L I B Y A

THE URGENT TRANSITION
TO ENVIRONMENTAL SUSTAINABILITY

The Environment General Authority, Tripoli

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LIBYA:
THE URGENT TRANSITION TO ENVIRONMENTAL SUSTAINABILITY

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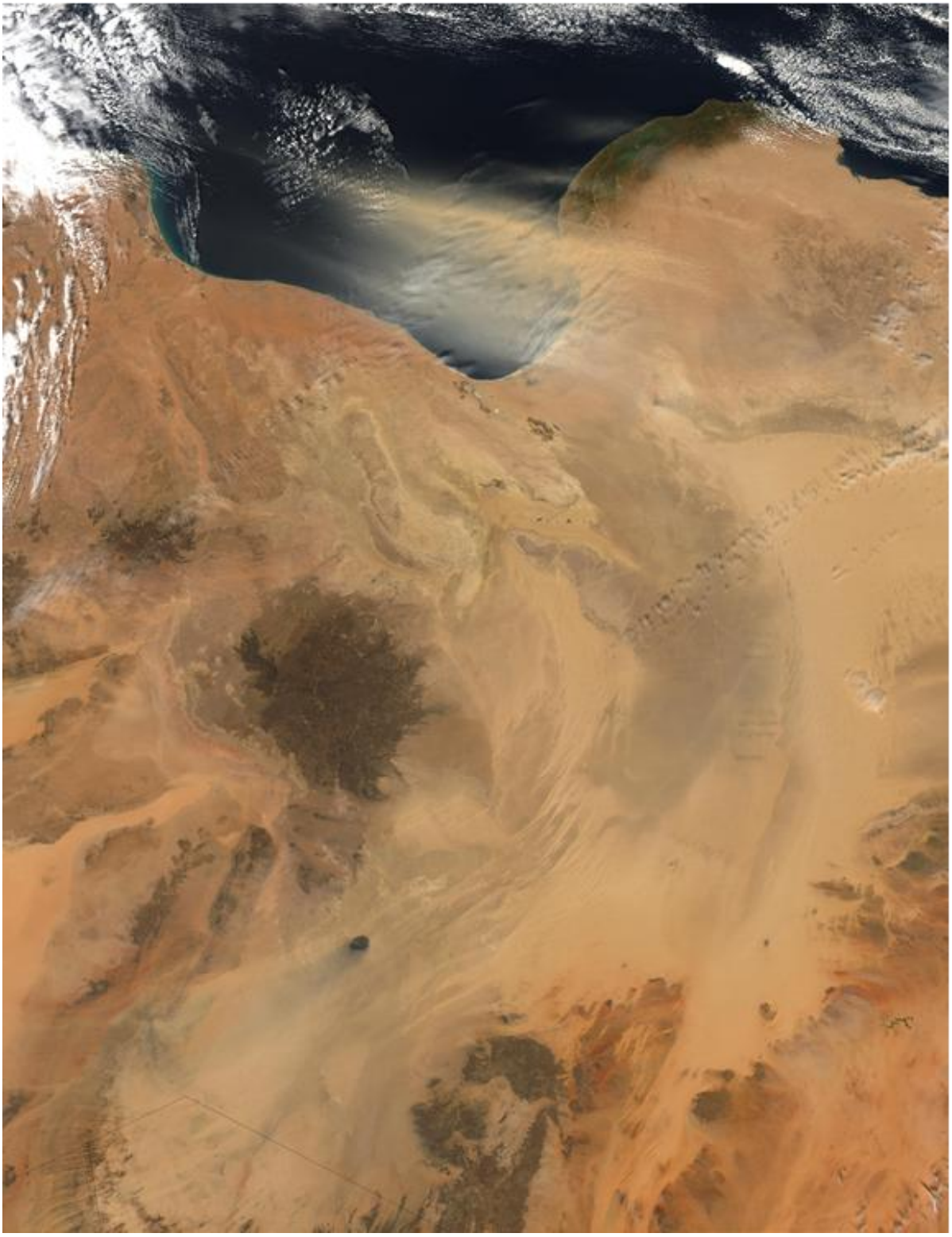
Acronyms and Abbreviations

ALARP	As low as reasonably practicable
BAT	best available technology
Bbl	barrels (of oil)
Bcf	billion cubic feet per day
Bcm	billion cubic meters
Bn.	billion
C	Celsius
c.	approximately
CAFÉ	corporate average fuel economy
CEMP	Center for Environmental Management & Planning
CFCs	chlorofluorocarbons
CLC	Civil Liability Convention, 1992 and the Compensation Fund IOPC
CO_2	carbon dioxide, the main anthropic greenhouse gas
EGA	Environment General Authority, Tripoli
EIA	environmental impact assessment, now often EA
EITI	Extractive Industries Transparency Initiative
EMP	environmental management plan, an integral part of ESA that operationalizes its recommendations and specifies how it will be implemented
EMS	environmental management system, designed to manage a corporation's processes and environmental results; not part of the ESA.
EPSA	exploration and production sharing agreements (see PSA, PSC)
ESA	environmental and social assessment, the current preferred term
ESIA	environmental and social impact assessment, a more complete term than EIA.
ESHIA	environmental, social and health impact assessment, the most complete term (see also ESA, EIA, ESIA, HIA, SIA)
FIPOL	Les fonds internationaux d'indemnisation pour les dommages dus à la pollution par les hydrocarbures; see IOPC
FOC	flag of convenience
FSO	floating storage and offloading system
FPSO	floating production, storage and offloading vessel
FPS	floating production system
FSU	floating storage unit
GDP	gross domestic product
GECOL	General Electric Company of Libya
GEF	Global Environment Facility (UNEP, UNDP, World Bank)
GHG	greenhouse gas, mainly carbon dioxide from burning hydrocarbons, causing climate change
GMR	Great Man-Made River Water Supply Project
GPCI	Geographic Planning Collaborative
GSI	Global Subsidies Initiative
HIA	health impact assessment, an integral part of ESA
HSBC	Hong Kong & Shanghai Bank Corporation
HSE	health, safety and environment, a common corporate grouping
H_2S	hydrogen sulfide
HVDC	high voltage direct current
IAIA	International Association for Impact Assessment
IIED	International Institute for Environment and Development (see MMSD)
IISD	International Institute for Sustainable Development
IMO	International Maritime Organization
IUCN	International Union for the Conservation of Nature
IOPC	International Oil Pollution Compensation Funds (IOPC Funds)
LED	light emitting diode
LDC	Less Developed Country
LYD	Libyan Dinar
LNG	liquefied natural gas

LPG liquefied petroleum gas
MAB Man and Biosphere Programme, UNESCO
Maghreb Member states of the Arab Maghreb Union: Morocco, Algeria, Tunisia, Libya, and Mauritania
Mcm million cubic meters
MARPOL International Convention for the Prevention of Pollution from Ships
MENA Middle East & North Africa
MODU modal offshore drilling unit
Mte million tone equivalent
MW megawatt
NGL natural gas liquids
NOC National Oil Company
OBM oil-based muds
OECD Organization for Economic Cooperation and Development
ORF oil reserve fund
OSPAR The Convention for the Protection of the Marine Environment of the North-East Atlantic www.ospar.org and www.offshore-environment.com/ospar
OSRL Oil Spill Response Ltd, Southampton, UK
PAH polycyclic aromatic hydrocarbons
PFW Produced and Formation Water, usually hypersaline water accompanying produced oil, always tainted with oil and other contaminants.
POLMAR Pollution Marine: www.polmar.com. French government's oil-spill response procedures.
POPs Persistent Organic Pollutants
ppm parts per million
PPP purchasing power parity
PSA production sharing agreement
PSC production sharing contract
SBM synthetic-based muds
SEA strategic environmental assessment of a program, region or sector, not of a project
SIA social impact assessment, an integral part of ESA
SoE State of the Environment (report)
Tcf trillion cubic feet
TREC Trans-Mediterranean Renewable Energy Cooperation
TWh terawatt hours
TWj terawatt joules
UNCTAD United Nations Conference on Trade and Development
UNEP United Nations Environment Programme
UNESCO United Nations Educational, Scientific and Cultural Organization
UNFCCC United Nations Framework Convention on Climate Change
UNSD United Nations Statistics Division
US AID Agency for International Development
US EPA Environmental Protection Agency
VOC volatile organic compounds
WBM water-based muds
WHO United Nations World Health Organization
WWF World Wildlife Fund



Libya from space

Executive Summary

This book outlines how Libya could become sustainable if it so chooses. Libya is a unique nation in many ways: especially its location that contains the highest solar insolation on the planet. The paramount needs are to make water supply sustainable and to make a transition to renewable energy as fast as possible. Both water and oil stocks are depleting and will become scarce unless conserved. The two urgent needs of sustainable water and energy are related. Sustainable water means solar-powered desalination and solar-fuelled water pumps. Sales receipts from Libya's declining oil and gas resources could be allocated to accelerate the transition to solar electricity, which should fast become the most profitable and sustainable export to Europe. Conservation of water is essential for water supply and food production. Conservation of hydrocarbons is essential to boost oil and gas exports to finance solar electricity. As climate change intensifies, Libya is well placed to become carbon neutral and to help Europe reduce its greenhouse emissions by importing Libya's solar electricity.

This book offers signposts towards achieving Libyan environmental sustainability, but also is a foreigner's guide to Libya's fascinating but little-known environment. It is one of the first attempts to outline how to achieve environmental sustainability for a single nation. The surprising finding of this work is that Libya is poised to become a world leader in sustainability should it so choose.

Libya's 20 Dhiram banknote shows a map of the Great Man-Made River

Foreword

Libya faces a gigantic opportunity: We can become one of the first nations in the world to become environmentally sustainable if we so choose. We can grasp this opportunity now by acting to relieve our two biggest constraints to prosperity, namely the risks of depletion of fresh water and oil. This action promises to lead our citizens to enjoy a better standard of living and improved health in perpetuity. I am enthusiastic because sustainability would make us all winners and is feasible for us to achieve as a society. The opposite is too grim to imagine: scarcity of fresh water and of energy stifling our nation.

We are fortunate that this book offers us a bold and optimistic vision of how Libya can become environmentally sustainable. In essence, its basic message is common sense. First, let us use solar power to make fresh water sustainable. And second, let us use oil receipts to make a transition to generating solar electricity from our valuable deserts. These two activities within Libya could serve as a model to the world. Further, by exporting solar power to other countries, Libya could have a significant global impact on mitigating the risks of climate change.

The book also guides us to progress towards sustainability in transportation, food supply and conservation of the Mediterranean Sea on which we depend. One of the book's strengths is its distillation of international scientific literature showing how to progress towards sustainability.

Transitions to sustainable water and sustainable energy are two of the top current worldwide challenges, from which Libya is luckily in a position to profit. However, taking advantage of such an opportunity will not be a matter of luck, but rather of making the right choices from among a number of options. I am not claiming that these transitions will be easy—but they are feasible and indeed essential if we are to prosper in the future. My hope is that this book will spark a national debate, leading us to the goal of sustainability as smoothly and promptly as possible. It's up to us.

Dr Abdul-Hakim Elwaer
The Islamic Development Bank Group
Director, African Union Commission, Addis Ababa
Former Director, Environmental General Authority, Tripoli

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Libya
International boundary
Baladīyat boundary
National capital
Baladīyat capital
Railroad
Road
Track
0 100 200 Kilometers
0 100 200 Miles
Lambert Conformal Conic Projection, SP 8N/32N
Baladīyah (municipalities)
1. AN NUQAT AL KHAMS
2. AZ ZĀWIYAH
3. AL 'AZĪZĪYAH
4. TARĀBULUS
5. AL KHUMS
6. TARHŪNAH
7. ZLĪṬAN
8. MIṢRĀTAH
9. AL JABAL AL AKHḌAR
Presently Libya has 25 municipalities. An unconfirmed press article reports that the municipalities were replaced with 1,500 communes in 1992.
Base 801963 (R00515) 5-93
Mediterranean Sea
Ionian Sea
Gulf of Sidra
TUNISIA
ALGERIA
NIGER
CHAD
SUDAN
EGYPT
MALTA
GREECE
Sicily (ITALY)
Crete (GREECE)
Tripoli
Valletta
Tunis
GHADĀMIS
GHARYĀN
SAWFAJJIN
SURT
AJDĀBIYĀ
ṬUBRUQ
AL JUFRAH
SABHĀ
AWBĀRĪ
ASH SHĀṬI'
MURZŪQ
AL KUFRAH
AL FATIH
DARNAH
BANGHĀZĪ
YAFRAN

1. INTRODUCTION

1.1 Environmental Vision

The best, most sustainable, most efficient nations are going to have the best environmental practices. Nations with a good reputation for sustainability have a competitive edge in sales. Conservation, efficiency, reduction of waste and sustainability buffer a nation against shocks.

In Libya, a national, forward-looking environmental policy makes its exports more attractive. And Libya becomes more attractive for ecotourism. It is therefore highly commendable that Libya wants to become sustainable, boost the importance of environment, and galvanize Mediterranean conservation.

The less oil is consumed domestically, the more oil is available for export, and the more foreign exchange becomes available for sustainable investments by Libya's Oil Reserve Fund (OFR). See Annex B on the importance of the Oil Reserve Fund for the long-term future of Libyans.

Conservation

The Koran and the Prophet's *hadiths,* or sayings, emphasize the importance of environmental conservation, with emphasis on respect for all creation, protection of the natural environment, and avoidance of all wasteful activities that may harm the environment. The centrality of water in Islam underlies the injunction to conserve water and not to waste it, but also not to waste any natural resources (Amery 2001, Izzi Dien 2000, Kula 2001, Schwarte 2003).

This book emphasizes conservation as more effective and less expensive than cleanup or remediation. Conservation means doing better with the resources available and extracting more human well being out of each unit of oil or water used. Conservation means preventing damage, reducing waste and boosting the efficiency of resource use. Conservation by reducing waste means not destroying parts of the environment, taking actions such as preserving Libya's archeological sites or turning off taps and lights after use. Conservation also means preventing damage to assets or preserving them in a safe and sound manner, such as through maintenance of sewage treatment plants and recycling, rather than wasting sewage effluent. Boosting efficiency means extracting more utility from the same unit of water or energy, such as by switching from incandescent to fluorescent to LED light bulbs, or by changing wasteful aerial-spray irrigation to ultra-efficient drip irrigation.

The Audience for this Book

This book is designed for all those interested in improving the environmental sustainability of Libya. It should therefore be useful for environmentalists, ecologists and Greens in general, both governmental, especially the Libyan Environment General Authority (EGA), and in civil society. Academia should find it useful as a source book for working on environmental sustainability of Libya. Planners and development professionals, especially those supporting reconstruction of Libya following the 2011 Revolution may find it especially useful. All those controlling the allocation of irrigation water and managing water in general should find it useful and challenging. Energy planners will find it useful as they plan for sustainability in their sector.

What is Not the Focus of this Book

There are four main types of sustainability: social, human, economic and environmental, as defined and compared in Annex B. This book focuses on environmental sustainability, my sole specialty. The crucial linkages between environmental sustainability and the other three types of sustainability are not the focus of this book. The exceptionally important topics of people's livelihoods, poverty, peace and security are not focused on although they are mentioned in many instances. In addressing the issue of social sustainability, I look carefully at the drivers and linkages between social and environmental change. Thoroughly addressing environmental sustainability, which this book does in detail, goes a long way to laying the groundwork for social, human and economic sustainability and its linkages to relevant sectors. Important aspects related to environmental governance, including institutional issues, access to and control of natural resources by the communities, peace and conflict resolution, capacity strengthening, institution building, economic analysis, youth unemployment and underemployment, the creation of green jobs, and the mainstreaming of social and environmental sustainability into development policies, strategies and plans are mentioned throughout, but are not the focus of this book.

The World Bank, International Monetary Fund (IMF) (e.g., Chami, et al. 2012) and others will certainly take up these fundamental issues, as they write: “In the short term, the authorities must restore security, bring hydrocarbon production fully online, exercise fiscal discipline, resuscitate the banking system, and maintain macroeconomic stability.” But Libya also faces the formidable challenges of responding to the underlying causes of the revolution and building a democratic regime in the midst of heightened regional risks and global uncertainties. Therefore, medium-term efforts should focus on capacity building, infrastructure renewal, private-sector development, improving education, job creation, and putting in place an effective social safety net, within a framework of transparent and accountable governance. At the request of the Libyan authorities, international financial institutions are engaged in policy consultations and technical assistance, aimed at maintaining macroeconomic stability and developing an institutional infrastructure to promote economic diversification and employment growth (Chami et al. 2012). As environmental sustainability is a relative newcomer to economic development, it is often overlooked in conventional economic circles. This book, it is hoped,

will accelerate the inclusion of environmental sustainability into economic planning of post-revolutionary reconstruction.

1.2 The Impacts of the 2011 Revolution

The nation faces the challenges of building modern institutions, repairing infrastructure and diversifying the economy, according to the IMF (Chami, et al. 2012).

Libya's economy is likely to rebound sharply this year from a deep contraction in 2011 as the country rebuilds from civil war and oil production recovers to levels last seen during Muammar Gaddafi's rule. Democratic elections were held in July 2012, the first since 1952. The private sector is thriving, oil exports already have returned to 90 percent of pre-revolution levels.[1] Increased hydrocarbon revenues will provide a current account surplus of 22 percent of 2012 GDP. The health and education sectors are in dire states and civil society is developing slowly. But a drop in the country's high level of unemployment is not likely without reforms. IMF forecast growth would skyrocket 116.6 percent in 2012 (some sources claim 122 percent) following a contraction of 60 percent in 2011. The IMF also warned that continued political uncertainty, insecurity and the possibility of a drop in global oil prices were all risks to Libya's economic outlook. In July 2012, around half of Libya's oil exporting capacity was shut down and production cut by about 300,000 barrels per day (bpd) from about 1.3 million bpd after protests by groups demanding autonomy for eastern Libya, the source of most of the country's oil. The oil price at which Libya's budget is balanced was about US$91 per barrel in 2012, an increase from US$58 a barrel in 2010, and was set to exceed US$100 a barrel from 2013.

As Libya began its recovery from conflict in 2011, the World Bank was asked to lead the effort in the areas of public expenditure and financial management, infrastructure repair, job creation for young people and service delivery. The World Bank joins the United Nations and the European Union as one of the three institutions invited to coordinate assistance for the North African nation as it forges a path forward after months of violent conflict. This group has been asked to examine the need for repair and restoration of services in the water, energy and transport sectors and, in cooperation with the IMF, to support budget preparation and help the banking sector get back on its feet. Employment generation for young Libyans has been added as an urgent need facing the country. (Chami et al. 2013, see also St. John 2011; Vanderville, 2011).

[1] According to the *Independent* of September 13, 2013, Libyan oil production plunged from 1.4 mbpd to possibly as low as 100,000 bpd. Diesel and petrol are now imported. Militias, striking guards and mutinous military units linked to secessionist forces in the east of the county, and the Justice and Constructions Party, a Moslem Brotherhood affiliate, seem to have stymied or even partly taken over the Tripoli government despite the latter gaining only 10 percent of the vote in last year's parliamentary elections.

1.3 Structure of this book

The goal of this monograph is to identify opportunities for Libya's EGA and other decision-makers to ramp up environmental management in Libya and set out on the path towards sustainability. The main opportunity is to conserve Libya's three main natural resources, water, oil and the Mediterranean. Conservation of these resources will firmly catalyze Libya's transition to a sustainable economy while improving the quality of life. This book focuses on conservation of water, energy, transport and the Mediterranean. Annex A outlines the main opportunities for EGA. Annex B provides a technical section on the meaning of environmental sustainability and how it is best applied to nonrenewable resources. Comprehensive guides to the published environmental literature, mainly on Libya, reinforce each section of this book.

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Close up?

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2. CONSERVATION OF WATER, IRRIGATION, DESALINATION

As oil conflicts were central to 20th century history, the struggle over freshwater is set to shape a new turning point in the world order. Water scarcity, which already affects one in three people on earth, is set to increase in magnitude and scope as the global population grows, increasing affluence drives up demand, and the climate changes. Half the world's population will be living in areas of high water stress by 2030, including 75 to 250 million people in Africa. In the Sahel region of Africa, desertification caused by overgrazing, unsustainable farming, and the collection of wood for fuel is already responsible for systemic crop failure, soil erosion, and devastating famine. Failure to act on water scarcity will lead to more of the same. To peacefully overcome water scarcity, leaders at all levels must prioritize efforts to cooperatively increase water-use efficiency, reduce water waste, and manage demand.

To Combat Scarcity, Increase Water-Use Efficiency in Agriculture,
Sophie Wenzlau, 2013

2.1 Conservation of Water

On the conservation of natural resources, the Quran says: "*Waste not by excess: for Allah loveth not the wasters*." (Al-Anam: Verse 141). Because of Libya's desertic nature, water is paramount for sustainability and economic development. Libya's Environmental Law 15 (Article 41) specifically emphasizes that water is to be used economically and that technologies must be used to minimize water consumption in all activities. Conservation of water is thus the law of the land. Oil is nearly as paramount as water, as it is needed to pump fresh water in the near term, until water pumps become based on solar and wind energy.

FINDINGS

Practically all (c. 96 percent) of Libya's fresh water is groundwater, mostly (75 percent) from the Great Man-Made River (GMR). The average precipitation is only 28 millimeters per year (mm/year). Most (95 percent) of Libya receives between 0 and 25 mm/year of rainfall. Surface water accounts for 2.3 percent, while recycled sewage effluent provides 0.9 percent. Water from desalination is about 0.7 percent (1990 data). Agriculture consumes 3,800 million cubic meters (Mcm) of water annually, or 85 percent of Libya's freshwater supplies. Urban areas consume about 400 Mcm, or 11.5 percent. Industries including the oil sector consume about 150 Mcm, or 3.5 percent.

RECOMMENDATIONS

The two starting points for Libya's desire for sustainability are:

- **On the input side:** choosing how fresh water is pumped and desalination is powered, either by fossil fuel or by solar power.

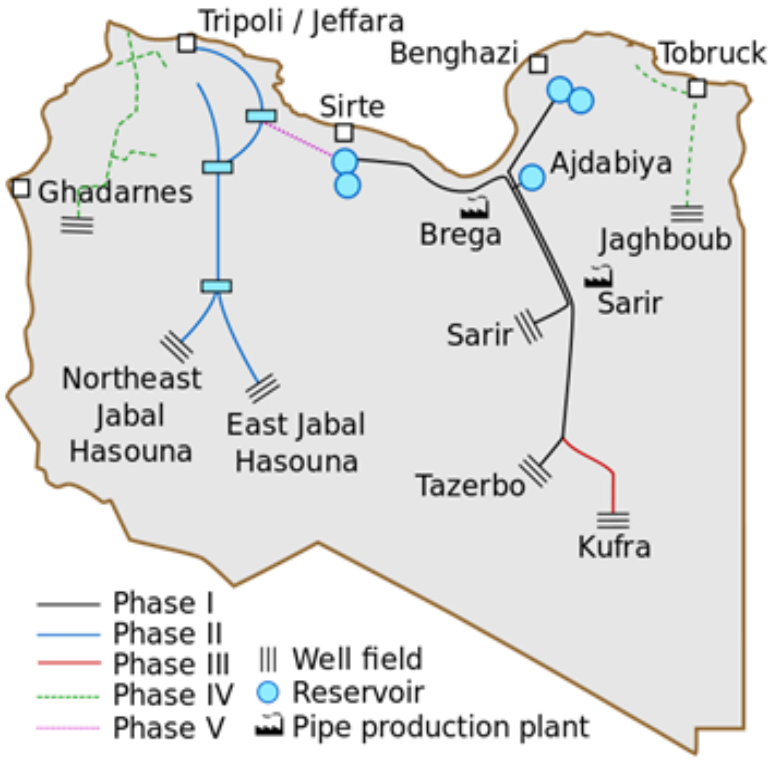
- **On the output side**: viewing radical conservation and efficiency as essential in agriculture, by far Libya's biggest consumer of water.

Libya's leadership in water was internationally recognized when it received the UN's International Water Prize, specifically for the GMR, in 2005. Water technology is continuously improving: there have been advances in the systems for building pipelines in Libya's saline conditions, as demonstrated recently in the construction of GMR (Hurley and Blake 2002), in lining canals, in greater water-use efficiency, and so on.

2.2 The Main Source of Water: GMR

FINDINGS

The Great Man-Made River (GMR), also called An-Nair Sinai, transports fossil water from the vast Nubian Sandstone Aquifer System in the south of Libya, northwards to the populated coastal cities. In 1983, GMR was originally intended to supply 67 percent of the agricultural sector's needs. It now provides about 75 percent of Libya's annual water demand (urban plus agriculture), from 1,000 wells, through 4,000 km of buried 4-meter-diameter pipe, with some surface water impoundments for interim water storage.



GMR's first aquifer, the Kufra Basin in southeast Libya, has an estimated groundwater storage capacity of nearly 5,000 cubic miles, in the Libyan sector alone. GMR's first stage, completed in 1991, supplies Benghazi and fills coastal reservoirs. As mentioned below, desert reservoirs have huge risks of evaporation. GMR has supplied Tripoli's water since 1997. Ultimately GMR is expected to provide 3,000 Mcm annually from its 30,000 cubic kilometer aquifers.[2] The goal is to supply

[2] Four major underground basins have been discovered so far. The Kufra Basin, in the southeast, near the Egyptian border, covers 350,000km², forming an aquifer layer over 2,000m deep with an estimated capacity of 20,000km³ in the Libyan sector. The 600m-deep aquifer in the Sirt Basin is estimated to hold over 10,000km³ of water, while the 450,000km² Murzuk Basin, south of Jabal Fezzan, is estimated to hold 4,800km.³ More water lies in the Hamadah and Jufrah Basins, which extend from the Qargaf Arch and

5 million cubic meters per day to coastal populations. Caveat: Global estimates of the availability of ground water often are optimistic; Libya is no exception.

Water is priced by fiat; lowest (LYD 0.048) for agriculture, double that for domestic use (LYD 0.08), and highest for industry (LYD 0.796), according to the World Bank (2006). These prices are deeply subsidized, rarely adjusted, and fail to reflect the cost of production.

Trucks transporting GMR water pipeline sections.

Although two-thirds of GMR water was originally allocated to irrigation, now 98 percent of GMR water is consumed domestically.[3] Even pessimists admit Libya's GMR has one century of function; optimists claim five centuries. (Super-optimists mention 4,000 or even 4,860 years, *fide* Bissani et al. 2004.) GMR officials say it will last 50 years (*fide* Killgore 2001).

Jabal Sawda to the coast. There is little discussion of treating and re-using contaminated water "produced" from oil and gas fields.

[3] The economic tradeoffs need to be focused on prudently, but are not the topic of this book. The overriding criteria are prudence in investments (see the cautionary tales of Alaska and Nauru in Annex B), and transparency, using solely Hicksian income, not receipts or capital. Note that GMR is financed "off-budget," with proceeds from a 2 percent tax on luxury goods such as cigarettes, international travel and fuel. GMR may eventually cost c. $30 billion invested over decades as oil is exported and as luxury goods are taxed. This does not mean $30 billion is or was available in one sum for investment. Taxing tobacco and luxury goods is fine, but under-taxing fuel while providing most water free or well below the cost of its production, severely distorts the economy and makes Libya less sustainable and more precarious.

CEDARE (2001) estimates 225 years, assuming an acceptable drawdown of 100 meters (long since exceeded) and a planned future abstraction of 1,090 Mcm annually. Of course, water lifting and pumping costs rise sharply as the water levels decline.

GMR aquifers, though gigantic, are finite. They have limits, even if those limits are not yet known. The aquifers contain fossil water many thousands of years old, which is not being recharged. GMR water may be c. 10,000 years old having accumulated during the last ice age. Claims that Libya may be tapping into Nile seepage seem far-fetched in view of the long distance from any GMR pumping station to the Nile's hydrographic influence. In fact, the contrary may be more likely. The vast aquifer around Jabal Al Jweinat, the meeting point of Sudan, Egypt and Libya, is utilized only by Egypt. As GMR water is thousands of years old, Nile water found in aquifers is easily distinguishable from the fossil water. The International Atomic Energy Agency (IAEA) is active in dating groundwater in Libya to infer flow patterns and any recharge. Most desert aquifers are smaller than Libya's, and most are rapidly retreating worldwide under heavy pumping.

Could it be that the bigger constraint becomes the availability of fuel for pumping the water from ever-deeper levels? At present, pumping water from possibly as many as 1,000 wells, from as deep as 2 kilometers (km) up to the pipeline system, consumes much fuel. Once in the pipeline, gravity, supported by some pumps, feeds the demand centers. The pipelines are getting longer, water levels are falling and demand is soaring. Thus the fuel consumed in pumping is already expensive for Libya and will become more so as global oil prices rise. Every barrel of oil needed for pumping costs Libya US$90 or more in foregone exports.

RECOMMENDATIONS

- The sooner water pumping can be powered by renewable energy (wholly or partly); the sooner Libya will become sustainable.
- The transition from fossil-fuel GMR water pumps to solar-energy water pumps is possibly the most important step for Libya's approach to sustainability.

2.3 Desalination of Water

Libya is ranked fifth in the world in the use of desalination technologies, even though less than 2 percent of its annual water demand is satisfied by desalinated water. Twenty –one planned and under-construction facilities are expected to produce 986 Mcm of water per day.

FINDINGS

Libya has 17 significant desalination plants (out of a total of 400 desalination plants according to its State of the Environment report 2002) with an installed capacity of more than 100 Mcm/year, or 33,374 cubic meters per day (cm/day), although actual production is only 18 Mcm/year (Porter and Yergin 2006), only 1 percent of annual national demand.

Thermal technology plants are co-located at electrical generation facilities. Most desalination plants run only sporadically due to scaling, corrosion and maintenance problems. Most desalination (60 percent) in Libya is by the thermal-plus-flash vaporization method (multistage distillation). Reverse osmosis output is about 20 percent, as at the Tajura facility. Electro-membrane separation plants produce about 10 percent. Three build-own-transfer (BOT) desalination plants companies went bankrupt (see comments in Algahariani 2003).

Production costs for one cubic meter of desalinated water are 0.76, 0.86, and 1.30 LYD respectively for desalinated water from large, medium and old plants. In comparison, GMR water has a total cost of around US$30 billion, or a unit price of between 70 and 160 LYD per cubic meter of water.[4] The same volume produced by desalination of seawater would cost between 320 and 620 LYD. Desalination costs are falling worldwide, but GMR costs are rising over the years. GMR may be conveying less than 25 percent of its design capacity, according to Norton Rose (2003).

Fifty percent of desalination costs accrue from energy costs. The most efficient reverse osmosis plants need 3.7 kilowatt hours (kW/hrs) of electricity to produce 1,000 liters of drinking water. Improved technology may lead to lower costs.[5] However, desalination can be expected to consume large amounts of energy regardless of the technology; as the cost of energy rises, it may cancel out the benefit of more-efficient technology. Conversely, the physics of reverse osmosis means that costs fall rapidly as the salinity of the input decreases. Desalinating brackish water may require only 2 to 10 U.S. cents per cubic meter of treated water; making the process much more competitive.

Desalination of water worldwide is now mostly by reverse osmosis, but this method of desalinating seawater costs about eight times more costly than obtaining water from conventional supplies in wet climates. The General Electric Company of Libya's (GECOL's) plans to install a 300 cubic meters per day (cu. Mts/day) reverse osmosis desalination plant fuelled by renewables needs to be replicated and accelerated.

[4] GMR's Phase I requires extensive repairs of corroded piping. The Korean Dong Ah Construction Industrial Company, lead contractor of GMR's Phases I and II, collapsed financially in 1998 and declared bankruptcy in 2001, where it remains as of 2013. The Ministry of Construction and Transportation said that it plans to establish another company so that Dong-Ah's ongoing foreign contracts, including those in Libya, can be separated from the ailing company and continue despite liquidation.

[5] For example, Saltworks Technologies (www.saltworkstech.com/products) does not use high pressure so cheap plastic piping can be used rather than expensive steel piping which brine corrodes fast. The pumps are low pressure so suitable for solar power. This encouraging technology is based on resilient ion exchange membranes for desalination, and advanced ionic species separations. The thermo-Ionic process arrangement harnesses solar heat or waste heat as low as 35° C to offset electrical energy consumption.

In 1995 the 11,066 desalination plants in the world had the potential to produce 7.4 billion cubic meters of fresh water per year, a mere 0.2 percent of world water use. The world's largest solar desalination plant is the Jebel Ali Desalination Plant (Phase 2) in the United Arab Emirates. Renewable energy-based desalination plants include Abu Dhabi's solar-based plant that produces 80 cu. Mts/day and Spain's Almeria solar plant that produces 3,000 liters per hour (lt/hr).

Libya's Renewable Energy and Water Desalination Research Center merits substantially increased financing and should be replicated fast in order to standardize desalination and pumping based on renewable energy.

The official news agency Jana reported that the General People's Committee (GPC, Parliament) had approved development of a nuclear power deal with the United States to generate electricity and boost desalination. The Libyan foreign ministry was authorized in 2007 to negotiate with the United States for assistance for construction of the country's first nuclear power station. Similarly, France and Libya signed a c. €2 billion agreement on

BOX 1: SOLAR ENERGY: NO PIE IN THE SKY

Egypt's Kuraymat solar power plant, which opened in 2012, is an example of a good-practice solar plant, because of its geographic proximity and climatic similarity. The 150 MW plant occupies an area of 130,000 square meters, and its construction cost was roughly the amount of income the oil industry provides every three days. Scores of similar plants could be built in Libya's 1.5 million square kilometers of empty desert. Only 20 similarly-sized plants would produce 3 GW of energy per year. This is to say nothing of the fact that the technology is developing rapidly producing more efficient and larger-scale designs every year.

Even bigger are several solar and solar/gas hybrid plants of up to 1,000 MW each in California. China's 2 GW Ordos solar plant in Inner Mongolia will produce a fifteenth of the entire Libyan energy usage when finished. Large-scale projects are not the only way solar power can be utilized. Small-scale domestic units could reduce dependency on the electricity grid for water heating, which accounts for approximately 10 percent of household electricity usage. So far, Africa's biggest solar plant is Ghana's 155 MW solar photovoltaic Nzema plant near Aiwaso, which will be fully operational by 2015.

Libya could generate approximately five times the amount of energy from solar power that it currently produces in crude oil, according to Nottingham Trent University research (*fide:* Energy Digital 10 March 2013). The study led by the university's School of Architecture, Design and the Built Environment found that the oil-rich nation could generate enough renewable power to meet its own demand and a "significant part of the world energy demand by exporting electricity." Libya is located on the cancer orbit line and is exposed to the sun's rays throughout the year with long days. It has an average daily solar radiation rate of about 7.1 kilowatt hours per square meter (kWh/m²/day) on a flat plane on the coast and 8.1 kWh/m²/day in the south. By comparison, the United Kingdom's average solar radiation rate is less than half that amount at about 2.95 kWh/m²/day. If Libya used 0.1 percent of its landmass to harness solar power, it could produce the equivalent of almost 7 million barrels of crude oil per day in energy, the study found. Currently, Libya produces about 1.41 million barrels of crude oil per day (Ahmed Mohammed et al. 2013).

the civilian use of nuclear energy on December 11, 2007. Seawater desalination, uranium yellowcake surveying, and Areva Corp., also were mentioned.

The Sirte Depressions Project proposes to import seawater by gravity canals to depressions below sea level, 20–50 km from the coast to become lakes for recreation and improvement of the microclimate.

RECOMMENDATIONS

- The first step is to charge all sectors the market price for water. The poor should receive a lightly subsidized 'life-line' minimal volume of water.
- Although GMR water is unparalleled worldwide, some diversification of water supply for Libya would be prudent because GMR water will become more expensive as the ground water level falls and more energy is needed to extract it. As water must be pumped from lower levels, desalination becomes more cost-competitive. Desalination costs are dropping internationally; international desalination costs of US$0.60 to US$1.00 per cubic meter (excluding distribution costs) are already approximating the full costs of GMR water.
- Renewable energy should be used both to pump GMR water and desalinate other water. The costs of conversion will be more than paid for by the export of the increased volumes of oil that will be freed by the use of renewable energy.
- In the interim, flared gas is useful as a fuel to bridge the gap between fossil fuels and fully-renewable energy.
- When all sectors pay the full market price for water, the economics of desalination become attractive.
- As soon as all wastewater is treated and recycled, desalination needs to be fostered as the economics improve over the next few years, even if desalination is not yet totally competitive with GMR water (which is debatable).
- While a nuclear power station would help diversify desalination energy, its costs may exceed gas-fuelled and eventually solar-based desalination.
- The risks should be assessed for contamination of freshwater supplies by brine in the Sirte Depressions Project.

BOX 2: GOOD PRACTICE EXAMPLE: TRANS-MEDITERRANEAN RENEWABLE ENERGY COOPERATION AND YEMEN'S SANA'A SOLAR WATER PROJECT

With around 2 million people, Yemen's Sana'a region is growing rapidly, thanks to the easy access to fossil water in the Sana'a Basin. The basin, however, is expected to be depleted before 2020, with no realistic alternative supply in sight. The Trans-Mediterranean Renewable Energy Cooperation (TREC) proposes a sustainable supply scheme by desalinating water with the waste heat of solar thermal power plants at the Red Sea and using the power for pumping the water to the elevation of 2,500 meters, where Sana'a is located. The solar technology is available. First cost estimates are encouraging. TREC has started negotiations with Yemenite authorities on defining and financing a feasibility study. A project with a desalination capacity of nearly 1 billion square meters per year would be sufficient to serve the Sana'a region and generate cost reduction of solar thermal energy for desalination and power to below-2004 costs of fossil-fuel electricity. At the November 2004 "Arab International Conference of Solar Energy Applications" in Tripoli, TREC presented its proposals in four (out of seven) plenary talks. In two follow-up meetings with Libyan authorities, TREC was urged to create a Middle East and North Africa (MENA) solar energy R&D association, MENA-SUN. The Libyan government has offered to support this effort, organizing a demand and financing package for solar power and desalination plants of critical volume for cost reduction by economies of scale to compete with oil between US$30 and US$40 a barrel. Oil cost was more than double that (≥US$90 a barrel) as of December 2007.

2.4 Environmental Impacts of Desalination

FINDINGS

The ultimate phase of desalination impact reduction is to phase out of natural gas and into renewable energy. Air pollution will be reduced as gas displaces diesel as a desalination fuel. Emissions, including greenhouse gas (GHG) emissions, from burning gas, will be avoided as the conversion to renewable energy proceeds.

Prudent disposal of hypersaline brines (which always accumulate other contaminants) from desalination plants is central to sustainability. The common solutions of disposal of brines into surface pits or into useless or depleted aquifers become riskier over time. Other water may eventually become contaminated by such brines in a desert climate.

In desert climates, saline waters eventually accumulate metals, metalloids and non-metals, including radioactive constituents that become toxic to organisms and ruinous to agriculture, recreation and marine biota (R. Moran 2013, pers. comm.)

Preventing contamination of Libya's precious water is a big step towards sustainability. When all water is pumped, desalinated, distributed and recycled by renewable energy, sustainability will have been achieved. That will be very profitable for Libya.

RECOMMENDATIONS

- The environmental impacts of desalination, such as hypersaline brines, thermal discharges and air pollution, should be integrated.
- Hypersaline brines should be disposed of prudently.
- Accumulation of salts from all sources—An-Nair irrigation, coastal aquifer irrigation and even "desalinated" water—must be addressed.

2.5 National Sustainable Water Strategy

The sustainable water strategy would balance water conservation, water pricing, GMR water, desalination, groundwater and imports of fresh water. The strategy should calculate the least-cost water expansion strategy. However, the first and least-cost measure for approaching sustainability is conservation of water. The Kufra Water Conveyance scheme will provide an additional 1.68 million cubic meters of water per day to the GMR main spine and will increase the hydraulic capacity of the existing conveyance systems to transport this additional flow by 2015 (SNC 2010).

FINDINGS

Losses have to be tackled continually. Technology improves over the years, so tightening conservation is a never-ending struggle.

Most household water supply is already metered, which is good practice. Most water is consumed by affluent households. Reportedly, more than 60 percent of households do not pay their water bills. This means the government is subsidizing the rich, which is inefficient.
Conservation and loss reduction can be achieved if consumers have to pay the full costs of supply. The poor must not be penalized: Government can efficiently subsidize the average allocation of water to the poor.

Evaporation from Libya's 18 reservoirs and canals is another source of water loss. Each pipeline discharges into a circular earth embankment end reservoir, with a storage capacity of 6.8 million cubic meters at Sirt and 4.7 million cubic meters at Benghazi, to balance fluctuations in supply and demand. In addition, large reservoirs—37 million cubic meters in the Sirt area and 76 million cubic meters in Benghazi—have been built as storage facilities for summer or drought conditions; the big Ajdabiya (900 meter diameter) reservoir and the two end-reservoirs at Sirt and Benghazi are open to the sun and dry wind.

Commendably GMR has at least three 170,000 cubic meters of offline steel-header tanks or reservoirs from which evaporation is negligible.

BOX 3:
AN ALTERNATIVE SOLUTION TO THE WATER SHORTAGE PROBLEM IN LIBYA

In Libya, demand for fresh water is increasing, but the fossil groundwater supply is limited. This water supply situation has become more problematic with rapidly increasing population and low rainfall. The agriculture sector especially was exceeding its traditional supplies. Soon after the discovery of fresh groundwater in the deserts of southern Libya, the Libyan Government made huge efforts to address its water deficit problems, mainly through the implementation of the Great Man-Made River Project to sustain its economy. It began to design and install the hydraulic infrastructure needed to withdraw and transport fossil water to demand sites along its Mediterranean coast where most of the population lives and where the water is used. Fossil groundwater resources are over-exploited to meet irrigation demands as a result of a self-sufficiency policy in food. Rapid development of agriculture, expansion of irrigated areas and over-irrigation practices lead to more depletion of water resources. The supply-driven approach to water management has been unable to deliver water sustainability on the national level. Despite the strenuous efforts made by the government, the country still faces serious water deficits due to continuously increasing water demands beyond the limits of its available water resources. Appropriate actions have to be implemented to reduce agricultural water consumption to avoid serious environmental and economic crises. Reorganization of water consumption patterns to maintain the country's standard of living and to ensure the economic security for future generations is drastically needed. Wheida and Verhoeven suggest the country's water management requires water policy reforms with emphasis on supply and demand management measures and improvement of legal and institutional provisions. Agricultural water policies should be reviewed to minimize local water deficits and to avoid water quality deterioration in the coastal areas. Developing non-conventional sources of water supply needs to be considered. Water institutions lead by professional staff should help draft legislation and take decisive measurements to allocate water among consumptive sectors as well as to ensure the protection of the environment.

Source: Wheida and Verhoeven 2007.

RECOMMENDATIONS

- Meter water consumption; this good practice is well on the way to achievement.
- Phase in full-cost pricing of water along with removal of subsidies.
- Offer the poor low-cost water up to “average” household consumption, with progressively higher rates for water above that volume.
- Arrearages must be minimized if social justice is to be achieved. They must lead eventually to cutoff of water supply above the “average” volume.
- Households repeatedly in arrears should be offered debit cards for payment of water in advance.
- Where brackish wells are available, brackish-water use should be maximized for all

purposes not needing high-quality freshwater.

- Rooftop collection and storage should be encouraged. Mandating building codes for rooftop rain collection will promote conservation.
- Leakage losses from supply pipes and reservoirs are significant and should be kept under control. A program to control leaking equipment must be kept up-to-date.

Minimize evaporative losses from reservoirs and canals by:

- Keeping water retention time as short as possible;
- Evaluating monomolecular layers of retardant;
- Determining if physically covering the water reservoir is feasible;
- Using windbreaks (see: tree planting, below) to reduce wind speed over reservoir surfaces;
- Investigate modern methods of storing water in underground cisterns and caverns, as has been done for millennia in the Middle East with little evaporation;
- Balance irrigation of the most profitable crops with importing grains and other food.

2.6 The Importance of Planting Trees

"Whoever reclaims and cultivates dry, barren land will be rewarded by God for the act."
al-Munawi, Fayd al-Qadir, vi, 39; Haythami, Majmau al-Zawaaid, iv, 67-8.

Trees decrease wind, soil erosion, dust and evaporation while providing shade and food and improving soils. Peri-urban agroforestry seems the most effective system to achieve sustainability goals. Such agroforestry can re-use urban graywater. The combination of 'free' water, short distances to food demand centers, and short distances to sources of employment, is powerfully attractive. The key is to reduce the need for expensive GMR or desalinated water. Integrating trees, especially nitrogen-fixing legumes, with crops can double or triple crop yields. Trees provide shade, wind breaks, and enrich the soil while providing multiple products, including fruits and seeds and fuel wood. Above all, agroforestry systems generate sustainable jobs. Peri-urban agroforestry belts can be expanded so that they conserve and recycle every drop of urban gray water.

The tree species used depend on site conditions, but there are many candidates such as: olives, acacias (and *Faidherbia*), bamboo, Tamarix, Khamt (*Salvatora persica*), Sidr (*Cedrus*), Manna (*Alhagi maurorum*), Myrrh (*Commiphora*, *Burseraceae*), fig trees, (*ficus)*, Giant Tree Aloe (*Aloe dichotoma)*, Joshua Tree (*Yucca brevifolia*), Australia's Soap Tree *(Alphitonia excelsa*), Magaria (*Daisylirion wheeleri)*, Gharqad or Boxthorm (*Lycium)*, many palms (e.g., date palm, doum palm), some species of eucalyptus, and certainly whatever fruit trees will thrive, possibly grapes and pomegranate, apricot, quince, almond, carob (*Ceratonia siliqua*), and walnut. Tamarind and Neem (*Azadirachta indica*) and Jujube are useful in some dry sites. Where gray water is plentiful, breadfruit, jackfruit and mangoes make excellent firebreaks and can be enhanced with fishponds and ducks to reduce pests and weeds.

Goats and other grazers would have to be excluded, as would fuel-wood collectors. Peri-urban tree planting seems more feasible than creating greenbelts to control the Sahara desert. Some wadis (valleys or riverbeds) have sufficient phreatic water to sustain trees. The trees fringing oases can be expanded with protection from fire, goats and wood collectors.

2.7 Importing Water

Norton Rose (2003) predicted a worsening shortfall of water of 1,309 billion cubic meters by 2006–07. There is some mention of a water crisis in Tripoli. Turkey offered to sell water to Libya after Israel rejected a similar offer, according to WorldTribune.com (11 February 2002). Ha'aretz reported (2 April 2003) that the Turkish government was considering an agreement to export 3.5 billion cubic feet of water annually to Libya. Libya discussed importing 100 million cubic meters of water annually from Turkey's Manavgat River in October 2006. Despite the high costs of tanker shipping (possibly in huge plastic bags), Libya may look on water imports as a supplement to desalination. The finance ministry is said to oppose importing water, since its price is 80 U.S. cents per cubic meter, as opposed to 50 cents for desalinated water.

2.7 Recycling and Wastewater

FINDINGS

Treating and reusing wastewater can be expanded to improve conservation.

Libya treats about 40 million cubic meters per year of wastewater. All treated wastewater is used for agriculture.

Irrigation water is essentially free, thus removing any incentive to use it most efficiently. In Israel, 70 percent of municipal wastewater is treated and reused for irrigation. In California, golf courses and crops are irrigated and aquifers are recharged with recycled wastewater.

In the 1970s and 1980s about 40 sewage treatment plants were built near most big cities in Libya, with an aggregate design capacity of 175 million cubic meters per year. Most suffer from lack of maintenance and most are broken or inadequately maintained according to EGA (2006). All Libya's hospital incinerators are nonfunctional, so that toxic and medical wastes are said to be accumulating (or are being disposed of in a manner risky for public health).

Libya has great potential to conserve water by using water-saving toilets, some of which use

brackish water or seawater, as done successfully in Hong Kong.

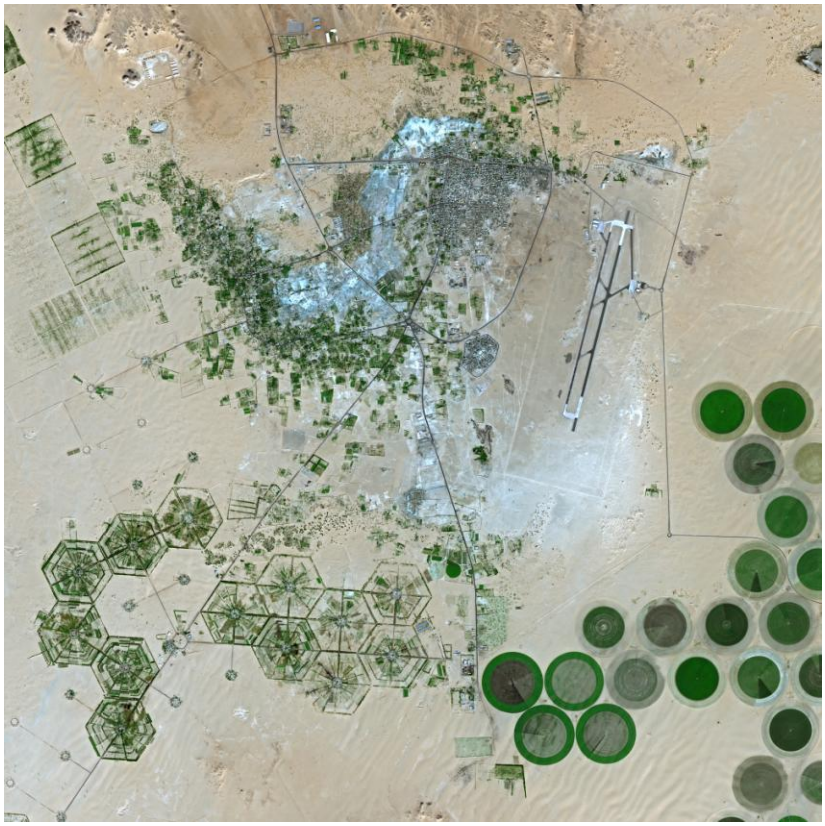
A commendable wastewater collection system serves 97 percent of the population. Treated effluent is currently allocated to fodder irrigation.

RECOMMENDATIONS

- Increase the use of wastewater for irrigation.
- Employ water-conserving toilets using low flush, dual-flush or no-flush compost, brackish water or seawater.
- Ensure efficiency and conservation by constantly adjusting the price the industrial sector pays for water.
- Increase profitability by increasing treated effluent to higher-value and perennial crops.
- Expand peri-urban agroforestry systems based on gray water to boost employment while conserving water and providing food.

The most useful sources include: Rohilla and Dwivedi 2013 and Centre for Science and Environment, New Delhi, “Catch Water Where It Falls-Toolkit on Urban Rainwater Harvesting,” 2013, video.

Satellie image of irrigation circles at Khufa, Libya



2.8 Allocation of Irrigation Water

FINDINGS

Libya imports 75 percent of its food, indicating its harsh climate. Libya subsidizes food imports at more than 2 percent of GDP. Flour subsidies alone approximate the administrative budgets of the Ministries of Justice and Foreign Affairs combined (World Bank 2006a).

Less than 2 percent, or 2.2 million hectares, of Libya is arable. Of this arable land, about 309,000 hectares are irrigated, mainly from groundwater extraction, which is depleting and related to saline intrusion.

Only 2 percent of GMR water is allocated to irrigation at present. Yet irrigation accounts for 85 percent of all water use in Libya. In other words, Libya's irrigated food is not only extremely costly in the use of water and in energy costs for pumping water, but also inefficient and wasteful. One source claims, "At present, no water fees are imposed on [irrigation] water users" (FAO c. 1998). If so, this explains much of the low efficiency and low productivity of Libya's irrigation.

Libya's surface water resources are roughly estimated at 100 million cubic meters (Mcm) per year. Sixteen dams were constructed by 1991, with a total storage capacity of 387 Mcm and an expected average annual volume of water controlled on the order of 60 Mcm. Additional dams are planned to achieve a total storage capacity of 686 Mcm. This disproportion between the average annual runoff and the storage capacity of the dams has the purpose of storing the runoff water of exceptionally wet years.

Groundwater from tube wells in the coastal agricultural zone exceeds regeneration, hence is depleting. In addition, saline intrusion has moved inland as much as 10 kilometers and is increasing in coastal-zone wells. Intrusion of seawater into and under coastal, relatively freshwater, aquifers, already identified in the literature, means management of irrigation return water and coastal groundwater is fundamentally important for sustainability. All quality water eventually picks up salt and other contaminants.

Highly subsidized groundwater prices for irrigation of US$0.03 per cubic meter (LYD 0.048) were set by decree in 1993 and are well below cost, which is on the order of US$0.09 per cubic meter. Massive subsidies to irrigation water have led to inefficient allocation to low-return crops and fodder. Because irrigation of fodder crops is very difficult to justify on economic, logical, conservation and other grounds, it is not pursued here.

RECOMMENDATIONS

- Efficiency of water use must be the sustainability goal. Policies should be put in place to ensure that irrigation efficiencies are as high as possible. (Environmental Law 15 specifies in Article 41 (Para. 4) that irrigation must use less water and must boost efficiency).
- Irrigation water must be allocated only to the crops with the highest returns. Consideration should be given how best to balance irrigation of dates, citrus, vegetables and olives, which are profitable, against irrigating grains, which are much less so right now.
- Consider reducing water subsidies and raising irrigation water prices towards the costs of production.
- In the near future, expansion of GMR water, powered by renewable energy, could be allocated to irrigation. The added benefit would be in job creation, both unskilled and skilled, to manage the irrigation technology.
- The long-term issue of progressive contamination of all waters and irrigated soils in a deserted climate must be a central management focus (R. Moran 2006, pers.com.).

2.9 The Soil Resource

Plants thrive in water without soil; plants die in soil without water. Of course soil is a valuable natural resource in many countries, but soil is useful only to the extent water is obtainable. It is almost immaterial whether or not desert soils are fertile. Water is the over-riding limiting factor. If water is available from whatever source – rain, GMR, desalination, irrigation — practically any soil can be made adequate by the addition of organic matter, limestone and fertilizers. Libya is well endowed with limestone hence its sizeable cement production. Dolomite (calcium and sulfate) is available too. The oil industry has diversified to a certain extent into the downstream production of urea and ammonia. Libya's potash deposits at Marada-in-Sirtica have been exploited for decades. Tripolitania's phosphate deposits are well known although much phosphate is now imported from nearby Tunisia. Tunisia is the world's fifth biggest phosphate producer and 25 percent of the country's economy is based on the phosphate industry. Thus, Libya has access to calcium, sulfur, nitrogen, potash and phosphate, which are not major constraints. Organic matter should come from composting and agricultural wastes. But as mentioned, soil nutrient supply is relatively unimportant compared with water availability. This fact reinforces the priority for Libya to convert its water supply to some semblance of sustainability by means of conservation and efficiency, all powered by solar energy.

2.10 Domestic Grain Production vs. Imported Grain

FINDINGS

About 25 percent of Libya's grain demand is satisfied domestically. What is the best balance between domestic grain and imported grain? Since it takes 1,000 metric tons of water to produce one metric ton of grain, importing grain is the most efficient way of importing water. Grain is "concentrated water." One metric ton of imported grain implies importing the equivalent of at least 1,000 metric tons of water. But the world grain market has entered a period of price volatility, mainly due to climate change, which seems likely to worsen. 2013 U.S. corn exports are poised to drop to the lowest level in over 40 years, falling below wheat exports. Harsh weather across the world in 2012 led to low grain yields and a hike in prices. Total reliance on global grain imports may not be the answer. As Lester Brown (2006) warned:

> The 2006 world grain harvest fell short of consumption by 61 million tons, marking the sixth time in the last seven years that production has failed to satisfy demand. As a result of these shortfalls, world carryover stocks at the end of this crop year dropped to 57 days of consumption, the shortest buffer since the 56-day low in 1972 that triggered a doubling of grain prices. World carryover stocks of grain, the amount in the bin when the next harvest begins, are the most basic measure of food security. Whenever stocks drop below 60 days of consumption, prices begin to rise. It thus came as no surprise when the U.S. Department of Agriculture (USDA) projected in its 2006 world crop report that that year's wheat prices rose by 14 percent and corn (maize) prices rose by 22 percent over last year's.

Unfortunately, grain is increasingly allocated to agrofuels, and climate change may be starting to impair grain harvests so that prices for food grain have begun to soar. In 2008, food riots broke out in Morocco, Yemen, Mexico, Guinea, Mauritania, Senegal and Uzbekistan. Pakistan reintroduced rationing for the first time in two decades. Russia froze the price of milk, bread, eggs and cooking oil for six months. Thailand planned a freeze on food staples. After widespread protests in Indonesia, Jakarta increased public food subsidies. It looks as if only the richest nations will be able to purchase internationally traded food and such food will be increasingly expensive and scarce.

In seven of the last eight years world grain production fell short of demand. By early 2008, wheat exceeded the US$10 per bushel level for the first time ever; corn (maize) exceeded US$5 per bushel, close to its historic high; and soybeans prices reached US$14 per bushel, the highest price on record. These prices are likely to double in a few years. As continuation of these price trends seems likely, Libya will have to allocate more of its budget to food imports. In the future, assuming Libya is achieving sustainability in water, the balance will have to be between having money to purchase world-market grain (the rational choice today), or having some domestic grain production. When Libyan water becomes fuelled by renewable energy, domestic grain production will become much more economical.

RECOMMENDATIONS

- Domestic grain production should be determined by the sustainability of the water supply.
- Future world grain shortages and price rises suggest that Libya needs to accelerate its priority for sustainable water.
- While working towards sustainability, planners must strike a balance between domestic grain production from water derived from renewable energy versus reliance on the global grain market.
- Perennial crops protect the soil for longer than annual crops, thus reducing water loss from runoff. Annual grain crops can lose five times as much water and 35 times as much nitrate as perennial crops.

2.11 Achieving Efficient Irrigation

FINDINGS

Irrigation efficiency has been increased with drip irrigation and micro-sprinklers, which achieve water use efficiencies of 95 percent, compared to efficiencies of 60 percent or less in flood irrigation. Good practice shows that on-farm water productivity generally doubles as soon as drip irrigation is phased in. Drip irrigation cuts water use by 30–60 percent while boosting yields by up to 50 percent. Libya's State of the Environment report 2002 depicts the least-efficient steel-beam irrigation system spraying the sky with valuable freshwater above alfalfa and orchards.

Micro-irrigation was developed in the 1960s and has spread rapidly to cover an estimated 2.8 million hectares worldwide, a 50-fold increase over the last 20 years but still only about 1 percent of the world's irrigated area. The potential for expansion is enormous.

RECOMMENDATIONS

The most profitable intervention for EGA is to persuade the Ministry of Agriculture to hasten the phase-out of wasteful irrigation technology and to accelerate drip and other efficient types of irrigation. EGA and the Ministry of Agriculture could combine forces with the Ministry of Economics to phase in full-cost water pricing and phase out subsidies, except for the very poor. EGA can regulate irrigation to foster these two efficiency transitions. Or EGA can use the Environmental and Social Assessment (ESA) process to reduce wasteful irrigation technology and promote only the most efficient irrigation technologies in new systems.

Over the long term, the potential for salinization of land irrigated by An-Nair waters needs to be addressed. Conjunctive use of surface and ground water delays salinization, so must be pursued.

2.12 National Groundwater Policy

FINDINGS

A National Water Policy would scrutinize the inescapable "cost-of-water equation" through:

- Conservation, recycling and full-cost pricing of water;
- GMR water;
- Desalination water;
- Importation of water.

Conservation is the top priority and is a continual process forever. Water conservation technology improves steadily, and what is not economical to conserve this year may be economical next year.

GMR water depletion rates and pumping costs change through the years, hence GMR water costs will vary.

Desalination costs are gradually falling as technology improves and as solar pumping displaces pumping based on hydrocarbons.

Imported water costs rise with the rising cost of tanker transport and with water depletion rates in the exporting country. Turkey, for example, does not have unlimited supplies of water to export, and its own domestic use is burgeoning. Competition from other countries to import Turkey's water will increase prices further.

Irrigation circles in the Libyan desert

RECOMMENDATIONS

An important first step in developing a realistic groundwater policy is for governments to commission transparent, credible, unbiased assessments of the long-term rate of recharge for every groundwater basin or aquifer. This establishes the limit of sustainable use.

The second step is for all concerned parties—scientists, farmer and community groups, and government agencies—to devise a plan for balancing pumping with recharge.

Transparent water budgets are needed for all significant users. If current pumping exceeds the sustainable limit, achieving this goal means pumping reductions. Artificial recharge does not seem possible in Libya (Postel 1999).

Diversification of water supplies is essential for reliability in Libya; hence all four sources need to be addressed simultaneously.

The National Water Policy should adjust the balance between each of the four sources at least annually.

2.13 Sustainability of Food Supply

FINDINGS

Most of Libya's oil profits go towards increasing food imports for its growing population. At present, it makes sense to export abundant and expensive oil and gas for foreign exchange to enable Libya to import 80 percent of its food. But that has to change if Libya wants to become sustainable.

Libya averages 1.4 million metric tons of imported wheat a year. Flour and grain represent the import of "concentrated water," as it takes 1,000 metric tons of water to produce one metric ton of grain, as mentioned earlier.

Libya's basic exchange of oil for food is rational. International foodstuffs are available and not expensive. However, importing 75 percent of a nation's food requirements has an element of risk. In addition, importing so much food and subsidizing it so heavily decreases job creation within Libya. As noted in the previous section on the balance between imported and domestic grain, world grain markets look set to tighten substantially, and the international grain price is likely to soar.

Although it would not be economical for Libya to aim for self-sufficiency in food, some balance would be beneficial.

RECOMMENDATIONS

The following steps will encourage more self-sufficiency in Libya's food supply.

- Adopt efficient irrigation practices outlined in previous sections.

- Phase down the water and electricity subsidies for agriculture. Once costly irrigation water subsidies are phased down, agriculture will greatly improve in efficiency. Full-cost pricing of water and energy would, by themselves, improve Libya's food security.
- Add hydroponic agriculture. Much food can be economically produced, partly based on treated and recycled water, in greenhouses surrounding cities. Libya's constraint of sandy soils could be avoided in hydroponics; hence efficiencies in water, energy and fertilizer could become impressive.
- Vigorously promote the use of locally produced compost to increase the moisture-holding capacity of fields and orchards. Compost locks carbon in the soil. Composting buffers crop roots from heat and drought while increasing food-crop yields. By simply increasing organic matter in their fields from 1 percent to 5 percent, farmers can increase water storage in the root zones from 33 pounds per cubic meter to 195 pounds. The best sources of compostable waste are Libya's cities. All green waste now generating methane emissions from landfills should be mandated to transition to green-waste sorting and composting, which could then be distributed to nearby farms (Nabhan, 2013).
- Use renewable-energy desalination water for irrigation or hydroponics. Job creation would be an added benefit.

BOX 4: WATER MANAGEMENT ENTITIES IN LIBYA

The General Water Authority (GWA) was formed in 1972. GWA is responsible for management of conventional water, both surface and groundwater, but not Great Man-Made River water (see below), desalination, or wastewater. GWA acts as a hydrogeologic consultant to the GMR and to parts of the Ministry of Agriculture.

The Great Man-Made River Authority (GMMR) designs, operates and maintains all aspects of the Great Man-Made River projects.

The General Electric Company of Libya (GECOL) promotes desalination mainly for its own use, as do other industrial water users.

The Energy Department designs and maintains desalination plants and is responsible for implementing the GMR.

The Tajura Renewable Energy and Water Desalination Research Center is associated with the National Bureau of Research and Development to research all aspects of desalination.

The Environment General Authority is responsible for water quality.

The Housing and Utilities Department runs domestic water supply well fields, pumps, distribution, chlorination and metering, as well as the construction and operation of sewage treatment plants.

2.14 Government Water Management

FINDINGS

There is no overarching water ministry or authority in Libya responsible for strategic planning or coordination of all aspects of water use and supply. Water management is fragmented (see Box 4). A proposal is circulating to create a water coordination and integrating ministry.

RECOMMENDATIONS

Encourage swift creation of a ministry to oversee water coordination and integration to hasten achievement of Libya's important goal of water conservation.

Sustainable Libya Information Sources: Conservation of Water

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3. CONSERVATION OF ENERGY: OIL, GAS AND RENEWABLES

3.1 Conservation of Energy

FINDINGS

The hydrocarbon sector—oil and natural gas—as the mainstay of the Libyan economy, contributes more than 72 percent of the GDP in nominal terms, 94 percent of export earnings, and 93 percent of government revenues according to the World Bank (2006). Oil production decreases during the 2011 revolution have fast climbed back to pre-revolution levels. In 2013, Libya produced about 1.4 million barrels per day (Mbd) or 90 percent of pre-war levels.

Libya has low production costs (down to US$1 a barrel in places), high-quality oil, proximity to European markets, a well-developed infrastructure, and vast unexplored reserves.

It is odd that the amount of exploitable hydrocarbons remaining is not known with any precision, as much crucial planning should be based on that estimate. Proven reserves — the largest in Africa—will last for at least 20 years, or 60 years at current production rates. (Some authors claim proven oil reserves of 100 billion barrels) Cumulative oil production to date is equivalent to 60 percent of present estimates of recoverable reserves.[6]

Libya is well endowed with oil and gas and has major potential to increase the production and export of both. Oil production is constrained primarily by lack of upstream investment.[7] The revenues from increased production and export of oil and gas could finance job creation, thus reducing the 25 percent unemployment rate, and diversify away from dependence on oil.

Libya has 40-50 trillion cubic feet (tcf) of proven gas reserves (some say 120 tcf). This is expected to rise to c. 70 tcf, as gas reserves have been less explored than oil reserves.

[6] Oil: 39.1 billion barrels of proven reserves, according to OPEC and US DOE (2006); 37 billion barrels, according to Shokri Ghanem, then head of Libya's National Oil Co., (NOC) and 53 tcf of natural gas as of 12 September 2006. NOC claims there could be as much as 117 billion barrels of oil, 51.3 bcf or 1,450 bcm of natural gas (2006).

[7] Libya's six oil terminals and Total's 900,000 FPSO off Al-Jurf, with 2 million tons deadweight from c. 30 oil and gas tankers.

Production exceeds 1.5 billion cubic feet per day (bcf/d) of gas; 50 percent is sold, 30 percent re-injected, 15 percent flared and 5 percent used in-field. Libya's 516 km submarine (to 1,127 meters deep) Greenstream gas pipeline to Europe (Gela, Southern Sicily) exports up to 8 bcm/year. Greenstream's capacity can be boosted to 385 bcf annually from its current 280 bcf. Construction of a second, bigger, Mediterranean pipeline was discussed between National Oil Corporation (NOC) President, Shokri Ganem, and Russia's Gazprom CEO Alexei Miller on 9 July 2008, which is helping Libya upgrade and expand its oil refining capacity.

The Mellitah oil and gas complex near Zwara, west of Tripoli

The Mellitah oil and gas complex (pictured above) near Zwara, west of Tripoli, turned off gas exports through the Greenstream gas pipeline to Sicily on 2 March 2013 after a firefight between security guards, armed groups from Zuwara and Zintan militias. "Gas exports have been completely halted," Mustafa Sunalla, NOC deputy chair, announced on 3 March, but resumed on 8 March. ENI, Italy's largest energy company, operates in Libya in a joint venture with NOC.

To the extent that European consumers are trying to reduce emissions of greenhouse gas, Libya natural gas exports will command a premium, as natural gas emits a fraction of the GHGs from coal and oil.

If Libya's hydrocarbon exports accelerate Europe's switch from coal towards gas, it will be a major benefit in meeting the UN Kyoto treaty targets.

Jana, the official Libyan news agency, reported in February 2007 that India's minister for petroleum and natural gas planned to support Libya's proposed oil pipeline, which would transit from Libya, Sudan and Djibouti and terminate at the Gulf of Aden.

In January 2007 Economy, Trade and Investment Minister Tayeb Safi Tayeb outlined an oil pipeline, a gas pipeline connecting with Tunisia, and a possible joint Libyan-Tunisian oil refinery in the al-Skira region in Tunisia. However, the days of oil are short. With oil exceeding US$100 a barrel during compilation of this book,[8] extraction rates will probably rise sharply.

In any event, Libya has several decades (some say 40 years) to diversify away from oil and become sustainable. Note that one estimate of groundwater depletion is also about 40–50 years. The worst-case scenario is the risk of both oil and groundwater becoming problematic simultaneously. Depletion of oil and groundwater are tightly linked: As groundwater becomes deeper, more energy will be needed for pumping. If groundwater becomes deeper and requires more pumping energy at about the same time that oil is becoming scarce, the problem is stark.

Libya well knows that: *The day will come when oil will run out, and if we wait for that it will be too late*. (New York Times 9/23/2007). Libya's 'several decades' until groundwater and oil become scarce is sufficient time to reach sustainability, but only if it is vigorously and promptly sought as a national priority.

As Libya is so well placed to generate solar electricity, the most sustainable choice is to accelerate the transition to renewables before international treaties force coal, and later oil, to be left unused in the ground. Libya could lead in making Europe carbon-

[8] The price of crude remained relatively steady at about US$20 barrel throughout much of the 1990s. The price slowly climbed to US$30 a barrel in 2001, but soared from 2005 on. The price tripled to over US$100 a barrel in 2008. The crude price was more than US$100 a barrel in 2013 and was thought likely to rise a year or so thereafter. U.S. fracked gas may exert downward pressure on the crude price. In the low-carbon scenario supported by this book (See: 'Conclusion' to this Chapter), demand for crude oil would be significantly lower than it is today, exerting downward pressure on crude prices. The IEA (omrpublic.iea.org/) gives a wide range of estimates. At the low end, oil sands breakeven price of US$65-55 a barrel applies to expansions rather than greenfield projects, which would more likely be at the top end of the range (US$85-105 a barrel).

neutral by massive exports of solar electricity. This plan would be highly profitable for Libya and, at the same time, help the world move towards climate stability. Harnessing Libya's desert would be particularly effective because the sunlight in this area is especially intense: solar photovoltaic (PV) panels in Libya could generate up to three times the electricity compared with similar panels in northern Europe.

Libya's dependence on energy, mainly oil, exports, now 80–95 percent of the national budget, is increasing. Today's production of 1.8 million barrels per day (Mbd) could be boosted to at least 3 Mbd. Libya has already been a net exporter of electricity, with a partial grid connecting it to Tunisia, Egypt and Jordan.

Conservation of energy is important to facilitate the transition to a sustainable economy. Gas flaring of 0.35 billion cubic feet a day wastes a precious nonrenewable resource, harms human health and exacerbates global climate change and desertification.

Non-hydrocarbon exports are negligible and declining. Only the small tourism sector is growing.

RECOMMENDATIONS

- Pursue sustainability as a national priority before groundwater and oil reserves become scarce.
- Maximize production and exportation of natural gas.
- Develop a national program to reduce gas flaring.
- Accelerate the transition to renewables before international treaties force coal and later oil to be left unused in the ground.
- Develop a national program to reduce gas flaring.

3.2 Electricity

FINDINGS

Libya's 5.2 gigawatts (GW) of electricity production, with a peak load of 3.875 GW, is mainly (68 percent) oil-fuelled. Natural gas fuels 32 percent of electricity generation. Nine of Libya's power plants are on the coast. One, the 620 MW West Mountain Gas Station (Eljabel Elgharbi), is inland.

Libya has about 1 million electricity customers. Electricity consumption is about 39 percent domestic, followed by 17 percent industrial, 14 percent commercial, and 12 percent agricultural. State offices and street lighting make up the balance.

Libya's power demand is growing fast (c. 8 percent per year) and is projected to reach 10 GW by 2020. During summer 2004 Libya was hit by widespread blackouts as power

plants could not keep up with demand. To prevent future blackouts and to meet surging power consumption, Libya's state-owned General Electricity Company (GECOL) planned to invest $3.5 billion through 2010, building eight new combined-cycle and steam-cycle power plants. Before the 2011 Revolution, construction had started at a couple of the new plants because GECOL has serious financing issues due to heavily subsidized electricity prices (around 0.02 LYD per kilowatt-hour; consumers pay the equivalent of 2 U.S. cents whereas the production costs exceed 3 U.S. cents, and arrearages (only 40 percent of Libyans pay their electricity bills).

GECOL knows that much electricity is wasted because 40 percent of consumers do not pay, and electricity prices are kept artificially low: electric power is 60 percent subsidized. This situation has led to over-consumption, especially for air-conditioning. Subsidies for electricity and gasoline undermine conservation and sustainability. Transportation fuels also are subsidized, further reducing incentives to conserve. Subsidizing electricity will keep killing attempts to phase in wind and solar energy. There are far more efficient means of supporting Libya's poor than through energy subsidies. In any event, such subsidies benefit the rich more than the poor. Ballut & Ekhlat (1998) calculate that conservation could reduce demand by 20 percent or 50 million barrels of oil by 2020.

Solar and wind energy are under-exploited for electricity generation. This is odd as Libya is so exceptionally endowed with solar energy. The total solar energy reaches 7.1 kilowatt hour per square meter (KWh/m^2) per day in places. Most of southern Libya averages over 6 KWh/m^2 per day of global radiation, whereas northern Mediterranean countries receive less than 3 KWh/m^2. Libya has a potential 140,000 terawatt hours per year (TWh/y) of solar electricity (Ekhlat et al. 2007).

Libya has used 50-100 megawatt (MW) wind pumps in many oases since 1940. A 10 kilowatt (KW) model wind pump was installed in 1993. A 25 MW electricity generation wind turbine was expected to enter service by 2008. Libya's wind resources, potentially 15 TWh/y, were mapped and inventoried in 2003. Coastal sites average wind speeds of over 6 meters per second at 40 meters high.

Wind energy has come of age. Global installed wind power now exceeds 100,000 MW. Climate change risks and the desire for energy security have encouraged one in every three countries to generate electricity from wind, with 13 countries now exceeding 1,000 MW of installed wind energy capacity.

Algeria is developing 6,000 MW of solar-thermal electric-generating capacity, to export to the European grid via the undersea cable by 2020. The electricity from this single project is enough to supply the residential needs of a country the size of Switzerland. Tunisia already generates 20 percent of its electricity from solar. Libya's partnership with India to phase into solar energy looks promising.

RECOMMENDATIONS

- Phase out subsidies for electricity, except for the very poor.
- Increase the use of solar and wind energy for electricity generation, especially for water pumping and desalination.
- Define the scope of solar and wind-powered pumps to extract water.

3.3 Sustainable Energy

FINDINGS

The paramount consideration for environmental sustainability is the amount of energy needed to ensure adequate supplies of freshwater, whether fossil water or though desalination. Both sources are very energy-intensive. This fact emphasizes Libya's two paramount needs, first for stringent water conservation and second for reducing the cost of water through use of solar energy.

Reducing wastage of water and reducing the hydrocarbons needed to pump GMR water are possibly the most important elements of Libya's approach to environmental sustainability. The more energy allocated to securing freshwater, the less will be available for export and earning foreign exchange.

An array of Libyan solar collectors

Major oil consumers claim renewable energy is not yet fully competitive with fossil energy. That is mainly because fossil energy externalizes major environmental costs (e.g., sulfur pollution, acid rain and GHG emissions). The regulatory, technological and commercial trends are all on the side of renewables.

Biomass, cellulosic alcohols, charcoal, biogas, and geothermal do not seem to have great potential in Libya. As Libya is 88 percent desert, solar energy is the most promising renewable, followed by wind energy.

RECOMMENDATIONS

- Now is the time to start the transition to renewables if sustainability is sought in a few decades.
- Efforts should focus first on solar energy, then on wind energy.

3.4 Solar Energy

FINDINGS

Libya has little solar electricity right now.

The two main types of solar energy are **passive and active.** **Passive solar** includes rooftop hot-water systems that are low tech, low maintenance and low cost. There may be a niche market for solar cookers and solar crop driers. **Active solar** is mainly solar thermal electricity.

In March 2007 Spain inaugurated a 50 MW solar-thermal electricity plant, using molten salt to store heat for nocturnal generation. This plant will soon generate enough electricity for all of the city of Seville—some 180,000 homes. The same plant sited in Libya would generate about twice as much electricity as in Spain because of more intense insolation. Kurokawa et al. (2007) show the feasibility of big photovoltaic systems in deserts.

Some industries can use solar boilers for steam. Solar thermal concentrates sunlight to generate steam from high temperatures (over 800°C) for gas turbines, and then steam powers the co-generation turbines.

Solar electricity has low environmental impact. In densely populated or agricultural sites, the main impact is land use. This need not apply in Libya.

Photovoltaic (PV) electricity is useful for small water-well pumps, isolated uses and small household lighting. PV production has increased 25 percent per year for the past decade and 45 percent in 2005 alone. The costs fall 5–8 percent each year. The price of one watt of solar electricity fell from US$20 in the 1970s to less than US$3 today. Qatar has PV parking meters.

BOX 5: LIBYA'S SOLAR-THERMAL EXPORT OPPORTUNITIES

Libya could replace all energy used for GMR water pumping and desalination with solar-thermal energy, which has the added benefit of producing no greenhouse gases. Libya could also become the biggest seller of sustainable electrical power to Europe in perpetuity. Europe is increasingly uneasy about its reliance on Russia's energy supplies after disruptions caused by disputes between Moscow and neighboring states such as Belarus and Ukraine. Europe is actively seeking to diversify away from reliance on Russia and away from fossil fuels. Libya fits both criteria admirably. Greenhouse gas-free electricity would command a premium from European consumers. The electricity can be transmitted by submarine high-voltage direct current (HVDC) to Europe.[a] Libya receives the almost optimal sunlight of 3000 kWh/m^2 at 23°N latitude, which is excellent for base-load generation. Solar-thermal is competitive with oil at US $60 a barrel; oil was selling for nearly US$100 a barrel in early-2013. Germany's Ministry for Environment approved funds for two important studies in 2004, one on the potential of concentrated solar energy in countries around the Mediterranean and the other on transmission of clean power from the Mediterranean and North Africa to Europe. The study is led by the German Aerospace Center, and the Trans-Mediterranean Renewable Energy Cooperation (TREC). In 2006 the German space agency made presentations and proposals on solar-thermal exports to Libya's EGA and the government in Tripoli. It is in Germany's interest to finance Libya's solar-thermal for the following reasons:

- Only 254 x 254 km of Libya's desert could meet total world electricity needs.
- The total electricity needs of the 25-member European Union could be met from 110 x 110km.
- Germany's total electricity needs of 500 TWj/yr could be met from 45 x 45 km.
- Since 1997 the Maghreb has been transmitting 1.5 TWH/yr by submarine cables.
- Libya and Tunisia have been interconnected at 630 kV since 2003.
- More than seven submarine cables transmit power or are under advanced construction across the Mediterranean, mainly by direct current.

The 423 km HVDC (200 kV) submarine line between Corsica, Sardinia and Italy has been transmitting 300 MW reliably since 1967.

Sources: May 2005, Mariyappan and Anderson 2002, Muller-Steinhagen and Nitsch 2005, Muller-Steinhagen and Ruhter 2005, Broesamle et al. 2001, Mills and Dey 2001.
Note: a. Direct current (DC) electricity can be efficiently exported to Italy and other places in southern Europe, thus contributing to the European grid. In the future, derivatives of electricity such as hydrogen (and possibly methanol) may be sold further afield, according to IPCC (2007)

The biggest PV system at the moment is in cool, gloomy Leipzig, generating at €3.25 per watt. Replicated further in the northern Mediterranean, for example in sunny southern Italy, this would correspond to electricity prices 15 U.S. cents per kWh, already less than what the average consumer is paying. Replicated on the southern Mediterranean to capture Libya's exceptionally intense solar energy, the price would plummet to less than 10 U.S. cents per kWh.

PV rural electrification began in 2003. Libya's PVs are growing in size and number,

exceeding 690 KW in 2006. PV has powered cathodic protection of the Dahra to Sedra oil pipeline since 1976. PV is widely used to energize communication repeater stations; nine of Libya's 100 repeater stations were PV energized by 1997, and four of these were still running as of 2007. El-Agailat's irrigation pumps have been solar powered since 1983. Many oases now have PV-powered water pumps. More than 6,000 domestic PV-solar heaters have been built since 1980. Now Libya commendably reaches 99 percent of its population with electricity. GECOL has valuable experience is rural electrification based on PVs in 340 remote villages and hamlets. PV is lower cost for such villages than both grid connections and the diesel option. GECOL's planned to build a 1 MW PV grid-connected pilot plant in 2007, and possibly 10 more later on. This schedule needs to be replicated and accelerated. The experience is there; PV is proving to be reliable, with very low running and maintenance costs, and is highly cost-effective. The need now is to ramp up PVs, especially for water pumping. Standard PV packages of 10 KWh/day should be widely deployed. PV displacement of diesel should be a national priority.

Libya's huge potential for solar-hydrogen storage of energy is mentioned in the literature (Broesamle et al. 2001, May 2005, Muller-Steinhagen and Ruhter 2005). See Box 6.

BOX 6: STATUS OF SOLAR ENERGY PLANS

Libya is nearly ready to issue tenders for two new solar plants and aims to get a fifth of its power from renewable sources by 2020, while its sunshine could one day supply all of Europe, according to the Libyan electricity minister (Reuters 11 April 2013). "In 20 to 30 years Libya may run out of oil, therefore we plan to replace it with renewables," stated Electricity Minister Ali Mohammed. "My projection is 20 percent (renewable electricity) by 2020, mainly through solar energy." If Libya uses less than 5 percent of the Libyan Desert, annually it could power the whole of Europe." The European Commission supports working with North African nations to develop their vast wind and solar potential and eventually connect it to the European grid. It supports Desertec, a German consortium set up in 2009, which envisages Europe will import up to a fifth of its electricity from solar and wind parks in North Africa and the Middle East by 2050.

RECOMMENDATIONS

- Replace all GMR water pumping and all desalination energy with solar thermal.
- Export sustainable, greenhouse gas-free electrical power to Europe.

BOX 7: LIBYA'S OPPORTUNITIES FOR ENERGY CONSERVATION

1. Water conservation is paramount because desalination consumes a huge 2,001,000 megawatts per hour (*fide*: SoE 1995).
2. Building codes to reduce energy and water use, especially in new offices and hotels. Libya's 5,000-year-old mud brick buildings are blissfully cool without air conditioners. Insulation and shade (from trees) are important and low-cost elements of conservation (Ealiwa et al. 2000).
3. "Smart meters" price electricity during peak demand (often for midday air conditioning) when solar panels produce their greatest power output.
4. Phase in full-cost pricing (remove subsidies) while expanding low-cost lifeline rates for the poor. Introduce debit cards for further power (these can be subsidized). Tighten up on arrearages of big consumers.
5. Find the most efficient balance of fossil vs. renewable energy: solar cells and wind turbines. Are winds strong and stable off Libya's coast? Desert winds are very strong in places. Offshore oil rigs converted to wind turbines after oil depletion as the existing stable platforms cut costs by one-third.
6. Any storage ponds of fresh water needed for cleaning should be covered to minimize evaporative losses and reduce the attraction to plants and animals which may be incinerated in concentrated solar infrastructure.
7. Implement appliance efficiency standards for air-conditioners, fans, refrigerators and water heaters. Automatic shut-offs when not in use should become mandatory.
8. Keep raising vehicle fuel standards.
9. Balance air freight, fast ferry freight and the potential for rail.
10. Determine the optimal balance between private automobiles and mass transit. Tripoli's 20-passenger minibus is a good solution if systematized and made safe and on schedule. Subsidize free transit for the poor?
11. Institute pollution control, especially for offshore oil.

The Pros and Cons of Concentrating Solar Power (CSP)

Solar thermal or concentrating solar power (CSP) is a commercially available technology that uses direct sunlight and mirrors to boil water and drive conventional steam turbines. Although it may be argued that the projections for CSP plants and the projections for "export solar" are too optimistic, the high levels of oil and gas use in power generation in the 2005–2010 period are not sustainable. If solar CSP technology can fill the gap, there are important implications for Middle East and North African countries, regardless of whether power is exported to Europe. Hermann Scheer, President of Eurosolar (The European Association for Renewable Energy) stated that if the aim were to enable Saharan countries to make the transition to electricity generation from renewable energy sources, the plan would make sense. A big reduction in the cost per kWh of CSP offers not only a possibility for the Saharan countries, but for all countries that have significant amounts of desert land. "Clean Power from Deserts" provides some useful technical analysis, which has been obscured by the political and public relations context including the discussion of electricity export.

In July 2009, a group of 11 leading European firms and one Algerian firm, led by Munich Re and including Deutsche Bank and Siemens, announced that they were going to craft a strategy and funding proposal to develop solar thermal generating capacity in North Africa and the Middle East. Their proposal would meet the needs of the producer countries and supply part of Europe's electricity via undersea cable. This initiative, known as the Desertec Industrial Initiative, could develop 300,000 MW of solar thermal generating capacity—huge by any standard. Caio Koch-Weser, then vice chair of Deutsche Bank, noted "the Initiative shows in what dimensions and on what scale we must think if we are to master the challenges from climate change." Even before this proposal, Algeria—for decades an oil exporter—was planning to build 6,000 MW of solar thermal generating capacity for export to Europe via undersea cable. The Algerians note that they have enough harnessable solar energy in their vast desert to power the entire world economy. This is not a mathematical error (Earth Policy Center 2002).[9] The German government was quick to respond to the Algerian initiative. The plan is to build a 1,900-mile high-voltage transmission line from Adrar, deep in the Algerian desert, to Aachen, a town on Germany's border with the Netherlands.

Detractors claim the Desertec project is a mirage.[10] If the aim were to enable the Saharan countries to make the transition to energy generation almost completely from renewable sources, many would fully agree to the Desertec plan. The European Union would make both an essential contribution towards stable economic and social prospects for the southern Mediterranean countries and to fighting climate change. Given their solar and wind power potentials, these countries would even be able to move completely to renewable energy for their electricity supply within less than 20 years. The beneficial effect to their economies would be much stronger compared with exporting power to Europe.

There are several essential reasons why the Desertec concept for large-scale solar power exports to Europe has to be updated. The expected costs are underestimated, while the possibilities to save costs when building the high-voltage direct current transmission lines are overestimated. Even if the plan for supplying 15 percent of the European Union's electricity demand with a supposedly €400 billion investment would be feasible, it would not be less costly than generating power from renewable energy within the European Union itself. In Germany alone, since 2000 – that is within a decade – the percentage of electricity generation from renewable energy has increased nearly 20 percent, while the volume of investment has been more than €80 billion. The costs per generated kilowatt-hour keep falling.

[9] www.earth-policy.org/images/uploads/book_items/WOTE_Fact_Sheet.pdf.

[10] Sources: Desertec report on Clean Power From Deserts (WhiteBook, 4th edition), Figure 6 page 33. www.spiegel.de/international/europe/the-desertec-solar-energy-project-has-run-into-trouble-a 867077. html2012. Desertec and Medgrid cooperation on solar energy in North Africa and the Middle East IP/11/1448; 24/11/2011.

Desertec underplays the new technological possibilities for storing solar and wind power within Europe. Expansion of renewable energy within Europe requires decentralized dispatchable power generation that can be fed into the grid more than base-load power stations in the desert.

Decentralized electricity generation from renewable energy, 100 percent cost effective and flexible, will be possible in Germany soon. One truly major project, a counter to the Desertec concept, has been in full operation since 2000. Germany's Renewable Energy Sources Act has brought about hundreds of thousands of investors since enactment.

Desertec advocates must also answer another crucial question. Where will the value added of renewable energy occur in the future? There is a fundamental difference depending on whether renewable energy is produced in a decentralized manner with the value added distributed to the decentralized producers, on the one hand. Or, on the other hand, whether it is produced by big utilities in a few big power stations concentrating the monopolistic value added.

Even non-economists have, on occasion, rightly perceived that mineral extraction revenues are not wholly current income. A small and developing country such as Libya could thus legislate as early as 1963 (when it first began to extract petroleum in commercial quantities) that at least 70 percent of petroleum proceeds had to be allocated to development. The perception was strong at the time that this unique wealth truly belonged to future generations and should not be squandered on current consumption.

The main factors for profitable solar energy are sites with much insolation, adequate cleaning water, fewer dust storms and shorter power transmission lines to demand centers. When stability fully returns to Libya, it will be a prime candidate.

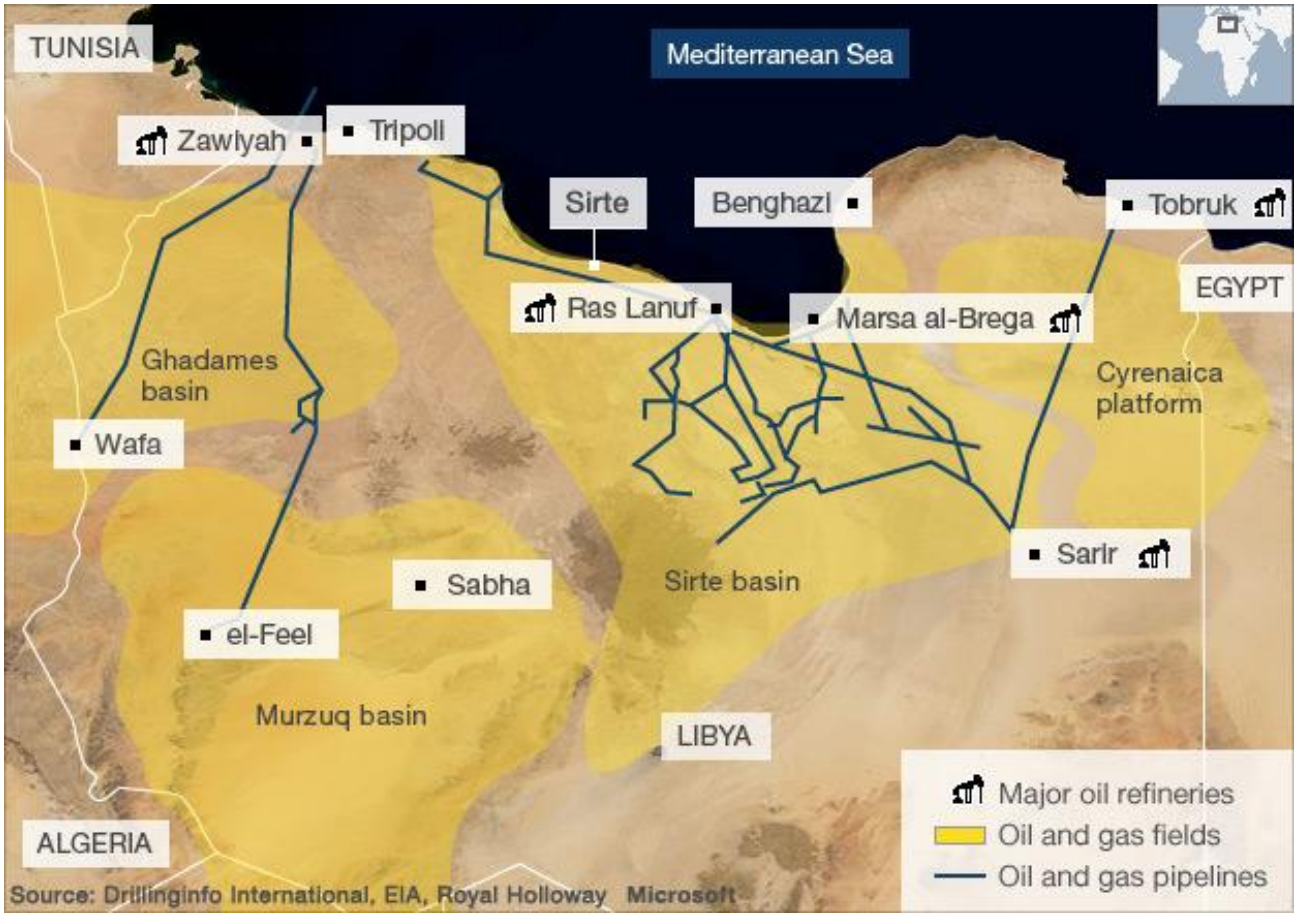
Prudent pre-construction solar energy siting should consider migratory paths to prevent bird and bat deaths, and post-construction maintenance should include inspection for bird and bat corpses. Such data should be widely shared given the newness of the impacts of solar and wind generators.

Libya is aware of the importance of renewable energy. The Renewable Energy Authority of Libya (REAOL) and the World Bank organized a workshop, "Renewable Energy and Energy Efficiency," in Tripoli in April 2013. The workshop promoted the integration of renewable energy technologies (solar and wind) with the National Electricity System of Libya, and explored means of energy efficiency implementation measures, with a particular focus on the building sector. Libya's recommended target is a minimum of 10 percent of electricity to be generated by renewable energy by 2025.

Libya Seeks to Update Oil and Gas Law

Libya is drafting an oil and gas law to reorganize the governance of a sector that has become a battleground between conservatives who want to tighten conditions for foreign companies and reformers trying to open up the economy. "We have to agree on a law suitable for the era," said Shokri Ghanem, then chairman of Libya's National Oil Corporation in an interview with the *Financial Times*. "We [also] need to create a consensus on the new organizational framework for the industry and on the issue of governance." Mr. Ghanem was considered a reformist, who had been pressing for political and economic liberalization.[11] Mr. Ghanem was adamant the law will not contain unpleasant surprises for foreign companies seeking to tap Libya's proven oil reserves totaling 43.6 billion barrels, the ninth largest in the world.

Libya's Oil and gas fields, oil pipelines, and major refineries.



[11] Minister Ghanem's body was found floating in the Danube near Vienna in April 2012.

3.5 Wind Energy

FINDINGS

Wind is the world's fastest-growing energy source, with an average annual growth rate of 29 percent over the past 10 years. In contrast, over the same time period, coal use has grown by 2.5 percent per year, nuclear power by 1.8 percent, natural gas by 2.5 percent, and oil by 1.7 percent. Worldwide wind power production has increased 25 percent per year over the past decade and now exceeds 60,000 MW.

Wind power is the cheapest form of new electricity, costing between 4 and 7 U.S. cents per kilowatt-hour and falling fast. Overall the cost of wind power has decreased by nearly 90 percent since the 1980s, to 4 U.S. cents or less per kilowatt-hour in prime wind sites. In some markets wind-generated electricity is already cheaper than electricity from conventional energy sources. The cost of wind power has fallen because of advances in technology, declines in the costs of financing wind projects, and the economies of scale of turbine and component manufacturing and construction. Modern turbines are taller and have longer rotor blades than the turbines of 20 years ago, allowing them to produce up to 200 times more power.

Since the "fuel" for wind power is free and unlimited, 75–90 percent of the costs of generating electricity with wind lie in manufacturing and constructing wind turbines and connecting them to the grid. The remaining costs are primarily turbine operation and maintenance, land-use royalties and property taxes (Florence 2006 EPI). Unlike solar power, wind turbines do not need frequent cleaning with fresh water.

In general, wind power development creates low impact. However, that is not always the case so pre-construction planning is essential to minimize bird and bat deaths by prudent site selection. Such studies are low cost and can reduce conflicts with radar and airports. (Ledec et al. 2011; Molvar 2008). Shut downs for operational maintenance of both wind and solar generators can effectively be scheduled during predictable migration of birds each year.

North African countries are beginning to develop wind power and have installed 310 MW. Egypt and Morocco have installed 150 and 60 MW of wind capacity, respectively. The prices of wind-generated electricity are more stable and not subject to the price volatility of fossil fuels. Wind power supports local economic development since the jobs, royalties and tax revenues from wind-generated electricity production tend to stay in the community. Thus, wind energy (turbines), especially on the Mediterranean coasts and offshore, is promising. Since wind is inexhaustible it offers long-term energy security that electricity derived from non-renewable fossil fuels cannot. Wind water pumps at the farm level are in use with potential for expansion, but climate change does not augur well for desertic food production.

Wind-generated electricity should be important for Libya because the electricity can be transmitted from where the winds are strongest to where the energy is needed, namely in groundwater pumping and desalination. In addition, wind electricity complements solar-thermal electricity by generating more power at night after the sun has set.

While solar-thermal electricity is likely to be the most profitable of Libya's exports, diversification would be prudent by means of a modest component of wind electricity in the national energy mix.

RECOMMENDATIONS

Wind-generated electricity should be a component of Libya's national sustainable energy strategy.

3.6 Gas Flaring Policy

FINDINGS

Libya's EGA has an opportunity to regulate gas flaring. Gas is too valuable a commodity to permit unnecessary losses by flaring. In addition, flaring spreads ultra-fine carbon particles over extensive areas. In the Niger Delta, for example, soot has one of the most damaging impacts on human health, while also depressing agricultural yields.

There may be minor exceptions to a no-flaring policy, such as limited use during commissioning.

The Shell Petroleum Development Company of Nigeria Ltd., was ordered to cease flaring gas in the Iwherekan community in Delta State by April 2007 by the Nigerian High Court. The court ordered Shell's managing director in Nigeria and the Nigerian Minister for petroleum resources to appear in person before the judge in open court in Benin City with detailed plans for putting gas flares out by that date.

RECOMMENDATIONS

EGA may want to adopt a mandatory policy of zero gas flaring to be complied with in all environmental assessments from now on. Carbon neutrality should be the goal in all development projects.

EGA's policy should foster re-injection of produced gas in wells that can be commercially exploited later, when they become most profitable. If gas is re-injected into a depleting oil well, it can boost pressure and oil recovery. The composition of the gas should be determined as part of the ESA, especially so that sulfur (H_2S) content becomes known to prevent re-injection of sulfur-containing gas from souring the oil wells. Gas often starts off without sulfur and becomes sulfurous only at a later stage.

3.7 Conclusion: Regulations Internalizing GHG Emissions Costs

Unless fossil fuels pay their true costs, people will just keep burning them. This book asserts that most (c. two-thirds) of known fossil fuel reserves remaining in the ground will have to stay there — safely buried and unused — in order to reduce climate risks to a prudent level. Between 60 and 80 percent of coal, oil and gas reserves of publicly listed companies are 'unburnable' if the world is to have a chance of not exceeding global warming of 2°C. Technically, TEEB (2013) calculates that the world's currently indicated fossil fuel reserves equate to 2,860 billion metric tons of carbon dioxide, but that just 31 percent could be burned for an 80 percent chance of keeping below a 2°C temperature rise if the world is to meet existing internationally agreed targets to avoid the threshold for "dangerous" climate change. If the agreements hold, these reserves will be unburnable — hence worthless — leading to massive market losses for fossil fuel owners and others. But stock markets are betting on countries' inaction on climate change. Stock markets worldwide are cumulatively valuing coal, oil and energy companies' huge reserves of fossil fuels as if they will all be burned. This so-called "carbon bubble" is the result of an over-valuation of oil, coal and gas reserves held by fossil fuel companies. There is either a carbon bubble with investors and companies wildly over-speculating on the value of owning fuel reserves that can never be burned, on the one hand, or on the other hand, nobody believes there is the remotest chance that the world will stick to the limits on fossil fuel use congruent with preventing dangerous levels of global warming.

Most unpriced natural capital costs are from greenhouse gas emissions (38 percent), followed by water use (25 percent), land use (24 percent), air pollution (7 percent), land and water pollution (5 percent), and waste (1 percent). Of the top 20 region-sectors ranked by environmental impacts, none would be profitable were environmental costs internalized. Externalizing costs are the main way businesses privatize and boost their profits, while increasing costs to society. Industry forces us, society, to pay for the cleanup of industrial pollution and the damage, public health, asthma, and cancers that it causes, while the corporations that pump it out increase their profits because society as a whole pays the bill for the externality of pollution.

The world is now realizing that fossil fuels are not the cheapest. If the fossil fuel subsidies are phased out and if external costs are included in their price (human health effects of air pollution and water pollution from burning and mining of fossil fuels are presently paid by the public entirely without any of the health effects being charged to the fossil fuel industry) then fossil fuels would be seen as totally uneconomic (Victor 2009, HSBC 2013). The public picks up the health costs and the effects of climate change. The increased climate extremes are already causing expensive events. Not one of the world's top industrial sectors would be profitable if it were paying its full costs.

Lord Stern (Carbon Tracker 2013) said that far from reducing efforts to develop fossil fuels, the top 200 companies spent US$674 billion (£441 billion) in 2012 to find and exploit even more new resources, a sum equivalent to 1 percent of global GDP, which could end up as "stranded" or “valueless” assets. Fossil fuel corporations in 2012 alone spent US$674 billion to find and develop new potentially stranded assets. Carbon Tracker (2013) concludes that governments and investors must re-evaluate energy business models against carbon budgets, to prevent a US$6 trillion carbon bubble in the next decade.

Lord Stern said that investors clearly did not believe action to curb climate change was going to be taken.[12] They can't believe that and they also believe that the markets are sensibly valued now.

Estimates differ greatly about when a scenario in which most fossil fuel becomes ‘stranded’ or ‘valueless’ assets will occur. A key moment may come as soon as 2015, at the Paris UNFCCC Climate Summit, when the world's governments have pledged to strike a global deal to limit carbon emissions. In 2015, governments are expected to gather in Paris at the annual United Nations climate change summit to sign a treaty that will commit everyone to action that will achieve this aim.

Fossil fuel corporations, fossil fuel users, governments, institutional investors, regulators, stock markets, fund managers and concerned citizens need to act now. If they wait till 2015 it may be too late. Investors will also be able to consider whether it is better to stay with high-carbon assets, or instead seek new opportunities in businesses that are best positioned to gain in a low-carbon economy. By 2030, renewables will account for 70 percent of new power supply worldwide, according to projections released on 22 April 2013 by *Bloomberg New Energy Finance*, which examined gas prices, carbon prices, the shrinking price of green energy technology, and overall energy demand. Bloomberg found solar and wind beating fossil fuels like coal and natural gas by 2030. But fossil fuels have such a historic grip on the power market

[12] Some investors have started to act. For example, San Francisco’s Board of Supervisors voted in April 2013 to sell off more than $583 million worth of shares in Chevron, ExxonMobil, and some 200 other fossil-fuel companies. This makes San Francisco the biggest city to join the divestment campaign. Seattle was the first of more than 100 US cities city to divest from fossil fuels. University College London follows suit. Similar campaigns are burgeoning in Canada, UK, Netherlands and Australia. Carbon Tacker and the Climate Institute (2013) conclude that Australian and overseas investments in Australian coal rest on a speculative bubble of climate denial, indifference or dreaming. This report shows they do not [take climate change seriously] or are taking risky gambles. Citibank’s Elaine Prior (http://citi.us/agM7hm) agrees. Not being able to predict the future, I cannot state which scenario is more likely. But whatever scenario comes true, Libya is well advised to ponder deeply on these possibilities before it is too late.

that even this projected massive growth won't suffice to achieve sustainability. By 2030, non-renewable sources will still account for half of the world's total power supply, unless prudent action is taken.

Carbon Capture and Storage (CCS)

Carbon capture and storage (CCS) technology could, in theory, allow fossil fuels to be burned in a way that is consistent with the aim of reducing emissions, according to Lord Stern in *Unburnable Carbon* 2013. "Unburnable Carbon 2013: Wasted capital and stranded assets". However, this report shows that even an optimistic scenario for its deployment would make only a marginal difference to the amount of fossil fuels that can be consumed by 2050. Even if CCS is deployed in line with an idealized scenario by 2050, it would only extend fossil fuel carbon budgets by 125 gigatons of CO_2. This is equivalent to 12-14 percent (50-80 percent probability) of carbon budgets to limit global warming to 2°C and to only 4 percent of total global reserves. As the idealized scenario illustrates, CCS will only come online at scale from 2030 onwards, by which point the carbon budget may have been used up, Lord Stern (in *Unburnable Carbon* 2013) summarizes.

> The conclusions for Libya of such all-too-likely scenarios are twofold. First: accelerate the transition to sustainability, especially by powering GMR water and desalination to solar and wind power just as soon as possible. Second, allocate substantial portions of the remaining oil receipts to expedite the export of solar energy to Europe, before Libyan oil depletes in possibly 20 years, or before international climate treaties constrain oil production at an even earlier date. Timing of Libya's transition to sustainability is nothing less than crucial. The agreement expected from the Paris 2015 UN Climate Conference will take effect in 2020, which is also the new (April 2013) estimate by Libya's Electricity Minister, Ali Mohammed, of when Libya's oil reserves will start to run dry. There is no time to waste.

Sustainable Libya Information Sources: Conservation of Energy

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4. CONSERVATION IN TRANSPORTATION

Libyan motor vehicles consumed 36 million liters of fuel in 1992, the latest figures available. Of that total 73 percent was benzene/petrol and 27 percent was diesel. Owing to the specifics of Libya's five refineries, gasoline has to be imported, so its conservation and substitution are important for the economy. Retail gasoline prices were subsidized at about half the Mediterranean average for 2004. Once national agreement has been reached on making transport sustainable, the rest is relatively straightforward. A judicious combination of incentives, grants and standards will make Libya a leader in sustainable transport.

4.1 Balance Mass Transit with Private Vehicles

FINDINGS

What is the best balance between mass transit and automobiles? Reliable and free mass transit could more than offset a phasing out of gasoline subsidies.

Tripoli has no municipal transport. Libya's private fleet of 8- and 16-passenger minibuses is efficient but lacks safety and runs without schedules.

RECOMMENDATIONS

- EGA and the municipalities should regulate fuel efficiency and safety standards of mass transit. This program would be modestly subsidized to reduce car usage, hence air pollution, while preserving oil for export,

- Free mass-transit passes should be offered first to the elderly, the handicapped, the vulnerable and children, then to all poor households.

4.2 Vehicle Fuel Efficiency

FINDINGS

EGA can improve vehicle efficiencies by mandating kilometer-per-liter (km/liter) standards, or by corporate average fuel economy (CAFE) standards for all new vehicles combined with incentives to phase out gas-guzzlers. Environmental Law 15, Article 16, specifically provides for this authority.

The most powerful incentive to improve efficiencies and promote mass transit is to phase out current wasteful fuel subsidies.

China's fuel economy rules are 20 percent tighter than those of the United States, for example. Because Libya currently imports all vehicles, the easiest way to improve fuel efficiencies is for EGA to mandate them as part of the importation permit process.

Tax credits are effective in phasing out inefficient vehicles.

Congestion taxes or time-of-day user road costs are effective in preventing congestion, time and fuel wastage while improving the quality of life and the environment. In view of Libya's pleasant climate, ecotourism will be fostered and air pollution decreased by making ancient city centers car-free, at least during the day.

RECOMMENDATIONS

- Mandate fuel efficiency standards for all new vehicles.
- Phase out current fuel subsidies. Offer mass-transit debit cards to poor households to ensure they are not penalized by the removal of fuel subsidies.
- Offer incentives, such as tax credits, to phase out inefficient vehicles.
- Set annual permits for inefficient gas guzzlers higher than for efficient vehicles.
- EGA should mandate fuel efficiencies on all imported vehicles as part of the importation permit process. Only vehicles with fuel efficiencies better than x kms/liter will be permitted. This regulation should be phased in with the information that such efficiency regulations will be raised gradually and transparently through the years.
- Consider assessing fees such as a congestion tax or time-of-day tax.
- Augment the use of efficient mini-buses, and group or shared taxis (Salem 2007).

Alternate Fuels

FINDINGS

Liquid petroleum gas (LPG), a byproduct of gasoline, has lower carbon emissions than gasoline and is easy to use in vehicles. "bi-fuel" or "flex-fuel" vehicles are now on sale. Many families can use conversion kits at home.

If any of Libya's flared gas or associated gas can be used in vehicles, it would benefit the nation and the environment.

As soon as solar-thermal electricity begins, practically all Libya's transportation should be by electric-powered vehicles or rail.

RECOMMENDATIONS

- Explore and encourage the use of alternate fuels, such as LPG or flared gas.
- Offer a tax write-off for hybrid, electric and solar-powered vehicles to promote their use.
- Encourage the use of zero-emission electric vehicles, powered first by formerly flared gas, then by solar electricity to free-up more oil for export.

4.3 Rail Transport

Rail is the most fuel-efficient form of transport, as it uses the least energy per metric ton of freight or per passenger. One diesel locomotive can move one metric ton of cargo 436 miles on a single gallon of fuel making rail 10 times thriftier even than a new hybrid car. Rail is also the least carbon-intensive form of transport. Solar-thermal electricity facilitates rail links. For liquids (e.g., oil, water), pipelines are often the most cost-effective mode of transport.

Linking Libya's principle ports, Benghazi and Tripoli, is the rail priority. The Railway Project, an ambitious 4,800 km trans-Africa rail network planned to link Tunisia and Egypt, was expedited in 2006. Estimated to be worth US$9 billion, the Railway Project was given national priority by Dr. Baghdad Mahmudi, then Libyan prime minister. The Railway Executive Board is responsible for the implementation of the project. The first two sections of the planned 3,170 km railway in Libya are starting to take shape. The chairman of Libyan Railways Executive Board, Mohammed Abdulssamed Ali, aims at "connecting Egypt with Tunisia by building 2300 km of new railway along the coast."

4.4 Marine Transport

FINDINGS

Libya's reliance on ocean freight, containers and refrigerator ships means the ports and export terminals have to be as efficient as possible.

RECOMMENDATIONS

Efficient ferries would help the transition to sustainability. High-speed catamarans and hovercraft may be feasible, as the slow Malta ferries deter passengers.

4.5 Air Transport

Airfreight is the least fuel-efficient transport method. Libya's most sustainable methods of transportation are marine and rail. Highways come next, while air transport is the most expensive choice.

5. CLIMATE CHANGE

"Recent greenhouse gas emissions place the Earth perilously close to dramatic climate change that could run out of control, with great dangers for humans and other creatures. Only intense efforts to curb man-made emissions of carbon dioxide and other greenhouse gases can keep the climate within or near the range of the past 1 million years."

James Hansen et al., Royal Society, 2007

5.1 Libya and Climate Change

FINDINGS

On World Environment Day 2007, UNDP/Libya emphasized the threat of climate change. All leading scientists rank climate change as one of the world's greatest environmental risks. Stabilization of climate change is one of the world's most urgent needs.

Conservation of water first and oil/gas second are Libya's two most urgent needs. This is best achieved by rapid displacement of diesel pumps, desalination energy and oil-fired electricity generation by wind and solar energy. Libya's single 25 MW wind farm for example will save 80,000 metric tons of CO_2 emission annually. Climate change highlights Libya's sustainability challenge and brings together conservation of water and oil. Climate change unifies Libya's challenge of sustainability.

European demand for carbon-free electricity is enormous because the European Union wants to reduce GHG emissions by at least 15 percent from current levels by 2020. In addition, geopolitical realities argue for reducing Europe's dependence on Russian natural gas, while strengthening economic integration with the Mediterranean region. Libya wants to accelerate the generation of solar electricity to meet rapidly-growing domestic demand, while redirecting natural gas production towards more profitable export opportunities.

While climate change could be devastating for Libya (see Box 8), it is to the nation's benefit to help Europe become carbon-neutral by exporting solar electricity northward. The Mediterranean is now encircled by power transmission lines (Daboub 2002), and about seven submarine power cables, most of them DC, stretch across the Mediterranean. GECOL is upgrading its 220 kV grid to the efficient 400 kV line linking Egypt with Tunisia. This line stretches north to Syria and Lebanon. Libya is linked at 400 kV with the Morocco-to-Spain cable. The submarine DC connection with Italy will greatly facilitate Libya's exports of electricity. Most GHG emissions (c.50 million metric ton equivalent [Mte]) are from electricity generation (38 percent), followed by transport fuel (20 percent) and industry (8 percent). Libya's third undersea fiber optic cable linked with Greece in 2013 at a length of 425 km.

BOX 8: POSSIBLE IMPACTS OF CLIMATE CHANGE ON LIBYA

Libya is at risk from climate change because of current severe water scarcity and high temperatures and because of its generally low elevation with respect to the Mediterranean Sea level. Climate change impacts have not been systematically assessed for Libya, so this section is based on projections.

Rainfall: Climate change may decrease the amount of rainfall, increase the intervals between rainfalls and abbreviate duration of rainfalls. Already dry Libya will become even more arid. Water conservation will become even more necessary.

Temperature: The deadly heat waves around the Mediterranean that killed 18,000 people in 2003 are projected to become the norm if climate change is not stabilized. The number of dangerously hot days is predicted to increase 200–500 percent around the Mediterranean (Diffenbaugh 2007). Higher temperatures boost evaporation rates, thus intensifying aridity. Higher temperatures decrease organic matter in the soils, reducing their permeability and water-retaining capacity. Infiltration rates decline, leading to increased runoff and less moisture availability in the soil profile. This process undermines Libya's already fragile agricultural production.

Sea Level Rise: Much of Libya is low in elevation. Substantial rise in the level of the Mediterranean Sea could therefore lead seawater to flood inland. Storm surges are expected to increase markedly. Much Libyan agriculture is above the lowest-lying elevations but could be at risk. Coastal wetlands are at high risk of submersion. Coastal zone management and protection of vulnerable low-lying sites would be prudent.

Food Production: Is climate change more likely to improve or damage Libya's food production? The higher temperatures and less rain seem likely to make food production more difficult than it is already. Higher temperatures increase water demand of crops while decreasing yields. Pasture quality will decline; fodder production may halt. Only the rich will be able to afford cattle. Water wells in wadis are declining at an alarming rate. This decline bolsters the argument for stringent improvements in irrigation and continual tightening in the conservation of water. Libya's food production should be buffered against climate change to the fullest extent possible. Peri-urban food production based as much as possible on wastewater is likely to become even more cost-effective as climate change starts to bite.

The Effect of Climate Change on Poverty: To the extent that temperatures rise and droughts become more severe, food prices will rise along with water prices. Cooling and energy prices also will rise. Poverty safety nets need to be scrupulously maintained to buffer the poor from climate change. Lifeline rates of water, staples and electricity need to be prudently overhauled and maintained.

Apart from oil depletion, the main constraint on oil use is climate change. In my view climate change may prove to be a more immediate constraint on Libya than depletion. Opinions differ on this crucial point because the stock of oil is not yet known precisely, and extraction rates are volatile. The stock of oil seems large, and extraction rates are still relatively low. However, the risk of climate change is intensifying fast. Stabilizing climate change seems to have become an imperative, not a choice. Governments are running out of time to address climate change and avoid the worst effects of rising temperatures, according to the United Nations International Panel on Climate Change (IPCC).

Concerted international action is needed to reduce greenhouse gas emissions. In May 2007 the IPCC warned that less than a decade remains to tackle rising emissions to avoid the worst effects of global warming. In fact, as little as eight years could be left to avoid a dangerous global average rise of 2˚C or more, according to the IPCC. Because of the 30-year time lag between taking action to curb emissions and those actions having any discernible effect, the lower end of the increase is inevitable even if tough curbs are introduced immediately.

Carbon dioxide emissions between 2000 and 2004 increased at a rate three times greater than in the 1990s, according to the 2007 climate study in the Proceedings of the U.S. National Academy of Sciences. Instead of rising by 1.1 percent a year, as in the previous decade, emissions grew by an average of 3.1 percent a year from 2000 to 2004, the latest year for which global figures are available (Raupach, 2007). This is faster than the IPCC's most pessimistic projections. It is also faster than economic growth, suggesting that the world is not only consuming more energy, but also releasing more GHG per unit of energy produced.

If this is so, then Libya needs to grapple with mandatory international agreements more than with oil depletion. An increasing number of scientists warn that oil use will be constrained more by international treaties to prevent climate change than by depletion of the oil itself.

Climate change is right at the top of the political, economic and regulatory agendas; decision-makers should be planning with this imperative in mind. Norway was the first nation to announce in 2008, that it will achieve carbon neutrality by reducing its GHG emissions to zero by 2030 or paying for equivalent reductions elsewhere. Norway's current carbon tax rate is €50 per metric ton. Norway's Statoil began capturing and sequestering carbon dioxide in 1997, five years after the government introduced the carbon tax. The European Union plans to reduce its emissions by 20 percent by 2020. At its June 2007 summit, leaders of the Group of Eight club of wealthy nations agreed on the goal of halving dangerous greenhouse gas emissions by 2050 in a landmark pact on global warming. This agreement was advanced at the 2007 UN meeting in Bali, but progress stalled as of 2013.

Convinced that rules to slow climate change are inevitable, hydrocarbon-fuelled power generator operators are reexamining construction plans, fund managers are raising billions of dollars to invest in projects to combat climate change, and insurance firms are devising new products. Taxes on corporate carbon emissions are being discussed. Forward-looking corporations are beginning to adopt carbon-neutral strategies. Nations and companies that approach carbon neutrality by reducing emissions or by sequestration will be the winners. The faster Libya can accelerate the transition to solar energy for export and ensure that its water use becomes sustainable, the better off its citizens will become. Libya can be a world leader in this regard if it so desires.

RECOMMENDATIONS

- Export solar electricity northward to benefit Libya while helping Europe to become carbon neutral.
- Pursue rapid transition to solar energy for export and to ensure the sustainability of the water supply.

5.2 How Can Libya Reduce GHG Emissions?

FINDINGS

The government can constrain carbon in three ways: through standards or regulations, carbon or GHG pricing, and removal of subsidies (Goodland 2007, 2008).

Standards and regulations have been suggested earlier. Standards of insulation and regulations fostering energy conservation are examples.

Mandating that solar energies increase at a predetermined rate annually is the most effective way of reducing GHG emissions.

Some claim that government standard-setting on the private sector is less efficient than letting the marketplace allocate investments. But given society's interest and concern in eliminating waste, standards will be necessary, although not sufficient, until the market stringently reduces waste.

RECOMMENDATIONS

- Encourage all electricity generators to accelerate their use of renewable energy.
- Mandate that use of solar energies be increased at a specified rate per year.
- Apply energy efficiency codes to buildings and air conditioners.
- Increase fuel efficiency standards in water pumps and vehicles.
- Accelerate the phase-out of incandescent light bulbs and the phase-in of compact fluorescents and LED bulbs.
- Bolster standards through carbon pricing and subsidies for renewables.
- **Carbon pricing** seems to be the most effective way of reducing carbon emissions (Goodland and El Serafy 1981, 1998; El Serafy 2013). The best way of getting the price right is through a tax on GHG emissions. This tax makes the polluter pay while internalizing the social and environmental costs of energy consumption.

For the first time in human history, concentrations of carbon dioxide in the atmosphere exceeded 400 parts per million (ppm) for sustained lengths of time from May 2013. Climate scientists have long maintained that concentrations need to be kept below 350 ppm if the world is to stand a reasonable chance of meeting international targets to

keep average temperature increases below 2°C, while concentrations of above 400 ppm put the planet on track for levels of warming deemed 'dangerous' by the international community.

To stabilize atmospheric CO_2 concentrations at a hopefully safe level of 350 ppm, (2013 levels are 395 ppm and rising), carbon or GHG emission prices range from US$5 to US$30/metric ton by 2025 and between US$20 and US$80 by 2050 (de Coninck et al. 2007). The government has to protect the poor and vulnerable from the carbon tax by guaranteeing lifeline rates and similar measures. Making carbon taxes revenue neutral through commensurate lowering of income or other taxes also will help.

Persuading the nations of the world to adopt a meaningful carbon tax is probably the biggest challenge of our times. Europe already has adopted a cap-and-trade mechanism. Increasing numbers of big corporations are calling on their governments to immediately enact mandatory national legislation to cap and trade greenhouse gas emissions. Major greenhouse gas emitters such as automotive, oil and chemical companies are among the new members of the Climate Change Partnership.

RECOMMENDATIONS

- Enact a carbon tax to help curb carbon emissions. All proceeds remain in Libya.
- Protect the poor and vulnerable from the carbon tax with measures such as lifeline rates.
- Make carbon tax revenue neutral by lowering other taxes commensurately.

Subsidies will be needed temporarily to boost the transition to renewable energy. The main subsidy should foster solar electricity generation on a big scale. The solar electricity will fuel water pumps and desalination to reach the goal of sustainable water supply. Then solar electricity should rapidly become Libya's most profitable and sustainable export commodity.

European countries (such as Germany) wanting to become carbon neutral may well invest their own funds in accelerating Libya's transition to solar electricity. The private sector has a major role in this transition. Manufacturers of solar generators could earn carbon credits for generating solar electricity for export by Libya.

RECOMMENDATIONS

Create a large-scale subsidy for solar electricity generation. One mechanism would be to hypothecate a fraction of oil royalties for the transition to solar electricity. This might take the form of a dedicated tax earmarked for the solar transition.

BOX 9: DESERT POWER: THE ECONOMICS OF SOLAR THERMAL ELECTRICITY FOR EUROPE, NORTH AFRICA, AND THE MIDDLE EAST.

A climate crisis is inevitable unless the world limits carbon emissions from the power sector in the near future. This will only happen if low-carbon technologies become cost competitive for private investors, because feasible international subsidies for clean technology will be tiny relative to the needed sectoral investment. Success will require focusing on strategic investments that create a market cost advantage for clean power.

A leading candidate for investment is solar thermal or concentrating solar power (CSP), a commercially available technology that uses direct sunlight and mirrors to boil water and drive conventional steam turbines. Solar thermal power production in North Africa and the Middle East could provide enough power to Europe to meet the needs of 35 million people by 2020. The subsidies needed to bring CSP to financial parity with fossil-fuel alternatives are modest. Large-scale deployment of CSP is attainable. With Ummel's and Wheeler's (2008) assumptions, the scenario is for unsubsidized CSP projects to be competitive 'soon' with coal- and gas-based power production in Europe.

The question is not whether CSP is feasible but whether programs using CSP technology will be operational in time to prevent catastrophic climate change. For such programs to spur the clean energy revolution, efforts to arrange financing should begin right away, with site acquisition and construction to follow within a year.

Source: Ummel & Wheeler 2008.

5.3 Carbon Sequestration

FINDINGS

A world carbon price of about US$30 would make carbon sequestration economic. That cost is expected to fall as the technologies are commercialized.

While Libya has ample empty oil and water reservoirs in which to sequester greenhouse gases, the costs of importing GHGs from Europe suggest that this is not an immediately promising choice for Libya. In the future, sequestration reservoir space could become scarce, especially in the United States, which might offer opportunities for Libya.

The other method of carbon sequestration is planting trees. Libya has the land and sunlight but lacks the water, so this is not a promising option. Afforestation can benefit Libya in many ways, but scarcely on a scale meaningful for carbon sequestration.

RECOMMENDATIONS

Carbon sequestration is not a viable option for Libya and should not be pursued at this time.

5.4 Climate Change: An Attractive Opportunity for Libya

FINDINGS

Libya is well placed to prosper from climate change. As the impacts of climate change intensify, progress will accelerate. Recent years have seen massive reversals by climate change deniers. BP's chief economist Peter Davies claimed in 2007 that when peak oil comes, it is just as likely to come from consumption peaking as from production peaking, perhaps because of climate change policies.

Just as Ali Rodriguez-Araque, one of the founders of OPEC, quipped, "The Stone Age didn't end because we ran out of stones," oil use may become constrained more by mandatory international agreements than by depletion.

RECOMMENDATIONS

Establish the key goals of (1) allocating oil revenues to making water sustainable as quickly as possible; and (2) becoming self-reliant in renewable energy, (3) exporting as much sustainable solar electricity to Europe as possible.

Sustainable Libya Information Sources: Climate Change

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6. CONSERVATION OF THE MEDITERRANEAN

6.1 Conservation

FINDINGS

Of Libya's four most valuable natural resources — sunlight, GMR water, hydrocarbons and the Mediterranean — the first is in excellent shape; GMR water and hydrocarbons are in relatively good shape. The fourth, the Mediterranean, is in poor shape and is deteriorating fast. The demise of the 422,000 square kilometer Black Sea, which is 90 percent anoxic and scientists claim is moribund, is a clear warning for the Mediterranean. How to prevent the Mediterranean from a fate similar to that of the Black Sea?

Although most of Libya's oil comes from inland, there is new activity offshore. Within five years, offshore hydrocarbon production may exceed onshore oil production. While oil production in the desert still needs attention, EGA has an opportunity to regulate the impending offshore oil projects and contribute in a major way to Mediterranean conservation. For these reasons, this chapter focuses on offshore oil while leaving terrestrial or desert oil until later.

Whenever a nation's two important industries operate in the same seas, there will be potential conflicts between offshore petroleum activities and fisheries. Prudent coexistence between oil and fisheries is the goal. If oil producers follow good practice, then fisheries and ecotourism can flourish.

Currently, less than 1 percent of the Mediterranean Sea is protected. What is the scope for marine conservation units, marine parks and fishery zones?

EGA seeks to keep Libya's coasts free of pollution mainly by using environmental assessment process (see below).

RECOMMENDATIONS

All new oil and gas projects offshore must comply with the law. EGA can ensure that all oil companies follow the law. [13] A top priority is working upstream (terrestrial part) and

[13] Later EGA may want to put the name-shame-and-blame method on a systematic basis. One model for such a process is the Toxics Release Inventory (TRI). This a publicly available, US-EPA database that contains information on toxic chemical releases and other waste management activities reported annually by certain covered industry groups, as well as federal facilities in the USA. This inventory was established under the US Emergency Planning and Community Right-to-Know Act of 1986 and by the US Pollution Prevention Act of 1990. Nowadays anyone in the USA can enter his or her zip or postal code into the database to learn who the riskiest polluters are near home.

ensuring local cooperation between central/local authorities, private developers and civil society.

Coastal Zone Management

FINDINGS

Libya's Gulfs of Sirte and Cyrenaica are the foci for special conservation.

RECOMMENDATIONS

- EGA must control coastal construction (including hotels), industrial pollution, intensive agriculture and oil spills.
- Ensure that wastewater collection and treatment is done effectively and efficiently. Avoid coastal erosion with appropriate infrastructure design and building.
- WWF recommends banning trawling in the Mediterranean's 13 priority zones.

Mediterranean Over-Fishing

FINDINGS

Around 1.5 million metric tons of fish are caught in the Mediterranean each year. Destructive and often illegal fishing methods, including use of bottom trawlers, dynamite, long lines, and drift nets, have depleted fish stocks. The use of drift nets is also responsible for the accidental deaths and incidental catches of flagship species such as cetaceans and marine turtles.

Depleted fish stocks are also reflected in the undersized catch. Eighty-three percent of all bluefin tuna and swordfish caught in the Mediterranean Sea are undersized. The International Commission for the Conservation of Atlantic Tunas, one of five major international tuna regulators, decided in February 2007 to slash the annual catch in both the Mediterranean Sea and the eastern Atlantic Ocean. Member countries may see their fishing quotas for bluefin tuna cut, in principle, by a uniform 23.2 percent.

In 2010, Greenpeace activists using helicopters, divers and rancid butter confronted Libyan and Italian fishermen in order to release hundreds of threatened bluefin tuna, which they strongly suspect were illegally caught off the Libyan coast. In the first action of its kind in North African waters, the international crew of the California-based Sea Shepherd Conservation Society released around 800 tuna from a cage being towed behind the Italian trawler *Cesare Rustico* in June 2010. A 222 kilogram bluefin tuna sold for 155.4 million yen – a new record for a single fish – at the first auction of 2013 at Tsukiji fish market, in Tokyo. The record bid was three times higher than in last year's auction.

A single nation seeking to enforce international law on illegal fisheries is doomed to fail. Modern fishing vessels are fast, often have their own helicopters and are armed with powerful weaponry. The need for conservation of the Mediterranean is so great that a quasi-military force may be necessary. Even if the fishing vessel being chased cuts off and abandons its illegal drift nets, it is a partial victory and well worth achieving.

Fishing permits are issued by the Ministry of Marine Resources, a committee under the prime minister's office. That EGA is not part of that committee is a gap. EGA's role is to build awareness about fishing practices without the power to influence other agencies. Illegal fishing is a massive issue. With integration into the European Union, Libya will be able to better control over-fishing. Libya periodically exceeds its legal quota for tuna, according to the World Wildlife Fund (WWF). Libya's excellent Coast Guard is no longer permitted to address illegal fishing since it was moved into a different department, the Ministry of Interior, to tackle illegal immigration instead of coastal protection.

RECOMMENDATIONS

- Enforce international law on illegal fisheries under the United Nations.
- Consider the possibility of supporting a fleet of multinational environmental enforcement vessels. This fleet should be able to apprehend illegal fishing vessels to foster compliance. Confiscation of assets (vessels, helicopters, nets, etc.) would be the first penalty for infractions. Satellite positioning, helicopters, excellent radar and other communications would be essential.
- EGA should be included on the committee of the Ministry of Marine Resources.

The endangered warm-blooded Atlantic Bluefin Tuna *Thunnus thynnus*

6.2 Mitigation of Offshore Oil

RECOMMENDATIONS

- All oil proponents operating in Libya should be aware of, fully subscribe to, and fully meet the requirements of all relevant international agreements before seeking oil and gas project permitting throughout the life of the project.

- EGA and NOC should join forces and agree on the clauses in the drilling permit. Good practice includes performance bonds, insurance, compensation or legal liability and indemnification.[14]

EGA can specifically include all relevant international standards, such as International Maritime Organization's (IMO's) Intervention Convention, Oil Pollution Preparedness, Response, and Cooperation and the International Convention for the Prevention of Pollution FromShips (MARPOL). These provisions also apply to all incoming empty tankers seeking to load oil from Libya.

- The proponent is expected to advertise that it will not load Libyan oil to any tanker not fully meeting the above safety and other international standards.
- Double-hulling of incoming tankers should be mandated.
- The suggested regulations listed here should be discussed widely inside EGA and agreed to with NOC, as well as with concessionaires and other stakeholders.
- When EGA has agreed on which suggested regulations to adopt, the regulations should be integrated into the standardized oil and gas permitting process, the standardized Production Sharing Agreements and the EGA's ESA regulations.

FPSO Units and Double-Hulling

FINDINGS

Most offshore oil will be pumped to shore-based facilities for the immediate future. Soon, however, it is probable that offshore oil will be discovered too far from the coast. Then floating production, storage and offloading (FPSO) units, which process offshore oil, s will become a big issue for EGA. FPSOs are not regulated by IMO rules.

[14] NOC seeks to foster re-injection or detoxification and recycling of toxic-produced water, which currently contaminates groundwater. Oil-based muds need to be phased out. Drilling mud pits must be safely lined. Cuttings need to be cleaned (Law 15 is in need of revision). Gas flaring needs to be phased sharply down. Poor households, especially those without elevators, use less gas for domestic purposes because the 15 kg and 20 kg cylinders are too heavy to drag up many flights of stairs, and many cylinders leak. When a cylinder is empty, it is thrown out the window, which increases subsequent leakage. Ten-kg cylinders need to be the interim measure until gas can be piped to multifamily apartment blocks.

In July 2003, The IMO's MARPOL Annex 1 offers thes best practice; single-hulling is riskier. The Oslo and Paris Conventions for the Protection of the Marine Environment of the North-East Atlantic (OSPAR conventions) ban single-hulled converted FPSOs throughout Europe.

Vessel losses increase exponentially after 20 years of life. The riskiest is conversion of old (more than 25 years) oil tankers into FPSOs. The riskiest vessels are those serving as production platforms and storage vessels.

RECOMMENDATIONS

- The choice of FPSO should be guided by Bureau Veritas, the American Bureau of Navigation, parts of MARPOL's Annex 1, and the MODU Code.
- The EGA's environmental assessment procedures should pay special attention to the choice of the oil-loading terminal and should recommend double-hulling.
- If an FPSO is selected, its choice must be transparently justified in advance. In addition, the type of FPSO is critical.
- Only FPSOs meeting international standards will be permitted. If an FPSO would be banned in European or U.S. waters, there is probably reason not to permit it in Libya either.
- EGA's ESA procedures should mandate empty lateral reservoirs as a safety precaution in single-hulled FPSOs.
- The areas around the FPSO need to be zoned into prohibited areas and restricted zones. These zones have to be clearly demarcated with reliable navigation aids.
- The ESA must persuade all concerned that the proposed FPSO meets industry standards and is not risky, using Bureau Veritas and MARPOL Annex 1 criteria for risk assessment.
- EGA's ESA regulations would be well advised to mandate risk insurance if an oil proponent claims that a converted single-hulled and old FPSO is its choice. U.S. Coast Guard insurance provisions seem to be the most applicable to Libya's ESA regulations. Such insurance will be expensive but better than the alternative.
- Performance bonds set commensurate with worst-case cleanup costs should be essential.

Management of Discharges

FINDINGS

Foreign oil corporations in Libya's desert do not have ideal performance records with regard to environmental prudence. Safe disposal of produced water, cuttings and drilling muds has not always been followed. Decommissioning, rehabilitation and restoration are looming problems.

RECOMMENDATIONS

- EGA has a prime opportunity to get involved in offshore oil projects early on and learn from the experience in the deserts. This will ensure that the unsatisfactory track record in the deserts will not be repeated in the much more sensitive Mediterranean.
- As EGA is responsible for water quality, independent data monitoring of discharges will be influential.

Zero Discharge

FINDINGS

Best practice is zero discharge. The zero discharge policy means zero discharge into the sea of production and formation waters (PFW), drill cuttings, drilling muds, sump and lubricating oils, anti-fouling paints, ballast water, oily washing waters, and so on.

Zero discharge began in 1995 when BP re-injected PFW in its Ulla field in Norway. Zero discharge is now standard, especially where fisheries are important to the nation in areas such as Norway, the Netherlands, Shetland Islands region, and Denmark. Angola and Nigeria's petroleum industries have progressed towards zero discharge. Nigeria's Chevron Texaco has a dedicated zero-discharge team.

In 1998 the environment ministers from the member countries of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) mandated the goal of zero discharge. Touchoilandgas.com now lists 113 entries for zero discharge offshore.

The largest discharges of oil from petroleum activities come from the discharge of produced water.

The Norwegian government's zero-discharge policy provides an overview of established technical solutions based on an evaluation of potential solutions in each case. Based on an overall assessment, the operating companies must implement the measures that provide the greatest contribution towards stopping the discharge of environmentally hazardous substances and reducing the risk to the environment from discharges. The government expected compliance by the end of 2005. Reduced water production, re-injection and improved cleaning of produced water contribute to achieving the objective of zero discharges to sea from petroleum activities. NorskHydro's comprehensive plan, submitted to the Norwegian Pollution Control Authority in 2003 reduces the environmental impact of offshore operations by 80 percent. The main measure is the re-injection of produced water at the Oseberg field. NorskHydro met the authorities' demands for zero discharge into the environment by the end of 2005 (offshore247.com).

RECOMMENDATIONS

Zero discharge is best practice and should be a national goal.

Drilling Muds

FINDINGS

As mentioned above, industry best-practice policy is zero discharge of any drilling muds. In North America and offshore Europe almost all discharges of oil-based drilling muds (OBM) ceased some years ago. The United States still permits synthetic-based drilling mud (SBM) discharges, but they are currently being phased out in European waters (Wills 2000). Despite being less noxious than OBMs and SBMs, water-based muds also need precautions according to OSPAR, whose members are Belgium, Denmark, the European Commission, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Proven technology exists to re-inject and contain contaminated drill cuttings in underground reservoirs, either by installing equipment on each rig, platform or drill ship, or by shipping the wastes to a port for onshore re-injection. Alternative disposal methods, such as treatment, recycling, incineration and/or landfill onshore, are available.

Of the less damaging types of drilling muds, some are better than others.

Water-based muds (WBM) have ecological effects that may be more serious, widespread and prolonged than some industry sources would suggest. In particular, the effects of underwater plumes of extremely fine particles are not properly understood and may damage larval stages of commercial fish and shellfish.

The search to locate a geological formation in which production water and formation water can be re-injected is urgent if the already stressed Mediterranean fisheries are to be conserved.

RECOMMENDATIONS

- EGA's policy on drilling muds should foster use of the most benign types of drilling muds, to use less of them, to phase out the riskiest forms of drilling muds and to recycle all muds.
- The ESA needs to specify which drilling muds will be used, the rationale for their selection, the volumes and timing of their expected use, and their separation goals.
- After use, drilling fluids should be cleaned, all cuttings separated out and all hydrocarbons (especially PAH/VOC) and heavy metals removed. The clean drilling muds should then be stored in tanks for eventual re-use.
- Designing re-injection should be mandated in the ESA well before EGA and NOC

permit oil production.

- The most prudent course for future oil projects is to mandate re-injection (or other disposal methods other than discharge into the sea) as a condition of EGA's permitting process.

Disposal of Cuttings

FINDINGS

Drill cuttings, the broken bits of solid material removed from a drilled borehole, are often contaminated with oil residues and process chemicals that intensify the harm to fisheries. The best practice is not to discharge cuttings into the Mediterranean. Cuttings themselves form turbidity and sediments prejudicial to fisheries. Dumping is environmentally damaging and technically unnecessary. State-of-the-art landfills are necessary for most of the oil industry.

Production and Formation Water

FINDINGS

Libya's fishery zones are more fragile than its desertic lands and therefore need greater protection.

Production water, the water associated with oil in the well, always contains dispersed and dissolved oil from long contact between the oil and water before drilling. Production waters often contain high concentrations of salts, heavy metals, PAH and occasionally radioactivity. In addition, production waters are anoxic; they contain no oxygen as most water does, hence any oxygen-breathing organisms in them will die.

Industry best practice is to re-inject production water deep into the seabed, either into an abandoned oil well or into a well drilled for re-injection of production water or other discharges. In onshore production sites, re-injection of produced water is almost universal.

RECOMMENDATIONS

If re-injection is unfeasible, the proponent has to prove that. The proponent should then show another acceptable method for disposal of production water after treatment to reduce hydrocarbon levels.

Sewage and Solid Wastes

FINDINGS

Overboard discharge was used in previous years when the Mediterranean and most of its fisheries were not under threat, oil rigs were few, and marine traffic was less

common. The impacts of overboard disposal from a very few rigs and tankers were then acceptable.

This situation has changed. The Mediterranean already is suffering, the damage is intensifying, and most of its fisheries are depleted. Offshore oil rigs are becoming numerous, and tanker traffic has burgeoned.

One has to be crystal clear in this case: The Mediterranean can no longer afford to receive any raw sewage. Even primary treated sewage can no longer be discharged into the Mediterranean.

Overboard disposal no longer meets industry best practice and is, in general, prohibited in Libya.

RECOMMENDATIONS

- Primary treated sewage effluent should be treated up to the agricultural level and recycled on land in the Mediterranean water-scarce countries.
- If overboard discharge is the only solution, the proponent has to make the case why best practice cannot be achieved and obtain a waiver from EGA well in advance.
- If they are scrupulously separated, human and kitchen wastes (disinfected sewage, washing water, food wastes) should be macerated to an agreed-on diameter, so that agreed-on volumes may be discharged overboard at approved sites and times.
- All other wastes, including oily wastes, should be stored in tanks for subsequent onshore disposal.

Onshore Disposal

FINDINGS

The oil industry depends on authorized and well-managed landfills and similar facilities for waste treatment and recycling. These may not be available in all countries.

RECOMMENDATIONS

Libya's landfills need upgrading. It is the oil industry's responsibility to work with municipalities to ensure adequate onshore landfills and other disposal sites of suitable dimensions for anticipated use.

Oil Spills

FINDINGS

Experience worldwide proves that oil spills are inevitable. They must be accepted as a fact of life. Spills can be reduced in number and severity by using best available

technology (BAT) and by training, but they cannot be totally eliminated.

Oil spill damage can be minimized by efficient responses. Libya is already considering using satellite-monitoring systems for all vessels in national waters. This would greatly reduce risks. Hydrocarbon corporations could benefit from financially supporting the installation of a satellite monitoring system.

Standard policy is to contract in advance with a specialist emergency firm that can be mobilized by dedicated air transport as soon as the agreed-on trigger event (such as a Level III spill) occurs (as in Southampton's UK firm "Oil Spill Response Limited" OSRL). Libya is progressing, in that equipment has been stockpiled and training and early warning communications are in hand.

RECOMMENDATIONS

Oil spill response plans should be elaborated and in place before the first oil spill. Industry oil spill contingency plans (OSCP) should be regulated, implementation monitored and complemented by central and local ggovernment plans.

- Equipment (booms, skimmers and dispersants) must be purchased and stockpiled at appropriate sites.
- EGA and NOC should specify the nature of acceptable dispersants in the ESA.
- Training must have been completed before the first oil spill and must be updated systematically.
- Communications and early warning systems must be in place, tested and maintained.

Legal Responsibility for Oil Spills

FINDINGS

Has Libya signed and ratified the 1992 Civil Responsibility Convention and the latest amendments to IOPC/FIPOL 2003 to activate those provisions in the case of a major oil spill?

EGA's role is to regulate and to ensure that precautions (equipment, training, insurance, performance bonds) are in place before spills, but it cannot lead the spill response.

RECOMMENDATIONS

- EGA's ESA regulations must clarify who bears the responsibility and legal liability for oil spills before the ESA is accepted.
- EGA's ESA regulations should include an independent inspection agency to inspect all FPSOs and similar vessels periodically, and especially before the ESA can be approved.

Ballast Water Policy

FINDINGS

Libya is unusual in that incoming vessels do not balance outgoing vessels as to type. Container ships arrive laden and leave mainly empty. Cargo vessels and most tankers arrive empty and depart laden. Ballast flushing therefore needs tight management.

How will Libya's dumps and landfills be made adequate in time to prudently handle major expected volumes?

RECOMMENDATIONS

EGA's ballast water policy should include the following recommendations.

- All proponents in Libya should follow the IMO Convention, even though it is not yet in force.
- The MARPOL Convention's Annex II should be followed.
- All tankers in Libyan waters must have segregated ballast.
- Ballast flushing and cleaning must use land-based receiving facilities.
- Ballast discharges in the Mediterranean must be prohibited.
- Ballast discharge in the Atlantic outside the coastal limit of 50 nautical miles and in waters exceeding 200 meters depth may be permitted by the relevant authorities, but that is outside the jurisdiction of EGA.
- Oils must be separated from ballast water.
- Anti-fouling paint residues (such as organic tin) must be monitored.
- Ballast tanks must be cleaned regularly of silts and muds, which should be pumped into storage tanks and later discharged at appropriate land-based facilities.

Anti-Fouling Paints

RECOMMENDATIONS

- Highly toxic anti-fouling paints should be prohibited according to IMO and World Health Organization (WHO) regulations, with special precautions for organic tin salts, which cause sex changes in the fish food chain.
- EGA and the Ministry of Health need to take the lead on this regulation in cooperation with NOC.

Exploration and Seismic Surveys

FINDINGS

Exploration, prospecting and especially seismic surveys have significant environmental impacts.

Woodside Petroleum Ltd. holds leases on 60,000 square kilometers of offshore and

onshore sites in Libya, at least one inside a proposed protected area, not a good practice.

RECOMMENDATIONS

These activities must be subject to environmental and social assessment (ESA) in advance. For example, an ESA will state site specifics about where seismic surveys are not permitted (protected areas) and the seasons (months) when seismic activities can be permitted to reduce impacts on fish reproduction and migrations.

Flags of Convenience

FINDINGS

A number of vessels suffering from declining standards, whose flag states disregard safety, pollution, and environmental regulations, emerged from state vessel "open registries" that do not have strict registration requirements in terms of nationality, safety record, labor practices or other traditional factors. These vessels fly "flags of convenience" of a state whose government sees registration as a service it can sell to foreign vessel owners, rather than a method to control its vessels (Ferrell 2005).

Unscrupulous ship owners look for the cheapest and least regulated ways of operating their vessels. They are more likely to use risky vessels, apply unjust labor standards, or carry illegal cargoes (such as humans, drugs, wildlife, timber, fish, armaments and hazardous waste).

Such owners may operate under any flag, but they are more likely to use a “flag of convenience” that provides a less-than-genuine link between the flagging state and the vessel. This contravenes Article 91 of the UN Convention on the Law of the Sea.

Both the Law of the Sea Convention and the Geneva Convention on the High Seas state that a genuine link must exist between the state and the ship, and require this "genuine link" between state and ship for registration. The genuine link requirement has proven malleable and open to widely different interpretations, as evident in domestic ship registration legislation.

More than 60 percent of the total tonnage of the world's merchant fleet was registered outside the owner's domicile as of 2003.

Because Flags-of-Convenience (FOC) nations dominate the voting structure of the IMO, it has been unable to enforce Article 91. Four of the five largest shipping registries by tonnage belong to FOC nations: Panama (122), Liberia (52), the Bahamas (22) and Malta (27) (Lee 2003). Of Japan’s FOC fleet, for example, 43 percent is flagged in Panama; 71 percent of Greek FOC vessels are flagged in Cyprus; 24 percent of U.S. vessels are flagged in the Bahamas.

Flags of convenience are not best practice. Royal Dutch Shell feels so strongly about flags of convenience that it now prohibits their use throughout its fleet.

Best practice is voluntary in the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU), the Code of Conduct for Responsible Fisheries and the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement).

RECOMMENDATIONS

- Libya should phase out of flags of convenience and promote national flagging.
- Libya should not accept flags of convenience in its waters.

6.3 Mediterranean Environmental Conventions

FINDINGS

EGA is the lead agency fulfilling Libya's international agreements and uses that process effectively to foster domestic environmental progress. Its role is commendable and exemplary in this regard.

RECOMMENDATIONS

- If Libya wants to lead on good practice in the Mediterranean, it may want to foster compliance with the tools already in use (See Box 10). This will also reinforce its role as the lead nation in fulfilling international agreements.
- Libya's ratification of the 13 instruments would be beneficial and greatly help its efforts to conserve the Mediterranean. Ratification would foster significant international financing and cooperation to help Libya optimize use of (and profits from) the Mediterranean.

BOX 10: EGA AND INTERNATIONAL ENVIRONMENTAL CONVENTIONS

EGA is the lead agency in most of the following international conventions (not a complete listing):

Rome Agreement: General Council for Mediterranean Fisheries, established Rome 1949, ratified by Libya 1963.

UNESCO Cultural Heritage: Paris 1973, signed 1972, ratified 1979.

The Bern Convention: Convention on the Conservation of European Wildlife and Natural Habitats 1979, also known as the Bern (or Berne) Convention, 1982. It has been signed by the 39 member states of the Council of Europe, together with the European Union, Monaco, Burkina Faso, Morocco, Tunisia and Senegal.

The Barcelona Convention: Convention for the Protection of the Mediterranean Sea against Pollution, signed 16 February 1976, in force 12 February 1978 (revised in Barcelona, 10 June 1995), as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Alawar et al. 2005).

The Program for the Assessment and Control of Pollution in the Mediterranean Region: (Med Pol) began in 1975 and directly supports implementation of the LBS and Dumping Protocols, now extended to persistent organic pollutants (POPs).

The Strategic Action Plan for Conservation of Marine and Coastal Biodiversity in Mediterranean Region (SAP BIO).

UN Biodiversity Convention, Rio de Janeiro (1992); Cartagena Protocol (Libya signed in 2005).

UN Ramsar Convention on Wetlands (1971)

Action Plan for the Conservation of Marine Vegetation in the Mediterranean: Protects the endemic sea-grass *Posidonia oceanica*, which plays a crucial role in coastal protection by acting as a buffer to currents and waves.

Action Plan for the Conservation of Bird Species: Listed in annex II of the Protocol concerning Specially Protected Areas and Biological Diversity in Mediterranean.

UNEP/MAP Mediterranean Action Plan for Marine Mammals: Protects monk seals. Within MAP: Action Plan for the Management of the Mediterranean Monk Seal. The monk seal (*Monachus monachus*) has 350–400 individuals surviving in the world.

Action Plan for the Conservation of Cetaceans in the Mediterranean Sea: Protects 18 cetacean species, of which seven can be observed throughout the year: *the long finned pilot whale (Globicephala melaena*), *fin whale (Balaenoptera physalus*), sperm whale (*Physeter macrocephalus*), *short beaked common dolphin (Delphinus delphis*), striped dolphin (*Stenella longirostris*), bottlenose dolphin (*Tursiops truncatus*) and Risso's dolphin (*Grampus griseus*).

Action Plan for the Conservation of Marine Turtles: Protects the green turtle (*Chelonia mydas*) and the 100-million-year–old species of loggerhead turtle (*Caretta caretta*) that nests on Mediterranean beaches. Loggerhead turtle nesting beaches in Libya could

become a big draw for ecotourists. Libya's loggerhead populations may be the biggest in the Mediterranean (Laurent et al. 1995).

Regional Activity Center: RAC/SPA of the Mediterranean Action Plan aims to implement its recommendations for the UNEP/MAP Centre for Specially Protected Areas in Tunis.

Mediterranean Science Convention: With headquarters in Monaco, 23 member states and a network of several thousand marine researchers, aims to protect the fast-changing, highly affected Mediterranean Sea. Structured in six committees and various taskforces. The Mediterranean Science Commission, or *Commission Internationale pour l'Exploration Scientifique de la Méditerranée* (CIESM). CIESM runs expert workshops, collaborative programs and regular congresses, delivering authoritative, independent advice to national and international agencies.

Bucharest Convention: Convention on the Protection of the Black Sea against Pollution, in force 1994.

UN Agreement on Ocean Law, Montego Bay, Jamaica, 1982, effective 1994.

Prevention of Sea Pollution from disposal of wastes, 1975, signed and ratified 1976.

Libya's 2002 State of the Environment report (42–43) lists 13 international environmental conventions and agreements and indicates that Libya has yet to sign or ratify significant environmental arrangements.

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7. ECOTOURISM

"Libya will be the most favorable tourism country in the world if the tourism industry is respected".

The ex-Leader on the First September Great Alfatah Revolution.

The main purpose of addressing the potential of ecotourism in this book is its value for economic diversification out of oil revenues. It is risky that Libya ranks among the most hydrocarbon-dependent countries, especially if new (2013) estimates of oil depletion really are nearer 20 years than the 50 years used in this book. The race for Libya to diversify out of oil and to make its water supply sustainable is a monumental challenge and time is exceedingly short.

Libya's new (since 2013) Tourism Minister Ikram Bash stresses, "We want to open Libya to the world." Libya's ecotourism potential is enormous. Morocco and Tunisia receive 6 million tourists each year, and Egypt more than 10 million. Why does Libya receive only a few hundred thousand in recent years? Tourism in general will become a huge economic opportunity as soon as Libya wants to diversify out of dependence on oil exports. Ecotourism can be sustainable and generates a large number of reasonable in-country jobs, from drivers, through handicraft manufacturers and sellers, to tour guides, tourism managers, hoteliers and national park personnel. Now that current tourist destinations are saturated and may be in decline (Northern Mediterranean, Spain, southern Italy, southern Greece), there is a major potential role for low-impact, sustainable eco-tourism, based on the equally attractive southern Mediterranean coasts with their rich archeology. Of the several types of ecotourism, bird watching alone can generate huge profits from a relatively few bird habitats, such as those in Libya.

Libya's potential for tourism includes an attractive climate year round, which is only three hours' flight from northern Europe. Libya has more than 1770 kilometers of white sandy Mediterranean beaches, ranking among the best in the world. Libya has great potential for desert and camel treks. The Ubari sand sea and dunes (Idehan Ubari) has a dozen pavonian-blue hypersaline lakes and fresh-water wells in southwestern Fezzan. The Dawada ethnic minority live around the Gabraoun oasis harvesting *Artemia* brine-shrimp in the salty lakes, hence their epithet "Worm-Eaters." Treks are arranged to the extinct volcanoes of Waw and Namou ("Oasis of Mosquitoes"), 547 meters in elevation in the desert with a 4-kilometer-wide caldera, scoria cones, and explosion craters. The 1,200 meter-high Haruj volcano is 750 kilometers southeast of Tripoli. Haruj is a huge black volcanic field, a granite and basalt moonscape, spread across 45,000 square kilometers in central Libya. It contains about 150 volcanoes, including numerous basaltic scoria cones and about 30 small shield volcanoes, along with craters and lava flows.

BOX 11: WHAT IS ECO-TOURISM?

Eco-tourism is based on natural environmental, cultural and social resources, local and indigenous people, such as natural coasts, clean oceans, natural scenery, archeological and historic patrimony, and wildlife. The International Ecotourism Society (TIES) defines eco-tourism as "responsible travel to natural areas that conserves the environment and improves the well-being of local people." Sustainable tourism is used here to include eco-tourism and means responsible tourism, which is both ecologically and culturally sensitive. Specifically, it is low-impact tourism, which does not degrade the resources or the societies on which it depends. 'Normal' tourism tends to degrade the values on which it depends, such as when sewage from beach hotels is allowed to pollute (Becker 2013). On the contrary, both ecotourism and sustainable tourism should protect, enhance and expand the resources on which they depend. For example, more sites are protected thus attracting more birds to be seen. More ruins are excavated and conserved by being converted into sites for archeological tourism. Locals participate actively in sustainable tourism and take responsibility for the results. Some ecotourism guides are paid extra commensurate with the number of different species of wildlife observed during that visit. Ecotourism can create cottage industries in handicrafts. Ecotourism depends on prudent management on the ground, an activity at which some Libyans excel. Protected areas and biota outside them need scrupulous monitoring and conservation. Such conservation is a worthy life-long profession as promoted by the Quran.

Sources: Page et al 2007, Fennel 2007, & Brebbia et al. 2006; also: sustainabletourismcriteria.org.

Libya is a nation of superlatives, formerly holding the world's record for the hottest recorded temperature of 57.8˚C (136° F), in September 1922 at L'Aziziyah 43 kilometers south of Tripoli.[15]

Petrified forests on the east of Al Haruj, near Wadi Bu Shubariyim (Ham 2008) are exceptional. The dense evergreen forests of the Green Mountains, Jabal Akhdar, have a fair amount of annual rainfall, 300 millimeters, possibly the origin of the Greek myth: "Libya" meaning "dripping rain?" The highest point is 10,335 feet Libya has 16 natural springs, 12 major lakes and a dozen inhabited oases. The system of National Parks is unparalleled for birding.

These assets make Libya an exceptional country for ecotourism. The balance between natural features (white sandy beaches) and abundant archeology has major potential. The secretary of Libya's Tourist Development Authority, Dr. Ali Fares Aweda, signed a contract in January 2007 with the French agency for tourism (ODIT), which will offer technical assistance for 17 new tourist investment zones along 180 kilometers of coast near the eastern towns of Tubruq and Sabratha. Some of the biggest archeological sites of the Roman civilization in Libya, Tellil and Mellita, about 20 kilometers from the western coast, will be included.

[15] The World Meteorological Organization overturned Libya's record, which had long been questioned. The record then went to Death Valley CA. The record is now held by the Lūt Desert, Iran, where 159.3 °F (70.7 °C) was recorded in 2005.

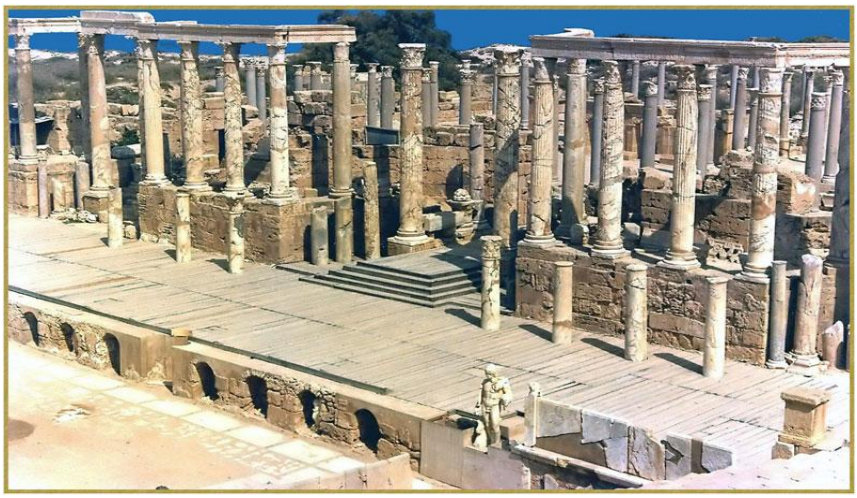
The Green Mountain Sustainable Development Area is a 2007 plan to create a 5,500 square kilometer carbon-neutral green development zone in Cyrene, an area the size of Wales centered on ancient Greek ruins and the Temple of Zeus, nicknamed the Athens of Africa. It will be powered by wind and solar energy. All wastes will be recycled. Trash will be digested to biofuel. The plan will protect Libya's world-class Greek and Roman ruins, as well its fragile coastal ecosystem— one of the last remaining natural areas of the Mediterranean—from damaging development. Oilman Hassan Tatanaki commissioned British architectural firm, Norman Foster & Co., led by Stefan Behling, to design this "Green Mountain Conservation and Development" zone. Aljabel Alakhdar literally translates as 'The Green Mountain,' supported by UNESCO.

7.1 Archeological and Historic Patrimony

Libya's archeological sites are among the richest in the world; hence form an outstanding attraction for tourists. Bennett & Barker (2011) put it best: Libya's archeological heritage is truly spectacular, comparatively little studied and hugely under threat. Following an extended period of isolation, improvement in Libya's relations with the rest of the world and a rise in the price of oil have stimulated a huge amount of development in the country, especially in the hydrocarbon and infrastructure sectors of the economy. With a rapidly growing population, and expanding youth unemployment, the Libyan government is attempting to develop a new way forward for its society and economy. Archeology and heritage have not traditionally been high on Libya's agenda. The custodian of Libyan heritage, the Department of Antiquities, has been poorly supported by the state (perhaps in part relating to postcolonial Libya's ambivalent feelings towards its past) and is now badly positioned to deal with the nature and scale of development threats in the cities, the agricultural zone, and especially the desert where the greatest number of heritage assets are located. Most major development projects in these areas and elsewhere have been undertaken with little or no archeological impact assessment, monitoring or mitigation activities, with unfortunate consequences for buried and standing archeological remains. There are some encouraging signs of a sea change in the state's attitude to archeology, heritage, conservation and tourism (Bennett & Barker, 2011).

The following boxes offer a sampling of these remarkable sites.

BOX 10: THE RUINS OF LEPTIS MAGNA



Ruins of Leptis Magna in Khoms, Libya.

In 193, a native son, Lucius Septimius Severus, became the emperor of Rome. He favored his hometown above all other provincial cities transforming Leptis Magna into the third-most-important city in Africa, rivaling Carthage and Alexandria.

The subsequent fate of parts of Leptis Magna is cautionary for ecotourism. The Prince Regent (George Augustus Frederick 1762–1830, later UK's King George IV) was a notorious "ruin gazer." Colonel Hanmer Warrington, the British consul-general in Tripoli, knew this, and in 1816 he persuaded the local governor to allow the Prince Regent to "help himself" to the remains of the Roman imperial city of Leptis Magna. Despite stiff local opposition and resistance, Warrington arranged for Commander W.H. Smyth to ship many pieces of this ruin to England: 22 granite columns, 15 marble columns, 10 capitals, 25 pedestals, 7 loose slabs, 10 pieces of cornice, 5 inscribed slabs, and various sculptural fragments. When the shipment arrived in London it also included the colossal bust of Memnon from the temple of Ramesses at Thebes (the inspiration for Percy Shelley's "Ozymandias" of 1818), which had been collected at Malta. In 1826, after several years in the British Museum, the ruins from Leptis Magna were transported on gun carriages to Virginia Water, a royal site within Windsor Great Park, near Heathrow Airport. There, according to The Royal Landscape website, between 1827 and 1828, they "were arranged by Sir Jeffry Wyatville, George IV's architect, in the form of a ruined Roman temple," which came to be called the "Temple of the Gods."[a] The Duke of Wellington's bust in Gibraltar still stands on a marble column also stolen from the ruins of Leptis Magna.

Between 1686 and 1708, the French consul in Tripoli, Claude Lemaire, took away several (some say 600) cipollino (a much prized type of marble) columns. Much of these spoils were reused when the Palace of Versailles, Rouen Cathedral and the church at St-Germain-des-Près were built for Louis XIV. In 1693, Denis Dussault and Dey El-Hadj Abdallah sold marble columns from Leptis Magna to France.[b] Libya's government says it wants to draw more tourists to its ancient sites and has been tracking down items that were sold, given, or taken over four centuries of Turkish Ottoman and Italian rule and during the British occupation of 1943-1951.

Notes: a. www.thecrownestate.co.uk /media/123360/leptis_magna_ruins.pdf.
b. historyofafricaotherwise. blogspot.com/2011/10/libya-ancient-rome-other-libyan.html.

BOX 11: FAMOUS LIBYANS

St. Mark: The Green Mountains are the birthplace in the first century of the Apostle Mark, the Evangelist, and author of the second Gospel (MacDonald 2000). St. Mark was born in Cyrene in Pentapolis, the eastern part of Libya, west of the border with Egypt. St. Peter, who was married to a relative of St. Mark's father, took care of St. Mark and considered him a son: "The Church that is in Babylon, elected together with you, salutes you and so does Marcus (Mark) my son"; (1 Peter 5:13). The Eastern Orthodox and the Coptic Orthodox Churches believe him to be the first Pope of Alexandria. He was killed in 68 CE.

Emperor Caesar: The exploits of Lucius Septimius Severus, born and raised in Leptis Magna, who became Emperor Caesar in 193, and died in 211 on 4 February (or 212) in York (England). Hadrian, Marcus Aurelius, and Claudius all left their marks.

Barbarossa: Tripoli's Mamluk architecture and Ottoman forts once housed Barbarossa (aka Aruj 1474-1518, also known as Redbeard), a Mediterranean pirate and slaver, later an Ottoman naval commander.

Omar Mukhtar (1862–1931) was born in Cyrenaica. He led the resistance movement against the Kingdom of Italy (Savoy). Italian military occupied Libya from 1910 through 1947.

BOX 12: FAMOUS ARCHEOLOGICAL SITES

Prehistoric rock painting (12,000 years old), the world's oldest cave paintings (e.g., Jebel Acacus), petroglyphs (e.g., Msak Settafet), and much other rock art.

Many Phoenician (Punic), Greek and Roman sites, such as Leptis Magna (146 CE) elevated to a UNESCO World Heritage Site in 1982.

The archeological sites at Susaa, Tulmitha, Cyrene, Benghazi and Ras Helal are matchless.

Some of Tripoli's everyday restaurants operate in the midst of magnificent archeological remains.

Emperor Justinian's Byzantine mosaics of Qasr Libya (AD 529-540) were discovered accidentally in 1957. Includes one of the few pictures of the seventh of the Seven Wonders of the World, Alexandria's Lighthouse, built in the third century BCE.

Underground houses (Dammous) built by the ancient Berber indigenous peoples. Good examples in Gharyan, Abu Hamam and elsewhere.

Sufi *zawiyahs* of Benghazi; the Sanusiyah, a religious brotherhood of Cyrenaica established a network of these religious retreats in remote areas. In World War I the Sanusiyah who destroyed most of the *zawiyahs* during their occupation in the 1915-1917 war. During World War 1, the Bedouin Army of the Grand Sanusi, Sayyid Ahmad al-Sharif, fought the British on the border with Egypt at Sollum (McGuirk 2007). The Grand Senussi's grandson became King Idris of Libya in 1951.

The Italo-Libyan War of 1911-1912 over the Ottoman Empire's last African territory (Bono, 2005).

World War II's 240-day Siege of Tobruk (June-November 1942), in which Gen. Erwin Rommel's Deutsches Afrikakorps (which evolved into the Deutsch-Italienische Panzerarmee) lost when Gen. Bernard Montgomery's Eighth Army arrived (Fitzsimons, 2006).

BOX 13: TOURISM ISSUES IN COMPARABLE COUNTRIES

Some Islamic nations, such as Turkey and Egypt, have lucratively diversified into tourism where it contributes substantially to their GDP. Instructive for Libya's tourism is the example of Iran's Kish Island, where Iran is struggling to reconcile Iranian values with tourism. Kish Island is one of the most beautiful resorts in the world. The snorkeling and scuba diving are among the world's best. Kish Island's tourism began in the 1960's when the last Shah started to transform it into a playground for the rich and famous. A big improvement is that a visa is not now required before arrival, as it is in Libya. There are many duty-free shopping malls, but no ATMs or credit card facilities. There used to be an "international beach" where male and female foreign tourists could swim together, but the government closed it. Now women are restricted to the women-only beaches. Upon landing, all female passengers are immediately escorted to a room and politely ordered to wear headscarves and long robes to cover their entire body. This would be unheard of in Libya. On Kish Island, bikinis are prohibited on all beaches and swimming pools. Casinos have been closed for gambling. Alcohol is now banned.

In Egypt, Turkey, Tunisia, Lebanon, Malta and Indonesia, beer is widely available. Pakistan permits the sale of alcohol to foreigners. In Algeria, Qatar and Bangladesh, legal alcohol can be found if one searches, and even more easily in Morocco. The World Health Organization[a] provides alcohol consumption statistics by country. Libya's Health Ministry states that consumption and sale of alcohol is banned in Libya. But locally brewed concoctions called Bokha and Akatashi distilled from figs, dates or grapes are sold on the black market. *Ogogoro*, a Nigerian term for a drink, originally from the sap of the Raffia palm (*Raphia ruffia)* or oil palm (*Elaeis guineensis*) also is sold. The provenance of these homebrews is uncertain at best.

Figures differ for the numbers of poisoning depending on source. "There have been 378 (or 1,044) cases of alcohol poisoning in Tripoli so far," Minister Nouri Doghman said, plus 15 (or 87) deaths thought to be from methanol contamination.[b] Libyan authorities declared a state of emergency in Tripoli's hospitals. Libyan red grape wine from Zlitin farms is said to be excellent. Libyan netizens are debating whether alcohol should be allowed prompting a heated discussion on whether lifting the alcohol ban, taxing and regulating the alcohol trade would reduce such wide-scale tragedies from happening again.[c] In 2009 an Italian tour operator started bringing Italian tourists to Dart Eleel (a then newly built hotel close to the incomparable UN World Heritage Site of Sabratha). The idea was to see the magnificent Roman ruins and a beautiful stretch of Mediterranean beach. Now imagine yourself a group of true Italian tourists, who, after asking for a glass of red wine with their dinner, were told "Malesh, mafish wine (sorry, no wine)." The news made its way to Italy, and after only very few weeks tourists stopped coming.

Alcohol originates from the Arabic term for distilled essences, namely al-kuḥl. The Quran 37:47, uses the word الْ غول al-ġawl – properly meaning "spirit" or "demon" – with the sense "the thing that gives the wine its headiness." Alcohol is glorified in the classic "One Thousand and One Nights" and in the Persian poetry on wine. The textual prohibition is against 'Al-Khamr,' which is the generic term for fermented drinks. Chronologically, the first Quranic verse (16:67) to deal with alcohol was revealed in Mecca: "And from the fruit of the date-palm and the vine ye get out wholesome drink and food: behold in this also is a Sign for those who are wise." In Quran 5. 90–1/93–4, wine is linked with

gambling as a creation of Satan. In contrast, Quran 47. 15/16 states that in the Garden are "rivers of wine, a joy to those who drink." Some interpret the Quran and the *hadiths* as prohibiting intoxication or drunkenness, not alcohol itself. The prohibition was revealed in stages. The clearest is Quran 5.90–1/93–4, from Medina, which trumps all previous guidance: "Intoxicants (all kinds of alcoholic drinks), gambling, idolatry, and divination are an abomination of Satan's handiwork. So avoid that (Satan's handiwork) so that you may be successful."

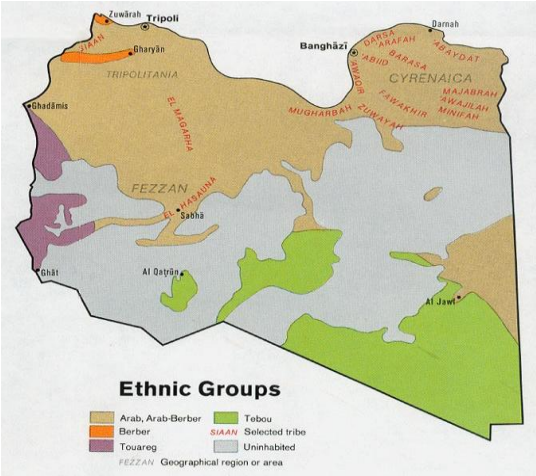
Notes: a. www.who.int/substance_abuse/publications /global_ alcohol_report /profiles/en/index.
b.worldnews.nbcnews.com/_news/2013/03/12/17280948-health-ministry.
c. (globalvoicesonline.org/2013/03/11).

BOX 14: LIBYA'S DATE PALMS

The versatile date palm *(Phoenix dactylifera)* is now cultivated in many desertic countries for its nutritious and abundant fruits. Libya produces 160,000 metric tons annually. Libya's ancient Town of Ghadames "Jewel of the Sahara," the 3000 BCE UNESCO World Heritage site, has a traditional "Festival of the Date Harvest" every October. A single female tree produces up to 150 pounds of fruit in 5-10 bunches, each containing c.1,000 dates. The great value of the date palm is that it can thrive in brackish water. Libya has abundant sunlight and space for trees; the main constraint is water. Depending on the salinity, date production is reduced but still worthwhile. Libya has brackish water in abundance, such as when any GMR water is too saline for human use, any water rejected from desalination plants, as well as urban gray water. Water produced from oil wells is usually too saline for plants. Dates are cross-pollinated so it should be possible to breed for saline tolerance. All parts of the tree are useable, but the use of leaves for livestock fodder and the use of any parts for biofuels will not foster sustainability. Date palms could become a useful component of urban windbreaks especially downstream from gray water outlets. (cf. Ezebilo et al. 2013).

Date Palms

BOX 15: INDIGENOUS PEOPLES



Libya's main minority groups are the Berber (Amazigh, pl. Imazighen) with an estimated 236,000 to 590,000 people, 4-10 percent of the Libyan population, who are made up of different Indigenous Groups including the Tuareg, with an estimated 17,000, members making up 0.3 percent of the population, and the Tebu, who speak a Nigerian-like language. The black Tebu residents of Kufra, Sebha, and Muzuq and the white Arab tribes – the Zawiya or Zaway Indigenous Peoples, the Awlad Suleiman and the Warfella – are the main Indigenous Peoples in Libya.[a] Gadaffi suppressed tribal traditions but they are expected to burgeon since his demise. The Tebu people of Kufra, Sebha, and Muzuq are part of a wider ethnic group called the Teda, desert warriors living in the eastern and central Sahara, a black people without nationality. Most can be found in the Tibesti Mountains on the Libyan-Chad border (Hweio, 2012).

Nomads and Bedouin relations between the Sway and the 12,000-15,000 Tebu are still tense following the 2011 Revolution. Tebus were stripped of their citizenship by Gaddafi in 2009 following a Tebu uprising the previous year, itself the result of persecution by the regime. Gaddafi's people pursued a program of 'Arabisation'. Traditionally the Zawiya practiced nomadic pastoralism of sheep and camels in a triangular area with its apex at Ajadabia. The Zawiya conquered Kufra in 1840, subduing the indigenous Tebu. The Zawiya tribe owns most of the date palm groves of the Kufra oases, employing the Tebu tribesmen as laborers.

Source: Jamestown Foundation, 2013, www.unhcr.org/refworld/publisher,the_JF,LBY,0.html.

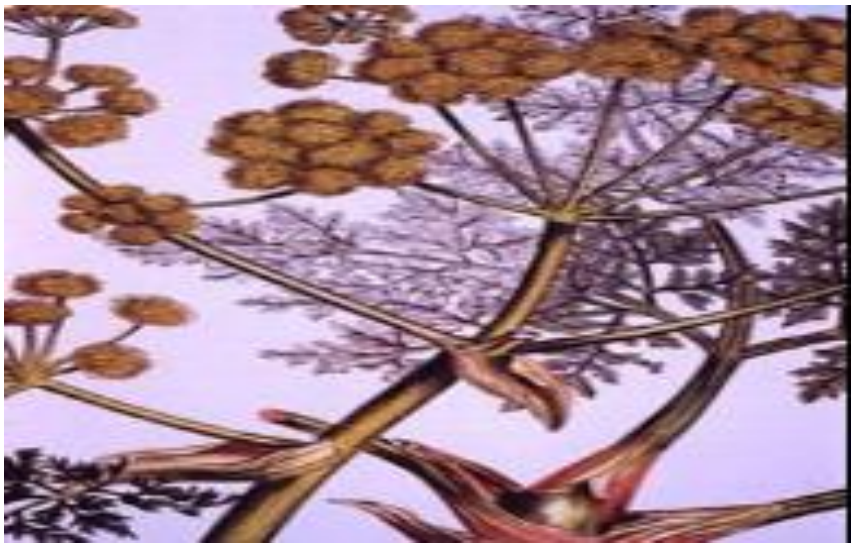
Notes: a. Severe misgivings concern ecotourism involving Indigenous Peoples worldwide. Rarely does it bring major benefits for the Indigenous Peoples involved. The prime criterion to be sought is Free Prior, Informed Consent (FPIC) as established by the United Nations General Assembly. In time and with great care, it might be possible to substantially benefit these people after FPIC has been obtained.

BOX 16: LIBYA'S TOP EXPORT EXTINCT

Ferula (silphion; [σίλφιον]) is an umbelliferous (the family *Apiaceae*) plant that used to be Cyrenaica's most profitable export, but is now thought to be extinct. It is closely related to the spices asafoetida (*Ferula assa-foetida, F. foetida, and F. narthex*), fennel (*F. communis*) and *Thapsia garganica.* Its main value was as a medicinal. Apparently silphion grew in a restricted area, approximately 125 miles by 35 miles, on the coastal plateaus of Cyrenaica. Silphion was first mentioned c. 6 BCE, in the 4th and 5th century Hippocratic texts and by Theophrastus (died c. 287 BCE) in his "History of Plants." It became extinct by the end of the 1st century CE, according to Strabo (c.63 BCE–24 CE). Pliny (23–79 CE) said the last sample of silphion was sent to Nero (37–68 CE). As a substitute for silphium, asafoetida came into prominence during Alexander the Great's (356–323) invasion of Asia that began in the spring of 334 BCE. (Kiehn 2009; Lykoudis n.d.; and Peretz 2005.) Silphium may not have vanished from the face of the earth, though; some believe it was the plant now known as *Ferula tingitana*, a giant fennel that has returned to North Africa. Bishop Synesius, born in Cyrene c. 370 seems to have known of its existence as a cultivated plant. Reports of its rediscovery on Jebel Akhdar in 1991 remain to be confirmed. Like the bits of Noah's Ark rediscovered at the start of each tourist season in Turkey.

Note: *Sylphium* spp., a genus of North American prairie daisies should not be confused with Silphion.

A rendering of Silphion.



7.2 Libya and Biodiversity

Biological Diversity, or Biodiversity for short, is the variety of all life on earth. It includes the numbers of species of plants, animals and in-between organisms (e.g., microorganisms, viruses, prions), plus their genes and the ecosystems of which species are the building blocks. Tropical forests and coral reefs are rich in biodiversity, while deserts and the polar regions have much less.

Sustainability means non-declining biodiversity. If biodiversity declines, reliable sustainability cannot be achieved. Libya's richest biodiversity is in the Mediterranean Sea (Chapter 6) and the Green Mountain forests. Libya's once main export, Silphion, is now extinct (Box 16), but one individual of Libya's largest rodent species, crested porcupine, *Hystrix cristata,* thought to be extremely rare or extince, was found dead-on-road in 1962 in a suburb of Tripoli (Walid Fathy 2011), suggesting that Libya's wildlife is not well documented. The magnificent desert ungulates (Section 7.4) are depleted and some may be extinct as they cannot survive high-powered weaponry and all-terrain vehicles. Libya's remaining wildlife is best represented in conservation units (Box 17). That is why conservation of National Parks is so urgent.

7.3 Conservation Units

FINDINGS

Elwaer's ecotourism and sustainable development congress (2007) put forth detailed action plans for biodiversity assessment of coastal and marine areas, a network of protected areas, a cost/benefit of such priorities, and the potential value of sustainable tourism. Ecotourism will benefit from Libya's 11 conservation units (Hamza and Alkekli 2000), especially the Green Mountain National Park. Birders will focus on Libya's two UN Ramsar wetlands, Sebkhet Ain Ashigiga and Sebkhet Ain Azzarga.

RECOMMENDATIONS

Seven more recommended sites should be officially designated. These are: Farwa, the Taourgha complex, Sebkhet Sultan, Sebkhet Karkoura, Benghazi Lake, Sebkhet Al Kouz, and Sebkhet Temimi/Ain Al.

Libya's National Parks and Protected Areas

On migrating to Medina, God's Messenger organized the planting of trees and of date groves. He made the forests and green spaces conservation areas where every sort of living creature lived. These were called sanctuaries (hima). For example, a strip of land approximately twelve miles wide around Medina was proclaimed a sanctuary and made a conservation area.

Ibrahim Ozdemir, An Islamic Approach to the Environment, www.ecologyandislam.wordpress.com/ 2010/01/03/an-islamic-approach-to-the-environment-ibrahim-ozdemir-ph-d/ and treesgivelife.org/quran

The 1949 Law on Forestry, the first conservation legislation in Libya, sought to protect forests, soil, water sources and tracts at risk of desertification. The 1970 Law for the Protection of Agricultural Land includes an ordinance on the protection of "green areas." The first national park was set up by special decree in 1978. The national park system was designed to foster protected areas to "create meaningful National Parks for the Libyan people and international tourism." The 1978 decree sought to restore and protect native wildlife in reserves where they had been exterminated. Protected areas are now under the jurisdiction of the 1990 Technical Committee of Wildlife and National Parks.

BOX 17: LIBYA'S NATIONAL PARKS AND PROTECTED AREAS[a]

National Parks
Abughilan NP
El Kauf NP (in Jabal Al Akhdar)
Karabolli NP
Kouf NP
Naggaza NP
Rajma NP
Sirman NP

Nature Reserves
Benghazi NR
Bier Ayyad NR
New Hiesha Natural Reserve
Tripoli NR
Zellaf NR

Wetlands of International Importance (UN Ramsar Sites)
Ain Elshakika 30 ha.

World Heritage Convention Sites
Archaeological Site of Cyrene
Archaeological Site of Leptis Magna
Archaeological Site of Sabratha
Old Town of Ghadames
Rock-Art Sites of Tadrart Acacus

Protected Areas
Ain Zayanah PA
Ajdabiya Marsh PA
Al Jaghbub Oasis
Berjuj Valley
Bombe Gulf
Fezzan valleys
Garabulli
Harouj Mountain
Jalo
Kufrah Oasis
Nefhusa (Jebel Nafusa)
Oasis of Ghat
Ouau en Namu lakes
Qaminis and Tukrah salines
Rajma plantations
Sabratha
Sebkha el Sahel
Serir
Shahaat
Taizerbo
Taoulga islands (Thaouara)
Wadi Kham

Other Areas
Belkarra-Boulelli

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Note: a. An underwater archeological park is planned for Apollonia in Cyrenaica, an ancient harbor with ruins, which would be an itinerary for divers and glass-bottom boats . Pizzinato, C. and C. Beltrame. 2012. A Project for the Creation of an Underwater Archaeological Park at Apollonia. *Underwater Technology* 30(4):217-224.

7.4 Libyan Desert Antelope


Some of the few remaining Addax, Libya's lost antelope.

FINDINGS

The desert and semi-desert covering 85 percent of Libya appears at first glance to have been unchanged for millennia. However, the North African bubal hartebeest (*Alcelaphus buselaphus*) was lost before the end of the 19th century. Until relatively recently, North Saharan countries had an abundance of addax (*Addax asomaculatus*), Dama gazelle (*Nanger dama*), and scimitar-horned oryx (*Oryx dammah*). Intense hunting pressure has extirpated these species along with their great predators, the North African lion *Panthera leo*) and the leopard (*Panthera pardus*). Cheetah (*Acinonyx jubatu)* exist in isolated pockets. Scattered groups of slender-horned gazelle (*Gazella leptoceros*) and Dorcas gazelle (*Gazella dorcas*) have been reported in Libya.

Re-establishing this desert-adapted large mammal assemblage is a conservation challenge. Aside from the Arabian oryx reintroduction in Oman, there are few examples of rehabilitating desert ecosystems. No one has recovered an entire assemblage of predators and prey, although the technologies required to do so are available or can be developed. Restoring these flagship species of desert biodiversity will be a significant challenge to Libya's long-term ecological recovery and sustainability. (Information kindly provided by Dr. John Seidensticker, National Zoo, Washington, DC).

The Houbara bustard (*Chlamydotis undulata*) is on the verge of extinction over much of its wide desert range, partly because it is prized by rich Arabian falconers. Hunting with falcons cannot be part of ecotourism, even with the captive breeding of bustards.

RECOMMENDATIONS

- Facilitate the 'visa-on-arrival' option for ecotourists.
- Update and implement the National Ecotourism Strategy. Refer to Dr. Hakim Elwaer's 2006 "Linking tourism development and nature conservation," the 1998 "Tourism Master Plan" from the General People's Committee for Tourism, and the "Transformation Plan for Tourism Sector, Period 2006-2010."
- Allocate a fraction of tourism receipts to nature conservation, to EGA and to the tourism authority.
- Prepare ecotourism guidebooks to attract and educate tourists.
- Conduct surveys to establish the distribution of gazelle and other large mammals.

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8. CONCLUSION

When Libya focuses on environmental sustainability, it will spark national discussion. As soon as Libya decides to become sustainable, training programs will be essential. This work is designed to inform the nation-wide discussion and training towards sustainability.

First, the most significant finding of this analysis is that conservation of fresh fossil water is urgent and that its use should largely be solar-powered, not powered by oil as it is today. How much of Libya's fresh water should be allocated to irrigated crops and fodder? Much less than at present.

Second, desalination, currently a big consumer of oil, also should be solar-powered to the fullest extent possible.

The third step on the path to sustainability is to export solar electricity to Europe. Achieving sustainability in fresh water is the major achievement necessary for Libya. Importing one metric ton of grain is equivalent to importing 1,000 metric tons of water, so conserving fresh water is beneficial for Libya. Import of liquid fresh water is too expensive and supplies, such as those from Turkey, are limited and declining.

Libya's two gigantic imponderables are the amounts of oil and of fossil water remaining in the ground. These closely guarded state secrets or unknowns should become transparent in order to calculate the necessary timing of the transition to sustainability. Based on what little is divulged of these two estimates, Libya may have on the order of 50 years to become sustainable. Capital forces oil reservoirs, aquifers, and mines to be harvested faster than originally planned, just like fisheries, so the peak and the drop-off always come faster than expected. Doubling reserves only delays exhaustion by c.14 years at typical discount rates.

Libya is unusual in that it has the financial and other resources to become sustainable fast if it decides to aim for sustainability. Libya's solar energy on the other hand is among the most intense in the world and inexhaustible. Accelerating the development of solar energy (and wind) will enable Libya to export hydrocarbons for much longer.

Oil reserves are finite and being depleted unnecessarily. Discovery of new reserves lags behind depletion. The transition to solar power would enable much more oil to be exported to pay for the solar transition. At the moment, much oil is allocated to water pumping and desalination. Depletion of oil and greenhouse gas regulations will eventually shrink oil use. Sustainability will benefit Libya to the fullest extent before oil depletion and GHG regulations hit. Worldwide, most coal and other fossil fuels cannot be used; they have to remain unmined in order to achieve some semblance of climate stability. The challenge is to ensure that by then Libya will be based on sustainable solar-

powered water supply, and the export of sustainable solar-powered electricity.

The fourth priority for environmental sustainability is for Libya to reduce risks by diversifying its economy. At the moment, 85 percent of national receipts stem from the hydrocarbon sector. Such an "all eggs in one basket" approach must be replaced by sustainable job creation in other sectors such as value added and domestic processing, including promotion of eco-tourism.

As Libya tackles the expensive task of reconstruction in the aftermath of the 2011 Revolution, it will benefit greatly if it has sustainability in mind in designing reconstruction.

How realistic is it to imagine that Libya can transform itself fast enough to become sustainable before depletion or other constraints on its lifeblood of oil or water start to grip? Pessimists claim that the notion that we can move so fast is naive, even preposterous. Energy transitions are *always* slow. Modern energy infrastructures, assembled over decades, cannot be revamped overnight. The sort of rapid transition to sustainability that Libya needs has never occurred before, especially after two years of civil war. That opinion would lead to Libya falling into destitution within decades.

However, optimists note that no physical law says such transitions must be slow. Societies have changed rapidly, even when it cost a lot of money. The usual example is from 1942 when President Roosevelt banned the manufacture of civilian automobiles, prohibited driving for pleasure and halted residential and highway construction. "In retrospect, the speed of this conversion from a peacetime to a wartime economy is stunning." (Brown 2009). Nobody can predict the future, but it is dumbfounding to hear left and right alike bemoaning the "reality" that society cannot change, particularly at a time when both sides are bemoaning the consequences of convulsive social change (Mann, 2013).

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Robert Goodland served the World Bank Group as environmental adviser for 23 years, where he drafted and persuaded the Bank to adopt most of its current mandatory social and environmental ”safeguard” policies. He served as H.E. Minister Emil Salim’s Technical Director of the independent Extractive Industry Review of the World Bank’s oil, gas and mining portfolio (EIR.org). He was elected chair of the Ecological Society of America (Metropolitan), and President of the International Association for Impact Assessment. Last year, the World Conservation Union awarded him its first Coolidge medal for outstanding lifetime achievement in conservation.

ANNEX A. THE ENVIRONMENT GENERAL AUTHORITY

FINDINGS

Libya's Environmental General Authority (EGA) has two powerful tools that are somewhat underutilized at present for understandable reasons.[16] They are (1) preparation of the annual State of the Environment Report (SoE) and (2) environmental assessment. These tools will help EGA conquer what it considers its main problem, namely that powerful agencies refuse to take EGA seriously.

The SoE and the EIA are both mandated by Libyan National Law. If any agency declines to fulfill its legal obligations under this law, EGA can and should sue that agency for redress.[17] That is EGA's national duty. However, given limited resources EGA must choose its targets well. The threat of a lawsuit should be enough to secure compliance or rectification of environmental damage.

EGA realizes it can afford to pursue extremely few court cases, and this is as it should be. It may take winning one well-chosen lawsuit for EGA to earn the respect and attention it deserves. In addition, well-publicized fines or compensation for environmental damages can exert a salutary effect on other agencies or companies.

RECOMMENDATIONS

- As EGA accumulates personnel and resources, it may want to use its two tools—the SoE report and environmental assessment—to assert its authority.
- Make the SoE annual when possible.
- EGA should consider suing any agency that declines to fulfill its legal obligations, but it should be selective in choosing its targets.
- Fines or compensation for environmental damages can be used as a deterrent and to garner respect for the agency.

[16] The structure, staffing, mission and organization of EGA are well set forth in EGA's March 2006 Stakeholder Survey (279–310), so they are not repeated here. It is difficult to ascertain EGA's position following the 2011 Revolution.

[17] In the United States, the federal Agency of International Development claimed it did not have to comply with the 1969 National Environmental Policy Act (NEPA) in the development projects it financed overseas. In 1975, USAID was taken to court by environmental NGOs. Soon after, USAID capitulated and settled the lawsuit out of court; from then on, USAID faithfully complied with NEPA and other environmental laws.

A1.1 Libya's State of the Environment Report

FINDINGS

The process of preparing the State of the Environment (SoE) report is one of EGA's most powerful tools in accelerating improvement of environmental quality and approaching sustainability. The SoE process is the most efficient way of finding information gaps, and it is where information technology can be best applied. In addition, it can be effective in boosting awareness in civil society, including among politicians and industrialists, as well as in municipalities and other institutions.

Although EGA would phrase it more diplomatically, the SoE is partly a "name-shame-and-blame" tool.

The SoE process fosters nationwide discussion and broad agreement on national environmental priorities. This is a valuable process that takes time. Central to this discussion will likely be the use of as much renewable energy as possible in pumping groundwater and powering desalination.

The SoE process starts with broad grassroots brainstorming with academia, professional associations (such as engineers and teachers), civil society and municipalities. As in the valuable 2002 SoE, each chapter deals with a single sector.

A valuable coincidence is that in August 2006 Libya's leading environmental NGO, the Environment Friends Association, started its own "National Roundtable Discussion" for each sector, including the National Oil Company, Housing, Health and even EGA itself.

Each sectorial discussion will be thoroughly covered on television and radio. Law 19 of 2001 provides for NGOs to sue agencies and institutions for environmental damages in court. As many Libyans are taking up Western diets, obesity is burgeoning (Elmehdawi, 2012). Sustainability would be helped and public health improved if traditional Libyan diets are resumed.

RECOMMENDATIONS

To maximize the value of the SoE, EGA should lead the preparation of the SoE and be central in the preparation process.

EGA may want to engage consultants such as Egypt's Jafari Co., to help in the mechanics but not to take the lead. UNEP sometimes provides useful steering committees to optimize the process and to encourage all relevant ministries to participate fully. In addition, upon request UNEP can help ensure that international standards are met and international comparisons are drawn.

SoE should identify every year's best environmental achievements in the most important categories and include ranked lists of the most environmentally damaging projects, companies or events.

The process of discussion and agreement on national environmental priorities is more effective if it is not hurried. It is best carried out at all levels over a period of months.

All government ministries must be copied on progress and plans and invited to participate in the process.

The sectorial roundtable discussions of the Environmental Friends Association may be valuable to EGA in preparing the State-of-the-Environment report. There would be great synergy if EGA and EFA could collaborate on this National Environmental Roundtable process.

A1.2 EGA and the Implementing Ministries

FINDINGS

Since 1995 incessant bureaucratic reorganization and changes in leadership have weakened EGA, which has had seven chairmen in the past five years. Recently EGA was demoted within the government hierarchy, from directly answerable to the General People's Congress to one of the units in the Ministry of Health.

After the opportunity of the SoE process, the second means by which EGA can exert more influence over powerful bodies is by generalizing its commendable relationships with the National Oil Company (NOC) and extending them to other ministries. EGA fostered the creation of a Health, Safety and Environment Unit (HSE) inside NOC. This modest but dynamic unit is the first line for promoting environmental prudence inside NOC and all its subsidiaries. It reports directly to the president of NOC. In this way NOC's HSE Unit is an extension of EGA, hence influential in improving environmental precautions throughout the hydrocarbon sector.

One of the earliest and most laudable achievements of NOC's HSE Unit was to mandate that each foreign oil corporation operating in Libya create its own in-house HSE Unit. These foreign corporate HSE Units are each staffed with two to 40 professionals. This increases EGA's reach. As Libya hosts more than 20 multinational oil corporations, these arrangements are powerful in promoting environmental improvements and in achieving good practices. NOC's HSE Unit sets out the contents and quality of the environmental assessments and baseline data required by EGA for all new infrastructure projects. In particular HSE can ensure that all production-sharing contracts contain effective clauses on environmental assessment, environmental training, performance bonds and insurance for spills. These Exploration and Production Sharing Agreements (EPSA) in turn are checked by EGA, which is responsible for the content and standards that

multinationals follow under NOC's guidance.

RECOMMENDATIONS

- EGA would be more effective if its line of responsibility were returned to the General People's Congress.
- EGA should require all relevant ministries to create either their own in-house HSE Unit or an environmental unit, with health and safety responsibilities assumed elsewhere.
- An early step is for EGA to decide which ministries or agencies it wants to catalyze first with this requirement. Such units will then become EGA's main entry point into each ministry. Once those eight or more HSE Units have been galvanized, EGA influence over these authorities and ministries will soar.
- EGA may want to outplace an EGA official in each of those HSE Units to facilitate information exchange, promote cooperation and boost training.
- EGA will find it effective to convene an annual meeting of HSE Units to explain the new regulations being contemplated, to ensure that the views of the HSE Units are fully reflected in the draft regulations affecting them so they can learn from one another by sharing successes and failures, and to create a forum for training and capacity strengthening.

A1.3 EGA's Links with Implementing Ministries and Authorities

The main candidates needing HSE or Environmental Units or enhancement of existing arrangements are shown in Box A.1.

BOX A.1: MAIN GOVERNMENT BODIES THAT PROMOTE SUSTAINABILITY, PRE-2011

The Ministry of Industry for air pollution and toxics, cement dust and respiratory disease, phase-out of fuel oil and phase-in of natural gas.

Tripoli Municipality for sewage maintenance and recycling, rodent control through management of household garbage (rodent-proof receptacles, reliable collection, safe disposal). Households will not recycle plastics until it is made easy for them.

The Water Authority and the Great Manmade River Authority for conservation of water, water pricing, transition to pumping with renewable energy.

The Ministry of Agriculture for conservation of water, water pricing, to boost the efficiency of irrigation, phasing down the most wasteful irrigation technologies.

The Department of Energy to foster the transition to renewable energy, conserve oil and gas use, and improve waste management.

The General Electricity Company of Libya (GECOL) to accelerate its goals of phasing in the use of natural gas, phasing out oil and phasing in renewables, reducing arrearages, phasing out subsidies, moving towards full-cost pricing and reinforcing the three-tier price system to support poor households.

The Transportation Department to mandate improved fuel efficiency standards for imported vehicles, promote bus systems and debit bus cards for poor households.

Ministry of Marine Resources will be pivotal if Libya wants to lead Mediterranean conservation.

A1.4 EGA and Municipalities

FINDINGS

All major municipalities (or districts or *shabiyates*) have their own environmental protection units separate from EGA. They appropriately deal with municipal priorities of solid waste disposal, landfills, plastics, and hygiene in commercial establishments. These municipal units are the first line in fostering environmental progress. Eight branches take care of all sha'biya. Sha'biya offices coordinate with EGA branch offices and also with Ministry of Health branch offices in sha'biya.

RECOMMENDATIONS

- Powerful synergies exist for EGA by encouraging these municipal units, arranging meetings to share experiences (what works well and what works less well), awarding prizes for the most effective units in each category and recognizing achievements in other ways.

- Rat control will likely be more effective with improvements in garbage receptacles and collection as opposed to poisoning or trapping, although all methods may be needed in certain cases.

A1.5 EGA and Civil Society

FINDINGS

EGA is responsible mainly for regulations and setting standards. But raising awareness is one of EGA's most important priorities. It is most effectively achieved through strong mutual partnerships with civil society. So it is commendable that EGA has close collaboration with Libya's 12 environmental NGOs.[18]

Some of Libya's environmental NGOs work at the sha'biya level; others work throughout the country. The Environment Friends Association (EFA), for example, is able to raise

[18] For example: Environment Friends Association, Azzeraah Sidi Al Masry (near the Arab Agricultural Development Organization), Tripoli, www.efflibya.org; info@efflibya.org.

awareness at all levels, especially among the grassroots, neighborhoods, municipalities, boy scouts and schools. In addition EFA organizes quality and professional scientific conferences from time to time with great influence on decision-makers, scientists and academia. The 2004 international scientific forum on environmental technologies was very influential in this regard.

The mutually beneficial cooperation between EGA and EFA is commendable. EGA will be able to use EFA in all environmental training.

EFA planned Libya's First Environment Congress for 2007. This was a valuable opportunity for EGA and for Libya, but it was postponed due to bureaucratic uncertainties. Support and encouragement for such congresses would greatly serve EGA's awareness-raising achievements.

National Law 19 sets out the ways NGOs operate in Libya. In some cases the law does not give adequate freedom to NGOs to conduct their activities.

RECOMMENDATIONS

- Continue to maintain strong partnerships and collaborations with environmental NGOs.
- Consider revising the law to give adequate freedom to NGOs to conduct their activities.

Strengthening Environmental Capacity

EGA fully understands that strengthening capacity is arguably its top challenge and has a commendable training center to handle this challenge. Capacity strengthening should continue to be EGA's priority and could be invigorated. The main opportunity is to transform EGA's capacity in environmental assessment. This task is feasible and need not take too long to achieve tangible results. This section outlines some ways for EGA to realize such results.

In-Country Training Courses

FINDINGS

Environmental training is not common in Libya. The Academy of Graduate Studies in Tropoli teaches a small master's degree program on science and environment. There is also an environmental training component in Libya's National University engineering program. EGA wants to determine the best balance between in- country and overseas training.

Production sharing contracts (PSCs) in the oil industry these days normally specify that

each oil concessionaire will finance and promote training in all aspects of the sector.

RECOMMENDATIONS

Three separate training courses are needed to fulfill EGA's three main roles (training, research, and standards and enforcement).

- One training course should be linked to EGA efforts to develop regulations for the permitting process and to integrate standard environmental and social clauses into Production Sharing Agreements (PSAs), to assist in standardizing the permitting process.
- A second course would be linked to EGA efforts to monitor compliance with regulations, also known as compliance audits.
- A third course should be linked to efforts to agree on remedies or penalties for noncompliance such as fines, compensation, performance bonds, escrow accounts and triggering insurance.
- Conflict management should be included in one of these three courses—whichever is deemed the most appropriate.
- In view of the large number of new oil concessions being addressed by NOC, an intensive, week-long course as the basic introduction to ESA should be repeated four or five times annually for the next three years.
- If EGA organizes the training, costs should be recovered as appropriate from oil concessionaires in light of the industry standard for such financing of training.
- NOC should ensure that from now on PSCs for oil operations in Libya specify that concessionaires finance and promote the needed range of environmental training.
- Staff from EGA and its cooperating ministries should be systematically included in ESA training. Relevant employees in the oil industry and other parts of the private sector would also benefit greatly from such training. Civil society (including the Environment Friends Association) and academia should routinely be invited. Other in-country training courses needed by the private sector, such as in oil spill response, should be opened to EGA and civil society as well.

Dr. Sandra Kloff (srkloff@hotmail.com), Clive Wicks (clivewicks@google.com) and Loïc Trebaol (trebaol.consult@wanadoo.fr) have had rich experience in offering environmental courses in the Mediterranean and on the oil sector; hence they could be consulted on the design of such priorities.

Training Resources

RECOMMENDATIONS

- EGA should retain copies of all course notes, manuals, handbooks, handouts, PowerPoint presentations, ESAs and other reports and relevant literature. These materials should be in a form readily accessible by EGA and others (mainly

electronic), backed up by EGA's excellent Training Resource Center or library with reading machines, disks, etc.

- IAIA's "EIA Training Course Data Base" is a must to jump-start training materials acquisition (info@iaia.org).
- UNEP's "Training Resource Manual for Environmental Impact Assessment" (second edition, available in Arabic), including transparencies and case studies prepared by UNEP, is also a must for EIA training. Dr. Hussein Abaza (hussein.abaza@unep.ch; Hussein.m.abaza@gmail.com), founder of UNEP's Geneva Program, is available to respond to all queries related to UNEP's excellent EIA training manual.
- The World Bank's three-volume "Environmental Assessment Sourcebook" is available in Arabic from the World Bank at worldbank.org.
- Most of the literature cited in this book should be obtained by EGA's Training Resource Center.
- The private sector should deposit electronic copies of all its reports and other documents in EGA's Training Resource Center as a matter of policy, and this should be specified in all PSAs.
- The Training Resource Center will need the periodic services of a librarian or bibliographer with computer skills to codify all materials and make them readily available as CD-ROMs.

On-the-Job Training

RECOMMENDATIONS

- All the training possible on the job should be done before separate intensive courses.
- Separate intensive courses should begin as soon as possible in the ministries, especially for those who already have on-the-job training.

Overseas Training

FINDINGS

UNEP and other UN members sponsor a one-year master's degree without a thesis at McGill University in Montreal. McGill also offers a two-year environmental master's degree. The Centre for Environmental Management and Planning (CEMP) of Aberdeen had short courses on environmental assessment, with emphasis on the hydrocarbon sector, sponsored by the UN and by WHO. CEMP also offered one-year ESA courses.

RECOMMENDATIONS

Appropriate candidates should be sent overseas for advanced training in environmental and social assessment. The optimal magnitude of such training needs to be discussed and agreed. Probably three or so EGA officials should be sent annually for a one-year master's course or equivalent over the next 10 years.

Foreign Advisers

FINDINGS

As the government is already overloaded with processing oil exploration and production permits, time is of the essence. EGA must get ahead of the curve as soon as possible.

RECOMMENDATIONS

- Foreign advisers should support EGA's preparation of environmental regulations, monitoring and enforcement.
- Foreign advisers should be matched with Libyan counterparts as a form of one-on-one training, with a view to phasing out the foreign counterpart as soon as practicable.

Environmental Assessment Training

RECOMMENDATIONS

- The urgent priority for ESA training should be undertaken by ESA specialists seasoned in Africa and preferably experienced in the oil sector and Libya.
- Such ESA specialists should contract to return to provide ESA training of various depths.

A1.6 Environmental Legislation

FINDINGS

Libya's Law 15 of the year 1371 (2002) on the environment is the main legal instrument extant. However, as is to be expected, it has to keep up with national priorities, which have evolved since the 1980s and 1990s, when the law was drafted. This book cannot analyze the law but can point out sources of support for any revisions deemed necessary.

RECOMMENDATIONS

- UNEP has an Environmental Law Capacity Building Program for Sustainable Development.
- Since 1970 the IUCN Environmental Law Centre (ELC) in Bonn has offered facilities for countries seeking guidance on environmental law. It can offer courses and analyses of existing laws.
- ECOLEX, an information service on environmental law, is available under the auspices of FAO, IUCN and UNEP. Its purpose is to build capacity worldwide by providing the most comprehensive global source of information on environmental law. It can be contacted at ELCSecretariat@iucn.org.

- EGA needs specific standards and regulations stemming from Law 15.

Certification

FINDINGS

EGA uses ISO methods certification 17000–025 for its own lab equipment.

RECOMMENDATIONS

- EGA may want to use the opportunity of a company qualifying for the ISO 14000 certification to send an EGA official to present a certificate, get to know the company and raise awareness.
- EGA should keep in mind that certification is better than no certification, but it is self-policed and not always flawless.

A1.7 Ecological Economics

FINDINGS

Ecological economics and environmental economics overlap, but the former is the more prudent approach. Ecological economics is the set of powerful mechanisms by which sustainability may be achieved and environmental problems prudently solved.

Libya's Oil Fund; incentives to conserve water, oil and gas and reduce waste; and the approach to sustainability are elements of ecological economics. Such topics need to be addressed. EGA's role is to ensure that they are addressed by the most appropriate agency. For example, the Ministry of Justice in cooperation with EGA best promulgates environmental legislation. Incentives to conserve water may best be led by the GMR in cooperation with the Irrigation Department, and so on. Ecological economics is so fundamental that it will be addressed in many agencies and ministries.

As this is not an economics treatise, this section is restricted to pointing out the need, not solving the problem.

RECOMMENDATIONS

- EGA should ensure that topics of ecological economics are addressed by the most appropriate agency.
- Ecological economics should be the focus of the re-energized National Commission on Sustainable Development (see section 8) or an interministerial commission.

A1.8 Health Impacts

FINDINGS

EGA is currently subsumed in the Ministry of Health, although its locus is revised frequently. Therefore public health, especially communicable disease, is a significant topic in the EGA. Libya has had a reasonable standard of living and a robust per capita daily caloric intake of 3,144. The country has made strides in public health and, since 1980, child mortality rates have dropped from 70 per thousand live births to 19 in 2009. Life expectancy has risen from 61 to 74 years of age during the same span of years. The biggest health problem in Benghazi right now is trauma, with over 25 fatal automobile accidents a day. Traffic accidents in other cities are similar. The communicable diseases leishmaniasis, schistosomiasis and malaria seem under control. One of the other health risks, HIV/AIDS, is not environmental. (FAO, Rome, Libya, Country Profile 2012.) Contamination-related morbidity in general is a focus of the Ministry of Health, supported by EGA.

The UN World Health Organization (WHO) has published a detailed manual and training guide on health impact assessment. WHO offers training and advanced courses on HIA on request (Martin@birleyhia.co.uk).

RECOMMENDATIONS

- Martin Birley (2011) and the WHO manual and training guides (e.g., Hassan et al. 2006) should be the centerpiece of EGA's health and ESA regulations.
- The ESA public health section should specify which employees will be health-screened before they are hired
- Strategic Impact Assessment should precede ESIA and should always contain health impact assessment (HIA).
- Health inequality should be an integral part of all HIA.
- Pulmonary disease from cement manufacture and rat control should be included in HIA regulations.

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ANNEX B. ENVIRONMENTAL SUSTAINABILITY

The 1987 UN report, *Our Common Future*, by the Brundtland Commission, pushed sustainability to the top of the international agenda. Sustainable development as a goal was confirmed by the 1992 UN Earth Summit's Agenda 21 and reconfirmed at the 2002 World Summit on Sustainable Development in Johannesburg. Sustainability was agreed as a top Millennial Development Goal in 2000: "The overarching goal is to define a global action agenda for sustainable development in the twenty-first century and beyond."

Sustainability is an effective framework that could convert economic development into a process that directly reduces poverty while conserving the life-support systems on which the poor and all others depend. Decision-makers must strive to create action plans to make each sector of the economy environmentally sustainable, as here defined, not just slightly less bad than yesterday. As Libya scored poorly in all measures of governance, according to the International Monetary Fund (IMF) (Chami et al. 2012), much emphasis must be given to boosting human capital. A skilled labor force and a smoothly operating labor market are important for economic development. To complement the governance framework, emphasis should be placed on improving productivity through strengthening the education system and increasing human capital to support the private sector. Libya has a young population—close to 50 percent are below 25 years of age—with a large influx of entrants to the labor market expected in the next decade. Transforming the economy will require a workforce with new skill sets, and private companies may struggle to find qualified and experienced personnel. To meet the demand, it will be important to establish training programs for workers and job seekers, and to reform the education system to reflect new needs, such as language and computer skills. In addition, the size of the civil service will need to be reduced, and public sector wages contained to limit growth in the reservation wage. The transition will not be easy: it will be important to strengthen social safety nets to support those in need while allowing the labor market to operate freely and effectively (Chami et al.2012).

Yale University's and Colombia University's Sustainability Index, ranks 146 countries according to their level of sustainability. It is easy to see that the more-sustainable countries (Scandinavia, Switzerland, Uruguay) have a better quality of life. Conversely, the less sustainable the nation (North Korea, Iraq, Haiti, Yemen), the more difficult it is to live there. Although many citizens do not fully understand the concept of sustainability, they strongly favor its manifestations, such as clean water, livable cities, a living wage, natural spaces, energy efficiency, population stability and local food production.

TABLE B.1 THE FOUR MAIN TYPES OF SUSTAINABILITY

Human Sustainability	Social Sustainability	Economic Sustainability	Environmental Sustainability
Human sustainability means maintaining human capital. Human capital is a private good of individuals, rather than between individuals or societies. Health, education, skills, knowledge, leadership and access to services constitute human capital. Investments in education, health, and nutrition of individuals have become accepted as part of economic development. As the human lifespan is relatively short and finite (unlike institutions), human sustainability needs continual maintenance by investments throughout the lifetime. Promoting maternal health and nutrition, safe birthing and infant and early- childhood care fosters the start of human sustainability. Human sustainability needs 2–3 decades of investment in education and apprenticeship.	Social sustainability means maintaining social capital. This can be achieved only by systematic community participation and strong civil society, including in government. Cohesion of community, connectedness between groups of people, reciprocity, tolerance, compassion, patience, forbearance, fellowship, love, are commonly accepted standards of honesty and ethics. Commonly shared rules, laws, discipline, etc., constitute the part of social capital least subject to rigorous measurement but essential for social sustainability. Social (sometimes called moral) capital requires maintenance and replenishment by shared values and equal rights, and by community, religious and cultural interactions. Without such care it depreciates as surely as does physical.	Economic capital should be stable. The widely accepted definition of economic sustainability is maintenance of capital, or keeping capital intact. Thus Hicks's definition of income —"the amount one can consume during a period and still be as well off at the end of the period"— can define economic sustainability, as it devolves on consuming interest rather than capital. Historically, economics has rarely been concerned with natural capital (such as intact forests, healthy air). To the traditional economic criteria of allocation and efficiency must now be added a third, that of scale. The scale criterion would constrain throughput growth—the flow of material and energy (natural capital) from environmental sources.	Although environmental sustainability (ES) is needed by humans and originated because of social concerns, ES itself seeks to improve human welfare by protecting the sources of raw materials used for human needs, and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans. Humanity must learn to live within the limitations of the biophysical environment. ES means natural capital must be maintained, both as a provider of inputs (sources), and as a sink for wastes. This means holding the scale of the human economic subsystem to within the biophysical limits of the overall ecosystem on which it depends. ES needs sustainable consumption by a stable population.

B2.1 Definition of Environmental Sustainability

The fundamental definition of environmental sustainability employs the input/output rule. Building on the definition of economic sustainability as "non-declining wealth per capita," environmental sustainability can be defined by the two fundamental ecosystem services—the source and sink functions—that must be maintained unimpaired during the time over which sustainability is required.

This definition applies to all countries, sectors and epochs. At the next level of detail, specific indicators of environmental sustainability can be created to measure conditions and trends.

The Three Rules of Environmental Sustainability

There are only three rules of environmental sustainability (Daly 1994, 2004):

- **On the source side:** Keep harvest rates of renewables within regeneration rates.
- **On the sink side:** Hold waste emissions within the assimilative capacity of the environment without impairing it.
- **Nonrenewable resources:** Nonrenewables cannot be made sustainable. But quasi-sustainability can be approached for nonrenewables by holding their depletion rates equal to the rate at which renewable substitutes are created (see below).

B2.2 Quasi-Sustainability of Nonrenewable Resources

FINDINGS

The Serafian Rule, developed by Salah El Serafy at the World Bank in the 1980s, is the positive and ex-post rule for calculating quasi-sustainability pertaining to nonrenewable resources, such as fossil fuels, fossil water and other minerals, as well as to renewables that are being "mined."

It states that the owners of these resources may enjoy part of the proceeds from their liquidation as income. But the remainder must be reinvested to generate income to replace the depleting asset. The interest rate to be used to estimate user cost should be low, say 2 percent or 3 percent, not the 10 percent or more that some institutions employ. The income stream must be prudently reinvested in Libya's Oil Reserve Fund to produce the optimal income in perpetuity.

Libya exports almost nothing but hydrocarbons. Oil revenues on their own will not guarantee improved livelihoods for Libya's citizens. On the contrary, unless prudently and stringently

managed, oil revenues often harm a nation—the widely cited "curse of oil."

Prudently managed, the 1995 Oil Reserve Fund is the key to preventing the curse of oil and promoting sustainability (see below). The Oil Reserve Fund is the main means to translate revenues from depleting oil into sustainable or Hicksian income in perpetuity.

Serafy's method shows that an easily calculable fraction (which changes from time to time) of oil revenue can be allocated to current expenditure for job creation, diversification out of oil, social safety nets (education, health, staple-food vouchers) and human capital formation. The other part must be reinvested to balance depletion of the nonrenewable resource to earn Hicksian income. Such oil reserve funds need to be transparent and subject to public accountability, so that revenues can be used to foster development and provide income against the time when the depleting asset is exhausted (see World Bank 2006b).

Roefie Hueting goes further, especially for nonrenewable energy, by basing a future acceptable rate of extraction on the historic rate at which improved efficiency, substitution, and re-use became available. These calculations show the folly of relying on technological optimism rather than a historic track record.

RECOMMENDATIONS

EGA and civil society have a role in ensuring that the crucial Oil Reserve Fund is managed prudently and transparently.

B2.3 The Timing of Sustainability

FINDINGS

Several variables govern the rate at which Libya can achieve sustainability. Part of the equation depends on estimates of the stock of groundwater and oil, but these are unreliable. The optimal extraction rate of hydrocarbons is important. If price of a barrel of oil increases substantially in the near future, then delaying peak production may be more profitable than accelerating production as soon as possible. On the other hand, some advise accelerating the production rate as fast as possible. Accelerating production in turn depends on the rate at which contracts can be signed and an oil field explored and developed. Those important rates are outside the scope of this report. For sustainability the important rate is the transition to renewables, namely how fast wind and solar can be brought on line.

RECOMMENDATIONS

- There are many benefits and few, if any, costs to accelerating the rate of transition to renewables as fast as possible.
- Delinking desalination and groundwater production from fossil fuels would be a

tremendous achievement for Libya. Most of Libya's oil could then be sold and the revenue invested in perpetuity.

B2.4 Sustainability and Population

Although Libya is the richest nation in North Africa, with a 2005 per capita income of nearly US$10,000, 1 million of its 6.4 million citizens (World Bank est.) live in poverty. Libya's population growth rate—more than 3.3 percent per year between 1960 and 2003—is one of the highest and least sustainable in the world. The 2006 estimate of 2.3 percent annually suggests population increases are gradually moving in the right direction at the moment. Libya's population is 86 percent urbanized, one of the highest rates in the world, and the rural exodus continues. In virtually every industrial society where women are well educated and have ready access to jobs, they have on average two children or fewer. Libya's 2006 census showed that only 30 percent of Libya's women participated in economic activity.

Libya's official unemployment rate of 17 percent is thought to be an underestimate. Assuming it is about 25 percent, and assuming half of the population is under 20 years of age, labor market tensions will intensify (World Bank 2006a). The 3.3 percent population growth rate means each person can earn a shrinking slice of the resource pie. Population increases intensify water and energy use, and exports decline. More effluents and wastes damage the Mediterranean, which is already over-fished. This degrades the quality of daily livelihoods, especially of the poor. Population growth and urbanization exacerbate water shortages (Kezeiri, 2003).

The Oil Reserve Fund can be spread thinly over a larger population or more effectively over a smaller one; that is Libya's choice. Immigration has already started to cause social tensions. Libya's 88 percent adult literacy rate is one of the highest in Africa, although women's literacy rate (71 percent) lags behind men's (91.8 percent).

BOX B.1: ECONOMIC TRADEOFFS

Economic tradeoffs need to be prudently focused, but are not the topic of this book. The overriding criteria are prudence in investments (see the cautionary tales of Alaska (Box B.2) and Nauru (Box B.4) and transparency, using solely Hicksian income, not receipts or capital. Note that GMR is financed "off-budget," with proceeds from a 2 percent tax on luxury goods such as cigarettes, international travel and fuel. GMR may eventually cost c. $30 billion invested over decades as oil is exported and as luxury goods are taxed. This does not mean $30 billion is or was available in one sum for investment. Taxing tobacco and luxury goods is fine, but under-taxing fuel, while providing most water free or well below the cost of its production, severely distorts the economy and makes Libya less sustainable and more precarious.

B2.5 Libya's Oil Reserve Fund

FINDINGS

Libya would also be well served by improving its Sovereign Wealth Fund (SWF) system, currently operating through the Budget Reserve Account, with clearly defined inflow and outflow rules. Unlike the existing arrangement, the system should be dynamic and completely transparent and accountable. The Budget Reserve Account and the Libyan Investment Account portfolio could be merged to create a single system with two sub-portfolios, with separate portfolio management objectives aligned with their respective stabilization and savings purposes. The SWF system should be based on well-specified and regulated investment criteria. Domestic investments that could have an adverse impact on monetary policy or that could lead to conflicts of interest and fragmentation of the budget framework should be eliminated. Outflow rules relating to long-term objectives or specified contingency events, outflows from the SWF system would only be earmarked to support the budget directly; all development spending would be channeled through the budget (Chami et al. 2012).

Building endowments to replace shrinking natural resources is a relatively recent mechanism. Permanent funds or sovereign funds are no more than sensible stewardship of one's national savings, part of "sovereign wealth management," and are well-known financial mechanisms created to ensure that oil receipts benefit the people in perpetuity. They also prevent allocation of all oil receipts to current expenditures, prevent the "Dutch disease"[19] and reduce the risk of inflation. Ideally, high-savings countries and those rich in oil receipts in the Middle East and Asia would liberalize their economies, allowing their own citizens to invest for themselves, rather than paying sovereign wealth fund managers to do it for them. But we are not at that point yet. Sovereign funds seem here to stay for at least the near future.

Permanent or sovereign funds are part of "sovereign wealth management". The United Kingdom oddly decided not to invest tax revenues from its £200 billion North Sea oil bonanza, which began in the mid-1970s, peaked in the late 1990s, and is now almost depleted. If this oil tax had been invested in a sovereign fund, it would have grown by now to more than £500 billion.

The best goals of sovereign wealth funds include (a) saving resources for the future so that by the time the resource has been exhausted, a sustainable income is available for Libyans in perpetuity; (b) stabilizing oil price volatility; (c) diversifying national revenues; (d) designing effective safety nets, creating jobs and increasing human capital formation in country. It seems better for an exporter to sell as much oil as it can today and invest the proceeds, than to leave

[19] The Dutch Disease is the harm (such as decline in wages, employment and budgetary attention) in traditional sectors (e.g., agriculture) and the narrowing of diversification resulting from booms following discoveries of natural resources. This occurred when the Netherlands discovered North Sea gas, Jamaica discovered bauxite, and Venezuela oil, for example. Exploitation of the natural resource appreciates the real exchange rate, raises wages in the new industry, and diverts resources away from traditional sectors.

the oil in the ground in the hope of spreading production over decades. Two new extra-budgetary funds have been created that could hamper Libya's progress towards sustainability, namely the Investment Fund and the US$5 billion Libya African Development Fund of 2006.

BOX B.2: REVENUE MANAGEMENT IN ALASKA
[WWW.APFC.ORG]

The experience of Alaska is useful for Libya. ExxonMobil Corp pays the oil owners (the state of Alaska) a royalty for permitting the company to extract the oil. Since 1976, Alaska has invested the royalties in the Alaska Permanent Fund. This fund is designed to transform nonrenewable oil receipts into sustainable income in perpetuity. The sustainable income from the fund's earnings on its investment portfolio is then divided equally among all Alaskan residents each year. Neither the fund's principal nor current oil revenues can be given to residents by law.

The Alaska Permanent Fund receives most of the state's oil receipts (severance tax, US$1.80/barrel; royalties from state lands, income taxes on wellhead income; tax on the pipeline profits totaling US$3.90/barrel). The fund prudently invests such receipts each year. A constitutional amendment would be required to touch these assets. All investments are transparent. Most investments are outside Alaska. Each Alaskan receives a detailed breakdown of what is invested and what is earned. The dividend from the investments goes equally to each resident of Alaska. The 1997 income, US$750 million, generated US$1,300 per resident, or US$6,500 for a typical family of five. It is frequently the largest source of cash income, especially for ethnic minorities. Such payments are federally taxable, so they represent a transfer from the state to the federal government. Now that Prudhoe Bay's peak of 2 million barrels per day (mb/d) has declined to 750,000 mb/d, fund income has exceeded oil receipts for the first time.

Partly because of Alaska's long history of boom-and-bust cycles (such as the gold rush of the 1890s and fluctuating oil prices), the state insisted on high degrees of economic prudence. The fund's income is divided into three parts. The first approximates the annual inflation rate measured by the consumer price index to inflation-proof the corpus of the fund. Second, about half of the residual (net of the inflation adjustment) is paid out as the annual dividend. Third, what is left is invested in the earnings reserve. In 1996, for the first time, the total income of the fund (now US$24 billion) rose to and equaled the declining oil receipts. In addition, Alaska has no debt while holding US$35 billion invested in financial assets.

The importance of funds saved from oil revenues in January 2007 is clear. Government had some 13 billion LYD (US$10.4 billion) in 2006, pushing the total consolidated funds to 65 billion LYD to date. Before the 2005 creation of the public fund saving mechanism, all annual oil revenues ended up being spent, and Libya's central bank reserves were meager. Out of the savings from oil revenue, 30,000 LYD will be allocated to each poor Libyan family, and the balance will be put in the Economic and Social Development Fund, to be used to purchase shares in banks and companies in Libya on behalf of the families. [20]

[20] Early sovereign wealth funds focused on recycling petrodollars. Sovereign wealth funds should focus on the sustainable development of their own internal economies. Investment in external economies should be kept balanced in order to diversify, spread risk, and promote sustainability of income, while maintaining development of their own economies as the priority. Diversification of Libya's economy away from oil exports, and towards sustainable water and energy, value added, domestic processing, and job creation, possibly by accelerating oil refining and petrochemicals, will be important for such funds. In the case of Nauru

It is difficult to convert nonrenewable resource extraction into any semblance of long-term sustainability, but quasi-sustainability can be achieved. Named after its inventor, Dr. Salah El Serafy, "Serafian quasi-sustainability of nonrenewables" splits the receipts from extraction into two streams. First is an investment stream or user cost, which has to be invested in a sustainable substitute so that it earns sustainable interest. The remainder is the true Hicksian income stream that can be allocated as Libya wishes. The Serafian method ensures that in a decade or so, when the oil has been liquidated, Libya will have a sustainable source of income for the future. The Norway Pension Fund is a well-known and well-managed fund, as is the Alaska Permanent Fund Corporation (see Box B.2). Serafian quasi-sustainability of nonrenewables thus is related to sovereign wealth management (Johnson-Calari 2007). The IMF is working on a code of conduct for sovereign wealth funds, which will be useful if Libya overhauls its approach to sustainability.[21] The extraordinary damage that occurs if depleting asset receipts are treated as income is outlined in Box B.4.

Libya's Oil Reserve Fund is very important for any approach to sustainability. This fund seeks to stabilize oil revenue volatility and is for savings from oil windfalls.

Libya is thought to have saved between US$ 33–50 billion as of 2007. This fund is the only way for Libya to achieve sustainability before the oil and possibly the groundwater run dry.[22]

Libya may have about 50 years to become sustainable and is unusual in that it has the financial and other resources to do so. Accelerating the development of solar and wind energy will enable Libya to export hydrocarbons for much longer. Management of this fund is outside the scope of this report.

RECOMMENDATIONS

- Sovereign wealth and economic and social development funds should be managed

(see Box B.4), most sovereign funds would be invested overseas; in the case of Libya, most funds should be invested nationally to make water and solar energy sustainable.

[21] As of 2008, sovereign funds adopted a voluntary code of conduct called the GAPP principles: http://www.iwg-swf.org/pubs/gapplist.htm.

[22] One of the first sovereign wealth funds was created in 1956, when the Gilbert Islands, now the Republic of Kiribati, levied a small set-aside on its phosphate-rich guano exports, which were depleted as independence was won in 1979. The Kiribati Revenue Equalization Reserve Fund has now grown to US$520 million or nine times the GDP (See Box B.4). Two of Kiribati's islands have recently been submerged, possibly by sea-level rise as part of climate change, thus over-crowding the 105,000 residents. The two biggest sovereign wealth funds are the Abu Dhabi Investment Authority of the United Arab Emirates of US$875 billion, followed by the Government of Singapore's (GIC) of US$330 billion. Norway's Government Pension (Global) Fund of US$380 billion is the most transparent, as it discloses portfolios and returns annually.

rationally and transparently to promote development. Report annually on motives and main holdings.

- The Oil Reserve Fund should be expanded as much as possible and invested prudently in sustainable assets, so that the people of Libya can live off income from the fund in perpetuity, even when most hydrocarbons have been sold and most fossil water has been depleted.
- The Oil Reserve Fund needs precise and enforceable accumulation and withdrawal rules.
- Transparency is essential because there is always pressure to draw down such funds for current expenditures.
- Transparency in subsidies also is important, to strive to meet the objectives of the subsidy more efficiently by other means.

The National Commission for Sustainable Development

FINDINGS

It is encouraging in regard to sustainability that the Libyan People's Congress created the National Commission for Sustainable Development on 14.4.1370 (2001). Its main task was the preparation of a national strategy for sustainable development for the UN Earth Summit on Sustainable Development. This commission has 22 members ex-officio and is chaired by the secretary of the General People's Congress. However, since then there seems to have been little follow-up.

RECOMMENDATIONS

- If Libya decides to accord more importance to environment, this is a possible place for reinvigoration, as it contains the top politicians and decision-makers.
- As depletion of oil and fossil water are so crucial for Libya and as climate change risks intensify, an effective Ministry of Environment is becoming more appropriate.

BOX B.3: ECOLOGICAL ECONOMICS VS ENVIRONMENTAL ECONOMICS

Ecological economics is the union of economics and ecology, where the economy is conceived as a subsystem of the global ecosystem that is sustained by a metabolic flow or throughput from and back to the larger ecosystem. The economic subsystem depends on a flow of raw materials and energy from the global ecosystem to the economic subsystem and back to the global ecosystem's sinks as wastes.

Environmental economics, a branch of neoclassical economics addressing environmental problems such as pollution, negative externalities, and valuation of non-market environmental services, assumes that the economic system is the whole and not a subsystem of the continuing and sustaining global ecosystem. Environmental economics focuses almost exclusively on efficient allocation (Daly and Farley 2004).

B2.6 Environmental Sustainability Indices

FINDINGS

The Environmental Sustainability Index (ESI) report measures overall progress toward environmental sustainability for 142 countries based on environmental systems, stresses, human vulnerability, social and institutional capacity and global stewardship.[23] The reports and their underlying data are available online at the Center for International Earth Science Information Network (CIESIN).[24] The documents on that Web site provide details of the analytical framework, quantitative methodology and data sources that underlie each edition of the ESI. Note that because of data and methodological improvements to each subsequent version of the ESI, the country scores cannot be utilized in time-series analysis.

Here is an example of an ESI:

UN Millennium Development Goal No. 7:

- Proportion of land area covered by forest (FAO);
- Ratio of area protected to maintain biological diversity to surface area (UNEP-WCMC);
- Energy use (kg oil equivalent) per $1 GDP (PPP) (IEA, World Bank);
- Carbon dioxide emissions per capita (UNFCCC, UNSD);
- Consumption of ozone-depleting CFCs (UNEP Ozone Secretariat);
- Proportion of population with sustainable access to an improved water source;
- Proportion of population with access to improved sanitation.

RECOMMENDATIONS

- The ESI has limited value for Libya.
- The UN Millennium Development Goal No. 7 may be useful as a guideline but would have to be tailored to Libya.

[23] World Economic Forum (WEF) Global Leaders for Tomorrow Environment Task Force, Yale Center for Environmental Law and Policy (YCELP)/Yale University, and Center for International Earth Science Information Network (CIESIN)/Columbia University. 2002. 2002 Environmental Sustainability Index (ESI). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/esi-environmental-sustainability-index-2002.

[24] See Center for International Earth Science Information Network (CIESIN) ciesin.info@ciesin.columbia.edu.

BOX B.4: REVENUE MANAGEMENT IN NAURU

After 90 years of mining, this 21 square kilometer Pacific island, the world's smallest island nation, has exported much of the island itself in the form of the world's highest-quality strip-mined phosphate rock. Now no arable land, no crops, no woodland is left and few coconuts remain. Abundant fish populations have disappeared. The exposed rock reflects radiation, driving away rain. Once abundant freshwater and the four-hectare Buada lagoon and surrounding swamps have dried up. The mined landscape has become a barren, impassable and unfarmable wasteland. Now all food and bottled water has to be imported. The phosphate started to decline in 1989 and is now essentially exhausted.

The commendable revenue management lesson is that phosphate export royalties were invested in the Nauru Phosphate Royalties Trusts, broad-based offshore trust funds, so that the country's GDP is US$59 million for its 12,088 inhabitants (4,000 of whom are foreigners). Revenues, possibly totaling US$1 billion at their peak, were invested in property around the Pacific Rim, equity in a range of businesses, and many financial schemes, some of which were ill advised. Declining phosphate rock production and its decreasing price led to shortfalls, which were passed to the trust. The deficit grew to 18 percent of GDP by 2000, according to the ADB. In the 1970s Nauruans were among the richest people on the planet. Now they are poverty-stricken and unhealthy. Nauru has one of the highest rates of obesity and diabetes in the world; life expectancy has dropped to 55 years, 20 years lower than in New Zealand. Only one-third of the children attend secondary school. Electricity and water are rationed between visits of the fuel ship for the island's desalination and power plants.

Australia officially declared Nauru to be uninhabitable and offered to settle the population to a deserted island off the coast of Queensland. Nauruans opted for independence from Australia, which forced Nauru to borrow heavily against potential future earnings to buy out Australia's and other foreign shares in the phosphate company. Nauru's case at the International Court of Justice at The Hague against former colonial governments for the destruction wrought by mining was settled out of court by Australia in 1993 for US$72 million. Nauru then embraced offshore banking, tax havens, and seems to be involved in money laundering. Nauru's foreign exchange earnings from Australia for acting as an immigration holding-pen for asylum-seekers, has come to an end, so income and employment has fallen still further.

Although the inhabitants will have an income as long as the trust funds earn interest, there is little employment on the devastated island. It is economically sustainable but environmentally and socially unsustainable. With hindsight, it would have been preferable to purchase another non-phosphate island or a similar tract of fertile land elsewhere, export the people and leave the barely habitable rock.

The balance between domestic processing for value added vs. export of unbeneficiated raw materials is important for job creation, and for more profits to remain locally. Domestic processing and value added, such as refineries, petrochemical industries and beneficiation, should be priorities for Libya. A newer phosphate beneficiation plant was built in the early 1980s. Possibly diversification would have prevented some of the island becoming uninhabitable. Domestic processing can make the difference between exploitation and sustainable development.

Note: a. Diversification, domestic production and value added are important elements for Libya's sustainability. The choice of downstream diversification of oil, such as refineries and oil-based products (pharmaceuticals, plastics) can create much long-term employment, hence must figure prominently in the decision-making, especially for the medium term. In the short term, ecotourism seems the most promising means of diversification.

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Praise for *Libya: The Urgent Transition To Environmental Sustainability*

"Today we all have to be more cognizant of planetary limits and take up the challenge of global environmental sustainability and the Green Economy. We have still not come far enough since the concept of sustainable development was elevated to the global policy agenda over two decades ago. Against the backdrop of last year's UN Rio+20 Conference on Sustainable Development, Mr. Goodland, however, makes a convincing case of promoting environmental sustainability in Libya - a case that would be a useful blue print on how to achieve this kind of progress across the globe. I hope your book and advice will be heard and find resonance among Libyans and those committed to supporting them."

Achim Steiner, Executive Director of the United Nations Environment Programme

"A great contribution to the region and particularly to Libya coming at a critical phase of the country's history. The publication provides insights of how the country can use its vast resources and potentials for shifting onto a more sustainable path for the benefit of its peoples. This book is of great use and value to policy and decision makers, as well as to practitioners."

Dr. Hussein Abaza, UNEP Director of Environment and Economics

"You may agree or not with Robert Goodland but you can rest assured that he has done his homework, is scrupulously fair, is telling the truth as clearly as it can be told, and will provide you with an absorbing read. Goodland was a committed ecologist long before it was fashionable and deserves to be heard, on Libya as on anything else."

Dr. Susan George, President of the Transnational Institute

"Making a poor desert country sustainable on the basis of wisely investing a patrimony of depleting oil and fossil water (50 year supply?) with a growing population is a challenge, to put it mildly. But your strategy is very reasonable. You have brought so much information to bear on it (technical, agricultural, hydrological, maritime, etc. with references) that the Libyans owe you a medal of honor. The analysis is sprinkled with insights, (like importing grain is the best way to import water, comparison of yields of same solar plant in Spain vs. Libya). My main question is who or what agencies in Libya might be capable of carrying out the time-limited strategy you outlined? Pulling so much real world information together into a coherent purposeful whole is a real talent, especially when the purpose is such a sane one. Bravo!"

Herman Daly, Co-Founder of Ecological Economics

"Environment is hardly the first word associated with Libya, but Robert Goodland has shown convincingly that even countries beset with challenges need to include concerns about water, energy, and land productivity in their planning for a sustainable future, from the very beginning. This comprehensive, thoughtful, and stimulating book should be required reading for all those concerned about the future of both Libya and the Mediterranean region more generally."

Jeffrey A. McNeely, Senior Science Advisor, IUCN

"Well structured and well written and a marvelous blueprint for the new Libya. I cannot praise highly enough the encyclopedic breadth of coverage."

Salah El Serafy, Lead Economist, World Bank

Flag of Libya