the major urban centres such as Addis Ababa. Recognizing the many risks involved with energy supply and demand EREDPC implemented an RandD programme in 2003 to explore the potential of high quality charcoal and charcoal briquettes from *Prosopis* grown in the Afar Region (and mainly in Amibara and Gewane townships).

The main objectives of the EREDPC RandD programme remain:

- to study and test the feasibility of using *Prosopis* fuelwood as a substitute for charcoal in the home;
- to reduce pressure on supplies of wood from natural forests (which are traditionally used for charcoal production);
- to provide additional livelihoods and sources of income to rural communities where agricultural/grazing lands have been lost to *Prosopis*;
- to reduce and/or eradicate *Prosopis* from invaded areas.

Prosopis is generally thought to have been first introduced into Ethiopia during the 1970s. It was planted in the valley of the Awash River for agro-forestry and soil conservation purposes, and to provide a windbreak for crops. It has subsequently spread during the ensuring 25 years and now occupies an estimated 100 000 ha in the Afar Region. It predominates in the dry land areas of Afar, Dire Dawa, Jijiga and Arbaminch - on lands that have traditionally been used for grazing. *Prosopis* is exploited for fuelwood, charcoal, construction materials (for houses and fences) and for shade. Exploitation is piecemeal and based on the capabilities of local people and local expertise and, meantime, the country continues to exploit scarce resources of native timber and land cover (to the detriment of the environment). Large-scale and organized production of *Prosopis* charcoal has the potential to provide reliable supplies of charcoal long-term.

Ethiopian charcoal makers continue to use traditional earth mound techniques notwithstanding proven inefficiencies (and charcoal that is contaminated with soil) and, typically, use a charge of 5-8 trees/kiln to produce 20 bags of charcoal. Charcoal makers almost always sell their charcoal immediately and accept prices of the order ETB 20/sack (i.e. US$ 2.50/sack). The artisanal charcoal maker and labourers/family produce 150-200 sacks annually; and, it follows, earns of the order ETB 3 000-4 000 (US$ 375-500). Costs for equipment, materials, tools, etc have to be met and reduce earnings accordingly.

Members of the Afar Charcoal Making Association (CMA) face significant problems into the next period and not least because of out-dated and inefficient technologies, but because charcoal making has become illegal. In an effort to protect remaining land cover (in what is a highly fragile environment), the state administration has banned the production of charcoal from native trees. Effort is being made by the CMA and others to lift the ban for charcoal made from *Prosopis* fuelwood (although herein are issues of proof and illegalities that may continue with charcoal makers continuing to exploit native trees). A tax will apply for every bag of charcoal made and transported.

7.2 *Prosopis* charcoal production

Incorporating the many and sometimes conflicting issues involved within their RandD programme, the EREDPC set out to improve the efficiency of charcoal making and to do this by providing an improved approach to production, new equipment and, importantly, training for local artisans. Implicit and *de facto* the EREDPC programme set out to raise awareness of environmental sensitivity and the value of maintaining land cover with native flora. In so doing the EREDPC has explored traditional earth mound production and introduced and compared it to improved earth production (called '*Casamance*'), portable metal kilns, the TPI

metal kiln[7], mini-metal kiln (diameter 2.27 m^3) and the drum charring unit. A comparison of methods follows.

Traditional earth mound. Used throughout country (and elsewhere in Africa), the technique combines simplicity with low investment, and has potential for carbonizing large volumes of wood. Local people are familiar with the technologies and methods involved, many of which remain within the family where skills are passed on from generation to generation. Unfortunately, these technologies are inefficient and wasteful (and typically waste 85-90 percent of the fuel wood used; less than 15 percent of the original timber is converted into charcoal). Moreover, there is lack of uniformity within the pile and the charcoal produced in contaminated with soil and other materials that will not burn. There are also issues of management, with performance and quality of output depending mainly on the ability of the charcoal maker – for carbonising can take from a few days to a month to be completed.

Improved earth mound. The Casamance technique is simply an improved version of the earth mound kiln, much of which depends upon the way in which the fuelwood is stacked in readiness for carbonising and how airflow and heat is dissipated in the stack. Wood is stacked on a circular platform with holes at the base and a chimney is located central to the stack. This is made from three-oil drums (i.e. 200 litre drums) stacked one on top of the other with a forth oil drum welded at right angles to the stack. The complete unit is then covered with earth and leaf material, and the fuel/stack fired in normal manner.

TPI kiln. A typical TPI metal kiln is illustrated in Figure 18: TPI metal kiln. Charcoal makers finalizing the stacking of fuelwood inside the main drum. Note the compact nature of the unit. It is cylindrical in shape and, when ready for firing, is fitted with a conical top cover section (where the labourers are working in the photograph). The kiln has eight inlet-outlet channels positioned under the base of the kiln (which can be clearly seen in the photograph) and four chimneys. These can be moved between the eight channels to boost the efficiency of the internal carbonising processes.

Mini-metal kiln. The mini-metal kiln comprises three main parts: 1. Cylinder, 2. Conical hood and 3. Cap – a small cap that fits over the top cover. This kiln (as its name suggests) is relatively small (at 1.70m diameter and 0.90m high) and easy to move around. It has capacity of 1 200-1 400kg fuelwood with charcoal yield typically 350-450 kg (and thus efficiency 30-35 percent, i.e. double that of traditional technologies).

[7] TPI metal kiln. Developed and popularized originally by the TPI of the UK during the period of the 1970s. Provides operational, management and handling information including preparation of charge fuel, loading, firing, control of air draught, control of charring, unloading, filling sacks, etc. Describes operational use with light woods and/or fragmented materials (such as coconut shell). An essential read for all small-scale charcoal makers and those who advise them. Reference cited below.

Figure 18: TPI metal kiln. Charcoal makers finalizing the stacking of fuelwood inside the main drum. Note the compact nature of the unit.

Drum charring unit. This is the smallest of the exploratory units introduced by the EREDPC programme and based on an oil drum 570 mm diameter and 910 mm height, and with a chimney fitted in the top cover. Small quantities of charcoal can be converted and, importantly, small quantities of distillate tar can be collected. Clearly, the small size of the unit means that wood must be cut proportionally to size and compacted into the drum. Figure 19 shows the EREDPC RandD team at work.

7.3 Charcoal briquettes

Briquettes, as their name suggests, are small blocks of charcoal that are packed into a solid mass together with a binder that provides for stability when handling or charging a fire. Briquettes are a logical development where there are large quantities of small volume timber to carbonise or for use of the dust, fragments and broken charcoal that result from charcoal making in a traditional kiln. If these smaller fractions are not collected and briquetted they can quickly become lost to the producer.

Prosopis makes excellent charcoal. Apart from trees that have been trained to produce a single trunk, much of the fuelwood harvested from *Prosopis* stands is made up of vines and/or small branches. This does not always produce suitable charcoal pieces – and it is more suitable for briquetting. Production introduces additional manufacturing processes for which some equipment is required – to separate charcoal fines, fragments, etc. with sieves and handling, to pulverize/crush to meet the specification for fines, to mix together with binders and to compress (i.e. densify) the mass into the moulds from which the briquettes are formed.

Chart 6 provides some indication of the processes involved for conventional briquettes - as developed/explored by the EREDPC RandD programme[8].

Figure 19: Drum charring unit. Drum charged and with chimney in place. Note the small fireplace beneath the drum. Note too, the lack of tree cover in the area.

Briquette making is not typical of artisanal charcoal production in Afar State with the result that small charcoal pieces (i.e. undersize, fragmented, dust, etc.) are normally lost on site. Herein is scope for small-scale production within an association of charcoal makers that these factions are captured and converted into briquettes. Further, briquettes can be made from any appropriate woody agro-residue (such as cotton stalks or stalks from the mild narcotic shrub ghat) including materials that would not normally be carbonised.

Given the higher cost of production, briquettes sell for higher prices and typically to people within the urban community who may have greater wealth. Charcoal and charcoal briquettes typically sell into different sectors of the same energy markets (and much the same is also typical of briquettes produced from urban refuse).

[8] Flow charts briquette manufacture. Chart 6 illustrates basic principles of production and forms part of the main paper. Two other charts were originally provided for beehive briquettes and agglo-briquettes, but added little additional information. They have not been included in the Proceedings. These charts simply showed different nodes for specialized briquetting post-carbonization and post-mixing with binders.

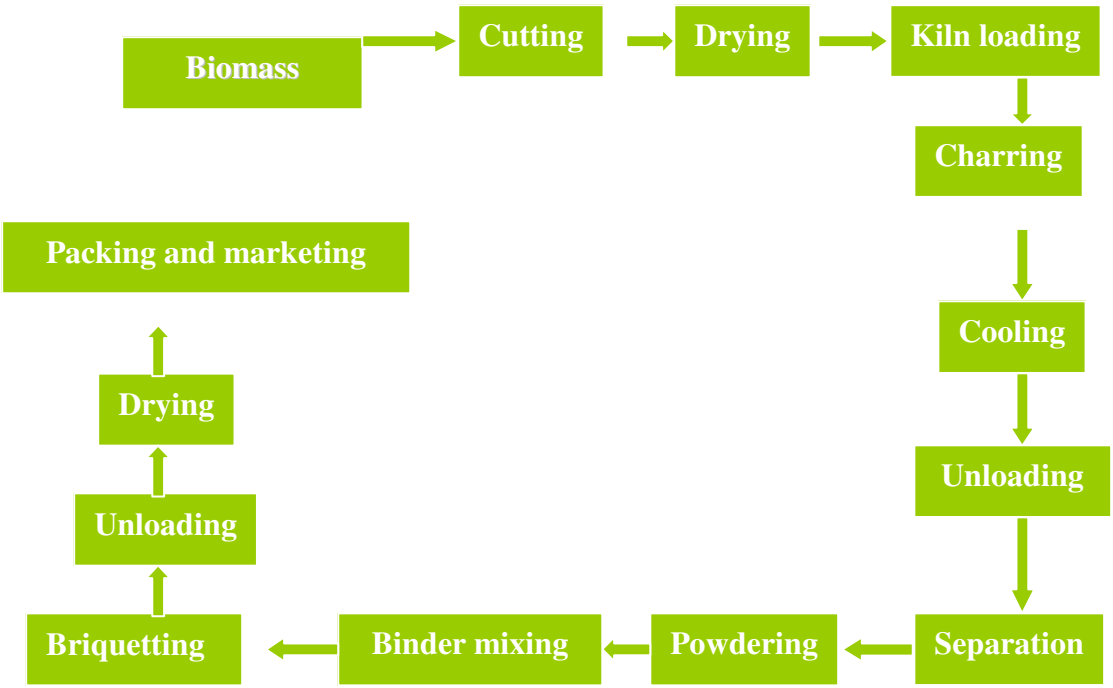

Chart 6: Charcoal production and briquette making technologies process chain

7.4 Briquette production

Different briquetting processes require different types of equipment. These can range from fully automatic manufacturing to artisanal level. Three types of briquettes have been explored by the EREDPC RandD programme including charcoal briquette (from a range of different materials – see Table 1), beehive briquette and agglomerator. EREDPC developed a simple hand-operated press capable of producing eight charcoal briquettes and/or one beehive briquette at a time, and the agglomerator (which is illustrated in Figure 20).

7.5 Properties of charcoal and briquettes

Charcoal can be tested in a number of ways. In the laboratory chemical and physical characteristics can be determined (as shown in Table 9). The laboratory is also a logical place to determine energy content, flammability and combustion. Different markets may require a different approach with the views of the household or trader taking priority. Here it is that appearance (e.g. in-bag and/or out-of-bag), contents (ratios of pieces to fragments and dust, for example, and contaminants) and burning properties will take priority. Price is also a factor that will determine market sales, with people seeking to buy high quality and to obtain value for money. Here it is that different communities and artisans can develop a useful commercial reputation.

Table 9: Analysis of Prosopis charcoal and comparison with charcoal from other materials

Type of charcoal	Moisture content (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Calorific value (Cal/g)
Acacia	3.67	22.90	3.64	69.79	7,780
Prosopis	3.90	25.90	3.50	66.80	6,959
Bamboo	9.31	15.03	14.80	60.86	6,256
Cotton stalk briquette	4.10	17.20	20.30	58.40	4,588
Ghat stalk briquette	8.04	28.58	16.54	46.84	5,100

The agglomerator comprises a drum that can be rotated by hand into which the charcoal powder and the binder (in this case typically molasses) are mixed and spun. The agglomerated charcoal briquettes are spherical and have a diameter of 20-30 mm. The production capacity of the agglomerator is 30-50 kg briquettes per hour.

Figure 20: Agglomerator

7.6 Conclusions and recommendations

A number of conclusions link logically to the findings of the EREDPC RandD programme and cover a range of inter-related sectors that link artisans, markets, environmental care and industrial development. Recommendations follow. Consider:

- introduction of legislation. The production of charcoal from *Prosopis* fuelwood is logical and practical. *Prosopis* charcoal has excellent handling and burning properties;
- taxation and licensing. Stumpage fees should be introduced to raise funds from within the industry – that can then be re-invested into management, control, training and/or information exchange. Competent charcoal makers should be licensed (for which a fee will also be payable) and their products sold into quality markets. Licensing should follow from the training provided to artisans;
- community participation. Local communities should be encouraged to take a controlling management interest in charcoal production within their communities and within their areas. This will ensure that planning and exploitation of *Prosopis* stands will be undertaken within strategies that are transparent and accepted. Further, participation will help eliminate illegal exploitation of native tree cover and/or

Prosopis that is not being cut for charcoal. Licensing and control by local communities will help regulate the development of charcoal making that artisans are trained, new technologies are introduced, illegalities are reduced and that the industry will be better organized and developed;

- area demarcation. Linked to community participation, areas should be designated for exploitation and/or control and/or eradication of *Prosopis* that people are better able to share resources and that these will be better used for the benefit of everyone in the community;
- markets high quality charcoal. Licensing, training, community participation, etc. will help ensure that only high quality charcoal is produced. In this way, the community/area will develop a commercial reputation that will ensure markets for their products;
- improved organization. Industrial support will lead to the introduction and use of improved technologies, equipment and skills. Here it is that charcoal makers need to be better organised within area and/or regional groups that investments can be shared. The Afar Charcoal Making Association may provide an appropriate central authority for improved organization within the state;
- improved technologies. Traditional charcoal making technologies have merit for cost and simplicity, but they are wasteful of resources and produce lower-quality charcoal. Equipment and technologies introduced by the EREDPC RandD programme should be further explored and introduced/adopted (if necessary with financial incentives). Manufacturing in larger-volume units with improved control over carbonisation processes is recommended;
- *Prosopis* promotion. Use of *Prosopis* charcoal should be promoted within local households and regional towns that people become aware of its value as an alternative to charcoal made from *Acacia* spp. This will help boost employment, livelihoods and income and, importantly, help better protect native flora. Promotion links to markets exploitation and to community participation.

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8. Management and Control of Prosopis spp: Experience from Kenya

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Summary

With large areas of the country ideal for growing *Prosopis*, there is risk that invaded areas in Turkana and the valley of the River Tana will provide the basis for further invasion. Notwithstanding voluntary planting 15-30 years earlier, effort is now being directed towards management for eradication and/or control. National strategies have been devised and key committees established for implementation and management. Thus far, success has been reasonable with understanding of the many complex issues involved and with the portfolio of counter-invasion effort, technologies and investments required. Herein is the role of local communities eradicating stands that are not required, ring-fencing stands that can be used, and, importantly, exploiting key products for markets that can be developed.

Project investment has led to the development of training programmes that have enabled more than 200 people to be trained across the country – in field/crop management techniques, in products extraction and preparation and in markets exploitation. Of particular interest has been the development of silviculture practices and timber growing for the production of high value timber (for exploiting novel markets such as decorative timber veneers). This represents niche markets, however, and the greater proportion of *Prosopis* products will be used in the home and local community for food, feed, construction and energy.

Kenya remains committed to sharing international resources for the better understanding of control, management and/or utilization of *Prosopis* that local communities are provided with the coping mechanisms required – and thus the economic security that follows.

8.1 Introduction

Prosopis is an invasive species, which has now become a serious weed crop in many tropical dry land areas around the world. (See Figure 21) Similar invasive species have also adversely affected Africa in recent years such as water hyacinth (*Eichhornia crassipes*) and the triffid weed[9] (*Chromoleana odorator*). In Kenya, the introduction and expansion of *Prosopis* spp. has followed similar patterns whereby dry land areas in need of environmental protection have been planted with robust cover plants such as *Prosopis*. For all the best of reasons, those introducing the plant expected to be able to manage it and to handle any issues of invasiveness. Introductions have taken place over more than 25 years, for example, in Bamburi cement factory (1973), Hola and Bura settlements (1975-1990), East Pokot rehabilitation project (1976-1982), Turkana rehabilitation project (1977-1988) and Baringo

[9] Triffid weed. Named after the carnivorous plant in the 1951 science fiction apocalyptic thriller written by John Wyndham, the plant has seriously over-run large areas of native bush in South Africa and is rapidly spreading into neighboring countries. Those affected could be forgiven for thinking that the triffid weed was also able to uproot and move freely given the dynamic nature of its behavior since introduction from Latin America more than 60 years ago.

fuelwood afforestation project (1983-1991). Figure 21 exemplifies the extent of invasion today – centred upon Turkana in NW Kenya and the valley of the River Tana in Eastern Kenya.

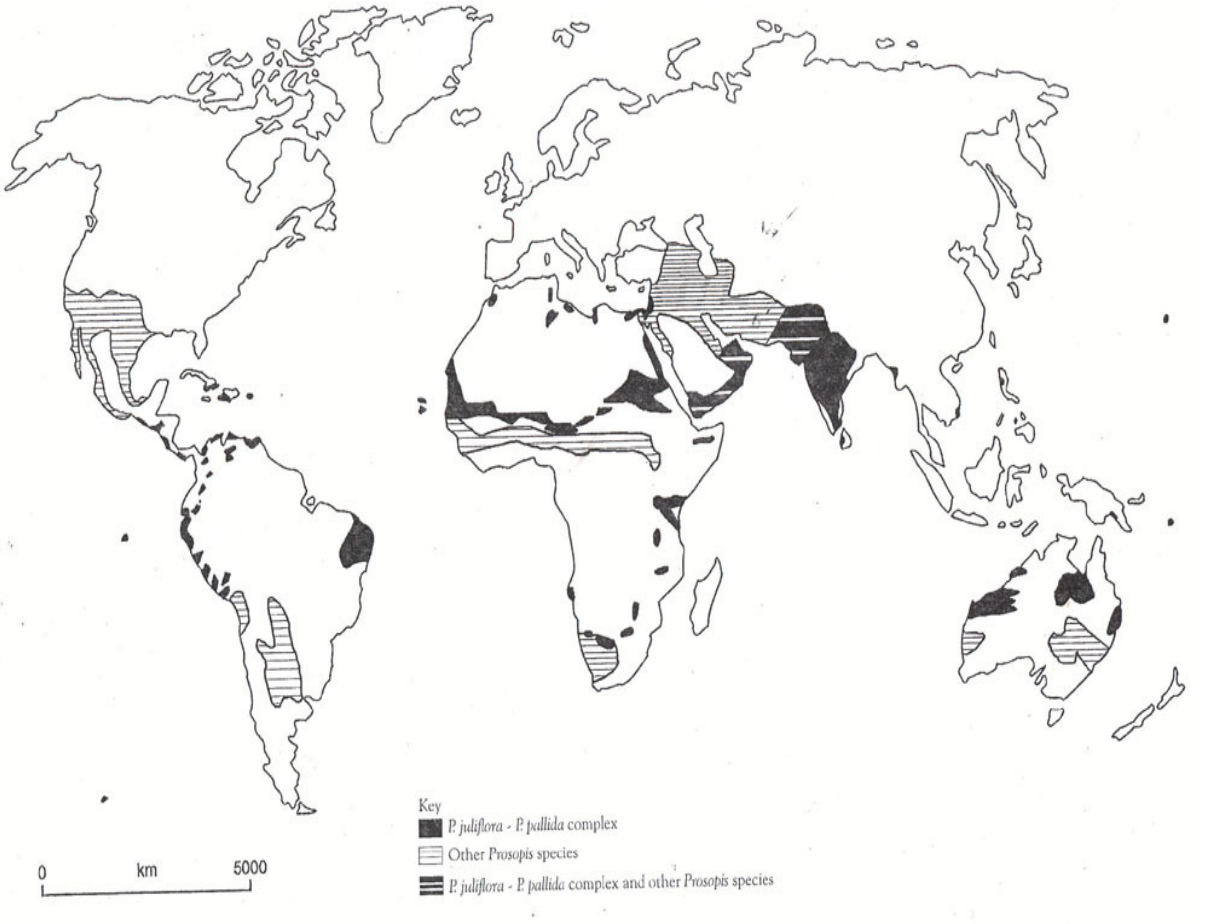

Figure 21: Global distribution of Prosopis (2000)

With hindsight and experience, the widespread invasion of *Prosopis* in areas of Kenya has generally been associated with gaps in existing knowledge at time of planning and introduction and, importantly, with the subsequent inability of local people to manage and cope with the plant. Expectations were simply too high that local people be expected to cope with a plant as aggressive and vigorous as *Prosopis*. Hindsight is a useful but damning tool. Local people and national experts alike were caught unawares (and notwithstanding experience from India, South Africa and elsewhere).

Coping brings real challenges for people with issues of exclusion, competitiveness, choked natural flora, powerful coppicing properties, massive underground seed bank, injury as the result of thorns (for people and livestock) and, for livestock feed, the insidiousness of high palatability and high sugar content of seedpods that encourage over-consumption and eventual loss of teeth of productive animals. Figure 22 shows the extent of invasion. Much of the rest of Kenya outside the Central Highlands provides highly favourable growing conditions for *Prosopis* – and the risk of spread remains real.

8.2 Shared international initiatives for managing Prosopis in Kenya

In recent times there have been a number of initiatives aimed at managing the *Prosopis* invasion in Kenya. Between 1999 and 2001, national surveys were undertaken in an effort to establish the status and impact of the species. In 2002, a pilot project proposal was drafted and implemented and, the following year, this resulted in the national workshop *'Integrated Management and Control of Prosopis in Kenya'*. The workshop brought together the extent of national experience and led to the establishment of a National Task Force.

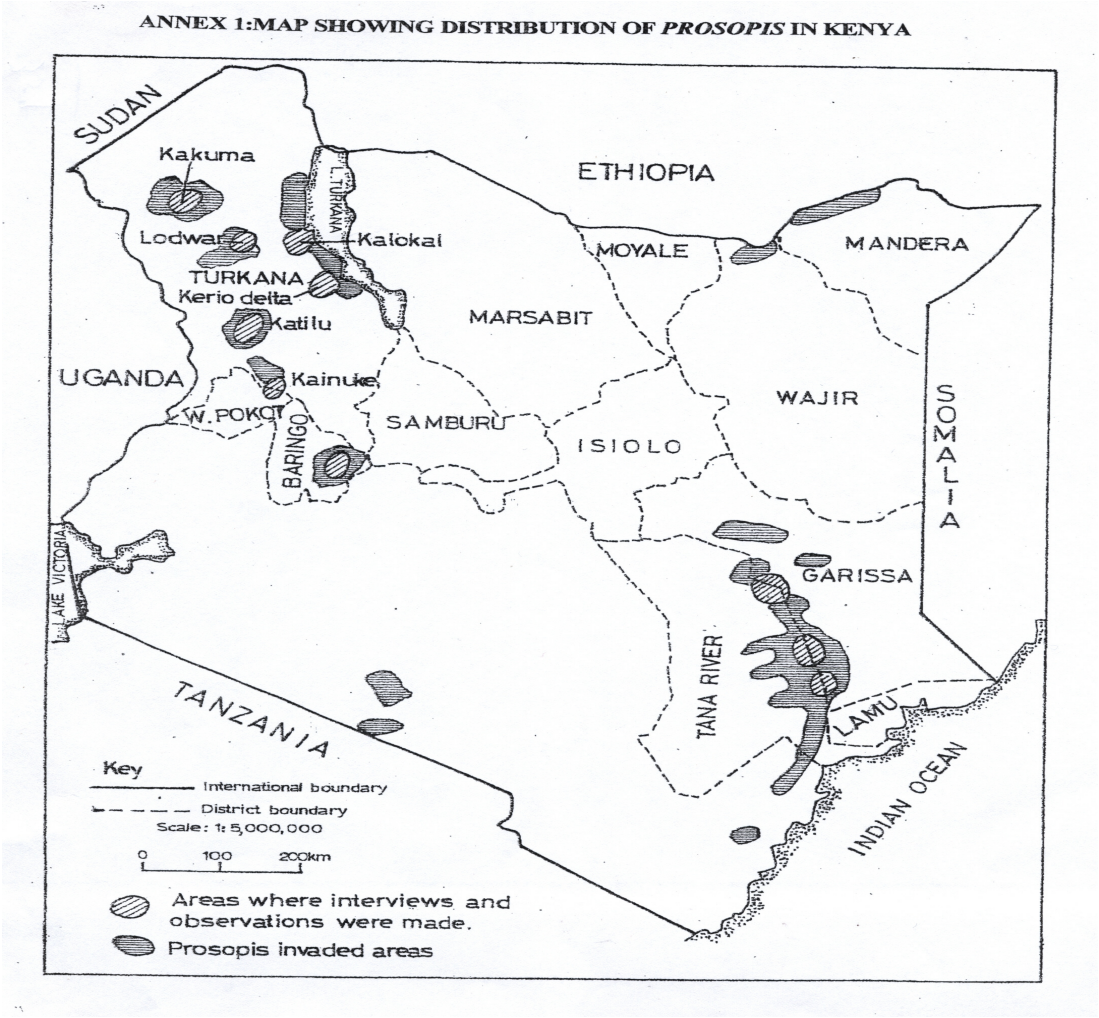

Figure 22: Cultivation and distribution of Prosopis in Kenya (2001)

During the period 2004-2006, FAO shared a project with the Government of Kenya for the development of a pilot project with objectives that were expected to provide greater understanding of the constraints (and opportunities) that prevailed for communities living in invaded areas. Key activities associated with the project included:

- establishment of a coordinated strategy for management and control of *Prosopis*;
- strengthening community capabilities for management of existing stands of *Prosopis;*
- harvesting selected *Prosopis* products and materials, and boosting utilization;
- initiating biological control as part of integrated management and control;
- informing communities on how best to control and manage *Prosopis*.

A major outcome of this project and associated initiatives has been the establishment of a national coordinated strategy with which to manage *Prosopis.* A *'Steering Committee'* was established with representatives from 10 key national institutions led by KEFRI. Meetings have been held every six months that key people remain informed and committed to the principles of shared information and shared decision-making. Given the extent of the invasion and indications that the plant continues to spread, there remains no room for complacency within national effort to contain it.

In additional to a well-informed leadership, an *'Implementing Committee'* has been designated with responsibilities for action required. The committee represents six local institutions and communities from within the geographic areas and technical sectors most closely linked to the plant. The committee meets every three months. KEFRI has taken leadership and all effort and investment required for coordinating field activities, providing technical support, administration and direction are vested in KEFRI people. During the period of the project KEFRI provided national project leadership, providing counterparts to international experts and facilities and more for FAO in Nairobi, Accra and Rome.

8.3 National investment in counter-*Prosopis* effort

The FAO/Government of Kenya project has now ceased, but the principles of management that were established have carried over into further national investment. For example, the network of expertise available to the project has been nurtured and has remained largely intact, and it continues to provide information, advice and encouragement. (The current Expert Consultation represents continuity of investment – and remains much appreciated by the Kenyan delegation.)

National investment has been re-directed into capacity building by strengthening local and national expertise and appropriate institutions responsible for management of the plant. For example, three international experts have been available within the country providing guidance and advice to national experts for control, management, eradication and/or use (with particular emphasis on livestock feed). Bio-control has also featured as a priority means of exploration.

National institutions/experts have been encouraged to become involved. For example a *'Training of Trainers'* course was undertaken with 24 facilitators representing 14 local communities and 10 government institutions. Farmer field schools (FFS) have been established in five locations, with the result that more than 200 farmers from invaded sub-locations have been fully trained (and are expected to share their new knowledge with other in home communities). National experts have undertaken training missions overseas, and have visited South Africa, India and Sudan in an effort to explore what others are doing. Throughout the period the core of national experts based around the *'Groups of Committees'* have continued to benefit from contact with the Plant Production and Protection Service (AGPP) and Forest Conservation Service (FOMC) of FAO Rome. FAO has continued to provide technical support when requested. From small project investments in 2004-2006 much has been achieved.

8.4 *Prosopis* utilization

Prosopis can be used successfully for a host of products – the simple-to-harvest fuelwoods, timber and seedpods; and the more product-specific feeds, foods, high quality timber and extracts. Most people lack understanding of how to shift from the *simple* to the *complex* and,

in any case they may also lack the information, investment and technical competence to do so. People in communities, however, can be taught. See Figure 23. Classroom and field training is required for all processing/products. For harvesting timber this has included tree management (to produce the timber), tree felling and sawing techniques, choice and maintenance of power saws, preparing logs for sawing and, once cut, how to handle, store and season the timber.

Figure 23: Capacity building. Field training that local people are provided with the knowledge and skills with which to cope with and/or exploit Prosopis

The development of appropriate and effective technologies/models for *Prosopis* land management is essential. There are a broad range of tree management technologies that have to be understood including thinning and pruning, choice of pruning methods, choice of spacing (i.e. wide or narrow), training for machine handling and the selective removal of *Prosopis* plants, timber and/or materials.

Eradication/control brings additional challenges for land management; the suppression of coppicing and regeneration (from inadequate clearing and follow-up), removal of stumps below ground level, burning stumps with the use of waste oil and heaped trash, encouraging natural vegetation of native flora (with the use of manures, cuttings, stock control) and similar. Long-term, previously invaded land will only remain clear of *Prosopis* on the basis of the care provided by the land user/owner - that seedlings, vines and re-growth are vigorously challenged.

One key approach to management is exploitation of the products of *Prosopis.* The tree is an excellent source of wood and non-wood products, with well-informed people capable of providing the crop production skills required (and having the tools and equipment with which to do so). See Figure 24. Here it is that field training is essential that people are invited to become *'part of the solution'*. Apart from products that can be used in the home – for food, materials and energy – sales outside the community will require assistance from government. Choices have to be made for preferred activities/products, guidance, investment effort, products development, efficient marketing strategies and, once the enterprises are underway, for business management assistance that the production-processing chain meets the demands of the client/market. Herein will be need for book-keeping skills that money can be made. Here it is that the women in the community have an important role.

Figure 24: Wood and non-wood products of Prosopis. High quality timber manufactured into floor panels; and exotic dairy cow successfully fed on feed including mixtures of seedpods balanced with roughage.

8.5 Control methods

The spread of *Prosopis* can be slowed by introducing natural biological agents that will attack and damage the plant (although this will not result in eradication). Typical agents include *Algarobius prosopis, Apion* spp., *Evippe* spp. (leaf-tying defoliator moth) and *Neltumius arizonensis* (identified more as a future potential agent). See Figure 25 - Figure 28. Considerable effort continues to be made to educate and train people in best-option methods for coping with *Prosopis* invasion.

Figure 25: Adult Algarobius prosopis

Figure 26: Adult Neltumius arizonensis

Activities outstanding from 2007 and expected to be carried over into the next period include:

- educational/training seminars held in new areas;
- formation of more counter-*Prosopis* area committees;
- more field demonstrations and particularly in Garissa, Tana River and Turkana Districts.

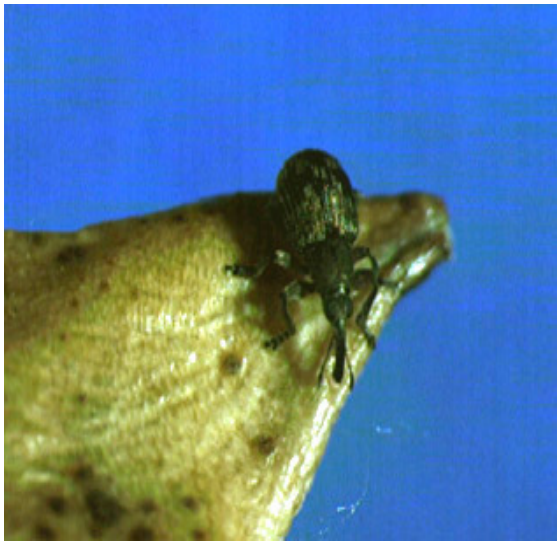

Figure 27: Adult Appion spp.

Figure 28: Adult Evippe spp.

8.6 Way forward and summary of long-term challenges

The next steps required for successful management of *Prosopis* should include:

- continuing reformulation and implementation of sustainable national strategies/effort required of management;
- continuing coordination of management, control and/or eradication effort that resources are provided for national (and regional) investment;
- continuing to mobilize local communities and to educate them and train them to cope; to adopt new approaches and technologies that will boost success (e.g. with similar success to that of HIV/AIDS models introduced[10]);
- continuing to determine the extent of invasion and the dynamics of land cover that comes from investment in inventories, surveys and mapping;

[10] HIV/AIDS models Kenya. The country has a population of more than 34 million of which estimated 1.3 million suffer from HIV and AIDS. The national strategic plan for handling the pandemic has resulted in a number of community-led models; that comply with good social practices, cost-effective methods for coping and economic security for affected-families. The country aims to reduce prevalence by more than 25 percent amongst those most affected (i.e. 15-25 year olds), provide increased care for infected people and boost response coordination. A number of response models have been introduced including the Academic Model for Providing Access to Healthcare (AMPAH). It provides robust support for more than 75 000 infected people with estimated 50 percent receiving anti-retroviral (ARV) drugs. Sectors and priorities may be different, but there are principles that can be learned from the one control programme that may apply to the next. *Prosopis* control and eradication strategies may need to mobilize similar levels of dynamic national support to succeed.

- boosting private sector involvement – encouraging entrepreneurs in local communities to seek partnerships with farmers, livestock producers and others living on invaded lands – for the exploitation of *Prosopis* products with commercial prospects;
- ring-fencing existing stands and preventing further spread of *Prosopis*; eradication and/or control as required; use of quarantine holding measures for livestock (to prevent spread of seeds);
- making effort to control existing stands and/or preventing new stands from becoming established;

A number of issues continue to apply for the long-term security of land in areas at risk of invasion of *Prosopis*. A brief summary includes:

- difficulties of communal land ownership (and, it follows, the 'tragedy of the commons', i.e. communal lands for which collective ownership exists);
- changing negative perceptions of *Prosopis* in local communities; shifting people to a more positive stance that coping can include practical exploitation and/or products developments from which money can be made;
- attaching monetary values to *Prosopis* products in an effort to stimulate people into action (and providing the support needed – economic, technical, financial, etc.); and then establishing sustainable production processes;
- firm support from government services – policies, practical effort, financial, etc. (and particularly where anomalies may exist with, for example, the energy sector);
- exploitation of domestic/local markets for '*traditional' Prosopis* products of livestock feed, food for people and timber, fuelwood and charcoal products. Targeting high quality at all times;
- seeking new and/or novel markets for *Prosopis* products. (Early days on this one, but markets are limited by the ability of local people to imagine and to invest, and to exploit opportunities. Considerable support will be required of public institutions);
- providing greater understanding for the differences that may apply between people in different areas, regions and/or countries that a measure of harmonization results with the exchange of information – for technologies, products, expertise, ideas, etc.

9. Prosopis: Potential for Utilization of Wood

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Summary

The exploitation of *Prosopis* for high value timber and timber products requires land-owners, growers, traders and others to see the plant differently – shifting from 'weed crop' to 'income earner'. Exploratory RandD work undertaken by the KEFRI and others in Kenya has shown the potential for specialised timber products, but people are slow to adapt and recognise potential. Here it is that the public sector has a role with the experience, innovation, technologies, equipment, skills training and services that will provide the basis for economically self-sustaining communities successfully exploiting *Prosopis* timber plantations. Where people are able to adapt and accept change and, importantly, are willing to manage *Prosopis*, then utilization should be encouraged. Where people are unable or unwilling to adapt then *Prosopis* should be eradicated. The plant is simply too dangerous to leave as a wild agent invading agricultural lands.

Value addition from harvesting and processing seedpods, fuelwood and charcoal are well-known practices in Kenya. High quality timber production represents a novel market. Issues of high quality demand arise and of continuity of supply into markets. Here it is that the public sector has a role for nurturing new enterprises within receptive communities.

9.1 Introduction

Prosopis is one of the most ecologically and economically important trees for dry land areas of Kenya. It has well-established potential for protecting the environment – providing land cover where few other plants will survive and, importantly, it provides a means of creating wealth in areas that may have few socio-economic opportunities for local communities. *Prosopis* exploitation enables people to boost incomes (and thus enables them to work themselves out of poverty). Notwithstanding these advantages the plant is not without risk. People and *Prosopis* work best where there is sufficient experience of management, control and/or utilization.

There are two widely held opinions in Kenya based on more than 40 years of experience of living with the plant, that is: 1) to plant more trees where utilization has been successful; and 2) to eradicate trees where the potential for utilization has neither been well accepted nor successful. This paper looks briefly at both options and, importantly, considers the changeover from eradication to utilization as communities become better informed and more willing to participate in exploratory ventures. Ultimately, successful ventures with exploitation and use provide that *'win-win'* scenario where everyone in the community stands to benefit – and the environment more so with the sustainability of natural resource utilization that results. Figure 29 provides that easy-to-understand image of the value of permanent land cover in dry land country – this is dust bowl to regenerated land that quickly attracts native fauna.

Figure 29: Baringo. Before and after the introduction of Prosopis

9.2 Managing *Prosopis*

Management requires that people make choices – for eradication, control and/or utilization of stands of *Prosopis*. People need to be informed before the correct decisions can be made. Start with existing stands of *Prosopis* before planting any new ones. The tree is highly invasive and cannot easily be eradicated in areas where it is not required – planting new areas may exacerbate eradication long-term. Control techniques vary, and choices need to be taken – for use of mechanical control *(with use of heavy equipment),* chemical control (with use of expensive chemicals that may also be hazardous to both people and the environment), the introduction of biological vectors that will attack the plant (again expensive, and irreversible) and/or a combination of these three approaches. Given the relative low value of much of the land being cleared (and the likelihood of low value cropping or grazing to follow) most mechanical clearing in Kenya (and in other African countries) is done by hand. This is socially and economically viable – requiring few external resources and providing useful income to local communities. Hand clearing of invaded lands is a logical approach for the region.

It is important to teach people how to clear land of *Prosopis*; and to follow-up with monitoring and evaluation of cleared lands to ensure that the correct methods are being followed. Clearing includes the removal of all living *Prosopis* material from the area. This includes all vines and seedlings (and not simply the larger trees). Stumps need to be removed from below ground level.

If existing stands are to be used for the production of timber long-term, then people need to be taught how to space the existing trees that will be required in the area – clearing around the trees that are left. Trees will need to be trained to produce a single straight stem that will eventually provide a useful source of timber. Encourage the tree to form a trunk and canopy and this will also ease harvesting of seedpods (without the hazard of working through untrained vines).

9.3 *Prosopis* materials and products

Harvesting seedpods before they are eaten by grazing livestock means that they can be used for livestock ration mixtures (with the reduction in risk that comes when livestock are allowed

to eat seedpods unchecked – bringing risk to both the animal and to the environment). Timber and seedpods represent valuable resources to local people and, moreover, managed stands of *Prosopis* provide for more living space in-and-around the trees. Grass can be encouraged to grow in open areas, livestock can find shade and there is less risk from injury to livestock and people. Control the distribution of seedpods and the plant cannot spread easily to new areas. Equally important, mature timber can be harvested over long period and provides a useful construction material, with lower quality wood and trimmings used to produce fuelwood or charcoal.

Prosopis compares favourably with other local timbers in Kenya. Given the ease with which the tree will grow and produce timber where other trees may need to be carefully nurtured to maturity, the properties and characteristics shown in Table 10 highlight the value of the tree to local people in lands where few other resources can be produced. Once harvested and cut, *Prosopis* timber has favourable seasoning properties and dries at a moderate rate with little or no loss of quality. It can reach 16 percent MC within 60 days (typical, for example, when air drying in Nairobi).

Prosopis has high energy content and burns well with calorific value 4.2–4.8 kCal/g for wood and 6.0–6.6 kCal/g for charcoal according to Pasiecznik, *et al,* (2001). The wood is easy to handle in the kitchen – it does not spark and produces little smoke. Natural durability is an advantage for construction timber - the heartwood is sound and does not need preservation. However, sapwood is perishable and must be preserved to protect it from insect attack or rotting. For best, sapwood should *not* be used for construction purposes.

Table 10: Properties of Prosopis compared to other timbers

Property	***Prosopis***	***Campor***	***Cypress***
Density (kg/m3)	891	438	429
Bending stress (MOE) N/mm2	125.83	77.10	72.99
Bending Stiffness(MOR) N/mm2	14.485	15.524	7.117
Crushing N/mm2	58.72	42.82	46.15
Shear/g N/mm2	19.95	11.66	14.42
Hardness (N)	12.35	3.00	3.31
Shrinkage	Large (>6%)	Small (< 3%)	Small (< 3%)
Movement in service	Small (<3%)	Small (< 3%)	Small (less than 3%)
Machining	Easy	Easy	Easy

9.4 Sawing timber

The high density of *Prosopis* timber raises issues for sawing in small communities. The timber is hard for normal saws and best sawn with carbide-tipped teeth saws (i.e. with carbide-hardened steel saws). For small-scale sawing power-driven chain saws are sufficient, but with both saw and people well protected (as shown in Figure 30 and Figure 31)[11].

[11] Protective safety wear. Power saws are dangerous when used incorrectly. Operators *must* be trained to use them safely. This includes the use of protective equipment and clothing. Note that the operator in Figure 30 and

Figure 30: Chain sawing free hand

Figure 31: Chain sawing with attachments

Different woods may require new sawing techniques – and these have to be learned/taught. High value timber requires to be treated with care; such timber is expensive and waste/damage represents loss of income. Recovery must be monitored within the sawing process that management can determine any losses. The use of chain sawing techniques has to be taught. Freehand chain sawing requires particular skills that come from many years of use (see Figure 30). Herein poor quality sawing may result in lower grade quality of the surface of the timber cut and, importantly, increased potential for accidents that may injure workers.

Chain sawing with use of attachments (as shown in Figure 31*)* can provide a clean cut, fairly good surface finish and relatively high recovery rates. Once skills have been mastered – it is easier than freehand cutting – and far safer. But chain sawing is not typical of the tools and methods used by local people living in communities where *Prosopis* is found growing. Neither are there traditions of producing sawn timber with use of chain saws. The challenges are many – funds and trained people have to be found, technologies and equipment have to be introduced, and skills have to be taught. Issues may be further compounded in local communities where there are people unwilling to accept change; for not everyone is interested in managing *Prosopis* stands and utilizing the timber produced. Similarly, markets can be slow to explore new timbers and their potential for development. Herein may be issues for continuity of supply - that the timbers or timber products may not be sustainable long-term.

Notwithstanding these challenges progress continues to be made. Work undertaken by KEFRI and others has shown that some novel interventions *are* successful and, it follows, help establish understanding for the value of *Prosopis* trees and the timber that can be produced from well-managed plantations - technologies can be introduced and skills can be taught. Here it is that production and processing technologies for a range of products (e.g. timber, timber products, charcoal, etc.) have been introduced and accepted by land owners, charcoal

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Figure 31 is wearing a hard helmet with earmuffs, leather gloves and, importantly, steel-capped boots. He also wears a full-length leather apron to protect his mid-body. The three bystanders in Figure 30 are too close to the operator (and subject to the noise, fumes and dust produced) and provide a distraction to the operator. Training requires particular skills – one of which is to simultaneously teach and to protect students.

producers, wood-workers, carpenters, builders and others and by those who trade in these products and services. With the assistance of the public sector a range of products can been explored, introduced and promoted. Table 11, for example, compares the novelty of flooring from *Prosopis* timber with timber from more traditional sources.

Table 11: Characteristics of Prosopis flooring compared to other timbers

Property	***Prosopis***	***Acacia melanoxylon***	***Olea capensis***	***Juniperus procera***
Density (kg/m3)	821	600-719	720-839	480-599
Hardness (N)	12.35	3.0-6.0	6.0–9.0	3.0–6.0
Movement	less than 3%	less than 3%	less than 3%	Stable
Seasoning	Moderate	Moderate	Slow	Fast
Machining (planning)	Easy	Easy	Difficult	Easy

9.5 Way forward

Lessons learned help focus investment into the next period. This is important for community perception, for the ability of people to accept change, for the use of different raw materials, to adapt to practices that are not traditional and to be willing to adopt new technologies and to learn new skills. An understanding of value chains may be needed that people become aware of markets for *Prosopis* products that can be developed and exploited.

Implicit within these challenges are those that shift *Prosopis* from low value weed crop to high value timber tree - for construction, housing, flooring and similar niche products/markets into the next period. Other products such as seedpods and charcoal are already well known. New markets will develop on the basis of promotion – of opportunity, productivity and cost-benefit to both producers and users alike. Introduce information, technologies, equipment, methods and skills into the community and this raises intellectual status, living standards and incomes. This is not always easy to see from the outset and the local community may need to be encouraged to become involved. Herein is a role for the public sector and supportive NGOs with access to the credit, technical services, information and support required of industrial development.

Market exploitation cannot easily be undertaken by local communities and particularly for high quality niche products such as timber flooring. Here there will be need for continuity of support – to provide guidance, establish networks of traders, for innovation and RandD, technical information and, importantly, to encourage and help people gain confidence with new ventures of this kind. Ultimately, products and markets will be supported entirely within the private sector but, at the beginning, they will need to be supported with public funding.

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10. Mesquite (Prosopis spp.): Experience and Lessons and the Way Forward in Sudan

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Summary

Many parts of Sudan provide ideal growing conditions for mesquite and, during a period of more than 60 years, considerable effort has been made to introduce the plant for purposes of soil conservation, dune stabilization and products utilization. Only during the past 20 years has the invasive nature of the plant taken priority, with effort made to eradicate it from valuable agricultural lands. Eastern Sudan has been extensively invaded with more than 200 000 ha lost (i.e. 90 percent of national coverage estimated at 230 000 ha). Eradication efforts have been piecemeal and erratic and with mixed success for long-term eradication. Follow-up procedures have been missing and land has been re-invaded.

Strategic development is required to counter the effects of mesquite invasion with government taking a leading role with coordination, investment and, importantly, implementing the legislation required. Experience has shown that mesquite has to be destroyed from outlying, strategically important and/or founder populations where it is unwanted; and exploited in areas where control and management can be assured, and where local communities are willing to take ownership of environmental responsibility.

Eradication and/or living with mesquite will require a long-term commitment from both the public sector and from local communities. It would be helpful to all concerned if central authority could be devised with a mandate and sufficient resources to make a difference. One such facility could come from the establishment of an institute of noxious and/or invasive plants with long-term objectives for containment and/or utilization. Herein is an opportunity for the international community to invest, advise and encourage.

10.1 Introduction

Mention '*mesquite'* in Sudan and people usually think of *Prosopis* spp. or the mesquite evergreen tree or shrub. The genus comprises 44 species worldwide, but only *Prosopis africana* is native to Africa. *Prosopis* species grow successfully in a variety of different environments given properties of self-incompatibility (that promote hybridisation), an ability to compete and to suppress other species and the copious quantities of seed produced. Seed remain in a well-protected seedpod with dormancy imposed by a thick seed coat. Seedpods remain unbroken when mature and do not release seed until minimal growing conditions are

met. This results in a huge and persistent seed bank in the soil. Flood and/or overland flow of seasonal waters can transfer viable seeds many hundreds of kilometres from the mother tree (i.e. seeds are well-adapted to endozochrory or spreading by water). Grazing livestock help further spread the plant with seeds passing undamaged through the digestive tract of the animals.

Mesquite can grow vigorously under the most disadvantaged conditions. It coppices well and was originally appreciated for plasticity, qualities of survival, sand-fixing potential and, not least, for the off-take available to local communities – for fuelwood, construction timber, livestock feed and food for people. For more than 60 years during the first part of the 20th century the plant has been considered a front-line option for controlling the desertification of farmlands in Sudan. Figure 32 provides an overview of the country showing the Nile Valley, the Red Sea and the borderlands of Eritrea; and with much of the area in between invaded by *Prosopis*.

10.2 Mesquite in Sudan: brief history

Mesquite (*Prosopis juliflora*) was first introduced into Sudan in 1917. Tolerance to drought and an ability to fix sand dunes quickly made it a success, and encouraged further use throughout the country such that by 1938 the plant had been widely introduced into central, northern, eastern and western Sudan. In 1947, a shelterbelt of trees was constructed around Kassala Town – much of it comprising *Prosopis*. In 1965, it was re-introduced into eastern Sudan and in 1966 into New Halfa. Drought throughout much of the 1970s rejuvenated interest in the tree and in 1974 seeds were first broadcast from the air in an effort to green the country around Kassala. Success with the Kassala shelterbelt led to similar plantings around the towns of Port Sudan and Tokar and in the valley of the Nile. In western and central Sudan, it was further promoted for shelterbelts and to protect farms and irrigations schemes including those in the Nile Valley. Several species of trees were planted with *Prosopis* dominating choice.

10.3 Current situation

The experience of mesquite during the past 20 years has been profound. Such has been the extent of invasion from lands originally sown to *Prosopis* and from neighbouring lands subsequently invaded by unwanted weed trees that a re-appraisal of the role of the tree had been made. Mesquite has since been labelled a noxious weed, as the result of widespread invasion of natural land habitat and civil infrastructure – watercourses, floodplains, highways, degraded abandoned lands and well-cultivated and irrigated lands. Not surprising given the effort made to establish and distribute the tree, invasion of new lands is more of a national issue in central, northern and eastern Sudan. Estimates suggest 230 000 ha have been invaded with more than 90 percent of this land in eastern Sudan. This comprises the areas of the Gash Delta to the borders of Eritrea, the Atbara River basin, Khor Baraka and the water collecting areas along the Port Sudan-Gadarif Highway.

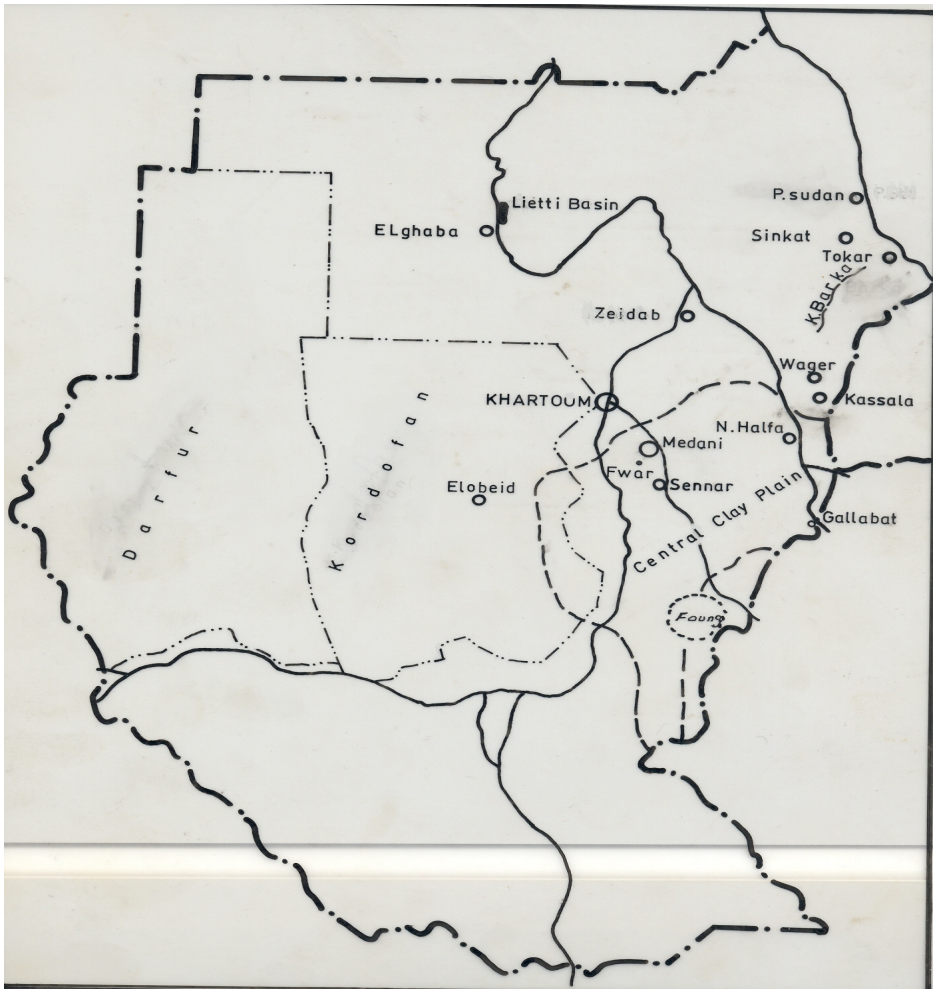

Figure 32: Sudan. Geography of the country showing the main regions where Prosopis invasion has occurred. Note - all areas in eastern Sudan have been serious affected by the introduction and spread of this plant.

The spread of *Prosopis* and replacement of indigenous species can be classified into three distinct periods (and defined from the 1960s onwards as the risks of invasion became better know – but note; it was still to be distributed during these times). From 1962-1978 invasion has generally been categorized as low. Official attitudes changed markedly during the second period 1978-1996 as the plant spread further and faster, occupying land at an estimated rate of 370 ha land annually. The years 1992-1996 are considered the third and final period during which the rate of invasion was estimated more than 460 ha/y (i.e. 30 percent higher).

Sudan is the largest country in Africa and the areas planted and invaded by mesquite, when considered in isolation, are not large. Significance arises with the impact of invasion on the focus communities. For example, in New Halfa and Tokar the areas occupied by mesquite in 1996 were, respectively, 18 500 ha and 27 300 ha. By 2004, these areas had grown four-fold and were estimated, respectively, at 88 000 ha and 100 000 ha. With estimates at best highly conservative and with rates of invasion increasing, the loss of agricultural and grazing lands in what is a highly vulnerable part of the country has highlighted the risks that the tree has brought to the land and its rural people. (See Figure 33). The reality is that the tree now dominates large areas of land that was once covered in native flora and which was the home of native fauna and nomadic agro-pastoralists and their herds. Impenetrable thickets of alien

species have resulted in loss of country, agro-potential and livelihoods (and notwithstanding the stability of dunes and the green cover that has been achieved by the original promoters).

Figure 33: Uncultivated fallow lands. The plant is highly resilient and re-growth is quick on land left fallow after clearing. Failure to remove all rootstock and/or to keep check on new growth results in land that continues to remain contaminated and lost (with

10.4 Mesquite and impacts on community

Communities in invaded lands have lost resources but, as one part of the initiatives of the earlier promoters, these same communities have also gained – with land/sand dunes fixed, households better supplied with fuelwood and with a host of novel and traditional industries exploiting mesquite products (such as charcoal making and livestock feed). But it is the negative aspects of invasion that have come to dominate in recent times. Small-scale invasion has been accepted (and for much of the past 60 years has gone largely unnoticed by senior decision-makers in the main centres), but such has been the rapid rise in invasion in recent times that more than 90 percent of livestock owners now consider Mesquite to be primarily a liability. Notwithstanding the relatively small proportion of seedpods eaten by livestock (assuming they can gain access to thickets), the disadvantages of living with the tree have become too significant. The thorns are hazardous and injurious to both people and livestock. Livestock feed mixes based on large quantities of seedpods are not beneficial to animals – digestive issues arise and relatively young stock lose teeth to decay. Moreover, land is no longer open (but closed into thickets) and this makes for difficult stock mustering - animals and people become lost.

10.5 Tokar Delta study

The case of mesquite invasion in the Tokar Delta was explored in a study undertaken during 2006. Invasion was estimated at 73 percent of total agricultural lands. In 1992, the area under cotton in the Delta was 5 870 ha. By 2005 (i.e. 13 years later) this area had decreased to

1 670 ha because of loss of land to mesquite invasion.[12] Additional control measures required for mesquite, damage to people and equipment and generally more difficult conditions of production have seriously raised the costs of cotton production in the Delta such that the crop has declined in economic importance, and is no longer a major source of income to local growers. Much the same has applied to other agricultural crops with the result that the social well being of local communities has fallen – with loss of employment, income and, ultimately, of productive people who migrate and seek opportunities elsewhere.

The demise of livestock farming has changed the composition of local flocks and herds. The price of vegetables, fruits, seeds and other foods has risen in local markets as production has fallen. Equally alarmingly, local government has reported a drop in the water table from 10 m to 14 m over a period of 15 years (Abdalla, 2007). Mesquite survives where other crops fail given an ability to seek water more than 20 m deep – with the plant better able to exploit water at depth than most native flora. Wells and pumps providing water to rural communities in invaded areas have been deepened to provide security of supplies.

10.6 Control and eradication

From the mid-1990s on efforts have been made to control and/or eradicate mesquite from productive lands and from civil infrastructure. Much of this effort has been ineffective and/or unsustainable. This included, for example, a programme of uprooting begun in 1995, and a containment programme for New Halfa and a *'Food for Work'* programme for Tokar Delta in 1996. The same year the government approved a national eradication bill, which led to concerted effort across invaded areas with the use of heavy machinery and large manual work programmes. More than 10 years later, these initiatives have been completed, and with mixed success. Work continues in Zeibad and has recently begun in the Tokar Delta (again) and in the Gash Delta. (See Figure 34) These are open-ended programmes of eradication/control with the messages that come from experience that show re-invasion of sites wherever follow-up procedures are ineffective. These eradication/control schemes are in areas that are surrounded by a '*sea of mesquite';* with all the resources required of re-invasion just a few metres away from the newly cleared lands.

There are complex issues that underlie the eradication (or, for best, the control) of mesquite in Sudan and, not least, the mixed history over almost 100 years of introduction, re-introduction and distribution, support received during times of drought (for fixing and greening land, etc.), and the perceived value of plant products during times of adversity.

[12] Land unit. Land area in Sudan is measured in '*feddans'* and, in case of the Tokar Delta study, recording and comparisons were made in feddans. Hectares have been used herein to provide for better international understanding. Note that 1ha = 2.4 feddans (and, it follows that 1 feddan = 0.42 ha). Thus the respective areas of cotton before and after mesquite invasion were 14 087 feddans and 4 000 feddans.

Figure 34: Infestation irrigation canal. Access to a ready supply of water and luxury growth of Prosopis quickly encroaches and engulfs an irrigation canal at Zeibad. Considerable manual effort is required to reclaim banks and water surface and then to rebuild the canal structure

10.7 Practical experience

The lessons learned are salutary. Once established the plant is fully capable of surviving with a proliferation of seeds that disperse over large distances. Land clearance that is unable to remove/destroy every living part of the plant provides only temporary clearance – and re-establishment follows. Local communities live under hard climatic conditions and over-exploit the natural cover (based mainly on *Acacia* spp. and native grasses). Loss of cover encourages desertification and the need to green and stabilize land (and therein the original reason for introducing the plant).

Mesquite protects for the short-term and occupies for the long-term with the inability of people or native species to repossess lands that have been lost to invasion. Mesquite is an alien and highly invasive species and, moreover, one that is free of natural enemies in the Sudan. The plant is competitive and aggressive and this, together with an allelopathic nature, makes it extremely difficult to destroy.

10.8 Enhanced utilization

Such is the dilemma surrounding issues of eradication and/or control of mesquite that eradication/control by consumption is not given the serious consideration that is deserves. The plant can be exploited for a selection of products – a key route to eradication/control should be to kill the plant in areas where eradication is required by consuming it. In areas of the world where the plant is a native, effort has to be taken to *protect* it from over-exploitation. Would the same approach apply to Sudan?

Mesquite pods were once an important part of the diet of native Americans, and the plant is still exploited for food in parts of the Americas. In Nigeria a local fermented food called '*kpaye'* is prepared from *Prosopis africana* seeds. Could this be introduced in Sudan? Mesquite pods can yield flour of high quality; and flour that can be mixed with normal baking flours (and *cassava* flour) to make a range of cakes, breads and pastries. Mesquite can be tapped for its water-soluble gum (in much the same way that *'gum arabic'* is harvested elsewhere in the country). Seedpods and leaves can be used as a feed supplement for livestock (but rations need to be balanced). Mesquite has firm application for agro-forestry in areas of low rainfall. Finally, but not least, mesquite timber can be produced that can be made into high value mechanical timber goods (with waste timber and all trimmings used for fuelwood or charcoal).

Community-scale harvesting and exploitation has a role with providing livelihoods, income and goods/services, but is unlikely to make much impact on eradication/control. Industrial-scale utilization for the extraction of materials could be linked into eradication; with the employment of large numbers of people clearing lands and/or harvesting materials. Here it is that the public sector/international community has a role to play with planning, investment and implementation.

10.9 Strategic development

Heavy and extensive infestation of mesquite is limited to selected areas of the country – and mainly in the east. However, scattered but small and relatively isolated foci are known to exist throughout the country; and this poses risk. Mesquite spreads easily from satellite foci, which can quickly develop into a founder population. Experience has shown that a strategy of containment should be in two parts, viz. 1) destroying outlying, strategically important and/or founder populations (and destroying these stands completely); and 2) nurturing stands in areas that require environmental care and, importantly, exploiting them for services, products and materials.

10.10 Options for the next period

Implicit and *de facto* developments with simple strategies (such as those described) is the need for coordination from within the public sector. Government ministries and agencies have to take control; and this requires investment from dedicated teams of people supported by adequate budgets. Herein is need for some kind of central authority; to remain involved and responsible for the duration of the period of control, etc. required. For Sudan this could include the establishment an institute for noxious invasive weeds; with a mandate to undertake the RandD required and long-term objectives of containment. Herein is a pragmatic opportunity for partnership with the international community.

Failure to centralize issues of control, management and/or eradication will result in continuity of current piecemeal investment and effort. For example, the current success of the New Halfa project is threatened because of lack of continued supervision and investment. Mesquite is returning to cleared lands. Separate and isolated interventions by themselves are not sufficient, but have to be contained within strategic planning for which government ultimately remains responsible. Strategic planning has to be supported by legislation, for example, for eradication of selected foci stands of mesquite or for the quarantine of suspect livestock.

The public sector also remains responsible for the RandD required of biological and/or chemical control, for improved product extraction, for the technologies of land utilization and

so on. And if not the public sector – who? Local communities have neither the mandate nor the vision to undertake long-term work of this kind, but their involvement remains important – for therein lays the sustainability of exploitation and/or land clearance. Local communities provide ownership. Devise appropriate livelihood options and share these with local communities with the support of the government, and mesquite becomes simply another well-understood and well-exploited land use option from which people can make money (from mesquite or, more likely, from lands cleared of mesquite).

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11. Summary and Conclusions Expert Consultation

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Summary

There was general consensus that the Expert Consultation had been successful with what it set out to achieve – to provide the more than 30 people attending with a forum at which to explore some of the more fundamental issues of management, control and utilization of *Prosopis* in the countries of the Horn of Africa. Modest investment in the EC/FAO project 'African *Prosopis*' has provided a measure of confidence for the future that comes from shared experience, concerns and opportunities. A post-project/consultation investment has been devised and, during the next period, will be developed in to an investment document that will be circulated to interested donors. Herein is the basis for a group of core countries linked to a regional network – with a mandate to make a difference. Mobilize the resources of those adversely affected by loss of land, promote and encourage novelty of ideas, technologies and approach - and change is possible. Land does not need to be lost to an alien invader. Reclaim lost lands and communities/people will gain food and economic security.

11.1 Introduction: considering the magnitude of the many issues involved

Countries adversely affected by *Prosopis* have declared it a national priority issue as a threat to food security. This highly invasive species of tree occupies significant areas of land meant for food production; it is harmful to livestock and kills large numbers of goats and sheep through tooth decay. A sustainable management strategy implemented in affected countries will *directly* contribute to improved food security in the region.

Because of mis-management and as a result of vigour and competitiveness, *Prosopis* has become a formidable invader of farmlands, ponds, river courses, lakes shores and swamps. It creates dense and impenetrable thorny thickets that have replaced native species such as *Acacia,* and continues to smother ground cover previously available to both farmers/graziers and wildlife alike; grasses can no longer compete. This happened to the extent that farmers and their livestock have been displaced in many areas and forced to seek new lands.

Further, dense thickets and thorns have been such a hindrance to farming in several agricultural schemes and surrounding areas that mechanization is no longer possible. The thorns cause serious injuries to people, children and livestock when they step on them.

Seedpods are highly palatable and easily pass through the digestive tract of livestock without harming them, and this helps to spread the plant further. Dense stands of *Prosopis* grow along grazing trails and across pasture lands, and spread into neighboring cropping areas as livestock range in search of feed.

The magnitude of *Prosopis juliflora* invasion is catastrophic for local people. Such are the limitations of local knowledge that the plant is virtually impossible to eradicate once

established. It occupies living space and dominates the agricultural calendar; and people frequently move to new areas in an effort to escape it (leaving behind an ever encroaching thicket of green cover).

11.2 Project investment – what we set out to do

The Expert Consultation has represented the major activity of project GCP/GLO/162/EC *'African Prosopis'*, and provides a catalyst for making change into the next period. The summary of the project is contained in Annex 5, but it is important at this juncture (when closing the Expert Consultation) to re-affirm some of the key elements of this EC/FAO investment. What we do collectively from now on will help provide better understanding of the constraints and opportunities that face people living with *Prosopis*. The EC/project is an important first investment designed to:

- long-term objective: to achieve improved food security through sustainable management of *Prosopis* in affected areas, countries and regions;
- direct output. to formulate a regional strategic action plan of action. The plan will be coordinate on-going and planned RandD and extension activities currently being implemented by participating national and/or regional organization/institutions in the Horn of Africa countries. The strategy can be summarized within a well-reasoned and viable log frame that will boost the integration of national initiatives and result in enhanced sharing of resources and expertise; with the aim of preventing the further spread of *Prosopis* into lands required for food production;
- immediate output. to agree an approach by key national partners from the participating regional countries - for the course of action to take in support of *Prosopis* eradication, control and/or utilization (that will help boost food security, create employment and raise incomes for rural people).

Following the presentations and debate at the Expert Consultation this week - there is a measure of optimism that these outputs are within reach. With the development of a strategic investment document, the long-term objective of the project should be attainable in the region.

11.3 Main results of the Expert Consultation – what was achieved

The Expert Consultation represented a means of stimulating the dialogue required - held 15-19 October 2008 in Awash in the Afar National Regional State of Ethiopia with objectives that can be summarized as providing for information exchange, experience sharing and pro-investment into programmes for *'Prosopis control, management and utilization'*. More than 30 delegates from Ethiopia, Kenya and Sudan attended (with technical assistance provided by FAO Addis Ababa, Accra and Rome). These people represented countries facing serious loss of productive land from invasion of *Prosopis.* The outline of a post- Expert Consultation investment plan has been prepared (and, following the Expert Consultation, will be expanded into a suitable document that will hopefully attract donor funding). A summary is contained in Annex 3.

Ethiopia, Kenya and Sudan will be considered '*focus'* countries within the regional project proposed with information, developments, etc. shared into '*network'* countries across the region and elsewhere. *Prosopis* spp. has invaded more than 15 Sahalian and Middle Eastern Countries, and project investment can be expected to have value within regional networks that will be established.

There was agreement for conclusions that highlighted the severity of the control required to check the spread of *Prosopis*, the need to introduce easy-to-understand control techniques, the ownership of natural resources required of local communities and, where practical, the livelihoods that could be established on the basis of exploitation and use. The Consultation was firm, however, that utilization alone was not sufficient for control long-term. The proposal was devised on the basis of an investment period of four years, and objectives and outputs that would provide synergy between national and regional eradication and management strategies in East Africa.

11.4 Field visits

Four-days of debate, information exchange and decision-making was supplemented with a field visit to local communities to see land clearance, agricultural development and micro-enterprise activities underway. No Expert Consultation can be complete without seeing first-hand the issues faced by local communities as they struggle to come to terms with a plant that has invaded their environment and completely changed livelihood opportunities. Livestock can no longer roam the country.

Courtesy of the NGO Farm-Africa, the delegates were coached to Bedlualle, Sedehafagae and Serkamo Villages to see demonstrations of land clearance, charcoal making, seeds collection and processing, and livestock feeding. Local community leaders and visiting experts met face-to-face to listen and talk, to exchange ideas, to explore options and to raise awareness of key issues. The scale of the challenges facing local administrations was tempered with the successes seen, for example, of land growing vegetables and forage that just one year earlier had been covered by impenetrable *Prosopis* thicket. Charcoal producers have been prompt to boost local incomes but, more recently, had come up against legislation that has stopped production. This is legislation originally intended to protect local species of trees. Issues are being sorted that the alien invader can continue to be turned into charcoal and sold.

11.5 Future –expected follow-up action

No one can be certain about what will happen next, but the Consultation concluded that:

- *Prosopis* will continue to encroach more land unless easy-to-apply practices for control and/or eradication are developed, promoted and taken up by local people;
- exploitation of the products of the tree will assist with control and, importantly, continue to provide valuable employment and income for those who are able to exploit the markets available; but this will not happen without technical guidance and business skills. (But note: utilization will not lead to eradication – the scale of land invasion is simply too large for local solutions);
- the Expert Consultation provided the group of scientists, extension workers, administrators and other experts with a useful starting point for *'what-to-do-next'*;
- the country is at the beginning of a period of interest and investment that will help control the tree and, where practical, shift *Prosopis* from *'devil tree'* to '*savoir'*.

12. End Note: Control and Management of Prosopis in Context

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Summary

There is a basic ecological tenant of dominance by the strongest; and the stability of apex communities of plants that are typical of the zone, area or region. This, however, changes when an alien invader is introduced out-of-context and with little in the way of natural checks (that have provided for a more amicable presence in the original host community). This is the case with *Prosopis* in Africa. It is, par excellence, the most dynamic plant in the drylands of the region. People remain largely ineffective with control and management, notwithstanding the considerable sharing of information and experience available. Invasion takes place where people remain inattentive, inactive or lack the resources to take control. Land reclamation comes from concerted effort of management and control. Utilization of *Prosopis* for various products is small-scale and currently has minimal effect on preventing invasion and/or eradication from invaded lands.

12.1 Reflection on reality

The contributions given in the proceedings express many different and valuable points of view of how best to tackle the reduction of areas invaded by *Prosopis*. In some cases the utilization of the plant is emphasized, and this results in economic benefit for the host communities. Nevertheless, the areas affected by *Prosopis* in regional countries are enormous, and this makes it difficult to reduce infestation with an approach that simply promotes the utilization of the mass removed.

Prosopis is a perennial plant with strong and aggressive re-growth after it has been cut and/or removed, and herein is the key to control and management. Communities should be able to determine their local needs for the products of *Prosopis* (whether timber, charcoal, seedpods, honey, forage, etc.); and to determine the mass required for long-term exploitation. With this knowledge the area of trees required can be determined and fixed; and, importantly, the remaining areas of invaded lands can be cleared completely. Control comes from regular use of cleared land and, if not used immediately, then managed for the removal of re-growth to prevent re-establishment of stands. Such is the nature of the plant (and particularly the roots) that re-colonization is fast and effective if cleared lands are left semi-abandoned and/or not managed intensively.

A key issue with control and management is to *plan* - the strategies and goals required for the control of *Prosopis* and to derive objectives that result in local communities taking ownership (of both objectives and cleared land). Eradication means reaching a state of zero presence of *Prosopis* in affected areas – that *not* one plant remains when land has been cleared. This is an operation that requires considerable resources and long-periods of time, and neither approach is typical of regional countries.

Eradication is simply not economically feasible in most low-income countries. It is more pragmatic and convenient is to remove the plant mechanically or manually (or a mix of the two) and then to plant other crops or grasses in cleared areas that will be able to compete effectively with *Prosopis* re-growth. In such cases, regular hand pulling or cutting is required to remove and/or kill new *Prosopis* plants that may re-grow on cleared lands.

No less important for the control of *Prosopis* is prevention of spread to other non-infested areas. Here biological control with the release of seed feeders may be of value. Prevention should be planned and conducted with the same emphasis as clearing invaded areas. Nothing is achieved if some areas are cleared and others are left vulnerable to invasion. In this case the simply mathematical equation equates to zero – nothing changes.

12.2 Messages to take home

The shared Expert Consultation 'Africa *Prosopis*' has helped with better understanding for people networking from within the Horn of Africa Region, but an exchange of information, expertise and ideas is simply not sufficient to prevent the domination of the plant in areas already invaded and the invasion of new lands. Control and management comes from the application of various (and all) strategies that have proven valuable and/or shown promise for reduction of *Prosopis* in invaded areas.

The end-result of the EC has been a clear understanding that the plant cannot be controlled by utilization, but by reduction from lands already invaded and by preventing it colonizing new lands. And for this there will have to be concerted national policies, programmes and investment and shared international effort across the region. Fail to do this and the plant will continue to dominate and take possession of lands.

Figure 35: Prosopis Experts East Africa. Much of existing experience of Prosopis control in the region was represented by the delegates at the Expert Consultation. These are the people to take messages home. Herein lie those future initiatives that will help reclaim lands lost to the plant.

Annex 1. Regional Prosopis Experts

Annex 1 contains a roster of regional Africa and international *Prosopis* experts; many of whom attended the Expert Consultation '*Prosopis Control and Management*' held in Awash Ethiopia 15-19 October 2007. Names designation and contact information has value for the network of people currently involved with control, management, utilization, etc. of *Prosopis*/products in the Horn of Africa countries and the mainly international people who support them from outside.

These people comprise the regional network that was assembled by the Expert Consultation and, importantly, offer collective potential for marshalling the ideas and effort for improved understanding of the role of this highly aggressive and adaptable plant as a means of driving socio-economic development in the region. The network has the expertise and enthusiasm to make a difference; and, equally, the experience to attract inward investment from the donor community with which to explore opportunities. Donor and/or public funding should logically lead to private sector investment that people living with *Prosopis* are able to develop their livelihoods further and boost community well being. Table 1.1 describes some of the key players involved.

Table 1. 1: Network of Prosopis people in the Horn of Africa countries and within the international community

Name and designation	**Contacts**
Dubale Admasin *Pastoral Advisor*	FARM-Africa Addis Ababa, Ethiopia. dubalead@yahoo.com
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Annex 2. Delegates attending Expert Consultation

Similar in concept and purpose to Annex 1, this annex lists the people who actually attended the Expert Consultation at Awash 15-19 October 2007. Logically, these will be people who may also be considered 'experts' within the sector – simply because they made the time and effort to become involved (and given the various definitions of 'expert' that can be devised). In many ways the two list are the same, but herein are also people specializing in different technical and/or socio-economic sectors – but all sharing a common focus for boosting understanding of the constraints that face people living with *Prosopis* invasion, and for helping to bring about change. Table 2.1 contains mainly names, titles and e-mail addresses.

Table 2. 1 Delegates attending the Expert Consultation Awash Ethiopia October 2007

Name and designation	Email address
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Annex 3. Concept Note Regional Project 'Prosopis and Food Security'

Outcome of Expert Consultation held Awash 15-19 October 2007 and preparatory framework required for an appropriate project investment in support of improved understanding of control, management and utilization of *Prosopis* spp. in Eastern Africa.

Summary of concept note

An Expert Consultation was held mid-October 2007 as the main activity in the programme scheduled for the joint EC/FAO/Government of Ethiopia project. More than 30 delegates attended representing the three countries in the region facing serious loss of productive land from invasion of *Prosopis* spp[13]. Two-days of debate, information exchange and decision-making was supplemented with a field day to local communities to see land clearance, agricultural development and micro-enterprise activities at first-hand. There was a measure of harmony for conclusions that highlighted the severity of the control required to check the spread of *Prosopis*, the need to introduce easy-to-understand control techniques, the ownership of natural resources required of local communities and, where practical, the livelihoods that can be established on the basis of exploitation. The Expert Consultation was firm, however, that utilization alone was not sufficient for control long-term. The design of an appropriate investment proposal was developed based on a period of four-years, donor funding of the order US$ 5 million and government funding of US$ 1.5 million, and objectives and outputs that would provide synergy between national and regional eradication and management strategies in Eastern Africa.

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1. Expert Consultation

Held 15-19 October 2007 at the Buffet Aouache Restaurant Hotel, Awash Township, Afar National Regional State, Eastern Ethiopia. The three-day Expert Consultation provided an opportunity for scrutinizing regional experience for the many issues and opportunities that currently prevail. Considered a success by delegates, debate lead directly into the preparation of a conceptual framework for developing model strategies that will apply for control, management and utilization of *Prosopis* spp. in the region for the next period. There was consensus that priority effort should shift to control and improved land-use for productive lands that were cleared; and that this should be done on the basis of appropriate eradication technologies that could be used by local communities. Where possible control/eradication/land-use should be linked into the exploitation of *Prosopis* products as the basis for creating employment and income, and boosting the well being of local communities. It remains essential for local communities to take '*ownership'* of the many opportunities that prevail.

2. Regional project initiative

[13] Regional countries. The Expert Consultation was attended by delegates from Ethiopia, Kenya and Sudan *(*with technical assistance provided by FAO Addis Ababa, Accra and Rome). The three countries will be considered '*focus'* countries within the proposed regional project with information, developments, etc. shared into a '*network'* countries across the region and elsewhere. *Prosopis* spp. has invaded more than 15 Sahalian and Middle Eastern Countries, and project investment can be expected to have value within regional networks that will be established.

Given the many people met during the field day, the regional project initiative can be considered the result of debate that involved more than 400 people during a period of four days. Project design may encompass:

- executing agency. Food and Agriculture Organization of the United Nations;
- partnership countries. Ethiopia, Kenya and Sudan;
- period of investment. Four-year period beginning January 2009;
- budget. Total US$ 6.5 million. Minimum donor contribution US$ 5 million. Augmented with national counterpart contributions from the three regional partner countries of the order US$ 500 000 each;
- development objective. Improved food security from the control and management of *Prosopis* spp. in affected areas, regions and countries.
- intermediate objectives. Four proposed:

    1. strategies for control. Strategic planning for reduction of area of *Prosopis*-affected lands to manageable levels by means of appropriate control and/or eradication techniques;

    2. capacity building. Capacity building within national institutions to create improved understanding of the prevailing issues and opportunities for *Prosopis*-affected lands;

    3. market exploitation. Enhanced appreciation of markets, resources, services and products (including energy) that will provide the basis for boosting livelihoods for communities in *Prosopis*-affected communities;

    4. livelihoods development. Development of appropriate livelihoods in which people in *Prosopis*-affected communities can boost food security and socio-economic well-being.

- outputs/activities. Will relate to separate Int/Objs, viz. viable well-informed institutions and communities, working within strategic plans for eradication/control of *Prosopis* within national territories and providing boost for livelihoods development based in *Prosopis* products and/or cleared land (and following crops/livestock);
- national counterpart departments, institutions, etc. (To be decided.);
- *modus operandi* project. Three core countries; project HQ Addis Ababa and two sub-regional centres in Khartoum and Nairobi. International CTA Years 1-2; and national management Years 3-4. Investments in support of national agreements linked to strategic regional need; work via national departments, institutions, centres, consultants, NGOs, etc. Supporting activities for local investment in control methods, model technologies, model industries, exploratory services, contracts, field visits, regional/ex-regional study tours, etc. Dissemination of results in workshops, expert consultations, publications, etc.;
- technical assistance; external. FAO plant, crops, biotechnologies, control, agro-services and technologies, etc. Lead Technical Unit FAO/AGPP/SFE. (ToR to be prepared);
- technical assistance; internal. National institutions, universities, centres, consultants, NGOs, etc. (ToR to be prepared);

- equipment and materials. Vehicles, office systems, field-cultivation, agro-industrial processing, energy extraction, etc. in support of HQ, field activities, etc. Choices and specifications to be prepared;
- contracts institutions and consultants. For service work in control, eradication, capacity building, market exploitation and livelihoods development. (ToR to be prepared);
- reporting. Following recommended FAO procedures for proposed work plans, six-monthly progress reports, terminal statements, technical reports, etc; to be augmented with mission reports, special reports, etc. ex-consultants, institutes, NGOs, etc.

3. End note

A highly productive Expert Consultation held in the centre of a seriously affected region of the country and attended by a host of experienced delegates from three regional countries have debated issues and opportunities for control, management and/or utilization of the invasive tree/weed *Prosopis*. Debate has resulted in the development of a framework of an appropriate project investment. The challenge facing the group is one of marshalling the resources required with which take this initiative further (given the many national priorities that prevail in the proposed focus countries); and obtaining the investment funds required during the next 12 months.

4. Contact FAO/Sub-Regional Office for Eastern Africa

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5. Further information

An electronic copy of the concept project document is available at:
http://waicent.fao.org/testsite/africa/sfe/projects0/technical-co-operation-programme-tcp/en/..

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20 October 2007

Annex 4. Summary Project Proposal 'Control, Management and Utilization of Prosopis'

Investment of the order US$ 470 000 has been proposed within a draft document prepared on behalf of the Government of Ethiopia for execution by the Ministry of Agriculture and Rural Development (MORD). Investment funding of the order 90 percent will be provided by the Technical Cooperation Programme of the Food and Agriculture Organization as a contribution to rural development in the country. A classic programme of RandD, investigation, extension and training has been proposed that will lead into a longer-term investment provided by an external donor. A key advantage of FAO/TCP investment is one of time – with relatively quick and well-positioned targeting during the period normally required for a more profound and higher investment regional programme. The FAO/TCP project was devised as a logical lead-in to the regional programme recommended at the Awash Expert Consultation.

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1. Introduction

The main components of the project proposed are shown in Table 4.1

Table 4. 1: Key parameters project proposal

Item	Category	Information
1.	Project	Technical cooperation Programme (TCP) FAO
2.	Title	Control, management and utilization of *Prosopis*
3.	Number	TCP/ETH/…(A)
4.	Starting date	June 2008
5.	Completion date	December 2009
6.	Government Ministry responsible for project execution	Ministry of Agriculture and Rural Development
7.	FAO contribution	US$ 420 000
8.	Government contribution	US$ 55 000 *(in kind)*
9.	Immediate objectives	Based upon control, management and utilization of *Prosopis* stands, *Prosopis* products and land from which *Prosopis* has been cleared – linked to control, use, management, capacity building, agro-processing, energy production, products development, information and strategy development.
10.	Outputs	Surveys, training courses, technical information, people trained, agro-enterprises established, technical manual, newsletter and strategy.

11.	Inputs	National Project Coordinator and T/Leader, International Consultant *Prosopis*, National Consultant Market/Agro-Processing, FAO/PP/TCDC Agro-Enterprises and Surveys (2), FAO Technical Officers Weeds and Plant Protection (2). Contracts RandD, training, technologies, etc. (4), Equipment for agro-processing, energy production, office, etc.

2. Summary

Shared project investment between the Government of Ethiopia and FAO during a period of 18 months beginning June 2008 will aim to boost understanding of the control and management required of *Prosopis juliflora,* to enable communities in areas invaded by *Prosopis* to live with the socio-economic changes that have adversely affected local livelihoods. Implicit and *de facto* in the approach that will be adopted will be improved utilization of *Prosopis* – that people are able to better exploit the potential of the plant and its products for employment, income generation and community well being.

The plant is estimated to have invaded more than 500 000 ha of land, much of which was previously grazed by cattle; thus pastoralists and others largely dependent upon livestock for a living have been significantly disadvantaged since the plant was first introduced 25 years ago as a means of combating environmental degradation. Such has been the bio-resilience and geomorphology of the plant that it quickly captured land from native species of grass, shrubs and trees, and spread into areas many hundreds of kilometres from where it was first introduced. Estimates suggest 150 000 ha and 100 000 ha of land has been lost to the plant in the two regions of the country mainly affected, respectively, in the valley/basin of the River Awash and adjacent to Dire Dawa City, both of which are in central eastern parts of the country. This is where the project will be located.

The technologies required of control, management and/or utilization will be introduced, explored and adapted on pilot-scale in three *Prosposis*-invaded areas. People will be provided with the skills, information and ability of how to make choices – for eradication of unwanted plant stands, for ring-fencing existing plant stands with commercial potential and, importantly, for exploiting the plant for commercial and household use – for feed, food, energy and other products.

A budget of US$ 420 000 will be contributed by FAO for purchase of technical expertise, processing equipment, materials and supplies, and training and supervisory activities; this will be supplemented by a Government of Ethiopia contribution of US$ 55 000 for project management and for supply of services, facilities and advisory assistance from public sector providers. Collectively, the project management team will be lead by a National Project Coordinator, complemented by FAO Technical Experts and short-term Consultants working in support of a programme that will aim to develop a strategy for control and management that will enable people to understand the plant; and to exploit it for household and economic security.

The project will explore practical developments already underway from within and outside the country including a study tour to Kenya and hire of selected contractors for training, supervision and technical backstopping. A national workshop in which to examine the

findings and outcome of the project will be held towards the end of field activities; and reporting used in support of the design required of a regional project that will be devised to enable findings from Ethiopia to be shared with counterparts in neighbouring countries. There will be a measure of continuity expected with similar projects and activities already undertaken in the region – as described at the Expert Consultation held October 2007 in Ethiopia – representing regional EC/FAO investment.

The investment proposed for the FAO/Government of Ethiopia project will provide the basis whereby information, expertise and technologies from neighbouring countries will be shared with national counterparts in-country that they are familiar with many of the challenges and opportunities already available to others in the region.

3. Budget proposed

Donor budget of US$ 420 000 proposed with estimated 15 percent costs expertise/consultants, 23 percent training, 26 percent equipment, 13 percent technical support and the remaining (23 percent) shared between general and direct operating costs, and miscellaneous costs. Estimated US$ 55 000 provided in kind by the host government.

4. Further information

A complete copy of the draft project document is available at:

http://waicent.fao.org/testsite/africa/sfe/projects0/technical-co-operation-programme-tcp/en/..

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Annex 5. Summary Document Project GCP/CLO/162/EC 'African Prosopis'

A three-day Expert Consultation was held on the basis of small investment funds provided by the European Commission and comprised the main activity during a period of three-weeks project duration. Small investments have value for the opportunity provided for regional experts to meet, debate and explore the existing situation for control, management and/or utilization of Prosopis in the Eastern Africa region. The Expert Consultation was successful and achieved what was expected. Follow-on recommendations for strategic planning and investment were captured in a conceptual note but, by project end, this had not been expanded into an investment document with which to attract donor funding. This remains in the pipeline. A national investment document, however, was prepared (for Ethiopia) with models, inputs, objectives, etc. that may apply to other countries invaded by Prosopis.

1. Introduction

The main components of the project undertaken in support of the Expert Consultation and exchange of information are shown in Table 5.1

Table 5. 1: Key parameters project proposal

Item	Category	Information
1.	Project	EC/FAO Cooperative Programme EC/FAO Facility for the Provision of Consultancy Services and in Support of the Global Donor Platform for Rural Development
2.	Number	GCP/GLO/162/EC
3.	Title	Increased food security through *Prosopis* control and management
4.	Starting date	July 2007
5.	Completion date	December 2007
6.	Government Ministry responsible for project execution	Ministry of Agriculture and Rural Development Ethiopia
7.	EC contribution	US$ 59 500
8.	Government contribution	US$ 6 000 (estimated in kind)

9.	FAO Contribution	Technical expertise, financial administration, organization of planning meetings and expert consultation, strengthening strategic partnerships, provision and dissemination of information, trouble-shooting, networking and general support before, during and following project implementation. Loan of equipment. Resources of FAO/SFE provided. All costs in kind. FAO Lead Technical Unit. AGPP – AgricProtection.
10.	Recipients/beneficiaries	National agencies, ministries, institutions and similar in Eastern Africa. Key agencies included: Kenya forestry Research Institute Plant Protection Service Sudan University of Science and Technology Sudan Crop Protection Department Ethiopia Ethiopian Agricultural Research Organization
11.	Immediate objective	To achieve improved food security through sustainable *Prosopis* management implemented in affected areas and countries.
12.	Inputs	Expert Consultation. 3-day meeting for invited experts. Technical Experts. National experts ex-Sudan, Ethiopia and Kenya. FAO TechManagement. Technical b/stopping AGPP Rome and SFE Addis Ababa. Technical papers. Country papers prepared by experts. TechConsultant. Management and organization EC; preparation technical inputs, draft proceedings, draft project investment document and reporting. FAO TechExpertise. Ex-Addis Ababa, Accra and Rome. Participate Expert Consultation preparation technical papers, etc.
13.	Outputs generic	Sub-regional strategic action plan. Based on application of integrated management, control, eradication and utilization of *Prosopis*. This will combine: * prevention. No further planting, no distribution of seeds and care with movement of livestock. * clearing invaded lands. Combination of labour-gangs, mechanical, chemical and biological eradication methods. * utilization. Community-scale and large-scale use as food, feed, timber, fuelwood, charcoal and energy resources

14.	Outputs actual	Expert Consultation. 3-days and more than 30 people attending. Proceedings. Reporting Expert Consultation. Regional strategy investment. Conceptual outline. Investment document country. Completed for Ethiopia. Newspaper article. Published Ethiopia/Addis Ababa. FAO Newsletter. Published for regional Africa.

2. Summary project design and outcome

The European Community (EC) financed project investment of the order US$ 59 500 to provide resources for a three-day Expert Consultation to be held in support for improved understanding of the issues, constraints and opportunities prevailing for existing '*Prosopis'* stands and products and, importantly, for land that has been cleared of *Prosopis*. Organized under the auspices of the FAO Sub-Regional Office for Eastern Africa, the Expert Consultation provided a forum for more than 30 experts, advisors and technicians to debate, inform, exchange and plan for management, control, eradication and/or utilization of *Prosopis*/products.

Project investment is summarized in Table 5.1, but suffice to note herein that nature of the investment and its value as a means of focusing attention on one of the most invasive plants in the region. Introduced for all the best environmental reasons during more than 70-years, the plant has proven durable and resilient such that people (i.e. small community people) have not been able to control it spread; and the plant has invaded large tracks of land in the countries represented at the Expert Consultation, and elsewhere in Africa and other dry land parts of the globe.

Notwithstanding the value of the investment, the project was considered a catalyst from the outset, and intended to lead into a regional development initiative in which the recommendations of the Expert Consultation would be implemented; and if not immediately, then sometime in the short-term future. There is value with exchange of information – that experts returning home are able to take new ideas, innovation and technologies, but without additional financial support from host government and/or international donor there is little likelihood of these being explored practically. This results in lack of confidence – for experts and *Prosopis*-affected communities alike. Thus, a key output of the EC/project investment has been the development of a regional investment document to encourage action.

Project duration of three weeks applied to the preparatory effort of the Expert Consultation, Expert Consultation implementation and post- Expert Consultation reporting. Therein were issues of time with the feedback required of national experts for participation within the regional planning document required. By the time of project closure in mid-December 2007 insufficient information and/or contributions had been received with which to shift from conceptual design (prepared as the result of the Expert Consultation) to complete draft document. Instead, an exploratory country document was prepared (for Ethiopia). This has been summarized in Annex 4.

Project management, organization and management of the Expert Consultation and reporting post- Expert Consultation was undertaken by FAO/SFE with responsibility for project

delivery shared between the FAO Lead Technical Unit Plant Production and Protection Service (AGPP) and the FAO/SFE Technical Officer AGPP.

Loss of productive lands to *Prosopis* invasion highlighted issues of food insecurity for the small communities affected, and provided the basis for the debate at the Expert Consultation (and design of follow-on initiatives). In theory it should be practical for well-informed and technically competent people in the small communities affected to be able to manage and control both the invading plant and their lands. The reality of experience, however, demonstrated the ineffectiveness of people left without the support of the central authorities; and of the highly aggressive nature of *Prosopis* once established. Considerable opportunities exist for utilizing the plant and its products, but emphasis during the next period of investment should be one of removal, eradication and/or control and, equally, follow-up activities on cleared lands. The reality is one of affected communities remaining vulnerable to food insecurity and at risk when trying to live with *Prosopis*. Small-scale effort, utilization, etc. will not remove the plant from host communities. It follows that strategic planning needs to be managed at national level with concerted activities, funds, expertise and effort directed into the long-term. No new plantings of *Prosopis* are recommended.

The Expert Consultation was largely successful with what it set out to achieve – raising awareness, information exchange, etc. but continuity into the longer-term investment required has not, thus far, been achieved (with the preparation of these proceedings more than 12 months after the Expert Consultation). Strategic regional investment remains in the pipeline.

3. Budget

Donor budget of US$ 59 000 provided with estimated 23 percent costs expertise/consultants, 67 percent training and travel (i.e. Expert Consultation) and 10 percent operating and miscellaneous costs. Estimated US$ 6 000 provided in kind by the host government.

4. Further information

A complete copy of the draft project document is available at:

http://waicent.fao.org/testsite/africa/sfe/projects0/technical-co-operation-programme-tcp/en/..

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Annex 6. People Eating Prosopis; Food Security for Everyone

People are by nature highly traditional with what they will eat; and the novelty of new foods takes time to be accepted. In its native environment in Latin America, *Prosopis* (better known as 'Mesquite') has a long and cherished history of providing food. In newly introduced regions of Africa, India and elsewhere, people are not familiar with it; and need encouragement to explore opportunities. Typically they also need the expertise, interest and, importantly, the recipes of others. The annex provides a brief glimpse of the many different ways in which flour made from *Prosopis* seedpods can be used in the kitchen. For best results long-term, *Prosopis* flour should be introduced within community programmes based upon a selection of well-proven and easy-to-use recipes (that can then be used to provide the basis of a local cookbook).

1. Introduction

There are a host of sources available with well-presented and well-researched recipes for using *Prosopis* as food for people. For this the modern-day cook typically undertakes an Internet search. Paradoxically, recipes of this kind are frequently only available to the elite (and those less likely to use them). This is because the cook needs to be computer literate, to have access to a computer and reliable power supply and, usually, to be able to read English or Spanish (these are the most popular 'development languages'). Annex 6 contains selected recipes that can be explored for use in the host community (with the assistance of the local MinAgric or similar). Importantly, all recipes have been prepared in the basis of traditions, novelty, inventiveness and practical application on the part of communities in *Prosopis*-growing areas. Recipes have come from Argentina, Arizona and Kenya.

2. Prosopis as food

The seedpods of *Prosopis* are highly nutritious and can be milled into flour that has a taste that has been described as 'sweet with a nutty tang and a hint of caramel'. The flour can be used in baking and/or as seasoning in foods and drinks. *Prosopis* flour is best used in mixtures with other more traditional flours up to a level of about 25 percent. Above this and the taste may be too strong. Sprinkle the flour on to a range of cooked foods – grilled, baked or fried; use it to thicken gravies or stews; add to puddings, scrambled eggs and so on – as a taste booster. Mix a tablespoon of flour into a drink as a mid-morning break.

3. Preparing seedpods

Collect only undamaged and ripened seedpods that remain on the tree (those that have been shed may already be contaminated by moulds or damaged by insects.). Reject all seedpods that are discoloured or damaged. Seedpods need to be well-dried before milling, and this normally takes 3-4 days for sun drying (but less if dried over a fire). Stack and dry on a table or rack and there is less chance of contamination – and drying will be more uniform. Seedpods can be pounded and broken down, but this produces course flour (and seeds may remain whole). For best a mill is required – hammer-mills or stone-mills, depending on availability. For the low-income community, coarse milling by hand is typically followed by hammer-milling; with the quality of milling learned from experience. Whether as seedpods and/or coarse or fine-milled flour, all foods should be stored in dry and vermin-proof containers.

4. Kenyan recipes

A recipe book was produced as the result of a workshop held in Baringo Kenya in February 2006 and supported jointly by the Kenya Forestry Research Institute and the Henry Doubleday Research Association (HDRA) of the UK[14]. Three of the eight recipes available include:

*** *Chapattis***[15]

4xCups wheat flour, 1xCup Prosopis flour, 1xTeaspoon sugar, 1/4xTeaspoon salt, 2xTablespoon oil and water.

Mix the dry ingredients in a bowl and add the oil. Add the water slowly and mix into a dough. Cover the bowl and leave for one hour. Form into small balls and roll these out on to a clean flat surface. Put a little oil in the frying pan and cook the chapattis on both sides.

*** *Savoury maize cake***

4xCups maize flour, 1xCup Prosopis flour and 10xCups water.

Heat the water in a saucepan. Before it reaches boiling point add a little flour. (This stops the mixture from forming lumps.) Once the water has boiled, slowly pour in the rest of the flour. Stir continuously and mash any lumps that form. Cook for 4 minutes and serve with meat and vegetables.

*** *Pancakes (x10)***

1xCup wheat flour, 1/3xCup Prosopis flour, pinch of salt, 1xTablespoon sugar, 2xEggs, 1.5xCups milk and oil for cooking.

Mix the flour, salt and sugar in a bowl and beat in the eggs. Beat in the milk until the mixture has a smooth texture. Spoon a small quantity into a hot frying pan with a little oil and cook, turning once. Eat the pancakes by themselves or spread with jam, lemon juice or honey. They are delicious.

5. Arizona recipes

The US state hosts *Prosopis* velutina as a common native species, but is also home to a variety of introduced species from Latin America (such as *Prosopis chilensis, Prosopis alba, Prosopis pubescens* and others). This raises issues for the hybridisation that takes place naturally and, importantly, for the different tastes that result from the flours derived from the different trees (the different woods also provide a variety of flavours when foods are smoked). Given the traditional nature of the tree/food to Native Americans and the high quality of extension services, social groups, networks and others available locally, a wide variety of

[14] Kenyan Cookbook. The HDRA/KFRI booklet comprises just five pages and describes *Prosopis* flour as food for people, its nutritional value and how to make use of it in a range of foods and drinks. Therein is a brief description of how to harvest and handle the pods, how to make flour and how to store foods; and eight recipes. Available at: http://www.gardenorganic.org.uk/pdfs/international_programme/CookingWithProsopisFlour.pdf..

[15] Equivalent measures. Cooks traditionally use '*spoons*' and '*cups*' when mixing and baking. These are the measuring 'tools' that are typically available in the kitchen. For those who like to be more precise then 1xTeaspoon=5 ml, 1xTablespoon=15 ml and 1xCup=240 ml.

different recipes have been developed and publications produced to describe *Prosopis* as food.[16]

**** Tortillas***

1.5xCups whole wheat flour, 1/2xCup mesquite flour, 8xDried chiltepines (crushed by hand), 1xTeaspoon salt, 3xTablespoons, 1xTeaspoon olive oil and 3/4xCup water.

Mix the dry ingredients (wheat flour, mesquite flour, salt and chiltepines) in a bowl, then add the olive oil and mix well with a fork. Gradually mix in the water and then knead the dough for about three minutes. Let the dough sit for 30 minutes in a covered bowl. Divide the dough into eight separate balls and, again, let these sit for 30 minutes in a covered bowl. Heat a metal comal over a medium hot fire. Take one dough ball and roll it out on to a floured cutting board until it is about 3 mm thick. Transfer the floured/rolled-out tortilla on to the hot comal. Let it cook for about 10 seconds, flip it over and cook on the other side for 15 seconds; then flip it again and cook on the first side for another 15 seconds. Take it off the comal. Repeat the same steps for the other seven balls. Take care when doing this because mesquite flour burns easily – adjust the cooking time with the heat of the comal.

**** Cookies***

1/2xCup margarine, 1/2xCup sugar, 2xEggs, 1/2xMesquite flour and 1.5xCups regular flour.

Mix and cream the margarine with the sugar, then add the eggs and mix well. Blend the regular flour and the mesquite flour, and then sift into the original mix. Bake in a hot oven (around 180 Cº) for 8-10 minutes.

**** Tea***

2xCups dry mesquite beans, 2xCups boiling water and 2xCups cold water.

Grind the mesquite beans into a fine powder (using a kitchen blender for best), add powder to the boiling water, mix well and strain through a fine sieve. Add cold water. Serve chilled or warm.

6. Argentina recipes

Shared investment between FAO and the Government of Argentina in support of *Prosopis* management and utilization during the mid-1990s resulted in the preparation of a useful booklet prepared by a Consultant from the University de Piura.[17]

**** Porridge***

1/2xCup oat flakes, 1/2xCup mesquite flour, 2.5xCups water, 1xCup evaporated milk and sugar to taste.

[16] Arizona recipes. Recipes available from:
http://tucsonivores.wordpress.com/2007/10/01/mesquite-flour-tortillas.
http://www.recipecottage.com/preserving/mesquite-bean-jelly.html

[17] Argentina recipes. National background, project experience and recipes available from: Grados, N. (1998). *El cultivo de algarroba*. Booklet. Project TCP/ARG/8821 *'Frutales par el arido'*. FAO, Buenos Aires, Argentina.

Mix sugar and oats into a cup of cold water. Boil 1.5 cups of water and stir into the water, oats and sugar mix. Continue to stir and slowly add the mesquite flour taking care that it mixes freely and does not form deposits. Slowly heat for 5-8 minutes. Add the evaporated milk and serve. (You can also dissolve the mesquite flour into the hot water as it slowly heats, before mixing with the oat flakes.)

**** Bread***

850 g wheat flour, 150 g mesquite flour, 300 g sugar, 300 g margarine, 30 g flavour improver and 10 g baking power.

Prepare in the same way as white bread.

7. Local recipe book for *your* country

Nothing is more valuable than local knowledge – and no matter that this may have come originally from outside (and have been adapted for local use). Knowledge is power – and this gives people both confidence and security. A local recipe book should have local ownership – with the pictures, words and methods that will be instantly recognised and adopted. For an investment of little more than US$1,000 it should be possible to prepare an appropriate national text/book/booklet and have this published on the Internet and, importantly, in hard copy numbers for local distribution. (Numbers will ultimately determine the cost.) The Kenya cookbook described earlier is a case in point. A recipe book will provide the basis for training people in local communities – and then this information will become part of local traditions.

Annex 7. Prosopis and the Internet

The annex briefly introduces the importance of the Internet as a logical source of information on *Prosopis*. The Expert Consultation recognized the value of these electronic data systems, and the services required with which to access them.

Summary

The Internet represents the most powerful and easily-accessible source of information on everything – including '*Prosopis*'. A dedicated search by an experienced operator will quickly enable specific information to be found. Access to both people and equipment/services by those in the low-income countries can be a challenge. The resources of 'Ecoport' represent an excellent starting point for searching for all subjects botanical – including '*Prosopis*'. This is recommended for everyone seeking to understand the plant. Of the many NGOs working with *Prosopis*-affected communities in the low-income countries, HDRA of the UK provide a logical partner from whom to seek information.

1. Introduction

For both the casual searcher and the dedicated web browser there are many thousands of pages of information available to describe '*Prosopis'*. Whether seeking information on the biology of the plant, issues of land management and/or uses for the different products that can be harvested, an electronic search will quickly help highlight some of the many key features involved with *'Living with Prosopis'*. Paradoxically, those in most need of this information will have neither the search capabilities nor the electronic equipment with which to undertake the search. Typically, they will not have access to a reliable source of electricity. It is presumptuous to suggest that times are changing and that this kind of services will soon be available everywhere – but they are coming; and if not by computer and mains electricity, then by mobile phone and low-cost charger (solar-powered of course). Meantime, services are normally available from (and have to be provided by) those with the responsibilities of the state – start with the MinAgriculture people working for local and/or central governments.

2. EcoPort

An excellent first place to look for information are the facilities provided by '*EcoPort*'[18] This is a highly versatile repository of all things botanical – classifications, information, pictures and captions, and text. Each page can be copied into Word and then shaped into an appropriate format. And the same can be done with photographs. Start by selecting a single photograph (by clicking on the photograph identification number) and copy the photograph and caption box. Example:

http://ecoport.org/ep?SearchType=pdbandPdbID=104877andsubjectType=EandsubjectId=8951).

Just about everything is possible with EcoPort. For example, thumbnail size pictures can easily be produced as posters. General information to describe EcoPort posters is available at: http://ecoport.org/posters.

[18] EcoPort. Nothing beats the introduction provided at: http://www.ecoport.org/. Take time out to explore and enjoy the information provided; and the large numbers of dedicated people who continue to service this database.

View all pictures with detail and thumbnail sizes at:
http://ecoport.org/ep?Plant=8951andentityType=PL****andentityDisplayCategory=Photographs_With_Thumbnails.

To seek specific information (such as 'crop', 'weed' and/or 'plant') use the following e-addresses:
http://ecoport.org/ep?Plant=8951andentityType=PL****andentityDisplayCategory=full

copy of "full category" - category 'Crop' information.

http://ecoport.org/ep?Plant=8951andentityType=PLCR**andentityDisplayCategory=full

copy of "full category" - category 'Weed' information.

http://ecoport.org/ep?Plant=8951andentityType=PLWE**andentityDisplayCategory=full

copy of "full record" – category 'Plant' information.

3. Garden Organic

Registered as a charity in the UK, Garden Organic comprises a trust and supporters based upon the Henry Doubleday Research Association (HDRA) who 'think organically and are united by their respect for the future' (as described at: http://www.gardenorganic.org.uk.) From small beginnings in the 1950, the Association has become the largest organic growing charity in the country (and pre-dates the environmental movement from the 1970s on). The Association has headquarters at Ryon near Coventry England. A variety of different programmes are supported including Overseas Development, School Gardens, Master Composting, Organic Weed Management and others.

The Kenya recipe book produced from the shared HDRA/KFRI project in 2005 was described in Annex 6. Although this represents a small part of the repository of *Prosopis*-linked information available it is important for topicality and location, and up-to-date for both food and products development from within the region. In addition to the cookbook that can be downloaded, a *Prosopis* marketing report and a report on the original project can be found at: http://www.gardenorganic.org.uk/pdfs/international_programme/*Prosopis*/baringo.pp.