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Implementation of the Multi-annual Adaptation Strategy for the Mauritian Sugarcane cluster (2006-2015)

Strategic Environmental Assessment

Final Report

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AGRECO Consortium
(agreco@agreco.be)

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- Mr. P. Kallee, Ministry of Environment and National Development Unit (Pollution, Prevention & Control Division)
- Mr. K. Heeramun, Ministry of Environment and National Development Unit (Pollution, Prevention & Control Division)
- Mr. R. Beedassy, Ministry of Environment and National Development Unit (Pollution, Prevention & Control Division)
- Mr. S. Gopaul, Ministry of Environment & National Development Unit (Air Pollution Monitoring Unit)
- Mr. S. Ramrekha, Ministry of Environment & National Development Unit
- Ms. R. Brizmohun-Gopaul, Ministry of Agriculture (Barkly Experimental Station)
- Mr. M. Puttoo, Ministry of Agriculture (National Parks & Conservation Services)
- Ms. H. Dowlut, Ministry of Agriculture (Agricultural Chemistry Division)
- Mr. R.K. Bunjun, Ministry of Agro-Industry and Fisheries
- Ms. K. Dosooye: Ministry of Public Utilities (Technical Services)
- Dr. G. Rajpati, Mauritius Sugar Authority
- Dr. K. Deepchand, Mauritius Sugar Authority
- Mr. J. Bundhoo, Mauritius Sugar Authority
- Mr. H. Booluck, Central Water Authority
- Mr. N. Toolsee, Irrigation Authority
- Mr. Kong Thoo Lin, Irrigation Authority
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- Mr. Rutchamah, Wastewater Management Authority

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- Dr. J.C. Autrey, Mauritius Sugar Industry Research Institute
- Mr. A. Bholah, Mauritius Sugar Industry Research Institute
- Mr. S. Seeruttun, Mauritius Sugar Industry Research Institute
- Dr. N. Govinden, , Mauritius Sugar Industry Research Institute
- Mr. R.Ng Cheong, Mauritius Sugar Industry Research Institute
- Mr. Serge Kong Win Chang, Mauritius Sugar Industry Research Institute
- Ms. Claudia Baider, Mauritius Sugar Industry Research Institute,
- Mr. K.P. Pillay, Mauritius Sugar Industry Research Institute
- Dr. B. Lalljee University of Mauritius (Faculty of Agriculture)
- Dr. S. Facknath, University of Mauritius (Faculty of Agriculture)
- Mr. Vincent Florens, University of Mauritius (Faculty of Science)
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- Vitash Tatayah, Mauritian Wildlife Foundation
- Mr. Kwok Yin Siong Yen, Mauritius Chamber of Agriculture
- Mr. S. Prefumo: Mon Desrt Alma
- Mr. Rajiv Ramlugon, Savannah (SUDS)
- Mr. Sydney Catherine: Savannah (SUDS)
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- Mr. Lloyd Coombes , Alcodis Ltd
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Acronyms used in this report

a.i.	active ingredients
AREU	Agricultural Research and Extension Unit
BOD	biological oxygen demand
CMS	concentrated molasses stillage
COD	chemical oxygen demand
GoM	Government of Mauritius
IRS	integrated resort scheme
MAAS	Multi Annual Adaptation Strategy of Mauritius(2006-2015)
MoE	Ministry of Environment and national Development Unit
MSA	Mauritius Sugar Authority
MSIRI	Mauritius Sugar Industry Research Institute
PM	particulate matters
R&D	research and development
VRS	voluntary retirement scheme
SEA	strategic environmental assessment
WS	workshop

Contents

Executive summary

The Multi-Annual Adaptation Strategy - Action Plan 2006-2015: Safeguarding the future through consensus" (MAAS) aims to increase the competitiveness of the Mauritian sugar cane sector. The overall objective of this strategy is to ensure the commercial viability and sustainability of the sugar sector for it to continue fulfilling its multi-functional role in the Mauritian economy through the following principal measures and intervention areas:

- Improving the cost competitiveness of the sugar milling sector via centralization of milling plants from 11 to 4. This intervention will be accompanied by measures for rightsizing of the labour force through various compensation packages.
- Mechanization of field operations to improve the cost competitiveness of sugarcane production and to increase sugar cane yield per hectare and regrouping of small planters to enable them to benefit from economies of scale and improved sugar cane yields
- Increased contribution of the sugar cane cluster to national electricity production through installation of new power plants in the remaining mills
- Producing 30 million litres of ethanol annually from molasses in two of the four remaining sugar factories
- Managing 5,000 ha of difficult areas under sugar cane through support measures to maintain sugar cultivation and converting the remaining areas to forests, other agricultural uses and Integrated Resort Schemes (IRS).

The Strategic Environmental Assessment (SEA) of the MAAS was carried out through consultations with 63 experts involved in in-country research and policy studies and through site visits to various milling plants, analyses of statistical data and comparative reviews of relevant in-country research studies with international literature.

Conclusions obtained from this analytical and participatory process indicate that the MAAS proposal, in terms of its overall implications, is likely to achieve positive environmental effects. This does not mean that no environmental risks will exist during the implementation of the MAAS. Indeed the SEA has identified several significant environmental concerns associated with some proposals contained in the MAAS. All these risks can however be managed if the adequate precautionary measures are taken during the implementation of the MAAS. Proper implementation of mitigation and enhancement measures recommended within this SEA should ensure that any remaining adverse impacts on the environment will be offset and exceeded by the environmental benefits of the MAAS.

Key findings and recommendations related to the MAAS proposal are as follows:

1. *Centralization of milling plants* is expected to optimize the use of energy, water and management of waste waters but it will increase transport demands for the harvested sugar cane. Such increase in transport, when compared with the overall transport flows in the regions concerned, was not perceived as a major issue of concern. It is however recommended that each centralized milling plant establishes a basic management system for optimizing transport flows and for

ensuring compliance of the vehicles used with the forthcoming regulations on emissions from diesel-driven vehicles.

2. *Mechanization of field operations and regrouping of small planters* is expected to improve soil management practices and is unlikely to cause any significant adverse impacts on soil properties. In order to ensure that the current trend towards green cane harvesting continues, it is recommended to require the regrouped planters not to begin sugar cane burning as a result of the mechanized harvesting. In order to ensure that all opportunities for the establishment of bio-corridors and for minimizing surface run-off are utilized, these should projects ensure – as they already begun to do now - that sugar cane farming is stopped within riparian zones along water courses and that the adequate buffer zones are established along amelioration channels in the sugar cane fields. Such an approach is already taken in the first regrouping projects and it should become a standard practice

3. *The proposed installation of new coal/bagasse power plants in the remaining mills* (FUEL and Medine) and the extension of the capacity of the CTSAV plant through an additional unit of 25 MW will enhance the effectiveness in the energetic use of bagasse and it will decrease reliance of Mauritius on the import of heavy oil. Any relative energy losses during the combustion of the coal at the modernized cogeneration units will be offset and actually significantly exceeded by significant energy gains from burning of bagasse. Modernizing of current combustion and flue gas treatment technologies at FUEL and Medine can also significantly reduce emissions of pollutants especially particulate matters. The modernizing is not expected to considerably reduce their emissions in terms of SO_x and NO_x - these emissions are likely to be at rates well below IFC standards, but they may however further decrease if the currently commercially viable technologies are used to replace the classic grate-firing boilers or pulverized fuel firing. Lastly, many options currently exist for a safe use of coal ash resulting from the use of coal during off-crop operations of these plants.

   EU support to the MAAS should, therefore promote the upgrading of cogeneration plants and should also stimulate potential use of modern combustion technologies - e.g. the use of 110 bar steam pressure boilers and turbo-generators for steam extraction & condensing, careful control of moisture contents of bagasse, use of topping/combined cycles or fluidized bed combustion processes. Project-level EIAs for these future power generation facilities should include a thorough modelling of impacts on the ambient air quality based on the requirements of the MoE to ensure that the applicable standards for the ambient air quality are not exceeded. It is also recommended that all power generation facilities in the sugar cane cluster gradually develop an ISO certified environmental management system. The basic monitoring system for the quality of the coal used in the cogeneration plants and procedure for consulting MoE on changes of the coal quality needs to be established as well.

4. *Producing 30 million litres of ethanol annually* from molasses will generate approximately 350,000 m^3 of vinasse. Such volumes of vinasse can be safely managed – provided that all precautionary measures proposed within this SEA are implemented - through combination of composting of vinasse, direct application

on fields located at least 100 metres from residential areas or through concentration of vinasse into CMS and its application on fields. It is important to ensure that adequate risk management plans are prepared for all chosen vinasse management options and that safety management plans are developed for transport of ethanol from the production sites and for the storage and export facilities.

5. *Managing 5,000 ha of difficult areas under sugar cane* through support measures to maintain sugar cultivation and converting the remaining areas to forests open significant environmental opportunities. Any conversion of these lands to other uses however needs to be properly managed through site-specific planning approaches. Planters who wish to diversify from sugar cane should be provided with support under the MAAS only if they choose appropriate crops for the local climatic and soil conditions to ensure that conversion of sugar cane lands to other crops is properly managed and if they agree to strictly follow recommendations from AREU on the use of agro chemicals. If it would be desirable if such planters subscribe to the code of practice for environmentally sound farming of vegetables elaborated by APEXHOM.

   On another hand, conversions of sugar cane lands – in difficult areas as well as on the productive lands – to integrated resort schemes (IRS) represent very serious long-term environmental risks. Projects on conversion of sugar cane lands to IRS, residential zones and golf courses in the costal areas should be allowed to proceed after completion of environmental assessment undertaken for the entire plan (i.e. preventing "salami slicing" approach) and involving in-depth site specific investigations of the quality of the receiving water bodies and analyze cumulative impacts of the proposed land-use options. It is also important to ensure that all new urban developments zones are provided with sewer network available to all houses and with the basic waste-water treatment facilities for both sewage as well as grey water.

The SEA also recommends the following enhancement measures to optimize environmental performance of sugar cane farming:

1. Avoidance of sugar cane burning is discussed between the EU and the Government of Mauritius by the end 2007 as one of the conditions for EU financial support for the implementation of the MAAS. It is suggested that the Government of Mauritius, starting in 2008, annually reports on the total area where intentional burning was practiced.

2. All planters (large or small) who obtain EU support within the MAAS should be formally required:
   - To strictly follow MSIRI advice on the use of fertilizers, on soil management practices and on sustainable agricultural practices. All supported planters (large and small) should keep records of fertilizers used for inspection.
   - To adopt minimum tillage (where the land has already been completely prepared for mechanization) or to establish "frameworks of vegetative buffers" (on those sugar cane lands where minimum tillage cannot be practised)
   - To stop farming within the buffer zones of rivers and streams (minimum of 15 metres from the river/stream bank). All projects on regrouping and

mechanization should establish – as they already begin to do now - minimal vegetative buffers along amelioration channels (e.g. 2 metres on each side of the channel bank) in the sugar cane fields. Such an approach is already taken in the first regrouping projects and it should become a standard practice.

- Irrigated lands with slopes over 10% should be accompanied by a targeted planting of protective vegetative buffers (e.g. vetiver) on borders of irrigated lands.

3. All sugar cane planters supported through the MAAS should adhere to an overall approach of weed management (i.e. accepting certain level of weed infestation which is harmless to the crop) rather then trying to exercise total weed eradication with the use of herbicides. MSIRI is already recommending weed management strategies along this direction, which will reduce further the amounts of herbicides used by sugar cane growers.

4. Implementation of the MAAS should be accompanied by a detailed study on nitrogen and phosphate balance of Mauritius which would verify and further refine preliminary conclusions reached within the SEA. Such study should adhere to principles contained in internationally recognized methodologies and the outcomes obtained should be reviewed through a wide participatory process (involving e.g. stakeholders consulted within this SEA). Future fertilizing guidelines for different crops should consider not only their nutrient needs but also a need to minimize any N and P surplus.

Lastly, the SEA recommends to consider the following 'flanking' mitigation and enhancement measures not strictly related to the MAAS but yet perceived as important given the ongoing environmental pressure on coastal lagoons surrounding Mauritius. These measures do not relate to decision-making on the MAAS, but they may be considered in other relevant planning and decision-making processes:

1. Should the balance of phosphate indicate that use of phosphate-based washing soaps and detergents pose a particular risk for eutrophication of the lagoon, the Government of Mauritius should be encouraged to consider possible regulatory arrangements for use of phosphate-free detergents and soaps in Mauritius.

2. All agricultural activities (e.g. farming of water cress) should be removed & relocated from the river streams.

3. Enforcement powers and resources of the competent authorities having responsibilities for protection of riparian zones should be enhanced.

4. Removal of sea-grass beds from the lagoon which currently done as part of beach preparation for IRS (and tourism projects generally) should be strictly banned.

5. Soak-in pits that are currently widely used to dispose household grey water should be forbidden in all new urban developments in the coastal areas.

6. Inappropriate planting practices (e.g. soil preparation that does not follow contours) should be legally banned.

7. The following support services should be in place to properly manage & supervise production of non-sugar cane crops:
   - Strategic research: analysing future demands (nationally and internationally) & identifying key crops that could be produced in Mauritius
   - Selection of crop varieties and production of planting materials which are adapted to the climatic (sub-tropical) conditions of Mauritius, which are pest & disease –free, etc.
   - Financial assistance (conversion, machinery, etc.): through advisory services for obtaining soft-loans, etc.
   - MQA-approved training and hand-on advising through extension services:
   - Supporting the certification & quality assurance for vegetables and fruits (especially for export and tourism industry);
   - Facilitating exchange of monitoring data on soil & water quality, quality of products, pesticide & fertilizer use.
   - Export promotion & possibly also assistance with branding

1. Nature and purpose of this report

Aims and objective of the SEA for the MAAS

The Strategic Environmental Assessment (SEA) of the MAAS is financed by the European Commission and is presented by the Agreco Consortium for the Government of Mauritius and the European Commission.

The overall objective of the SEA of the MAAS is to describe, identify and assess the likely significant environmental challenges, considerations and effects of implementing the MAAS with regard to the environmental impact of the sugar cane industry restructuring outlined in the MAAS. The specific objective of this SEA is to confirm and complete the findings and recommendations of the MAAS pertaining to environmental issues. In addition, the SEA aims to provide decision-makers in the EC and other donors and in the partner country with relevant information to be integrated in the decision-making and implementation processes.

This report does not necessarily reflect the opinion of the Government of Mauritius or the European Commission. It summarizes findings of an expert team composed of Mr. Jiri Dusik (team leader), Dr. Guy Mc Intyre (team member), Mr. Christophe Poser (team member) and Mr. Bernard Siegmund (team member). All team members have jointly discussed the analytical framework used in this SEA, jointly facilitated stakeholder consultations, individually drafted the detailed analyses which are annexed to this report, and agreed on the core conclusions presented in the chapter 3 of this report. The final SEA report has been edited by Jiri Dusik and Guy Mc Intyre.

Step of the SEA process

The SEA of the MAAS was carried out through analytical and participatory process which was carried out through three-stage process:

- Design of stakeholder engagement plan (15 January to 2 February 2007)
- SEA scoping study (field mission to Mauritius on 5-28 February, followed up by home office work between March and April 2007). The scoping study aimed to identify key issues that need further investigations during the full SEA Study. It was conducted through extensive consultations with key local stakeholders.
- Full SEA study (field mission to Mauritius from 16 April to 1 June 2007, followed up by home office work during 11-26 June 2007)**.** It involved consultations with experts involved in in-country research and policy studies, site visits to various milling plants, analyses of statistical data and comparative reviews of relevant in-country research studies with international literature.

SEA approach and methodology

The SEA used trend analysis focused on the main issues of concern addressed by the SEA. The trend analysis was used to interpret changes in the key environmental issues over time through data sets that illustrate evolution of key issues over time and story-lines that qualitatively describe relevant trends, their main drivers, territorial dimension (if any) and key concerns. The trend analysis helped to trace past trends

and patterns in the Mauritian sugar cane cluster and it helped to outline the future trends based on the expected changes in their drivers.

Stakeholder engagement during the SEA process

The Scoping Study was conducted through extensive stakeholder engagement programme that comprised the following 6 multi-stakeholder workshops:

- Workshop 1 "Environmental aspects of Sugar Cane Industrial Cluster in Mauritius" held on 12 February 2007
- Workshop 2 "Overall trends in soil management and the relative contribution of sugarcane farming to these trends" held on 13 February 2007
- Workshop 3 "Overall trends in water management and the relative contribution of sugar cane farming to these trends" held on 14 February 2007
- Workshop 4 "Overall trends in air quality and the relative contribution of sugarcane farming to these trends" held on 19 February 2007.
- Workshop 5 "Overall trends in biodiversity and the relative contribution of sugar cane farming to these trends" held on 20 February 2007
- Workshop 6 "Presentation of draft scoping report" held on 27 February. 2007

The SEA scoping concluded that the full SEA study should focus on the following detailed analyses

- options for the disposal of waste from the power plants at the centralized milling plants;
- impacts of power generation units at milling plants on the air quality; and
- options for management of vinasse/CMS;
- options for future conversion of sugar cane lands to residential purposes;
- options for future conversion of difficult areas under sugar cane regime;
- options for proposed options for phase out of sugar cane burning;

The full SEA Study addressed the above mentioned issues and verified and completed general analyses conducted during the SEA scoping. The full SEA study was conducted through individual consultations with experts involved in in-country research and policy studies and also involved site visits to various milling plants and the following multi-stakeholder workshops:

- Workshop 7 "Detailed analysis of options for management of vinasse" held on 3 May 2007
- Workshop 8 "Impacts of conversion of sugar cane lands to other uses" held on 22 May 2007
- Workshop 9 "Impacts of energy production and of sugar cane burning on air and soil quality" held on 23 May 2007
- Workshop 10 "Preliminary outcomes of the SEA of the MAAS" held on 25 May 2007

This final SEA report incorporates information obtained from these workshops and from comments on the draft SEA report. The report addresses all issues associated with the proposed reform of the Mauritian sugar cane cluster – starting by sugar cane farming and ending ethanol production. The report at the same time focuses on the specific issues identified during the scoping process for the SEA of the MAAS.

2. Overview of the MAAS and its institutional and legislative framework

The Multi-Annual Adaptation Strategy - Action Plan 2006-2015: Safeguarding the future through consensus" (MAAS) aims to increase the competitiveness of the Mauritian sugar cane sector. The overall objective of this strategy is to ensure the commercial viability and sustainability of the sugar sector for it to continue fulfilling its multi-functional role in the Mauritian economy.

The MAAS foresees among others a concentration of the industry, rightsizing of its labour force and optimizing the use of sugar cane by-products for energy production. The principal measures/intervention areas outlined by the MAAS are expected to be implemented as follows:

The principal measures/intervention areas outlined by the MAAS	Expected implementation arrangements
Improving the cost competitiveness of the sugar milling sector via mill centralization. The decrease in the number of factories from 11 to 4 will mean the laying-off of some 2000 workers. These workers will receive a compensation package: 2½ months per year of service, a plot of land, a training grant of MUR 5,000 (€135) and a business grant of MUR 50,000 (€ 1,350) or be redeployed into the remaining factories; *Rightsizing of the labour force* in order to reduce labour costs and create a more flexible workforce. This will entail the voluntary retirement of an estimated 6000 persons. Voluntarily retired workers will be provided with a compensation package[1] of maximum 2 months' salary per year of service and a plot of land with basic infrastructure. In addition, the regulatory framework will facilitate the use of seasonal labour. Moreover, prior to the voluntary retirement of an employee, he/she would be provided re-skilling/training opportunities for eventual redeployment into other economic sectors or support for the setting up of a small enterprise within the agricultural or non-agricultural sector; this will be implemented under the Government's new Empowerment Programme.	These measures will be facilitated by the proposed amendments of the Sugar Industry Efficiency Act is expected to be amended by early March 2007 in order to facilitate implementation of the VRS-2, to address social costs of the closure of mills and also the early retirement scheme (ERS) for employees of sugar milling factories that are not going to close down.

[1] Voluntary Retirement Scheme (VRS II)

Mechanization of field operations which includes: mechanical derocking of an additional area of 14 000 ha, mechanization of cultural practices on 19 000 ha and the irrigation of an additional 7000 ha of land. The aim of mechanization of field operations is to improve the cost competitiveness of sugar cane production and to increase sugar cane yield per hectare; *Regrouping of small planters* to enable them to benefit from economies of scale and improved sugar cane yields through modernized growing practices;	Field operations and regrouping of planters have actually been already initiated and Government of Mauritius guaranteed an initial loan of 500 million MUR to MSA to implement this project over a 10-year period.
Increasing the contribution of the sugar cane cluster to national electricity production with the installation of new power plants in the remaining mills. Electricity will be generated using bagasse, one of the main by-products of sugar cane; the present production of 300 GWh (16% of national electricity output) will be doubled to 600 GWh[2];	Belle Vue is already in operation. With respect to other 3 power plants, the Government of Mauritius has already adopted an implementation plan for power plants at CtSav/ South 3, FUEL, Medine.
Producing 30 million litres of ethanol annually from molasses in two of the four remaining sugar factories to be used locally for blending with gasoline[3]. This would provide additional revenue to the sugar industry and reduce total gasoline imports.	Ethanol Development Strategy has already gone through a preliminary review in the Cabinet and it is now being finalized by the Government of Mauritius.
Sustaining difficult areas (steep and/or rocky land of 5,000 ha) in order to prevent adverse environmental consequences (sugar cane helps to prevent soil erosion) and social consequences (cultivation by the poorer income groups of the sector). The objective is to maintain sugar cultivation on 2000 ha and the remaining 3000 ha will be reforested or used for Integrated Resort Schemes (IRS)[4] in respect of small and medium planters;	MSA has already started an initial project on investigation of possible options for difficult areas. Currently, these areas are being replanted using the 'minimum tillage' practice. Further options that are being considered include those outlined in the MAAS.

[2] Greater capacity could be generated through the use of cane trash as fuel and the cultivation of high-fibre canes.

[3] This will be used in a 20/80 gasoline mix.

[4] Properties sold to foreigners for residential and recreational purposes.

3. Key environmental impacts of the MAAS and relevant recommendations identified during the SEA process

3.1. Sugar cane farming

The MAAS envisages, that the sugar cane farming may gradually decrease from 70 550 ha in 2005 to some 63 000 hectares by 2015. This SEA analyzed overall environmental impacts associated with the continued sugar cane farming in Mauritius. Assessment of sugarcane farming focused on the following issues:

- Burning of sugar cane;
- Use of fertilizers;
- Use of pesticides;
- Impacts of sugar cane farming on soil properties;
- Impacts of sugar cane farming on erosion; and
- Water demands of sugar cane farming.

3.1.1 Burning of sugar cane

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 6 to the SEA report.

Current situation

All over the world the trend is to avoid sugar cane burning before the harvest because airborne particles emitted during burning are considered as an important nuisance factor. Mauritius generally follows this trend and the pressure from the local population and the tourists is expected to force the agricultural sector to stop burning within next few years.

Sugar cane burning in Mauritius has generally not occurred in areas managed by small planters who generally do not intentionally burn their fields before harvest. Small planters generally do not burn sugar cane in their fields before harvesting. Most of them have plots of land which cannot be split to burn. The day-to-day burning operation is the usual way to manage this practice. The small farmer's way of management, related with labour force and equipment resources require at least a minimum of 2 or 3 days to harvest their field and deliver their sugar cane to the factory. This too long period causes reduction of weight, reduction of sugar content and may cause difficulties during milling processes.

Sugar cane burning was practised in 1995 on approx. 35% of 48 000 ha managed by corporate miller-planters on both mechanically and manually harvested fields. There is no law that prevents such intentional sugarcane burning. After the adoption of a voluntary code of practice on cane burning by the sugar industry (signed by all cane producers and approved by MoE in 2001), cane burning reduced gradually to less then 10% of cultivated sugar cane area in 2005.

However, the full phasing-out of burning was constrained by :

- Intentional burning during mechanical harvesting which is undertaken to enhance efficiency of harvesters. As of 2006, it occurred on approx. 4000 ha (i.e. 20 to 25 % of mechanically harvested fields that covered 18 000 ha). For mechanical harvesting**,** efficiency of harvesters is increased up to 30 % (e.g. 40 - 50 t/hr in burnt cane[5]) when compared with cutting in green cane (an average of 30 - 40 t/hr). Such intentional burning occurs during several weeks per year, it is usually localized and its total air emissions decrease with use of "cool burning" during early morning hours.
- Intentional burning during manual harvesting that was practiced on about 6000 ha of cane fields managed by large planters and miller-planters.
- Accidental/criminal burning that recurrently affected about 1000-2500 ha annually. Such fires are nearly impossible to control due to difficulties in obtaining evidence of proof for legal actions and decisions by Courts.

Impacts of the MAAS proposal

The MAAS notices the gradual decrease in the sugar cane burning but does not provide any direct intervention to further minimize this practice.

The analyses performed by the SEA team however indicate that 33 880 ha will be by 2015 harvested mechanically by large and miller planters and 850 ha by small planters. This doubling of the mechanically harvested area of Mauritius will be prone to cane burning especially if the increased demand for efficiency during the sugarcane harvesting will prevent further uptake of the green cane harvesting.

The future cost saving measures may also increase sugar cane burning during the mechanical harvesting in humid areas and super-humid areas during the dry months of September to November. In such areas, a complete mulch blanket cannot be left on the fields because of its negative impacts on excessive soil moisture conservation and pest management. However, as the green cane harvesting becomes more widespread, new issues related to pest control emerge and research in this area is already being undertaken by MSIRI.

Recommended mitigation or enhancement measures

Due to significant benefits of green cane harvesting (decrease demands for herbicides, soil moisture conservation, prevent erosion, soil carbon storage) and social undesirability of cane burning in Mauritius (nuisance factor and negative esthetic impacts) it is recommended that:

- The financial support for mechanization of field operation through the MAAS should encourage continuation of the current trend

[5] Jacquin E., Mac Intyre G., Poser C., Pyneeandee J., Rivière V., Siegmund B. 1993. MSIRI-CIRAD Cellule mécanisation Rapport d'activités 1992-1993. Montpellier, CIRAD-CEEMAT, 48 p.

towards green cane harvesting. Large planters should be required to phase out cane burning and small planters should be required not to begin cane burning.

- Research should examine means for economically viable removal of trash (or a part thereof) and tops from the field in super-humid areas where leaving the trash blanket would cause agronomical problems. Such collected trash could be used in composting or for energy production.

Indicators for monitoring

1. EU and the Government of Mauritius discuss by the end 2007 measures to avoid sugar cane burning through the implementation of the MAAS.

2. Starting in 2008, the Government of Mauritius annually reports on the total area where intentional burning was practised.

3.1.2 Use of fertilizers

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 7 to the SEA report.

Current situation

There has been no significant change in the use of fertilizers in Mauritius over the past 10 years.

An annual consumption of N has slightly declined from 11 634 tonnes in 1996 to 9356 tonnes in 2005. An annual consumption of phosphate has stabilized around 4000 tonnes per year with possibly one-off increase to 5849 tonnes in 2005. An annual consumption of potassium has fluctuated between 14 500 and 11 500 tonnes. However, no change in these trends seems to be significant enough to cause any major change in the supply of nutrients into water bodies.

The field test results obtained during the an international research projects completed by the MSIRI in 2001[6] indicate that normally fertilized sugar cane fields in Mauritius may lose 2.2-8.8 kg of N/ha/yr and 0.5-0.9 kg of P/ha/yr. Based on these findings, the MSIRI concluded that:

- the transport of N and P through the surface run-off, during the periods of heavy rainfall, were insignificant from an agronomical viewpoint, but might however be an environmental concern since the concentrations of N and P in the run-off may raise above the limits for degraded waters;
- sugar cane cultivation impact on eutrophication of freshwater bodies in Mauritius probably small;
- climate/weather more important than soil conservation measures in affecting agrochemical movement (e.g. mulching did not have much impact on N and P moved by surface runoff when

[6] MSIRI paper "Measurement and Prediction of Agrochemical Movement in Tropical Cane Sugar Production"

compared with that of bare soil);
- the water contamination measures are best taken at source through improved fertilizer management (e.g. applying fertilizers in dry season and avoiding their excess usage);
- residual surface wash-off could managed especially through better improvement of riparian zones, combined with targeted uses of vegetative buffer (e.g. vetiver) and appropriate soil cover on sloping lands (e.g. minimum tillage).

The MSIRI at the same pursues the following research projects related to environmentally friendly forms of fertilizing:
- Biological fixation of nitrogen from the atmosphere by the right species of bacteria. In other sugar cane producing countries such as Brazil, nearly half the N requirement of the cane is met by this method.
- Green manuring with legume crops which are ploughed into the soil before replanting. A large amount of N (170 to 200 kg) per hectare can be fixed from the atmosphere by leguminous crops such as lablab[7].
- A possibility of using slow release fertilizer N which could again help to reduce the amount of N applied to sugar cane fields. This type of fertilizer could also, if found appropriate be useful to other crops, such as vegetables and fruit trees.

Impacts of the MAAS proposal

The MAAS proposal does not foresee – except improvements in the use of agrochemicals resulting from the regrouping projects - any changes in the fertilizing practices in the sugar cane cluster.

A *preliminary* nitrogen balance conducted within the SEA however indicated that Mauritian agricultural lands had received during 1996-2005 about 25 000 tonnes of N (or 2500 tonnes of N annually) in excess of the sound fertilizing practices recommended by MSIRI and AREU. Averaging[8] such an annual surplus of 2500 tonnes of N on all agricultural lands (approx. 85 000 ha) in Mauritius have annually received around 29.4 kg/ha of surplus N.

Such average annual surplus N in the use of the fertilizers in Mauritius would be in excess of the recommended limit of 25kg of surplus N/ha/yr which has been established by the European Commission and the IFC as the basic guideline for limiting eutrophication. Naturally, such surplus would not automatically enter into water bodies. The MSIRI's research indicates that 22% of the total N input on lands through fertilizers is immobilized in the soil and up to 15% could be lost through denitrification.

[7] Results obtained so far by the MSIRI show that only about 20% of such nitrogen fixation was actually absorbed by the plant cane crop. Further studies are presently under way at MSIRI to determine whether this N will still be available to the next ratoon.

[8] The SEA team is at the same aware that averaging surplus N on all agricultural lands does not provide precise results since many farmers do follow the advice on fertilizing properly, whereas others may not.

When one considers the fact that e.g. excrements contained in the waste-waters from the urban and rural population load approx 6700 tonnes of N per year – than the total annual surplus of N (2500 tonnes) through the excessive use of fertilizers on agricultural lands would imply that agricultural activities should be treated as only smaller contributing (rather than driving) factor in the eutrophication of water resources in Mauritius. At the same time, it is important to consider that Mauritius is surrounded by an extremely fragile coastal environment with a limited absorption capacity for nutrients.

Recommended mitigation or enhancement measures

1. All planters (large or small) who obtain EU support within the MAAS should be formally required:

- To strictly follow MSIRI advice on the use of fertilizers, on soil management practices and on sustainable agricultural practices. All supported planters (large and small) should keep records of fertilizers used for inspection.
- To adopt minimum tillage (where the land has already been completely prepared for mechanization) or to establish "frameworks of vegetative buffers" (on those sugar cane lands where minimum tillage cannot be practised).
- To stop farming within the buffer zones of rivers and streams (minimum of 15 metres from the river/stream bank). All projects on regrouping and mechanization should establish minimal vegetative buffers along amelioration channels (e.g. 2 metres on each side of the channel bank) in the sugarcane fields. Such an approach is already taken in the first regrouping projects and it should become a standard practice.
- Irrigated lands with slopes over 3% should be accompanied by a targeted planting of protective vegetative buffers (e.g. vetiver) on borders of irrigated lands.

2. Implementation of the MAAS should be accompanied by a detailed study on nitrogen and phosphate balance of Mauritius which would verify and further refine preliminary conclusions reached within the SEA. Such study should adhere to principles contained in internationally recognized methodologies (e.g. OECD/Eurostat Gross Nitrogen Balances Handbook) and the outcomes obtained should be reviewed through a wide participatory process (involving e.g. stakeholders consulted within this SEA). It would be beneficial if organizations such as the MSIRI, AREU and University of Mauritius would be collectively involved in such study.

3. Future fertilizing guidelines[9] for different crops should be based not only on their nutrient needs but also a need to minimize surplus N and P.

4. The ongoing research projects at MSIRI on green manuring and slow release fertilizer should be further pursued.

[9] MSIRI indicated that it already addresses this consideration for sugarcane.

Proposed flanking mitigation measures not strictly related to the MAAS

1. Should the balance of phosphate indicate that use of phosphate-based washing soaps and detergents pose a particular risk for eutrophication of the lagoon, the Government of Mauritius should be encouraged to consider possible regulatory arrangements for use of phosphate-free detergents and soaps in Mauritius.

2. Inappropriate planting practices (e.g. soil preparation that does not follow contours) should be legally banned.

3. All agricultural activities (e.g. farming of water cress) should be removed & relocated from the river streams.

4. Enforcement powers and resources of the competent authorities having responsibilities for protection of riparian zones should be enhanced.

Indicators for monitoring

1. The Government of Mauritius annually reports, starting in 2008, on:

- The total volumes of used fertilizers in the sugar cane sector (separate from the other sectors);
- The total area of sugar cane lands where minimum tillage or other; soil protection measures have been established;
- Total length of riparian zones where sugar cane farming was stopped due to regrouping projects (this to be compared with the total length of rivers and streams which border or intersect sugar cane fields);
- Total length of riparian zones converted to semi-natural state due to regrouping projects (this to be compared with the total length of rivers and streams which border or intersect sugar cane fields);
- Total length of amelioration channels with minimal vegetative buffers of 2 metres on each side of the channel bank;

2. Detailed study on nitrogen and phosphate balance of Mauritius is completed by 2008 and new guidelines for minimizing any surplus application of nitrogen- and phosphate- based fertilizers and/or for minimizing surface and sub-surface transport of nutrients are elaborated for various crops by 2009.

3. Should the phosphate balance prove that these substances pose particular risks for euthrophication of the lagoon, the Government of Mauritius should consider by 2010 possible measures for potential phase-out of phosphate-based detergents and soaps.

4. The Government of Mauritius bans by 2008 inappropriate planting practices (e.g. soil preparation that does not follow contours) and agricultural activities in the river streams.

5. The Government of Mauritius enhances by 2008 the enforcement powers and resources of the competent authorities having responsibilities for protection of riparian zones.

3.1.3 Use of pesticides

Current situation

The sugar cane industry uses the following chemicals for pest and disease control:

- No nematocides are used in Mauritius since no sugar cane is planted on sandy soils[10]
- Fungicides are applied on planting material in a very limited quantity (approx. 600 kg of a.i. every year).
- Very limited amount of insecticides on sugar cane lands are applied only during February around the Mauritius Airport to prevent possible invasion of alien insects that could be transported by airplanes (e.g. white grub from Reunion Island). Insecticides are also applied if severe attacks of army worms are noticed in certain sugar-cane fields. However, the total volume of applied insecticides is negligible,
- Herbicides of various forms represent the largest share of pesticides used in the sugar cane cluster in Mauritius.

The total application of herbicides on sugar cane lands in Mauritius peaked in 1975 when it reached 10 kg a.i./ha[11]. Such use of herbicides has decreased to a yearly average of 8.5 kg a.i./ha[12] in the 1980ies. Since 1992, the use of herbicides sharply declined and it eventually decreased to 4.1 kg a.i./ha in 2002[13]. This means that the application of pesticides has nearly halved between 1992 and 2002 because of the following factors:

- rapid increase in the price of herbicides;
- availability of more effective herbicides; and
- gradual uptake of green-cane harvesting which started in 1992 and which by 2002 has limited application of pesticides on “green harvested” sugarcane fields.

As the MSIRI expected this trend to continue in 2000, it proposed to further reduce the total annual herbicide application on sugarcane lands to 3.5 kg a.i./ha[14]. However, this target has not been achieved – on the contrary the actual application of herbicides doubled in 2005 and 2006 as compared with the expectation by the MSIRI. It reached an annual rate of 7.4 kg a.i./ha[15]. If 13 500 ha of sugar cane fields which were harvested in green cane in 2005 have not been,

[10] Nematodes occur mainly in sandy soils
[11] Approx. 840 tonnes of a.i. were applied on approx. 84.000 ha of sugar cane lands
[12] Approximately 680 tonnes of a.i. were applied on approx 80.000 ha of sugar cane lands. The fluctuations in data throughout the 1980ies can be attributed to storage of herbicides between years and the resulting variations in their yearly purchase figures.
[13] 300 tonnes of a.i. were applied on 73 000 sugar cane lands in 2002
[14] The intention was to apply 250 tonnes of a.i. on 71 500 ha sugar cane lands
[15] 523 tonnes 70 500 ha sugar cane lands

theoretically, subject to extensive application of herbicides, then an approximate rate of annual application of pesticides in Mauritius in the 2004 and 2005 ranged between 7.5 and 9.7 kg a.i./ha. This is twice as much as e.g. application on the neighbouring Reunion Island[16] and the latest rates of annual herbicide application roughly equal to rates used in Mauritius in the 1980ies.

Such rates of application of herbicides occur because with the VRS I, a part of the labour which used to manually weed cane fields, had retired. A herbicide application had therefore to be made to compensate for the manual operations.

Impacts of the MAAS proposal

The large-scale planters in Mauritius have traditionally become used to very rigorous control of weeds on their fields. This was feasible due to availability of off-season labour which was used to complete weed control by chemicals. With the MAAS, such availability of off-season labour will be significantly reduced. The VRS-II will further limit availability of the workforce for weed control at miller planters. This may lead to increased application of herbicides on sugar cane lands.

Recommended mitigation or enhancement measures

All sugar cane planters supported through the MAAS should adhere to an overall approach of weed management (i.e. accepting certain level of weed infestation which is harmless to the crop) rather then trying to exercise total weed eradication with the use of herbicides. MSIRI is already recommending weed management strategies along this direction, which will reduce further the amounts of herbicides used by sugarcane growers. In addition, MAAS promotes mechanized harvest and Green Cane Trash Blanket which will further reduce the amount of herbicides used.

Such transition from weed eradication to weed management will have a beneficial effect on the environment as well as on the profitability of the sugar cane farming. In order to facilitate such transition, the supported farmers (both large-scale or small-scale) should be encouraged to reduce the application of herbicides to 2-4 kg/ha/yr, as used e.g. in Reunion Island to 2010. This can be achieved and may even be lower than the above figures, by the use of more potent herbicides which are effective in grams rather than kg.

Indicators for monitoring

1. By 2009 all planters (large and small) that are supported through the MAAS will have agreed to adopt an overall approach of weed management (i.e. accepting certain level of weed infestation which is harmless to the crop) and to gradually lower application of pesticides to a maximum levels recommended by MSIRI.

2. Government of Mauritius starting in 2008.annually reports on the application of herbicides on sugarcane lands managed by all planters

[16] Herbicides in Reunion were applied on sugar cane lands at rates 2-4 kg of a.i./ha in 2005

3.1.4 Impacts of sugar cane farming on soil properties

Current situation

Even if sugar cane has been cultivated in Mauritius on the same land for centuries, there is no evidence of any deterioration of the soil properties. This is probably due to the fact that the sugar cane plant produces a large amount of underground organic material (roots, rhizome) which when degraded by soil micro-organisms will produce a fair amount of organic matter. The soil is not depleted of its nutrient content because the normal practice is to restore the needs of the crop with various nutrients.

Size of rocks is considered as essential to maintain soil structure and porosity properties. During heavy mechanical land management works (especially since the 1980's), small rocks are sometimes crushed and mixed with the soil to improve drainage. Use of heavy machinery does not seem to cause soil compaction and measures for soil conservation are usually taken.

Impacts of the MAAS proposal

The MAAS proposes land management practices that imply field lay-out, levelling, development of appropriate access roads, a good water management with, e.g., water ways for drainage and erosion control.

Proposals contained in the MAAS related to derocking of around 20 000 ha may lead to some damage to the soil, e.g. mixing the top soil and the subsoil, thus causing a lowering of the natural fertility of the soil.

Derocking, field preparation and regrouping of small planters will pave the way for mechanization of field operations. Full or partial mechanization will increase use of harvesters and other machinery. The use of harvesters on Mauritian sugar cane fields has been shown to cause soil compaction (increased soil bulk density) immediately after mechanized harvesting in the top 20 cm layer. However, research conducted by the MSIRI[17], [18]indicates that the bulk density decreases naturally through the season and measurements taken after 12 months show that bulk density is only slightly higher than pre-harvest values.

Recommended enhancement measures

Organic matter will need to be supplied to the fields, possibly using scums, available vinasse or CMS. Such practice has proved beneficial during the past twenty years of land preparation for mechanization.

[17] Ng Cheong, L. R., Rivière, V., Jacquin, E., Soopramanien, S., (1999). Soil compaction due to mechanized harvesting and loading. Proc. Int. Soc. Sug. Technol. 23 (2): 43 - 51.

[18] Rivière, V., Marot, C., Ng Cheong, R., Jacquin, E., (2001). Performance of chopper harvesters and their effects on soil and crops at Beau Champ S.E. In: Lalouette, J. A., Bachraz, D. Y., and Sakurdeep, N. (eds.). Proceedings of the 4th Annual Meeting of Agricultural Scientists, Boname Hall, MSIRI, Reduit, Mauritius, 21 - 22 October 1999. pp. 39 - 45.

3.1.5 Impacts of sugar cane farming on erosion

Current situation

The natural vegetation is the most effective protection against erosion. When natural ecosystems were in Mauritius converted to other uses, then sugar cane would be widely regarded as the best protective crop given the climatic and rainfall patterns (cyclone) and properties of local soils. Numerous research studies conducted by the MSIRI to analyse impacts of different sugar cane varieties on the soil erosion indeed indicate that the sugar cane rates as one of the best agricultural crops that limit soil erosion, particularly in slopes.

This however does not mean that the water erosion does not occur. Indeed, at least 5 local experts consulted during the Scoping Study shared their personal perception that river bodies during heavy rains reportedly transport considerable amounts of suspended solids into the lagoons. They noted that this fact must be taken into account since its may, together with industrial and urban effluents, cause synergistic impacts on hyper-nutrification of the coastal lagoons.

Impacts of the MAAS proposal

Regrouping and preparation for mechanization will require lay-out and especially levelling of fields. This implies making provision for water erosion control (water ways to improve drainage during heavy rainfall, plantation in contours).

Wind erosion is not expected to have a negative impact when fields are prepared for mechanization.

Recommended mitigation and enhancement measures

All projects on regrouping and mechanization should ensure that:

- Sugar cane farming is stopped within the riparian zone along rivers and streams (minimum of 15 metres from the river/stream bank) and that such riparian zone is converted to semi-natural state.
- minimal vegetative buffers are established along amelioration channels (e.g. 2 metres on each side of the channel bank) in the sugarcane fields. Such an approach already occurs in the first regrouping projects and it should become a standard practice.

Indicators for monitoring

1. Total length of rivers and streams which border or intersect sugar cane fields & total length of riparian zones where sugar cane farming was stopped due to regrouping projects & total length of riparian zones converted to semi-natural state due to regrouping projects

2. Total length of amelioration channels with minimal vegetative buffers (e.g. 2 metres on each side of the channel bank)

3.1.6 Water demands of sugar cane farming

Current situation

Official figures published by the Water Resources Unit (WRU) specify that some 50 per cent of the total of utilized water resources in Mauritius is destined to agriculture. Out of this, approx. 90 % goes to cane production (since sugar cane occupied 90% of agricultural

lands).

North: Altogether 20 million m^3 of water are required annually mainly for the sugar cane but also for other crops, mainly vegetables. It is partly supplied by the Midlands Dam (stage I). Stage II of this project is expected to significantly increase the capacity of the dam, a proportion of which is expected to be used for irrigation of a larger area of sugar cane fields and of vegetables.

A plan for the Bagatelle Dam has been prepared to provide additional domestic water supply to Port Louis. There is also an ongoing study to examine various options for the retention of water in the South for distribution to the southern region.

Other parts of the island: The sources of water for irrigation in other parts of island are:

- rivers;
- underground water; and
- 30 000 – 40 000 m^3 per day of treated urban waste-water at St Martin (in the West) which are diluted with river water in the ratio of 1 to 1 to meet irrigation standards and is used mainly for medium sugar cane planters.

Recent water-shortages are becoming increasingly frequent (e.g. 1999 was the driest year on record for the past 100 years; 2006 was also a fairly dry year). When this happens, priority is given to drinking water, thus significantly reducing the amount of water used for irrigation purposes.

The water demands increase rapidly and the UNDP is foreseeing a major water stress in Mauritius by 2025. Some tourist entrepreneurs are therefore starting investing in desalination plants. The main drawback is the relatively high price of this treatment.

The key issues of concern are the water rights defined under the Rivers & Canal Act that dates back to 1863. Additionally, the water right is protected by Section 8 of the Constitution. The specific water rights are granted by the Supreme Court according to an established procedure and they cannot be removed, varied or modified except by the Supreme Court itself.

The Central Water Authority has been examining water rights. A comprehensive water-related legislation has been drafted in Mauritius through cooperation of the relevant agencies, including the Ministry of Public Utilities (MPU) which has the lead responsibilities with regard to water supply issues. The proposed legal framework for water resource management is however not yet adopted and its impacts on the irrigation of sugarcane lands are yet unknown. The MoE particularly noted that such comprehensive water legislation is needed to allow for implementation of an Integrated Water Resources

Management concept which is currently proposed by draft White Paper on National Environment Policy.

Impacts of the MAAS proposal

The MAAS envisages that by 2015, 46 % of the area under sugar cane belonging to large planters / sugar estates and 57 % of land of small planters, will be irrigated. This implies a larger volume of water for irrigation. This additional water will be obtained from increased capacity of the Midlands Dam, pumping underground water from deeper layers and retention of water in the South of the island.

While it is understood that the required volume is likely to rise, this would however be mitigated by the increasing use of modern and more efficient irrigation systems such as pivot, dragline and drip, in both new irrigated areas and in replacement of current conventional irrigation systems still in use. The modernization of the irrigation sector will lead to more efficient and more judicious use of irrigation waters in the future (see the overview of irrigation systems for plots belonging to millers and large planters below).

Irrigation system	1996 (Ha.)	2005 (Ha.)	% change
High pressure guns	6 350	4 500	↓ 29%
Surface irrigation	1 600	780	↓ 51%
Pivot, drag line, drip	5 950	10 500	↑ 76%
Total	13 900	16 300	↑ 17%

Recommended mitigation and enhancement measures

The support under MAAS should consider financing especially of improved irrigation techniques to reduce water usage in sugar cane, such as the use of sprinklers.

It is also recommended that the current legal framework for water management which is based on the Rivers & Canal Act (1863) is gradually replaced by an integrated water management system which redefines the water rights and stipulates differentiated water pricing rules to encourage water saving.

Indicators for monitoring

An integrated water management system which redefines the water rights and stipulates differentiated water pricing rules that encourage water saving is developed by 2010.

3.2. Centralizing of milling operations

Assessment of the proposed centralizing of the milling operations focused on impacts of centralized sugar cane mills on water quality and on the increased transport from/to centralized milling plants.

3.2.1 Impacts of centralized sugar cane mills on water quality

Current situation

In 2006, 10 sugar mills were in operation. These decentralized mills generated – especially during the weekend cleaning - waste waters that contained mostly oil, small amounts of sugar, and other solid particles. These waste waters were treated by improved processes to provide acceptable quality (with respect to established regulations) for irrigation water.

Impacts of the MAAS proposal

The MAAS proposes that the number of mills be reduced from 10 to 4 in a few years (one in each of the four cardinal points). This will entail a significant reduction in the use of water for cleaning purposes and consequently the total volume of waste waters produced. The centralization of sugar cane mills is expected to decrease the water demands of the sugarcane processing by approximately 25% - i.e. from the current 8 m^3 water per tonne of cane to approx. 6 m^3 water per tonne of cane. The Belle Vue sugar factory has already reached a figure of less than 1.0 m^3/tonne of cane

The new mills will, as before, use all generated waste waters for irrigation purposes. They will however have to address a possible increase in waste water produced at each of these mills. In this regard, it is important to note that the centralized milling plants are expected to have better capacity for waste-water management than previous decentralized smaller-scale milling operations. Information obtained from the milling plants indicates that each plant will have an upgraded treatment plant which will be designed once the quantity and quality of the waste water produced after centralization is known. All the treated waste waters will continue to be totally used for irrigation purposes.

3.2.2 Transport from/to centralized milling plants

Current situation

Sugar cane cluster currently produces about 5 to 6 million tonnes of sugar cane annually. Until 2006, the large planters transported sugar cane directly to mills and small planters transported their harvest either to 20 loading stations located at past sugar mills or directly to operating cane mills.

Sugar cane cluster currently produces about 510 000 tonnes of sugar annually. Sugar is transported by lorries accepting 30 tonnes per load

and this requires approximately 17 000 trips made during approximately 160 days of the harvest period. This leads to approximately 100 to 110 trips per day from mills to the Sugar Bulk Terminal in Port Louis. Such transport can be regarded as negligible in the overall transport flows and its air quality impacts are not significant.

Impacts of the MAAS proposal

The MAAS aims to centralize milling operations to 4 plants. The number of loading stations will however not be affected as these are required to stay in operation by the existing agreements between the government and the industry. The transport of sugar cane from the loading stations will be organized by higher payload transport (approx. 30 tonnes per load) and part of it will be transported during the night. Despite this increased transport efficiency, the total transport demands for the harvested sugar cane (e.g. km tonne of cane) will surely increase as a result of centralization. The scale of such increase has not been precisely determined. However, its air quality impacts, when compared with overall transport flows in the concerned regions, were not perceived as a major issue of concern during the SEA scoping study, especially if the forthcoming regulations on emissions from diesel-driven vehicles are enforced within the sugarcane cluster.

The MAAS aims to maintain the overall amount of sugar produced on approximately the same levels, with the only difference being that that it will be transported to the Sugar Bulk Terminal in Port Louis from only 4 centralized milling plants instead of the current 10 mills. Impacts of this change on air pollution are negligible.

Recommended mitigation and enhancement measures

The centralized milling plants should establish the basic management systems for minimizing air emissions associated with the increased transport of the harvested sugar cane. Such systems should include plans for optimizing transport flows and measures taken to ensure that the used vehicles comply with the forthcoming regulations on emissions from diesel-driven vehicles.

Indicators for monitoring

The centralized milling plants develop the basic management systems for minimizing air emissions associated with the increased transport of harvested sugar cane by 2008 and provide this information to the relevant authorities for review.

3.3. Energy production at the sugar cane cluster

The proposed increase of the energy production in the sugar cane cluster was assessed with regard to the following particular issues:

- Impacts of energy production at the sugar cane cluster on the use of renewable and non-renewable energy sources;
- Air emissions of cogeneration plants at sugar cane cluster; and
- Management of generated coal ash.

3.3.1 Impacts of energy production at the sugar cane cluster on the use of renewable and non-renewable energy sources

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 1 to the SEA report.

Current situation

As at 2006, all 10 milling plants in the Mauritian sugar cane cluster operated power cogeneration plants (generation of steam and electricity). Three of them exported electricity to the grid throughout the year: namely FUEL, Belle Vue and Deep River- Beau Champ were producing electricity from bagasse during the crushing season and imported coal during the intercrop season. Another unit, Centrale Thermique du Sud (CTDS) was producing electricity all year round from coal only. The MAAS proposal indicates that all these plants collectively produced 1050 GWh of electricity (300 GWh from bagasse and 750 GWh from coal/bagasse) sold to the Central Electricity Board. The use of bagasse supplied approximately 20% of electricity produced in Mauritius over the past decade.

Impacts of the MAAS proposal

The MAAS proposal notes that so far 50% of the potential of bagasse is tapped to generate electricity for export to the grid and it suggests to double the energy generation from bagasse (from 300 GWh to 600 GWh). The MAAS at the same time suggests to increase energy generated from coal/bagasse by 2.5 fold (i.e. from present 750 GWH to 1700 GWh) by operating only 4 power plants that use high pressure and temperature (82 bars/525^{0}C) technologies that have a much higher bagasse/coal to electricity conversion efficiency. The plant at FUEL is planned to operate at 110 bars/5400C and the one at Médine at 82 bars/5250C. The boilers are planned to be equipped with travelling grates.

<u>Analysis of the MAAS proposal in terms of bagasse-electricity conversion efficiency</u>

Analysis of data obtained from the upgraded cogeneration plant at Belle Vue and the soon-to-be-completed cogeneration plant at Savannah indicate that both plants can produce 0.38 MWh of exportable electricity per tonne of bagasse. When 0.4 MWh of exportable electricity is used as a benchmark for, one can conclude that both plants reach 95% of the optimal performance for currently used 82 bars/525^{0}C technologies.

The data obtained from FUEL on its proposed upgrading of old cogeneration facilities indicate exportable electricity yields of 0.34 MWh per tonne of bagasse – i.e. 84% of the optimal performance if 0.4 MWh of exportable electricity is used as a benchmark for current technologies. The data on the proposed upgrading of old cogeneration facilities at Medine indicate exportable electricity yields of 0.32 MWh per tonne of bagasse – i.e. 80% of the optimal

performance. These plants could theoretically achieve even better performance if the readily available technologies (e.g. 110 bar steam pressure boilers, topping/combined cycles, etc.) combined with a careful control of moisture contents of the bagasse were to be used.

Analysis of the MAAS proposal in terms of coal-electricity conversion efficiency

The data obtained from the upgraded cogeneration plant at Belle Vue and the soon-to-be-completed cogeneration plant at Savannah indicate that both plants can produce 1.6-1.62 MWh of electricity per tonne of used coal[19]. Comparing these figures with a worldwide average production of 2 MWh/t of coal[20] leads to conclusion that both plants operate at approximately 80% effectiveness in terms of coal-to-electricity conversion rates. The same performance is also expected for the currently proposed plants at FUEL and Medine.

Analysis of the MAAS proposal in terms of overall coal-electricity conversion efficiency in the sugar cane cluster

An analysis of the overall coal-electricity conversion efficiency of the entire annual operation cogeneration plants indicates that any relative energy losses during the combustion of the coal at the modernized cogeneration units at Belle Vue and Savannah are offset and actually significantly exceeded by major energy gains from burning of bagasse. Indeed any calculation which would relate volumes of the consumed coal to the total annual electricity outputs from such plants (i.e. energy produced from coal and bagasse) can prove that such cogeneration plants offer a feasible alternative to coal-only power plants, especially if the Government of Mauritius would regard reliance on imported coal as an important strategic concern.

Similar conclusion can be also reached for the currently proposed cogeneration plants at FUEL and Medine. It should be noted that performance of these proposed cogeneration plants could be even further increased if they would opt for the most modern combustion technologies.

The above analyses provide solid reasons for a thorough consideration of possible prioritizing of investments into coal/bagasse power plants over coal-only power options in Mauritius. Minimizing reliance on the imported coal and maximizing use of renewable energy resources is currently a strategic priority for most

[19] The MSA noted that Belle Vue produces on average 1.65 to 1.70 MWh of electricity per tonne of used coal. At cruising speed higher yield can be expected. However, a power plant, on account of the night load demand constraints, has to substantially derate its output in the early hours of the morning. MSA also noted that in such circumstances, Savannah produces 1.7 MWh per tonne of used coal.

[20] This is an average coal-to-electricity conversion rate for the currently used thermal power plants worldwide.

energy policies worldwide and investments into upgrading of power generation facilities at milling plants offer a feasible way forward.

The amount of additional CO_2 per KWh exported from a bagasse/coal plants into the grid will be lower than that of a coal plants. Upgrading of old combustion facilities (such as Medine which uses 30-year old technologies) will also improve their currently high air emissions levels.

Recommended mitigation or enhancement measures

EU support to the MAAS should, as a priority measure, promote upgrading of cogeneration plants in the Mauritius sugar cane cluster. Such support should also stimulate the use of modern technological approaches - e.g. the use of 110 bar steam pressure boilers and turbo-generators for steam extraction & condensing, careful control of moisture contents of bagasse, use of topping/combined cycles or fluidized bed combustion processes - which can further significantly enhance energy production efficiency of such cogeneration units. The overall objective should be to increase the coal-to-electricity conversion rates above 80% for such plants.

Further to this, it is recommended that the EU support to the MAAS also stimulates:

- improvements in the energy efficiency of sugar factories;
- innovative uses of all forms of sugar cane biomass (such as use of the cane field residues or use of high-fibre cane); and
- research related to development of commercially viable Biomass Gasifier/Gas Turbines.

Indicators for monitoring

1. The Government of Mauritius conducts a thorough examination of total energy outputs of possible upgrading of all coal/bagasse cogeneration plants and compares it with the efficiency of planned coal-only power plants in the use of imported coal by the end of 2007. Conclusions obtained through the above examination are reflected in the future investment plans for development of the Mauritian energy sector by 2008.

2. All new cogeneration power plants that seek support through the MAAS consider possible use of modern technological approaches that enhance energy production efficiency. Applications for EU support should include analyses of options for achieving coal-to-electricity conversion rates around 2 MWh/tonne of coal.

3. The Government of Mauritius formulates by 2009 a research package on innovative measures to improve the overall energy efficiency of milling plants. This proposal is provided for consideration within EU R&D support to the MAAS.

3.3.2 Air emissions of cogeneration plants at sugar cane cluster

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 2 to the SEA report.

Current situation

Most of the old cogeneration plants in the Mauritian sugar cane cluster established before 1992 operated only basic air pollution abatement technologies (wet scrubbers) and their air emission were often significantly exceeding national standards for CO and particulate matters. Monitoring of ambient air quality and air emissions from boiler stacks done by the University of Mauritius is conducting (using equipment purchased out of GEF Fund of the World Bank) indicates that especially the levels of particulate matters were high being above 400-500 mg/Nm^3.

Impacts of the MAAS proposal

Future trends in air emissions due to proposals contained in the MAAS on upgrading of cogeneration plants can be illustrated on an example of modernized facility Centrale Thermique de Bellevue Limitée (CTBV) that operates as part of Belle Vue SE. The power plant at Belle Vue is the first one that innovated to operate high pressure (82 bars) boilers combined with electro-static precipitation systems.

The data obtained by the SEA team from the official monitoring report supplied by the MoE indicate that the air emissions of modernized facility Centrale Thermique de Bellevue Limitée (CTBV) are well below national air emission standards established by the Government of Mauritius and also well bellow air emission standards used by the International Finance Corporation (IFC).

The partial data obtained from all other cogeneration plants lead to a conclusion indicate that their modernizing through 82 bars/525^0C boilers and the use of relevant electro-static precipitators can generally reduce emissions of especially particulate matters. This expectation is valid particularly for the replacement of old combustion processes (such as those used in Medine), which would typically emit particular matter at rates of 600-800 mg/m^3.

The planned modernizing of cogeneration facilities is not expected to significantly reduce their emissions in terms of SO_x and NO_x. These pollutants are likely to be emitted at rates well below IFC standards. They may however further decrease if the currently commercially viable technologies based on combined cycles with fluidized bed combustion processes are used to replace classic grate-firing boilers or pulverised fuel firing.

Since these future estimates were obtained for imported South African coal which contains less than 1% sulphur, there is a need to ensure that the sulphur contents of any coal used in such power generation facilities does not significantly increase in the future.

Recommended mitigation or enhancement measures

The following basic precautionary measures, which are equally applicable to other coal-based power generation facilities in Mauritius, are recommended for cogeneration plans:

1. Project-level EIAs for all future power generation facilities needs to include a thorough modelling of impacts on the ambient air quality based on the requirements of the MoE to ensure that the applicable standards for the ambient air quality are not exceeded;

2. Cogeneration units (and all other power generation facilities in Mauritius) should be required to establish an ISO certified environment management system. A feasible option could be to begin by ISO 14031 “Environmental performance evaluation” or ISO 19011 “Environmental management systems auditing” and to gradually progress to the full environmental management under ISO 14001 or ISO 14004;

3. Quality of the coal used in the cogeneration plants (and any future coal-based power plants in Mauritius) should be monitored and a procedure should be in place for consulting MoE on any change of the coal quality.

Indicators for monitoring

1. Project-level EIAs for all future power generation facilities include a thorough modelling of impacts on the ambient air quality based on the requirements of the MoE to ensure that the applicable standards for the ambient air quality are not exceeded.

2. All power generation facilities in the sugar cane cluster establish an ISO certified environmental management system by 2010.

3. Basic monitoring system for the quality of the coal used in the cogeneration plants and procedure for consulting MoE on changes of the coal quality is established by 2008.

3.3.3 Management of generated coal ash

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 3 to the SEA report.

Current situation

Presently, all cogeneration plants produce fly ash from burning of bagasse and coal.

Fly ash from bagasse is an organic material that contains important soil nutrients and negligible levels of trace metals. It is thus used as fertilizer. Standard fly ash management practice in Mauritius includes its collection and direct applications on fields and/or mixing it with sugar factory scums to produce compost.

The coal ash is collected and used on access roads in the sugar cane fields and for land reclamation (levelling etc.).

Impacts of the MAAS proposal

The MAAS proposal suggests to expand the use of coal in the power co-generation facilities in the milling plants. The data on the proposed expansion of the use of coal in the co-generation units at the milling plants (see Annex…) indicate that powering of these co-generation units will annually require about 650 000 tonnes of coal. Such use of coal – if the South African coal will be used in the future – will produce approx. 90 000 tonnes of coal ash per year.

The SEA analysed the risks associated with the use of these volumes of the coal ash with regard to possible leaching of trace elements into water sources and risks associated with the possible presence of radioactive elements.

Possible leaching of trace elements from the coal ash in MU

The results of preliminary tests conducted by MSIRI in 2007 to determine concentrations of trace elements present in the coal ash produced by the power generation units at the Belle Vue and FUEL (on dry matter basis) broadly correspond with the values reported from Israel and USA. Such concentrations of trace elements (if proved by ongoing detailed testing) can be regarded as negligible.

Encapsulated use of coal ash (partial substitute for cement, aggregate in all kinds of concrete products, mineral filler in asphalt and pavements or controlled low strength materials) does not pose any risks of leaching.

Unencapsulated uses of coal ash in Mauritius are likely to have a little to no impact on groundwater and surface water quality, however some basic precautions is necessary. Use of coal ash for soil modification/stabilization, pipe bedding or fills below roads, buildings, parking areas, etc. should be preceded by:

- leaching tests using the method of dissolution of the coal ash in acid[21] which can be recommended as the most suitable tool for determining concentrations of trace elements in leachates.
- proper hydrogeologic evaluation to ensure adequate groundwater protection.

Risks associated with a possible presence of radioactive elements in coal ash

There is a reason for caution as the presence of radioactive elements may be an issue of concern in those construction materials that would contain coal ash at very high levels. Any possible larger-scale use of coal ash in the construction materials in residential and office buildings should be preceded by an analysis of radioactive elements present in the locally generated coal ash and by a comparison of the

[21] e.g. US EPA TCLP Method 1311 which can be adapted to test the leaching potential of heavy metals

obtained results with the concentrations of radioactive elements present in other materials used in the local construction industry. Outcomes of such analysis should be used to determine the maximum volume of the coal ash that can be used in the construction materials.

Proposed hierarchy of coal ash management options

An analysis of environmental impacts of possible alternative uses of the coal ash performed within this SEA suggests the following hierarchy of coal ash management options in Mauritius:

Fly ash
1. Partial substitute for cement
2. Mineral filler in asphalt, pavement & sealing materials
3. Ingredient in soil modification and/or stabilization, landscape repair or stabilizing foothills
4. Controlled low strength materials for road construction, vehicle parking areas or pipe bedding

Bottom ash
1. Controlled low strength materials for road construction, slope stabilization and erosion control.
2. Structural fills for foundations immediately below buildings and other structures, vehicle parking areas, or pipe bedding
3. Aggregate in lightweight concrete products for other than residential purposes
4. Aggregate in lightweight concrete products for residential buildings (if the potential risk of increased indoor radioactivity as a result of use of coal ash is ruled out)

Boiler slag
1. Mineral filler in asphalt, pavement & sealing materials
2. Aggregate in all kinds of concrete products for other than residential purposes
3. Structural fills for foundations immediately below buildings and other structures, vehicle parking areas,
4. Aggregate in concrete products for residential buildings (if the potential risk of increased indoor radioactivity as a result of use of boiler slag is ruled out)

Recommended mitigation or enhancement measures

The MoE within its existing mandate and powers defined by the Environmental Protection Act (Art. 7, item b) should establish a system for a centralized monitoring and supervision of all coal ash uses in Mauritius. Such system should be based on the following elements:

1. A system of an annual elaboration of coal ash management plans and of their compliance monitoring should be established. All power generation facilities using coal should be, at a minimum, required to annually provide the MoE with the following information for

approval:

- Results of the regular sampling of trace elements and of radioactive elements in the coal ash generated at the plant
- Proposed encapsulated uses (volume of coal ash to be used in different encapsulated uses)
- Proposed unencapsulated uses (volume of coal ash to be used/disposed in different locations & information on ground water levels in these sites)
- Information of the uses of coal ash during (any) previous reporting periods

2. The MoE should have an administrative authority to approve or amend the proposed coal ash management plans. All power generation facilities using coal should be also required to keep all records related to use/disposal of the coal ash and should make them available to the relevant monitoring agencies upon request.

3. The MoE should issue guidelines for the safe use and disposal of coal ash which can incorporate the proposed hierarchy of coal ash management options and additional detailed recommendations contained in the Annex 3 to this report. These guidelines should be used as support tool for the elaboration of the annual coal ash management plans by all major producers of coal ash in the country.

Indicators for monitoring

Government of Mauritius establishes a system for centralized monitoring and supervision of coal ash uses in Mauritius by 2009.

3.4. Production of ethanol

The assessment of the proposed production of ethanol focused mainly on vinasse management issues. The SEA also looked at the risks associated with the transport and storage of ethanol.

3.4.1 Management of vinasse

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 4 to the SEA report.

Current situation

Up to now, only about 1/3 of the molasses produced in Mauritius were used in 2 distilleries producing potable alcohol (Medine and Beau Plan) and one producing ethanol. The vinasse produced by Medine and Beau Plan is traditionally applied on fields around sugar factories. However Medine uses about 10% of its vinasse for composting with factory scums.

Information supplied to the SEA team on the management of vinasse in Medine SE and Belle Vue SE (see appendix to this analysis) indicates that their practices currently do not pose any major

environmental problems due to the limited volume of the produced ethanol and also due to availability of land for the direct application of the residual vinasse.

The SEA team also undertook one visit to Alcodis plant which indicated that the recent changes in the management of this plant and the investments into CMS production improved the previously heavily contested environmental management of this plant. However, one visit did not allow the SEA team to make any firm comments on the future environmental performance of this facility.

It was also noted that the MSIRI is currently conducting research on the application of vinasse (alone or mixed with other nutrients) on fields. The preliminary conclusions indicate that vinasse can safely be applied on sugar cane fields at rates of 12,000 to 15,000 litres per ha. Higher rates e.g. $100m^3$ ha^{-1} have also been found to be harmless to sugar cane and environmental consequences are being studied by MSIRI.

Impacts of the MAAS proposal

Overall analysis

The MAAS plans that all molasses produced in Mauritius will be used locally to produce ethanol. According to MAAS, 120 000 tonnes of molasses will be used to produce ethanol. The average production of vinasse is 12 litres per litre of ethanol. The yield of ethanol is approximately 240 litres/tonne of molasses, consequently, about 350 000 m^3 of vinasse have to be managed.

Vinasse generated during ethanol production is a major issue of concern. Vinasse is rich in K content and should not normally contain any heavy metals or toxic chemicals. However, vinasse is quite acidic, it contains high proportion of organic matter, it has high BOD (roughly as raw sewage) which means that vinasse can quickly (e.g. after 16-24 hours storage) be subject to anaerobic decomposition. Virtually all vinasse management options therefore, if inappropriately implemented and supervised, may considerably disturb neighbouring community with odour.

The SEA team analysed environmental risks associated with the various options for a disposal of the forecasted 270 - 360 million litres of vinasse and suggested the following 'general hierarchy' of vinasse management options[22]:

1. composting of vinasse;
2. concentration of vinasse into CMS and its application on fields (if CMS production uses residual energy from co-generation units);
3. direct application of vinasse on fields located at least 100 metres from residential areas and in the proximity of the ethanol

[22] This proposed 'hierarchy' only summarizes general recommendations formulated within this SEA. However a more precise hierarchy of vinasse management options for each ethanol plant needs to be determined through a detailed project level EIA.

distillery (to minimize transport demand)

Anaerobic digestion and partly also CMS burning offer possibly interesting future options for future energetic use of vinasse. However, each option so far poses significant environmental and technological risks. It is therefore recommended to continue research on these options to determine their technological and environmental constrains & opportunities. Such information can be used to inform the sugar cane industry community on the considerations on the possible future uses of these approaches in Mauritius after 2015 when the transitional support of the MAAS will have expired.

Recommended mitigation or enhancement measures

The recommendations below should be generally applicable to ethanol plants developed as the result of the MAAS as well as to any other ethanol producer in Mauritius, irrespective of whether locally produced or imported molasses are used.

1. As a matter of principle, any future ethanol producing facilities in Mauritius should be located:

- outside residential areas in order to minimize possible impacts of VOCs, H_2S and other odour causing substances. As a general pre-cautionary measure, it is recommended that ethanol plants and the nearest settlements be located at least 300 metres apart and this distance may be further increased depending on the local meteorological conditions (e.g. humidity, wind direction and topography). It is recommended that no developments be allowed within this buffer zone; and
- next to a sugar factory so that the ethanol production and vinasse management can effectively use the residual energy (which is usually available within the milling plant); and molasses which are directly available at the sugar factory are used (thus minimizing transport and storage demands).

2. New facilities for ethanol production need to ensure that the project design and the EIA process include:

- air modelling for the key emissions from the distillery and from the proposed vinasse management options (volatile organic acids and compound, H_2S or other odour-causing substances);
- analyses of possible risks in vinasse management (e.g. emergencies caused by overflows of storage areas; situations when vinasse or CMS cannot be temporarily transported out of the distilling plant; etc.); and
- a study to define an appropriate buffer zone from any existing and/or future urban settlement.

3. In order to ensure sound environmental management and compliance, all new ethanol plants supported through the MAAS should also operate an ISO certified environment management system (e.g. starting by ISO 14031 “Environmental performance evaluation” or ISO 19011 “Environmental management systems auditing” and

gradually progressing to full environmental management under ISO 14001 or ISO 14004).

4. Research and development assistance under the MAAS could also support analyses of technologies of ethanol production that produce smaller volumes of residual vinasse.

Indicators for monitoring

1. Project level EIAs for new ethanol plants include air modelling - with models that have been validated for the key emissions from the distillery; assess possible risks in vinasse management and define an appropriate buffer zone from any existing and/or future urban settlement.

2. All new ethanol plants supported through the MAAS operate an ISO certified environment management system.

3. Research and development assistance under the MAAS addresses technologies of ethanol production that produce smaller volumes of residual vinasse and technological/environmental risks and opportunities associated with the anaerobic digestion of vinasse and with CMS burning.

3.4.2 Risks associated with the transport and storage of ethanol

Impacts of the MAAS proposal

The MAAS aims to produce 30 million litres of ethanol annually. The ethanol is expected to be transported from distilling plants in volumes by lorries accepting approximately 30 000 litres per load. Hence, approximately 1000 trips will be needed to transport the produced ethanol from two centralized distilleries to the central blending station located at Port Louis or to the export facilities which may be located outside Port Louis. Impacts of such transport on the air quality are negligible, however due attention needs to be given to transport and storage of large volumes of ethanol which is highly inflammable.

Recommended mitigation measures

It is important to ensure that adequate safety management plans are prepared for transport of ethanol from the production sites and for its storage and export facilities.

Indicators for monitoring

Risk management plans for transport, storage and export of the planned 30 million litres of ethanol are elaborated and approved as part of the permitting system for new ethanol plants.

3.5. Conversion of sugar cane lands to other uses

Sugar cane lands are being increasingly converted to other uses, mainly for other agricultural activities (production of fruits, vegetables or livestock) or for development of infrastructure, e.g. housing, road or integrated resort schemes (IRS). Between 2001 and

2005, 6000 ha of sugar cane lands were converted to other uses - this means that on average, 1200 ha per year (i.e. approximately 1.6% of the sugar cane land) was lost annually during 2001-2005. This trend is increasing - according to the Chamber of Agriculture, 1700 hectares of sugar cane lands have been converted to other uses in 2006.

The decision of sugar cane planters (both large and small) to opt for other crops, pasture lands or even agro forestry, in lieu of sugar cane, is solely dictated by economic considerations. Currently, there are no precise objectives set, except for potato (which will continue to be grown on sugar cane lands – plant sugar cane interlines and between two cane crop cycles), as concerns non sugar activities.

Conversion of sugar cane lands to other uses is happening and is facilitated by the recent amendments to existing government regulations that removed a land-conversion tax for certain planters, for residential purposes or businesses. Abandonment of sugarcane farming in marginal and economically difficult areas is also becoming another important reason for conversion of sugarcane lands.

In this overall context, the SEA focused especially on:

- conversions of productive sugar cane-lands to other agricultural uses;
- conversion of sugar cane land in difficult areas to other uses; and
- conversion of sugar cane lands to housing & IRS.

3.5.1 Conversions of productive sugar cane-lands to other agricultural uses

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 5 to the SEA report.

Current situation

As per the Finance Act of 1994 and its subsequent amendments, the land devoted to other agricultural activities also increasingly includes sugar cane lands (e.g. plant sugar cane interlines and rotational lands-between two cane cycles) belonging to sugar estates, and rented out to small planters for food crop and tobacco production. Conversions of sugar cane lands are also likely to increase through the intended self-sufficiency of Mauritius in the production of vegetables and through interventions identified in the Non-sugar Sector Strategic Plan 2003.

Farming of vegetables and other short-term crops in Mauritius is generally believed to pose more serious environmental risks than farming of sugarcane because:

- Vegetables require finer land preparation than sugar cane and this can cause soil erosion by wind and water.

- Use of agrochemicals, especially pesticides, in most food crops is higher than in sugar cane.
- Vegetables would generally require more fertilizing and there is a risk that not all of the fertilizers applied will be taken up by the plants due to their relatively shallow root system. A certain proportion can thus be leached into ground waters.
- Vegetables also on average demand more water than sugar cane, and they need to be irrigated more regularly than sugar cane which can afford certain water stress. All these effects, when combined, may actually have adverse impacts on ground water quality and water availability, partly also on surface-run-off.

Other key issues of concern associated with the farming of food crops point to the following problems:

- licenses for application of agro-chemicals do not provide sufficient quality control (as these are often not required for purchase of agrochemicals);
- containers from the agrochemicals are often inappropriately disposed of, sprayers are washed in freshwater bodies, etc.;
- pesticide residues in the vegetables become an issue of concern, not only for the local population but especially as their future use in the tourism industry .

Impacts of the MAAS proposal

The MAAS proposal, besides its overall attempt to ensure continuity of the sugar cane cultivation on all suitable lands, does not directly deal with conversion of sugarcane lands to other agricultural uses. However, ongoing conversion of sugar cane lands to other uses is an issue that needs to be addressed.

Calculations of possible conversion of difficult sugarcane lands to other agricultural crops indicate that additional areas which would be occupied by crops other than sugar cane represent only 1,500-1,700 ha over the next 3-5 years, out of which approx. 500 would be feasible in difficult lands.

Thus, small planters on approx 1000-1700 ha may diversify from sugar cane to other agricultural uses. While such conversions may appear small, they may nevertheless cause environmental problems especially since small sugarcane planters do not generally have full expertise in farming other crops, except if they are also vegetable growers, which is sometimes the case.

The whole sub-sector of agricultural activities outside sugar cane at the same time appears as not fully planned and monitored (e.g. in terms of tillage or application of fertilizers & pesticides) and more stringent legislation and enforcement may be required (e.g. sellers of vegetables are currently not liable for quality of the vegetables sold). AREU is supporting planters of food crops but its resources and powers for enforcement have been limited so far. A draft code of practice for environmentally sound farming of vegetables that has

been elaborated, is being pilot tested but it still needs to be formally approved. Also resources for testing (chemical division of the Ministry of Agro-industry and Fisheries) have been so far very limited and reportedly sometimes focused on irrelevant tests.

Recommended mitigation or enhancement measures

A. Planters who wish to diversify from sugar cane should be provided with support under the MAAS only if they:

1 Choose appropriate crops for the local climatic and soil conditions. Such choice should ensure that conversion of sugar cane lands to other crops is properly managed (e.g. combination of crops, land management practices, wind barriers, erosion control plants such as vetiver etc.). The following particular factors need to be considered:

- In sloping lands: fruit trees, palm, pineapple. It is essential that regular contour rows of an anti erosion plant be established (e.g. vetiver, muguet). In cases where growers would like to keep sugar cane, palm or pineapple could replace alternate sugar cane row[23] in order to reduce competition for light. The sugar cane will not only serve as anti erosion agent, but can also be exploited in different ways.
- In relatively flat lands consideration should be given to sound management practices especially for water management, such as drains, waterways.
- Where vegetables are grown and for fruit trees in their young stages, it is necessary to establish wind breaks composed of suitable native plants which are adapted to the local climatic conditions of the region. The wind barriers should not be established using invasive species (e.g. to avoid plants like eucalyptus in dry areas)

2 In all cases, AREU recommendations on the use of agro chemicals (fertilizers and pesticides) and the adoption of proper varieties adapted to different soils types and climates should be strictly adhered to. Waste waters coming from the washing of spraying equipment should be collected into an impermeable space where organic materials can absorb the washings. Ideally, pesticides, which are in a powder form, should be packed in biodegradable/dissolvable plastic.

3 It would be desirable for planters diversifying from sugar cane to subscribe to the code of practice for environmentally sound farming of vegetables elaborated by APEXHOM.

[23] I.e. one row out of two sugar cane rows would be killed by a herbicide and this row would be planted by a palm (e.g. Pejibaye that does not need replanting after harvest)

B. The following support services[24] should be in place to properly manage & supervise production of these non-sugar cane crops:

- Strategic research: analyzing future demands (nationally and internationally) & identifying key crops that could be produced in Mauritius
- Selection of crop varieties and production of planting materials which are adapted to climatic (sub-tropical) conditions of Mauritius, which are pest & disease –free, etc.
- Financial assistance (conversion, machinery, etc.): through advisory services for obtaining soft-loans, etc.
- MQA-approved training and hand-on advising through extension services:
- Supporting the certification & quality assurance for vegetables and fruits (especially for export and tourism industry);
- Facilitating exchange of monitoring data on soil & water quality, quality of products, pesticide & fertilizer use. Twinning arrangements (possibly directly supported by EU) with similar R&D and assistance programmes in other ACP countries would be beneficial.
- export promotion & possibly also assistance with branding

Twinning arrangements with similar R&D and assistance programmes in other ACP countries (possibly directly supported by EU) are seen as beneficial.

Indicators for monitoring

Guidelines for diversifying from sugar cane are elaborated by 2008 and are formally endorsed by the relevant authorities by 2010 to ensure that any conversions of sugar cane lands to other uses are properly managed.

3.5.2 Conversion of sugar cane land in difficult areas to other uses

This sub-chapter summarizes outcomes of detailed analyses which are documented in the Annex 5 to the SEA report.

Current situation

The land under sugar cane to go down from 70 550 ha in 2005 to some 63 000 hectares by 2015.

In 2005-2006 MSIRI identified 12 341 ha of difficult lands where the abandonment of sugar cane will give rise to environmental, economic and social problems:

- Category A: 4642 ha of sugar cane lands which are either close to environmentally sensitive areas as proposed in the Review of the

[24] Agenda and outcomes to be co-agreed between key bodies (MSA, FARC, AREU, MSIRI, other research bodies – such as university of Mauritius; Chamber of agriculture, etc.) and beneficiaries to provide support services for these new crops. The funding should be provided only if the continuity after EU support is ensured.

National Physical Development Plan (April 2003) or present some economic/social risks to nearby villages, the tourism industry and artisanal fishing,

- Category B:1365 ha of sugar cane land on three inland slopes (of the same mountain ranges as Category A but not as steep) and one on the flanks of an isolated mountain,
- Category C: 6334 ha of flat to moderately sloping land in the humid to super humid regions.

The areas identified by MSIRI are larger than the 5000 ha stated in the MAAS because the MAAS adopted a different classification based on the following factors:

- Degree of rockiness is fairly high and intensive that even moderate derocking is uneconomical or the slope of the land under cane is steep;
- Mechanization even partial is difficult;
- Yields are fairly low;
- Cane cultivation costs are high;
- The very rocky areas are found in the drier parts of the country;
- They are most exposed to the adverse impact of drought and cyclones;
- Conversion into residential units and commercial sale is very difficult.

The MAAS suggests that these approximately 5000 ha of difficult areas could be released from sugar cane regime for:

- the cultivation of crops including fruit trees that have a positive effect on land conservation;
- the cultivation of high fibre cane or energy crops once identified and found to be commercially viable and sustainable[25];
- reforestation; and
- the development of eco-tourism and IRS projects, or
- establishing wind farms combined with cane in part of those areas moving away from sugar cane.

Impacts of the MAAS proposal

If one considers that the difficult sugar cane lands occupy 12 400 ha according to the MSIRI and that only 5000 ha would be converted to other uses under the MAAS, there would still be 7400 ha of difficult sugar cane lands which may be constrained by the decline in sugar cane profitability.

However, detailed calculations on conversion of difficult sugar cane lands to other agricultural crops performed within this SEA indicate only 500 ha of difficult lands can be expected to be converted to other uses. This leaves nearly 7000 ha of difficult lands which may be abandoned. Given the present context, it is unlikely that such area be rapidly converted to other uses. There is a risk that they may

[25] The MSIRI noted that such system can be sustainable if properly managed. MSIRI plans to initiate work on the specific cultural practices required for this new farming system.

become wastelands that represent particular environmental risks (wild fires, invasive species, etc.).

It this regard, it is encouraging to see that the New Forest Policy (2006) foresees an establishment of forests with multi-purpose tree species in combination with agricultural/horticultural crops for agro-forestry, deer ranching and eco-tourism on 7000 ha. This corresponds with calculations performed by the SEA team and it means that a serious attention should be given to an establishment of protected forests, nature parks or other agro-forestry projects using native species in difficult sugar cane area. Projects of this type could offer a feasible option for the conversion of sugar cane lands even in short time-spans (e.g. within 5 years).

Both small and large areas of protective forests or agro-forestry lands may also become a viable revenue-generating activity[26] if an economy-of-scale is established in this emerging sector. The practical implementation of these projects may, however, be constrained by the rental/ownership rights of the current land users. Such projects will also require a package of adequate support-measures that will be needed for the whole transition from sugar cane cultivation to protective forests or to agro-forestry projects.

Establishment of small atomized forests through conversion of the existing plots of land would certainly provide environmental benefits, but at the same time, such benefits may be even more significant if larger areas of protective forests are established with a help of some land-use exchange/transfer schemes.

Recommended mitigation or enhancement measures

All 12 400 ha identified by the MSIRI should be properly planned in terms of their potential for conversion to other uses while addressing the following site-specific factors:

- topography,
- soil properties,
- local climatic conditions,
- key features of plant crops,
- their demand for mechanization,
- requirement for infrastructure,
- resilience to fires,
- impact on the movement of invasive species, and
- landscape and wider land-use impacts.

Such conversions need to be planned and assessed in a site-specific context, ideally through an application of GIS-based tools which enable consideration of the above mentioned factors and which are available at MSIRI. In this regard, it is recommended that a close cooperation is established between the MSIRI, National Parks & Conservation Services, Mauritian Wildlife Foundation and also an

[26] production of honey, medicinal use, pesticide production

ongoing UNEP Integrated Assessment Project in Mauritius[27] which has a potential to provide useful inputs into these planning processes.

In the meantime, it would be useful to encourage planters in difficult sugar cane areas to keep sugar cane under cultivation with accompanying financial measures while planning conversion of these lands into alternative uses. The sugar cane would still be acting as an efficient erosion barrier during periods of moderate to heavy rainfall. During this transitional period, the cane could be exploited in different ways – e.g.:

- harvested as usual for sugar production;
- used for production of the cane juice for tourists in hotels (where fields are situated in their neighbourhood); or
- produce "Rum Agricole".

Planning conversion of these lands into other alternative uses during this transitional period could consider some of the following alternative uses which - if they are professionally managed –will have a positive effect on the environment (as there will be a complete ground cover after a few years and little amounts of fertilizers and pesticides):

- Deer ranching
- Cattle Ranching
- Fruit production
- Forestry
- Return to natural forest

Indicators for monitoring

Uses and conversions of all difficult areas identified by the MSIRI (12 400 ha) are properly planned by 2010 in terms of their potential, using appropriate planning and assessment tools (e.g. GIS) that allow for consideration of the following site-specific factors:

- topography,
- soil properties,
- local climatic conditions,
- key features of plant crops,
- their demand for mechanization,
- requirement for infrastructure,
- resilience to fires,
- impact on the movement of invasive species, and
- landscape and wider land-use impacts.

3.5.3 Conversion of sugar cane lands to housing & IRS

Current situation

Previous conversions of sugar cane lands to residential purposes were reportedly driven mainly by the following factors:

[27] UNEP/ETB project on Integrated Assessment of Trade Related Policies and Biodiversity Initiatives in the Agricultural Sector, implemented by the Ministry of Agro-Industry & Fisheries and AREU. Tge project is being financially supported by the European Commission.

- spontaneous conversions of sugar cane lands owned by the small planters to housing because of the low economic viability/profitability of the sugar cane farming; and
- planned interventions in the form of land-allocations under the VRS-I and conversions of sugar cane lands for development of new residential areas (morcellements) in order to finance the VRS-I.

The exact scale of larger land-use impacts of VRS-I is yet unknown as this issue has not been analysed so far. While some converted sugar cane areas were reportedly marginal lands, consultations during the scoping WS5 indicated that a considerable amount of the sugar cane lands converted to residential purposes under the VRS-I occurred on fertile lands (i.e. lands producing sometimes more than 80 tonnes of sugar cane per ha).

Environmental concerns of the previous spontaneous land-use conversions so far appear adequately managed under the Environmental Protection Act and also through supervision by the local governments. However, certain EIA provisions for land-use transfers were eased by the Business Facilities Act 2006 and such change in the EIA regime may weaken environmental supervision of the land-use conversions.

Planned conversion of sugar cane lands to IRS are however managed only through project-level EIAs which separately address many individual sub-projects in the IRS. There are concerns that such 'salami-slicing' approach to projects applications and EIAs may not allow authorities to address cumulative effects of such land-use changes.

Impacts of the MAAS proposal

Future conversions of sugar cane lands to residential purposes will be driven by the increased spontaneous conversions of sugar cane lands by the small planters and by newly planned interventions in the MAAS in the form of:

- land-allocations under the VRS-II (which will be available to 6000 field workers),
- land-allocations for laying off of 2000 factory workers; and
- corresponding conversions of sugar cane lands for development of IRS or residential areas in order to finance modernization of the milling plants and all financial packages outlined in the MAAS.

The land-conversions planned in the MAAS to IRS and residential zone in the coastal areas can cause significant negative long-term irreversible impacts on coastal environment. Various domestic

studies[28] suggest that in order to safeguard the quality of the Mauritian lagoons it is essential that zero impact of land-based activities on water resources be pursued as the ultimate target because the coastal waters are already under much stress.

Recommended mitigation or enhancement measures

Implementation of the MAAS should be accompanied by issuance of guidance on areas where such conversions can occur. In principle, the land-use conversions from sugar cane farming to housing should be allowed only in low productivity areas.

1. Projects on conversion of sugar cane lands to IRS, residential zones and golf courses in the costal areas should be allowed to proceed only:

- after completion of environmental assessment undertaken for the entire plan (i.e. preventing "salami slicing" approach) and involving in-depth site specific investigations of the quality of the receiving water bodies and analyze cumulative impacts of the proposed land-use options;
- if all new urban developments zones are provided with sewer network available to all houses and with the basic waste-water treatment facilities for both sewage as well as grey water. Pre-treated sewage and household waster-waters should undergo basic treatments for removal of N and P - e.g. land parcelling usually offers multiple options for design of artificial wetlands that can be significantly decrease nutrient loads and be at the same time integrated into land-use plans as landscaping elements of the new urban land zones)

<u>Proposed flanking mitigation measures not strictly related to the MAAS</u>

2. Removal of sea-grass beds from the lagoon which currently done as part of beach preparation for IRS (and tourism projects generally) should be strictly banned.

3. Soak-in pits that are currently widely used to dispose household grey water should be forbidden in all new urban developments in the coastal areas.

Indicators for monitoring

1. The Government of Mauritius establishes by 2008 an assessment system (SEA-type of procedure) to allow authorities to consider cumulative effects of IRS developments.

2. The Government of Mauritius by 2008 bans the removal of sea-grass beds from the lagoon and forbids soak-in pits for disposal household grey waters in all new urban developments in the coastal areas.

[28] Daby, D. (2001) A Review and Critical Assessment of Coastal Water Quality in Mauritius, In: Science And Technology – Research Journal – Volume 8 – 2001 , University of Mauritius, Réduit, Mauritius

4. Conclusions

4.1 Overall conclusions

Conclusions obtained from analyses performed within the SEA indicate that the MAAS proposal, in terms of its overall implications, is likely to achieve positive environmental effects.

This does not mean that no environmental risks will exist during the implementation of the MAAS. Indeed the SEA has identified several significant environmental concerns associated with some proposals contained in the MAAS. All these risks can however be managed if the adequate precautionary measures outlined below are taken during the implementation of the MAAS.

4.2. Proposed indicators for environmental monitoring and management of the MAAS implementation

In order to facilitate the practical use of the main recommendations formulated during the SEA of the MAAS, the key indicators for monitoring of the proposed environmental management system for the MAAS implementation are summarized in the table below. They have been clustered into:

- core indicators (outlining issues of highest importance);
- additional indicators (highlighting important issues which can be addressed through ad-hoc arrangements if they cannot be included into formal monitoring system); and
- indicators for implementation of flanking measures (which suggest actions that not directly related to the MAAS).

It is recommend that these indicators be formally considered and/or jointly approved by the European Commission and the Government of Mauritius.

#	Indicator	To be approved by the EC	To be approved by GoM
Core indicators			
1.	EU and the Government of Mauritius discuss by the end 2007 measures to avoid sugar cane burning through the implementation of the MAAS.		
2.	The Government of Mauritius annually reports, starting in 2008, on: • The total area where intentional burning was practised; • The application of herbicides on sugarcane lands managed by all planters • The total volumes of used fertilizers in the sugar cane sector (separate from the other sectors); • The total area of sugar cane lands where minimum tillage or other; soil protection measures have been established;		

	• The total length of riparian zones where sugar cane farming was stopped due to regrouping projects (this to be compared with the total length of rivers and streams which border or intersect sugar cane fields), the total length of riparian zones converted to semi-natural state due to regrouping projects (as compared with the total length of rivers and streams that border or intersect sugarcane fields), and the total length of amelioration channels with minimal vegetative buffers of 2 metres on each bank.		
3.	The Government of Mauritius establishes by 2008 an assessment system (SEA-type of procedure) for IRS developments to ensure that their cumulative effects are assessed.		
4.	Guidelines for diversifying from sugar cane are elaborated by 2008 and are formally endorsed by the relevant authorities by 2010.		
5.	Uses and conversions of all difficult areas identified by the MSIRI (12 400 ha) are properly planned by 2010 in terms of their potential, using appropriate planning and assessment tools (e.g. GIS) that allow for consideration of the following site-specific factors. Reforestation options are thoroughly considered in this planning process.		
6.	Government of Mauritius establishes a system for centralized monitoring and supervision of coal ash uses in Mauritius by 2009.		
7.	Applications for EU support for development of or upgrading of cogeneration plants at the sugarcane cluster analyze technological options for achieving conversion rates around 2 MWh/tonne of coal.		
8.	All power generation facilities and all new ethanol plants in the sugar cane cluster establish an ISO certified environmental management systems.		
Additional indicators			
1.	The Government of Mauritius conducts by the end of 2007 a thorough examination of total energy outputs of possible upgrading of all coal/bagasse cogeneration plants and compares it with the efficiency of planned coal-only power plants in the use of imported coal. Conclusions obtained through the above examination are reflected in the future investment plans for development of the Mauritian energy sector by 2008.		
2.	A basic monitoring system for the quality of the coal used in the cogeneration plants and procedure for consulting MoE on changes of the coal quality is established by 2008.		
3.	The centralized milling plants develop the basic		

	management systems for minimizing air emissions associated with the increased transport of harvested sugar cane by 2008 and provide this information to the relevant authorities for review.		
4.	Project level EIAs for new ethanol plants include air modelling for the key emissions from the distillery with models that have been validated; assess possible risks in vinasse management and define an appropriate buffer zone from any existing and/or future urban settlement.		
5.	By 2009 all planters (large and small) that are supported through the MAAS will have agreed to adopt an overall approach of weed management (i.e. accepting certain level of weed infestation which is harmless to the crop) and to gradually lower application of pesticides to a maximum levels recommended by MSIRI.		
6.	The Government of Mauritius formulates by 2009 a research package on innovative measures to improve the overall energy efficiency of milling plants. This proposal is provided for consideration within EU R&D support to the MAAS.		
7.	Project-level EIAs for all future power generation facilities include a thorough modelling of impacts on the ambient air quality based on the requirements of the MoE to ensure that the applicable standards for the ambient air quality are not exceeded.		
8.	Risk management plans for transport, storage and export of the planned 30 million litres of ethanol are elaborated and approved as part of the permitting system for new ethanol plants.		
9.	A basic monitoring system for the quality of the coal used in the cogeneration plants and procedure for consulting MoE on changes of the coal quality is established by 2008.		
10.	The centralized milling plants develop the basic management systems for minimizing air emissions associated with the increased transport of harvested sugar cane by 2008 and provide this information to the relevant authorities for review.		
Indicators for flanking measures which are not directly related to the MAAS			
1.	Detailed study on nitrogen and phosphate balance of Mauritius is completed by 2008 and new guidelines for minimizing any surplus application of nitrogen- and phosphate- based fertilizers and/or for minimizing surface and sub-surface transport of nutrients are elaborated for various crops by 2009. Should the phosphate balance prove that these substances pose particular risks for euthrophication of the lagoon, the Government of Mauritius should		

	consider by 2010 possible measures for potential phase-out of phosphate-based detergents and soaps.		
2.	The Government of Mauritius bans by 2008 inappropriate planting practices (e.g. soil preparation that does not follow contours) and agricultural activities in the river streams.		
3.	The Government of Mauritius enhances by 2008 the enforcement powers and resources of the competent authorities having responsibilities for protection of riparian zones.		
4.	Government of Mauritius by 2008 bans the removal of sea-grass beds from the lagoon and forbids soak-in pits for disposal household grey waters in all new urban developments in the coastal areas.		
5.	An integrated water management system which redefines the water rights and stipulates differentiated water pricing rules that encourage water saving is developed by 2010.		

Annex 1: Analysis of energy production at the sugar cane cluster on the efficiency in the use of imported coal

The primary author of this analysis is Jiri Dusik based on data inputs gathered by Guy Mc Intyre

Current situation

As of 2006, all 10 milling plants in the Mauritian sugar cane cluster operated power cogeneration plants (generation of steam and electricity). Three of them exported electricity to the grid throughout the year: namely FUEL, Belle Vue and Deep River-Beau Champ were producing electricity from bagasse during the crushing season and imported coal during the intercrop season. Another unit, Centrale Thermique du Sud (CTDS) was producing electricity all year round from coal only. The MAAS proposal indicates that all these plants collectively produced 1050 GWh of electricity (300 GWh from bagasse and 750 GWh from coal/bagasse) sold to the Central Electricity Board. The tables and graphs bellow illustrate that the use of bagasse supplied approximately 20% of electricity produced in Mauritius over the past decade.

Electricity production by source of energy, 1996 – 2005[29]

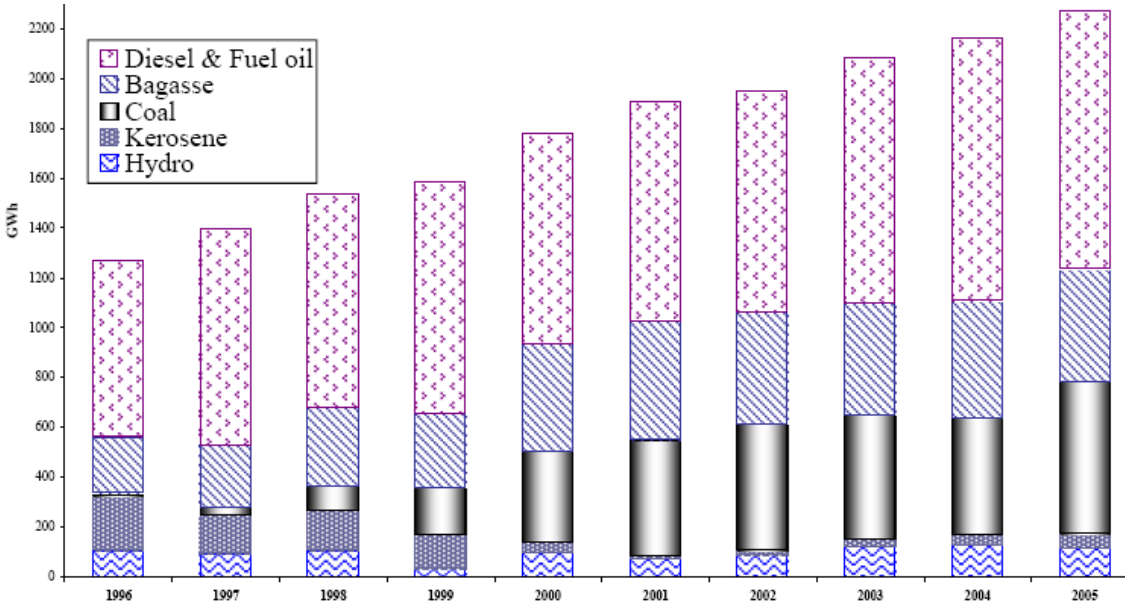
GWh

Power station	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CEB	**1,035.3**	**1,118.6**	**1,124.8**	**1,096.9**	**983.3**	**967.5**	**991.0**	**1,134.9**	**1,225.3**	**1,209.5**
Hydro	103.7	92.2	103.9	29.5	95.3	70.4	85.6	117.7	122.3	114.9
Wind	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
Island of Rodrigues	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.4*	*0.4*
Thermal	931.5	1,026.4	1,020.8	1,067.4	888.1	897.1	905.4	1,017.2	1,102.6	1,094.2
Island of Mauritius	*918.3*	*1,011.3*	*1,003.9*	*1,049.3*	*868.5*	*876.5*	*882.8*	*992.8*	*1,075.8*	*1,064.6*
Island of Rodrigues	*13.2*	*15.1*	*16.9*	*18.1*	*19.6*	*20.6*	*22.6*	*24.4*	*26.8*	*29.6*
IPP	**236.9**	**279.6**	**414.2**	**487.9**	**794.2**	**943.3**	**957.9**	**946.6**	**939.9**	**1,062.6**
Hydro	0.9	1.0	0.8	0.5	0.4	0.4	0.3	0.1	0.0	0.0
Of which : exported to CEB	*0.2*	*0.3*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Thermal [1]	236.1	278.6	413.4	487.4	793.8	942.9	957.6	946.5	939.9	1,062.6
Of which : exported to CEB	*128.8*	*148.0*	*256.7*	*343.7*	*601.2*	*710.2*	*746.7*	*729.4*	*725.1*	*835.4*
Coal (*Firm producers* [2])	9.8	23.4	62.4	155.2	322.7	413.7	447.6	433.4	407.2	533.8
Bagasse	119.0	124.6	194.3	188.5	278.5	296.5	299.1	296.1	317.9	301.6
Firm producers [2]	*79.6*	*66.1*	*81.8*	*110.8*	*167.0*	*182.8*	*171.1*	*176.2*	*191.0*	*185.0*
Continuous producers [3]	*39.4*	*58.5*	*112.5*	*77.8*	*111.5*	*113.7*	*128.0*	*119.9*	*127.0*	*116.6*
Total	**1,272.2**	**1,398.2**	**1,538.9**	**1,584.8**	**1,777.5**	**1,910.8**	**1,948.9**	**2,081.5**	**2,165.2**	**2,272.1**
Island of Mauritius										
CEB	1,022.0	1,103.5	1,107.8	1,078.8	963.7	946.9	968.4	1,110.5	1,198.1	1,179.5
IPP export to CEB	129.0	148.3	256.9	343.8	601.2	710.2	746.7	729.4	725.1	835.4
Total available for sales	**1,151.0**	**1,251.7**	**1,364.8**	**1,422.6**	**1,564.9**	**1,657.1**	**1,715.1**	**1,840.0**	**1,923.2**	**2,014.9**

[1] Estimates
[2] Producing electricity **all year** round with bagasse/coal
[3] Producing electricity with bagasse **only** during crop season

[29] Central Statistical Office, 2006

Electricity production by source of energy, 1996 - 2005[30]



Percentage share of electricity production by source of energy, 1996 - 2005[31]

Source of energy	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ISLAND OF MAURITIUS										
Primary energy	**8.2**	**6.7**	**6.8**	**1.9**	**5.4**	**3.7**	**4.4**	**5.7**	**5.6**	**5.1**
Hydro	8.2	6.7	6.8	1.9	5.4	3.7	4.4	5.7	5.6	5.1
CEB	8.1	6.6	6.8	1.9	5.4	3.7	4.4	5.7	5.6	5.1
IPP	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
of which: Export to CEB	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Secondary energy	**90.7**	**92.3**	**92.1**	**97.0**	**93.5**	**95.2**	**94.4**	**93.2**	**93.1**	**93.6**
Gas turbine (kerosene)	17.2	11.0	10.5	8.6	2.4	0.6	0.9	1.6	2.0	2.5
Diesel & Fuel oil	55.0	61.3	54.7	57.6	46.5	45.2	44.4	46.1	47.6	44.4
Coal (IPP)	0.9	2.1	6.1	11.9	20.4	24.4	25.9	23.9	21.7	26.8
of which: Export to CEB	*0.8*	*1.7*	*4.1*	*9.8*	*18.2*	*21.6*	*23.0*	*20.8*	*18.8*	*23.5*
Bagasse (IPP)	17.7	17.8	20.8	18.9	24.2	25.0	23.2	21.6	21.7	19.9
of which: Export to CEB	*9.4*	*8.9*	*12.6*	*11.9*	*15.7*	*15.5*	*15.3*	*14.2*	*14.7*	*13.3*
Sub total	**99.0**	**98.9**	**98.9**	**98.9**	**98.9**	**98.9**	**98.8**	**98.8**	**98.7**	**98.7**
RODRIGUES										
Primary energy										
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Secondary energy										
Diesel & Fuel oil	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3
Sub total	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.2**	**1.2**	**1.3**	**1.3**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

[30] Central Statistical Office, 2006
[31] Central Statistical Office, 2006

Proposals contained in the MAAS

The MAAS proposal notes that so far 50% of the potential of bagasse is tapped to generate electricity for export to the grid and it suggests to double the energy generation from bagasse (from 300 GWh to 600 GWh). The MAAS at the same time suggests to increase energy generated from coal/bagasse by 2.5 fold (i.e. from present 750 GWH to 1700 GWh) by operating only 4 power plants that use high pressure and temperature (82 bars/525^{0}C) technologies that have a much higher bagasse/coal to electricity conversion efficiency. The plant at FUEL is planned to operate at 110 bars/5400C and the one at Médine at 82 bars/5250C. The boilers will be equipped with travelling grates.

Analysis of the MAAS proposal in terms of bagasse-electricity conversion efficiency (operational during the crushing season)

Comparative studies on the use of bagasse-based power cogeneration in the US and India[32] indicate that up to 0.4 MWh of exportable electricity can be generally gained per each tonne of bagasse used in cogeneration units based on 82 bars/525^{0}C technologies. Use of readily available technologies (e.g. 110 bar steam pressure boilers) can increase electricity yields of cogeneration plants up to 0.5 MWh/tonne of bagasse. At the same time, future developments of commercially viable technologies for Biomass Gasifier/Gas Turbine (BIG/GT) offer even better prospects for such cogeneration units at milling plants. Such technologies may provide 0.6-0.9 MWh of exportable electricity per tonne of bagasse and they also open new opportunities for possible energetic use of sugarcane trash.

Analysis of data obtained from the upgraded cogeneration plant at Belle Vue and the soon-to-be-completed cogeneration plant at Savannah indicate that both plants can produce 0.38 MWh of exportable electricity per tonne of bagasse. When 0.4 MWh of exportable electricity is used as a benchmark for, one can conclude that both plants reach 95% of the optimal performance for currently used 82 bars/525^{0}C technologies. The data obtained from FUEL on its proposed upgrading of old co-generation facilities indicates exportable electricity yields of 0.34 MWh per tonne of bagasse – i.e. 84% of the optimal performance if 0.4 MWh of exportable electricity is used as a benchmark for 82 bars/525^{0}C technologies which are being the currently used. The data from planned upgrading of cogerenation plant at Medine indicates yields of 0.32 MWh per tonne of bagasse – i.e. 80% of the optimal performance.

All these plans could theoretically achieve even better performance if readily available technologies (e.g. 110 bar steam pressure boilers, topping/combined cycles, etc.) combined with a careful control of moisture contents of the bagasse[33] were used. However, the use of such technologies in the Mauritian sugar cane cluster appears uncertain given the ongoing discussion about the effectiveness of power generation at milling plants during their off-crop operations which require combustion of imported coal.

[32] Kevin Ho (2006) Potential of Bagasse-Based Cogeneration in the US, Columbia University, 2006
[33] An increase of 1% moisture in bagasse reduces boiler efficiency by 0.6%.

Analysis of the MAAS proposal in terms of coal-electricity conversion efficiency (operational during off-crop season)

The Official Energy Statistics of the US Government[34] indicate that each tonne of coal consumed at an electric power plant currently typically yields about 2 MWh of electricity. The specific production figures are determined by the technology chosen and by the heat content of the coal used. However, an average of 2 MWh/tonne of coal can be used as the general benchmark for comparison of coal-to-electricity efficiency of power cogeneration units at the Mauritian sugarcane cluster.

The data obtained from the upgraded cogeneration plant at Belle Vue and the soon-to-be-completed cogeneration plant at Savannah indicate that both plants can produce 1.6-1.62 MWh of electricity per tonne of used coal[35]. Both plants can thus operate at approximately 80% coal-to-electricity effectiveness during off-crop season. The same performance is also expected for the currently proposed cogeneration plants at FUEL and Medine.

Analysis of the MAAS proposal in terms of overall coal-electricity conversion efficiency in the sugarcane cluster

An overall coal-electricity conversion efficiency of the entire annual operation cogeneration plants has been prepared during the SEA (see appendix to this technical report). This analysis calculated the total annual electricity output of each cogeneration plant (i.e. electricity generated from coal and from bagasse) and divided this total annual energy output by the volume of the coal actually consumed.

The data obtained from this overall analysis indicate that any relative energy losses during the combustion of the coal at the modernized cogeneration units at Belle Vue and Savannah are offset and actually significantly exceeded by energy gains from burning of bagasse. Indeed any calculation which would relate volumes of the consumed coal to the total annual electricity outputs from such plants can prove that the cogeneration plants at the sugar cane cluster offer a feasible alternative to coal-only power plants. Similar conclusions were also reached for the currently proposed cogeneration plants at FUEL and Medine.

Naturally, the actual supply of the power into the electricity grid depends on many factors - such as energy requirements for cane processing, need for matching of energy export from the sugar cane cluster into the grid depending on the daily demand curve of the Central Electricity Board (which indicates the relativities between peak), base and night loads but also, more importantly, on the projected demand in time and the decommissioning schedule of old oil-based plants. In addition, coal/bagasse combustion allows the optimization of an environmentally friendly renewable resource, In terms of economic unit cost (or border cost), energy production at the

[34] US Energy Information Agency, April 2007

[35] The MSA noted that the cogeneration unit at Belle Vue produces on average 1.65 to 1.70 MWh of electricity per tonne of used coal. At cruising speed higher yield can be expected. However, a power plant, on account of the night load demand constraints, has to substantially derate its output in the early hours of the morning. MSA also noted that in such circumstances, Savannah should produce 1.7 MWh per tonne of used coal.

coal/bagasse plant is cheaper than the unit cost of a coal plant. It cannot be otherwise as bagasse is not imported.

To illustrate these consideration, the case of Savannah which will operate at 82 bars/525 degree C and Savannah will use a 2:1 coal/bagasse ratio is taken.

Yield after taking into account reductions to cope with night load	590 grams /KWh
Yield of a 110 bar/540 degree C plant using a fluidized bed and burning coal only taking into account reductions to cope with the night load	490 grams/KWh
One tonne of coal	70 US $ c.i.f
Cost of one KWh at Savannah after taking into account that bagasse is not an imported combustible	2.89 US cents.
Cost of one KWh in a coal dedicated plant	3.43 US cents

Conclusions and recommendations

The above analyses provide solid reasons for a thorough consideration of possible prioritizing of investments into coal/bagasse power plants over coal-only power options in Mauritius.

It is therefore recommended that investments into upgrading of power generation facilities at sugar cane cluster be considered as a priority. Upgrading of old combustion facilities (such as Medine which uses 30-year old technologies) are also likely to improve their current air emissions levels. Lastly, the amount of additional CO_2 per KWh exported from a bagasse/coal plants into the grid will be lower than that of a coal plants.

EU support to the MAAS should, as a priority measure, promote upgrading of cogeneration plants. Such support should also stimulate the use of modern technological approaches - e.g. the use of 110 bar steam pressure boilers and turbo-generators for steam extraction & condensing, careful control of moisture contents of bagasse, use of topping/combined cycles or fluidized bed combustion processes - which can further significantly enhance energy production efficiency of such cogeneration units. The overall objective should be to increase the coal-to-electricity conversion rates above 80% for such plants. It is also recommended that measures to control moisture of bagasse are taken to achieve a maximum moisture around 50%[36].

Further to this, it is recommended that the EU support to the MAAS also stimulates:

- improvements in the energy efficiency of sugar factories;
- innovative uses of all forms of sugar cane biomass (such as use of the cane field residues or use of high-fibre cane); and
- research related to development of commercially viable Biomass Gasifier/Gas Turbines.

[36] IFC recommends, that effective running of cogeneration plant requires controlling of moisture by a value of around 50%.

Appendix: Analysis of overall coal-electricity conversion efficiency in the sugar cane cluster

Plants	Currently operating key cogeneration facilities within the sugar cane cluster							Evaluation		
	Bagasse-based energy generation			Coal-based energy generation						
	Bagasse used [tonnes]	Energy produced from bagasse [MWh]	Bagasse-to-energy conversion efficiency [MWh/tonne of bagasse]	Coal used [tonnes]	Energy produced from coal [MWh]	Coal-to-energy conversion efficiency [MWh/tonne of coal]	Effectiveness in the use coal as compared with convention coal-only power plant producing 2 MWh/t of coal [%]	Annual performance of generation unit as compared with coal-only power generation with capacity 2 MWh/t of coal [%]	Annual volume of bagasse needed at the cogeneration plant to achieve the total efficiency of 2 MWh/t of coal [tonnes of bagasse]	Percentage of existing bagasse supply required for such performance
CTBV	262 140	99 500	0.38	161 145	258 500	1.60	0.80	111%	40 695	16%
Savannah	130 000	34 000	0.26	0	0	0.00	-	-	-	-
F.U.E.L	200 000	40 000	0.20	100 000	120 000	1.20	0.60	80%	250 000	125%
Medine	133 000	3000	0.02	0	0	0.00	-	-	-	-
Mon Desert Alma	129 000	32 000	0.25	0	0	0.00	-	-	-	-
Deep River - Beau Champ	185 818	64 700	0.35	64 458	101 443	1.57	0.79	129%	23 365	13%
Centrale Thermique du Sud - Union of St Aubin	0	0	0.00	141 776	239 800	1.69[37]	0.85	-	-	-
Total / Average	1 039 958	273 200	0.22	467 379	719 743	0.87	0.76			
Coal Ash produced [tonnes]				**65 433**						

[37] The MSA indicated that it believes that this figure is higher.

Plants	Cogeneration plants at sugar cane cluster after implementation of the MAAS							Evaluation		
	Bagasse-based energy generation			Coal-based energy generation						
	Bagasse used [tonnes]	Energy produced from bagasse [MWh]	Bagasse-to-energy conversion efficiency [MWh/tonne of bagasse]	Coal used [tonnes]	Energy produced from coal [MWh]	Coal-to-energy conversion efficiency [MWh/tonne of coal]	Effectiveness in the use coal as compared with convention coal-only power plant producing 2 MWh/t of coal [%]	Annual performance of generation unit as compared with coal-only power generation with capacity 2 MWh/t of coal [%]	Annual volume of bagasse needed at the cogeneration plant to achieve the total efficiency of 2 MWh/t of coal [tonnes of bagasse]	Percentage of existing bagasse supply required for such performance
CTBV	262 140	99 500	0.38	161 145	258 500	1.60	0.80	111%	168 059	64%
Savannah	360 000	137 000	0.38	122 000	198 000	1.62	0.81	137%	120 876	34%
F.U.E.L	510 000	172 000	0.34	310 000	492 000	1.59	0.79	107%	379 535	74%
Medine	147 000	47 000	0.32	60 000	96 000	1.60	0.80	119%	75 064	51%
Mon Desert Alma	-	-	-	-	-	-	-	-	-	-
Deep River - Beau Champ	-	-	-	-	-	-	-	-	-	-
Centrale Thermique du Sud - Union of St Aubin	0	0	0.00	141 776	239 800	1.69[38]	1.00	-	-	-
Total / Average	1 279 140	455 500	0.35	794 921	1 284 300	1.62	0.84			
Coal Ash produced [tonnes]	**111 289**									

[38] The MSA indicated that it believes that this figure is higher.

Annex 2: Air emissions of cogeneration plants at sugar cane cluster

The primary author of this analysis is Jiri Dusik based on data inputs gathered by Guy Mc Intyre

Current situation

Most of the old cogeneration plants in the Mauritian sugar cane cluster established before 1992 operated only basic air pollution abatement technologies (wet scrubbers) and their air emission were often significantly exceeding national standards for CO and particulate matters. Workshops conducted during the scoping study pointed out that especially the levels of particulate matters were high and above 400-500 mg/Nm^3.

A thorough study on the Characterization of Sugar Industry Wastes and Environmental Pollution Control had been undertaken by the MSA in the 1990ies. This Study looked at the status of pollution load of each one of the 19 sugar factories in operation then, their existing pollution abatement systems and measures in place and suggestion for improvement in such measures. It related to air emission, water effluent, noise and hazardous waste. This study, first one of its kind undertaken in anyone of the sectors of the economy, also served as basis for setting up the norms for the sugar industry. Another area where MSA provided support was in the preparation of the Environment Impact Assessment for the CTBV power plant with the support of an international consulting firm, KBN Engineering in the US.

Presently, the University of Mauritius is also conducting monitoring of quality of ambient air and air emissions from boiler stacks using equipment purchased out of GEF Fund of the World Bank.

Impacts of the MAAS proposal

Future trends in air emissions due to proposals contained in the MAAS on upgrading of cogeneration plants can be illustrated on an example of modernized facility Centrale Thermique de Bellevue Limitée (CTBV) that operates as part of Belle Vue SE. The power plant at Belle Vue is the first one that innovated to operate high pressure (82 bars) boilers combined with electro-static precipitation systems.

The data obtained by the SEA team (see the table on the next page) from the official monitoring report supplied by the MoE indicate that the air emissions of this modernized cogeneration plant are well below national air emission standards established by the Government of Mauritius and also well bellow air emission standards used by the International Finance Corporation (IFC). The only surprising finding were SO_2 emissions during the crushing season (September 2003) which, being well below the IFC limits, were unusually high given the fact that burning of bagasse should be normally sulphur-free. This may be indicative of a mistake in the monitoring system[39] or of burning of coal during the crushing period when bagasse should be normally used.

The partial data obtained from all other cogeneration plants (also summarized in the table bale) lead to a conclusion that their modernizing through 82 bars/5250C boilers and the use of relevant electro-static precipitators can generally reduce emissions of especially particulate

[39] Indeed, the SEA team noted a general comment by the MoE that the current air quality monitoring of power plants operated in Mauritius may not always be as precise as desired and that improvements could be made in this regard.

matters. This expectation is valid particularly for the replacement of old combustion processes (such as those used in Medine[40]), which would typically emit particular matter at rates of 600-800 mg/m3.

At the same time, the planned modernizing of cogeneration facilities is not expected to significantly reduce their emissions in terms of SO_x and NO_x. These pollutants are likely to be emitted at rates well below IFC standards. They may however further decrease if the currently commercially viable technologies based on combined cycles with fluidized bed combustion are used to replace classic grate-firing boilers or pulverised fuel firing.

Table: Overview of emissions of co-generation plants[41]

	Particulate Matter	Sulphur Dioxide	Nitrogen Dioxide
IFC Emissions Guidelines for Small Combustion Facilities (3MWth – 50MWth) using solid fuel	50-150 mg/m^3 as justified by EIA process	2000 mg/m^3 = 763 ppm	650 mg/m^3 = 345 ppm
Mauritian standards for emission of air pollutants (Government Notice no. 105 of 1998)	400 mg/m^3 for plants using bagasse 200 mg/m^3 for plants using other fuels	-	1000 mg/m^3 = 531 ppm
Modernized cogeneration[42] at Centrale Thermique de Bellevue Limitée, (CTBV)			
Bagasse-based operation	28-38 mg/m^3	124-135 ppm	88-165 ppm
Coal-based operation	63-88 mg/m^3	130-155 ppm	135-155 ppm
Planned cogeneration plant at Savannah (before modernising)[43]			
Bagasse-based operation	222 ppm	13.6 ppm	41.25 ppm
Current cogeneration plant at FUEL (before modernizing)			
Bagasse-based operation	82 mg/m³	18 ppm	83 ppm
Coal-based operation	144 mg/m³	25 ppm	178 ppm
Current cogeneration plant at Deep River–Beau Champ (Consolidated Energy Ltd)[44]			
Bagasse-based operation	94 mg/m³	10 ppm	67.73 ppm (36 mg/m^3)
Coal-based operation	No analysis	No analysis	No analysis
Current cogeneration plant at Medine Sugar Milling Co.Ltd.			
Bagasse-based operation	No data provided	No data provided	No data provided
Coal-based power plant at Centrale thermique du Sud St Aubin			
Coal-based operation	No data provided	No data provided	No data provided

[40] In this regard, it needs to be pointed out that Médine has so far made limited investment in pollution abatement measures and it is now equipped with an old system of pollution control and the particulate matter in the air emitted is much higher than the norms. However, Medine has always been planning to invest in a new power plant with state-of-the-art air pollution control system. This point has to be made in this paragraph. Once Médine invests in a new cogeneration facility, air emission standards will be met.

[41] Various ppm values were converted to mg/m^3 and vice versa using relevant molecular weights

[42] Since CTBV did not supply any information on its air emissions, the information obtained in this analysis has been obtained from air quality monitoring reports for CTBV from April 2003, Sept 2003, March 2004 and April 2004 provided by the MoE

[43] Average 4-year figures provided by the plant management

[44] Figures provided by the plant management based on annual test conducted on a 24 hrs basis

Conclusions and recommendations

In overall terms, it can be expected that the reduction of the number of power plants and the subsequent modernizing of cogeneration units will achieve a significant positive impact - both in terms of total air emissions as well as relative air emissions per 1 tonne of processed cane. However, it is important to ensure that EIAs for all future power generation facilities include a thorough modelling of impacts on the ambient air quality.

Since these future estimates were obtained for imported South African coal which contains less than 1% sulphur, there is a need to ensure that the sulphur contents of any coal used in such power generation facilities does not significantly increase in the future. Such arrangement is necessary in order to ensure that the requirements for the SO_x concentrations in the ambient air do not exceed national standards (see the estimated data in the table below). In this regard, it is also important to ensure that all project-level EIAs for all future power generation facilities include a thorough modelling of impacts on the ambient air quality, based on particular requirements of the MoE.

Ambient air quality monitoring by mobile stations, 2004 – 2005 (1)

		Mer Rouge			La Tour koenig			Grand River North West			
Pollutant	Unit	Minimum	Maximum	24 hour Average for the year	Minimum	Maximum	24 hour Average for the year	Minimum	Maximum	24 hour Average for the year	Ambient air quality standard [2]
		2005	2005	2005	2004/2005	2004/2005	2004/2005	2004	2004	2004	
Dust (PM_{10})	$\mu g/m^3$	19	119	25	8.8	27.1	16.4	8.2	33.8	14.8	100.0
Ozone (O_3)	ppb	8	26	15	3.2	14.2	7.4	2.6	22.0	11.4	46.7
Sulphur dioxide (SO_2)	ppb	…	7	3	0.0	16.7	3.5	1.4	34.9	12.7	70.0
Nitrogen dioxide (NO_2)	ppb	11	27	9	…	…	…	-	-	-	97.5
Carbon monoxide (CO)	ppm	0.15	8	0	0.1	0.5	0.3	0.0	0.3	0.02	8.0

Source: Ministry of Environment and National Development Unit.

[1] : Estimate

[2] *: 24-hour standard except for Ozone, Carbon monoxide and lead which are based on 1 hour , 8 hour and 3 month averages respectively.*

Note:(i) Conversion coefficients (at 25 ^{0} C and 1013 bar) have been used to convert the ambient air quality standards.
(ii)Measurements of the parameters are taken on a quarter hourly basis and the averaging time used is 24 hours.

In order to ensure sound environmental management and compliance monitoring for each individual project, it would necessary to ensure that:

1. Project-level EIAs for all future power generation facilities include a thorough modelling of impacts on the ambient air quality to ensure that the applicable standards for the ambient air quality are not exceeded.
2. The quality of the coal used in the cogeneration plants (and any coal-powered plants in Mauritius) is monitored and that a procedure is in place for consulting MoE on any change of the coal quality.
3. The cogeneration units (and all other power generation facilities in Mauritius) be required to establish an ISO certified environment management system. A feasible option could be to begin by ISO 14031 “Environmental performance evaluation” or ISO 19011 “Environmental management systems auditing” and to gradually progress to the full environmental management under ISO 14001 or ISO 14004.

Annex 3: Detailed analysis of options for management of coal ash

The primary author of this analysis is Jiri Dusik

Approach and methodology

The coal is an agglomeration of organisms and minerals accumulated over extended geological time periods. The coal thus contains most of the natural elements at concentrations that are characteristic of the environment of the deposit from which it was mined, including heavy metals and radioactive elements. During the combustion of coal, some of the elements evaporate and others concentrate in the coal ash.

The SEA team analysed the detailed management systems for the use of the coal ash in seven countries (the United States, Canada, Australia, India, Israel, France/Reunion Island and the Czech Republic). Based on comparison of these systems, the national management systems for sound environmental management of the coal ash use in the United States and Israel was chosen as the main point of reference. This choice was made for the following reasons:

United States: US Environmental Protection Agency (US EPA) conducted in 1993 and 2000 two extensive regulatory reviews of procedures for the management and use of coal combustion products that evaluated the following factors:

- The source and volume of coal combustion products generated per year.
- Current disposal practices.
- Potential danger, if any, to human health or the environment from the disposal of coal combustion products.
- Documented cases in which danger to human health or the environment has been proved.
- Alternatives to current disposal methods.
- The costs of such alternatives.
- The impact of those alternatives on the use of natural resources.
- The current and potential utilization of coal combustion products.

In conducting these two regulatory determinations, US EPA concluded that coal ash did not warrant regulation as a hazardous waste. US EPA at the same time determined that unencapsulated uses of coal combustion product would require proper hydrogeologic evaluation to ensure adequate groundwater protection.

Israel: Israel uses coal from variety of sources, including those from South Africa. More then 1 million tonnes of coal ash are annually produced in the country – such massive volumes of coal must be properly disposed of with all the associated economic and environmental consideration. Israel is also up to now totally dependent on its groundwater reservoirs which are very carefully protected since they are, given the local hydrological and geological conditions prone to accumulation of some heavy metals. Lastly, Israel established in 1993 “National Coal Ash Board” - a special governmental agency which coordinates national efforts to solve the problem of accumulating coal ash. This inter-institutional body is supervised by the Ministry of National Infrastructures, Ministry of the Environment, the Interior Ministry, the Israel Electric Company (IEC) and the National Coal Supply Company. Israel conducted in the past 20 years numerous reviews of possible environmental risks associated with the use of the coal ash. These reviews determined that coal ash should not be treated as hazardous waste but also rather as a "recyclable by-product of the energy production that requires environmental supervision for its uses".

Key environmental issues that must be considered in the uses of coal ash

The SEA focused on key environmental issues associated with the use of coal ash (leaching of trace elements into water sources and presence of radioactive elements) and elaborated a set of framework recommendations for a safe use of coal ash in Mauritius.

Possible leaching of trace elements into soil and ground waters

The coal ash is composed mainly of the inorganic constituents of the coal: oxides of silicon, aluminum, iron and calcium, but also of some trace elements which are hazardous to the environment.

1st level of analysis

Extensive chemical analyses performed in Israel on various samples of coal ash - including ash from South African coal – indicate that the concentrations of trace elements found in many fly ashes are similar to those found in naturally occurring soil. A summary of these analyses is presented in the following table.

Concentration of Trace Elements in Coal and Coal Bottom Ash and Fly Ash (parts per million - ppm)

Material	Ag	As	B	Ba	Cd	Co	Cr	Cu	Hg	Mn	Mo	Ni	Pb	Se	V	Zn
Coal	< 1	5	49	170	0.47	6.1	15	16	0.2	43	3.3	14	11	2.8	22	53
Fly Ash	5	23	225	1780	0.9	45	147	77	< 0.2	540	13	100	67	7	197	114
Bottom Ash	2	6	100	1560	0.2	31	144	43	0.2	350	4	69	18	3	127	47
Sedimentary rock*	0.1	10	130	600	0.3	20	90	60	0.4	800	2	70	25	0.5	120	150

* Average in the earth's crust

2nd level of analysis

Some heavy metals contained in the coal have a leaching potential which gets enhanced in the acidic pH range of 3 to 5. Possible percolation of trace elements contained to ground waters is thus largely determined by pH

In order to determine the actual risk of migration of these trace elements from the coal ash to the environment and to aquifers, the SEA team used the data from extraction tests performed in Israel on coal ash samples using also South African coals. These tests used the stringent method of dissolution of coal ash in acid and resulted in the following findings:

Concentrations of Trace Elements in the Extraction Solutions of Coal Fly Ash and Bottom Ash Compared with the Standards for Maximum Concentrations in Drinking Water (parts per billion - ppb)

	Ag	As	B	Ba	Cd	Co	Cr	Cu	Hg	Mn	Mo	Ni	Pb	Se	V	Zn
Fly Ash	1	175	7465	3810	1.3	24	455	15	0. 7	275	270	140	3.4	83	765	65
Bottom Ash	0.7	14	775	735	0.4	8.9	8.8	7.8	< 0.3	495	11	30	3.8	5.5	2.3	173
Drinking Water Standards in Israel	10	50	-	1000	5	-	50	1400	1	500	-	50	10	10	-	5000

The concentrations of all the trace elements in the extraction solutions of bottom ash were lower than the values permitted in the drinking water standards in Israel.

3r level of analysis: Leaching potential of mercury

The closest values to reaching the Israeli drinking water standard were concentration of mercury in the solutions of the coal ash. However, analysis of the leaching potential of mercury - using the results of the above tests and analysing concentrations of the mercury in the leachate - show that although mercury in coal ash can potentially be released into the environment, its actual releases from coal ash to the environment were negligible (0.35% and 0.15%). Furthermore, the extraction in water, which is more representative of the reality in the use of coal ash, would have resulted in even lower values.

Concentration of Hg in coal ash and its extracts using the dissolution in acid (parts per billion - ppb)

Source materials	[ppb]
Sedimentary rock*	400
Fly Ash	<200
Bottom Ash	200
Extracted solutions	[ppb]
Fly Ash	0.7
Bottom Ash	<0.3
Concentrations in the leachate	[%]
Fly Ash	< 0.35
Bottom Ash	0.15

These findings broadly correspond to extensive leachate tests for coals used in the US which showed that mercury was very stable in coal ash as it leached less than 1% of the initial mercury concentrations. The US EPA therefore in 2000 also concluded that the mercury releases from coal ash to the environment are negligible and it determined that the use of fly ash in the road basements or as a substitute for lime in agricultural applications did not pose a risk of concern.

Conclusions on possible leaching of trace elements from the coal ash in MU

The results of preliminary tests conducted by MSIRI in 2007 to determine concentrations of trace elements present in the coal ash produced by the power generation units at the Belle Vue and FUEL (done for dry matter) broadly correspond with the values reported from Israel and USA. Such concentrations of trace elements (if proved by ongoing detailed testing) can be regarded as negligible.

Based on the lessons learned from other countries, it is safe to presume that the unencapsulated use of coal ash in Mauritius likely to have a little to no impact on groundwater and surface water quality. However some basic precautions would be necessary and the disposal of large volumes of coal ash on lands should be preceded by proper hydrogeologic evaluation to ensure adequate groundwater protection (see the final recommendations).

If the local stakeholders in Mauritius are interested in confirming this overall conclusion through the exact laboratory tests on the locally generated coal ash, the method of dissolution of the coal ash in acid (e.g. US EPA TCLP Method 1311 which can be adapted to test the leaching potential of heavy metals) can be recommended as the most suitable tool for determining concentrations of trace elements in leachates.

Risks associated with a possible presence of radioactive elements

1st level of analysis

Like all rocks, coal also contains low concentrations of natural radioactive materials in general and specifically radioisotopes potassium 40 (40K), radium 226 (226Ra), and thorium 232 (232Th). As a result of the combustion process, the concentrations of these radioisotopes increase significantly in the ash (7 to 12 times).

The concentrations of radionuclides in coal ash from various coal sources used in Isreal which uses also coal from South Africa were determined to be as follows:

Coal source	K^{40}	Ra^{226}	Th^{232}
South Africa	154 - 181	179 - 230	176–246
Colombia	380 - 564	85 - 103	63 - 65
Australia	195 - 209	106 - 121	83 - 115
Indonesia	400 - 436	109 - 128	98 - 124

Radioactive materials that are present in the coal ash in concentrations are thus relatively higher than those in regular materials used in the construction industry.

Rock	K^{40}	Ra^{226}	Th^{232}
Basalt	231 - 419	10 - 22	10 - 21
Pebbles	9 - 425	10 - 22	1 - 14
Gypsum	30	13	1
Fossil Sand	148	21	13
Cement 42.5	105 - 212	29 - 69	7 – 41

2nd level of analysis: Use of coal ash in the construction materials

The results of tests on concrete samples with addition of South African coal ash (relatively rich in radionuclides) to construction materials used in Israel indicated that the addition of coal ash to concrete mixes used in the building industry would be liable to cause a small increase of exposure of the population to ionizing radiation.

Construction Product	K^{40}	Ra^{226}	Th^{232}	mSv/y
Concrete without Ash	46 - 57	33 - 34	8 – 10	0.45 – 0.47
Concrete with Ash	52 - 68	33 - 44	11 - 16	0.47 – 0.62

The key consideration is that building products rich with coal ash may be a source of radon gas. The WHO regards exposure to radon as one of the main health risks in the home and workplace since radon is the second leading cause of lung cancer. The US National Research

Council[45] e.g. estimated that indoor radon may cause about 15 000 lung cancer deaths per year.

Calculations by the US Geologic Survey indicate that concrete building products of all types contribute less than 10 percent of the total indoor radon. Testing done in Israel indicate that the use of South African coal ashes - which seem to be relatively rich in radionuclides –may increase radon emissions from concrete building products by up to 33% - e.g. increasing the overall exposure to indoor radon by 3%[46].

This corresponds to an extreme calculation carried out by the US Geologic Survey that assumed high proportions of fly-ash-rich concrete in a residence and compared them to normal concrete. These outcomes also suggested that such use of the coal ash could increase exposure to in-door radiation by a dose enhancement of 3%.

Conclusion on risks associated with a possible presence of radioactive elements in coal ash in MU

There is a reason for caution as the presence of radioactive elements may be an issue of concern in those construction materials that would contain coal ash at very high levels.

Any possible larger-scale use of coal ash in the construction materials in Mauritius should be preceded by an analysis of radioactive elements present in the locally generated coal ash and by a comparison of the obtained results with the concentrations of radioactive elements present in other materials used in the local construction industry. Outcomes of such analysis should be used to determine the maximum volume of the coal ash that can be used in the construction materials.

Overview of possible uses of coal combustion products

Combustion of coal as a part of the coal fired power plants operating processes usually produces the following wastes/by-products:

- **Fly ash** is a product of burning finely ground coal in a boiler. It is removed from the plant exhaust gases primarily by electrostatic precipitators and secondarily by scrubber systems.
- **Bottom ash** is agglomerated ash particles, formed in pulverized coal furnaces that are too large to be carried in the flue gases. Bottom ash is coarse, with grain sizes spanning from fine sand to fine gravel.
- **Boiler slag** is the molten bottom ash collected at the base of slag tap and cyclone type furnaces that is quenched with water. When the molten slag comes in contact with the quenching water, it fractures, crystallizes, and forms pellets. This boiler slag material is made up of hard, black, angular particles that have a smooth, glassy appearance.

[45] The US National Research Council (1999) "Health Effects of Exposure to Radon: BEIR VI, Committee on Health Risks of Exposure to Radon (BEIR VI), National Academy Press, 1999

[46] Tests carried in the US out on cement paste specimens with different fly ash contents, 0-60% by weight of the binder (cement and fly ash) found that the dosage of fly ash alone in cement paste has a limited radon exhalation rate, if the concrete mix was relatively dense.

Key management practices for the use and handling of coal ash

Application of fly ash on agricultural lands

Fly ash can be applied to land to improve the soil for crop or to alter land contours for landscaping purposes. Fly ash has potential for use in agriculture because it contains almost all macro as well as micronutrients except organic carbon and nitrogen. It may be used in conjunction with chemical fertilizer to increase the yield of various agricultural crops, the dose of which will depend on the types of crops as well as the types of soils also

An addition of appropriate quantities of the fly ash can also be used to:
- improve the soil texture
- enhance water holding capacity of soil
- alter soil pH and neutralize acidic soils
- reduce surface encrustation

Environmental concerns and recommendations
1. Local groundwater conditions need to be evaluated prior to using coal ash as a fill material. When coal ash would be located close to the groundwater table, the requirement for a capillary break must be evaluated.
2. The soil shall be mulched or covered by a layer of vegetated soil as soon as practical.
3. Adequate dust control shall be provided during transport

Use of fly ash in the concrete mixtures

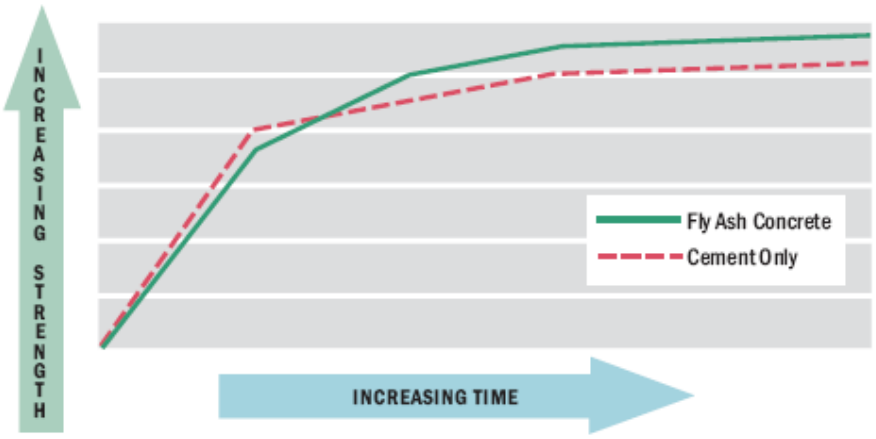
Fly ash has been used as an ingredient in concrete for more than 60 years and concrete suppliers routinely use it in their concrete mixtures.

In concrete, fly ash reacts with the free lime generated by cement hydration to form additional calcium silicate hydrate, which fills the voids normally associated with a cement pour. The permeability of the concrete is therefore reduced. Mixing fly ash with Portland cement mixtures can produce stronger and longer lasting concrete. Concrete containing fly ash is also easier to work with because the tiny, glassy beads create a lubricating effect that causes concrete to flow and pump better, to fill forms more completely, and to do it all using up to 10 percent less water.

Typically, at least 25% (and up to 50% in some mixes) of fly ash are used as a replacement for Portland cement in:
- various construction projects (including bridges, dams, etc.),
- precast concrete fabrication (blocks, bricks, pipes, etc.),
- pre-cast concrete for Marine Structure elements (piles, decking, ramps, breakwaters, etc.)

Long term advantages of using fly ash in concrete are
- Increases concrete strengths - studies have indicated that Fly Ash concrete will continue to gain strength past the age of 28 days (see the picture below). With improved workability and a reduction in water needed, Fly Ash concrete provides a lower water/cementitous ratio thereby producing superior strengths and longer life.
- Reduces drying shrinkage - By providing as much as a 10% water reduction in its plastic state, Fly Ash concrete maintains workability and reduces drying shrinkage.

- Reduced permeability - The packing effect of the spherical Fly Ash particles helps to reduce permeability. The chemical reaction between Fly Ash and lime forms additional (C-S-H) bonds that block bleed channels and fill pore spaces.
- Resistance to sulphate attack - Fly Ash combines with free calcium hydroxide making it unavailable to react with sulphates. In producing a less permeable structure there is increased resistance to aggressive soluble sulphate solutions resulting in longer life.
- Mitigates alkali aggregate - Fly Ash reacts with available alkalis in the hardened cement matrix making them less likely to react with the aggregate.



Source: U.S. Environmental Protection Agency and the Federal Highway Administration (2005) Using Coal Ash in Highway Construction: Guide to Benefits and Impacts

In addition to the long-term benefits, the use of fly ash in concrete in the ready-made mixes also brings the following "operational" benefits for constructors:

- Improved workability – the Fly Ash is spherical in shape it produces a paste with superior plasticity and reduces the amount of water needed in a mix.
- Reduced segregation - the improved cohesiveness of Fly Ash concrete provides added body to plastic state concrete which resists segregation.
- Increased pumpability - the spherical shape of Fly Ash acts like tiny ball bearings, reducing internal friction, thereby producing a mix that is easier to pump.
- Reduces equipment wear - Fly Ash concrete reduces wear on delivery and plant equipment because of the reduction of friction attributed to the spherical nature of Fly Ash.
- Reduces heat of hydration - Large masses of concrete typically produce high internal temperatures and thermal cracking. Fly Ash concrete produces appreciably less heat than Portland.

<u>Environmental concerns and recommendations</u>

1. Construction of bridges, dams, etc.: None
2. Construction of buildings: See recommendation on radiation

Use of bottom ash and boiler slag in the concrete mixtures

The boiler slag is in high demand for its use in concrete mixes. Its particles are uniform in size, hard, and durable with a resistance to surface wear. The boiler slag is therefore usually the most sought byproduct of the coal combustion.

Bottom ash has a porous surface structure that makes this material lighter than conventional aggregate and useful in lightweight concrete applications. The porous surface structure of

bottom ash particles however make this material less durable than conventional aggregates. However it is better suited for use in base course, as opposed to wearing surface mixtures.

Environmental concerns and recommendations
1. Construction of bridges, dams, etc.: None
2. Construction of buildings: See recommendation on radiation

Use of fly ash and boiler slag in asphalts and pavements

Boiler slag particles are uniform in size, hard, and durable with a resistance to surface wear. In addition, the permanent black color of this material is desirable for asphalt applications. The demand for boiler slag in highway applications thus e.g. in the USA currently exceeds the supply capacity of domestic coal power plants.

Fly ash can also be used as in asphalt pavements since it increases the stiffness of the asphalt mix, improves the resistance and durability of pavements. Concrete mixes with a very low water content and high use of fly ash allow complete compaction and provide exceptional quality concrete which brings many other chemical benefits and advantages. Use of such concretes (known also as Roller Compacted Concrete) has been increasingly used e.g. in Canada as a replacement of conventional concrete mixes since which provide significant savings and better roads.The US Federal Highway Administration is presently developing a long-life pavement systems that use fly ash and can last up to 50 years for roads—twice the lifetime of conventional pavements.

Environmental concerns and recommendations
None

Use of fly ash and bottom ash for structural fills or in controlled low strength material

Properties of coal fly ash make it highly suitable for use as structural fills or in “controlled low strength materials” (CLSM), provided that guidelines and regulations for their use are followed.

Structural fill is an engineered fill that is typically constructed in layers of uniform thickness and compacted to a desired unit weight (density) in a manner to control the compressibility, strength, and hydraulic conductivity of the fill.

Controlled low strength materials are easy to place, flowable mixes consisting of fly ash, bottom ash, cement, water and on occasion, sand. They provide engineers with a highly versatile, easy to use, low cost material for projects requiring backfill, temporary slabs, slope stabilization and erosion protection plus many more similar applications.

Structural fills or controlled low strength materials are a standard part of:
- Road construction, e.g. embankments for highways and roads.
- Foundations immediately below buildings and other structures.
- Vehicle parking areas.
- Slope stabilization and erosion control.
- Backfill for pipe bedding (sewer, water line or other pipeline) or transmission lines.

Environmental concerns and recommendations

1. Local groundwater conditions need to be evaluated prior to using coal ash as a fill material. Coal ash shall be placed above the seasonal high groundwater table. When coal ash is located close to the groundwater table, the requirement for a capillary break must be evaluated.
2. Coal ash shall be placed in well-compacted layers to reduce infiltration, thereby minimizing the quantity of leachate produced.
3. Exposed surfaces shall be either promptly covered with pavement or another form of permanent cover to prevent surface erosion and dusting.

Temporary storage of coal ash

Coal ash (and fly ash in particular) can become airborne during storage and processing, from traffic on roads, and through wind erosion during placement.

Workers involved with handling dry fly-ash can thus come in contact with fugitive dust. Health risks associated with the inhalation of these fugitive dusts in occupational settings are minor but can nevertheless be limited by following the relevant guidelines for occupational safety and health and practices.

Storage of the fly ash may result in little to no impact on groundwater and surface water quality, but some precautions are necessary.

Environmental concerns and recommendations

1. Local groundwater conditions need to be evaluated prior to using coal ash as a fill material. Coal ash shall be placed above the seasonal high groundwater table. When coal ash is located close to the groundwater table, the requirement for a capillary break must be evaluated.
2. Adequate dust control shall be provided during temporary storage.
3. Provision must be made for controlling possible leaching from the coal ash storage by providing surface cover and/or appropriate drainage.
4. Surface runoff from the site shall be contained in sedimentation traps constructed to capture suspended ash particles in the drainage water.

Recommendations

Overall recommendations

The MoE should within its existing mandate and powers defined by the Environmental Protection Act (Art. 7, item b) establish a system for centralized monitoring and supervision of all coal ash uses in Mauritius. Such system should be based on the following elements:

1. A system of an annual elaboration of coal ash management plans and of their compliance monitoring should be established. All power generation facilities using coal should be, at a minimum, required to annually provide the MoE with the following information for approval:

- Results of the regular sampling of trace elements and of radioactive elements in the coal ash generated at the plant
- Proposed encapsulated uses (volume of coal ash to be used in different encapsulated uses)
- Proposed unencapsulated uses (volume of coal ash to be used/disposed in different locations & information on ground water levels in these sites)
- Information of the uses of coal ash during (any) previous reporting periods

2. The MoE should have an administrative authority to approve or amend the proposed coal ash management plans. All power generation facilities using coal should be also required to keep all records related to use/disposal of the coal ash and should make them available to the relevant monitoring agencies upon request.

3. The MoE should issue guidelines for the safe use and disposal of which can incorporate the proposed hierarchy of coal ash management options (see below) and the specific detailed recommendations on the management of various coal ash uses contained in this report. These guidelines should be used as support tool for the elaboration of the annual coal ash management plans by all major producers of coal ash in the country.

Proposed hierarchy of coal ash management options

	Fly ash	**Bottom ash**	**Boiler slag**
1.	Partial substitute for cement	Controlled low strength materials for road construction, slope stabilization and erosion control.	Mineral filler in asphalt, pavement & sealing materials
2.	Mineral filler in asphalt, pavement & sealing materials	Structural fills for foundations immediately below buildings and other structures, vehicle parking areas, or pipe bedding	Aggregate in all kinds of concrete products for other then residential purposes
3.	Ingredient in soil modification and/or stabilization, landscape repair or stabilizing foothills	Aggregate in lightweight concrete products for other than residential purposes	Structural fills for foundations immediately below buildings and other structures, vehicle parking areas,
4.	Controlled low strength materials for road construction, vehicle parking areas or pipe bedding	Aggregate in lightweight concrete products for residential buildings (if the potential risk of increased indoor radioactivity as a result of use of coal ash is ruled out)	Aggregate in concrete products for residential buildings (if the potential risk of increased indoor radioactivity as a result of use of boil slag is ruled out)

Annex 4: Detailed analysis of vinasse management of options

The primary authors of this analysis are Guy Mc Intyre and Christophe Poser.

Introduction

Vinasse is a by-product of the distillation of molasses into alcohol/ethanol. It is an organic material which does not contain – except sulfuric acid, which is being added in order to stimulate fermentation of the yeast – any other elements to those contained in the sugar cane.

Vinasse is by far the most important liquid effluent in terms of polluting potential from both annexed and autonomous ethanol distilleries. Its acidic character, high BOD content, and significant volumes make its treatment the most decisive factor in the total environmental impact of an ethanol distillery. Vinasse may represent 70% of the polluting potential (volume x BOD) of an ethanol distillery[47].

Chemical composition of vinasse outlined in the table below shows that the main component of vinasse is potassium (K). The proportion of potassium can fluctuate due to the source of vinasse from 4.4 % to 15.5 % of dry matter[48]. Then vinasse contains (in the literature survey) around 6.5 kg to 18.2 kg of potassium (in the form of K2O) per 1 m^3.Recent analyses in Reunion Island[49], on 10 samples gives an average of 16,0 kg of K2O per m^3. In Mauritius the K20 content of vinasse may vary between 20 and 24 kg per m^3.

pH	4.3
Density (20 C°)	1.054
% dry matter	11.2
COD g/l	100.2
Total OM gr/100 of dry matter	6.6
N total g/100 of dry matter	2.71
P g/100 of dry matter	0.22
K g/100 of dry matter	14.2
Ca g/100 of dry matter	2.17
Mg mg/100 of dry matter	1.2
Fe mg/100 of dry matter	688
Mn mg/100 of dry matter	169
Cu mg/100 of dry matter	19.5
Zn mg/100 of dry matter	34.8
Q mg/100 of dry matter	19.5
Conductivity mS/cm	38.4
Sulfate mg/l	3,000 – 5,000
BOD mg/l	45,000 – 50,000

K20 content of vinasse, combined with a significant amount of organic matter, makes vinasse a good organic fertilizer (which only needs to be enriched by nitrogen, and phosphate if and

[47] Centurion and Derisio (1992
[48] Etude sur les vinasses à La Réunion- F. Feder , H. Saint Macary, Mars 2005 Cirad
[49] Guide de la ferilisation organique à La Réunion, P.F. Chabalier et al, 2006 Cirad

when necessary). Vinasse can be used as a partial replacement of mineral fertilizers which would otherwise have to be applied on sugar cane fields. So far, the analysis performed by Cirad Reunion[50] for local conditions, indicates that if vinasse is used at a rate of up to 15-16 m^3 per ha, it does not pose any risk of reducing soil fertility. MSIRI has suggested that between 2.5 and 5.0 m^3 can be applied to cater for the needs of sugar cane.Higher rates e.g. $100m^3$ ha^{-1} have also been found in Brazil to be harmless to sugar cane and environmental consequences. The impact on the environment is being studied by MSIRI.

Current uses of vinasse in MU

Up to now, only about 1/3 of the molasses produced in Mauritius were used in 2 distilleries producing potable alcohol (Medine and Beau Plan) and one producing ethanol. The vinasse produced by Medine and Beau Plan is traditionally applied on fields around sugar factories. However Medine uses about 10% of its vinasse for composting with factory scums.

Information supplied to the SEA team on the management of vinasse in Medine SE and Belle Vue SE (see appendix to this analysis) indicates that their practices currently do not pose any major environmental problems due to the limited volume of the produced ethanol and also due to availability of land for the direct application of the residual vinasse.

The SEA team also undertook one visit to Alcodis plant which indicated that the recent changes in the management of this plant and the investments into CMS production improved the previously heavily contested environmental management of this plant. However, one visit does not allow the SEA team to make any firm comments on the future environmental performance of this facility. Obviously, a proper monitoring & supervision is needed to check whether this plant operates in environmentally sound manner given its very sensitive location in the immediate vicinity of an urban settlement.

Proposals contained in the MAAS

The MAAS plans that all molasses produced in Mauritius will be used locally to produce ethanol. According to MAAS, 120,000 tonnes of molasses will be used to produce ethanol. The average production of vinasse is 12 litres per litre of ethanol. The yield of ethanol is approximately 240 litres/tonne of molasses, consequently, about 350,000 m3 of vinasse have to be managed.

Options for management of the forecasted volumes of vinasse

The following options/components for the management of vinasse were analysed:
1. Storage of vinasse;
2. Direct application of vinasse on fields (alone or mixed with other nutrients);
3. Concentration of vinasse into CMS and mixing it with other nutrients;
4. Drying CMS and burning it (alone or with pith);
5. Composting of vinasse (mixing it with sugar factory scums and/or bagasse);
6. Aerobic treatment of vinasse;

The main features of these options are summarized as follows.

Option 1	**Storage of vinasse**
Key features	A temporary storage will be necessary irrespective of how the vinasse is

[50] Valorisation agricole de la vinasse sur canne à sucre- Opération pilote de 1992 à 1995- SUAD 1996

of this vinasse management option	used. Two options exist: Storage in open air pools (most common option) and in closed tanks.
Main environmental impacts	Impacts on local air quality Volatile acids present in vinasse (1,5 % of volume of vinasse)[51] may cause odour during regular operations or during industrial accidents. Nuisance by odour depends on the wind speed and direction as well as air humidity. Impacts on water or soil quality Unless leakage occurs, there is no impact on water or soil quality during regular operation of vinasse storage. Majors risks occur during transfer, from distillery to storage area and from there to the site where vinasse is used or transformed.
Recommendations	The personnel of the distillery should ensure that the vinasse produced is used/converted within 24 hours of production, in order to prevent evaporation of volatile acids and/or H_2S. Vinasse should be stored and transported in appropriate non-corrosive materials. Any storage system should have: • a minimal buffer zone around such facilities • appropriate transfer zone including appropriate procedures and trained operators. • neccesary procedures for controlling leakage (which may be caused due to strongly acidic properties of vinasse) • an emergency procedure in case of accidents
Priorities for monitoring or further research	Any vinasse management option that involves storage of vinasse should be accompanied by establishment of a basic environment management system to ensure sound monitoring and compliance.

Option 2	**Direct application of vinasse on fields (alone or mixed with other nutrients)**
Key features of this vinasse management option	Vinasse contains mainly potash which is one essential fertilizing element for all crops; it also contains organic matter which has been found to improve soil quality properties. This, combined with a significant amount of organic matter, makes vinasse a good organic fertilizer (which only needs to be enriched by nitrogen, and phosphate if and when necessary) to fit to various agronomic needs. Vinasse can be used as a total replacement of potash in mineral fertilizers which would otherwise have to be applied on sugar cane fields. MSIRI studies have pointed out that, on a per 1 ha basis, 2.5m3 and 15 m3 of vinasse applied in the furrows (i.e. on about 1/3 of the sugar cane area) gave similar yields as 100 and 600 kg of KCL applied in the same way. The uptake of K was similar whether KCL or vinasse was applied and irrespective of whether applied each year or in one dose at planting for 6 years crop[52]. This is important, as the price of K is increasing on the world market, due to a high demand of this element. On sugar cane, vinasse should be applied as soon as possible after

[51] Bousquet N. 1987 Addition des effluents de distillerie à l'eau d'irrigation sur le perimètre ago-industriel de Medine (Ile Maurice). Rapport de DAA, ENSAT, Toulouse

[52] Ng Kee Kwong and Paul,1997,Rev. agric sucr. Ile Maurice, vol 76, no. 2

	harvesting to prevent any phytotoxic effect on the young regrowing cane. Application period will correspond mainly to the crushing season and not later than 2 weeks after harvest,i.e. before regrowth of the cane.
Main environmental impacts	Impacts on local air quality • Applications may cause odour during regular operations. Nuisance by odour may occur during application and will rapidly decrease within the next few days. Wind speed and direction as well as air humidity remain important factors. • However, presently, the totality of vinasse produced by Beau Plan (Grays) is sprayed in cane fields and no bad odour has been experienced. The same goes for Medine who sprays about 90% of the vinasse in the fields and the rest is composted with factory scums. In fact, as the vinasse is applied within 24 hours of production, the smell of the product is rather pleasant. Impacts on water and soil quality Results obtained in trials made by MSIRI in Mauritius[53] and by Cirad in Reunion Island[54] show that an application of vinasse on fields at rates between 2.5 and 15 m3 / year/ ha (the latter rate for 6 years), has so far led to no negative effects on the soil. In soils poor in K, it would be necessary to apply even more depending on soil analysis. So far, the analyses performed by Cirad Reunion[55] for local conditions, indicates that if vinasse is used at a an annual rate of up to 15-16 m3 per ha, it does not pose any risk of reducing soil fertility. MSIRI has suggested that between 10 to 12 m3/ha/yr can be applied on most Mauritian soils to cater for the needs of sugar cane. • Even if the soil pH is acid soon after application, soil micro-organisms will rapidly restore the previous pH. Also, the soil quickly regained its original physico-chemical status. • It has been observed that there was no leaching of the vinasse or its components to underground waters considering the relatively low amounts applied per hectare. • In Brazil[56], it has been found that when applied at rates varying between 10 and 20 m3, vinasse had a positive effect on sugar cane root development, on water retention and on soil microfauna and flora. Sugar cane yield was found to increase, however impacts of such rates of application on the ground water quality are unknown. Impacts on plant or sugar quality • If applied at the appropriate time and rate, the vinasse has no negative impact on either the sugar cane plant or the quality of the sugar produced.
Recommendations	As a precautionary measure,it is desirable to, as far as possible, choose fields not located very close to residential areas. In order to study the long time effect of vinasse application to sugar cane fields, it is important to monitor the situation in different soil types and climates on reference plots. Application on fields situated near the coast should be avoided, particularly

[53] K.F. Ng Kee Kwong and J.P. Paul, 1997
[54] Etude sur les vinasses à La Réunion- F. Feder , H. Saint Macary, Mars 2005 Cirad
[55] Valorisation agricole de la vinasse sur canne à sucre- Opération pilote de 1992 à 1995- SUAD 1996
[56] Penatti et al 2005

	during the warm season when heavy rainfall is encountered, and also if these areas are irrigated.
Priorities for monitoring or further research	With the large amount of vinasse that will be available, application will have to be made on a large area and for a long period. - Research should be carried out to study the impacts of such applications to new areas and on different soil types. - Reference plots in different areas should be used as control to determine whether any major changes in the soil properties have occurred where vinasse has been applied for a period of about 8 to 10 years. - Materials to be used for application should be regularly checked, particularly as regards the acidity of vinasse and the effect on the machinery and on the soil.

Option 3	**Concentration of vinasse into CMS and mixing it with other nutrients**
Key features of this vinasse management option	Vinasse could be concentrated to around 50 % dry matter to obtain CMS (compared to approximately 11-12% dry matter in the vinasse). This liquid can be later mixed with different amounts of phosphate and nitrogen to suit various crop needs. When CMS is mixed with other nutrients in the required amount it can produce a complete fertilizer for different crops.
Main environmental impacts	<u>Impacts on local air quality</u> The concentration process will remove the volatile acids, thus reducing or eliminating nuisance by odour. Information obtained during interview with directors of Alcodis indicates that the volatile acids can be collected during CMS process and be re-used in the fermentation of molasses which need an acidic condition to promote yeast action. <u>Impacts on soil and water quality</u> CMS has practically the same components as vinasse (except that the pH is less acidic[57], pH of CMS is 5.2 as compared to that of vinasse which ranged between 4 and 4.6). Therefore, no negative impact on the soil or water quality is expected when the guidelines for its sound application on the fields are respected. <u>Impacts on the use of energy</u> CMS production reduces transport demands for the application of vinasse on fields more than 4 times. However, in total terms, any energy gains achieved through such reduction of transport will be offset by energy demands of the concentration process.
Recommendations	Due to the risk of nuisance by odour, it is recommended that no residential developments be present within a radius of 300 metres from the distillating plant. In order to study the long time effect of CMS application to sugar cane fields, it is important to monitor the situation in different soil types and climates on reference plots.
Priorities for monitoring or further	Equipment used for the application of CMS should be regularly checked to ensure sound dosage/application of the product in the field. <u>Any vinasse management option that involves storage of vinasse should be</u>

[57] Resultats techniques de l'operation vinasse 1992-1995 Chambre d'agriculture de La Réunion dec 1995

research	accompanied by establishment of a basic environment management system to ensure sound monitoring and compliance. Research should be carried out to study the impacts of CMS applications to new areas and on different soil types and climates. Reference plots in different areas should be used as control to determine whether any major changes in the soil properties have occurred where CMS (with or without others nutrients) has been applied for a period of about 8 to 10 years.

Option 4	**Drying CMS and burning it (alone or with pith)**
Key features of this vinasse management option	Drying and burning of CMS is presently scaresely reported on international level. Also, information obtained from personal interview indicated that burning of vinasse is not used except experimentally in China. Due to the acidic nature of vinasse, burning of CMS is constrained by risk of corrosion of boilers, evaporators, pipes and pumps and also by a need of regular cleaning of these systems. MSIRI[58] informed SEA team that it may start a reseach project to examine possible use of this method. The SEA team thus highlighed only key concens about possible environmental risks of this vinasse management approach and recommends that these be considered in this forthcoming research.
Main environmental impacts	<u>Impacts on local air quality</u> • As every type of biomass incineration, burning of CMS may too pose significant risk of emissions of persistent organic pollutants - especially of dioxins which are highly carcinogenic. <u>Impacts on waste management</u> • Burning of CMS produces significant amounts of ash which needs to be properly managed. <u>Impacts on energy balance</u> • Burning of CMS may result in net energy losses when especially the energy required for the drying of the CMS is accounted for.
Recomme-ndations	Burning of CMS is not presently a readily available option for management of the forecasted volumes of vinasse. Further studies are needed to examine technological and environmental challenges in the possible use of this method.
Priorities for monitoring or further research	The MSIRI forthcoming reseach project on the possible use of CMS burning should also attempt to address the key environmental risks and concerns about this approach.

Option 5	**Composting of vinasse (mixing it with sugar factory scums or bagasse or dried cane leaves and tops)**
Key features of this vinasse management option	Vinasse could be transformed into compost by mixing with factory scums and / or bagasse and chicken manure to obtain a complete organic mixture applicable to sugar cane and other crops. Where scums and /or bagasse are not available, cane leaves and tops could be used as basic material to obtain another type of compost which could be used in sugar cane fields not necessitating phosphate, provided that an

[58] Dr JC Autrey(Director of MSIRI) during SEA restitution of 25/05/07

	appropriate source of nitrogen is mixed. To produce these different types of compost, adequate space and adapted equipments for mixing the different components must be available.
Main environmental impacts	Impacts on local air quality These various types of compost may cause odour during regular operations. The nuisance by odour depends on the wind speed and direction as well as air humidity. Impacts on soil and water quality Composts are stabilized products and there are no negative impact on soil and water quality, provided that they are used in appropriate recommended amounts. The organic matter contained in all those composts will be beneficial to the soil physical and chemical properties. General impact: A regular application of composts is expected to have a positive impact on physical and chemical properties of soils. It could also improve yields of sugar cane and other crops, and will reduce the use of chemical fertilizers.
Recommendations	Firstly, it is desirable to, as far as possible, choose sites not located adjacent to residential areas as a precautionay measure. Precautionary measures must be taken in order to ensure that the area chosen is fairly flat and that any liquid coming off, especially during rainfall, is collected by an adequate drainage system.
Priorities for monitoring or further research	It would be benefical to support research on composting vinasse with cane leaves and tops collected from fields. Outcomes of such research could be used in processes where little or no scums are available.

Option 6	**Anaerobic digestion (including use of methane) and disposal of sludge**[59]
Key features of this vinasse management option	The use of anaerobic digestion for treating industrial wastewaters has grown tremendously during the past decade. Presently, anaerobic digestion is experimentally practised for vinasse management in Guadeloupe, Venezuela, India, United States and a few other places. Anaerobic digestion uses microbiological processes in the absence of oxygen to break down organic matter into biogas (mainly methane), carbon dioxide and a stable solid residue. Ideally, the methane is recovered for its fuel value and the residue is returned to the field as a potash fertilizer or composted. There are many possible reactor designs and two methods are under experimentation for vinasse managemement - namely, a method proposed by SGN (Societe Generale pour les Techniquse Nouvelles) and an Upflow Anaerobic Sludge Blanket (UASB). The latter seems to be more popular, as it uses a smaller footprint and can handle larger volumes. However, the key to the success of the UASB digestor is the spontaneous formation of small granular bacterial pellets/granules in the reactor - it takes about 48 days to get a reactor operational[60].
Main environmental	Impacts on local air quality

[59] Information contained in this overview has been largely obtained from Carmen Baez-Smith (1996) Anaerobic Digestion of Vinasse for the Production of Methane in the Sugar Cane Distillery, 2006 SPRI Conference on Sugar Processing

[60] Schmidt and Ahring, 1996

impacts	• Risks of odour and explosions on site due to presence of methane • Positive impacts and less odour on the fields <u>Impacts on water & soil quality</u> • COD removal in an anaerobic digester can range from 65-93%. BOD is generally reduced by 60-70%, even though there is a potential for up to 85% reduction. Experimental modelling in the US[61] indicated that a 90% BOD reduction in the vinasse could be obtained if vinasse is retained in anaerobic environment for an average of 10 days at a temperature starting at 40ºC. • Residual sludge that contains predigested organic matter can be supplied to the fields <u>Impacts on energy ballance</u> • Byproducts of the digestion process – biogass (mainly methane and other gases) - can possibly supply up to 80% of energy required for ethanol distillation.
Recomme-ndations	Anaerobic digestion seems to be a promising future option for vinasse management. However, the volume of stored vinasse in such a process is significant - e.g. a distillery producing 10 million litres of ethanol per year (e.g. 30 000 l of ethanol daily, if it is to operate year-round) will produce about 330 000 to 400 000 l of vinasse per day. The resulting storage space for a minimal 10-15 day retention period of produced vinasse in the anaerobic digestion system (4000-5000 m3) would require a tank with a diameter 40 m and 10 m or a very large pool (3 m x 150 x 10 m). Such arrangement poses significant problems in terms of available space, technical feasibility and risks of possible accidents Further to this, anaerobic digestion can be difficult to control and its effectiveness is determined by the composition of the vinasse, its pH, temperature and presence of potentially toxic constituents (such as phenolics, volatile fatty acids and heavy metals). Tielbaard, 1992 e.g. reported a successful start-up in Venezuela that was able to remove 65-70% of the COD but also noted there were a lot of problems getting a UASB reactor to work properly for digestion of vinasse in India where even at 1:1 dilution the vinasse was toxic to methanogenic bacteria because of the high potassium, sulfide and volatile fatty acids present in the vinasse. The above concerns may limit any large-scale uptake of the of anaerobic digestion for vinasse management in Mauritius. However, it is recommended to follow developments of this method and its positive and negative environmental impacts through relevant research projects.
Priorities for monitoring or further research	The future research in the Mauritian sugar cane cluster should study the possible use of anaerobic digestion as a referential option for vinasse management.

[61] Anaerobic Digestion of Vinasse for the Production of Methane in the Sugar Cane Distillery, Carmen Baez-Smith, Smith Baez Consulting, Inc., Loxahatchee, Florida, USA

Overall comparison of available vinasse management options

Option[62]	Main advantages	Main disadvantages	Other comments
Anaerobic digestion of vinasse	- BOD reduction (up to 90 %) - Production of biogas used as energy for the distillation process - Supplying predigested organic matter and Potassium onto the field	- Long cycle which need storage (10 to 20 days) - Risk of odour	- Can be followed by composting of sludge or its application on fields - Anaerobic digestion may also include factory scums and waste waters
Direct application of vinasse on fields	- No industrial treatment needed - Limits storage risks - Potassium needs of sugar cane are met	- High volume to transport and apply - Highly excessive applications rates (depending of soil types) may enhance leaching of potassium and heavy metals into ground water	
Production of CMS	- No storage of vinasse - Easier use due to lower volume (25 % of vinasse volume) - Less acidic than vinasse - Easily mixed with other nutrients to get complete fertilizer	- Concentration process requires energy - Need for treatment of highly acidic waste waters obtained during condensation	- Followed by application on fields or possibly burning?
Using vinasse in composting with factory scums	- Positive impact on physical and chemical properties of soil	- Long cycle which require larger space - Appropriate site to minimize run off consequences	- Not a main option for management of future envisaged volumes of vinasse - probably only a supplementary measure(to about 10% of volume of vinasse)
Storage in open pools	- Temporary storage space	- Odour nuisance if stored for more than 24 hrs - Risk of pollution due to leakage or overflow (heavy rainfall or emergency situations)	- Only a supplementary measure - Should not be adopted on a large scale if ethanol production gets expanded

[62] Not all of these options are mutually exclusive – e.g. production of CMS can be combined with one or more options.

Proposed general principles for vinasse management in Mauritius

Based on the above comparisons and given the specific conditions of Mauritius, the following 'general hierarchy' of vinasse management options[63] can be recommended:

1. composting of vinasse;
2. concentration of vinasse into CMS and its application on fields (if CMS production uses residual energy from co-generation units);
3. direct application of vinasse on fields located at least 100 metres from residential areas and in the proximity of the ethanol distillery (to minimize transport demand)

New facilities for ethanol production need to ensure that these options for vinasse management are carefully analysed and compared during the project design and the EIA process. The respective EIA processes for such facilities need to include:

- air modelling for the key emissions from the distillery (volatile organic compounds - VOCs) and from the proposed vinasse management options (volatile organic acids and H_2S or other odour-causing substances);
- analyses of possible risks in vinasse management (e.g. emergencies caused by overflows of storage areas; situations when vinasse or CMS cannot be temporarily transported out of the distilling plant; etc.); and
- a study to define an appropriate buffer zone from any existing and/or future urban settlement.

As a matter of principle, any future ethanol producing facilities in Mauritius should be located:

- outside residential areas in order to minimize possible impacts of VOCs, H_2S and other odour causing substances. As a general pre-cautionary measure, it is recommended that ethanol plants and the nearest settlements be located at least of 300 metres apart and this distance may be further increased depending on the local meteorological conditions (e.g. humidity, wind direction and topography). It is recommended that no developments be allowed within this buffer zone;
- next to a sugar factory so that the ethanol production and vinasse management can effectively use the residual energy (which is usually available within the milling plant); and molasses which are directly available at the sugar factory are used (thus minimizing transport and storage demands).

In order to ensure sound environmental management and compliance, all new ethanol plants supported through the MAAS should also operate an ISO certified environment management system (e.g. starting by ISO 14031 "Environmental performance evaluation" or ISO 19011 "Environmental management systems auditing" and gradually progressing to full environmental management under ISO 14001 or ISO 14004).

The above recommendations should be generally applicable to ethanol plants developed as the result of the MAAS as well as to any other ethanol producer in Mauritius, irrespective of whether locally produced or imported molasses are used.

[63] This proposed 'hierarchy' only summarizes general recommendations formulated on the basis of preliminary analyses undertaken within this SEA. However A more precise hierarchy of specific vinasse management options for each ethanol plant need to be determined through a detailed project level EIA.

Site-specific recommendations

According to the MAAS, apart from Medine and Belle Vue, the two other sugar factories that will remain when centralization is complete, are FUEL and Savannah. It is logical to assume that each will have an ethanol producing plant. Neither of these plants have yet decided on their vinasse management options since these technological issues will be determined during the detailed project design and the respective EIA processes. However, the SEA team has conducted the following preliminary analysis of site-specific issues to determine whether both plants will have basic means for a safe disposal of vinasse they generate.

Savannah

The amount of cane expected to be crushed by Savannah in a normal year (i.e. without cyclone or drought) is about 1.6 million tonnes. The amount of molasse that will be produced is about 48 000 tonnes. Taking an average of 240 l of ethanol per tonne of molasses, it appears that about 11.5 million l of ethanol and 138 million l of vinasse would thus be obtained per year in Savannah.

The sugar estates that will be centralized in the South, will have an approximate area of 12 000 ha of land under sugar cane (Savannah : 2400 ha, Riche en Eau: 2500 ha, St Aubin and associates: 2800 ha, Mon Tresor: 2300 ha, Britannia: 1700 ha, St Felix: 450 ha). Given that between 2500 and 5000 l of vinasse can be applied to supply the annual K20 requirement of sugar cane, the 138 million l of produced vinasse would require about 25 000 to 50 000 ha of land. Therefore, practically all the land of the above estates are not enough to receive all the vinasse which would be produced by Savannah . Cosequently, less than 50% would be used. Therefore, the rest would have to be concentrated in the form of CMS.

Vinnasse management options at Savannah

Composting	According to the factory personnel of Savannah, there is a plan to install diffusion process which should produce either little or no scums. If composting was to be adopted for part of the vinasse, it would have to collect sugar cane leaves and tops from the fields for use as basic material.
Direct application on fields	The duration of the crop season varies between 150 to 160 days. Thus the distilling plant should be able to produce 72 000 l of ethanol per day if it is to operate only during that period and a proportinally smaller unit if it's for a longer period. At the same time, direct application on fields this would imply transporting the product to fairly long distances for application in the fields.
CMS	Feasible option throughout the year

Conclusions and recommendations for Savannah

Presuming that the ethanol distillery at Savannah will operate during the entire year, about 20% of the vinasse produced during the crop season can be directly applied on the fields located close to the distillery(on about 5000 ha of sugar cane land). The rest of the vinasse and that produced during the off-crop season can be concentrated to CMS and can be applied on distanced fields .There would still be about 40% of the CMS available for sale. The economic aspects of the proposals will have to be carefully examined before deciding on one or more of these options.

F.U.E.L

The sugar estates that will be centralized around FUEL will have an approximately the same area as Savannah. The total area of approximately 12 000 ha sugar cane lands will comprise the following estates: FUEL with 5400ha; Deep River- Beau Champ with 3600 ha; Mon Desert Alma with 2500ha and part of Mon Loisir (not decided yet where the sugar cane will be processed). Therefore, the situation with regard to vinasse management during the production of ethanol at FUEL is very similar to that of Savannah. Practically, 20% of the vinasse produced could be returned to the land of the above estates either in form of the vinasse direct application, compost or through CMS.

Vinasse management options at FUEL

Composting	The milling technology at FUEL is and will continue producing factory scums. FUEL thus has an opportunity to use the crop season for composing of up to 10% vinasse of annually produced vinasse. Vinasse can be composted with factory scums and possibly with trash collected from the fields.
Direct application on fields	150-160 days of the crop season may allow for an application of approximately 20% of annually produced vinasse by the distillery..
CMS	CMS production offers a feasible vinasse management option throughout the year

Conclusions and recommendations for vinasse management options at FUEL

FUEL will have multiple options for management of vinasse produced. These options include either 20% direct application on 50% of fields; 100% production of CMS or 20% direct application on fields combined with 80% CMS (or 70% CMS and 10% composting).The financial feasibility of these options and their environmental impacts can be easily determined during the detailed planning of the ethanol plant.

Recommendations for future research

Anaerobic digestion and partly also CMS burning offer possibly interesting future options for future energetic use of vinasse. While these options do involve important environmental and technological risks and not currently represent viable solutions for management of the forecasted volumes of vinasse in Mauritius, it is recommended to continue research on these options to determine possible options for minimizing these technological and environmental constraints. Such information can be used to inform the sugar cane industry community on the considerations on the possible future uses of these approaches in Mauritius after 2015 when the transitional support of the MAAS will have expired. Research and development assistance under the MAAS could also support analyses of technologies of ethanol production that produce smaller volumes of residual vinasse.

Appendix: Key parameters of three ethanol production facilities in Mauritius

Medine

Key parameters of ethanol production	2004	2005	2006	Expected figures in 2007-08
Amount of molasses used per day [tonnes]	88	88	88	88
Content of sugars [%]	45	45	45	45
Daily ethanol production [litres]	20 000	20 000	20 000	20 000
No. of working days per year	219	228		
Annual production/sale [litres]	3 470 000	4 109 000	4 821 000	5 500 000
Type of ethanol [% purity]	96.3	96.3	96.3	96.3
Vinasse produced per day [litres]	280 000	280 000	280 000	280 000
When concentrated to CMS, daily amount produced and % dry matter				
Type of fuel used	Steam & F oil	Steam & F oil	Steam & F oil	Steam & F oil
Litres/kg of fuel per day	8000	8000	8000	8000
Litres of ethanol per litre/kg of fuel	2.5 L Et / L F. Oil	2.5 L Et / L F. Oil	2.5 L Et / L F. Oil	2.5 L Et / L F. Oil
Air emissions • NOx, • SOx, • CO • VOC				
Waste waters • Volume [litres] • COD • pH				
How is waste water used/disposed of	Field app.	Field app.	Field app.	Field app.

Beau Plan(Grays)

Key parameters of ethanol production	2004	2005	2006	Expected figures in 2007-08
Amount of molasses used per day [tonnes]	108.740	102.569	100.259	102.821
Content of sugars [%]	40.00	39.70	39.90	39.96
Daily ethanol production [litres]	23,771	23,504	22,531	23,135
No. of working days per year	103	109	161	165
Annual production/sale [litres]	2,448,297	2,561,963	3,617,331	3,817,256
Type of ethanol [% purity]	96%	96%	96%	96%
Vinasse produced per day [litres]	410,371	367,890	400,724	393,939
When concentrated to CMS, daily amount produced and % dry matter	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Type of fuel used	Coal	Coal	Coal	Coal
Litres/kg of fuel per day	15,487	16,653	17,912	17,000
Litres of ethanol per litre/kg of fuel	1.53	1.41	1.25	1.36
Air emissions • NOx, • SOx, • CO • VOC	196 ppm Unknown 188 ppm Unknown			
Waste waters • Volume [litres] • COD • pH	About 10,000 litres per day No values are available for the C.O.D and pH			
How is waste water used/disposed of	Mixed with the vinasse			

Alcodis

Key parameters of ethanol production	2004	2005	2006	Expected figures in 2007-2008
Amount of molasses used per day (tones)			100	250
Content of sugars (%)				46 %
Daily ethanol production (litres)			20 000	65 000
Number of working days per year				330
Annual production/sale (litres)			4 000 000	19 000 000
Type of ethanol (% purity)			96,2	96,2
Vinasse produced per day (litres)				
When concentrated to CMS, daily Amount produced and % dry matter			150 T/D 55%	225 T/D
Type of fuel used			HFO	HFO
Litres/Kg of fuel per day			29 000	20 000
Litres of Ethanol/Kg of fuel			0,69	3,25
Air Emissions NOx SOx CO VOC CO2 Ethanol Vapour			 240 36 75 ppm Unavailable	 225 (Gas from Boiler) 25 58 ppm Unavailable
Waste Waters Volume (litres) COD pH				 180 m^3 1500 5.2
How is waste water used/disposed of				Reused in the ethanol production process Remaining water transported to Waste Water Authority Roche Bois

Annex 5: Detailed analysis of conversion of sugar cane lands to other agricultural uses

The primary authors of this analysis are Guy Mc Intyre and Bernard Siegmud. AREU extensively contributed and provided detailed data inputs.

Key trends in the conversion of sugar cane lands to other agricultural uses

The MAAS proposes to maintain cultivation of sugar cane on 63 000 ha, but some experts expect that the area under the sugar cane may gradually decrease even to less than 60 000 ha over the next 10-15 years due to conversion of sugar cane lands to other uses. Conversions of sugar cane lands are likely to increase through the intended self-sufficiency of Mauritius in the production of vegetables and through interventions identified in the Non-sugar Sector Strategic Plan 2003.

The Mauritius Chamber of Agriculture noted that the decision of sugar cane planters (both large and small) to opt for other crops, pasture lands or even agro-forestry, in lieu of sugar cane, is solely dictated by economic considerations. Currently, there are no precise objectives set, except for potato (which will continue to be grown on sugar cane lands –plant cane interlines and rotation between 2 crop cycles), as concerns non sugar activities. The land devoted to other agricultural activities also increasingly includes sugar cane lands (plant cane interlines and rotation lands-between two cane cycles-), belonging to sugar estates, and rented out to small planters for food crop and tobacco production, as per the Finance Act of 1994 and its subsequent amendments.

Overview of key features of other possible agricultural uses of sugar cane lands

The following possible agricultural uses for the sugar cane lands were examined in detail (see appendix to this report):

1. Potato
2. Onion
3. Tomato
4. Vegetables (Crucifers, cucurbits, legumes)
5. Palm
6. Mango
7. Litchi
8. Longan
9. Banana
10. Citrus
11. Pineapple
12. Papaya
13. Strawberry
14. Guava
15. 16. Passion fruit
16. “Underutilized” local fruits
17. Ornamentals
18. Spices
19. Medicinal plants
20. Fodder plants
21. Deer farming
22. Milk production
23. Meat production

General conclusions on the conversions of sugar cane lands to other agricultural uses

The MAAS, besides its overall attempt to ensure continuity of the sugar cane cultivation on all suitable lands, does not directly deal with conversion of sugar cane lands to other agricultural uses. However, conversion of sugar cane lands to other agricultural uses is happening and is facilitated by the recent amendments to existing government regulations that removed a land-conversion tax for certain planters, for residential purposes or businesses.

A summary of the main crops and their respective present and forecasted areas is given below:

Potato	700 ha.	(+300 ha)
Tomato	900 ha.	+ 200 ha.
Onion	250 ha.	+ 100 ha.
Vegetables	2 300 ha.	+ 450 ha.
Banana	500 ha.	+ 200 ha*
Palm	450 ha.	+ 150 ha*
Pineapple	200 ha.	+ 100 ha*
Mango/Litchi	100 ha.	+ 100 ha*
Others	200 ha.	+ 100 ha.

In this regard, comments obtained indicate that farming of vegetables and other short-term crops in Mauritius are generally believed to demand more soil manipulation (which increases risk of erosion) and also more fertilizing and pesticide use (which increases risk of nutrient run-off and leaching, especially when planted on sandy soils) than the current varieties of sugar cane which tend to be pest- and disease-free. Vegetables also on average demand more water than sugar cane, and they need to be irrigated more regularly than sugar cane which can afford certain water stress. These practices, when combined may actually have adverse impacts on ground water quality and water availability, partly also on surface run-off. Fruits and palms would generally require less fertilizing, soil manipulation and irrigation but may require more pesticides.

It is well known that vegetables require finer land preparation than sugar cane. This can cause soil erosion by wind and water.

Use of agrochemicals in most crops is higher than in sugar cane, especially pesticides. However, there is a risk that not all of the fertilizers applied is taken up by the plants due to their relatively shallow root system. A certain proportion can thus be leached into ground waters.

Excessive rates and applications of pesticides, the wrong disposal of containers and the washing of sprayers can lead to environmental pollution.

Recommendations

A. Planters who wish to diversify from sugar cane should be provided with support under the MAAS only if they:

1 Choose appropriate crops for the local climatic and soil conditions. Such choice should ensure that conversion of sugar cane lands to other crops is properly managed (e.g. combination of crops, land management practices, wind barriers, erosion control plants such as vetiver etc.). The following particular factors need to be considered:
- In sloping lands: fruit trees, palm, pineapple. It is essential that regular contour rows of an anti erosion plant be established (e.g. vetiver, muguet). In cases where growers would like to keep sugar cane, palm or pineapple could be grown in the interrows. It has been argued by MSIRI that the cane would after some time compete too much with the palm or pineapple. What could then be done is to kill 1 cane row out of 2 with the herbicide Roundup and plant the palm or pine apple on that row, thus preventing competition for light. The sugar cane will not only serve as anti erosion agent, but can also be exploited in different ways.
- In relatively flat lands consideration should be given to sound management practices especially for water management, such as drains, waterways…
- Where vegetables are grown and for fruit trees in their young stages, it is necessary to establish wind breaks composed of suitable native plants which are adapted to the local climatic conditions of the region. The wind barriers should not be established using invasive species (e.g. to avoid plants like eucalyptus in dry areas)

3. Subscribe to code of practice for environmentally sound farming of vegetables elaborated by APEXHOM.

4. In all cases, AREU recommendations on the use of agro chemicals (fertilizers and pesticides) and the adoption of proper varieties adapted to different soils types and climates should be strictly adhered to. Waste waters coming from the washing of spraying equipment should be collected into an impermeable space where organic materials can absorb the washings. Ideally, pesticides, which are in a powder form, should be packed in biodegradable/dissolvable plastic.

B. The following support services[64] should be in place to properly manage & supervise production of these non-sugar cane crops:
- o Strategic research: analysing future demands (nationally and internationally) & identifying key crops that could be produced in Mauritius
- o Selection of crop varieties and production of planting materials which are adapted to climatic (sub-tropical) conditions of Mauritius, which are pest & disease –free, etc.
- o Financial assistance (conversion, machinery, etc.): through advisory services for obtaining soft-loans, etc.
- o MQA-approved training and hand-on advising through extension services:
- o Supporting the certification & quality assurance for vegetables and fruits (especially for export and tourism industry);

[64] Agenda and outcomes to be co-agreed between key bodies (MSA, FARC, AREU, MSIRI, other research bodies – such as university of Mauritius; Chamber of agriculture, etc.) and beneficiaries to provide support services for these new crops. The funding should be provided only if the continuity after EU support is ensured.

- Facilitating exchange of monitoring data on soil & water quality, quality of products, pesticide & fertilizer use. Twinning arrangements (possibly directly supported by EU) with similar R&D and assistance programmes in other ACP countries would be beneficial.
- export promotion & possibly also assistance with branding

Twinning arrangements with similar R&D and assistance programmes in other ACP countries (possibly directly supported by EU) are seen as beneficial.

Specific conclusions on the conversions of sugarcane lands in difficult areas

The MSIRI has identified 12 341 ha of difficult areas which were clustered as follows:

- Category A: 4 642 ha of sugar cane lands which are either close to environmentally sensitive areas as proposed in the Review of the National Physical Development Plan (April 2003) or present some economic/social risks to nearby villages, the tourism industry and artisanal fishing,
- Category B:1 365 ha of sugar cane land on three inland slopes (of the same mountain ranges as Category A but not as steep) and one on the flanks of an isolated mountain,
- Category C: 6 334 ha of flat to moderately sloping land in the humid to super humid regions.

The study concluded that the formulation of an acceptable package of support measures may not be straightforward owing to the numerous questions the future of cane growing on these slopes gives rise to. This report also formulated several important questions about the long-term viability of sugar cane cultivation in these areas as follows:

- For how long can sugar cane cultivation be maintained through support measures?
- In the long run, what shall be the effect of these support measures on these regions, on the industry and on the national economy?
- Given the decline in sugar cane profitability, is it not preferable to look for other crop activities that are environmentally sustainable and economically viable?
- What are the views of the concerned planters as regards the future?

The areas identified by MSIRI are larger than the 5000 ha stated in the MAAS due to a different classification adopted, namely:

- Either the degree of rockiness is fairly high and intensive where even moderate derocking is uneconomical or the slope of the land under cane is steep;
- Mechanization even partial is difficult;
- Yields are fairly low;
- Cane cultivation costs are high;
- The very rocky areas are found in the drier parts of the country;
- They are most exposed to the adverse impact of drought and cyclones. Conversion into residential units and commercial sale is very difficult.

Calculations performed by the SEA team on conversion of difficult sugarcane lands to other agricultural crops indicate that an additional area which would be occupied by crops other than sugar cane represent only 1500 ha, out of which only 500 would be feasible in difficult lands. This leaves some 7000 ha of difficult lands which may be abandoned. The alternative uses could thus be:

- Deer ranching
- Cattle Ranching
- Fruit production
- Forestry
- Return to natural forest.

The above four possibilities are interesting, as, if they are professionally managed, will have a positive effect on the environment as there will be a complete ground cover after a few years and little amounts of fertilizers and pesticides are required.

Given the present context, it is unlikely that such area be rapidly converted to other uses. There is a risk that they may become wasteland which pose particular environmental risks (wild fires, invasive species, etc.).

In these zones it might be useful to encourage planters to keep sugar cane under cultivation with accompanying financial measures while planning conversion of these lands into other alternative uses. The cane would still be acting as an efficient erosion barrier during periods of moderate to heavy rainfall. During this transitional period, the cane could be exploited in different ways – e.g.:

- harvested as usual for sugar production,
- used for production of the cane juice for tourists in hotels (where fields are situated in their neighborhood)
- produce "Rum Agricole"

Planning conversion of these lands into other alternative uses during this transitional period could consider some of the following alternative uses which - if they are professionally managed –will have a positive effect on the environment (as there will be a complete ground cover after a few years and little amounts of fertilizers and pesticides)

Appendix

Crop	**Potato**
Adaptability to local climate	Grown between April and November
Actual cultivated areas	600 – 700 ha
Expected increase areas	300 ha
Impacts on soil (erosion & Use of machinery)	No negative impact on soil erosion, but use of machinery will increase if totally mechanized
Use fertilizers	650 kg/ha 16-22-22 + 150 kg/ha DAP
Use of pesticides	Mainly insecticides and fungicides applied every 7-10 days, after emergence
Employment potential in the whole process	Fairly low except if sprayings and harvest are done manually
Other comments	Potato is grown only on sugar cane lands ; therefore, no influence on land conversion. Transformation (e.g. into chips) will increase revenues

Crop	**Onion**
Adaptability to local climate	Grown between March and October / Well adapted in humid and sub-humid irrigated regions
Actual cultivated areas	250 ha
Expected increase areas	Additional 100 ha to boost early production from June-August when the country depends mostly on imports.
Impacts on soil (erosion & Use of machinery)	No negative impact on soil erosion as onion is usually cultivated on flat land. However, if grown in sandy soils, care must be taken to avoid/reduce leaching,by applying fertilizers in small repeated doses.
Use fertilizers	For a targeted yield of 40-50 t/ha, the rate of fertilizer

	application is of 95 kg N, 94kg P and110 kg k per ha
Use of pesticides	Regular application of pesticides required every 7-10 days
Irrigation demands	800-1000 mm water for a crop cycle of 5 -5.5 months
Employment potential in the whole process	High labour demand at transplanting and harvesting stages and for sprayings

Crop	**Tomato**
Adaptability to local climate	Adapted to all types of soil provided it has good drainage. Cultivated in humid and subhumid regions. Cultivated all year round, but less during hot wet season.
Actual cultivated areas	935 ha (As at year 2006)
Expected increase areas	A 20% increase over the next ten years is expected with respect to local demand and possibility for processing.
Impacts on soil (erosion & Use of machinery)	No negative impact when grown in flat land. Otherwise, erosion barriers necessary.
Use fertilizers	Rate of fertilizer used :110 kg N/ha, 71 P_2O_5 kg/ha, 110 K_2O kg/ha
Use of pesticides	Heavy use of fungicide (an average of 10 -12 applications) to control major disease like late blight and pesticide (an average of 14 -16 applications) to control fruit fly, fruit borer and red spider mite. Use of herbicide for weed control (1 application)
Irrigation demands	Partly rainfed cultivation and in irrigated areas, amount of irrigation water required per crop cycle is 2840 m^3/ha
Employment potential in the whole process	Intensive labour requirement mainly for transplantation, sprayings and multiple harvests and other cultural practices (earthing-up and top dressing)
Other comments	Vulnerable to natural calamities (drought, cyclone and heavy rainfall) / Susceptible to major diseases (late blight and bacterial wilt) and pests (fruit fly, fruit borer and Red spider mites) Production of salad tomato mainly in hydroponics. Demand for cherry tomato for hotel. Potential for production of tomato for processing to meet demand in period of scarcity. Ongoing breeding programme to develop heat and bacterial wilt tolerant varieties.

Crop	**Vegetables (Crucifers, cucurbits, legumes)**
Adaptability to local climate	Whole year depending on type of vegetables/ hybrid varieties available for off-season production
Actual cultivated areas	2 300 ha
Expected increase areas	20 % over a period of 10 years
Impacts on soil (erosion & Use of machinery)	No negative impact if on flat lands. However, if land is sloping, it is necessary to provide erosion barriers with vetiver.
Use fertilizers	Average 80 Kg N, 95 Kg P_2O_5 and 141 Kg K_2O /ha,
Use of pesticides	Around 16 applications per crop cycle
Irrigation demands	Rainfed production mainly in superhumid areas. Irrigated cultivation requires around 4200 m^3 per a crop cycle of 4 months per hectare

Employment potential in the whole process	Labour needed for sowing, transplanting, spraying and harvest
Other comments	Part of production is by hydroponics and protected cultures which has the advantage of cutting down on use of pesticides and herbicides. Production of these vegetables for processing and transformation

Crop	**Palm**
Adaptability to local climate	Well adapted to local climate. Local varieties adapted in humid and sub-humid regions. Pejibaye adapted to humid and super-humid regions
Actual cultivated areas	450 ha
Expected increase areas	25 % to provide the flourishing tourist industry
Impacts on soil (erosion & Use of machinery)	No negative impact, with Pejibaye, precautions to be taken at planting.
Use fertilizers	100 g 13:13:20:2 + 50 g TSP/plant at planting. Top dressing with CAN at 100g/plant after 3 months Subsequently top dressing every 6months.
Use of pesticides	Mainly insecticides applied occasionally
Irrigation demands	Mainly rainfed
Employment potential in the whole process	Labour demand specially at harvest
Other comments	May also be developed in difficult areas where sugar cane is not profitable Future increases in production are related to an increased local demand and in export

Crop	**Mango**
Adaptability to local climate	Well adapted to local climate. Regions at an altitude of less than 400m above sea level with rainfall regime less than 2000mm rain/yr are most adapted. Specific varieties exist for regions at altitude of 400m or above.
Actual cultivated areas	50 ha
Expected increase areas	50 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	kg/ha: N=300, P=100, K=470 (rate for an average adult plant(10yrs old) under high density planting
Use of pesticides	Pesticides used mainly during flowering and fruiting season to protect against diseases like powdery mildew, Anthracnose, flower midge and also against fruit fly .
Irrigation demands	There is need for water stress at certain times of year. (May-July). 90,000 (normal density) to 360,000 (for high density planting) m3 water/year for adult bearing plants.
Employment potential in the whole process	Labour needed mainly for harvest and pesticide sprays
Other comments	Possible increase in area cultivated because: There is increased possibilities for transformations (Fruit bars,

	jellies, juice) and also as ripe fruit for tourists & export market.

Crop	**Litchi**
Adaptability to local climate	Well adapted to local climate except at high altitude
Actual cultivated areas	50 ha
Expected increase areas	30 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	N=90kg/ha, P = kg/ha, K 168 kg/ha72 per year (adult tree)
Use of pesticides	Little use of pesticides. Fungicides used mostly for control of disease (anthracnose) and pest (fruit borer) during fruiting season.
Irrigation demands	No watering during April- mid-June. Outside this period an adult plant needs 800L/week (4.5 to 7 million litres per ha depending on planting density)
Employment potential in the whole process	Labour needed mainly for harvest and to carry out any specific treatment needed to induce flowering (manual tipping or hormonal sprays)
Other comments	The area under litchis could be more important if good husbandry is practiced. Certification by approved agencies is necessary if export is expected. Possible increase in area cultivated if transformation is developed and increase in export (fresh fruit)

Crop	**Longan**
Adaptability to local climate	Well adapted to local climate except at high altitude
Actual cultivated areas	3 ha
Expected increase areas	1 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	As for litchi
Use of pesticides	Little use of pesticides
Irrigation demands	As for litchi
Employment potential in the whole process	Labour needed mainly for harvest
Other comments	Preference may be given to litchi as longan fruiting periods coincides with peak cyclonic periods.

Crop	**Banana**
Adaptability to local climate	Well adapted to local climate
Actual cultivated areas	500 ha
Expected increase areas	200 ha
Impacts on soil (erosion & Use of machinery)	When grown on sloping land, erosion results
Use fertilizers	540 N, 200 P, 950K kg/ha/yr
Use of pesticides	used only for control of foliar disease
Irrigation demands	5 ,000,000 m3 /ha/yr
Employment potential in the whole process	Labour needed mainly for planting, crop management and harvest

Other comments	Only for local consumption and transformation. It is strongly recommended to have vegetable barriers such as vetiver every 3 rows, to contain soil erosion.

Crop	**Citrus**
Adaptability to local climate	Well adapted to local climate. Varieties adapted to zones: -45 Superhumid : mandarins, oranges, citron Meyer. -46 Subhumid : pamplemousses, lime
Actual cultivated areas	85 ha
Expected increase areas	1 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	105 N, 75P, 85 K (kg/ha/yr)
Use of pesticides	Heavy use of pesticides to control greening vectors, mites and citrus canker
Irrigation demands	Regular water supply is needed , but most orchards in superhumid./ humid areas
Employment potential in the whole process	No negative impact on the environment. However, care should be taken in sandy soils where smaller doses are applied at a time to avoid leaching into ground waters. Labour needed mainly for sprayings and harvest

Crop	**Pineapple**
Adaptability to local climate	Well adapted to local climate
Actual cultivated areas	105 ha
Expected increase areas	Double (200 ha)
Impacts on soil (erosion & Use of machinery)	On slopes, plantation should be in contour with establishment of barrier crops (e.g. vetiver)
Use fertilizers	Mainly require N and K N= 582 , P=almost negligible, K=875 kg/cycle/ha
Use of pesticides	Minimal use Plant growth hormones for flowering.
Irrigation demands	Low demand in water. If plantation located in subhumid areas then water should be supplemented in order to reach1200-1800 mm water needed
Employment potential in the whole process	Labour needed mainly for plantation, sprayings and harvest
Other comments	Increase in production if exported in large amounts and transformation If grown on plastic sheets, these should preferably be biodegradable.

Crop	**Papaya**
Adaptability to local climate	Well adapted to local climate (prefers warm & humid)
Actual cultivated areas	5 ha
Expected increase areas	4 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	460 N, 460 P, 750 K (kg/ha/yr)

Use of pesticides	Mainly for mite, Asperisporium & fruit fly control
Irrigation demands	1000 -2600 mm /ha/yr
Employment potential in the whole process	Labour needed mainly for plantation, sprayings and harvest
Other comments	Potential for local market, tourist industry & export

Crop	**Strawberry**
Adaptability to local climate	Varieties adapted to different climatic conditions needed
Actual cultivated areas	2 ha (65000 plants/ha)
Expected increase areas	2 ha
Impacts on soil (erosion & Use of machinery)	Land preparation should not be carried out during rainy season
Use fertilizers	Triple superphosphate: 100g/10m^2, Sulphate of potash:700g/10m^2, Calcium ammonium nitrate: 400g/10m^2
Use of pesticides	For disease (powdery mildew, anthracnose, botrytis) and pest (snails, rodents)
Employment potential in the whole process	Very labour intensive; labour needed mainly for plantation, sprayings and harvest
Other comments	In superhumid zone, protected cultivation is recommended to reduce disease incidence & fungicide application. Strawberry is grown on plastic mulch. The plastic should preferably be biodegradable.

Crop	**Guava**
Adaptability to local climate	Well adapted to local climate
Actual cultivated areas	50 ha
Expected increase areas	5 ha
Impacts on soil (erosion & Use of machinery)	Can partially prevent erosion
Use fertilizers	100 N, 120 P, 150 K (kg/ha/yr)
Use of pesticides	Fruit fly control mainly as guava is very susceptible
Irrigation demands	During flowering and fruit set
Employment potential in the whole process	Labour needed mainly for plantation, sprayings and harvest
Other comments	May also be developed in difficult areas Future increases in production are related to an increased local demand and transformation.

Crop	**Passionfruit**
Adaptability to local climate	Well adapted to local climate. Specific varieties exist for each agro-climtic zone.
Actual cultivated areas	2 ha
Expected increase areas	10 ha
Impacts on soil (erosion & Use of machinery)	No negative impact
Use fertilizers	Moderate - 41kg sulphate of ammonia + 834 kg 13:13:20:2 /ha per year
Use of pesticides	Pesticides used mainly during fruiting season to protect against Anthracnose and against fruit fly.

Irrigation demands	2000 mm water/year for an adult bearing plant.
Employment potential in the whole process	Labour needed mainly for harvest and pesticide sprays
Other comments	Potential for local & export market as fresh fruit and processed form (juice, concentrate, fruit bar)

Agricultural activity	**"Underutilized"local fruits**
Adaptability to local climate	Well adapted to local climate
Actual cultivated areas	0.5 ha
Expected increase in areas	2 ha
Impacts on soil (erosion & Use of machinery)	None
Use fertilizers	200 N, 100 P, 500 K (kg/ha/yr)
Use of pesticides	minimal
Irrigation demands	Very low demand
Employment potential in the whole process	For planting and harvest
Other comments	May increase with possibilities for transformation and development of tourist industry. No negative impact on the environment.

Crop	**Ornamentals**
Adaptability to local climate	Different ornamentals adapted to varying climates
Actual cultivated areas	80 ha
Expected increase areas	20% over a period of ten years
Impacts on soil (erosion & Use of machinery)	No negative impact. Usually established in protected areas and flat surfaces.
Use fertilizers	After plantation N:P:K is 1:1:1; at flowering 2:1:4
Use of pesticides	Regular use of insecticides and fungicides on commercial species
Irrigation demands	700-1000 ml/ plant/day
Employment potential in the whole process	Labour needed mainly for plantation, sprayings, harvest and post-harvest and packaging (export) Trained personnel needed if complying to EUREP-GAP Potential for entrepreneurs for value-added products
Other comments	Majority of rose and gerbera production is under protected cultivation. Potential for export to neighboring countries. No negative effect expected on the environment.

Crop	**Spices and condiments**
Adaptability to local climate	Well adapted to local climate. Ginger and garlic grow best in humid & sub-humid regions. Cardamom grows best in humid and super humid regions.
Actual cultivated areas	Ginger : 1 011 t (2005) : 54 ha Garlic : 93 t (2005): 12 ha Cardamom: 2 t : 8 ha
Expected increase areas	Additional 25 ha mainly for garlic and cardamom
Impacts on soil (erosion & Use of machinery)	No negative impact if on flat lands. Dans les autres conditions, il est nécessaire de prévoir les systémes qui permettent de limiter ces risques (vetyver, muguet…)
Use fertilizers	Garlic: 600 kg 13:13:20:2/ha at planting + 235 kg SOA 3-

	4 weeks after planting Ginger: 375 kg KCL+208 kg TSP/ha at planting + 2 top dressings of 250 kg SOA/ha 6 and 8 weeks after planting.
Use of pesticides	Ginger & Garlic: Regular applications of pesticides. Cardamom: No major pests and diseases
Irrigation demands	Cardamom is rainfed. 550 mm for a crop cycle of garlic; 840 mm for a crop cycle of ginger
Employment potential in the whole process	High labour demand at harvesting stage specially for cardamom which requires much labour for processing also.
Other comments	Cardamom can be successfully grown in the ex-tea belts Increase in garlic production can help substitute imports to a small extent

Crop	**Medicinal plants (**Aloe vera, Stevia, Noni, Basil and Lemon grass)
Adaptability to local climate	Widely adapted to our agro-climatic conditions
Actual cultivated areas	Some backyard cultivation of Lemon grass, Noni, and Aloe vera
Expected increase areas	Future increases related to development of processing facilities
Impacts on soil (erosion & Use of machinery)	No negative impact if on flat lands. Otherwise, it is necessary to set up erosion barriers made up of vetiver.
Use fertilizers	Very low fertilizer requirement Aloe vera: FYM-15 t/ha at plantation, 500 kg of N/ha annually Stevia: organic fertilizer Noni: 500 kg/ha of N,P,K
Use of pesticides	Not recommended for medicinal plants
Irrigation demands	Aloe vera: low water requirement; rainfed Stevia: frequent , shallow irrigation Noni: low water requirement; rainfed Basil: rainfed Lemon grass: rainfed
Employment potential in the whole process	High labour demand at harvesting .At processing level, it varies with the crop.
Other comments	These potential crops for medicinal purpose require processing facilities for value addition. They are low input and low maintenance crops. It is not expected that the setting up of medicinal plants will have a negative impact on the environment.

Agricultural activity	**Forage**
Adaptability to local climate	Well adapted to local climate and available all year round
Actual cultivated areas	8 to 9 ha consisting of *Setaria* spp, herbe elephant and mixed fodder (Mont-Bois)
Expected increase areas	20 % increase depending on development in the livestock sector
Impacts on soil (erosion &	Risk of soil compaction due to transportation of fodder by

Use of machinery)	lorries and tractors
Use fertilizers	Complex fertilizer to be applied at planting, N based fertililzer 3-4 weeks after planting and after every harvest. Rate will depend on type of fodder species grown.
Use of pesticides	One application of herbicide before land preparation
Irrigation demands	Mostly rainfed
Employment potential in the whole process	Low labour requirements. Harvest can be done mechanically
Other comments	About 255 ha of fodder sites consisting mainly of mixed fodder are available on state lands. Sugar cane tops are mainly used as forage in villages.

Agricultural activity	**Milk Production**
Adaptability to local climate	Adapted to local climate
Actual no. of heads	2000 cows out of 6300 heads
Expected increase in no. of heads	10 % increase
Impacts on soil (erosion & Use of machinery)	No impact in confined or semi-opened system
Impact of waste on environment	Manure and wastewater may pose problem if not properly managed. Composted manure is used as organic fertilizer in vegetable production.
Use of chemicals	Chemical control of stomoxys and ticks. Biological control of flies
Water requirement	Moderate
Employment potential in the whole process	Traditionally labour intensive activity unless modernized using milking machines and equipment for harvesting of forage and cleaning of pen
Other comments	Current supply is only 2 % of the local milk consumption. Possibility for zoning of livestock activities and regrouping of cattle breeders into cooperatives Establishment of pastures to obtain reserves, particularly in winter, is essential if milk production is planned. This requires fodder of a good quality and in sufficient amounts. Also, another source of food would be to collect cane trash from mechanically harvested sugar cane which would significantly contribute to a good milk production. If possible, areas that can be mechanized are preferable so as to reduce labour requirement.

Agricultural activity	**Deer Farming**
Adaptability to local climate	Well adapted to local climate All regions provided dry areas have irrigation facilities. Mountain slopes or rugged areas where mechanization not possible
Actual No. of heads	70,000
Expected increase in no. of heads	10 % under semi- intensive system of production
Impacts on soil (erosion &	Management of feedlots can partially prevent erosion

Use of machinery)	Appropriate stocking density or carrying capacity
Use fertilizers	Advisable for higher production in grazing system
Use of pesticides	Chemical control of stomoxys and ticks. Biological control of flies
Irrigation demands	In drier areas only
Employment potential in the whole process	Not labour intensive
Other comments	May also be developed in difficult areas Development of export needs to provide adequate facilities in slaughterhouse which should be at European norms Major constraints – poaching, high cost of pasture creation and maintenance, stomoxys flies,

Agricultural activity	**Beef Production**
Adaptability to local climate	Adapted to local climate
Actual no. of heads	6300 heads
Expected increase in no. of heads	up to 8000 heads
Impacts on soil (erosion & Use of machinery)	Negligible if grazing is properly managed
Use of fertiliser	Low fertilizer input in fodder production
Use of pesticides	Pesticides used for control of ticks and diseases
Water requirement	Water is required for high productivity of pastures and fodder plantation
Employment potential in the whole process	Traditionally labour intensive
Other comments	Activity maybe developed in difficult areas Possibility exists for further processing of meat into sausages, meat preparations. In order to increase the production of meat, either by deer farming and/or cattle rearing, permanent grazing areas must be established to provide enough fodder for the animals. These grazing lands can be established even in difficult zones such as sloping lands. Risks of erosion exist only at the start of the process. However, should such a system be started on lands already under sugar cane, this crop should not be removed to serve as a barrier to erosion.

Annex 6: Detailed analysis of trends in sugar cane burning

The primary authors of this analysis are Christophe Poser and Guy Mc Intyre.

Current situation

Currently, sugar cane burning is practised before harvesting to increase efficiency of harvesters. This practice represents a physical advantage to reduce the obstacle represented by trash around the stalk of sugar cane in manual or mechanically conditions. In some countries, fire is used to remove snakes or other dangerous animals but it's not the purpose in Mauritius.

In the case of **mechanical harvesting,** efficiency is increased up to 30 % when cutting in burnt cane with an average of 30 - 40 t/hr in green cane (current conditions of yield up to 110 t/ha) compared with 40 - 50 t/hr in burnt cane[65].

In the case of **manual harvesting**, efficiency of cutting is increased by about 20 to % when cutting in burnt cane.[66]

In Mauritius, "Cool burning" practice, recommended by MSIRI, during early morning hours decreases its total air emissions. After the adoption of a voluntary code of practice on cane burning by the sugar industry signed by all cane producers (and approved by MoE in 2001), sugar cane burning has reduced gradually to less than 10% of cultivated sugar cane area.

General environmental impacts of sugar cane burning

The coarse particulate matters emitted during the burning of sugar cane are not treated in Mauritius as air pollution but rather as an important nuisance factor since proportion of small particulate matters (e.g. PM10 or smaller particles that cause health hazards) in the total emissions from the cane burning is quite low.[67] It may, however, still cumulatively affect well-being[68] of local inhabitants and it also decreases attractiveness of certain locations for tourists. The cane burning was therefore regarded as a problem by stakeholders consulted during the SEA Scoping Study[69] because the fly ash represents a nuisance for housing and for the tourism sector.

General overview emissions during sugar cane burning (kg/t of burned cane) [70]

Pollutant / references	Diarly and Learman 1995	Asocana, Colombia 1992	Shearrer 1971
Particular	3.6	2.8	1.26
CO	35.3	-	8.4
HC	5.2	-	1.68
NOX	-	-	0.17

[65] Jacquin E., Mac Intyre G., Poser C., Pyneeandee J., Rivière V., Siegmund B. 1993. MSIRI-CIRAD Cellule mécanisation Rapport d'activités 1992-1993. Montpellier, CIRAD-CEEMAT, 48 p.
[66] MSPA, Rat of pay for cutting & Loading as from 1 July 2005
[67] Florida Sugar Cane League : Ambient Air Monitoring Report- Particulate Sulfure Dioxine 1996-1997 Southern Environmental Sciences, Inc.
[68] Arbex, 2001; Cançado, 2003 ; Roseiro, 2002.
[69] WS4 and WS5
[70] Regis Lima Verde Leal, presentation WWF -Work shop London June 2005

Further to this, sugar cane fields may actually host invasive alien species (such as rats, hares, etc.) and burning of these artificial mono-crops may actually drive these invasive alien species into neighbouring ecosystems. An uncontrolled burning -- especially accidental and criminal fires -- may also spread to the remaining fragments of natural ecosystems in the vicinity of sugar cane lands and they may also negatively affect native species (e.g. disorientation of fruit bats). Therefore, in the overall balance, sugar cane burning is regarded to have a negative impact on native biodiversity.

Burning may at the same time create – especially if done in the dry areas - very high temperatures for a short period of time. Such exposure to heat, however short, may affect micro-organisms in the top layer (3-5 cm) of soil. Limited studies on this topic are presently available in Mauritius. The actual impacts of burning on the micro-flora/fauna (insects, fungi) of the top-layer of soil were disputed during the scoping study. Another disputed issue in scoping, related to the effects of the sugar cane burning on the organic matter content of the soil.

Advantages and disadvantages of green cane harvesting

All over the world the trend is to avoid sugar cane burning before the harvest.
Mauritius follows this trend. General trends, population a tourism demands will force the agricultural sector stop burning within next few years.

Advantage of green sugar cane cutting associated with proper trash management has been studied in many countries where sugar cane is cultivated and proved since the1990ies in Mauritius**.**

The main agronomic advantages of green cane cutting and trash blanketing are as follows:

- positive effect on soil water conservation as its may intercept 44mm of rain, reduce runoff/storm flow by 39 mm, reduce soil evaporation by 152mm, increase drainage by 53mm, and increase transpiration by 92 mm[71];
- limiting erosion of the soil[72], especially in dry area in rainfed conditions[73, 74];
- positive effect on herbicide management;
- positive effect on soil carbon storage[75] and decreasing CH4 emissions. Moreover, adopting harvesting without burning has other positive effects onto the quantity and biodiversity of the soil macro fauna.[76]

Also, accidental or criminal burning represents uncontrolled fire associated with danger. At present, there is no law that prevents such cane burning in Mauritius. Considering Reunion experience, generally accidental or criminal burning decreases as soon as the practice of burning is not any more a legal practice. Therefore, criminal fires need to be referred to a specific law adapted to Mauritius.

The outstanding difficulties in the management of the trash in the fields and for the management of the fire include:

[71] Thompson 1965
[72] Canellas et al., 2003)
[73] Van Den Berg et al, 2006 Proc S AFr Sug Technol Ass (2006) 159-162
[74] Van Den Berg M, M.Jones, R.Van Antwerpen 2006
[75] Graham MH, et al, Proc S Af Sug Technol Ass (2001) 228- 234
[76] Cerri et al, Academie d'Agriculture de France. (cf Razafimbelo et al 2003)

- The amount of trash in the super humid areas represents a physical obstacle to the normal development of sugar cane because of higher moisture retention, reduced temperature which has a negative impact on sugar cane growth.
- Cutting mechanically in green cane causes some loss in term of tonnage. During the harvesting process[77] in difficult land condition (slope or humid conditions) or if the field has not been well prepared for mechanization. Harvesting machines do not cut sugar cane at its base (highest sugar content), leave sugar cane on the field and take soil at the same time [78],[79]. All this leads to loss and /or damage during the process[80].
- Cutting in green cane condition also increases harvesting and transport costs and may cause an upsurge of insect pests(e.g. army worms)[81]

Impacts of the MAAS on sugar cane burning

The MAAS notices the gradual decrease in the sugar cane burning but does not provide any direct intervention to further minimize this practice. The future cost saving measures may however increase sugar cane burning especially for the mechanical harvesting in humid areas and super-humid areas during the dry months of September to November. In those latter areas, a complete mulch blanket cannot be left on the fields because of its negative impacts on excessive soil moisture conservation and pest management.

Small planters generally do not burn sugar cane in their fields before harvesting. Majority have one plot of land which cannot be split to burn. The day-to-day burning operation is the usual way to manage this practice. The small farmer's way of management, related with labour force and equipment resources require at least a minimum of 2 or 3 days to harvest their field and deliver their sugar cane to the factory. This too long period causes reduction of weight, reduction of sugar content and may cause difficulties during milling processes.

Planters	Area	Present situation regards to burning	Expected situation regards to burning after the MAAS
Millers planters & large planters **48 000 ha harvested**	Cutting mechanically 17 000 ha *(2005 MSIRI)* Cutting manually 31 000 ha	- the burning has been decreasing from **23 %** of mechanical harvested fields in 2004 (3 636 ha of 15 884 ha) to **15%** in 2005 (2 550 ha of 16 832 ha) *(MSIRI Annual Report 2005 page 29)* - 7500 ha* burnt out of 31 000 ha manually harvested (24 %) *including accidental and criminal burning	The planned derocking to promote mechanization on additional **16 880 ha (MAAS table 2 § F.6.1.2 - 74% of 44 000ha less the 17 000 ha already mechanically harvested = <u>33 880 ha)</u>** may increase the risk of cane burning - especially on irrigated area - and in wet regions during dry season. MAAS plans to decrease hand cut cane to 8 800 ha (20 % of the 44 000

[77] Jacquin E., Mac Intyre G., Poser C., Pyneeandee J., Rivière V., Siegmund B. 1993. MSIRI-CIRAD Cellule mécanisation Rapport d'activités 1992-1993. Montpellier, CIRAD-CEEMAT, p32/4.
[78] Sugar Journal october 1998 vol N° 61- «The USDA Tak Force on Agricultural Air Quality» N. Rozeff
[79] Gosnell and Lonsdale, 1978 Int Sug J 80 : 299-303.
[80] Gosnell and Lonsdale, 1978 Int Sug J 80 : 299-303.
[81] Oliver FC and Singels A Proc S AFr Sug Technol Ass (2006) 80 P 178- 181 from Meyer *et al, 2005*

			ha) **MAAS table 2 § F.6.1.2**)
Small planters **23 000 ha**	Cutting manually 100 % Cutting mechanically 5 % (850 ha) out of expected 17 000 ha	Small planters generally do not burn before harvesting. They may however burn the cane before last harvest or burn the trash before land preparation.	The MAAS will promote fully mechanized harvesting on 5 %* of the expected 17 000 ha , this means that approx. 850 ha may face a risk of burning because of the efficiency of harvesters. * likely to increase to 20 % - information from Workshop of the 23 May 2007

Conclusions and proposed mitigation measures

The analyses performed by the SEA team indicate that by 2015, 33 880 ha will be harvested mechanically by large and miller planters and 850 ha by small planters.

This **doubling of the mechanically harvested area of Mauritius** will be prone to cane burning especially if the increased demand for efficiency in sugar cane harvesting will prevent further uptake of green cane harvesting.

Land management in regrouping small farmer's fields will represent a priority for new areas on which green cane mechanical harvesting is expected. This experience is available in Mauritius.

Due to the significant benefits of green cane harvesting (decreased demands for herbicides, soil moisture conservation, erosion control, soil carbon storage, etc.) and social undesirability of cane burning in Mauritius (nuisance factor and negative esthetic impacts) it is recommended that:

1. The financial support for mechanization of field operations through the MAAS should require its recipients to maintain green cane harvesting (for the small planters) and to avoid burning of cane (for other growers). Ideally, this condition should be included in the contract agreement with the recipients of the financial support.

2. The commercial exploitation of use of cane field residues (trash, top and leaves) for energy production (e.g. burning and/or gasification) and / or composting should be investigated. Environmental, agronomic aspects and economical viability should be studied.

Annex 7: Preliminary analysis of the overall nitrogen balance of the Mauritian agricultural sector

The primary authors of this analysis are Jiri Dusik and Guy Mc Intyre

Overall context

The scoping study for the SEA of the MAAS noted the increased occurrence of algal blooms in the Mauritian lagoons and suggested that the full SEA includes an assessment of impacts of the MAAS on the pollution of coastal waters.

Anthropogenic supply of nutrients into freshwater bodies, ground waters and the coastal lagoons in Mauritius can be basically attributed to the following main sources:

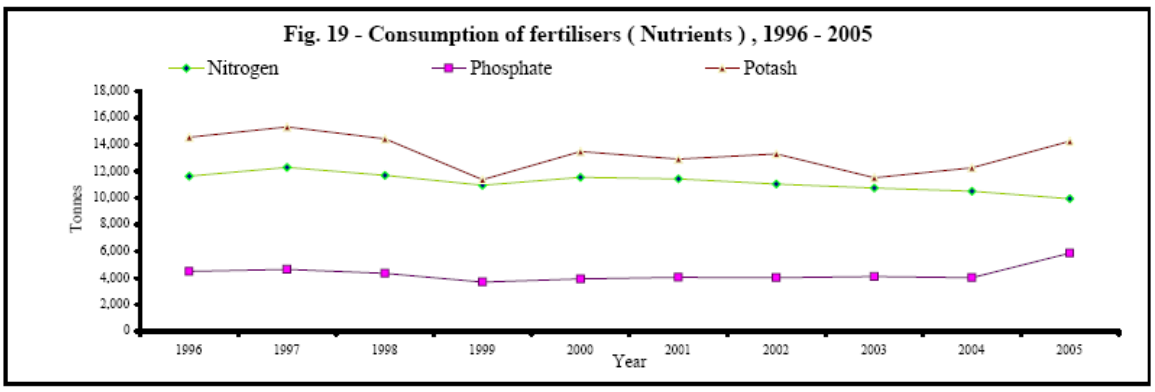
- use of fertilizers in agriculture (N & P);
- existing urban centres (N & P);
- tourism and residential zones in the coastline areas (N & P);
- use of detergents & washing soaps (P).

Use of fertilizers in agriculture

As the table below illustrates, there has been no significant change in the use of fertilizers in Mauritius over the past 10 years. An annual consumption of N has slightly declined from 11 634 tonnes in 1996 to 9356 tonnes in 2005. An annual consumption of phosphate has stabilized around 4000 tonnes per year with possibly one-off increase to 5849 tonnes in 2005. An annual consumption of phosphates has fluctuated between 14 500 and 11 5000 tonnes. However, no change in these trends seem to be significant enough to cause any major change in the supply of nutrients into water bodies.

Tonnes

Year		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Product weight		70,092	73,740	69,486	62,721	67,044	65,527	64,739	63,507	61,266	50,870
Nutrients Content	Nitrogen	11,634	12,294	11,681	10,941	11,550	11,428	11,028	10,742	10,499	9,936
	Phosphate	4,506	4,644	4,342	3,684	3,940	4,059	4,011	4,094	4,022	5,849
	Potash	14,550	15,326	14,444	11,351	13,464	12,911	13,296	11,516	12,248	14,250



Trends in the developments of tourism

As the table below illustrates, the number of visiting tourists as well as their length of their stay has increased 2,5-times since 1990. Most hotels in the coastal areas have the basic waste-water treatment facilities but lack tertiary treatment necessary for the removal of N and P.

Tourist nights spent during period, 1989 - 2005[82]

Period	Tourist arrivals			Tourist nights spent	% change over previous year	
	Sea	Air	Total	during period	Tourist arrivals	Tourist nights
1989	840	261,950	262,790	3,196,780	+ 9.8	+ 6.5
1990	1,200	290,350	291,550	3,564,930	+ 10.9	+ 11.5
1991	2,500	298,170	300,670	3,696,990	+ 3.1	+ 3.7
1992	2,630	332,770	335,400	4,110,430	+ 11.6	+ 11.2
1993	5,710	368,920	374,630	4,610,400	+ 11.7	+ 12.2
1994	6,383	394,143	400,526	4,359,303	+ 6.9	- 5.4
1995	6,105	416,358	422,463	4,434,891	+ 5.5	+ 1.7
1996	6,484	480,383	486,867	4,957,683	+ 15.2	+ 11.8
1997	7,476	528,649	536,125	5,451,314	+ 10.1	+ 10.0
1998	17,109	541,086	558,195	5,567,889	+ 4.1	+ 2.1
1999	13,852	564,233	578,085	5,729,464	+ 3.6	+ 2.9
2000	10,677	645,776	656,453	6,412,876	+ 13.6	+ 11.9
2001	10,532	649,786	660,318	6,527,800	+ 0.6	+ 1.8
2002	14,180	667,468	681,648	6,768,870	+ 3.2	+ 3.7
2003	12,155	689,863	702,018	6,952,313	+ 3.0	+ 2.7
2004	11,390	707,471	718,861	7,118,603	+ 2.4	+ 2.4
2005	13,321	747,742	761,063	7,498,251	+ 5.9	+ 5.3

Use of detergents & washing soaps

Overall data on the domestic sales of soaps and detergents are missing. However, the growth in the tourism sector, combined with the increasing affluence of the population, would imply that the use of detergents & washing soaps has significantly increased in the past decade.

Detergents and washing soaps sold in Mauritius contain phosphates that normally represent 15-30% of the total volume detergent, dependent on the nature of individual products.

Trends in wastewater treatment in the existing urban centres

Mauritius has since 1990 a stabilized population growth of approximately 1% per annum. In 2005, the population stood at 1 225 000 inhabitants. About 45% of the population lives in urban centres that are being since early 1990ies supplied with the basic waste water treatment facilities.

The total population of the island (1 225 000) is likely to produce approx. 6700 tonnes of N in excrements (0.015 kg of N/person/day) and approx. 980 tonnes of P (2.2 grams of P/person/day).

The table below illustrates that presently, only 25% of the population is connected to sewer networks and waste water treatment plants. The table below also indicates that treatment of

[82] Central Statistics Office, 2006

waste water has increased by 50% in the past decade from approx 20 million m3 in 1997 to 30 million m3 in 2005.

Volume of wastewater treated by public treatment stations, 1997 - 2005[83]

Station	1997	1998	1999	2000	2001	2002	2003	2004	2005
Fort Victoria	5.10	5.10	5.20	5.20	5.30	5.30	8.10	5.06	5.20
Baie du Tombeau	4.70	4.70	4.75	4.80	4.85	4.85	8.26	8.27	8.27
Pailles TP [1]	0.08	0.08	0.08	0.08	0.08	0.08	0.11	0.12	0.18
B. Marchand [1]	0.18	0.18	0.18	0.18	0.18	0.18	0.26	0.27	0.19
Riviere du Rempart [1]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Borstal [1]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Pte aux Sables	1.32	1.33	1.33	1.34	1.34	1.34	1.34	1.34	1.34
St. Martin	8.12	8.14	8.16	8.18	8.20	8.20	10.89	13.10	13.88
Kennedy [2]	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.36
Robinson	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Vuillemin [1]	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07
Flacq [1]	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.18	0.23
Dubreuil[3]	0.10	0.13	0.13	0.13	0.13	0.13	1.22	0.68	0.68
Total	20.16	20.22	20.39	20.47	20.64	20.65	30.74	29.56	30.51

Source : Wastewater Management Authority

[1] Serves CHA houses

[2] Serves CHA houses and V. Hospital

[3] Serves CHA + NHDC houses

[83] Central Statistics Office (2006), Digest Of Environment Statistics: 2005, November 2006

Approach and methodology used for assessment of water pollution loads used in this analysis

Review of in-country research on relative contribution of the sugar cane farming on pollution of water bodies

MSIRI research "Measurement and Prediction of Agrochemical Movement in Tropical Cane Sugar Production" completed in 2001 concluded that:

- the transport of N and P through the surface run-off, during the periods of heavy rainfall, were insignificant from an agronomical viewpoint, but might however be an environmental concern since the concentrations of N and P in the run-off may raise above the limits for degraded waters.
- sugar cane cultivation impact on eutrophication of freshwater bodies in Mauritius probably small,
- climate/weather more important than soil conservation measures in affecting agrochemical movement (e.g. mulching did not have much impact on N and P moved by surface runoff when compared with that of bare soil)
- the water contamination measures are best taken at source through improved fertilizer management (e.g. applying fertilizers in dry season and avoiding their excess usage)
- residual surface wash-off could managed especially through better improvement of riparian zones, combined with targeted uses of vegetative buffer (e.g. vetiver) and appropriate soil cover on sloping lands (e.g. minimum tillage)

Preliminary overall analysis of the nitrogen balance of the Mauritian agricultural sector

In order to supplement this analysis by an overall overview, the SEA conducted a preliminary overall analysis of nitrogen balance of the Mauritian agricultural sector. Nitrogen balances are currently used by the OECD and EEA as the best available measure for nutrient leaching risk because they integrate the most important parameters with regard to potential nutrient surplus. Given then closed nature of Mauritian ecosystems, they nitrogen balances (and balances of other nutrients) may provide useful overall insight into links between agricultural nutrient use, changes in environmental quality, and the use of soil nutrient resources.

A preliminary overall nitrogen balance has therefore been prepared to estimate the ratio between nitrogen added to an agricultural system and nitrogen removed from the system per hectare. The nitrogen inputs considered within this overall analysis included the amount of nitrogen applied via mineral fertilizers[84] and nitrogen output calculated the nitrogen contained in the harvested crops[85]. Other minor additional uses[86] of nitrogen-based fertilizers were disregarded from this preliminary overall balance.

In order to eliminate any unrepresentative sample, the SEA team used the long-term data sets for use of nitrogen and sugar cane production during 1996-2005. Using this long-term data set helped overcome variations between years. The SEA team would at the same time like to acknowledge that such analysis can serve only as general guide for analysis of the magnitude

[84] Nitrogen inputs in form of animal manure, nitrogen fixation by legumes, acid and dry deposition of N from the air, and some other minor sources were disregarded

[85] Nitrogen outputs through escape of nitrogen to the atmosphere (e.g. as N_2O) and nitrogen contained in the grass and crops eaten by livestock were not taken into account on the presumption that these can be partly offset by those N inputs which were not considered in this overall balance

[86] Fertilizing of other lands (e.g. gardens, golf courses and areas for deer farming) with N and the use of fertilizers on the Rodriguez Island has not been considered as a major factor in the overall consumption of N on the island and it thus has been left-out of this overall analysis

of potential excessive use of fertilizers. A more detailed review of the exact use of fertilizers and more detailed nitrogen balance would be needed to provide detailed data.

Fate of nitrogen in sugar cane soils

It is useful to start by stating the role of nitrogen in plant growth. Nitrogen is essential in the metabolism of plants. It improves crop yield mainly by increasing the size and number of leaves and influence positively the photosynthetic process, stimulating the chlorophyll production. The plant absorbs nitrogen in the form of ammonium or nitrate. Anyway, in whatever form applied, the fertilizer will be nitrified by soil bacteria to the nitrate form. This process takes in this country about 12 to 13 weeks.

According to MSIRI recommendations, 1.2 kg of N should be applied for each tonne of sugar cane expected (the recommendation always takes in consideration the current price of the fertilizer which means that it‘s the optimum rate which should be applied and not the maximum). Studies made by the above- named institution reveal that:

- between 33 to 36% of the amount applied is actually taken up by the plant,
- 22% is immobilized in the soil, and
- leaching accounts for less than 5% . The field test results obtained during MSIRI research on run-off indicated that the sugar cane fields may lose 2,2-8.8 kg of N/ha/yr,
- the remaining 40% of the N input remains unaccounted for.

In the super humid zone (i.e. areas receiving an annual rainfall of more than 2500 mm) 15% is lost through denitrification (as nitrogen, nitrous oxide and/or nitric oxide), about 33% is taken up by the sugar cane plant, 22% is immobilized and only 25% is "unaccounted for". The schematic illustration of this break-down determined by the MSIRI is shown below.

Calculation

The data on the use of fertilizers indicate that approximately 112 000 tonnes (111,913 tonnes exactly) of nitrogen have been supplied to agricultural lands in Mauritius over the period of the 10 years (1996-2005)[87].

If one assumes that 1 tonne of sugar cane annually required approx 1.2 kg of N, this would imply that the total yields of 52 124 000 tonnes of cane during 1996-2005 have absorbed approx 73 000 tonnes of N. If one considers that the food crops and fruit trees cultivated on the island were supposed to consume – if the advice by AREU was followed – 14 000 tonnes of N at the most. Adding these two consumptions of fertilizers (both of which show uses of fertilizers that would be strictly based on the advice by the MSIRI and AREU and would correspond to the expected yields), one can conclude that that Mauritian agricultural lands had during 1996-2005 a total surplus of 25 000 tonnes of N (or 2500 tonnes of N annually).

Averaging such annual surplus of 2500 tonnes of N on all agricultural lands (approx. 80 000 ha) in Mauritius would indicate that these lands annually receive approximately 31 kg on surplus fertilizers, as compared with the needs of the crops. In the case of sugar cane lands (which are supposed to receive 100 kg of N /ha/yr), this may actually account for nearly 30% over-application of N-based fertilizers.

[87] The rates of application have been slightly decreasing since 1999, possibly because of the recent decreases in area under sugarcane which has been decreasing at an approx. annual rate of 1,8% - e.g. over 9% of SC lands have been converted to other uses.

Conclusions

Such surplus - when compared with the fact that e.g. excrements contained in the waste-waters from the urban and rural population load approx 6700 tonnes of N per year - could be regarded only as a contributing factor to eutrophication of water resources in Mauritius.

The surplus in the use of the fertilizers in Mauritius would be slightly in the excess of the recommended limit of 25kg of surplus N/ha/yr which has been established by the European Commission and the International Finance Corporation as the basic guideline for limiting nitrification of surface and ground waters.

Recommendations

One needs to also consider that Mauritius is surrounded by extremely fragile coastal environment with a limited absorption capacity for nutrients. In this overall context, the following conclusions and recommendations are proposed.

1. All planters (large or small) who obtain EU support within the MAAS should be formally required:

- To strictly follow MSIRI advice on the use of fertilizers, on soil management practices and on sustainable agricultural practices. All supported planters (large and small) should keep records of fertilizers used for inspection.
- To adopt minimum tillage (where the land has already been completely prepared for mechanization) or to establish “frameworks of vegetative buffers” (on those sugar cane lands where minimum tillage cannot be practiced).
- To stop farming within the buffer zones of rivers and streams (minimum of 15 meters from the river/stream bank). All projects on regrouping and mechanization should establish minimal vegetative buffers along amelioration channels (e.g. 1 meter on each side of the channel bank) in the sugar cane fields. Such an approach already occurs in the first regrouping projects and it should become a standard practice.
- Irrigated lands with slopes over 3% should be accompanied by a targeted planting of protective vegetative buffers (e.g. vetiver) on borders of irrigated lands.

2. Implementation of the MAAS should be accompanied by a detailed study on nitrogen balance of Mauritius in order to verify and further refine preliminary conclusions reached within this SEA. Such study should adhere to internationally recognized methodology (e.g. OECD/Eurostat Gross Nitrogen Balances Handbook, OECD Paris, 12/2003) and its outcomes should be reviewed through a wide participatory process (involving e.g. stakeholders consulted within this SEA). Ideally, it would be beneficial if organizations such as the MSIRI, AREU and University of Mauritius would be directly involved in such study. Future fertilizing guidelines for different crops should consider not only their nutrient needs but also a need to minimize any N surplus.

3. The ongoing research projects at MSIRI should be further pursued and possibly supported from R&D budget of the MAAS.

- Biological fixation of nitrogen from the atmosphere by the right species of bacteria. In other sugar cane producing countries such as Brazil, nearly half the N requirement of the cane is met by this method.

- Green manuring with legume crops which are ploughed into the soil before replanting. Theoretically, a large amount of N (170 to 200 kg) per hectare can fixed from the atmosphere using such method[88].
- A possibility of using slow release fertilizer N which could again help to reduce the amount of N applied to sugar cane fields. This type of N could also, if found appropriate be useful to other crops, such as vegetables and fruit trees.

4. Proposed additional measures not related to the MAAS:
- Control inappropriate planting practices (e.g. soil preparation that does not follow contours),
- All agricultural activities (e.g. farming of water cress) should be removed & relocated from the river streams
- Powers and resources of the competent authorities for enforcement of the protection of riparian zone should be enhanced to ensure proper enforcement.

[88] Results obtained so far by the MSIRI show that only about 20% of such nitrogen fixation was actually absorbed by the plant cane crop. Further studies are presently under way at MSIRI to determine whether this N will still be available to the next ratoon.

Administrative appendix 1: Terms of reference for this SEA

BACKGROUND

The European Commission requires a Strategic Environmental Assessment (SEA) to be carried out for the implementation of the "Multi-Annual Adaptation Strategy- Action Plan 2006-2015: Safeguarding the future through consensus" (MAAS) and the EC support to this "MAAS" (Annex II). The major policy documents to consider in the framework of this assignment are listed in Annex III to these Terms of Reference.

Given the impact on the environment from the sugar sector reform process, it is essential from the onset, for stakeholders and decision-makers to have an environmental baseline as well as relevant recommendations which will be used to mitigate the possible adverse impact of the implementation of the MAAS. Although the main contours of the environmental baseline are well integrated in the MAAS, environmental impact assessment studies will need to be carried out more systematically to ensure that the country's environment is not further adversely affected.

1.1 Context

The MAAS forms an integral part of the comprehensive ten-year economic reform programme of the Government and aims at strengthening the sustainability of the sugar sector in light of the internal EU Sugar Market Regime Reform. The overall economic reform programme supports to increase the competitiveness of the sugarcane sector and endeavours to ensure a smooth social transition related to the MAAS. The restructuring of the sugar sector foresees among others a concentration of the industry, rightsizing of its labour force and optimising the use of sugarcane by-products for energy production. The MAAS's overall objective is to ensure the commercial viability and sustainability of the sugar sector for it to continue fulfilling its multi-functional role in the Mauritian economy.

The principal measures/intervention areas outlined by the MAAS are as follows:

- Improving the cost competitiveness of the sugar milling sector via mill centralisation. The decrease in the number of factories from 11 to 4 will mean the laying-off of some 2,000 workers. These workers will receive a compensation package: 2½ months per year of service, a plot of land, a training grant of MUR 5,000 (€135) and a business grant of MUR 50,000 (€ 1,350) or be redeployed into the remaining factories;
- Rightsizing of the labour force in order to reduce labour costs and create a more flexible workforce. This will entail the voluntary retirement of an estimated 6,000 persons. Voluntarily retired workers will be provided with a compensation package of maximum 2 months' salary per year of service and a plot of land with basic infrastructure. In addition, the regulatory framework will facilitate the use of seasonal labour. Moreover, prior to the voluntary retirement of an employee, he/she would be provided re-skilling/training opportunities for eventual redeployment into other economic sectors or support for the setting up of a small enterprise within the agricultural or non-agricultural sector; this will be implemented under the Government's new Empowerment Programme.
- Mechanisation of field operations which includes: mechanical derocking of an additional area of 14,000 ha, mechanisation of cultural practices on 19,000 ha and the irrigation of an additional 7,000 ha of land. The aim of mechanisation of field operations is to improve the cost competitiveness of sugarcane production and to increase sugarcane yield per hectare;

- Regrouping of small planters to enable them to benefit from economies of scale and improved sugarcane yields through modernised growing practices;
- Sustaining difficult areas (steep and/or rocky land of 5,000 ha) in order to prevent adverse environmental consequences (sugarcane helps to prevent soil erosion) and social consequences (cultivation by the poorer income groups of the sector). The objective is to maintain sugar cultivation on 2,000 ha and the remaining 3,000 ha will be reforested or used for Integrated Resort Schemes (IRS);
- Increasing the contribution of the sugarcane cluster to national electricity production with the installation of new power plants in the remaining mills. Electricity will be generated using bagasse, one of the main by-products of sugarcane; the present production of 300 GWh (16% of national electricity output) will be doubled to 600 GWh;
- Producing 30 million litres of ethanol from molasses in two of the four remaining sugar factories to be used locally for blending with gasoline. This would provide additional revenue to the sugar industry and reduce total gasoline imports.
- Reducing institutional expenditure;
- Undertaking Research and Development in areas of sugarcane crop improvement, biotechnology, by-products and biomass utilisation in order to increase sugar cane yield;
- Optimising the use of sugarcane lands via production of horticultural crops on rotational land and in sugarcane interlines, as well as the lands freed up from sugarcane production;

In this context, the EC will seek to ensure that the economic welfare of the small planters is adequately safeguarded within the sugar reform process, and to undertake a comprehensive assessment on the viability of sugarcane production by small planters compared to alternative income-generating activities.

During the formulation phase of the MAAS, Landell Mills Consultancy International (LMC) undertook a comprehensive analysis of the principal environmental issues such as soil conservation; water quality; water supply (availability); biodiversity (inland and marine); health and safety; noise, nuisance and odour; and global environmental and made recommendations on mitigation measures. The relevant details of the study will be made available to the consultant after signature of the contract.

1.2 Stakeholders

The sugar industry is one of the most well-structured sectors in the Mauritian economy with a strong institutional framework enhanced by a strong and effective public-private partnership and the pro-active participation of the civil society. At present the key stakeholders within the sugar industry is the private sector (10 factories and 20 sugar growing companies as well as around 30 000 small planters). The Government acts as a regulator in the growing, milling and marketing filière. A list of the key stakeholders is presented in Annex IV.

In order to achieve a consensus and full ownership of the MAAS by the key stakeholders of the sugar industry (public and private), the Government established a dialogue process with the stakeholders based on the principle of a bottom-up approach. Stakeholders have actively participated in these consultations, and only a minority have expressed reservations regarding the rightsizing of the labour force and the corresponding social package in light of their position being insufficiently considered in the final document. Notwithstanding this, there is a full ownership of the sector policy by the key stakeholders.

DESCRIPTION OF THE ASSIGNMENT

2.1 Global objective

The overall objective of undertaking the SEA is to describe, identify and assess the likely significant environmental challenges, considerations and effects of implementing the MAAS with regard to the environmental impact of the sugar restructuring outlined in the MAAS.

2.2 Specific objective

The specific objective of this SEA is to confirm and complete the findings and recommendations of the MAAS pertaining to environmental issues.
In addition, the SEA will provide decision-makers in the EC and other donors and in the partner country with relevant information to be integrated in the decision-making and implementation processes.

2.3 Requested services, including suggested methodology

The SEA is composed of two parts: a Scoping Study and an SEA Study. The Scoping Study will define the critical issues that need to be addressed in the SEA Study, considering the specific context in which the MAAS is being developed and is likely to be implemented. The activities and detailed calendar for the SEA Study will be determined on the basis of the conclusions of the Scoping Study.

2.3.1 Scoping Study

2.3.1.1 Overview of the MAAS and its institutional and legislative framework

A description must be made of the MAAS's institutional and legislative framework, including the institutions responsible for the implementation of the MAAS, for the management of its environmental impacts and for the SEA process, as well as the relevant environmental policy and legislation. The specific decisions and process that should be influenced by the SEA must be identified. Issues to be analysed should include: the link between institutions and the regulatory framework; health and safety regulations for sugarcane workforce in light of accelerated restructuring and Regulatory framework for industrial emissions.
An overview must also be given of the wider policy framework related to the MAAS in order to identify other planning or policy documents which will need to be explored in the SEA Study.

2.3.1.2 Description of key stakeholders and their concerns

The involvement of stakeholders in the SEA process is a key success factor. The consultant should identify key stakeholders (key groups and institutions, environmental agencies, NGOs, representatives of the public and others, including those groups potentially affected by the likely environmental impacts of implementing the MAAS).

Consultants must review records of any national public consultation processes that may have taken place as part of the MAAS preparation process. Based on this review and on additional consultations, they should identify key stakeholders' concerns and values with respect to the MAAS under consideration. The stakeholder engagement strategy to be employed has to be agreed with the Commission and the Government of Mauritius before being implemented in order to avoid unnecessary conflicts or raising of expectations. The strategy should provide stakeholders an opportunity to influence decisions. If the public is not used to being engaged, particularly at the strategic level, and if there are no precedents, it would be important to include an education component in the stakeholder engagement process.

Due to the large geographical areas that may be covered by the MAAS, stakeholder engagement may focus on key stakeholders, especially targeting directly affected and vulnerable groups as well as key stakeholders that may not have been adequately represented in the MAAS formulation. Records must be kept of all consultations and comments received.

2.3.1.3 Description of key environmental aspects to be addressed in the SEA
On the basis of the policy, institutional and legislative framework analysis, as well as the participation of stakeholders, the consultants must identify the key environmental aspects that should be addressed in the SEA Study. That is, the key MAAS – environment interactions that need to be given special consideration and emphasis. Areas to be appraised include: water management; soil conservation; clean production technologies (power plant bagasse-coal and ethanol plant); alternative land uses; biodiversity (marine and inland); institutional capacities; coastal areas. Depending on expected impacts on society and the scope of other studies, there is also a need to determine to which extent social impacts should be assessed89.

2.3.1.4 Description of the scope of the environmental baseline to be prepared in the SEA Study
On the basis of the information obtained above, the consultants shall provide indications on the scope of the environmental baseline needed for the SEA Study. As Mauritius is an island of volcanic origin, with a total land area of 1,860 sq km on which cultivated lands account for 43 % (with a total of 39 % of the country's land under sugar cane), the consultants should give particular attention to the following areas related to the sugarcane cultivation and sugar production: sugar cane fields and sugar factories, bagasse/coal power-plant and their adjacent areas (In particular lagoons and coastal zones, river catchments and aquifers, factories areas, difficult areas under sugarcane : seaward mountain slopes where field mechanization cannot be contemplated).

2.3.1.5 Recommendations on specific impact identification and evaluation methodologies to be used in the SEA Study
Consultants should provide an indication of the impact identification and evaluation methodologies that will be used in the SEA Study. Special attention should be given to identifying those environmental interactions that will merit quantitative analyses and those for which qualitative analyses should be carried out.

2.3.2 SEA Study
The scope of the SEA Study will be agreed with the Commission and the Government of Mauritius on the basis of the results of the Scoping Study. The SEA study will be based on the results of the scoping stage and include an environmental baseline study, an identification of environmental opportunities and constraints, an identification and assessment of the potential environmental impacts, an analysis of performance indicators, an assessment of the institutional capacities to address environmental challenges and conclusions and recommendations.

2.3.2.1 Environmental baseline study
A description and appraisal must be made of the current state of the environment, focusing on those key environmental components identified by the scoping study. The trends for the various environmental components must be identified and a projection must be made of the state of the environment on the short-, medium- and long-term in the assumption of no implementation of the MAAS. External factors must be taken into account, including the influence of other sectoral policies.

[89] In this case, impacts on people should be disaggregated according to sex, age, or other relevant social criteria.

2.3.2.2 Identification and evaluation of environmental opportunities and constraints
The environmental factors and resources that can affect (positively or negatively) the effectiveness, efficiency and sustainability of the MAAS should be identified, described and assessed for each project identified in the MAAS. These factors may include expected impacts from other sectors or policies. This part of the study should also consider the environmental issues that could potentially be addressed by the assessed Programme. The study should assess if the MAAS provides an adequate response to these opportunities and constraints.

2.3.2.3. Identification and evaluation of impacts
The potential environmental impacts and risks from implementing the MAAS must be identified and described for each project being studied, taking into account the views and concerns of stakeholders. Their significance should be determined according to their characteristics (e.g. duration, probability, magnitude, mitigability, reversibility) and the sensitivity of the environment. Those impacts which are significant should be assessed in detail taking into account:
the views and concerns of stakeholders,
the consistency with international commitments (MEAs),
the socio-economic consequences (especially on vulnerable groups and ethnic minorities),
compliance with environmental regulations and standards,
consistency with environmental objectives and policies, and
their implications for sustainable development.

2.3.2.4 Analysis of performance indicators
Performance indicators proposed by the MAAS (and already envisaged under the EC support to the MAAS) should be assessed and revised from an environmental perspective, i.e. their usefulness to identify the environmental effects (positive and negative) of MAAS implementation. Proposals should be made for the MAAS environmental performance indicators and corresponding monitoring system.
The set of indicators may include:

- “Pressure” indicators;
- “State” indicators, for sectors with a direct and major link with key environmental resources (e.g. fish stocks for fisheries, soil for agriculture, forest resources for forestry);
- Indicators of other specific issues, such as key institutional weaknesses identified by the SEA.

2.3.2.5 Assessment of the capacities to address environmental challenges
The capacity of regulatory institutions to address the environmental issues, especially the impacts identified, should be assessed. In addition, national budget availability and commitment for environmental issues in the MAAS should be analysed.

2.3.2.6 Stakeholder engagement
Stakeholders should be engaged throughout the SEA study according to the stakeholder engagement strategy agreed in the scoping stage.

2.3.2.7 Conclusions and recommendations
This chapter of the SEA study will summarise the key environmental issues for the sector(s) involved, including policy and institutional constraints, challenges and main recommendations. Recommendations should be made on how to optimise positive impacts and the opportunities to enhance the environment, as well as on how to mitigate environmental constraints, negative effects and risks. The SEA is expected to confirm and

complete where required the measures recommended in the MAAS or provide additional recommendation. The SEA study recommendations must identify the projects where EIAs should regularly carried out.

The recommendations for MAAS enhancement should be addressed to the EC for incorporation in its policy dialogue with the Partner Government.

The SEA study recommendations should also identify the areas where technical assistance or other aid modalities (e.g. projects) are required to address specific weaknesses in the environmental institutional, legal and policy framework. They should also include proposals for indicators.

The limitations of the SEA and its assumptions should be presented. The recommendations should take into account the views presented by the stakeholders and explain how these were integrated. In the case of concerns that were not integrated in the final recommendations, the reasons thereof should be given.

2.4 Required outputs

The SEA Scoping Study will deliver the following results:

- A description of the MAAS and projects identified therein ;
- A brief description of the institutional and legislative framework of the sector;
- A brief presentation of the relevant environmental policy and objectives in the country (taking into account the information provided in the MAAS and the CEP);
- An identification of the key stakeholders and their concerns;
- An identification of the key MAAS-environment interactions;
- A description of the scope of the environmental baseline to be prepared;
- An identification of the impact identification and evaluation methodologies to be used in the SEA Study;

The SEA Study will deliver the following results:

- An environmental assessment of the MAAS, taking into account the potential environmental impacts of its implementation and its consistency with the Government of Mauritius's and the EC’s environmental policies and objectives;
- Recommendations for further actions/possible solutions to mitigate adverse impacts of the implementation of the MAAS. Elements which should be addressed in particular are:
- industrial waste management,
- long-term planning of water resources use (including irrigation efficiency issues)
- inland soil and agrochemical management,
- alternative land use (including land use planning)
- coastal zone management plan (including coastal erosion management)
- empowerment and recycling of factory workers

Recommendations for EC support implementation (including performance indicators, use of technical assistance and other aid delivery methods) and for MAAS enhancement.
The SEA study will allow for a clear definition of the EIA studies to be carried out in the future.

EXPERTS PROFILE

3.1 Number of requested experts per category and number of man-days per expert
For this assignment a team of three experts will be required as follows:

	Indicative Schedule (mandays)		
	Expert I	Expert II	Expert III (local expertise)
Engagement plan (in consultant's head office)	5	5	0
Scoping study (including field phase & possible workshop)	18	0	18
SEA Study (including field phase)	45	45	45
Finalising of the report (in consultant's head office)	5	5	0
Total days	73	55	63

3.2 Profile required (education, experience, references and category as appropriate)
Environmental Expert – Category I
Qualifications
Minimum an MSc in environmental management or an equivalent field
A recognised certificate for Proficiency in English (written and spoken)

General Experience
At least 15 years practical experience in environmental issues, including institutional aspects, socio-economic aspects, international environmental policies and management, and environmental assessment techniques or other related issues.

Specific Experience
At least 3 years experience in the implementation and follow-up of Strategic Environmental Assessments (SEA)
At least 6 months experience in the implementation of Environmental Impact Assessments (EIA) as well as related issues (Environmental Management Plans, etc.)

Additional advantages
Familiarity with co-products/carbon emission credit computation
Familiarity with EC guidance on programming, country strategies, PCM, policy mix and integration of environmental issues into other policy areas;
An understanding of the EU environment and development policies;
Previous working experience in the region
An understanding of the EU Sugar Market Regime;

Sugar Sector Expert – Category II
Qualifications
Minimum an MSc in agricultural science or an equivalent field
A recognised certificate for Proficiency in English (written and spoken)

General Experience
At least 10 years practical experience in sugarcane sector, including agronomic aspects, water management and environmental-related issues or other relevant experience.

Specific Experience
At least 2 years practical experience in the cane sugar production process

At least 1 year practical experience in land use management
At least 1 year experience in the implementation and follow-up of Environmental Impact Assessments (EIA)

Additional advantages
Knowledge in soil conservation practices
Knowledge in ethanol and power production using sugarcane by-products
Knowledge in control and monitoring pollution (air, water and noise) arising from cane processing and energy production;
An understanding of the EU Sugar Market Regime;
Familiarity with the SEA methodology and implementation.
Previous working experience in the region

Sugar Sector Expert – Category III
For this expert, the consultants must privilege the use of local expertise and specify how they intend to use local skills.
Qualifications
Minimum a BSc in agronomy or an equivalent field
A recognised certificate for Proficiency in English (written and spoken)

General Experience
At least 5 years practical experience in sugar sector, including agronomic aspects

Specific Experience
At least 1 year practical experience in land use project management including reforestation, diversification, etc.
A least 6 months proven experience in biological control of pest and disease in sugar cane

Additional advantages
An understanding of Mauritius environment and development policies;
Familiarity with the EIA methodology and implementation.
Water management and environmental-related issues

3.3 Working language(s)
The working language shall be English however good knowledge in French is also required

LOCATION AND DURATION
4.1 Starting period
The assignment shall commence on January 15 2007.
4.2 Foreseen finishing period or duration
The assignment is expected to end on June 16 2007
4.3 Planning
The planning of the assignment is as follows:

Date*	Planned Assignment	Remarks
January 15 2007	Commencement of the assignment	Consultants' headquarters
January 22 2007	Submission of the stakeholders' engagement plan	The EC Delegation and the representatives of the GoM will provide their feedback on the plan prior to the commencement of the scoping study

SCOPING STUDY		
February 5 2007	Induction meeting	With the EC Delegation and the representatives of the GoM
February 6 2007	Commencement of Scoping Study	
February 19 2007	Submission of Draft Scoping Study Report	
February 23 2007	Submission of comments on the draft Scoping Study report by the EC Delegation	Comments submitted will include the comments made by the representatives of the GoM
February 27 2007	Presentation of Final Scoping Study Report during a Workshop	The workshop will be organised by the consultants in collaboration with the Ministry of Agro-Industry and Fisheries and the Mauritius Sugar Authority
February 28 2007	End of first phase of assignment	
SEA STUDY		
April 16 2007	Commencement of SEA Study	
June 15 2007	Submission of Draft SEA Study Report	A meeting will be held with the EC Delegation and the representatives of the GoM wherein the consultants will present their findings/recommendations
June 16 2007	END OF ASSIGNMENT IN MAURITIUS	
June 29 2007	Submission of comments on the draft SEA Study report by the EC Delegation	Comments submitted will include the comments made by the representatives of the GoM and other key stakeholders
July 6 2007	Submission of Final SEA report to EC Delegation	

* Dates are indicative

4.4 Location of assignment

The assignment shall be undertaken in Mauritius as per the planning indicated in § 4.3

REPORTING

5.1 Content

The presentation of the reports is explained in Annex V.

5.2 Language

The report shall be written in English with the executive summary only being presented in French as well.

5.3 Number of copies for reports
The detailed stakeholder engagement plan to be presented 2 weeks after kick-off shall be submitted to the European Commission for comments in 5 copies and one CD-Rom.
The draft Scoping Study Report shall be submitted to the European Commission in 5 copies and one CD-Rom. The draft SEA Study Report shall be submitted to the European Commission in 5 copies and one CD-Rom. The final report shall be submitted to the European Commission in 5 copies and one CD-Rom.

6. ADMINISTRATIVE INFORMATION
6.1 Other authorized items to foresee under 'Reimbursable'
The expenses required for the workshop

Annex III Relevant Documents

Ten Year Economic Reform Program 2006-2015 (see Budget Speech 2006/2007 9 June 2006)
Sugar Industry Efficiency Act 2001 as amended
Cane Planters and Millers Arbitration and Control Board Act 1973
Bagasse Energy Development Programme 1991
Environment Protection Act 2002
National Environmental Policy 2006
Land and Development Act 2004
Utility Regulatory Act
EC Regulation n0 266 /2006
10th EDF Country Strategy Paper + Country Environmental Profile
Ethanol Development Strategy 2006-2015
National Forestry Policy 2006
Characterisation of Cane Sugar Factories Wastes and Pollution Control
Sugar Cane Co-products Development Programme for Mauritius
Blue Print on Centralisation of Cane Milling Activities
A Strategy Paper on Training Needs of Employees in the Sugar Industry
Report on the Existence of Asbestos in the Sugar Industry

Annex IV- List of Key Stakeholders

Ministries:
Agro-industry and Fisheries (MoA)
Environment and National Development Unit,
Finance and Economic Development (MOFED)
Land & Housing
Labour, Industrial Relations and Employment
Public Utilities
Social Security

Parastatal organizations:
Agricultural Research and Extension Unit (AREU)
Board of Investment (BoI)
Central Electricity Board (CEB)
Central Water Authority (CWA)
Farmers Service Corporation (FSC)

Food Agricultural & Research Council (FARC)
Irrigation Authority (IA)
Mauritius Standard Bureau (MSB)
Mauritius Sugar Authority (MSA)
Mauritius Sugar Industry Research Institute (MSIRI)
Sugar Cane Planters Trust
Sugar Industry Labour Welfare Fund (SILWF)
Sugar Investment Trust (SIT)
Sugar Planters Mechanical Pool Corporation (SPMPC)
Tea board
Wastewater Management Authority (WMA)

Private Sector
Joint Economic Council (JEC)
Mauritius Chamber of Agriculture (MCA)
Mauritius Sugar Producers' Association (MSPA)
Mauritius Sugar Syndicate (MSS)

Trade Unions

Annex V – Standard format for reports

SEA Scoping Report

Maximum length of the main report (without appendices): 25 pages.

The following text appears on the inside front cover of the report:
This report is financed by the European Commission and is presented by the [name of consultant] for the Government of Mauritius and the European Commission. It does not necessarily reflect the opinion of the Government of Mauritius or the European Commission.
1. Executive summary
2. Description of the Sector Programme under consideration
3. Overview of the policy, institutional and legislation framework
4. Description of key stakeholders and their concerns
5. Description of key environmental aspects to be addressed in the SEA Study
6. Description of the scope of the environmental baseline to be prepared in the SEA Study
7. Recommendations on specific impact identification and evaluation methodologies to be used in the SEA Study
8. Proposal of time frames and resources needed for the SEA Study
9. Technical appendices
I. Stakeholder engagement methodology
II. List of stakeholders engaged or consulted
III. Records of stakeholder participation.
IV. List of documents consulted

SEA report

Maximum length of the main report (without appendices): 100 pages.

The following text appears on the inside front cover of the report:

This report is financed by the European Commission and is presented by the [name of consultant] for the Government of Mauritius and the European Commission. It does not necessarily reflect the opinion of the Government of Mauritius or the European Commission

1. Executive summary
2. Scope
3. Background
    - 3.1 Sector Programme justification and purpose
    - 3.2 Alternatives
    - 3.3 Environmental policy, legislative and planning framework
4. Approach and methodology
    - 4.1 General approach
    - 4.2 Geographical or environmental mapping units
    - 4.3 Assumptions, uncertainties and constraints
5. Environmental baseline study
6. Impact identification and evaluation
7. Analysis of alternatives
8. Mitigation or optimising measures
9. Indicators and institutional capacities
10. Conclusions and recommendations
    - 10.1. General conclusions
    - 10.2. Recommendations for EC support of the MAAS
    - 10.3. Recommendations for MAAS enhancement
11. Technical appendices

Maps and other illustrative information not incorporated into the main report
Other technical information and data, as required
List of stakeholders consulted/engaged
Records of stakeholders' participation

11. Administrative appendices

Study methodology/work plan (2–4 pages)
Consultants' itinerary (1–2 pages)
List of documentation consulted (1–2 pages)
Curricula vitae of the consultants (1 page per person)
Terms of Reference for the SEA

Administrative appendix 2: CVs of SEA team members

Jiri Dusik (Team Leader)

1. Family Name: Dusik
2. First Name: Jiri
3. Date of birth: 22.02.1969, Plzen
4. Nationality: Czech
5. Civil Status: married, two children
6. Education:

Institute	Degree(s) or Diploma(s) obtained
Czech Technical University, Faculty of Civil Engineering, Department of Water Resources, Prague, 1987 – 1993	Diploma in Civil Engineering Thesis: Use of Multi-criteria Analysis in EIA of Watershed Management Projects

7. Language skills: Indicate competence on a scale of 1 to 5 (1 – excellent; 5 – basic)

Language	***Reading***	*Speaking*	*Writing*
Czech	1	1	1
English	1	1	1
Slovak	1	2	2
Russian	2	2	3

8. Membership in Professional Bodies, Fellowships and Awards :
   - IAIA 2007 Individual Award from the International Association for Impact Assessment
   - Special award for innovation from the Czech Council for Science and Technology for research project Use of Aquatic Plant for Waste Waster Treatment"
   - International Fellow at the International Institute for Environment and Development, London (2006-2008)
   - International Association for Impact Assessment (member of the Board of Directors in 2003-2006 and co-chair of the 1st IAIA conference "International Experience and Perspectives in SEA")
   - Editorial Advisory Board Member of the Journal of Environmental Assessment and Policy Management (since 1998)
   - Member of the NATO/CCMS study group on Focalization and Methodology of EIA (1993-1994)

9. Other Skills: Work in multi-cultural environment,
   Project management & staff supervision
   Computer literacy (Windows XP, MS Office Tools)

10. Present Position: Senior Advisor, Strategic Environmental Assessment

11. Key Qualifications: Strategic environmental assessment, Environmental impact Assessment, Sustainability appraisal, Integrated assessments, EU Cohesion Policy and EU Structural Funds, Spatial planning, Environmental planning, Public participation & community organizing

13. Specific experience:

Region/ Country	Date from – Date to

Global	• Member of the OECD-DAC Task Group on Strategic Environmental Assessment (2004-2007) • Co-author of the GTZ/InWent Training Course on SEA (for GTZ, 2006) • Co-Chair of IAIA global conference "International Experience and Perspectives in Strategic Environmental Assessment" (for IAIA, 2004-2005) • Core team member in the UNEP initiative on Integrated Assessment and Planning for Sustainable Development (for UNEP/ETB, 2003-2005)
Regional projects in member states of the UN Economic Commission for Europe (UNECE)	• Co-author of "Resource Manual for the Practical Application of the UNECE SEA Protocol" developed under work plan of the 3rd Meeting of Parties to the UNECE EIA Convention (implemented in cooperation with the UNECE, European Commission, WHO/Euro and UNDP, 2004-2006) • Team member in an informal advisory group for drafting the initial elements for the SEA Protocol to the UNECE EIA Convention (for UNECE, 2000) • Manager of "International Workshop on Public Participation and Health Assessment in SEA" (for UNECE and WHO/Euro, 2000)
Regional projects in member states of the European Union (EU25)	• Lead author of "SEA Handbook for EU Cohesion Policy in 2007-2013" (for the UK Environmental Agency and the European Commission - DG Regional Policy and DG Environment, 2005-2006) • Team member in "Methods and Tools for Integrated Sustainability Assessment" (for the European Commission, 2005-2006) • Team member in "EIA Screening in selected countries from the 15 Member States and 10 new Member States and justification of individual thresholds of Annex II projects" (for the European Commission - DG Environment, 2004) • Team member in "Background for the Integration of Environmental Concerns into Transport Policy in the Accession Candidate Countries" (for the European Commission and Institute for European Environmental Policy, 2001)
Regional projects in South East Europe	• Author of "SEA Training Manual for South East Europe" (for the Netherlands Ministry of Housing, Environment and Spatial Planning, 2003-2005) • Co-director of "Advanced International Training Course on EIA in South East Europe" (for Sida and Ramboll Natura, 2004) • Team leader in "Capacity Building for EIA in South East Europe" (for the European Commission, August 2001- August 2003) • Team leader for "Capacity Building for SEA in Stability Pact Countries" (for the US EPA, since Sept. 2001-September 2003) • Secretary to the Sofia EIA Initiative (for the EAP Task Force and the Ministry of Environment of Croatia, September 1996 – May 2003)
Albania	• Scoping advisor for SEA of Territorial Development Study and Plan of Southern Coast of Albania (for the World Bank, 2004)
Armenia	• Project director in Capacity Development Strategy for Implementation of SEA Protocol in Armenia (for UNECE and UNDP, 2005-2006) • International advisor for "SEA of Master Plan of Yerevan" (for UNDP 2004-2005)
Austria	• Team member in charge of SEA approach and methodology in "SEA of Territorial Cross Border Cooperation programme for Austria - Czech Republic in 2007–2013" (for Austrian Federal Chancellery, 2006)
Belarus	• Project director in "Capacity Development Strategy for Implementation of SEA Protocol in Belarus" (for UNECE and UNDP, 2005-2006) • International advisor for "SEA of Tourism Development Programme" (for UNDP 2004-2005)
Bosnia and Herzegovina	• Project director for "Capacity Building in SEA for Nature Protection and Protected Area Management in Bosnia and Herzegovina" (for the World Bank, 2005)
Brazil	• International advisor for Integrated assessment of Sustainable Development Plan for Trans-Amazonian BR163 Highway (for UNEP and Ministry of Environment of Brazil, 2004-2006)

Bulgaria	• International advisor for "SEA of Regional Operational Programme, Bulgaria" (for DHV and Ministry of Regional Development and Public Works, Bulgaria 2002) • International advisor for "Practical Implementation of Environmental Assessment for Plans and Programs for Bulgaria" (for DHV and Ministry of Environment and Waters, Bulgaria 2001) • International advisor for "Community Participation and Community Development" (for UNDP, 1997)
Cyprus	• International SEA consultant at "Coastal Area Management Programme in Cyprus" (for UNEP PAP/RAC, 2006-2007) • Project director in "Building capacity on the EU Environmental Impact Assessment Procedures" (for UNDP and UNOPS, 2006)
Chile	• International advisor for Integrated Assessment of Environmental Agenda of Ministry of Agriculture (for UNEP and Ministry of Agriculture of Chile, 2004-2006)
China	• SEA Adviser at "Yunnan Environmentally Sustainable Development Capacity Building Project" (for Sida and Ramboll Natura, 2006-2008) • Guest speaker at the "1st China International Forum on EIA" (for the State Environmental Protection Agency of PRC, 2005) • Team member in "SEA Distance Learning Programme for China" and trainer at the 3rd and 4th workshop to present this programme in China (for the World Bank, State Environmental Protection Agency of PRC and IAIA, 2004)
Colombia	• International advisor for Integrated assessment of trade liberalization in agricultural sector (for UNEP and Ministry of Environment of Colombia, 2004)
Czech Republic	• Team member for "SEA of National Development Plan of Czech Republic for 2007-2013" (for Ministry of Regional Development, Czech Republic, 2005) • International advisor for "Guidelines for Integrated Assessment of National Development Plan of the Czech Republic" (for UNEP, 2004-2005) • Team member in "SEA of Development Concepts of Ostrava Region – Energy, Waste Management, Mining and Air Pollution" (for Ostrava Regional Authority, Nov. 2003-April 2004) • Team member in elaboration of "SEA Guidelines of MoE CR" (for the Ministry of Environment, Czech Republic, 2003) • Team member in "SEA of Resource Management Policy of Ostrava Region" (for Ostrava Regional Authority, Nov. 2003-April 2004) • Team leader for "SEA of National Development Plan of Czech Republic for 2004-2006" (for Ministry of Regional Development, Czech Republic, 2002) • Team member in SEA of National Tourism Policy of the Czech Republic (for the Ministry of Regional Development of Czech Republic, 2002) • Head of the Czech Delegation for the negotiations on the Strategic Environmental Assessment Protocol to the UN/ECE Convention on EIA in Transboundary Context (on behalf of the Ministry of Environment of the Czech Republic, May 2001 - November 2002) • Team member in SEA of Operational Programme for Tourism (for the Ministry of Regional Development of Czech Republic, 2001) • Leader of the task force on elaboration of "Methodology for SEA of Regional Development Concepts" (for the Ministry of Environment and the Ministry of Regional Development of Czech Republic, 2000-2001) • Team member in "SEA of Development Programme for Plzen Region" (for Regional Development Agency Plzen, 2000) • Advisor for SEA methodology in SEA of Regional Operational Programme for South-West (for Ministry of Regional Development of Czech Republic 1999-2000) • Team member in SEA of the draft Czech National Development Plan (for the Ministry of Regional Development of Czech Republic 1999-2000) •

Czech Republic	• Team member in SEA of National Strategy for Regional Development of the Czech Republic (for the Ministry of Regional Development of Czech Republic, 1999-2000)Team member expert task force on design of new Czech EIA Act (for the Ministry of Environment of the Czech Republic, 1999-2000) • Deputy Team Leader in "Integrated Environmental Decision-making and Support to Public Participation" (for Phare and the Ministry of Environment of the Czech Republic, 1999-2000) • Team member in SEA of Development Strategy of Plzen Region (for the Regional Development Agency of Plzen Region, 1999), • Team member in SEA of Transport Development Networks in Czech Republic (for the Czech Ministry of Transport, 1998-99) • Chief advisor for SEA of Czech Energy Policy (for the Czech Ministry of Industry and Trade, 1997-98)
Estonia	• International advisor for SEA of National Development Plan - Single Programming Document of Estonia (for the Ministry of Finance, Estonia, 2002-2003)
Georgia	• International advisor for "SEA Training Manual for Georgia" (for UNDP, 2005)
Hungary	• International advisor in SEA of Regional Operational Programme, Hungary (for the Office of the Prime Minister, Hungary, 2002-2003) • Manager of REC Public Participation Training Project for Hungary (1996-1997)
Iran	• International consultant for SEA of Gas Exploration and Processing for Iran-Qatar PARS Gas Reserve in Bushehr Province (for UNDP Iran, 2005-2006)
Italy	• Visiting lecturer at "Course for Sustainability" (for Venice International University, 2005)
Japan	• Team member in "Effective SEA systems and case studies" (for the Ministry of Environment of Japan, 2002)
Kyrgyzstan	• Consultant for elaboration of MSP on 'Global Environmental Mainstreaming into Poverty Reduction Strategies' (for UNDP and GEF, 2006)
Maldives	• Trainer at UNEP EIA workshop for Maldives (for UNEP, UNDP and International Association for Impact Assessment, 2006)
Malta	• International advisor for "SEA approach and methodology for Regional Development Plan of Malta for 2007-2017" (for Malta Environment and Planning Authority, 2005)
Moldova	• Project director for Capacity Development Strategy for Implementation of SEA Protocol in Moldova (for UNECE and UNDP, 2005-2006) • International advisor for "SEA Training Manual for Moldova" (for UNDP, 2005)
Poland	• International advisor for SEA of National Development Plan of Poland (for Ministry of Economy, Industry and Social Affairs, Poland, 2002-2003)
Philippines	• Advisory services for drafting of SEA provisions in the Philippine Bill on Environmental Assessment (for the World Bank, December 2005)
Romania	• Short term SEA advisor in 'Ex-ante evaluation of Operational Programmes in Romania' (for the European Commission and Ministry of Public Finance, Romania (2006-2007)
Russian Federation	• Project director for "Reform of local and regional planning in Russian Federation" (for TACIS, 2004- 2005)
Slovenia	• Team member in "Conformity checking of SEA Directive transposition in Slovenia" (for the European Commission, 2006) • International advisor for "Public Participation Guidelines for SEA" (for Ministry of Environment, Slovenia, 2003) • International advisor for Environmental and Health Impact Assessment of National Development Plan of Slovenia (for Ministry of Economic Affairs, Slovenia 2000)

South Africa	• Team member in "Support of SEA in SADC countries" (for the Czech Ministry of Environment and the Council for Scientific and Industrial Research of South Africa, 2003)
Tajikistan	• Consultant for elaboration of MSP on 'Global Environmental Mainstreaming into Poverty Reduction Strategies" (for UNDP and GEF, 2006)
Tunis	• Trainer at "SEA Training for the staff of African Development Bank (for the African Development Bank and GTZ, 2006)
Turkey	• Lead trainer at a workshop "SEA of Regional Development Plans in Turkey" (for the European Commission and REC, 2005) • Senior expert in "Establishing an EIA Center in Turkey" (for DHV, 2003-2004) • Short-term advisor in "Practical Implementation of Environmental Assessment in Turkey" (for DHV, 2002)
Thailand	• Co-facilitator of a 'Regional planning workshop for SEA of Economic Sector Strategies and Corridors in the Greater Mekong Subregion' (for the Asian Development Bank - Core Environment Program of the Greater Mekong Subregion, 2006) • Trainer and international resource expert at "International Workshop on SEA" (for the Health System Research Institute, November 2003)
Ukraine	• Project director for "Capacity Development Strategy for Implementation of SEA Protocol in Ukraine" (for UNECE and UNDP, 2005-2006) • International advisor for "SEA Training Manual for Ukraine" (for UNDP, 2005)
Uzbekistan	• Consultant for elaboration of MSP on 'Global Environmental Mainstreaming into Poverty Reduction Strategies' (for UNDP and GEF, 2006)
Vietnam	• SEA Specialist at 'Capacity Building in Strategic Environmental Assessment of Hydropower Sector in Vietnam (for Asian Development Bank and International Center for Environmental Management, 2006-2007) • Lead trainer in GTZ SEA Training Course for Vietnam (GTZ, 2006) • SEA Adviser at "Strengthening Environmental Management and Land Administration in Vietnam" (for Sida, Ramboll Natura and Ministry of Natural Resources and Environment, 2005-2008)

15. Other relevant information (e.g., publications):

Dusik J., Jurkeviciute A. and J. McGuinn (2005), SEA Handbook for EU Cohesion Policy in 2007-2013, GRDP consortium, UK Environmental Agency, European Commission, 2005

Dusik J. and B. Sadler (2004), Reforming Strategic Environmental Assessment Systems: Lessons from Central and Eastern Europe, In: Impact Assessment and Project Appraisal, volume 22, number 2, June 2004

Miazga A., Dusik J. and B. Sadler (2003). EIA Training Resource Manual for South Eastern Europe, REC, June 2003

Dusik J., Fisher, T. and B. Sadler (2003): Benefits of Strategic Environmental Assessment, REC and UNDP, May 2003 (English and Russian versions)

Dusik, J (ed.) (2001): Public Participation and Health Assessment in Strategic Environmental Assessment, REC, UN/ECE, WHO/Euro, November 2001

Mikulic, N., Dusik, J., Sadler, B. & S. Casey-Lefkowitz (eds.) (1998): Strategic Environmental Assessment in Transitional Countries: Emerging Practices in Transitional Countries, REC, Szentendre, May 1998,

Richardson, T., Dusik, J. & P. Jindrova (1998): Parallel Public Participation in EIA: An Answer to Inertia in Decision-making, In: EIA Review 1998, 18:201-216, Elsevier, N.Y., April 1998

Dusik, J. & K. Nagels (1995): Comparison of Public Participation under EIA Systems in Selected NATO and NATO-CP Countries, report presented at NATO/CCMS Workshop on EIA, Kussadasi, April 1995

Dr. Guy Mc Intyre (national expert)

1. Family name: Mc INTYRE
2. First name: Guy
3. Date of Birth: 14 July 1941
4. Nationality: Mauritian
5. Civil status : Married, with 4 children
6. Professional experience: 43 years
7. Specific competencies

- Weed control and entomology
- Weed Agronomy and Cultural Operations (sugar cane)
- Mechanization of sugar cane field operations
- Safe use of pesticides

8. Membership in professional bodies

- Fellow of the *Linnean Society of London* (FLS).
- Member of the *Weed Science Society of America*.
- Member of the *International Allelopathy Society*.
- Member of the *European Weed Science Society*.
- Member of the *Royal Society of Arts and Sciences of Mauritius*
- Member of the *Societe de Technologie Agricole et Sucrière de Maurice*

9. Education

Date	May 1960 to March 1963.
Name of School	Mauritius College of Agriculture (Mauritius)
Degree obtained	Diploma in Agriculture and Sugar Technology

Date	1973
Name of School	University of London (UK)
Degree obtained	BSc (Special) in Botany with chemistry and statistics as subsidiaries

Date	1998
Name of School	University of London (UK)
Degree	PhD (Thesis on Cyperus rotundus, its allelopathy, biology and control by natural and chemical

obtained methods)

10. Language skills

Language	*Reading*	*Speaking*	*Writing*
English	5	5	5
French	5	5	5
Mauritian Creole	NA	5	NA

11. Countries of work experience
    - Cote D'Ivoire, Malawi, Kenya, Swaziland, South Africa, Reunion Island, Burundi.
    - Australia, China, Brazil, India, Thailand and Indonesia.

12. Key qualifications

Guy Mc Intyre is a Mauritian citizen with a European educational background: he obtained his BSc from the University of London (UK) and his PhD from the same university. He first graduated (Diploma in Agriculture and Sugar technology) from the Mauritius College of Agriculture, now converted to the University of Mauritius.

Dr Mc Intyre is a specialist of weed control in sugar cane but his research and practical experience also cover general agronomy and safe use of pesticides. He has been working for the Mauritius Sugar Industry Research Institute (MSIRI) for more than 35 years where he has held the post of Head of department of the Weed Agronomy and Cultural Operations Department before accessing to the position of Deputy Director of the institute in 1996.

Dr Mc Intyre has also a broad knowledge of the sugar sector in Mauritius and has thorough experience in other sugar-related fields of work, including environmental aspects. Indeed he has devised what was later termed “Minimum Tillage" to control erosion on sloping lands (this also enabled the reduction of costs of replanting and increased yields). He has been involved in derocking projects for the sugar cane industry in the context of national programmes for mechanization of field operations contributing in the effort for improving the cost competitiveness of sugar cane production in Mauritius.

Moreover, he has also been responsible of the newly created Mechanization Department and of the Extension and Liaison Dept. within the MSIRI, where he had the opportunity to work closely with all categories of planters involved with sugar cane in Mauritius. His involvement with World Bank projects allowed him to set up various projects for the benefit of small planters. He has also acquired extensive experience in land area management in the context of the optimization of the use of sugar cane fields.

Dr. Mc Intyre is presently the sugar sector expert appointed by AGRECO a leading European consortium who has been granted the contract to undertake the Strategic

Environmental Assessment (SEA) of the Multi Annual Adaptation Strategy (MAAS) 2006-2015 of the Republic of Mauritius by the European Commission.

13. Professional experience

Date:	January 2006 to-date
Employer:	*Self-employed*
Location:	Mauritius (with international assignments)
Position:	*Consultant*
Description	• Sugar Sector Expert part of the AGRECO Consortium for the Strategic Environmental Assessment (SEA) of the Multi Annual Adaptation Strategy (MAAS) 2006-2015 of the Republic of Mauritius, project funded by the European Commission (on going) • Private Consultancy for matters relating to Weed control in sugar cane and many other crops, such as maize, potato, onion, garlic, tomato, peas, beans, ginger, carrots, creepers, cabbage, cauliflower, broccoli, cabbage palm, fruit orchards flowers (e.g., Anthuriums and industrial weed control) • Some of these consultancies included training of personnel

Date:	From 2002 to 2005
Employer:	*Roger Fayd'herbe & Co. Ltd*
Location:	Mauritius
Position:	Technical Adviser
Description	• In charge of weed control and general use of pesticides within a company engaged in the development, formulation and sales of pesticides.

Date:	Mid April 1964 to July 2001
Employer:	*Mauritius Sugar Industry Research Institute(MSIRI)*
Location:	Mauritius (with international assignments)
Position:	Research scientist

Description	From 1964 to 1970: Field officer (Weed control and entomology). From 1970 to1996: Head of Weed Agronomy and Cultural Operations Department From 1988 to 1992: In charge of the Extension & Liaison Department and of the Mechanization Department. From 1996 to 2001: Promoted to Assistant Director and Deputy Director Main assignments • Devised what was later termed "Minimum Tillage " to control erosion on sloping lands, reduce costs of replanting and increase yields. This technique was then developed on flat land also, where adequate derocking had been performed. • Worked closely with all categories of planters. • Set up various projects namely with World Bank to strengthen the small planters sector. • Advised small planters to group them in Land Area Management Units (LAMU)

Date:	1980-2000
Employer:	*Various*
Location:	Mauritius
Position:	Lecturer/ Trainer
Description	• Lecturer (including practicals) on Weed Control and Cultural Operations of sugar cane for BSc and MSc courses a the *University of Mauritius* (1990-2000) • Trainer for courses aimed at African countries (one- 3 month crash course for French and another for English speaking Africans) and also for Mauritian employees of the local sugar industry, delivered by the *Regional Training Centre* (a UNDP funded project) during more than 10 years. (1980-2000)

Date:	May 1963 to April 1964
Employer:	*Benares Sugar Estate*
Location:	Mauritius
Position:	Assistant Chemist and Agronomist
Description	• Assistant chemist for the sugar factory during crop season and agronomist during intercrop season

14. List of selected publications:

1. Mc Intyre,G., Barbe,C., Pitchen,J. and Yerriah.M.(1984.) *Minimum tillage in Mauritius- an adopted technique for the replanting of sugar cane in sloping lands*. Sugar Cane(4), 1-3.
2. Mc Intyre,G and Barbe,C.(1990).*The effect on sugar cane yield, weed control, physical and*

chemical properties of the soil of minimum tillage v/s normal mechanical tillage. Proc.int. Soc. Sug.Cane Technol. 20:586-590.

3. *Trash Management in Mauritian sugar cane plantations*. Proc. int. Soc. Sug. Cane Technol. 22:213-216. (Abstracts published in Int. Sug. J.v. 97.)

4. Mc Intyre, G.(1992). *Weeds of sugar cane in Mauritius- their description and control.* Mauritius Sugar Industry Research Institute . 151 pages, 64 pl.

5. Mc Intyre, G. and Barbe, C.(1988). *Le controle de Cynodon dactylon L. Pers.à l'ile Maurice.* Proc. Third Congress ARTAS : 380-388.

6. Mc Intyre,G.(1991). *Evaluation of herbicides for use in mixed cropping situation*. Revue agric.sucr. Ile Maurice 70(1/2): 53-56.

7. Mc Intyre,G (1978)..*Experimentation with DPX 3674 (Velpar) alone and in mixtures with diuron in plant and ratoon canes*. Proc.int. Soc. Sug. Cane Technol. 16:1211-1217.

8. Mc Intyre,G.(1985). *Weed control in various food crops in Mauritius with particular reference to mixed cropping*. Revue agric.sucr.Ile Maurice 64:111-116.

9. Govinden,N. Mc Intyre,G. Autrey,L.J.C., Rajabalee, A. *Growing potatoes*. Mauritius Sugar Industry Research Institute. 12 p.(Advis. Bull.)

10. Mc Intyre,G. Barbe,C. (1994). *Chemical v/s hand weeding in young citrus and mango orchards*. Revue agric. sucr, Ile Maurice 73(3) : 44-47.

11. Mc Intyre, LFG.(1998). *Cyperus rotundus- Allelopathy, competition and reaction to herbicides.* PhD thesis. University of London. 130 pp. 13 pl.

Christophe Poser (Key Expert II)

1. Family name: POSER
2. First name: Christophe
3. Date of birth: 1966
4. Nationality: French
5. Civil status: Married
6. Education:

Institution, date	Degree(s) or Diploma(s) obtained
Cranfiel University, London UK 2002	MSc Tropical Environment and biodiversity valorization: Thesis on "Crop shifting banana-sugar cane and soil characterization around the sugar cane root system"
ISTOM (International Institut Supérieur Technique d'Outre Mer),1986-1990 Specialization: Cranfield University, Silsoe College UK	MSc Agro-economy for tropical regions Specialization : Farm machinery (field crops and especially sugar cane)

Other education:

- Project management at Cegos (2003)
- GIS and remote sensing training at GDTA (Groupement pour le Développement de la Télédétection Aérospatiale) / Toulouse/France (1992)
- GIS and Arc Info training at IGN (Institut National Géographique) / Paris/France (1990)

7. Language skills: Indicate competence on a scale of 1 to 5 (1 - excellent; 5 - basic)

Language	Reading	Speaking	Writing

French	Mother Tongue		
English	5	4	5
Spanish	3	3	3

8. Membership of professional bodies: -

9. Other skills: computer literate and development of a cost analyses software

10. Present position: Research Engineer and Consultant - CIRAD La Réunion

11. Years within the firm: 8 years

12. Key qualifications:

- **Production** :
  - Design and operation of production systems and pilot cultivation adapted to tropical crops
  - Settlement and follow up of rural microfinance schemes for farmers
  - Training, management and animation of research teams
  - Control and responsibility for the supply of an agro-industrial complex (harvest, transport, product reception)
  - Tropical crops production : sugar cane and associated crops (peanut, soybean, maize, peas and vegetables) as shifting cultivation options for better land use management and for soil conservation.
  - Feasibility studies (technical, financial, economic, social), EIA audits in commercial agriculture
  - Irrigation: studies, analysis, management (gravity, sprinkling, drop system).

- **Research** :
  - Coordinate research programs with professionals from private sector(organization of agronomic trials, pest and disease control, extension of results) in sugar cane
  - Prospect and finalisation of agreements between research institute and professionals including SEA, R&D, mechanization and by-products valorisation pilots or trials (energy, fertilizers…)
  - Expertise in : cropping systems, water management, land use management, soil conservation control, diffuse pollution monitoring and reduction of pesticides use
  - Management of a research station: budget, infrastructures, daily operation.

14. Professionnal experience:

Date from Date to	Location	Company	Position	Description
Since 1998	**FRANCE**	CIRAD	Research engineer and consultant	Three positions and project responsibilities: *__Montpellier (France)__: Assistant to the **Sugar Cane** Program Head: specific studies on cropping systems, water management, pest and disease control of sugar cane; follow up of research agreements with international partners; preparation of international cooperation projects on sugar cane R&D *__Guadeloupe (French West Indies)__: 1)Research program on shifting cultivation systems sugar cane-banana; support programs with local farmers for cultivation practises, soil management, trials, extension; research results presentation at the Seminar on Sugar Cane-Stella Matutina in october 2002; 2°Head of the CIRAD R&D station of Roujol: team organization, technical management, budget, scientific exchanges with local partners: Chamber of Agriculture, SICA,CUMA,CTICS, Planters organization *__Reunion Island (Indian Ocean)__ Head of CIRAD sub-station of Les Hauts: focus of trials and activities on sugar cane cultivation and inter-relations with environment and good cultural practises (ARTAS)

1995-1998	**VIETNAM** (province of Tay-Ninh Sud)	Sugar Factory (Groupe BOURBON)	Managing director	Beginning of project in 1995 ; sugar plant inception in February 1998 (capacity of 8000 mt over the 130 days of the sugar harvesting season) ➢ **First phase (1995-1997): Selection of site, implementation of managerial and local technical staff, organisation and management of the "Planters service"** **« Planters service »** : -Setting up of the service in 1995 in order to facilitate sufficient sugar cane production around the future plant (harvesting season from December to April) -Setting up of production groups and cooperatives, hiring of 60 cultivation controllers, construction of 8 cane collecting platforms all around the production area. -Finalization of the planting calendar over the 4 years to reach 100% of production capacity with the season 99/00 -Setting up of investment plans and rural credit schemes with VBARD branch in TAY NINH -Implementation of the computerized system for the supply of the plant, for the organization of the harvesting and transportation calendar, for the improved access to the plant, for the weighing stations, for the sampling and analyses laboratory and for the payment system to the farmers. -Management and daily operation responsibility

				R&D services -Creation of an experimental farm of 30ha staffed with 20 technicians in order to develop good cultivation practises and transfer modern techniques to farmers : organization of **4 services**- **plant genetics** (variety selection, multiplication techniques for varieties fit to the region and country, vegetal material import regulations, quarantine tests), **crop protection** (biological control, limited chemical uses), **agronomy** (sugar cane cultivation models, shifting cultivation opportunities according to the plant development, harvesting mechanization) and **irrigation** (gravity fed systems, drainage systems, drop systems...) -Staff training -Management and daily operation of the services Creation in early 1997 of the **production farm for planting material** (200 ha staffed with 15 permanent technicians) in order to multiply certified planting material (disease free) and distribute them to the farmers in the production area. Setting up of an **irrigation experimental plot** of 2000ha around the sugar plant (including the experimental farm and the experimental services) to test different options and select the optimum one (season 97/98); 1000 ha completed for season 98/99 and other 1000 ha for season 99/00 ➢ **2nd phase (1998) : management of services /plant inception** **Planters service** : Organization of the first harvesting season with 7000 ha contracted (3500 planters / 350000 mt) and 12000 ha for the season 98/99 **R&D Services** -Publication of the first report activity for season 96/97 -Extension services provided to company technicians and farmers (publications, brochures) -Set up of different irrigation systems on the experimental farm and the planting material plot (sprinklers, drop systems, classical arm system, floppies over the 120ha) -Experimental trials of annual crops as shifting cultivation (peanut, soyabean, maize, chillies and sweet cucumbers) -Sale to planters of the first certified planting material from Bourbon variety imported and adapted in Vietnam for first 500 ha

1990-1994	**MAURITIUS**			**First phase : Technical assistant to French Embassy (technical cooperation section)** for 16 months at MSIRI (Mauritius Sugar Industry Research Institute) **Setting up of the farm mechanization division at MSIRI :** - Definition of the missions of the division (technical and scientific) - Organization of the working team - Organization of the joint cooperation agreement with CIRAD in Reunion Island as well as with the Sugar Cane professional institutions in the island **Second phase: Project manager at MSIRI** (30 months) **R&D activities (mechanization and land use management)** -Studies on soil management and preparation, sugar cane planting specifications, improvement of harvesting techniques, economic studies, improvement of yields -Development of MECABASE software (mechanization of harvest according to maturity of sugar cane in fields) -Land use management and soil preparation trials before sugar cane planting -Trans disciplinary collaborations organized with CIRAD on soil physics, digital mapping, extension services to farmers, biometry) **Third phase: Consultant to the MSIRI Mechanization Division** (7 months) -Analysis of the Division results after 4 years of technical and scientific cooperation -Communication on results through workshops, conferences, visits, publications -Support to MSIRI to organize the 1994 ISSCT International meeting (International Society of Sugar Cana & Technologists)
1989	**LA REUNION**	CIRAD-CEEMAT		6 month internship at CIRAD in Reunion Island on sugar cane harvest mechanization. - Evaluation of mechanization needs to improve harvest and reduce production costs - Development of the French prototype for a sugar cane harvester (LEGRAS). - Development of a software on Cost analysis in sugar cane cultivation

15. Other: reports and publication: list available on request

Bernard Siegmund

1. **Family name:** **SIEGMUND**
2. **First name:** **Bernard**
3. **Date of birth:** July 31st 1958
4. **Nationality:** French
5. **Civil status:** Married
6. **Education:**

Institution, date	Degree(s) or Diploma(s) obtained
IAE- Institute for Enterprise Management (joint programme with University of La Reunion) 1996	Certificate in Business management
ISTOM (International Institut Supérieur Technique d'Outre Mer) 1981	MSc Agro-economy for tropical regions Specialization: Crop protection and farm machinery

8. Language skills: Indicate competence on a scale of 1 to 5 (1 - excellent; 5 - basic)

Language	Reading	Speaking	Writing
French	Mother Tongue		
English	4	4	4

8**. Membership of professional bodies:** ISSCT (Farm mechanization and agronomy committees)

9. **Other skills:** Computer literate and development of cost analysis software

10. **Present position:** Managing director of CERF

11. **Years within the firm:** 15 years

12. **Key qualifications:**

*** Production** :

- Design and operation of sugar cane production systems and pilot cultivation adapted to tropical crops (pilot trials organised with selected farmers in Réunion Island)
- Training, management and animation of research teams
- Feasibility studies (technical, financial, economic, social), EIA audits in commercial agriculture
- Irrigation: studies, analysis, management (gravity, sprinkling).

*** Research and development** :

- Coordinate research programs with professionals from private sector(organization of agronomic trials, pest and disease control, extension of results) in sugar cane
- Prospect and finalisation of agreements between research institute and professionals including R&D, mechanization and by-products valorisation pilot trials (energy, fertilizers…)
- Expertise in : cropping systems, water management, land use management, soil conservation control, diffuse pollution monitoring and reduction of pesticides use, by products valorization
- Management of a research station: budget, infrastructures, daily operation.

*** International consultancy**

14. Professionnal experience:

Date from Date to	Location	Company	Position	Description

Since 2006	**REUNION Island** **Various developing sugar producing countries**	**CERF**	Managing director and consultant	**CERF (Research & development,Training Center on sugar cane)** based in La Réunion Island (sister island to Mauritius) at the service of 2 main local sugar producers (Sugar Company of Bois Rouge and Sugar Company of Reunion Island). CERF is focusing on : • Agronomic aspects (crop selection and breeding adapted to local conditions) • Agro industrial aspects (sugar processing and valorization of by-products) CERF is also providing technical assistance to other sugar producing countries (Mauritius, Guadeloupe in French Caribbean, Cameroon, Chad, Congo, Tanzania- Tanzanian sugar producers association, Mozambique, Malawi…) The CERF team includes 60 persons and among them 9 engineers, 11 technicians and 40 other staff including agricultural one. In charge of : • CERF's Management (Budget, business plan, human resources) • Teams and programs management • Prepare the 5 year development Plan of the Center • Participate to the Sugar Cane development plan of La Reunion • Transfer know how and related technologies at international level **TANZANIA :** Support to TSPA (Tanzanian Sugar Producers Association) in applied research. **VIETNAM:** Diagnosis of sugar production in Tay Ninh Province in view of investment of a Sugar Group in Réunion Island, Bourbon Group (2000) **MADAGASCAR:** Expertise mission to Siranala Sucrerie de Morondava (1995) **MAURITIUS** 1) Drafting and follow up of an applied research program within MSRI (Mauritius Sugar Industry Research Institute) for the development of sugar cane farms mechanization (>1500 ha) et en milieu paysan (exploitations < 2 ha). 1989 - 1992 (1 week per month). 2) Training of executives of the sugar industry regarding farming techniques and mechanization.1988 to 1997 (1 to 2 months per year). 3) Project « SUCRETTE » (sugar cane plantation and production by remote sensing),in collaboration between CIRAD Guadeloupe/La Réunion and MSIRI 2003-2004.

2005	**REUNION Island**	**CIRAD**	Head of Sugar Cane program (specifically sugar cane cropping systems)	Program with 47 persons (18 engineers and 29 administrative and technicians) based in Reunion Island but with strong relationships with Guadeloupe, Montpellier-France (CIRAD Headquarters) and Sénégal. Main activities in the Sugar cane program are: * Define with the team the strategy of the sugar cane research unit in accordance with CIRAD main scientific strategies * Prepare a five year plan for the unit taking into account scientific animation, draft the budget and follow up its execution, manage human resources and the available lab equipment and facilities * Promote the research unit at international level and facilitate the best partnerships for the implementation of the five year Plan.

July 2000 till December 2004	**REUNION Island**	**CIRAD**	Research engineer and consultant	Main activities at the Sugar cane research and development Program : * Management of the team of the Program (agronomy / irrigation / farm mechanisation / users and farmers associations / harvesting techniques) * Promotion of the CIRAD Sugar Cane activities in the region (Mauritius/Madagascar) and organization of joint cooperation R&D activities Develop good cultivation practises and transfer modern techniques to farmers : organization of **4 services- plant genetics** (variety selection, multiplication techniques for varieties fit to the region and country), **crop protection** (biological control, limited chemical uses), **agronomy** (sugar cane cultivation models, shifting cultivation opportunities, harvesting mechanization) and **irrigation** (gravity fed systems, drainage systems, drop systems…) **Setting up of the farm mechanization division with MSIRI** with the support of a permanent technical assistance with Mr Christophe POSER - Definition of the missions of the division (technical and scientific) - Organization of the working team - Organization of the joint cooperation agreement with CIRAD in Reunion Island as well as with the Sugar Cane professional institutions in the island One week every month during 2 years

July 1992 to June 2000	**REUNION Island**	**CIRAD** **ARMES**	Research engineer Technical coordinator	**<u>ARMES or Reunion Island Association for the modernization of sugar sector</u>** ARMES is an association managed by the representatives of the French Ministry of Interior (Préfet) grouping all the stakeholders of the sugar sector. ARMES is playing a key role for the main orientations of the sugar sector and organize the necessary means to reach the main targets and fulfil the main objectives. Technical coordination of ARMES included : * Setting up of working groups with the management and local authorities * Preparation of technical and financial objectives with the political authorities (State and local authorities) and discussion with potential donors agencies (ODEADOM, EU, Regional Council) * Support to the 5 ARMES main organisms in charge of all activities at farmers level (among them SICA PROMOCANNE) * Management and follow up of all development operations with partners in Mauritius mainly
December 1996 to January 1998	**REUNION Island**	REDETAR	Interim Managing director	**<u>REDETAR</u>** (REgie Départementale des Travaux Agricoles et Ruraux) : * Re-orientate of the activities of the Centre on farm mechanization * Re-define technical production means and modernization of the equipment of the Centre * Re shape the status of the Centre to an agricultural cooperative managed by professionals, already users of the services of the Centre
1981-1992	**FRANCE** **REUNION Island**	CIRAD-CEEMAT	Research engineer	**<u>CEEMAT</u>** (Centre d'Etudes en Mécanisation Agricole et Technologie agro-alimentaire, CIRAD department), in charge of the program: Mechanization (soft/heavy investments) of sugar cane farms (St Denis. Ile de la Réunion). Research programme developed in collaboration with all stakeholders of the sugar cane sector : * Farm equipment developments within the particularities of Reunion Island (stones collection, planting techniques, harvesting techniques, trucks loading improvement) * Definition of the best soil preparation practises with trials in sample farms

15. Other: Organization and numerous papers presented at congresses and seminars: ARTAS, AFCAS (French Association of Sugar Cane), STASM (Mauritius Society for sugar technology and farming systems, ISSCT.