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Soda Ash Mining in Lake Natron: A Reap or Ruin for Tanzania?

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Abstract - The XI/22 decisions of the Convention on Biological Diversity (CBD) at its eleventh Conference of Parties invite parties to integrate the three objectives of the CBD into sustainable development and poverty eradication programs, plans, policies, and priority actions, taking into account the outcomes of the Rio+20 Conference. Based on this ground a Cost Benefit Analysis (CBA) of a proposed new development (establishment of soda ash facility) in the Lake Natron area in Tanzania was carried out to inform decision regarding the proposal. The costs and benefits of this project were compared with that of two other alternatives namely the "Business as Usual" (BAU) and "Sustainable Ecotourism" (SE). The results of analysis showed that at the present levels of soda ash prices and investment costs the benefits of ecosystem conservation outweigh the benefits of soda ash mining. We furthermore argue that Lake Natron is part of an important network of ecosystems and should not be viewed as a separate entity altogether. The Lake's ecosystem needs to be managed wisely by introducing only livelihood initiatives or developments that are linked to the survival of wildlife which it supports, including the lesser flamingo. Sustainable ecotourism is one of such initiatives. Its benefits spill over beyond the local and national boundaries to beneficiaries at regional and international levels. We therefore underscore the needs for different stakeholders to share the costs of developing a sustainable eco-tourism industry in the Lake Natron ecosystem. This can be achieved through negotiations with regional and global partners for more resources.

Keywords - Soda Ash Mining, Economic Development, Biodiversity Conservation, Lake Natron Area, Cost Benefit Analysis

1. Introduction

The depletion of biodiversity is now one of the most important environmental threats that humanity faces (Ostrom, 2012; MEA, 2005; Chapin et al., 2000; Tilman, 2000). It is estimated that between 150 and 200 species go extinct every 24 hours (United Nation Environment Programme, undated). This problem is particularly important especially for less developed regions in the world where the poorest and most vulnerable to biodiversity loss live and where the threats to biodiversity are the highest (Du castel, 2007). The Sub-Saharan Africa (SSA) region is listed a good example of these regions (Amin & Choumert, 2013). It ranks first in terms of highest and relatively steady poverty rate since 1981 according to the World Bank reports (Haughton & Khander, 2009). At the same time, the region is also renowned as a home to almost one-quarter of the "biodiversity hotspots", i.e. areas around the world where exceptional concentrations of endemic species are undergoing exceptional loss of habitat (Myers et al., 2000; Amin & Choumert, 2013). Recognizing this and the challenges born from the context of economic development in poor countries a better understanding of the trade-offs between economic development and biodiversity loss is therefore critical (Amin & Choumert, 2013; Ostrom, 2012). This is in line with the XI/22 decisions of the Convention on Biological Diversity (CBD) at its eleventh Conference of Parties which invites parties to integrate the three objectives of the CBD into sustainable development and poverty eradication programs, plans, policies, and priority actions, taking into account the outcomes of the Rio+20 Conference (UNEP, 2012). In the same vein, Target 2 of strategic goal A of the Aichi Biodiversity Target also recommends that by 2020, at least, biodiversity values should be integrated into national and local development and poverty reduction strategies and planning processes and incorporated into national accounting, as appropriate, and reporting systems (UNEP, 2010). We accentuate the argument that biodiversity conservation is important, and especially so in developing countries. It is therefore apparent that the tradeoffs between any new development to meet economic development and poverty reduction and wildlife conservation must be evaluated to ensure that the new development is not indestructibly compromising biodiversity (Amin & Choumert, 2013).

Important in this regard is the question of whether economic development worsens or strengthens biodiversity

conservation. This is extensively debated in the literature with a number of scholars sharing a pessimistic view and forecasting a conflict between economic growth and biodiversity conservation (Czech, 2003; Trauger et al., 2003; Chambers et al., 2000 just to mention few). They suggest that increased growth of the economy implies higher threats to biodiversity (Freytag et al., 2009; Asafu-Adjaye, 2003). On the other hand, a counter view exists which more optimistically rejects this generalization arguing that the relationship between economic growth and biodiversity conservation varies along the development path. The latter school of thought predicts a "virtuous circle" after a threshold of development is reached, thus implying an environmental Kuznets curve for biodiversity (Mills & Waite, 2009; Pandit & Laband, 2007; McPherson & Nieswiadomy, 2005; Naidoo & Adamowicz, 2001). The logic is that when enough financial wealth accumulates, especially in per capita terms, society refocuses on solving environmental problems (Czech, 2008). Apparently it is important that new developments, especially in ecologically sensitive areas are thoroughly evaluated prior to implementation. The best way of doing this is to undertake a Cost Benefit Analysis (CBA) to inform decision makers whether the benefits from the developments outweigh the costs of implementing them or not.

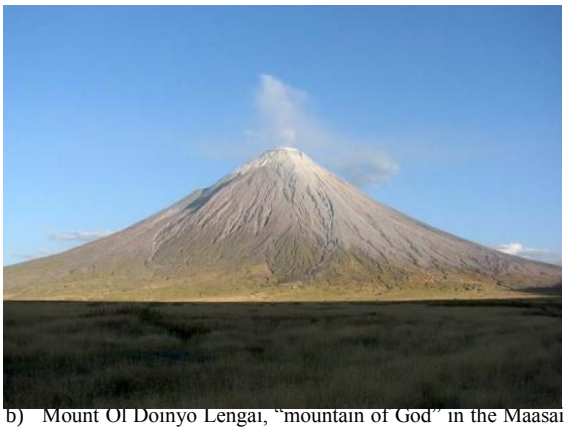
In this paper we investigate and provide a sound analysis of the costs and benefits resulting from a proposed soda ash project in Lake Natron area in Tanzania. The paper benefits from a study which was conducted in Lake Natron area between September 2011 and May 2012. The need for the study emanated from emerging new development plans in the study area. Some of these developments have raised concerns from different stakeholders, including conservation agencies and local communities, especially regarding their likelihood of causing damages and threats to the integrity of the Lake Natron's ecosystem. Of interest is the 2006 proposal to construct a soda ash processing facility on the Eastern part of the Lake which is planned to process 500,000 metric tonnes of soda annually and later upgrade to 1 million tonnes per year. This proposal was initially put forward by Tata Chemicals Ltd in collaboration with the National Development Corporation of Tanzania (NDC). However, in May 2008 Tata announced its withdrawal from the project. The project plan however, seemed to remain live since then. For example, in April 2011 the President of Tanzania ordered the project to be fast tracked though in October 2011, the Director of Environment in the Vice-President's office suggested that the government position for the Lake Natron site is to maintain ecological system so that flamingos continue to breed for the benefit of current and future generations. Working in association with the National Development Corporation (NDC), the Minister for Industry and Trade has of recent, reported to have concluded a scientific study to prevent environmental degradation in Lake Natron due to mining of soda ash. Presenting his Ministry's budget estimates for Financial Year 2012/13 before the National Assembly, the Minister said that a study which focused on chemical, ecological, hydrological dynamics has been completed noting further that the implementation of the project would largely be subject to infrastructural development like revamping of the Tanga-Arusha railway line, expansion of the Tanga port and construction of a railway line from Arusha to Lake Natron. At the same time Tata denies to be involved in the current plans of the project.

The soda ash mining proposal has generally met stiff opposition from conservation agencies and local communities who cite the uniqueness of Lake Natron as a tourism attraction (Figure 1), a source of livelihoods and the only regular breeding site for Lesser Flamingo (*Phoenicopterus minor*) in Eastern Africa (The East African, 2013; Daily News, 2012; Friends of Serengeti, 2012; RAM Team, 2008; Hughes, 2008). The lake is designated as a Ramsar Site and is an important bird area (see the satellite images of the lake in Figure 2).[1] Responding to these oppositions the National Environment Management Council (NEMC) in Tanzania demanded that an Environmental and Social Impact Assessment (ESIA) be carried out and a report be produced and discussed by the stakeholders. This report was produced (see NORCONSULT, 2007) and discussed at a public meeting held in Dar in February 2008 and the soda ash project was widely rejected by the public.

One of the contentious issues in the ESIA report was the costs and benefits related to soda ash mining in comparison to the option of promoting tourism and sustainable utilization of Lake Natron's resources. The report suggested economic benefits of "several million dollars" but it remained silent on the magnitude of costs and benefits that are associated with the establishment of the soda ash facility. The stakeholders therefore expressed the need for a Cost Benefit Analysis. In this regard, the Lake Natron CBA study was commissioned, a study which has adopted the Total Economic Value (TEV) concept where goods and services that are not tradable in the market and yet have a value were taken into account.

[1] The images simulate natural colour, showing where the salt-loving microorganisms have coloured the lake's salt crust red or pink. The salt crust changes over time, giving the lake a slightly different appearance each time is photographed by astronauts or imaged by satellites. This forbidding environment enables Lake Natron to serve millions of flamingos as the ideal nursery; would-be predators avoid the saline lake and leave young birds in peace.

a) Lesser flamingo (*Phoenicopterus minor*) a near threatened species breeding principally on the highly caustic Lake Natron. Its other African breeding sites are at Etosha Pan, Sua Pan, and Kamfers Dam



b) Mount Ol Doinyo Lengai, "mountain of God" in the Maasai language, is an active volcano located in the Gregory Rift, south of Lake Natron (Elevation: 3,188m)

Figure 1. Lesser flamingo and Mount Ol Donyo Lengai are only two of many tourist attractions in Lake Natron ecosystem

a) Satellite image captured on March 8, 2003

b) Satellite image captured on July 6, 2003

Sources: a) NASA image courtesy NASA/CSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team;
b) http://eoimages.gsfc.nasa.gov/images/imagerecords/5000/5465/natron_ast_2003067_lrg.jpg

Figure 2. Satellite images of Lake Natron area

2. Research Approach and Methodology

2.1. Data Collection

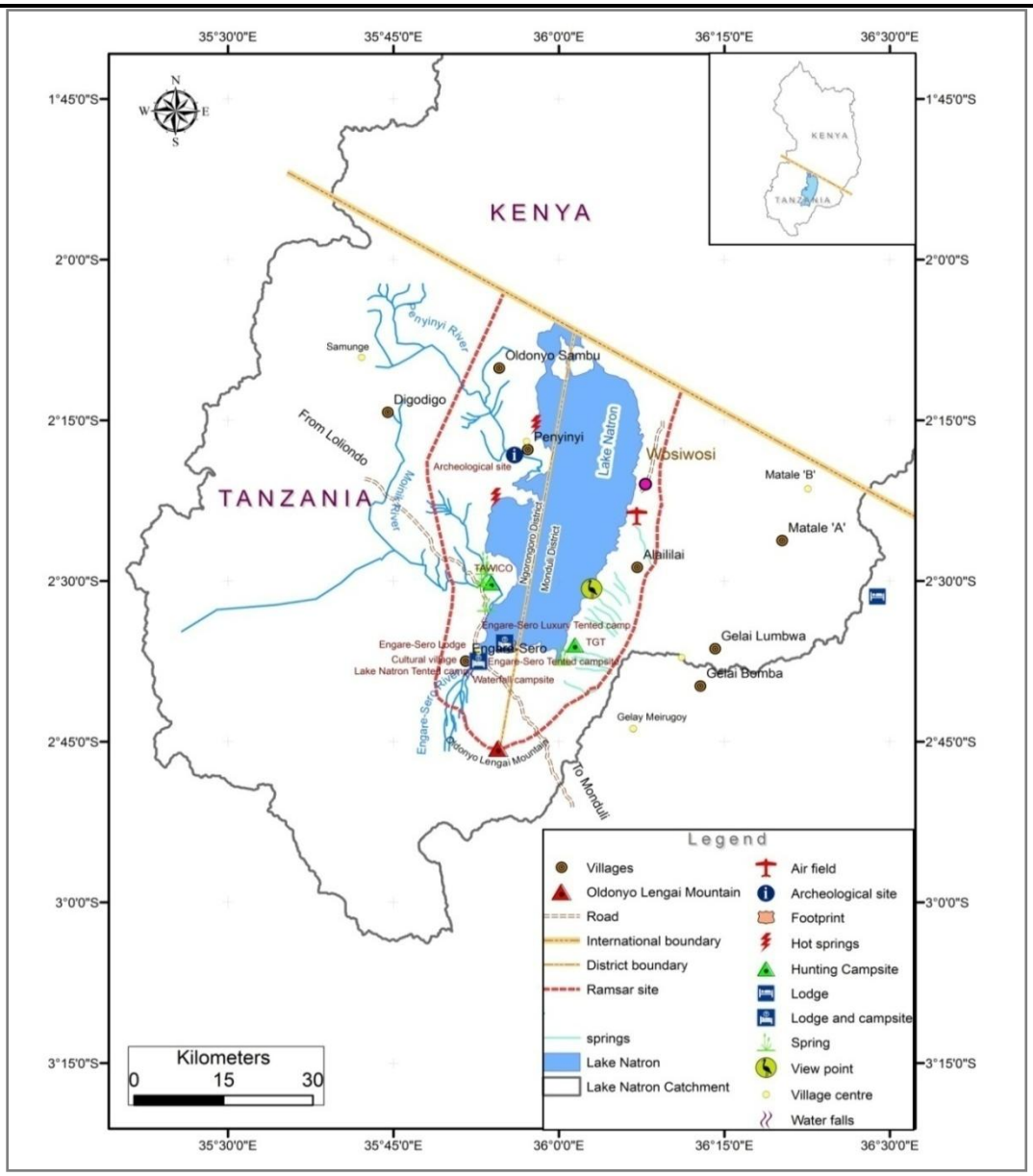
The study benefited enormously from stakeholder consultations, deskwork review of literature, Focus Group Discussions (FGDs) and questionnaire surveys. The stakeholder consultations were meant to determine interest, conflict lines, and the effects of various development and management options on the various groups affected by those options. Different stakeholders were consulted both in Tanzania and outside Tanzania. Outside the country, the consultations were extended to stakeholders based in Kenya, including the Magadi Soda Company in Kenya, currently called Tata Chemicals Magadi Limited. In addition, consultations were also made with stakeholders outside Africa through teleconferencing, for example, with partners and representatives of the BirdLife International, Royal Society of Protection of Birds (BirdLife Partner) in UK, and with the Lake Natron Consultative Group.

Consultation and stakeholders' analysis beyond the boundaries of Tanzania was conducted based on the understanding that the imperilment of biodiversity in the country may affect biodiversity in adjacent countries. This is inline with findings of a spatial analysis of development and biodiversity conservation in SSA by Amin and Choumert (2013) who show that exogenous shocks in neighboring countries

may cause changes in the percentage of threatened birds in a country. In the study area the FGDs, formal questionnaire interviews were conducted in eight villages surrounding Lake Natron as shown in Table 1 and Figure 3.

Table 1. Sample villages for the household survey in Lake Natron

Village	Ward	District	Number	%
Engare-Sero	Pinyinyi	Ngorongoro	18	20.9
Pinyinyi	Pinyinyi	Ngorongoro	14	16.3
Oldonyo-Sambu	Oldonyo Sambu	Ngorongoro	14	16.3
Digodigo	Digodigo	Ngorongoro	12	14.0
Gelai-Bomba	Gelai Merugoi	Longido	6	7.0
Gelai Lumbwa	Gelai Lumbwa	Longido	6	7.0
Aleililai	Gelai Lumbwa	Longido	8	9.3
Matale A	Matale	Longido	8	9.3
TOTAL			**86**	**100**



Data source: Tanzania Natural Resources Information Centre (TANRIC) and Field Data; Coordinate System: Geographic, WGS1984

Figure 3. Map of Lake Natron area showing the study villages and key tourist attractions

In total, 86 households were interviewed (with 97.7% practicing pastoralism and agropastoralism as their major occupation). About 81% were male headed households and the remainder (19%) were female headed. About 40% of the head of households had no formal education and about 48% had education level of standard four and seven. The study population in this case included human populations in the wards surrounding the lake Natron.

2.2. Analysis of project alternatives

Three project alternatives were compared: the soda ash production; business as usual (BAU), and sustainable eco-tourism alternatives. The stream of costs and benefits used in the analysis of BAU and sustainable eco-tourism options covered crop production, pastoralism and other sectors which involve direct uses of natural resources, including tourism at the local and national levels as well as camp site and tour-guide operations. Other benefits included those which are realized from non-tangible or indirect uses and non-use/intrinsic/existence of the Lake Natron ecosystem. Revenues from flamingo tourism at the regional level were analysed together with the costs and income earned by operators of lodges, hotels and camp sites. The benefits of Lake Natron at the international level were evaluated using the Travel Cost Method which is based on a theory of consumer behaviour that suggests that people value an ecosystem because they value the characteristics of the ecosystem rather than the ecosystem itself. The method is widely used in valuing environmental resources associated with recreational activity. In this case the information on fees, distance or origin the visitors and total costs of visiting the Lake Natron area were used as a valuable input to the valuation exercise.

The soda ash alternative was furthermore sub-divided into eight investment and production options or scenarios as specified in Table 2. These scenarios were furthermore grouped into two types based on whether the investor was assumed to incur the costs of construction/rehabilitation of the road to plant and Tanga to Arusha railway or not. This was purposefully done to enrich the analysis of costs and benefits of the soda ash facility recognizing that there are more than one production options that the investor may wish to choose in the production process.

Table 2. Soda ash investment and production scenarios

Annual production of soda ash in metric tonnes	**Construction/Rehabilitation costs of the road to plant and Tanga to Arusha railway**	
	INCURRED	**NOT INCURRED**
500,000 constantly over 50 years	A	B
Increasing annually by 2% from 500,000 to a maximum of 1,000,000 in year 38	C	D
Increasing annually by 5% from 500,000 to a maximum of 1,000,000 in year 17	E	F
1,000,000 constantly over 50 years	G	H

2.2.1. Valuation of direct and indirect use and non-use values

The study employed the concept of the "Total Economic Value (TEV)" an individual may derive from the ecosystem. TEV is essentially the same concept as "net benefit", but it recognizes that the value derived from the quality of the ecosystem can be subdivided into two main categories: *use value* – the value an individual derives from directly using the resource; and *non-use value* – the value given to the existence of an ecological or environmental resource even though it is not currently used. The analysis of the direct monetary costs and benefits of the soda ash facility benefited from the information provided in the ESIA report (NORCONSULT, 2007) and other soda ash related reports and documents. Future costs and benefits were evaluated using discounted measures of project worth, specifically the CBA approach. The determination of costs and benefits considered not only the potential costs and revenue to the investor, but also that of the government and local communities based on current market prices.

The identification and valuation of direct and indirect use and non-use values of the Lake Natron ecosystem, including the non monetary and non-monetary benefits was done using the secondary data (from literature review) and primary information gathered from FGDs with representatives of community members in Lake Natron area as well as formal and informal interviews with other stakeholders, like tourists and operators of lodges, camp sites and tour companies.

The ESIA report (NORCOSULT, 2007) identified and ranked most of the likely administrative and planning impacts; changes to the physical/chemical environment; changes to the biological/ecological environment; social and cultural impacts; and economic impacts. However, the report does not provide quantitative data on many of the environmental or non monetary impacts. In our CBA study, we identified and assessed these impacts. In addition, an analysis of the trade-offs between ecosystem services/other non monetary values of Lake Natron basin and development of the proposed soda ash facility was done. To capture these values, a quick field survey was conducted using the Contingent Valuation Method (CVM) and Travel Cost Method (TCM) which is a standard approach currently available for the valuation of both use and non-use values and it is the most widely used method for estimating non-use values. The method is widely used as one of the only ways to assign monetary values to non-use

values of the environment—values that do not involve market purchases. In this study, CVM was purposefully adopted to evaluate non-use values.

Table 3. Comparison of the soda ash, business as usual, and sustainable eco-tourism scenarios

Alternatives	NPV (r = 10%, t = 50 yrs)
Soda ash – Scenario A	-492,142,797
Soda ash – Scenario B	-416,494,917
Soda ash – Scenario C	-281,571,086
Soda ash – Scenario D	-205,923,206
Soda ash – Scenario E	-44,186,282
Soda ash – Scenario F	42,384,728
Soda ash – Scenario G	454,891,663
Soda ash – Scenario H	530,539,543
Business as usual*	1,260,526,983
Business as usual**	1,505,351,816
Sustainable eco-tourism: low growth*	1,283,427,704
Sustainable eco-tourism: high growth*	1,317,426,340
Sustainable eco-tourism: low growth**	1,532,700,411
Sustainable eco-tourism: high growth**	1,573,370,857

*Component of indirect and non-use/intrinsic values estimated using the Contingent Valuation Method (CVM) but values of Willingness to Pay (WTP) were adopted

**Component of indirect and non-use/intrinsic values estimated using the Contingent Valuation Method (CVM) but values of Willingness to Accept Compensation (WTAC) were adopted

3. Results and Discussion

The results of comparative analysis of the NPVs in the eight investment and production options and the alternative options of BAU and sustainable eco-tourism are summarized in Table 3.[2]

3.1. Benefits of Proposed Soda Ash Mining Facility

3.1.1. Potential benefits to investor

The results of CBA for scenarios A to E (Figure 4) suggested that the costs of proposed soda ash mining were disproportionate to the benefits of implementing the project, at a *social discount rate* of 10% even when the investor was as assumed to be exempt from paying loyalty and VAT. This suggests that the soda ash mining project is not worth undertaking at the present level of soda ash market price of USD 270 per tonne and production level of 500,000 tonnes per annum. The project remained economically unjustifiable (not worth undertaking) even when the investor was as assumed to be exempt from incurring the costs of construction/rehabilitation of the road to plant and Tanga to Arusha railway.

Scenarios G and H of soda ash investment and production arrangements were worth undertaking but they essentially requiring that the project should operate at the highest production capacity of 1,000,000 metric tonnes per annum throughout the project life. Experience from other similar soda ash processing facilities in developing countries, including the Magadi Soda Company – a factory which has recently been acquired by Tata Chemicals Magadi Limited,[3] suggests that this level of production is both socio-economically and environmentally damaging and too hypothetical to be achieved at the present levels of demand, technology, prices and costs of production, especially for a newly established plant, like the proposed Lake Natron soda ash plant. Therefore, the feasibility for the plant to start with a full capacity of producing 1,000,000 tonnes per annum, right from the beginning or launch of the plant is unrealistic, as also implied in the project plan.

[2] The figures presented in Table 2 are NPVs of income less the associated costs of production.

[3] Mining of soda ash at Lake Magadi has taken place over 100 years. The social and environmental issues associated with the plant are different from that of Lake Natron, at least from the Lesser Flamingo breeding perspective. Lake Natron is the only regular breeding area for Lesser Flamingo in East Africa.

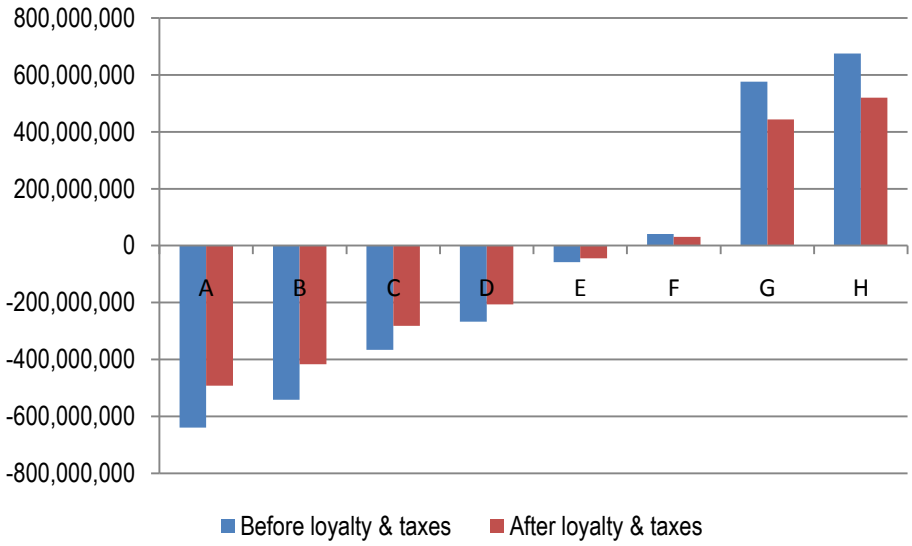


Figure 4. Potential revenue to the investor for different soda ash scenarios in USD, for r = 10% and t = 50 years (P = 270 per tonne)

When the analysis was repeated using an opportunistic export price of USD 412 per tonne of soda ash (i.e. 34.47% increase from the current price of USD 270), a price which was considered to yield positive NPVs for the soda ash project, the NPVs at discount rates equal to or less than the *social discount rate* of 10% (i.e. $r \leq 10\%$) were positive for all soda ash investment and production scenarios (Figure 5). This result was however considered as very intuitive and misleading assumption as it assumes that the export price can increase by about 34.5% when other factors that may influence the soda ash price at the world market are kept constant. The assumption that other factors, including technology and production costs remain constant is economically flawed and is less likely to happen as the increase in soda ash price will obviously trigger more suppliers of soda ash which will in turn flood the world market and push down the price of soda ash. It is also questionable whether this huge increase in soda ash price is likely to occur in the near future given the emergence of synthetic soda ash and stringent competition from China and other producers. In fact, the future for natural soda ash in the world market can be described as less gleaming.

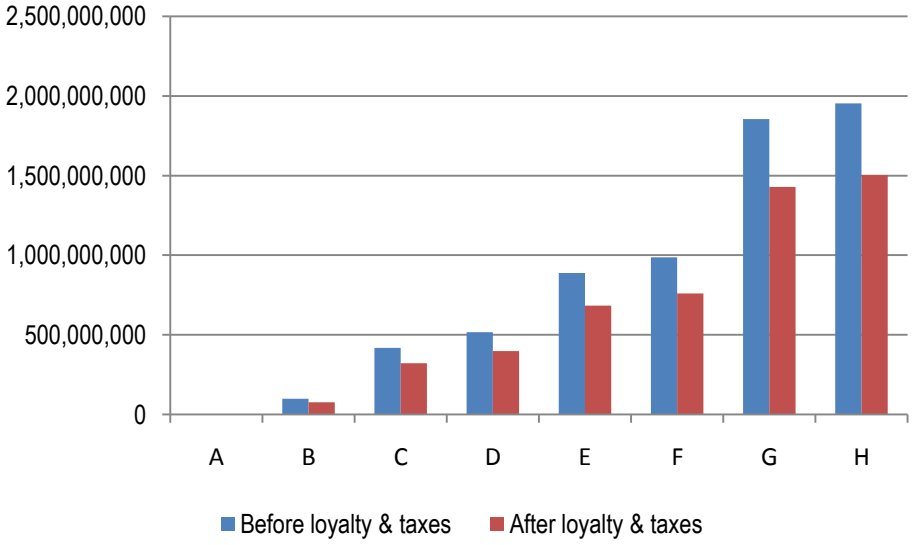


Figure 5. Potential revenue to the investor for different soda ash scenarios in USD, for r = 10% and t = 50 years (P = 412 per tonne)

3.1.2. Potential revenue to the Government

At a social discount rate of 10%, the positive revenue to the government will only be achieved when either of the soda ash scenarios F, G, and H area adopted. The benefits (NPVs) for the three scenarios were estimated to amount to USD 9.4

million; 13 million; and 155.2 million respectively. The highest NPVs of government revenue will therefore be realized if scenario H will be adopted. With the current export price of USD 270 per tonne soda ash, this scenario requires that the proposed soda ash project operates at a full production capacity of 1,000,000 metric tonnes per annum throughout the project life. An important question however, remains that of whether this scenario is realistic or feasible at the present levels of demand, technology, prices and costs of production, especially when a newly established plant is considered. This is important recognizing the stringent competition facing natural soda ash producers from synthetic soda ash producers in the global market.

3.1.3. Potential revenue to the local communities

Using experiences from similar soda ash projects in developing countries, the potential benefits to the local communities were identified to constitute mainly community development supports and provision of some social services like health facilities and water for domestic uses. The local communities can benefit from gross income of casual labouring during the construction phase. This was estimated as equal to 10% of fixed capital investment, equivalent to USD13 050 000. The net benefits from casual labouring during the construction phase of two years for staff sourced locally from villages within Lake Natron were estimated at USD 8 352 000.

In addition, the time spent by local communities to access health services, especially those living in the wards of Gelai Lumbwa and Gelai Meirugoi in Longindo District, will be cut by 50% after the improvement of road infrastructure and health services following the establishment of the soda ash facility. The total benefits from improved road infrastructure and health services at the local level were estimated at USD 44,262 per annum, equivalent to NPV of USD 483.1 thousand at a *social discount rate* of 10%.

3.2. Benefits in the Business As Usual (BAU) Alternative

The economic costs and impacts of soda ash mining were evaluated by comparing the potential benefits from soda ash mining versus those in the Business as Usual (BAU) and Sustainable eco-tourism scenarios. The NPVs or TEV of the Lake Natron ecosystem in the BAU scenario were estimated at about USD 1.50 billion and USD 1.26 billion when the indirect use and intrinsic values were valued using the WTAC and WTP approach respectively, at a *social discount rate* of 10%, t = 50 years.

In general, the results of analysis in this study indicate that the soda ash plant would deliver far worse returns for local people. There will be losses of benefits from different uses. When the WTP values were used in the valuation of indirect use and intrinsic values, the losses of benefit at local, national, regional and international levels due to construction of soda ash plant in Lake Natron were estimated to amount to NPVs of about USD 49.8 million or USD 101.7 million for the "low impact" and "high impact" scenarios respectively, at a *social discount rate* of 10%, t = 50 years. Alternatively, when the WTAC values were used in the valuation of indirect use and intrinsic values, the losses of benefit were estimated at NPVs of about USD 60.9 million or USD 124.0 million for the "low impact" and "high impact" scenarios respectively.

3.3. Benefits in the Sustainable Eco-tourism Alternative

In the sustainable eco-tourism alternative, the NPVs were estimated to amount to approximately USD 1.28 billion and USD 1.32 billion for the low and high impact scenarios, when WTP values were used in the valuation of indirect use and intrinsic values at a *social discount rate* of 10%, t = 50 years. When the WTAC values were used, the NPVs for the sustainable eco-tourism scenario were estimated at about USD 1.53 billion and USD 1.57 billion for the "low" and "high" impact scenarios respectively.

4. Conclusion and Recommendations

At the present levels of soda ash prices and investment costs the benefits of ecosystem conservation outweigh the benefits of soda ash mining. The results of quantitative analysis in this study were also supported by the qualitative information gathered during consultations with stakeholders in Longido, Ngorongoro, and Monduli Districts and other stakeholders consulted in Arusha region. About 84% of 175 stakeholders who were consulted opposed the development of soda ash facility; 10% supported; and 6% were neutral. This finding is particularly important as it clearly illustrates the perspective of the local communities who can best be viewed as "stakeholder number one." Importantly also, are the potential environmental costs or damages which relate to loss of biodiversity and deterioration of rural livelihoods in Lake Natron area. Lake Natron is an important, but a very fragile ecosystem requiring careful management. This not withholding, Tanzania has an obligation for ensuring wise-use of Ramsar sites which provides legal underpinning for sustainable management of the Lake Natron Ramsar site. It is also worth recalling the recommendations which were put forward by the Ramsar Advisory Mission in 2008. The Mission recommended the Tanzania government to suspend the decision-making process on the current ESIA as it does not deal with the full scope of the project's impact. Furthermore, the Mission recommended that the government should consider completing the development of the Tanzanian Wetland Strategy and other policy frameworks before taking any decisions on the soda ash project.

Lake Natron is part of an important network of ecosystems and should not be viewed as a separate entity altogether. The major driver for the proposal to develop a soda ash facility in Lake Natron area was "money" or nicely labelled as "economic development." But, money cannot buy everything: when the flamingo ceases to breed and exist in Lake Natron, there will be no replacement for the species. This suggests a precautionary principle to be adopted in making the final decision regarding the use of the Lake Natron ecosystem. This

requires that the Lake Natron ecosystem is managed wisely by introducing only livelihood initiatives that are linked to the survival of wildlife which it supports, including the lesser flamingo. Sustainable ecotourism is one of such initiatives. It does not dilute, but it adds value to conservation efforts and maintenance of sustainable livelihoods. Its benefits spill over beyond the local and national boundaries to beneficiaries at regional and international levels. To realise potential benefits the costs of developing a sustainable eco-tourism industry in Lake Natron should be shared by different stakeholders through negotiations with regional and global partners for more resources.

Based on the findings and conclusions of this study, the following key recommendations are drawn:

a) Lake Natron is very important for Tanzanians, especially the local communities in the area. It is also important for the countries at regional scale as well as the global community as a whole. There are therefore both trans-boundary and global issues that need to be considered before reaching at the decision to alter the current uses of Lake Natron ecosystem. It is important that the government, through its appropriate machinery undertakes adequate stakeholder consultations prior to making decisions to implement projects which threaten the integrity of the Lake Natron ecosystem. Stakeholders at all levels need to be not only consulted but effectively consulted. This is also in line with the East African Community Trans-boundary Ecosystem Bill 2010 which was passed on 31 January 2012 during the East African Legislative Assembly (EALA)'s Third meeting of the Fifth session in Kampala, Uganda. The new regional framework is set to benefit trans-boundary ecosystems like Lake Natron and Serengeti National Park which, in the recent past, have drawn global attention as a result of proposed large scale development project. It aims to enhance the quality of the environment and ensuring sustainable utilisation of shared natural resources in the five-nation East African Community (EAC) namely, Tanzania, Kenya, Uganda, Rwanda and Burundi;

b) Adequate support from the government and global partners is needed to develop a sustainable ecotourism industry in Lake Natron, increase the contribution of local communities to locally managed ecotourism and maintain potential ecotourism attractions, such as the lake itself and its lesser flamingos, water springs, cultural sites and mountain Ol Doinyo Lengai, just to mention few; and

c) Capacity building and awareness campaigns are key to the successful management of the Lake Natron resources. Starting from the grassroots to the national, regional and international levels, these campaigns should also reflect on issues and capacity to implement regional and international policies and conventions, like the AEWA Action Plan, Ramsar Convention and Protocols.

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Supplementary Tables

Supplementary Table 1: Summary of NPVs of benefits to the investor for the soda ash scenario (net values discounted using different discount rates, P = USD 270/ton and t = 50 years) (USD)

a: Before VAT and Loyalty						
Soda ash scenarios	**Discount rates**					
	0.50%	**1%**	**10%**	**12%**	**15%**	**20%**
A	-2,214,805,422	-1,987,070,381	-639,146,490	-565,130,490	-489,495,295	-412,853,347
B	-2,097,460,422	-1,872,028,881	-540,902,490	-468,387,990	-394,593,795	-320,386,347
C	1,089,167,343	812,617,760	-365,676,735	-375,749,978	-371,755,792	-350,625,099
D	1,206,512,343	927,659,260	-267,432,735	-279,007,478	-276,854,292	-258,158,099
E	2,510,371,469	2,106,351,031	-57,384,782	-138,553,504	-206,613,245	-253,581,366
F	2,627,716,469	2,221,392,531	40,859,218	-41,811,004	-111,711,745	-161,114,366
G	3,610,134,078	3,170,712,619	576,582,510	435,422,010	292,249,205	149,610,653
H	3,727,479,078	3,285,754,119	674,826,510	532,164,510	387,150,705	242,077,653
b: After VAT and Loyalty						
A	-1,705,400,175	-1,530,044,193	-492,142,797	-435,150,477	-376,911,377	-317,897,077
B	-1,615,044,525	-1,441,462,238	-416,494,917	-360,658,752	-303,837,222	-246,697,487
C	838,658,854	625,715,675	-281,571,086	-289,327,483	-286,251,960	-269,981,327
D	929,014,504	714,297,630	-205,923,206	-214,835,758	-213,177,805	-198,781,737
E	1,932,986,031	1,621,890,294	-44,186,282	-106,686,198	-159,092,199	-195,257,652
F	2,023,341,681	1,710,472,249	31,461,598	-32,194,473	-86,018,044	-124,058,062
G	2,779,803,240	2,441,448,717	443,968,533	335,274,948	225,031,888	115,200,203
H	2,870,158,890	2,530,030,672	519,616,413	409,766,673	298,106,043	186,399,793

Supplementary Table 2: Summary of NPVs of benefits to the investor for the soda ash scenario (net values discounted using different discount rates, P = USD 412/ton and t = 50 years) (USD)

a: Before VAT and Loyalty						
Soda ash scenarios	**Discount rates**					
	0.50%	**1%**	**10%**	**12%**	**15%**	**20%**
A	848,681,278	725,541,419	236,910	-38,913,990	-78,355,595	-117,038,947
B	966,026,278	840,582,919	98,480,910	57,828,510	16,545,905	-24,571,947
C	5,890,298,979	4,997,658,138	417,531,499	250,066,643	101,306,165	-22,083,251
D	6,007,643,979	5,112,699,638	515,775,499	346,809,143	196,207,665	70,383,749
E	8,058,951,201	6,971,799,277	887,962,184	612,010,892	353,301,459	125,998,297
F	8,176,296,201	7,086,840,777	986,206,184	708,753,392	448,202,959	218,465,297
G	9,737,107,478	8,595,936,219	1,855,349,310	1,487,855,010	1,114,528,605	741,239,453
H	9,854,452,478	8,710,977,719	1,953,593,310	1,584,597,510	1,209,430,105	833,706,453
b: After VAT and Loyalty						
A	653,484,584	558,666,893	182,421	-29,963,772	-60,333,808	-90,119,989
B	743,840,234	647,248,848	75,830,301	44,527,953	12,740,347	-18,920,399
C	4,535,530,214	3,848,196,767	321,499,254	192,551,315	78,005,747	-17,004,103
D	4,625,885,864	3,936,778,722	397,147,134	267,043,040	151,079,902	54,195,487
E	6,205,392,424	5,368,285,443	683,730,881	471,248,387	272,042,124	97,018,689
F	6,295,748,074	5,456,867,398	759,378,761	545,740,112	345,116,279	168,218,279
G	7,497,572,758	6,618,870,889	1,428,618,969	1,145,648,358	858,187,026	570,754,379
H	7,587,928,408	6,707,452,844	1,504,266,849	1,220,140,083	931,261,181	641,953,969

Supplementary Table 3: Summary of NPVs for the Business As Usual (BAU) scenario (net values discounted using different discount rates and t = 50 years) (USD)

Type of value	Discount rates					
	0.50%	1%	10%	12%	15%	20%
I) Crop production	38,457,769	34,243,513	9,298,232	7,926,563	6,525,929	5,111,238
II) Pastoralism	520,830,826	463,757,458	125,925,300	107,348,881	88,380,189	69,221,130
III) Other direct uses of natural resources	598,167,879	532,619,809	144,623,678	123,288,886	101,503,574	79,499,627
IV) Tourism revenue via TH & CITES*	16,505,126	14,696,471	3,990,572	3,401,885	2,800,768	2,193,617
V) Campsite and lodges	81,501,353	72,570,321	19,705,213	16,798,313	13,830,028	10,831,954
VI) Tour operation	50,324,631	44,809,987	12,167,375	10,372,452	8,539,626	6,688,406
VIIa) Indirect use and non-use/intrinsic value: WTP	9,348,734	8,324,287	2,260,316	1,926,876	1,586,394	1,242,496
VIIb) Indirect use and non-use/intrinsic value: WTAC	1,021,951,600	909,964,719	247,085,149	210,635,307	173,415,765	135,822,691
VIII) National level: Revenue from tourism in Lake Natron	2,543,850	2,265,091	615,046	524,315	431,668	338,091
IX) Regional level: Government revenue from flamingo tourism	191,481,113	170,498,346	46,295,871	39,466,334	32,492,580	25,448,837
X) Regional level: Lodges, hotels and camps	3,650,924,891	3,250,851,452	882,712,370	752,495,211	619,528,295	485,226,937
XI) International level (Travel Costs to Lake Natron)	53,491,317	47,629,664	12,933,010	11,025,140	9,076,983	7,109,275
Total – excluding VIIa (with WTAC)	**6,226,180,355**	**5,543,906,831**	**1,505,351,816**	**1,283,283,287**	**1,056,525,405**	**827,491,803**
Total – excluding VIIb (with WTP)	**5,213,577,489**	**4,642,266,399**	**1,260,526,983**	**1,074,574,856**	**884,696,034**	**692,911,608**

* TH stands for Trophy Hunting; and CITES for Convention on International Trade in Endangered Species.

Supplementary Table 4: NPVs of loss of benefits for the BAU scenario when the soda ash scenario is opted (net losses discounted using different discount rates and t = 50 years) (USD)

Type of value	Discount rates					
	0.50%	1%	10%	12%	15%	20%
I) Crop production						
Low impact scenario	752,117	667,832	168,926	141,493	113,480	85,186
High impact scenario	1,880,293	1,669,580	422,316	353,732	283,701	212,966
II) Pastoralism						
Low impact scenario	10,185,868	9,044,401	2,287,757	1,916,229	1,536,855	1,153,674
High impact scenario	25,464,670	22,611,001	5,719,393	4,790,572	3,842,138	2,884,185
III) Other direct uses of natural resources						
Low impact scenario	11,698,346	10,387,384	2,627,462	2,200,766	1,765,059	1,324,981
High impact scenario	29,245,864	25,968,460	6,568,654	5,501,914	4,412,649	3,312,451
IV) Tourism revenue via TH & CITES						
Low impact scenario	806,975	716,543	181,248	151,813	121,757	91,400
High impact scenario	1,613,950	1,433,085	362,495	303,626	243,515	182,800
V) Campsite and lodges						
Low impact scenario	3,984,797	3,538,245	894,990	749,645	601,231	451,327
High impact scenario	7,969,594	7,076,490	1,789,980	1,499,290	1,202,461	902,654
VI) Tour operation						
Low impact scenario	3,341,127	2,960,885	712,969	590,004	464,812	339,061
High impact scenario	4,745,272	4,207,853	1,029,488	855,341	677,874	499,302
VIIa) Indirect use and non-use/intrinsic value (WTP)						
Low impact scenario	457,082	405,860	102,661	85,989	68,965	51,770
High impact scenario	914,164	811,719	205,322	171,978	137,930	103,540
VIIb) Indirect use and non-use/intrinsic value (WTAC)						
Low impact scenario	49,965,668	44,366,324	11,222,345	9,399,853	7,538,876	5,659,222
High impact scenario	99,931,335	88,732,647	22,444,690	18,799,706	15,077,752	11,318,444
VIII) National level: Revenue from tourism in Lake Natron						
Low impact scenario	124,375	110,437	27,935	23,398	18,766	14,087
High impact scenario	248,750	220,874	55,869	46,796	37,532	28,174
IX) Regional level: Government revenue from flamingo tourism						
Low impact scenario	9,361,971	8,312,833	2,102,709	1,761,232	1,412,545	1,060,358
High impact scenario	18,723,943	16,625,666	4,205,419	3,522,465	2,825,089	2,120,715
X) Regional level: Lodges, hotels and camps						
Low impact scenario	178,502,485	158,498,813	40,091,859	33,581,001	26,932,655	20,217,587
High impact scenario	357,004,969	316,997,625	80,183,717	67,162,001	53,865,309	40,435,174
XI) International level (Travel Costs to Lake Natron)						
Low impact scenario	2,615,319	2,322,236	587,404	492,010	394,602	296,217
High impact scenario	5,230,638	4,644,473	1,174,807	984,020	789,204	592,434
Total loss (NPVs) for the low impact scenario (+WTP)	**221,830,462**	**196,965,469**	**49,785,920**	**41,693,580**	**33,430,727**	**25,085,648**
Total loss (NPVs) for the high impact scenario (+WTP)	**453,042,107**	**402,266,826**	**101,717,460**	**85,191,735**	**68,317,402**	**51,274,395**
Total loss (NPVs) for the low impact scenario (+WTAC)	**271,339,048**	**240,925,933**	**60,905,604**	**51,007,444**	**40,900,638**	**30,693,100**
Total loss (NPVs) for the high impact scenario (+WTTAC)	**552,059,278**	**490,187,754**	**123,956,828**	**103,819,463**	**83,257,224**	**62,489,299**

Supplementary Table 5: Summary of NPVs for the sustainable eco-tourism scenario (net values discounted using different discount rates and t = 50 years) (USD)

Type of value	Discount rates					
	0.50%	1%	10%	12%	15%	20%
I) Crop production						
Low increase/growth scenario	39,209,886	34,911,345	9,467,159	8,068,056	6,639,409	5,196,424
High increase/growth scenario	40,338,062	35,913,093	9,720,548	8,280,296	8,280,296	5,324,204
II) Pastoralism						
Low increase/growth scenario	531,016,694	472,801,859	128,213,058	109,265,110	89,917,045	70,374,804
High increase/growth scenario	546,295,496	486,368,460	131,644,694	112,139,454	92,222,327	72,105,315
III) Other direct uses of natural resources						
Low increase/growth scenario	609,866,224	543,007,193	147,251,140	125,489,652	103,268,634	80,824,608
High increase/growth scenario	627,413,743	558,588,269	151,192,332	128,790,801	105,916,223	82,812,079
IV) Tourism revenue via TH & CITES						
Low increase/growth scenario	16,827,916	14,983,088	4,063,071	3,462,611	2,849,471	2,230,177
High increase/growth scenario	17,312,101	15,413,014	4,171,820	3,553,699	2,922,525	2,285,017
V) Campsite and lodges						
Low increase/growth scenario	83,095,272	73,985,619	20,063,209	17,098,171	14,070,520	11,012,485
High increase/growth scenario	85,486,150	76,108,566	20,600,203	20,600,203	14,431,259	11,283,281
VI) Tour operation						
Low increase/growth scenario	51,308,827	45,683,891	12,388,427	10,557,605	8,688,123	6,799,878
High increase/growth scenario	52,785,123	46,994,747	12,720,005	10,835,335	8,910,868	6,967,086
VIIa) Indirect use and non-use/intrinsic value (WTP)						
Low increase/growth scenario	9,531,567	8,486,631	2,301,380	1,961,271	1,613,980	1,263,204
High increase/growth scenario	9,805,817	8,730,147	2,362,977	2,012,865	1,655,359	1,294,266
VIIb) Indirect use and non-use/intrinsic value (WTAC)						
Low increase/growth scenario	1,041,937,867	927,711,248	251,574,087	214,395,248	176,431,315	138,086,380
High increase/growth scenario	1,071,917,267	954,331,042	258,307,494	220,035,160	180,954,641	141,481,914
VIII) National level: Revenue from tourism in Lake Natron						
Low increase/growth scenario	2,593,600	2,309,266	626,220	533,674	439,174	343,726
High increase/growth scenario	2,668,225	2,375,528	642,981	547,713	450,434	352,178
IX) Regional level: Government revenue from flamingo tourism						
Low increase/growth scenario	195,225,902	173,823,479	47,136,955	40,170,827	33,057,597	25,872,981
High increase/growth scenario	200,843,085	178,811,179	48,398,580	41,227,566	33,905,124	26,509,195
X) Regional level: Lodges, hotels and camps						
Low increase/growth scenario	3,722,325,885	3,314,250,977	898,749,114	765,927,611	630,301,356	493,313,972
High increase/growth scenario	3,829,427,376	3,409,350,264	922,804,229	786,076,211	646,460,949	505,444,524
XI) International level (Travel Costs to Lake Natron)						
Low increase/growth scenario	54,537,444	48,558,558	13,167,971	11,221,945	9,234,824	7,227,761
High increase/growth scenario	54,537,444	48,558,558	13,167,971	11,221,945	9,234,824	6,516,841
NPVs for low increase scenario (+WTP)	5,315,539,217	4,732,801,906	1,283,427,704	1,093,756,533	900,080,133	704,460,020
NPVs for high increase scenario (+WTP)	5,466,912,622	4,867,211,825	1,317,426,340	1,125,286,088	924,390,188	720,893,986
NPVs for low increase scenario (+WTAC)	6,347,945,517	5,652,026,523	1,532,700,411	1,306,190,510	1,074,897,468	841,283,196
NPVs for high increase scenario (+WTAC)	6,529,024,072	5,812,812,720	1,573,370,857	1,343,308,383	1,103,689,470	861,081,634

Supplementary Table 6: Comparison of the soda ash; business as usual; and sustainable eco-tourism scenarios

Scenarios	NPV (r = 10%, t = 50 yrs)
Soda ash – Scenario A: P = USD 270/ton (after VAT and loyalty)	-492,142,797
Soda ash – Scenario B: P = USD 270/ton (after VAT and loyalty)	-416,494,917
Soda ash – Scenario C: P = USD 270/ton (after VAT and loyalty)	-281,571,086
Soda ash – Scenario D: P = USD 270/ton (after VAT and loyalty)	-205,923,206
Soda ash – Scenario E: P = USD 270/ton (after VAT and loyalty)	-44,186,282
Soda ash – Scenario F: P = USD 270/ton (after VAT and loyalty)	42,384,728
Soda ash – Scenario G: P = USD 270/ton (after VAT and loyalty)	454,891,663
Soda ash – Scenario H: P = USD 270/ton (after VAT and loyalty)	530,539,543
Business as usual (with indirect use and non-use/intrinsic value estimated using WTP)	1,260,526,983
Business as usual (with indirect use and non-use/intrinsic value estimated using WTAC)	1,505,351,816
Sustainable eco-tourism (wit indirect use and non-use/intrinsic value estimated using WTP): low growth	1,283,427,704
Sustainable eco-tourism (with indirect use and non-use/intrinsic value estimated using WTP): high growth	1,317,426,340
Sustainable eco-tourism (with indirect use and non-use/intrinsic value estimated using WTAC): low growth	1,532,700,411
Sustainable eco-tourism (with indirect use and non-use/intrinsic value estimated using WTAC): high growth	1,573,370,857