BACKGROUND

There is a group of entrepreneurs and civil servants with a vision for a crop-oil-based industry in Namibia:

AN ESTABLISHED BIO-OIL-ENERGY INDUSTRY THAT CONTRIBUtes TO A THRIVING AND PROFITABLE BIO-OIL-ENERGY ECONOMY AND MEANINGFULLY SUPPORTS NAMIBIA’S DEVELOPMENT GOALS AS ENVISAGED IN VISION 2030.

These people have initiated a process to give wings to the dream of agricultural diversification, improved livelihoods, improved energy security, new economic and technological opportunities and improved air quality through the reduction of the burning of fossil fuels. The development of a crop-oil-energy industry offers multiple advantages for the people of Namibia, arising from high and rising crude-oil prices, scientific innovation in technology, and market mechanisms introduced by the Kyoto Protocol.

However, the development of a crop-oil-energy industry faces many challenges. Agricultural potential in Namibia is restricted by climatic, water-resource and biodiversity constraints. Potential production areas are remote from Windhoek and Walvis Bay, the economic hubs of Namibia. As with any new enterprise, there are many poorly known variables that can ultimately ruin the fledgling industry.

In an attempt to minimise these unknown factors, assist potential developers and advise the Government of Namibia on policies and strategies, the compilation of a ROADMAP FOR BIO-OIL-ENERGY was commissioned by the Ministry of Agriculture, Water and Forestry. An Interim Bio-Energy Committee, with administrative support from the Namibian Agronomic Board, supervised this consultative process, which was executed by a joint team from CIC International (Dr. Fred Kruger and Jackie Crafford from the RSA; Geoff Oliver from Zimbabwe) and BARS Intelligent Solutions (Corne Roos), assisted by Siegfried Engels of the Ministry of Agriculture, Water and Forestry. Extensive consultation with (potential) stakeholders also took place. The full document can be obtained from the Namibia Agronomic Board.

This article summarises some information from the Roadmap, particularly on alternative bio-energy pathways, suitable oil crops for Namibia and what would be required in terms of mechanisation. The main conclusions and recommendations from the Roadmap appear at the end of the article.

THE THREE INDUSTRIAL BIO-ENERGY TECHNOLOGY PATHWAYS

Three new crop-oil-energy technology pathways are of interest to Namibia (in addition to traditional wood-fuel). These technologies are distinguished by the biomass sources used as raw material, namely PLANT OILS, NATURAL SUGARS and LIGNOCELLULOSES MATERIAL (biomass).

Plant oils, derived from oil-rich seed crops, may be converted to products that activate compression-ignition

Figure 1. The Plant-Oil Technology Pathway.
engines, as partial or full replacement for heavy fuel oil or conventional mineral diesel. These liquid fuels may be used for operating automotive engines, water pumps or diesel generators. This Plant-Oil Pathway also yields various by-products for non-energy markets, as described in Figure 1. Oil-seed crops (such as sunflower, *Jatropha curcas* and others) produce seed that, after an oil-expelling or -extraction process, yields plant oil and seed-cake. The plant oil forms the raw material for a chemical engineering process termed trans-esterification. This process yields fatty acid methyl ester (FAME), which, when used as a substitute for or additive to mineral diesel, is commonly known as biodiesel. Biodiesel may be sold to various liquid fuel markets, for automotive or household use, or electricity generation. Each of the products generated at the various processing steps in the Plant-Oil Technology Pathway may be sold to various product markets. Tallow, the fatty cattle waste product originating from abattoirs, may also be used as a trans-esterification raw material.

Natural sugars, derived from sugar or starch-producing crops, can be converted to bio-ethanol and used in place of petrol in spark-ignition engines. Figure 2 describes this Natural Sugar Technology Pathway. Crops such as sugar cane, maize and others yield the raw material required for ethanol production. Sugar products include sugar, molasses and bagasse. The hydrolysis and fermentation processes, although indicated as separate activities in the figure below, take place in a dedicated processing plant. Each of the products generated at the various processing steps in the Natural Sugar Technology Pathway may be sold to various product markets. The potential for growing sugar or starch crops in Namibia is very low, and therefore the natural sugar pathway is an unlikely option for Namibia.

Lignocelluloses material, such as agricultural waste and wood, is a natural source of hydrocarbons that may be converted, by many different processing techniques, to crop-oil-energy products. The Lignocelluloses Technology Pathway, as shown in Figure 3, is complex, with many processing options available. Product markets include the liquid-fuel, heat, electricity and biochemicals markets, in addition to the conventional wood-fibre markets that may include timber and charcoal.
The processing technologies for the Plant-Oil Pathway and the Natural-Sugar Pathway are mature and are widely available. This is also the case with digestion and fermentation of lignocelluloses materials. However, the processing technologies for the other options in the Lignocelluloses Pathway (combustion, gasification, pyrolysis, Fischer-Tropsch Synthesis) are either still in development and probably will not be commercially feasible within the next five to ten years, or are proprietary technology. The Directorate of Forestry has embarked on a project to investigate the feasibility of this pathway for Namibia, thus the Roadmap on Bio-Oil-Energy does not cover this technology exhaustively.

INTERNATIONAL APPROACHES TO BIO-ENERGY

Before the large-scale production of crude-oil products, bioethanol and plant oils were some of the most cost-effective fuels available. With current escalating crude-oil prices and refinery costs, biofuels are once again becoming cost-effective alternatives to crude-oil-based liquid fuels. Although many small businesses globally have managed to manufacture biodiesel at competitive prices, using waste products such as spent cooking oils and tallow, national strategies for biofuel production have been constrained by national needs for energy security and independence. Agricultural development, balance of payments concerns and changing World Trade Organisation regulations on agricultural subsidies and environmental legislation have also played important roles in various country strategies.

The major economies are increasingly including bio-energy in their energy portfolios (Table 1). This requires large-scale planting of dedicated bio-energy crops. The countries that lead the world in bio-energy production (Brazil and the USA in ethanol, and Germany in biodiesel), have, furthermore, combined bio-energy-economy developments with large-scale agricultural development initiatives, and consume large quantities of canola-oil products to support rural economic development. Most countries are rapidly developing bio-energy strategies, most notably the European Union, India and China.

A rapid survey of these country strategies shows that correct public policies are vital for successful bio-energy development. Promotional activities, fiscal support such as budgetary grants (funded implementation, research-and-development programmes, subsidies) and tax concessions form integral parts of country strategies to support the development of bio-energy industries. The private sectors in these countries are responding strongly to the initiatives.

The Southern African Development Community (SADC) commissioned a study, completed in August 2005, on the feasibility of the production of biofuels in the SADC region. This study concluded in favour of regional biofuels development and set out a number of policy recommendations.

Press reports reflect strong interest among some governments and private-sector role players in establishing biodiesel and/or bioethanol manufacturing industries in the SADC region. Diverse policy initiatives are under way; for example, South Africa is currently developing a biofuel strategy. However, aside from the 25-year-old ethanol plant in Malawi, the industry as a whole still finds itself in what

Table 1. Salient features of various country bio-energy strategies

<table>
<thead>
<tr>
<th>Country</th>
<th>Brief Description</th>
<th>Key development imperative</th>
<th>Institutional Interventions</th>
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<tbody>
<tr>
<td>Brazil</td>
<td>25-year-old sugar-cane-based ethanol industry, biodiesel industry now emerging</td>
<td>Agriculture development, fuel security</td>
<td>Early years: considerable state grants, tax concessions and assistance through Petrobras. Current: fast tracking of flexi-fuel vehicles, regulation of the ethanol fuel blend between 20-26%</td>
</tr>
<tr>
<td>USA</td>
<td>20-year-old maize-based ethanol industry, biodiesel industry now emerging</td>
<td>Agriculture development, fuel security</td>
<td>US$ 14 c/litre tax concession/import tariff protection</td>
</tr>
<tr>
<td>Germany</td>
<td>10-year-old canola-based biodiesel industry</td>
<td>Agriculture development, environmental considerations</td>
<td>Fuel tax concession on biodiesel = ±US$ 25 c/litre</td>
</tr>
<tr>
<td>India</td>
<td>Industry under establishment, both ethanol and biodiesel, very large <em>Jatropha curcas</em> initiative</td>
<td>Rural development and poverty alleviation, fuel security and environmental considerations</td>
<td>Government-led implementation programme with large R&amp;D, project development and fiscal support</td>
</tr>
<tr>
<td>Australia</td>
<td>Industry not yet established, mostly considering the ethanol pathway</td>
<td>Agriculture development, fuel security, environmental and health considerations</td>
<td>Government-led implementation programme</td>
</tr>
<tr>
<td>Malawi</td>
<td>25-year-old sugar-cane-based ethanol industry</td>
<td>Agriculture development, fuel security</td>
<td>Government-led implementation programme</td>
</tr>
<tr>
<td>South Africa</td>
<td>Industry not yet established, considering ethanol and biodiesel pathways</td>
<td>Job creation</td>
<td>40% fuel tax concession on biodiesel (= ±US$ 7 c/litre)</td>
</tr>
</tbody>
</table>
may be described collectively as a feasibility phase. The large industrial and mining companies Sasol and De Beers have reported feasibility investigations and the commissioning of biodiesel manufacturing initiatives. Sugar and maize farming cooperatives are considering start-up ethanol plants.

In addition to these larger projects, there are several smaller initiatives under way in most of the Southern Africa countries. For example, Zimbabwe has had 20 years or more experience in the agronomy of *Jatropha curcas*, there is already a 4 000-ha plantation of *Jatropha curcas* in Zambia, and many smaller plantations elsewhere. In Namibia, too, there are early initiatives under way now, including intended investments involving extensive outgrowing among farmers on communal land in Kavango and Caprivi, involving multiple shareholders.

From both primary production and processing points of view, the Plant Oil Technology Pathway is considered to be a suitable option for Namibia.

**SUITABLE LOCATIONS**

Limited rainfall and incidence of frost are climatic constraints to crop-oil-energy production. This limits several crop options to situations where irrigation is possible, for example sugar, maize, cassava, soy and sunflower. The Green Scheme intends to expand the current Namibian irrigation capacity from approximately 10 000 ha to approximately 37 000 ha for purposes of agricultural development, mainly in the north. This bold initiative is to be implemented with the government’s assistance of N$ 1 billion over a ten-year period. However, the scarcity and cost of water prohibit irrigation for all crops other than those of the highest value and those of strategic national importance, specifically food crops.

Most contributors to the Roadmap stressed that bio-energy crops should not be grown in competition with food- and valuta-earning crops, because they must not use precious irrigation water resources and the best soils. The bio-energy crops should be assigned to dryland areas, degraded areas and those with marginal soils. This points to the Kavango and Caprivi, where the median rainfall exceeds 450 mm per year, where frost incidence is low and where the growing season exceeds 90 days per year, for dryland production of various species.

In these regions, although they have relatively high concentrations of people, there is land available. These areas are distinguished by a communal-property regime, and have such relatively low inherent levels of soil fertility, compounded by nutrient depletion through monoculture (mahangu) and slash-and-burn, that they are at the point of being abandoned. For a biofuels industry, competition for land, the problem of proper security of tenure and the risk of further land degradation are major considerations.

The Kavango and Caprivi boast some of Namibia’s greatest diversity of animal and plant, which must be conserved.

Because so much of these regions is degraded, with consequent loss in biodiversity, there is a potential to employ biofuels initiatives to rehabilitate the areas and wholly or partially restore their biodiversity values. In these areas there are several optional industry models to pursue (see below). The development of the crop-oil-energy industry must be subject to proper environmental assessment and management, and should, as far as possible, contribute to biodiversity protection and eco-tourism development in Namibia.

**SUITABLE OIL CROPS**

In Namibia, annual oil-seed crops would require irrigation and would be in conflict with national food-security goals. Though it should not be promoted as a national strategy, the option to grow these crops, where feasible, will be open to individual farmers.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Assessment of Potential</th>
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<tr>
<td><strong>Irrigated Agriculture</strong></td>
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<tr>
<td>Soy</td>
<td>Uncertain: grower to choose</td>
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<tr>
<td>Sunflower</td>
<td>Possible: proven yield in Namibia, grower to choose</td>
</tr>
<tr>
<td>Canola (Oil Seed Rape)</td>
<td>Unsuitable: requires cool temperate climate</td>
</tr>
<tr>
<td>Cotton</td>
<td>Unsuitable: complex crop, commercially marginal under Namibian conditions</td>
</tr>
<tr>
<td><strong>Rainfed Agriculture</strong></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>Possible: proven yield in Namibia, grower to choose</td>
</tr>
<tr>
<td>Cotton</td>
<td>Unsuitable: complex crop, commercially marginal under Namibian conditions</td>
</tr>
<tr>
<td>Castor</td>
<td>Uncertain: requires further investigation but improbable</td>
</tr>
<tr>
<td><em>Jatropha curcas</em></td>
<td>Possible: comparative success in Zimbabwe, Zambia, West-Africa, India and Central America indicates substantial promise, proven yield in Namibia</td>
</tr>
<tr>
<td><em>Moringa oleifera, Ximenia caffra, Capparis sp</em></td>
<td>Unsuitable: low yields, oils best used for high value niche markets</td>
</tr>
<tr>
<td><em>Pongamia pinnata</em> (Indian Beech)</td>
<td>Uncertain: suited to humid tropical conditions, requires further investigation</td>
</tr>
</tbody>
</table>

Experience and research from around the world show that feasible crop options for plant-oil production in Namibia include the annual crop sunflower, and the perennial crop *Jatropha curcas*. Further investigation is required into other crops such as soy, castor and *Pongamia pinnata*, as at present there is insufficient information regarding their suitability. The Roadmap thus recommends that *Jatropha curcas*, though not yet properly commercialised, should be promoted in dryland conditions in Namibia.

*Jatropha*, being a perennial plant with multiple uses, will be a welcome addition to farmers’ crop portfolios in their uncertain operating environments, but will require careful
development to counterbalance the risks attached to a new crop system. These risks, including matters of toxicity and invasion, are not insuperable. *Jatropha* should be grown only in regions with 450-500 mm rainfall and more, and where there is low incidence of frost, meaning in the Otavi and Grootfontein constituencies of the Otjozondjupa, and the Kavango and Caprivi regions north of the 450 mm rainfall isoline.

Around homesteads in dryland conditions in the northern areas of Namibia, *Jatropha* is already growing and bearing fruit. The fact that it is not yet horticulturally domesticated in Namibia is a risk, and research and development work is required for its establishment as an oil crop. There is about 20 years' experience of growing and processing *Jatropha* on a small scale in the region, and especially in Zimbabwe. Furthermore, *Jatropha* is now widely cultivated for plant-oil production in Africa, India, Central America and elsewhere.

In India, where the species has been cultivated for several hundred years, reports indicate that 150 000 ha have already been planted and the intended target for the country is 3 million ha. Domestication and commercialisation is proceeding particularly fast in that country. A substantial body of scientific knowledge and technology has been built up around all these initiatives, leading to rapid progress in the development of know-how, improved genotypes, operational manuals and other useful innovations, from which Namibia can benefit.

India, Central America and Africa are obvious sources of knowledge and technology. The University of Hohenheim in Germany is a centre of excellence for *Jatropha* research and development. Furthermore, Germany is leading the biodiesel revolution internationally, and is therefore at the forefront of technology development in the Plant-Oil Technology Pathway.

_Jatropha_ may be planted using a forestry-type business model, which lends itself to lower production costs. Furthermore, it is suited to outgrowing initiatives. Into the bargain, because of the multiple markets available for the _Jatropha_ oil, it offers alternative and complementary value chains that are likely to give greater scope for development.

A thorough programme of field trials will be required, in order to provide the information needed for selection of commercially viable sites, species and cultivars for oil-seed production, as dryland plant-oil production in Namibia will require the use of novel crops whose performance in the relevant areas is largely unknown. Literature should be scoured to find alternative crops that may thrive in local conditions, and these should be test-grown in a variety of locations.

TECHNOLOGY AND THE ECONOMY OF SCALE

A number of technology characteristics must be considered when selecting a process technology: The level of maturity of a technology is an indication of its availability and reliability. The technology supporting the Plant-Oil Pathway is mature, widely available and reliable.

Economy of scale is a technology descriptor that incorporates a large set of complex production and price variables, broadly indicating break-even production levels. Turnkey trans-esterification plants for the manufacturing of FAME (biodiesel) are feasible at moderate economies of scale (about 10 million litres per year). A related concept is the potential of a technology to be implemented through an incremental approach as opposed to a turnkey approach. Whereas the turnkey approach requires large industrial development, the incremental approach allows for smaller-scale SME development, and in some cases even business franchising. Ideally, plant-oil industry development, as envisaged here, requires a technology pathway that lends itself to both the incremental and turnkey approaches, in order to ensure maximum participation of a wide variety of entrepreneurs, which is the case for the Plant-Oil Technology Pathway.

The plant-oil pathway offers the most feasible and desirable course for the envisaged new industry in Namibia, offering both incremental and turnkey options for crop-oil-energy production. This pathway lends itself to numerous product markets. Some farmers in Namibia are already starting up small FAME industries, mainly to replace their on-farm diesel consumption.

SOME PROPOSED PRODUCTION SYSTEM ALTERNATIVES

Some plant-oil production will undoubtedly take place on freehold land, but the bulk of production is expected to take place on communal land, particularly in the higher-rainfall regions of Kavango and Caprivi. This means that the production systems must be designed to comply with traditional tenure arrangements, the provision of the Communal Land Rights Act and Namibian policies for land reform and land resettlement. Below, five distinct institutional models pertaining to communal land, communal land under lease and freehold land respectively, are proposed:

The **Homestead Model** makes provision for hedges and small plantings on margins of crop fields on communal land and tended by the household. This would involve the use of land already deforested. It is not envisaged that the household will own processing plants, but that it will opt to sell harvested seed to oil_pressers associated with larger institutional models, local industries (such as soap producers) or FAME plants. This would not prevent more entrepreneurial households from growing their plantings or acquiring small processing plants (e.g. oil_presses and soap-making).

The expectation is that these plantings will take place on land where the households have permission to occupy (PTO). Extension services and systems will be required to support this model. These may be attained through Community
Forestry initiatives, community-based organisations such as the FIRMs (Forums for Integrated Resource Management), and mobilisation of NGOs and aid agencies. The extension services should include support through know-how transfer, provision of nursery plants and securing of seed markets.

Although the household’s seasonal calendar of work is flexible, it is quite demanding. It is likely that a household’s capacity to establish and maintain a Jatropha plantation will be relatively small, perhaps not exceeding 200 trees (± 0.2 ha). Therefore, assuming nearly full participation of approximately 40 000 households, it may be expected that the Homestead Model could yield 8 000 ha of Jatropha plantations.

Loslappie (‘Scattered Patches’) Model: Dryland plantations of Jatropha on irrigation schemes can make use of presently un- or under-utilised, scattered portions of rain-fed land between centre pivots (so-called loslappies). The seed yielded from these will, in all probability, be processed on-farm, in farm- or cooperative-owned transesterification plants, into FAME as a replacement for on-farm diesel consumption. These processing plants may become a market for homestead growers. The approach will be entrepreneurial and rely on technology and know-how available through the Green Scheme support system. It is estimated that for every 100 ha of irrigated area, the potential dryland is approximately 60-70 ha. Therefore, the estimated 15 000-20 000 ha of irrigation potential in the North indicates a potential dryland-based Jatropha-growing area of approximately 10 000-13 000 ha.

The Concessions (‘Estate’) Model will be applicable to new leases on communal land, in the range of 10 000 to 20 000 planted hectares. The plantings will be rain-fed and should be confined to deforested land. This model may also accommodate outgrower farmers leasing up to 50 ha plantings, in an arrangement similar to that of the Green Scheme. The legislative framework for this model is contained in the Communal Land Rights Act.

However, it is expected that there may be competition for well-located land. It would be advisable to use degraded land, but the extent of this is uncertain. Developments of these magnitudes may be hazardous to natural habitats if implemented irresponsibly, therefore effective environmental impact assessments are essential. Anchor clients and markets for this model are also essential. The typical owners or operators will be entrepreneurs, possibly in joint-venture arrangements with the government or its representative organisations. It is conceivable that at least two concessions, each of 20 000 ha and each producing 20 million litres of crop oil per year, may be established over a three- to five-year period.

Resettlement Model: Land in Caprivi and in the vicinity of Sibbinda in Kavango would be suitable for plantations of 5–10 ha on farms allocated for resettlement. These would be occupied by new farmers requiring substantial support, along the lines of the same system as would apply to households. It is envisaged that these farmers could be integrated into the value chain of the concession model and share the same support system.

Commercial Farm Model: Commercial farmers in Namibia are ready for Jatropha, and should welcome an alternative perennial crop for their crop portfolios. They, however, await markets for Jatropha seed or oil. Such markets may be created through possible on-farm diesel production, sales to off-grid generators or localised soap-manufacturing. It is anticipated that these farmers may put up to 10 ha per farm under Jatropha, with an initial average planting of 5 ha per farm. They may therefore have to form Jatropha-processing cooperatives to ensure reasonable processing economies of scale. Some extension support services may therefore also be provided by such cooperatives.

An area in excess of 60 000 ha can be planted in Kavango and Caprivi alone, yielding returns that could increase the Namibian GDP by 0.5%.

TECHNOLOGY FOR Jatropha CROP-OIL PRODUCTION

At present, there is no mechanised picker for Jatropha on the market, so hand-picking is the order of the day. No doubt these developments will be forthcoming as farmers experience the picking operation and lend their natural ingenuity to the problem.

After being picked, the Jatropha seed pods need shelling – separating the seed from the pod. This operation is a relatively simple one, the dry pods separating readily. However, this can be a time-consuming task and in the commercial situation will add significantly to the unit cost of seed. A rotating-drum-type shelling machine, like that of some groundnut shellers, is suitable for this operation. A small motorised machine of this kind, as used in Nicaragua, will more than cope with the hand-picking output of 30 to 50 labourers. Its output (consisting of the complete mix of loose seed and broken shells), is fed into a motorised rotary wire-mesh drum, which separates the seed for bagging. In Zimbabwe, hand-operated groundnut shellers are available, to replace hand-shelling in communal areas. Groundnut shellers that shell and separate in one operation are available in South Africa.

The seed is then fed into an oil-press of one kind or another. Again the range is from hand-operated ‘ram-presses’, through batch-type spindle-presses, to motorised continuous-feed spindle-presses. The spindle-press is not recommended for production levels of above 10 to 15 litres of oil per day. It may, therefore, have an application at village level and for research purposes. The ‘ram-press’ is designed for village use and has a potential output of approximately 15 litres per day, dependent entirely on the level of human energy applied. Motorised screw-presses are recommended where the accumulated seed harvest is measured in tonnes, e.g. by a commercial farmer producing oil for biofuel production. Where conveniently situated, the farmer may be
able to press oil from seed brought in from the surrounding community. A typical screw-press suitable for this situation would have a seed throughput of 50 to 100 kg per hour. The more efficient presses will run from a 5 to 7 kW electric motor and should have the facility for on-the-go adjustment. Machines of this throughput category are available from Zimbabwe, Zambia and, apparently, Botswana. They are also available from China and other countries. It is strongly advised that potential users investigate the important aspects of power requirement and convenient adjustment before purchase. Of course, much larger machines are available (from various overseas manufacturers) for large commercial-scale use.

In its raw state *Jatropha* oil can be used in simple, handmade wick lamps. More sophisticated lamps will require that the oil be processed into ‘bioparaffin’. A raw-oil *Jatropha* cooking stove is in final stages of design in Tanzania. There is not a large amount of long-term experience in this field of *Jatropha* technology, but with the current ‘explosion’ in the southern African region of *Jatropha* plantings, a concomitant level of technological advancement is expected.

**RISKS**

Six types of risks were identified in relation to establishing a functional crop-oil-energy industry in Namibia:

- risks of policy failure;
- new-market risks;
- risks of production failure;
- pre-project regulatory risks;
- risk of failure in environmental compliance;
- risk to workers;
- operator’s risk.

Risks of policy failure probably constitute one of the two greatest risks, given the experience of other countries that have entered the bio-oil-energy development path. The hazards lie in many fields of policy, starting with land tenure and land-use planning, and have substantial potential for conflict. Defusing these hazards requires clear, appropriate and harmonious policies and policy instruments from the outset and, equally important, consistency during implementation.

**NEW-MARKET RISKS** are probably the second greatest group of risks that the new industry faces. Establishing a new industry based on a new crop on a very large planted area will be a challenging operation.

Risks of oil-seed production failure are that the resource-base of *Jatropha curcas* might fail to deliver the quantity of seed required by the buyers. This may be a consequence of external hazards, such as frost incidence and drought, and/or internal systems factors, such as failure to harvest the crop. External hazards need to be countered by the proper know-how framework, through, for instance, bilateral and multilateral agreements with countries and organisations further advanced in the bio-oil industry. Knowledge of production systems, processing, products, markets and marketing-risks is essential. Internal hazards need to be countered firstly by ensuring the effective delivery of the right supporting know-how, and secondly by the operator.

The **PRE-PROJECT REGULATORY RISK** is that the fledgling industry may lose momentum. It may also be impaired by delays or obstructions in meeting the requirements of current regulations, such as phytosanitary delays on seed and other germplasm imports, delays in decisions concerning environmental assessment, and/or lengthy and costly methodological procedures for the Clean Development Mechanism. Policy environment and policy instruments need to be emplaced, and bilateral and multilateral agreements concluded as early as possible.

Risk of failure in environmental compliance relates to the likelihood and consequence of any one or more enterprise failing to meet the environmental conditions imposed on the project permission. This could result from unsatisfactory specifications being given by the relevant authority of the environmental management system to be applied in the project, including the specification of systems too complex and elaborate for cost-effective implementation by the enterprise. It could also be a consequence of one or more of the participating enterprises underperforming in their environmental management systems.

Risk to workers and their families refers to normal safety and health risks in the operating environment, and risks arising from the toxicity of *Jatropha curcas*. The risk of toxicity is not excessive, and may be dealt with alongside other work-related risks. In the Homestead Model, a balance needs to be found between the desirability, on the one hand, for all family members to contribute to the family's livelihood, and the danger, on the other hand, of exploitation of children, particularly AIDS orphans in extended families.

**OPERATOR’S RISK** concerns the management of any of the new enterprises in the crop-oil-energy industry envisaged here. The success of this venture will be largely dependent upon the entrepreneurial and management capability of the farmers and owners of processing plants.

**CONCLUSIONS AND RECOMMENDATIONS FROM THE ROADMAP**

The Roadmap is a policy document that aims to integrate development imperatives and existing policy, as well as government, NGO, aid-agency and private-sector resources, to mobilise technology and take advantage of market opportunities. In addition, it introduces the reader to the salient facts of a crop-oil-energy industry. The most important conclusions and recommendations of the Roadmap are:

1. The plant-oil bio-energy pathway is seen as the preferred option for Namibia.
2. The perennial oil-nut-bearing shrub/tree *Jatropha curcas* is currently viewed as the most feasible plant for dryland cultivation for the extraction of crop oil.

3. *Jatropha* can be grown in approximately the same areas as can maize, but not in frost-prone areas, i.e. only Caprivi, Kavango and the Maize Triangle are suitable for *Jatropha*.

4. *Jatropha* is suited to small-holder as well as to large-scale farming.

5. It is envisaged that approximately 63 000 ha of *Jatropha* may be planted in Namibia by 2013 (phase 1 towards 2030). This translates to an industry that would contribute an additional N$189 million in GDP to the Namibian economy. Based on 2005 prices, this would contribute 0.5% to GDP.

6. It is likely to be used in the crop-oil-energy sector as follows:
   - Blending into commercial diesel, probably up to 5% (as is already law in many developed countries);
   - Decentralised on-farm/village-level blending into agricultural diesel;
   - Exports to specialised niche markets;
   - Running an envisaged 12 small 1 megawatt decentralised power stations in Namibia (this should attract ‘carbon credits’ under the Clean Development Mechanism for developing countries under the Kyoto Protocol);
   - Substitution for paraffin;
   - For soap-making.

7. The four intermediate objectives to achieve the above goals would be to:
   - Establish and maintain the necessary bilateral and multilateral agreements and arrangements that are required to promote rapid exchange of scientific know-how, germplasm and technology, and to facilitate trade in relevant goods and services, including carbon credits and other environmental goods and services;
   - Establish and maintain a policy environment and portfolio of policy instruments that supports the rapid development of a sustainable crop-oil-energy industry, with particular attention to risks external to the project or the operator;
   - Ensure proper and effective management of process, product, and market risks;
   - Ensure achievement of optimum primary production of crop-oil-energy raw materials supplying technology pathways, by appropriate choice of production systems, supported by best and scientific know-how.

8. To oversee and administer the above:
   - A National Bio-oil-Energy Committee (NABEC), comprised of the six main ministries concerned and a wide variety of private sector organisations and entrepreneurs, should be formed;
   - NABEC should be chaired by the Namibian Agronomic Board;
   - NABEC and the Agronomic Board will need at least one full-time high-level focus official to coordinate and steer the fledgling industry;
   - Fund-raising for the costs of such official/s should commence as soon as possible, as no practical implementation work can be put into action without this guidance.

9. *Jatropha curcas* and, when necessary, other plant-oil crops should be gazetted in terms of Section 2(a) of the Agronomic Industry Act of 1992. This includes the in-principle agreement to payment of levies by the industry (producers and processors) to cover its administration costs, at the stage when sizable crops are harvested, which would be about three years from the launching of the industry.

10. Appropriate regulations for liquid-fuel standards in terms of the Petroleum Products Act should be gazetted.

The Roadmap is a strategy to achieve the desired contribution of a crop-oil-energy industry to Namibia’s Vision 2030, including the objectives and activities that must be achieved on the path to this Vision. However, as the future is by definition uncertain, these objectives and activities are presented as a schematic plan. This plan aims to give the Namibian Bio-oil-Energy Committee (NABEC), who will be tasked with the implementation of the Roadmap, the flexibility in decision-making that will be required during the roll-out of the Roadmap.

The process has already started, with potential producers of crop oil organising themselves into a National *Jatropha* Growers Association, and NABEC convening for the first time in November 2006.