EVALUATION OF TOURISM IN THE OKAVANGO DELTA IN BOTSWANA USING ENVIRONMENTAL ACCOUNTING

By

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This work is dedicated to the people and wildlife of Botswana and their future.

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In order to successfully use tourism as a driver of economic development while preserving natural resources in developing countries, it is important to understand in qualitative as well as quantitative terms the impact that tourism development has on resource flows at the national, regional, and local scale. This study uses the emergy methodology to analyze tourism development in the Okavango Delta of Botswana, with special consideration of community based natural resource management (CBNRM). Emergy analyses were conducted at three scales: the nation of Botswana, the wildlife management area NG 41, with the village of Mababe and hunting camps which are involved in CBNRM, and a specific safari lodge in the Okavango Delta.

This study shows that in spite of Botswana's strong economic performance, which is mostly based on diamond resources, the resource flows are typical of a developing nation that exports more resources than are imported, thus impeding its own development. Resource flows associated with tourism are significant at the national scale

but remain an order of magnitude smaller than the local renewable inputs. Therefore tourism does not dominate resource flows at the national level and has only a limited impact on the pattern of resource flows. At the local level, tourism and the implementation of CBNRM has dramatically changed the pattern of resource flows, mainly by adding new inputs from outside the region. The emergy signature of the village of Mababe had changed from being nearly 100% reliant on local renewable resources to receiving about 60% of inputs from outside the region. The empower density of Mababe increased by 2.5 times as a result of CBNRM, because of the qualitative difference between the natural resources sold and the concentrated purchased inputs that were received. The increase in empower density indicates that larger amounts of resources are available to the villagers as a result of CBNRM. The safari lodge analysis showed that at the tourism intensity levels currently characteristic of the Okavango Delta, about 50% of inputs to the tourism experience are based on local environmental resources. The emergy value received by tourists exceeds the price that tourists pay. Were tourism numbers to be increased, the relative contribution of environmental resources would decrease and the value received by tourists would fall below what they are currently paying for the experience.

CHAPTER 1
INTRODUCTION

Statement of the Problem

Tourism and especially eco-tourism is often perceived as a sustainable way to generate revenue in developing countries that are poor in extractable natural resources and lack industrial infrastructure but are rich in natural beauty, wilderness, and scenery (Nuttall 1999). It is hoped that by developing the tourism sector, some degree of protection to natural resources and wildlife can be achieved while providing local people with a source of income (Naguran 1999). If local people can generate income from tourists who are willing to pay money to experience undisturbed ecosystems or view wildlife, they are less likely to engage in practices that have detrimental effects on their natural resources, such as poaching and excessive burning of forests (Lepp 2002, Reid et al. 1999).

On the other hand, tourism development is associated with certain threats to cultural and natural integrity in developing countries (Hachileka 1999). When natural resources are developed for tourism, local populations often lose excess to these resources upon which their subsistence depended. With only limited capability to profit from the tourism development, local communities may fall into poverty (Naguran 1999). As a result, agencies that aim to promote sustainable tourism in developing countries have serious concerns and are expanding considerable effort to ensure that local communities benefit from tourism development (CASS Consultants 1999, Reid et al. 1999).

This study investigates the costs and benefits of tourism in Botswana's Okavango Delta. Special attention was paid to Community Based Natural Resource Management (CBNRM), a strategy employed by development agencies in Botswana and other developing countries to integrate community development needs with environmental conservation. The basic concept of CBNRM is that conservation of natural resources can be achieved more efficiently and successfully if local people are involved in decision making processes and can gain benefits from conservation efforts. Examples for the application of CBNRM are the CAMPFIRE (Communal Area Management Programme for Indigenous Resources) project in Zimbabwe (CASS 1999) and the ADMADE (Administrative Management Design for Game Management Areas) program in Zambia (Lewis 2001). In Botswana, where most land is communally owned, CBNRM is used by the government to re-introduce management and planning into land use issues (Cassidy 2000). The form of CBNRM investigated in this study was tourism based CBNRM which gives a community resource rights over an area which the community can either tender to tourism operators or establish a community run tourism operation.

This investigation of tourism in Botswana was conducted at three scales: the country of Botswana, CBNRM in the Wildlife Management Area NG 41 with the village of Mababe and hunting camps, and a safari lodge in the Okavango Delta. In the analysis of Botswana important characteristics of the national economy were illustrated and tourism was put into the national context. The analysis of a tourism lodge gave an exemplary account of how different resources contribute to the tourism enterprise. The analysis of NG 41 quantified the resource flows associated with tourism driven CBNRM and the costs and benefits of CBNRM to a local community.

The main questions to be addressed in this study are:

1. What are the characteristics of the economy of Botswana in terms of emergy and what is the magnitude of tourism related resource flows in relation to the overall economy?
2. How does the implementation of tourism based CBNRM change the pattern, composition and magnitude of resource flows in a region, and what are potential implications for the local community?
3. What is the composition and magnitude of resource flows that support safari lodge tourism in the Okavango Delta and how do changes in tourism density change the composition of flows and the nature of the tourism enterprise?

The Country Botswana

Botswana is a land-locked country, bordered by South Africa, Namibia, Zimbabwe and Zambia, with a total land area of 582 000 square kilometers and a population of 1.4 Million (USAID 1997).

Okavango Delta

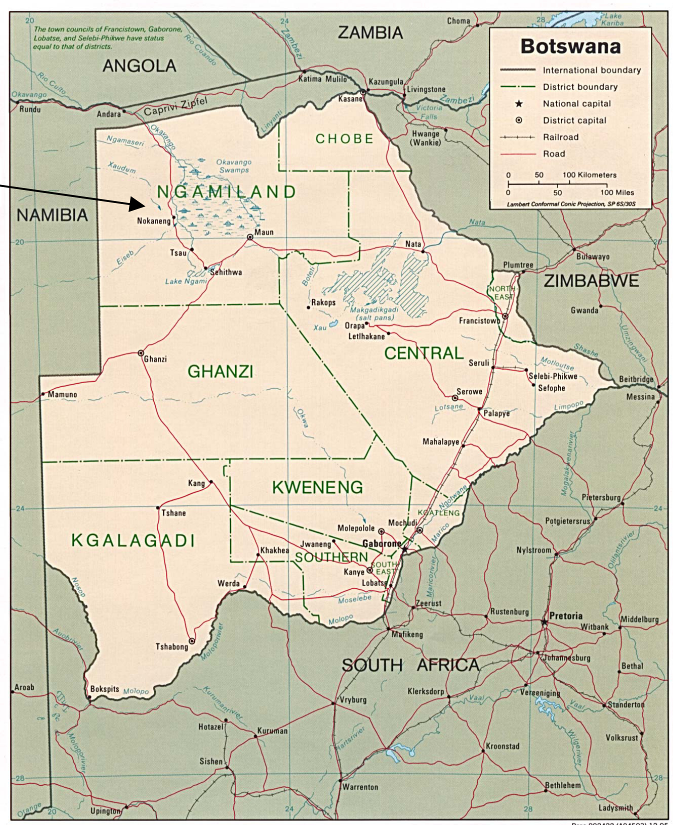

Figure 1-1. Map showing the country of Botswana with district boundaries. The Okavango Delta is in the North west corner of Botswana, within Ngamiland District.

The country was one of the poorest in sub-Saharan Africa when it reached independence in 1966 but the discovery and subsequent exploitation of diamonds one year after independence has made it the second richest in the region (Jones 1997). Presumably the income acquired by extraction and marketing of diamonds, has resulted in a government that is one of the most stable democracies in the region. In 1998 Diamonds accounted for 70.3 % of the monetary value of all exports from Botswana (Central Statistics Office 2000a).

In spite of Botswana's relatively strong economy, there is a large gap between rich and poor; in 1991 64% of the population was estimated to live below the poverty line and the situation does not seem to have improved much since then. Most of the poor live in rural areas and are strongly dependent upon renewable natural resources, such as veld products, grazing area for livestock and wildlife resources to support their livelihoods (Jones 1997). Cattle used to be (and still is) an important component of the economy of Botswana, although it is now subsidized by the government with money from the diamond industry. Over the last ten to fifteen years however, the cattle industry has been under increasing pressure, due to severe droughts and major disease problems.

The Government of Botswana has adopted a policy of economic diversification, which is reflected in the National Development Plan 8. This plan places a stronger emphasis on the sustainable use of renewable resources such as veld products and wildlife. Also tourism is seen as a potential 'engine for growth' (Jones 1997). Tourism is mainly focused on wildlife and nature experiences and therefore the Government places an emphasis on the conservation and sustainable use of these resources. Most of the tourist activity is focused on the Okavango Delta.

The Region Okavango Delta

The Okavango Delta is a 16,000 km^2 wetland ecosystem in northern Botswana (see Figure 1-1). It is a RAMSAR (International Convention for the Preservation of Wetlands) site and is a rich resource for the local population who use it for fishing, hunting, floodplain-farming, and reed collection, and it also provides habitat for a high density and variety of vegetation and wildlife. All of the famous ‘Big Five’ of Africa (Lion, Leopard, Buffalo, Elephant, and Rhino) can be found in the Okavango Delta, as well as many predatory animals, large numbers of antelopes, and a highly diverse avian population. Location and hydrology are the main factors facilitating high productivity and biological diversity.

The Okavango Delta is an inland delta, located on a tectonically forced alluvial fan, in northern Botswana. Unlike most river deltas, the Okavango does not drain into the ocean but fans out and forms a large wetland in an otherwise very arid region, with the Kalahari Desert to the south and east. There are major variations in the size of the actual wetland seasonally as well as from year to year, depending on rainfall intensities in the contributing watershed and other factors (McCarthy et al. 2003). About half of the wetland in permanently inundated whereas the other half isonly seasonally flooded (Anderson et al. 2003) the two areas are referred to as the permanent swamp and the seasonal swamp respectively.

The dominant sources of water for the Okavango Delta are river discharge from the Okavango River and rainfall. The amount of water discharged into the delta is fairly stable from year to year at around $11 * 10^9$ cubic meters per year (Ellery 2003), which translates into about 1570 mm/yr. Combined with an average of 500 mm/yr in rainfall (Scudder et al. 1993) this results in just above 2000 mm/yr water input into the wetland.

The Okavango Delta is a wetland in the middle of a desert region. It can be maintained as such because of its hydrolics. The Okavango River that provides the majority of water input into the wetland is fed by rainfall in the large watershed in the Angolan highlands. The contributing watershed of the Okavango Delta encompasses about 135,000 km^2, which is about nine times the size of the Okavango wetland. Because of the long distance between the highlands and the Okavango Delta, the floodwaters generated by summer rains (Nov-Jan) arrive at the mouth of the Okavango River with a delay of approximately two months. There the floodwaters spread out over a large area because of the very low surface gradient. Water travels another two to three months before they arrive at the lower reaches of the Delta. The arrival of water during the dry season makes the Okavango Delta a magnet for wildlife and people.

Tourism in the Okavango Delta

Ultimately the Okavango Delta is very important ecologically as well as economically. The remoteness, spectacular landscape, and richness in wildlife make the Okavango Delta a magnet for tourists and tourism has become the second most important sector of the Botswana economy (Central Statistics Office 2000a).

When tourism was first targeted as a potential engine of economic growth by the Government of Botswana, a deliberate focus was put on high value-low volume tourism. The rational was that fragile ecosystems such as the Okavango Delta, the Kalahari, and Chobe National Park (Botswana's other major tourist destinations) were not deemed suitable for high volumes of tourists. In economic terms, the high value low volume stratetgy had the affect that by keeping tourist number small, higher prices could be charged for a more exclusive safari experience. The tourism industry in Botswana at the beginning of the 21st century is mostly composed of high end, luxury operations. In recent years the high value-low volume policy has been challenged from various sides, with the aim of increasing tourism revenue by increasing the volume of tourists.

So far the high value-low volume strategy seems to have worked out well. With an average cost of $ 400 US for one night in a safari lodge (Mbaiwa 2003) the Okavango Delta is more expensive than most other safari destinations in Africa but tourists are willing to pay the high prices. Tourists are willing to pay higher prices for an exclusive safari because they consider the encounter with other tourists as detrimental to their safari experience. Lodges that are located close to other lodges go to great length to shield the camps from each other and create a sense of remoteness and exclusivity.

Tourism Driven Community Based Natural Resource Management

CBNRM is conceptualized by development agencies as a strategy to raise community income in developing (rural) areas while sustaining natural resources (USAID 1997). In the Okavango Delta CBNRM projects focus on wildlife utilization, both consumptive and non-consumptive. The whole Delta, except for the Moremi Wildlife Reserve, was divided into Controlled Hunting Areas (CHAs) under the Wildlife Conservation and National Parks Act 28 of 1992 by the Government of Botswana. The controlled hunting areas are a sub-category of wildlife management areas. Each area is designated for either consumptive or non-consumptive wildlife utilization. The Department of Wildlife and National Parks establishes quotas for the extractive utilization of each species of wildlife in each area where hunting is allowed (Cassidy 1997). CBNRM projects were established in various wildlife management areas and through these projects the control over the quotas and utilization of natural resources was given to the local people living in the area. In order to participate in CRNRM the villagers have to form a Community Based Organisation which will handle the use of quotas and resource rights for the common good of the community. The people participating in the CBNRM project have a choice between using the quota for themselves, for example for subsistence hunting, selling the quota directly to tourists in the context of community operated tourism operations or sell their quota (or part of it) to commercial safari operators. In areas designated for non-extractive use, the villagers can offer photographic tourism operations or form a partnership with a photographic tourism operator. If the CBO decides to sell quotas or resource rights, it has to make sure the money gets invested in projects that benefit all members of the community that it represents. For an overview of the legal background of CBNRM in Botswana and implications for the implementation of CBNRM projects, please refer to Cassidy 2000.

CBNRM in Mababe (NG 41)

The village of Mababe is located on the eastern edge of the Okavango Delta, in the Mababe Depression (see map). The wildlife management area (WMA) to which Mababe belongs is NG 41, which has been designated for extractive wildlife utilization. The villagers embarked upon the CBNRM process by forming the Mababe Zokotsama Community Development Trust, which handles the villages' CBNRM activities. Because Mababe is the only community in NG 41, control over the resources, in the form of a Resource Use Lease for the entire NG were turned over to the Mababe Trust from the Land Board. Because of NG 41s designation for extractive wildlife utilization, this includes quotas for hunting wildlife.

The Mababe Zokotsama Community Development Trust formed a joint venture with a hunting safari company, and sold most of their hunting quota to this company. The revenue from selling the hunting quota goes to the community trust which decides how the money should be spent. The hunting safari company has established two hunting camps, Zooi and Kudikoo, in the vicinity of the village of Mababe. The camps have a combined capacity of 16 beds and employ 90 villagers from Mababe in different capacities, such as hunting guides, drivers of game drive vehicles, cleaning personnel, and kitchen helpers. A staff village is located in the vicinity of the two hunting camps and villagers who work at either of the camps do not always return to the village of Mababe for the night.

Tourists visit these camps to participate in hunting safaris. The tourists keep the trophy parts of the animals and consume some of the meat but the people of Mababe are entitled to use a portion of the meat and hides of any killed animal. The duration of the safari varies but certain minimum stays apply for various species. For example the minimum stay when hunting elephant is 15 days and the minimum cost of such a safari would be about 20,000 US$. It is not unusual for hunting safaris to last three or four weeks or longer.

Plan of Study

To investigate the costs and benefits of wildlife based tourism in Botswana, three scales of analysis were conducted:

1. Tourism contributions to the national economy of Botswana were evaluated and put into the context of the overall economy by quantifying all national resource flows and comparing them on a common basis.
2. The effect of CBNRM on the economy and environment were likewise evaluated on a common basis and thus the effect of CBNRM activities can be quantified.
3. The analysis of an individual safari lodge quantified on a common basis the contribution of the environment, employees, and purchased goods and services. Therefore it was possible to compare the contribution of wildlife and nature to the other inputs necessary for the experience. The effect of increasing numbers of tourists on the value of the tourism experience was predicted.

The method used in this study is emergy analysi (Odum 1996). Data on the economy of Botswana was obtained from statistical reports published by the government of Botswana. Information on tourism and CBNRM in Botswana was derived from reports by government agencies and aid organizations, books on eco-tourism in Africa, and the Okavango Delta as well as interviews of safari operators, tourists, and villagers participating in CBNRM.

CHAPTER 2
METHODS

General Methodology of Emergy Analysis

The environmental accounting method of emergy analysis quantifies flows of materials, energy, and services (Odum, 1996). Emergy accounting translates all resource flows into energy of one kind, generally solar energy, to allow for full comparability between different processes. Emergy is measured in units of emjoules, which is the unit for all energy (in joules) that it took to make and maintain something. The basis that is most commonly used in emergy analysis is solar energy, measured in solar emjoules, sej for short. The ratio between the Gibbs free energy of a product, measured in joules and its emergy is called transformity and has units of sej/J. Transformities are used to determine on a common basis the total amount of energy required to make something.

Transformities have been calculated for most common resources and commodities, such as fuels, minerals, metals, agricultural products, and manufactured goods. Most transformites used in this study are global averages taken from Odum (1996). Human service is evaluated in monetary units and then converted to emergy using the average ratio of emergy to money (sej/US$) for the specific economy.

In any economic transaction, money is paid for the human labor that went into the extraction and transformation of resources, never for nature's work in making the resources. To calculate the value received per monetary unit, the total resource base of a country is divided by the GNP of that country. To make an emergy analysis easier and faster, known transformities are often used combined with calculation of new transformities.

Because of limited data, necessity to make estimates of energy flows and the use of averages, interpretation of the results must be made with caution. Order of magnitude differences are generally considered significant; sometimes a difference of a factor of two can be of interest also.

The first step in conducting an emergy analysis is to draw a diagram of the system that is being analyzed. The diagram is crucial for the emergy analysis and specific rules and procedures are given in Odum (1996). The diagram establishes the system boundary and connections among the components of the system. The connections account for all inputs and outflows of the system as well as the internal flows among components.

An emergy table is constructed based on the diagram. The table has a row for each flow that crosses the systems boundary, thus accounting for all inputs into the system and all outflows, thus providing a complete account of the energy that drives the system. All flows are quantified and multiplied by their transformities to derive the emergy of each flow. The sources of information, and calculations needed to provide numbers for the table are included in an extensive set of footnotes associated with each table.

The emergy/money ratio is calculated by dividing the emergy base (all emergy inputs) of a country by that country's GDP. This ratio signifies the average amount of emergy that one unit of currency, commonly transformed into US $, can buy within that country. Emergy values can be divided by the emergy/money ratio, which yields units of Emdollar (Em$). Emdollar translates the emergy value into terms of emergy buying power, in a macroeconomic sense (Odum 1996). Expressing emergy flows in terms of

Em$ makes it easier to relate the magnitude of different emergy flows to the market economy.

Data Used for the Three Scales Analyzed

At the country scale, data were gathered on the economy of Botswana from published economic statistics, with a special focus on the tourism component of the economy. The resource flows in the community managed area NG 41 were evaluated using published data and interviews with local CBNRM participants. Resource flows of the safari lodge were obtained through informal personal interviews of safari camp operators.

Emergy Evaluation of Botswana

The country analysis was conducted according to the rules laid out in Chapter 10 of Odum (1996). All resource flows entering and leaving Botswana were evaluated. As a first step in the analysis, the boundary of the system was defined as the country border. The systems diagram of the country was drawn, showing all imports, exports and important storages and processes within the country. Once the diagram was complete, an emergy table was generated. The table contained one row for each of the renewable energy inputs, all imports, all exports, and extracted non-renewable resources from within the country. All renewable environmental inputs into the country were evaluated and the largest used as the renewable resource base of Botswana. To avoid double counting, which would lead to overestimation, the largest renewable energy inflow is used because of complex connections between all basic energy sources driving the earth (Odum, 1996). It was decided to err of the side of underestimation rather than overestimation. In addition to these area based renewable inputs Botswana receives significant inflow of river water through the Okavango River, which is an input from outside the area of the country. This flow was added to the renewable resource base since it results from the convergence of global resource flows in a large watershed outside of Botswana.

Use of renewable resources within the country was evaluated, as well as extraction of non-renewable or slowly renewable resources. Imports and exports were evaluated in physical units based on external trade statistics (Central Statistics Office 2000a). Additionally the monetary value of all imported items was multiplied by the global average money/emergy ratio, as opposed to Botswana's ratio, and the monetary value of exported items was multiplied by the money/emergy ratio for Botswana (calculated in this study). The different ratios had to be used because the amount of resources and services received per dollar equivalent varies between countries.

Tourism was evaluated in two ways, the import of emergy in the tourists themselves and the export of emergy by the tourists' non-consumptive use of natural resources. The import of tourism emergy is calculated by multiplying their transformity by the respiratory energy use per person per day, which yields emergy/person per day. The transformity of tourists was on a U.S. American with a college education (3.59 E15 sej/J), as calculated in Odum (1996). The emergy per person per day is multiplied by the total tourists-days per year. The tourist days were determined by multiplying the number of tourists per year by an average stay of four days. The export of resources by tourists was calculated by dividing the amount of money spent by tourists per year by the emergy/money ratio of Botswana.

Methods of the Mababe/CBNRM Analysis

The systems boundary for the Mababe/CBNRM analysis was the wildlife management area NG 41, which was the area over which the villagers from Mababe hold the resource use rights. NG 41 is located to the east of the Okavango Delta, in a fairly dry area known as the Mababe Depression. The system includes two subsystems, the village and the hunting camps, both of which were shown as subsystems in the diagram. There were two hunting camps in NG 41. They were diagrammed and evaluated as one unit because the operation is similar. The values of flows from both camps were added and presented as one unit.

The flows that cross the systems boundary as well as flows between the village and the hunting camps were evaluated. First, all renewable resources, indigenous energy extracted, and imported resources were evaluated and then a second table was created to account for important internal flows between the hunting camp, the village, and the environment.

The analysis of the hunting camps was based on the following assumptions:

- The entire area of NG 41 was the environmental support area for the system. Although hunting is not conducted in the entire area, the hunting quotas are set based on the entire area, and therefore all of NG 41 is the support area of the hunting activities.
- The camp is only operated during the hunting season, which is five months long, from mid March to mid September.
- There are a total of 16 beds at the two hunting camps.
- During the hunting season, the average occupancy rate is 60%.
- The average price per bed per night was estimated at 1200 US$. This price is based on the assumption that on average $500 US are paid in trophy fees per day and 50% of visitors do not hunt but pay an observer fee (300 US$/night).

The following assumptions were used to calculate the internal flows between the village of Mababe, the environment and the hunting camps:

- The environmental support area of the village was assumed to be a circle with a radius of 5 km around the village. This choice was made, because it seems that this is the area that villagers could use for resource extraction in the absence of modes of transportation other than walking in the dry climate.

- The money flow into the village was calculated as 192,000 US$ per year, the sum of ~110,000 US$ (676,000 Pula in 2000, according to Mbaiwa, 2003), 81,000 US$ in wages, and 1,000 US$ in tips.

- Wildlife products entering the village where assumed to be 10% of total wildlife extraction. This value was used because although villagers could probably use a higher percentage of the meat, most animals are not killed in close proximity to the village and villagers have limited access to transportation. The remainder of a killed animal is left on site.

- The emergy flow from the village to the hunting camp in the villagers that work at the camp was calculated based on 90 workers working 120 days per year. The transformity of these villagers was based on a Botswana national with a primary school education, as calculated in Table A-2.

- The emergy flow tourist information into the village was calculated by multiplying the total tourist emergy by the fraction of time that villagers spent in the camp.

Methods of the Safari Lodge Analysis

The analysis of lodge tourism in the Okavango Delta was done using the example of one generic safari lodge. The lodge is used for photographic (non-extractive) tourism, which is the only type of tourism allowed within the Okavango Delta. The lodge is diagrammed showing all inputs and outputs as well as some internal processes. The lodge exemplifies the average lodge in the Okavango Delta. The following assumptions were made in the emergy analysis:

- There are a total of 16 beds at the lodge.

- There are 10 tourists staying at the lodge each day of the year, based on an average occupancy of about 60%.

- The area used by the lodge was assumed to be 113 km^2. Concession areas vary greatly in size for each lodge and some are shared between several lodges. The value of 113 km^2 is based on the assumption that the lodge actively uses the area in a radius of 6 km around the lodge. Although the actual concession area might be much larger than this, game drives or mokoro (dug-out canoe) tours generally do not travel far from the lodge but roam around in search of animals. It was assumed that the actively used area contributes to the emergy of the lodge.

- Investment in the permanent structure of the lodge and vehicles are pro-rated over a period of 15 years. The lodge structure was considered as only the building structure of the lodge, not including moveable assets.

- The price paid by tourists per night at the specific lodge evaluated is $350 US, slightly lower than the average of $400 US. This value constitutes the service component of resource flows. To avoid double counting, the monetary value of services which were included in the analysis, such as purchased food, fuels, payments to the government, etc., is subtracted from the price paid by tourists. These expenses by the lodge operator amount to about $100 US. Therefore, the value of services is $250 US per tourist per night.

- Staff members work for eight hours per day and on average ten staff members were present. The transformity of staff members was based on a Motswana (Botswana national) with primary school education, as calculated in this study (Appendix A)

- The government regulates tourism activity in the Okavango Delta and therefore also contributes to the safari. The contribution by government was assumed equal to the payments made by the safari company to the government, as listed in Appendix B.

To predict the effect of increasing numbers of tourists the emergy evaluation was repeated for larger tourist numbers, assuming that the inputs from the local environment remain the same but increasing all other inputs (purchased goods and services, employees, etc.) in direct linear proportion to the increase in tourists. To calculate the total emergy received by a tourist per night, the total emergy value of the lodge operation for one year was divided by the total number of tourist nights per year. At each tourism density, the ratio between local environmental inputs and purchased inputs was calculated by dividing the environmental inputs by the sum of all other inputs.

CHAPTER 3
RESULTS

Results of the Country Analysis

Systems Diagram of Botswana

Figure 3-1 is an emergy systems diagram of the country of Botswana. On the left side are the renewable energy sources (sun, wind, rain, and river water) that primarily drive the natural and agricultural ecosystems of the country. Rain and river water entering the country through the Okavango River also contribute to water resources in the country.

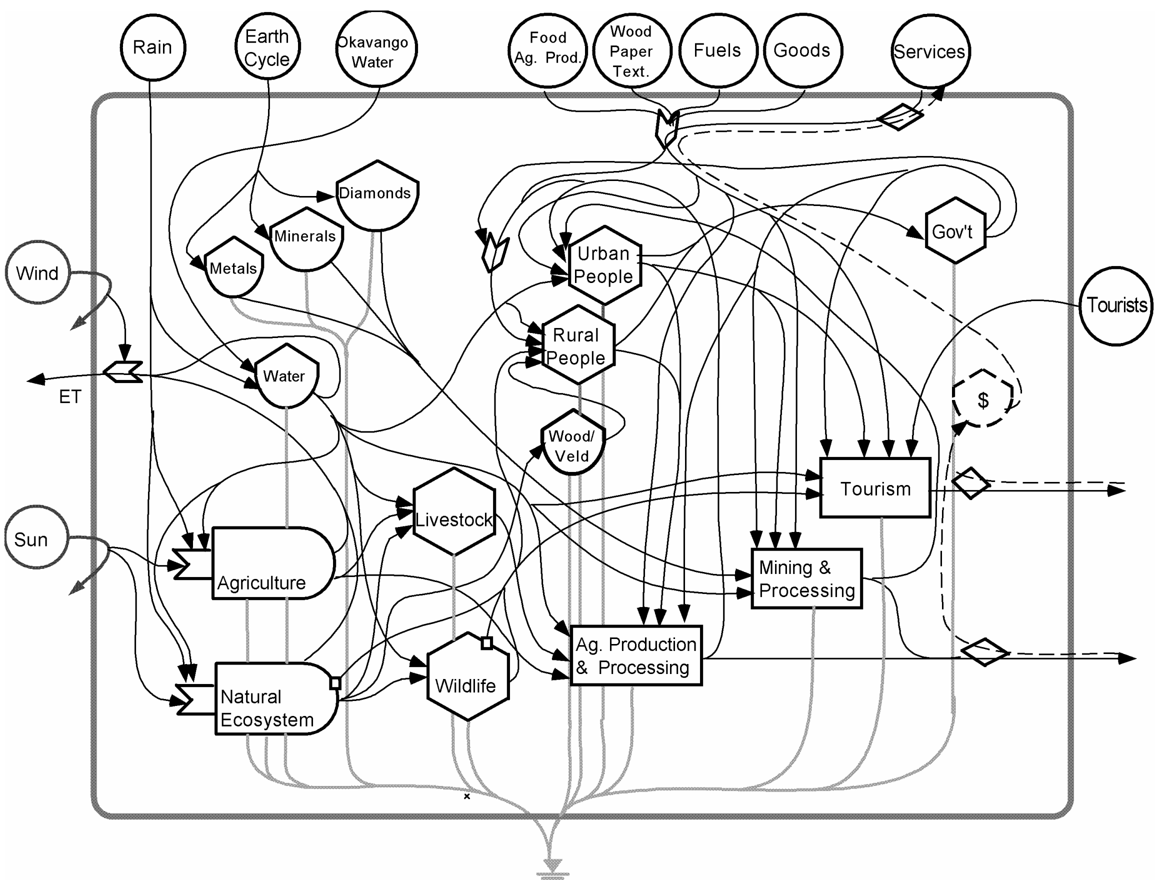

Figure 3-1: Systems diagram of the country of Botswana, showing flows of energy, matter and money.

Natural and agricultural ecosystems are depicted as the bullet shaped producer symbols in the lower left corner of the diagram. The natural ecosystem supports wildlife as well as livestock, which uses natural areas for grazing, whereas agricultural lands primarily support livestock. Both livestock and wildlife are shown as consumers in the diagram.

The processes of agricultural production and processing receive inputs from the agricultural ecosystem and associated livestock and is supplemented by human labor from within the country as well as imported fuels, goods, and services. Some percentage of agricultural production is used by rural and urban people within the country and the remainder is exported, in exchange for money (dashed line).

Geologic processes over long time periods have produced reservoirs of mineral and other valuable resources in the country. In Botswana the most significant resources are diamonds, coal, copper, nickel, and soda ash. These resources are shown as the storage tanks in the upper left corner of the diagram. Because of the very slow renewable rates of the resources, they are generally considered non-renewable. The extraction of these resources takes human labor and the use of imported (and local) fuels, goods, and services. In the case of Botswana, diamonds are exported without much (if any) processing or use within the country. The other extracted resources go through some processing before being exported. In exchange for the exported resources, Botswana receives money, shown as the dashed line entering the country. The government facilitates the trade in resources in several ways. The government is a major partner in all diamond mining operations in Botswana and profits accordingly from the operation of diamond mines. Additionally, the fact that Botswana's government is stable and democratic also facilitates foreign investment and facilitates trade relations.

Tourism, shown on the left side of the diagram, is an important aspect of energy flows in Botswana. The beauty and remotes of the natural ecosystem and the abundance of wildlife are the main attractions for tourists to visit Botswana. The arrival of tourists is facilitated by services from outside the country, such as transportation, advertisement, and foreign travel organizations. Inside the country tourists themselves contribute to the tourism industry, goods and services from outside the country, urban and rural people who work in the tourism industry, water, the image of the natural environment, locally produced foods and products, and wildlife. Wildlife gets used in a non-extractive way in photographic tourism, where only the image is used, and directly in hunting safaris. During their stay, the tourists use a portion of the countries resources, which is shown by the emergy flow leaving the country. The experience of nature and wildlife enriches the tourists and the value of this enrichment leaves the country with the tourists. Tourists pay for their experience as shown by the dashed line entering the system. The government regulations have limited the amount of tourism development in Botswana, thus providing a more exclusive experience for visitors. Furthermore stable and democratic government also stimulates tourism by giving tourists a sense of security.

Emergy Evaluation of Botswana

Table 3-1 is the emergy evaluation table for the country of Botswana. Flows of energy, resources, and money that cross the nation's boundary are indicated. Line items one through six are the renewable energy flows driving the country. In Botswana, deep heat (line item number five) was the largest renewable energy source (321.5 E20 sej/J). For the total renewable resource base, the Okavango River water was added, because the watershed of the Okavango is located outside Botswana. The total renewable resource base for Botswana was the sum of deep heat and the emergy of the chemical potential of the river water (344.5 E20 sej/year), shown as variable R in Table 3-2.

Line items seven and eight are the indigenous energy sources that are mostly based on renewable energy flows and that are used within the country, namely agricultural products and livestock. The value for livestock production was more than five times higher than the value for crop production, which reflects the fact that Botswana is an arid country with limited irrigated agriculture. The combined value of agricultural and livestock production is 7.6 E20 sej/year, which is twice as much as the emergy in imported food and agricultural products (3.8 E20 sej/year).

Line items nine through fifteen are non-renewable resources extracted within the country. Fuel wood and forest extraction (line items nine and ten) were included as non-renewable resources because the extraction of wood has led to a noted depletion of woodlands, which indicates that forest resources are not renewable at current extraction levels. Wood has three major uses: fuel wood, fencing material, and building poles. Additionally land is cleared of woods to expand agricultural lands. The emergy table shows that fuel wood was about nine times as important as wood extracted for other uses. Fuel wood use is not limited to remote areas but also in the capitol people use fuel wood as a source of energy.

The mineral non-renewable resources from within the system were soda ash and coal (line items 11 and 12). Coal, which was the largest of the non-renewable resources in Botswana and accounts for about 2% of emergy inputs into the system, was extracted and used to generate electricity, mainly used within the country.

Table 3-1: Emergy evaluation of the country of Botswana, showing resource flows in raw units, their transformity, the emergy value, and the Em$ value. Details on the calculation of each resource flow and data sources can be found in Appendix C.

Note	Item	Raw Units		Transformity (sej/unit)	Solar Emergy (E20 sej)	EmDollars (E6 1998 US$)
RENEWABLE RESOURCES:						
1	Sunlight	4.60E+21	J	1	46.0	231.7
2	Rain, chemical	1.00E+18	J	18199	182.2	917.0
3	Rain, geopotential	6.62E+17	J	27874	184.5	928.8
4	Wind, kinetic energy	3.06E+18	J	1496	45.8	230.7
5	Okavango Water	4.74E+16	J	48500	23.0	115.7
6	Earth Cycle	9.35E+17	J	34377	321.5	1618.6
INDIGENOUS ENERGY:						
7	Agriculture Production	6.97E+14	J	2.00E+05	1.4	7.0
8	Livestock Production	3.08E+14	J	2.00E+06	6.2	31.0
NONRENEWABLE SOURCES FROM WITHIN SYSTEM:						
9	Fuelwood Extraction	1.58E+16	J	1.87E+04	3.0	14.9
10	Forest Extraction	1.71E+15	J	1.87E+04	0.3	1.6
11	Soda Ash	1.64E+11	g	2.20E+09	3.6	18.2
12	Coal	2.11E+16	J	4.00E+04	8.4	42.5
13	Copper	1.99E+10	g	1.00E+09	0.2	1.0
14	Nickel	2.13E+08	g	1.00E+09	0.0	0.0
15	Salt	1.57E+11	g	1.00E+09	1.6	7.9
IMPORTS AND OUTSIDE SOURCES:						
16	Electricity	3.55E+15	J	1.65E+05	5.9	29.5
17	Coal	1.91E+14	J	4.00E+04	0.1	0.4
18	Oil derived products	9.93E+15	J	6.60E+04	6.6	33.0
19	Metals	9.15E+10	g	1.80E+09	1.6	8.3
20	Mineral Products	8.69E+09	g	1.00E+09	0.1	0.4
21	Food & ag. products	1.90E+15	J	2.00E+05	3.8	19.1
22	Livestock, meat, fish	3.31E+13	J	2.00E+06	0.7	3.3
23	Plastics & rubber	1.31E+15	J	6.60E+04	0.9	4.4
24	Chemical Industry	4.17E+10	g	3.80E+08	0.2	0.8
25	Wood, paper, textiles	3.11E+16	J	3.49E+04	10.9	54.6
26	Mech & trans equip.	2.10E+08	US$	1.66E+12	3.5	17.5
27	Service in imports	2.26E+09	US$	1.66E+12	37.5	188.7
28	Tourism (Tourist MRG)	7.38E+05	day	3.59E+15	26.5	133.3
EXPORTS:						
29	Diamonds	3.29E+06	g	???	???	???
30	Diamonds (service)	1.60E+09	US$	1.99E+13	317.8	1600.0
31	L-stock, meat, meat prod.	9.34E+13	J	2.00E+06	1.9	9.4
32	Copper matte	6.09E+10	g	1.00E+09	0.6	3.1
33	Salt	2.82E+10	g	1.00E+09	0.3	1.4
34	Vehicles and Parts	1.75E+05	US$	1.99E+13	0.0	0.2
35	Tourism (service)	1.83E+08	US$	1.99E+13	36.4	183.0
36	Service in exports	2.12E+09	US$	1.99E+13	420.8	2118.4

The service component of imported products (line item 27) is the largest imported source (37.5 E20 sej/year).It was calculated by diviging the total money spent on exports with the global emergy/money ratio (1.66 E12 sej/US$).

Botswana imported significant amounts of electricity and oil derived products (5.9 and 6.6 E20 sej/yr, respectively) but only a small amount of coal (0.1 sej/yr) because significant amounts of coal (8.4 E20 sej/yr) are extracted from within the country.

Botswana generates about 75 percent of the electricity it uses, so the imported amount of electricity of 5.9 E 20 sej/year accounts for about one quarter of all electricity used in Botswana (Central Statistical Office 2000).

Very few metals and minerals (line items 19 and 20) were imported, and of those metals imported, a large percentage was re-exported (External Trade Statistics 1998). The remaining imports were goods of different kinds, of which wood, paper, and textile products were the largest (10.9 E20 sej/yr), mostly because these products are not produced within the country. Botswana is not suitable for growing cotton and does not have an organized forestry sector. As far as food is concerned, Botswana largely relies on its own production for meat products (mainly beef) but imported a larger amount of other agricultural products.

By far the largest export was the service in exports (line item 36), which was more than one order of magnitude larger than all other exports. Service in exports (420.8 E20 sej/yr) was calculated by multiplying the money received for exports (2.12 E9 US$) by the emergy/money ratio of Botswana (19.9 E12 sej/US$). The much larger emergy value for the services in exports was a result of the much larger emergy/money ratio of Botswana, compared to the global average. The second most important import was the emergy of tourists that visit Botswana (26.5 E20 sej/year).

In monetary terms, diamonds accounted for a little over 70% of all exported goods (External Trade Statistics 1998). No transformity was available for diamonds; therefore Diamonds were evaluated based on their monetary value, which only accounts for the human services in extracting the diamonds, which represents an underestimation of the true emergy value. The value for services exported, includes this number.

Livestock and meat products (line item 31) accounted for 1.9 E20 sej/yr in exports. A little less than one third of all meat and livestock produced in Botswana was exported. The other exports, copper matte, salt, and vehicles and parts (line items 32 to 34), together account for less than 1 E20 sej/year. Despite strong efforts to diversify the economy, Botswana apparently was still heavily dependent on diamonds.

Line item 35 is the emergy received by tourists (36.4 E20 sej/year) while visiting Botswana. The emergy value embodied in the tourists visiting the country. Is 26.5 E20 sej/year.

Table 3-2: Summary values of the country analysis derived from Table 3-1.

Variable	Item	Solar Emergy (E20 sej/y)	Dollars
R	Renewable sources (rain, tide, earth cycle)	344.5	
N	Nonrenewable resources from within Botswana	17.1	
N0	Dispersed Rural Source	3.3	
N1	Concentrated Use	13.8	
N2	Exported without Use	???	
F	Imported Fuels and Minerals	14.2	
G	Imported Goods	16.3	
I	Dollars Paid for Imports		2.3E+09
P2I	Emergy of Services in Imported Goods & Fuels	37.5	
E	Dollars Received for Exports		2.1E+09
P1E	Emergy Value of Goods and Service Exports	423.6	
x	Gross National Product 1997/1998 (US$)		2.1E+09
P2	World emergy/$ ratio, used in imports	1.7E+12	
P1	Botswana Emergy/$ ratio	2.0E+13	

Table 3-2 summarizes the emergy flows for the country of Botswana. The renewable energy flows were large compared to most other flows but on a per year basis the emergy exported was twice the renewable yearly emergy basis.

Table 3-3: Emergy indices for Botswana. Based on the summarized flows in Table 3-2, the indices give an overview of the economy of Botswana and show some of its characteristics.

Item	Name of Index	Expression	Quantity
1	Renewable emergy flow	R	3.4E+22 sej/yr
2	Flow from indigenous, non-renewable reserves	N	1.7E+21 sej/yr
3	Flow of imported emergy	F+G+P2I	6.8E+21 sej/yr
4	Total emergy inflows	R+N+F+G+P2I	4.3E+22 sej/yr
5	Total emergy used, U	N0+N1+R+F+G+P2I	4.3E+22 sej/yr
6	Total (?) exported emergy	P1E	4.2E+22 sej/yr
7	Fraction emergy use derived from home sources	(NO+N1+R)/U	0.8
8	Imports minus exports	(F+G+P2I)-(N2+B+P1E)	-3.6E+22 sej/yr
9	Export to Imports	(N2+P1E)/(F+G+P2I)	6.2
10	Fraction used, locally renewable	R/U	0.8
11	Fraction of use purchased	(F+G+P2I)/U	0.2
12	Fraction imported service	P2I/U	0.1
13	Fraction of use that is free	(R+N0)/U	0.8
14	Ratio of concentrated to rural	(F+G+P2I+N1)/(R+N0)	0.2
15	Use per unit area	U/(area)	7.1E+10 sej/yr
16	Use per person	U/population	1.3E+16 sej/yr
17	Renewable carrying capacity at present living standard	(R/U) (population)	2.7E+06 sej/yr
18	Developed carrying capacity at same living standard	8(R/U)(population)	2.1E+07 sej/yr
19	Ratio of use to GNP, emergy/dollar ratio	P1=U/GNP	2.0E+13 sej/yr
20	Ratio of electricity to use	(el)/U	2%
21	Fuel use per person	fuel/population	4.1E+14 sej/yr

Table 3-3 examines the relationship between different emergy flows and summarizes some characteristics of resource use and economics in Botswana, based on values from Table 3-2. Botswana generated 84% of all emergy used from home sources (item 7), which shows limited dependence on imports. The sectors where Botswana was most dependent on imports are fuels, agricultural products (other than meat), textiles, and electricity. Only 2% of the total energy used was electricity, which is an indication that Botswana relies more heavily on energy sources with a lower transformity. The fraction of electricity in total energy use is often used as an indication of how developed a country is.

To put the indices for Botswana into perspective, the values from Table 3-3 were compared to emergy indices for the United States of America in Table 3-4, based on data from Odum (1996). Eighty percent of the yearly resource use in Botswana could be sustained by locally available renewable sources, compared to the USA, where 10% of the energy used was locally renewable (item 10).

Table 3-4: Comparison between Country Indices of Botswana and the USA. Values for Botswana were based on this study, Table 3-3, and values for the USA were adopted from Odum 1996.

Item	Name of Index	Quantity			
		Botswana		USA	
1	Renewable emergy flow	3.4E+22	sej/yr	8.2 E+22	sej/yr
2	Flow from indigenous nonrenewable reserves	1.7E+21	sej/yr	534.6 E+22	sej/yr
3	Flow of imported emergy	6.8E+21	sej/yr	193.6 E+22	sej/yr
4	Total emergy inflows	4.3E+22	sej/yr	810.6 E+22	sej/yr
5	Total emergy used, U	4.3E+22	sej/yr	785.1 E+22	sej/yr
6	Total exported emergy	4.2E+22	sej/yr	87.0 E+22	sej/yr
7	Fraction emergy use derived from home sources	0.85		0.76	
8	Imports minus exports	-3.7E+22	sej/yr	84.1 E+22	sej/yr
9	Export to Imports	6.4		0.5	
10	Fraction used, locally renewable	0.81		0.10	
11	Fraction of use purchased	0.16		0.25	
12	Fraction imported service	0.09		0.18	
13	Fraction of use that is free	0.82		0.22	
14	Ratio of concentrated to rural	0.2		3.4	
15	Use per unit area	7.1E+10	sej/m2	8.4 E+11	sej/m2
16	Use per person	1.3E+16	sej/pers	3.4 E+16	sej/pers
17	Renewable carrying capacity at present living standard	2.7E+06	sej/yr	23.4 E+6	sej/yr
18	Developed carrying capacity at same living standard	2.1E+07	sej/yr	187.2 E+6	sej/yr
19	Ratio of use to GNP, emergy/ dollar ratio	2.0E+13	sej/$	2.4 E+12	sej/$
20	Ratio of electricity to use	0.02		0.17	
21	Fuel use per person	4.13E+14	sej/pers	1.5 E+16	sej/pers

The emergy use per capita in Botswana was about one third of the per capita use in the USA (item 16) and the energy use per area in Botswana was one order of magnitude smaller than the respective value for the USA (item 15). These values indicate that

Botswana has a strong sustainable resource base, a small population, and a low population density.

Results of the Mababe/CBNRM Analysis

Systems Diagram of Mababe and CBNRM in NG41

The diagram in Figure 3-2 depicts the major emergy flows in NG 41, with the three main components of: the ecosystem, the village of Mababe, and the hunting camps. On the far left side of the diagram are the components that constitute the natural environment. Sun, wind, rain, and deep heat are the four renewable energy sources into the system and they drive primary production.

The village of Mababe is shown in the lower right corner of the systems diagram. The flow of energy from the ecosystem combines with energy from the villagers and their assets as well as their social organization in the subsistence process to provide a wide range of services to the village community. The services include the building and maintenance of assets, use of these assets by villagers, direct sustenance for the villagers, as well as strengthening and development of social organization. The villagers themselves also maintain social organization through activities such as formal village meetings (kgotla) and more informal social interactions that might change hierarchies or distribution of wealth in the village.

Flows from outside of the study area (NG41) enter the village system. These flows include those goods and services purchased by villagers as well as those provided by the tour operator. These flows also include goods and services that are provided by the national government, such as health care, emergency food rations during drought conditions, and schooling materials and teachers. The government effort in providing these goods and services to the villager is shown in the diagram and the money the government spends is shown by the dashed line.

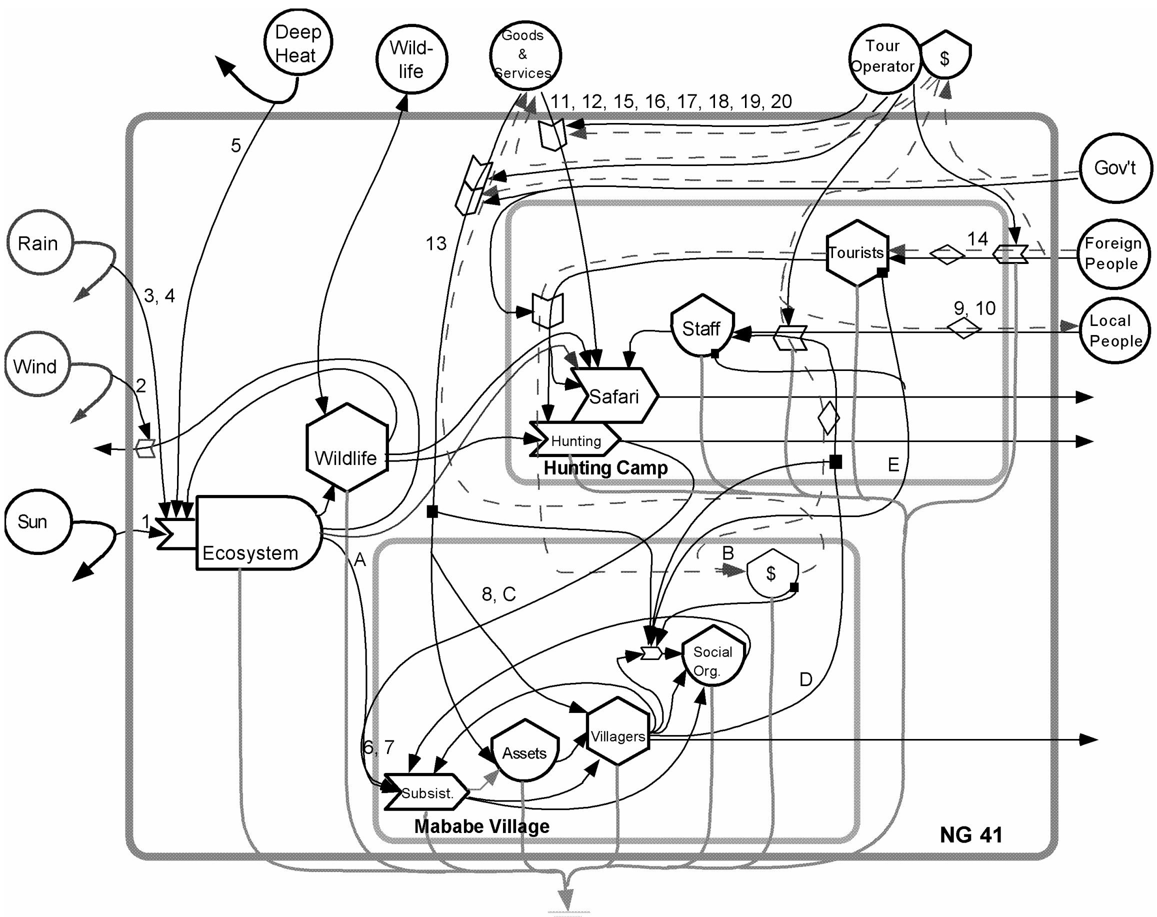

Figure 3-2: Systems diagram of the Wildlife Management Area NG 41, including the village of Mababe and hunting camps. Numbers indicate the line items in Table 3-5 and letters correspond to items in Table 3-6

The flow of outside resources into the village system also has an effect on the social organization as shown by flow path. The inflow of emergy from outside the system is a contributing factor to the following changes in social organization such as changing the traditional value system due to exposure to a moneyed economy, and migration of young people to seek better economic opportunities elsewhere.

Flows also enter the village system from the hunting camp. The villagers are entitled to a portion of the meat of the animals that are killed during a safari. This flow of meat and animal products, such as bone and skin that is not wanted by the tourists, is shown by the flow path from the hunting interaction symbol into the village.

The presence of the hunting camp and implementation of CBNRM also lead to the accumulation of money in the village, as shown by the storage tank with the dollar symbol and the money flow path depicted with a dashed line. One source of money is the money paid by the tour operator to the Mababe Zokotsama Community Development Trust for the right to use resources in the community controlled area. This money goes into an account and the community organization decides how to use this money, which is a length process. Money also enters the village economy in the form of wages and tips that the villagers who work in the camp receive. This money is more directly available to purchase goods and services.

Money that is spent leaves the storage tank and runs in the opposing direction of the flow of goods and services that enter the village in return for the money. The money that enters and leaves the system has an effect on the social organization of the villagers. For example conflicts arise about the use of the money in the community trust, villagers that earn more money might rise in status above what the traditionally would have been their role, and a monetary based value system might replace traditional value system.

During the actual hours that villagers spend in the hunting camp, they do not participate in the subsistence or community activities of the village. This export of energy is shown by the flow path from the villagers to the staff in the hunting camp, this is a drain of energy out of the village and the absence of productive villagers also affects the social organization of the village in positive or negative ways. The interaction between the villagers and the tourists also has an effect on the attitudes and perspectives of these villagers and when they return to the village, the changes in their perspectives also affect the social organization.

The upper right corner of the systems diagram is devoted to the energy flows in the hunting camp. Foreigners come into the hunting camp as tourists and bring with them a flow of money (dashed line). The major part of this money goes to the tour operator, who spends some resources to facilitate the tourists coming into the camp. While at the hunting camp, the tourists go on safaris, during which they also hunt for wildlife. The government regulates the number of tourists that can stay in each of the concession areas and also sets quotas of how many animals of different wildlife species might be killed by safari hunters each year. These regulating activities are shown by the line connecting the government (shown as an emergy source) to the safari operation.

Many other flows go into the safari and hunting activity. The work by the villagers and other local people represents an inflow of human emergy. The safari operator pays money to the staff members (dashed lines) and also pays for delivers rations to the staff members who come from the village of Mababe. These efforts and rations are an inflow of goods and services into the village. The ecosystem and wildlife also contribute to the hunting safari and hunting process. At the end of the safari the tourists leave the hunting camp and take with them some parts of the killed animals, mostly trophies.

Emergy Evaluation of Mababe and CBNRM in NG 41

The emergy table presented in Table 3-5 gives the amount of driving emergy from flow paths as well as emergy that is extracted from sources within the system. Additionally some internal emergy flows are presented in Table 3-6. These internal flows allow a comparison between the intensity of the village economy and the relative magnitude of influence of CBNRM and the hunting camps.

Table 3-5: Emergy evaluation of NG 41 with the village of Mababe and two hunting camps. Flows of money, matter, energy, and information were evaluated and translated into common units of emergy. Footnotes to Table 3-5 can be found in Appendix C

Note	Item	Raw Units		Transformity (sej/unit)	Solar Emer (E18 sej)	EmDollars (E3)
RENEWABLE RESOURCES:						
1	Sunlight	1.68E+19	J	1.00E+00	16.8	846.7
2	Wind, kinetic energy	1.12E+16	J	1.50E+03	16.8	843.2
3	Rain, chemical	3.67E+15	J	1.82E+04	66.7	3351.8
4	Rain, geopotential	2.42E+15	J	2.79E+04	67.6	3394.7
5	Earth Cycle	3.08E+15	J	3.44E+04	105.8	5316.5
INDIGENOUS ENERGY:						
6	Livestock Production	6.70E+08	J	2.00E+06	0.0	0.1
7	Fuelwood Extraction	1.50E+12	J	1.87E+04	0.0	1.4
8	Wildlife Extraction	3.40E+11	J	5.18E+06	1.8	88.5
IMPORTS OF OUTSIDE ENERGY SOURCES						
9	Lodge Manager	3.00E+02	day	7.67E+14	0.2	11.6
10	Personell from Outside NG41	6.00E+02	day	3.32E+14	0.2	10.0
11	Lodge Infrastructure Material	1.17E+07	g	1.00E+09	0.0	0.6
12	Lodge Infrastructure Labor	8.37E+08	J	2.46E+07	0.0	1.0
13	Staff Rations	1.96E+11	J	2.00E+05	0.0	2.0
14	Tourist - Emergy	1.44E+03	day	3.59E+15	5.2	259.7
15	Tourist Food	1.81E+10	J	2.00E+06	0.0	1.8
16	Tourist Drinks	2.52E+06	J	7.50E+07	0.0	0.0
17	Fuel	7.15E+11	J	6.60E+04	0.0	2.4
18	Freight	6.75E+10	J	6.60E+04	0.0	0.2
19	Vehicles	1.60E+06	g	6.70E+09	0.0	0.5
20	Services	1.73E+06	US$	1.99E+13	34.4	1728.0

The largest of the renewable resources driving the system was the earth cycle or deep heat energy (105.8 E18 sej/yr), same as in the analysis of the country. The people from outside NG 41 that come into the system to work at the hunting camps accounted for a total of about 0.4 E+18 sej/yr based on the total of line items 9 and 10. The total value of goods and services that were imported into the hunting camps was 34.6 E18 sej/yr (sum of line items 12, 13, and 16-20) with services (line item 20) being by far the largest. The goods and services which were imported into the village in the rations that were given to villagers that work in the hunting camps accounted for 0.04 E18 sej/yr and were in the same order of magnitude as the emergy that was derived by the villagers directly from indigenous sources 0.03 E18 sej/yr (line items 6 and 7). The second largest import into the hunting camps was the emergy value of the tourists themselves (5.2 E18 sej/yr).

Table 3-6: Evaluation of emergy flows between the village of Mababe and the hunting camps. Footnotes to this Table can be found in Appendix C

Note	Item	Raw Units		Transformity (sej/unit) *	Solar Emergy (E18 sej/yr)	EmDollars (E3/yr)
A	Ecosystem inputs into village	1.10E+14	J	3.44E+04	3.8	189.95
B	Money flow into village	1.92E+05	US$	1.99E+13	3.8	192.00
C	Wildlife meat into village	3.35E+10	J	1.01E+06	0.0	1.70
D	Villager input into camp	1.08E+04	day	2.22E+14	2.4	120.44
E	Tourist information into village	6.48E+02	day	3.59E+15	2.3	116.87

The main interest of this part of the analysis is the costs and benefits in terms of emergy to the village as they are generated by the hunting camps and CBNRM activities, therefore those emergy flows that enter the village system as a result of tourism and CBNRM were calculated in Table 3-6. To avoid confusion with Table 3-5, the line items in Table 3-6 are labeled with letters instead of numbers. The ecosystem input into the village was calculated in line item A and had a value of 3.8 E+18 sej/yr, which is the renewable resource base for the village.

The emergy value represented by the total amount of money flowing into the village (line item B) as a result of the presence of the hunting camps and the implementation of CBNRM was the same as the renewable resource base. The total emergy that could potentially be bought and brought into the village with this money (based on the average emergy/ money ratio for Botswana) was 3.8 E+18 sej/yr.

The villagers receive a portion of the meat from killed wildlife, which amounted to 0.03 E18 sej/yr and was only a small contribution to the village economy (line item C).

Less tangible than the wildlife meat was the inflow of tourist emergy into the village (line item D). This influence amounted to 2.3 E18 sej/yr. In the opposite direction, there is an emergy flow from the village to the hunting camp in the form of the villagers that work at the camp (line item E). Based on the number of villagers that work at the camp and the average working time, the value of their work was 2.8 E18 sej/yr. The value of villager emergy leaving the village to work at the hunting camp was larger than the tourist emergy entering the village.

Results of the Safari Lodge Analysis

Systems Diagram of a Safari Lodge in the Okavango Delta

Figure 3-3 is a systems diagram of a safari lodge in the Okavango Delta. The left side of the diagram shows the natural ecosystem driven by renewable energy sources, vegetation and wildlife.

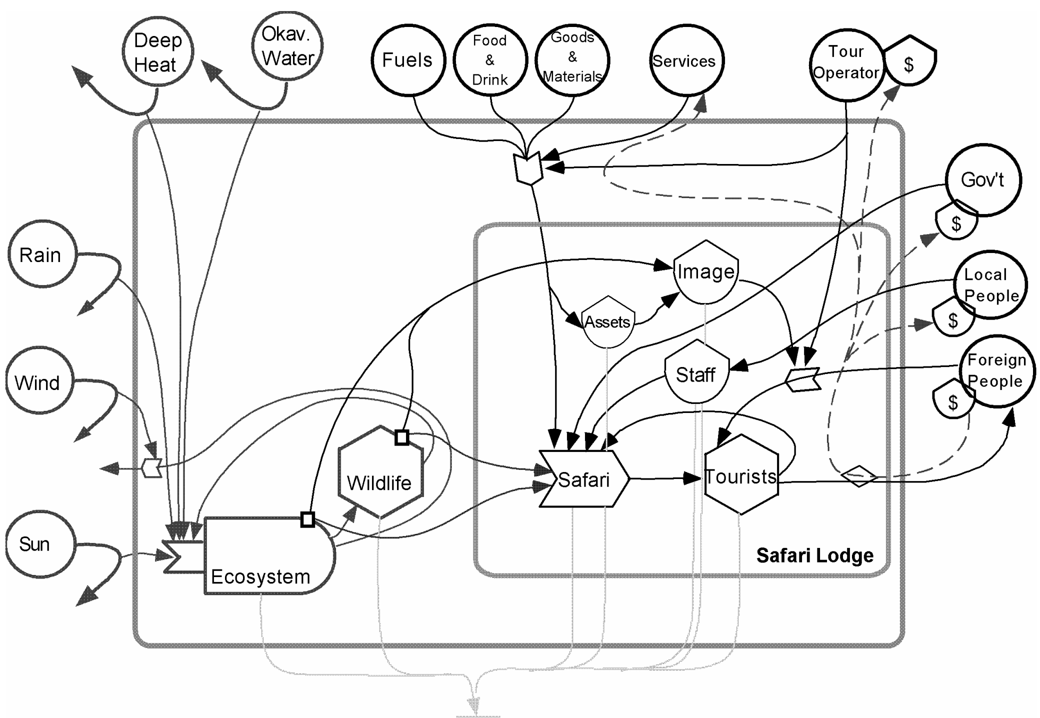

Figure 3-3: Systems diagram of a safari lodge in the Okavango Delta, showing flows of matter, energy and money

The right side of the diagram shows the tourism industry as represented by a safari lodge. People from foreign countries are attracted to visit Botswana and especially the Okavango Delta by the image of unspoiled and remote wilderness and high quality safari lodges. This image is generated by the ecosystem and wildlife in the delta as well as the structures that the safari operators place within the delta. The arrival of the tourists is facilitated by tour operators that organize the safari, promote tourism, provide transportation, and provide other services. Within the systems boundaries of the tourism sector, the tourists are the consumers of all the energy flows that flow through the process of safari and safari hunting. The tourists themselves contribute energy to the safari as shown by the feedback loop. Local people who work in the safari lodges as staff members contribute to the safari. The government contributes, as previously indicated, in the country diagram, by providing a framework for an exclusive and safe experience.

The lodges and safaris require a large amount of outside resources. This flow includes fuel, used to transport people, goods and services to the remote lodges, as well as for providing fuel for game drive vehicles and generators. High quality food and drink are imported, often times from outside Botswana, to maintain the high standards expected for luxury safaris. Large amounts of goods and materials are also required, some of which form the assets of the lodge and others are consumables. The tour operator organizes and facilitates the flow of all goods and services to the safari lodge.

The natural ecosystem makes a major contribution to the safari, in fact, without the ecosystem and the associated wildlife there would be no safari tourism. The use of natural resources can either be consumptive in hunting safaris, or non-consumptive for photographic safaris.

The money paid by tourists for the safari experience flows to several recipients. Local people receive wages for their work in the camp, the government receives payment for resource use and taxes, the tour operator is paid for services in organizing the safari, and payments are made for the services embodied in all purchased goods.

Emergy Evaluation of a Safari Lodge in the Okavango Delta

Table 3-7 is the emergy evaluation of the lodge. The value of services, (1.8 E19 sej/yr) was the highest input into the system. Government service (line item 11) was based on the amount of money paid to the government in the form of taxes and resource rental (see Appendix B). This was a fraction of the total value of services (line item 12) and had a value of 160.3 E15 sej/yr. The value for total services, line item 12, was the money paid by tourists (350 US$) minus the money value of goods, services, wages, taxes, and resource rental that were included elsewhere in the emergy analysis (see Appendix B).

The environmental input (line item 1) was the second largest input into the system (1.69 E19 sej/yr). Line items two and three are the flows from outside the system that form the assets within the system. While line item two covers all the materials (11.7 E15 sej/yr), line item three includes all the labor used in construction (23.2 E15 sej/yr). The labor of lodge construction was twice as high as the materials because mostly wood and other natural materials with low transformities were used, and the construction process was mostly based on manual labor.

Line items four and five are energy flows associated with the staff of safari lodges. Line item four is the value of the rations that were given to the staff members (7.6 E15 sej/yr). Many lodges give the staff members ration packages, and others provide cooked meals. Line item five is the service value for the staff members themselves (27.0 E15 sej/yr).

Table 3-7: Emergy evaluation of a safari lodge in the Okavango Delta. All inputs material, energy, service, and information were evaluated and translated into common units of emergy. Footnotes for this table can be found in Appendix C

Note	Item	Raw Data	Units	Transformity sej/j or sej/$	Solar Emergy E15 sej/yr	Em$ Cost 1,000Em$/yr
1	Environmental Inputs	3.47E+14	J/yr	4.85E+04	16,852.5	846.9
2	Lodge Infrastructure Materia	1.17E+07	J/yr	1.00E+09	11.7	0.6
3	Lodge Infrastructure Labor	9.42E+08	J/yr	2.46E+07	23.2	1.2
4	Staff Rations	3.82E+10	J/yr	2.00E+05	7.6	0.4
5	Staff - Emergy	1.27E+09	J/yr	2.12E+07	27.0	1.4
6	Tourist - Emergy	3.82E+09	J/yr	7.33E+07	280.0	14.1
7	Tourist Food	4.58E+11	J/yr	2.00E+06	916.7	46.1
8	Fuels	1.81E+12	J/yr	6.60E+04	119.6	6.0
9	Freight	3.19E+11	J/yr	6.60E+04	21.1	1.1
10	Vehicles	1.60E+06	J/yr	6.70E+09	10.7	0.5
11	Government Services	8.05E+03	$/yr	1.99E+13	160.3	8.1
12	Services	9.11E+05	$/yr	1.99E+13	18,128.6	911.0

The emergy embodied in the tourists themselves was also an input into the system and was accounted for in line item six (280.0 E15 sej/yr). The emergy input from tourists was an order of magnitude larger than the input from the staff.

Line items seven through nine are goods that were imported and include food, fuel, and freight. These three items combined have a value of 1.0 E18 sej/yr and together were the third largest input.

Table 3-8 summarizes the values from table 3-7, showing the relative contribution of each of the energy, materials, and service flows. Of the total inputs into the system, services and environmental inputs, each accounted for about half of all inputs, with services being slightly larger than the environmental input (51% and 47% respectively). Imported goods (not including their embodied services) and the emergy of tourists and staff members each accounted for about one percent of all inputs into the system.

Table 3-8: Summary of values from Table 3-7 and relative importance of different flows.

Summary Items	Emergy (sej/yr)	% of total inputs
Environmental Inputs (Item 1)	1.69E+04	47.1
Imported Goods (Sum of items 2,4,7,8,9,10)	1.09E+03	0.8
Human Emergy Inputs (Sum of items 3,5,6)	3.30E+02	0.9
Tourist Emergy (Item 6)	2.80E+02	0.8
Total Non-Environmental (Sum of items 2-12)	1.97E+04	53.9
Services (Items 11+12)	1.81E+04	49.6
Total Inputs	3.66E+04	100.0

Table 3-9 evaluates emergy flows after increasing the number of tourists by two, five, and ten times while keeping the environmental support area constant. The evaluation shows that increasing numbers of tourists led to a decrease in the value received by tourists.

Table 3-9: Emergy evaluation of lodge tourism with increasing number of tourists. The evaluation is based on the calculations in Table 3-7.

	10 tourists 1000 Em$	20 tourists 1000 Em$	50 tourists 1000 Em$	100 tourists 1000 Em$
Environmental Inputs	846.9	846.9	846.9	846.9
Lodge Infrastructure Material	0.6	1.2	2.9	5.9
Lodge Infrastructure Labor	1.2	2.3	5.8	11.6
Staff Rations	0.4	0.8	1.9	3.8
Staff - Emergy	1.4	2.7	6.8	13.6
Tourist - Emergy	14.1	28.1	70.3	140.7
Tourist Food	46.1	92.1	230.3	460.7
Fuels	6.0	12.0	30.1	60.1
Freight	1.1	2.1	5.3	10.6
Vehicles	0.5	1.1	2.7	5.4
Government Services	8.1	16.1	40.3	80.5
Services	911.0	1822.0	4554.9	9109.8
Total (per year) in 1,000 Em$	1837.1	2827.4	5798.2	10749.6
Total (per day) in Em$	5033.2	7746.3	15885.6	29450.9
Value per tourist per night in Em$:	503.3	387.3	317.7	294.5
Ratio Environmental/Purchased	0.9	0.4	0.2	0.1
Ratio Environmental/Total	0.5	0.3	0.1	0.1

The value received by a tourist per night at the lodge at current levels of tourism density was 503.3 Em$, which was significantly more than the 350 US$ paid by tourists. Doubling the number of tourists, while keeping the environmental support area constant, led to a decline of value received to 387.3 Em$. Increases in tourist numbers by five and ten times the current numbers lowered the total EmDollar value of the experience received by tourists to 317.7 Em$ and 294.5 Em$ respectively, both of which are below the price paid at current tourism levels (350 US$).

CHAPTER 4
DISCUSSION

Discussion of the Country Analysis

Characteristics of the Economy of Botswana

Botswana has a rich natural resource base, a strong economy, and balanced external trade. These features are often cited by development agencies as prerequisites for nations to become developed. But in spite of Botswana's strong economic performance, Tables 3-1 through 3-4 show that the country of Botswana displays several characteristics that are typical of developing countries. Such indicators include a net export of emergy, a high emergy/money ratio, and a large import of services. Perhaps the strongest indicator that Botswana is a developing country is that Botswana is a net exporter of emergy to the global economy. Generally standard of living is a consequence of the amount of emergy available per person (Odum and Odum 2001). Therefore the goal of economic transaction should be to maximize the amount of emergy available per person within the country. Clearly a net loss of emergy per person would reduce standard of living.

Botswana exports about 6.5 times the amount of emergy that is imported. Therefore, like most supposedly developing nations, Botswana subsidizes the higher living standard in developed nations perhaps to the detriment of living standards in Botswana. Although trade was nearly balanced in monetary terms, which would be considered a positive sign in terms of economic development, the emergy analysis revealed that the pattern of Botswana's resource flows does not facilitate sustained economic growth and prosperity because more resources are exported than imported.

Economic growth is another indicator that is often considered as a prerequisite for economic development of a nation. Between the late 1960s and the early 1990's Botswana has experienced strong and sustained economic growth and prosperity, outperforming other developing countries as well as developed nations (EIU 1997).But in spite of this strong indicator of economic development, the emergy/money ratio in Botswana is very high, which indicates limited economic power. A country with a high emergy/money ratio is at a disadvantage in the global economy, because developed nations can purchase resources cheaply in nations with a high emergy/money ratio and the monetary revenue generated in this way will buy a smaller amount of resource in the global economy, because of the higher emergy/money ratio of the global economy. This leads to an imbalance in the emergy trade balance, as discussed in the previous paragraph.

A high emergy/money ratio is not detrimental to a national economy, as long as the country trades with partners that have a similar or higher emergy/money ratio, or does not engage in external trade at all. Trade in the global economy will be detrimental to economic development of nations with a high emergy/money ratio because they will sell out their natural resources and decrease the amount of emergy available within the country. Having larger amounts of emergy available within the country has the potential of increasing prosperity and well-being of the population in the long run.

Services were the largest import into the country (Table 3-1, line item 27). This is important, because many developing countries rely on the import of finished products which cost a lot of money, whereas importing raw materials would allow for generating added value in the country, thereby increasing economic prosperity. However, the processing of raw materials in most cases requires infrastructure that is not available in many developing countries.

The limited ability to add value to raw resources is one of the main reasons for limited long term economic success of developing nations, because by exporting raw resources which have a relatively lower price and importing finished products which have a higher price, the extraction rates of raw resources have to be increased constantly to make up for the gradient in quality (as indicated by transformity) by increasing the quantity of the lower quality product. In the long run such an economy will drain the resource base.

Tourism Aspects of Resource Flows in Botswana

Tourism appears in the country analysis in two different ways, first by the import of emergy in the form of the tourists that spend time in Botswana (Table 3-1, line item 28), and second by the export of emergy, as measured by the amount of money spent, and thus resources consumed by tourists (Table 3-1, line item 35).While the import of tourism emergy seems to have a larger effect on the organization and patterns of resource flows in a country, the export of emergy seems to be more relevant in terms of how much of a drain on local resources it represents.

The emergy signature of a country or region, defined as the relative contribution by the various emergy flows (local renewable resources, purchased inputs, human service, etc.), defines the pattern of resource flows. Significant changes in the emergy signature of a country or region will have profound effects on social and economic organization. In developing countries with small resource flows, the presence of tourists, who have a high transformity and carry with them a large amount of information, can dominate all other flows and therefore significantly change the emergy signature of that country. In

Botswana, tourism emergy was the second largest of all imported outside emergy sources.

Although the tourism flows were significant compared to imports and export, they were one order of magnitude smaller than the environmental inputs. Brown and Ulgiati (2001) suggest that the intensity of an economic development in a developing region should not be much greater than the intensity of the surrounding region, in order to be more easily integrated into the existing patterns and structure of the region. Although the intensity of tourism is significant at the country level, it does not dominate the system. The emergy signature of Botswana is not changed a lot by the inflow of tourist emergy and therefore it seems that the level of tourism development is appropriate for the country at this scale of analysis and will not change the patterns of resource flows in the country much.

The export of emergy in line item 35 (36.4 E20 sej/yr) is the amount of resource that tourists use during their stay in Botswana and was measured in terms of the amount of money spent by tourists multiplied by the countries emergy/money ratio. This flow contains the goods and services that were consumed by tourists during their stay and also includes those natural resources that the tourists enjoy during their stay. The tourists pay money to experience certain aspects of Botswana, such as wildlife, remoteness, and unspoiled wilderness. Although these things do not leave the country, as would be the case with regular exports, by making certain areas exclusively available for tourists, these areas are not available for other uses by local people and therefore the tourist use of these areas is counted as a cost to the country. The use of natural areas by tourists represents an opportunity cost to local people because their ability to use those areas is reduced. At the same time, experiencing wilderness is a benefit to the tourists. Because of the largely non-extractive nature of tourism operations, their impact on the availability of resources is often underestimated. The emergy analysis showed that at the country level, the export of resources in tourism is the second largest export.

At the level of the country of Botswana, the export of emergy through tourism is the second largest of all exports but is one order of magnitude smaller than environmental inputs. Similar to the import of tourism emergy, the export of emergy is significant but does not change the emergy signature of the country in a major way. Although the export of emergy does not seem to have a large impact at the national scale, the impact can be very significant at the local scale. The opportunity cost to the local population of devoting large areas to the exclusive use by foreigners can be significant, because traditional lifestyles can get lost and disruption of social organization can occur.

Discussion of the Mababe/CBNRM Analysis

Changes in the pattern of resource flows in Mababe

The establishment of hunting camps and CBNRM has had a significant impact the emergy signature of the village of Mababe and therefore on the pattern of emergy flows within the village. Before tourism and CBNRM got established, the village had little contact with the monetary economy and few flows other than local renewable resources crossed the systems boundary of the village. In times of drought the government sent some assistance but other than said assistance, few purchased inputs entered the village and NG 41. Before tourism based CBNRM was established in NG 41 the village of Mababe was mainly driven by environmental inputs, as calculated in Table 3-6 (3.8 E18 sej/yr).

The establishment of CBNRM and the hunting camps has added resource flows to the village system, most importantly the tourist emergy that enters the village (2.3 E18 sej/y), money (3.8 E18 sej/yr). As an effect of these new flows, the total emergy input into the village has more than doubled, which is a significant change in the emergy signature of this system. To use these newly available resources efficiently, new patterns of resource flow have to develop. If these patterns can not develop within a reasonable timeframe, the demise of the original system can be the result. An example would be local communities that get destroyed by excessive alcohol and drug consumption when large amounts of money become available in an area that previously had only small emergy flows (mining operations in remote location, intensive tourism in close vicinity to indigenous communities, etc).

Development strategies like CBNRM often aim at increasing the benefit, defined as access to resources, to local populations. However, with the background outline above, it appears that the simple increase of emergy flows into a local system is not a good measure for the success of a development strategy. Measuring the amount of emergy on feedback loops within the system might be a better way of assessing the success of development strategies, because it would give an indication of how well new patterns of resource flows have been developed to make efficient use of newly available resources.

A large percentage of the younger and able bodied villagers participate in tourism activities and are not available to participate in village processes. The emergy value of villagers leaving to work at the hunting camps was 2.4 E18 sej/yr, as calculated in Table 3-6. The amount of emergy that leaves the village on this pathway is more than 60% of the value of environmental emergy input, which indicates, that the villagers work at the camps represents a significant drain of village resources. Compared to the increase in emergy flows as a result of CBNRM and the hunting camps, this export of emergy might not seem very important. However, functionally it could be very important. As outlined above, for the efficient use newly available resources, new patterns of resource utilization have to develop within the village.

Young, strong villagers, that have been exposed to the tourists might be most able to facilitate the process of developing those new patterns, but it is exactly those villagers that spent a lot of their time outside the village working and the hunting camp and not contributing the village processes. The absence of young and more exposed villagers might be detrimental to the village's adaptation to the new resource flows. Perhaps the development of much needed feedback loops to use newly available resources is severely impeded by the exodus of young people.

Emergy Trade Balance between the Villagers and the Hunting Camps

The resource use rights that the villagers have sold represent the emergy value of the entire NG 41 (105.8 E18 sej/yr) which was about 30 times the Em$ value of the payments received by the villagers (3.8 E18 sey/yr), as calculated in Tables 3-5 and 3-6 respectively. In emergy terms, the villagers received less than what they gave up, but at the same time, the resource they sold was highly dispersed whereas the money received for the resource was used to purchase goods and services that represent more concentrated energy and thus have a higher transformity. The difference can be seen when comparing the empower density of the village before and after the implementation of tourism based CBNRM. Before the establishment of CBNRM and hunting camps in NG41, the village relied to nearly 100% on natural resources and therefore the empower density was 4.8 E10 sej/yr/ m^2 (environmental inputs, 105.8 E18 sej/yr, divided by the area of NG 41, 2.2 E9 m^2). When adding the emergy flows entering the village as a result of CBNRM, the empower density of the village increases to 1.3 E11 sej/yr/m^2 (sum of inputs from Table 3-6, 6.2 E18 sej/yr, divided by the support area of the village, 7.8 E7 m^2). The increase in empower density suggests that the amount of emergy available in the village area has increased by about 2.5 times. This can be interpreted as an increased potential benefit to the local population. Although the villagers trade a larger amount of emergy (the resource use rights they sell to the safari operator) against a smaller amount of emergy (the money the villagers receive), the CBNRM process seems to generate benefit to the village community, because the amount of resource available within the village is increased. The goods and services that villagers can purchase with the money earned through CBNRM have a higher transformity than the natural resources that were sold. The higher transformity indicates more concentrated resources which potentially have a higher utilitarian value to the villagers.

Discussion of the Safari Lodge Analysis

Natures Contribution to Lodge Tourism – Defining Ecotourism

Lodge safaris in the Okavango Delta in the early part of the 21st century are marketed as high end, exclusive nature tourism. The remoteness and pristine nature of the ecosystem are the reason why people want to visit the delta and are willing to pay high prices. Table 3-8 shows that local renewable resources in the support area of the lodge account for 47 % of the total inputs to the tourism lodge. A study by Brown and Ulgiati (2001) found the local environmental component of a tourism lodge in Papua New Guinea to be an order of magnitude smaller than the purchased inputs and two orders of magnitude smaller for a four-star hotel in Mexico.

The ratio between local renewable inputs and total inputs (including purchased ones) might be used to suggest levels of purchased inputs beyond which the tourism enterprise is no longer nature tourism. For comparative purposes we might assume a cutoff value of 50% to achieve matching between natural and imported emergy. Any less that would mean more emergy is spent by the tourist than the tourist gains from the experience. For the lodge evaluated in this study, this would mean that increasing the number of tourists beyond current levels, while keeping the support area constant, would increase the percentage of purchased inputs such that they would outweigh the contribution from the environment.

When the purchased inputs get very large in comparison to the local environmental resource flows, the emergy signature of the local system changes, which most likely would have an affect on the local environment, for example by the impact of increasing waste products, noise, and crowding. It could be assumed that if a tourism development reaches a magnitude where it changes the emergy signature of a region, it starts altering the natural patterns of resource flows, and might alter ecosystem structure in a way that makes it no longer desirable for tourism. Such alterations include noxious algal blooms, eutrophication of animal habitat, loss of large animals through migration and lowered production, and habituation of remaining wildlife.

An eco-tourism operation depends on a large contribution of local environmental resources. A large contribution of purchased inputs, however, might be seen as indicative of conventional luxury tourism. On the other hand, eco-tourism that receives 80% of its emergy inputs from the natural environment will most likely not provide many amenities to the tourist. While this type of tourism is popular amongst adventure tourists, it undervalues the ecotourism and so does not generate as much revenue as it could. It seems that tourism in Botswana is successful because by maximizing purchased inputs as well as nature's inputs, a balance was found where possibly the highest revenue can be generated.

Tourism Density and the Quality of the Tourism Experience

The total Em$ value of the tourist experience decreased with increasing numbers of tourists and fell below the price that tourists pay at current tourist densities. The cost of one night at the evaluated lodge was 350 US$ and the value received per tourist at densities characteristic of the early part of the 21st century was 503 Em$. Were tourist number to be quintupled while the area used remains constant, the total value received by tourists would fall to 318 Em$, below the price actually paid (350 US$). This drop in value is a result of the natural resource being shared by more tourists. While the input of purchased goods and services per tourist can be kept constant, the contribution of the local environment to each tourists experience will decrease. The Okavango Delta is attractive to tourists because of its remoteness and the exclusiveness of the tourism experience, which results from low tourist numbers. The perceived smaller value of a tourism experience in a less exclusive area with larger numbers of tourists is reflected in the smaller emergy values of the tourism experience for larger numbers of tourists.

To avoid significant drops in the Em$ value received by tourists, the purchased component could be increased to compensate for the loss in environmental input. However, this would mean a turn away from eco-tourism towards conventional tourism. A significant increase in purchased resources relative to local environmental inputs will have an impact on the nature and structure of the ecosystem because the emergy signature of the system would be changed.

Alternatively, the area used for tourism in the Okavango Delta could be increased but there is a limit to the area available in the Okavango Delta and the needs of tourism and local people for space need to be balanced. Three questions appear to be vital in determining the appropriate tourism density for the Okavango Delta:

- How large a portion of the Okavango Delta should be devoted to tourism and what portion should be reserved for use by local people?
- How far apart do lodges need to be spaced for tourists to feel they are having an exclusive wilderness experience?
- At what level of tourism density do the tourism induced changes in the emergy signature of the ecosystem lead to changes that make the ecosystem seem less pristine?

Conclusions

The following conclusions may be drawn from this study.

- Although several economic indicators seem to show that Botswana is on a strong trajectory towards becoming a developed country, the emergy analysis shows that Botswana behaves very much like a developing country in the global economy and has several characteristics that impede economic development, as is the case for most so called developing nations.

- Tourism is an important aspect of the economy of Botswana. In imports as well as exports, tourism related flows are the second largest after services. However, the tourism flows are one order of magnitude smaller than the environmental flows. Although tourism is important to the national system, it does not dominate the resource flows at that scale.

- CBNRM in NG 41has changed the resource flows in the region and especially in the village of Mababe. The village economy used to rely to nearly 100% on local environmental resources pre-CBNRM. After the establishment of CBNRM the environmental component was reduced to about 30% of all inputs. This is a major change in the emergy signature of the village of Mababe, and requires dramatic changes in the pattern of resource flows within the system.

- While tourism in Botswana does not seem to have a significant impact on the emergy signature at the national scale, the impact on the local scale is very large.

- In the CBNRM process, the villagers sell natural resources for less than their actual emergy value. In spite of this, the empower density, indicative of the emergy available to the villagers, increases by 2.5 times as the result of CBNRM, because of the different quality of natural resources and purchased inputs.

- At current levels of tourism density, local natural resources constitute about 50% of inputs into the tourism experience at a safari lodge in the Okavango Delta. At this level of intensity, the emergy value received by tourists exceeds the price they pay. At a higher tourism density, the relative contribution of the environment decreases, as purchased inputs increase, and the emergy value received by tourists falls below the price they pay. It is suggested when purchased inputs are larger than the local environmental inputs a tourist enterprise should not be labeled as nature tourism anymore.

APPENDIX A
TRANSFORMITIES CALCULATED FOR THIS STUDY

Transformity for Wildlife in Botswana

The transformity of wildlife had to be calculated because none was available. The transformity for wildlife in Botswana was calculated based on emergy of the support area and the amount of wildlife in that are. If the emergy of the support area is A sej/yr, and there are B Joules/yr of wildlife in the area (transforming mass of wildlife into Joules), then the transformity of wildlife in that area is A/B sej/J.

The emergy basis of the Okavango Delta was calculated in Table 3-5 and was 1.7 E19 sej/yr. Scudder et al (1993) estimates an average standing stock of wildlife in the Okavango Delta of 110 E6 kg. This number was transformed into energy assuming a water content of 80% and 5 cal/ g of dry weight. The emergy basis of the Okavango Delta was divided by the total energy of wildlife, as demonstrated in table A-1 below. The resulting transformity was 5.18 E6 sej/J.

Table A-1: Calculation of the transformity of wildlife in Botswana

Item	Value
Wildlife Standing Stock (kg)	110,000,000
Transforming mass to energy:	(kg)*(1E+03 g/kg)*(20%)*(5 Cal/g)*(4186 J/Cal)
Wildlife Energy (J/yr)	4.6E+14
Okavango Emergy (sej/yr)	2.4E+21
Calculating Transformity:	Okavango Emergy/ Wildlife Energy
Wildlife Transfomity (sej/J)	**5.18E+06**

Human Transformities for Botswana

Humans are an important input into tourism, both in the form of the tourist as well as the personnel working in the tourism industry. People from different societies use different amounts of energy. Therefore the transformity of different peoples can vary considerably, because they were the recipient of different amounts of emergy.

Transformities do not only vary between members of different nations, they also vary depending on the level of education of an individual. The energy cost of a university education is higher than a highschool education.

Odum (1996) calculated the transformities for Americans of different education levels. The transformities were calculated by dividing the total emergy of the United States per year by the energy value of all people in different categories of educational level. Humans were transformed into energy, based on their metabolic rate, using the following equation:

$$(2500 \text{ kcal/day})*(365 \text{ days/yr})*(4186\text{J/cal}) = 3.82 * 10^9 \text{ J/person/yr (Odum 1996)}$$

It was assumed that it takes the entire emergy used in a country to support each of the educational levels, as each level is built on the next. Therefore, the total emergy of a country was divided by the number of individuals in a category (e.g. all individuals with a college education). This calculation yields the Emergy/ individual in that category. To calculate a transformity, the emergy/individual was divided by the energy per person per yr, $3.82 * 10^9$ J/person/yr, as derived above.

The same methodology as described above was used to derive transformities for people in Botswana. The total annual emergy use of Botswana has been calculated in

Table 3-3 of this work and is 4.3E+22 sej/yr. The total population of Botswana was 1.6 million in 2000 (Statistical Office 2000). The numbers of people with different levels of education were calculated based on the current enrollment in different school levels and the percentage of people in the relevant age brackets that were enrolled in different school levels in 1990. This was done, to account for people in school right now and the educational level of the adult population. The illiteracy rate of 0.21 (CIA world factbook) was also taken into account. The total population was used to calculate a baseline transformity that does not account for education.

The results for the baseline calculation as well as for different educational levels are presented in table A-2 below.

Table A-2: Human transformities for Botswana

Categories	Number of Individuals (1,000)	Emergy per Individual (x 10^{16} sej/ind/yr)	Transformity (1,000,000 sej/J)
Total Population (Baseline)	1694	2.5	6.6
Primary school	531	8.1	21.2
Secondary school	355	12.1	31.8
University	23	184.4	482.7

APPENDIX B
COSTS PER BED PER NIGHT

The following table shows the itemized 2002 bed per night costs for a lodge in the Okavango Delta. The safari operator who provided this data wishes to remain anonymous. The costs are quoted in the local currency, Botswana Pula (BWP). The approximate exchange rate in 2002 was six BWP for one US$.

Table B-1: Itemized costs for one bed per night in a lodge in the Okavango Delta as reported by a safari operator

Item	BWP per bed per night
Salaries	52.57
Wages	99.47
Rations	20.58
Uniforms	1.84
Gas	8.47
Camp Maintenance	32.37
Camp Supplies	12.79
Depreciation	34.45
R&M Vehicles	14.49
Consumables	3.70
Area Rental	78.31
Sales Tax	6.23
Freight	36.99
Liqour	35.97
Perishables	51.55
Non-Perishables	34.40
Fuel	29.77
Medivac	5.36
Resource Rental	29.80
Agents Discount	51.20
Park Fees	24.27
Total:	664.60

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