

European Space Agency: EO4OG onshore

D1 Appendix B: EO opportunity for focus countries

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Appendix B: Earth Observation opportunity for focus countries

This section provides an overview of the geography, climate and O&G sector within each of the profiled countries, and an overview of considerations relating to areas of special interest for the EO sector.

1 Algeria

The O&G industry in Algeria is well established. After Nigeria the country is the largest O&G producer in Africa. Field production declines, together with increased domestic consumption has led to a decrease in Algeria's export capacity impacting export revenue. In an effort to arrest this decline the Algerian government has implemented a strategy to incentivise foreign investment. This includes a package of fiscal measures (mainly tax incentives) which promote the development of offshore and shale gas fields.

The O&G industry is largely dominated by the national oil company Sonatrach. The company is legally required to take a controlling stake in all hydrocarbon developments. As a result, more than 80% of hydrocarbon production is owned by the NOC. The country's difficult security situation, along with government corruption, continue to be an impediment to further international collaboration with the world's oil companies.

Regional geography and climate

The largest country in Africa, Algeria's geography and climate is dominated by the Sahara Desert. Much of the land topology is shaped by winds and very occasional rain. Lack of water and baking heat limit plant growth in the desert. As a consequence there is little vegetation in the way of established forests. Most plant life consists of robust plant varieties including grasses and shrubs. Surface water is also scarce resulting in mainly seasonal river flow.

In the north and south are mountains which lie on the country's borders with Niger, Libya and Tunisia. Algeria's populace is largely restricted to the north although small population centres do exist in the south. With a relatively low elevation, Algeria's climate is primarily arid and temperatures in the centre of the country frequently exceed 40°C. Albeit seasonal, mountains in the north often experience temperatures in which snow can fall.

Infrastructure

Algeria has a fairly comprehensive road network that spans most of the country. The country is relatively flat making the construction of transportation infrastructure reasonably simple. The maintenance of roads is generally considered to be poor with many in need of urgent upgrade. Crude oil and natural gas in the form of LNG are exported mainly from port facilities in the Mediterranean. O&G produced in Algeria's interior is piped to northern export terminals and refineries. Most pipeline infrastructure is owned and operated by Sonatrach. Algeria's domestic natural gas pipeline network is very extensive with large amounts of integration. International pipelines to Europe cross the Mediterranean - two to Spain and one to Italy (via Tunisia).

E&P status

The Algerian O&G industry is very developed. Sonatrach, the national oil company engages with international oil companies in both exploration and production as well as in the development of transportation infrastructure. BP, Eni, Statoil, Repsol and Total are already heavily invested in the region. Many of these companies engage directly with Sonatrach, although some are through subsidiaries of the NOC. The Introduction of new hydrocarbon laws in 2012 are expected to increase the investment appeal of Algeria, especially in the area of shale gas development. Algeria is considered to be relatively underexplored and increasing foreign investment is expected to assist with changing this situation.

EO applicability

Looking to increase its production base, Algeria is expanding exploration into regions and fields where little geological information presently exists. Exploration into shale reservoirs and areas otherwise unexplored, highlights a clear need to understand surface geology that can facilitate seismic measurement. Understanding the movement of geological structures such as sand dunes and locating roads and pipeline infrastructure form a part of pre-licensing due diligence which would benefit from remote surface analysis based on EO.

From the perspective of operators looking to gain access to Algerian hydrocarbon plays, EO might prove a useful tool for undertaking initial surveys to isolate the best targets for seismic evaluation. This monitoring technique could also reduce the exposure of personnel to terrorist threats (eg: Armenas Gas field, Jan 2012) and the harsh environments common to the deserts of Algeria. Subsequent to the pre-licensing phase, EO surveys could be further refined to enable more rigorous analysis of surface topology for service road and pipeline installation.

EO has been well used already in Algeria in relation to monitoring ground movement from the In Salah CCS project. The nature of the ground and climate have seen EO applications used to maximum effect.

2 Democratic Republic of Congo

The Democratic Republic of Congo (DRC) has immense natural resources but has been plagued by political instability and conflict since independence from Belgium in 1960. It was at the heart of 'Africa's World War' between 1998 and 2003 and rebels remain active in some border regions, particularly in the far north eastern DRC. The modern government has the support of western governments and regional allies including Angola and South Africa and since a peace accord in 2007 the Ituri region, bordering Uganda near the oil fields of Lake Albert, has been relatively quiet which has led to oil firms such as Tullow Oil investing to access reserves.

Regional geography and climate

The DRC's border countries include Angola, Burundi, Central African Republic, Republic of the Congo, Rwanda, South Sudan, Tanzania, Uganda and Zambia. It also has a 37 km stretch of coastline to the Atlantic Ocean and has a diverse population as a result of the mass migration of displaced populations both into and out of the country, often causing or stimulated by conflict.

The country can be subject to droughts in the southern region and seasonal flooding from the Congo River. The central river basin and eastern highlands consist of dense tropical rainforest which form internationally recognised habitats, such as Virunga National Park - Africa's oldest national park and UNESCO World Heritage Site, eastern DRC. Deforestation, mining, poaching and water pollution are amongst its key environmental concerns.

Infrastructure

As a result of its history of conflict, the DRC's road and rail infrastructure is dilapidated and in need of rehabilitation. The country's vast geography, low population density, extensive forested areas (tropical rainforest within the vast central plateau) and criss-crossing river network further increase the complexity of infrastructure development. Transportation via the DRC's river network is feasible with minor modifications.

E&P status

It is estimated that the DR Congo produced 20,160 bbl/day of crude oil in 2011, approximately 50% of which was exported. This confirms DRC as a frontier region, as by comparison, Saudi Arabia (which has an approximately equal land area) produced 10,000,000 bbl/day in 2012 and a typical mid-capacity refinery would output in the region of 200,000 bbl/day. The DRC has 180 million bbl of proved oil reserves (2012) and 991.1 million cu m of proved gas reserves. The DRC's NOC is Cohydro and current areas of onshore exploration include blocks within the Albertine Graben basin

along the eastern border with Uganda, and the Central Basin which has mainly been developed along the western border with Angola.

Oil concessions have been allocated covering 85% of the Virunga National Park. This has stimulated concern from NGOs including the World Wildlife foundation, and the UNESCO World Heritage Committee has called for the cancellation of oil permits. Soco (a UK based firm) is the only oil company to pursue operations within the park after Total refused to do so. Soco also operate within the North Congo Basin.

EO applicability

The development of an O&G sector in the DRC has suffered dramatically as a result of the country's conflict ridden history. Consequently, as a frontier region, EO has high applicability throughout the entire lifecycle of field development, although there is a far reduced need for decommissioning in the short term. The proposed development of internationally recognised environments such as Virunga National Park will be associated with intense focus from NGOs and pressure groups which is likely to ensure that environmental mitigation and monitoring is undertaken using the best available technology. As a non-invasive method of monitoring, EO has a clear role here. There is also a distinct lack of infrastructure within DRC, making the use of EO for seismic planning, logistical planning, and development planning highly relevant. This scenario may be further complicated by the political landscape that may restrict cross-border travel or developments. Furthermore, if an oil company is willing to accept the risk of investing in a country with a history of political unrest and conflict, they will want to ensure their assets and people are protected. EO may offer a solution to this challenge - monitoring assets whilst reducing HSE exposure to staff.

3 Mexico

Production declines from offshore fields have recently prompted the government to denationalise the O&G sector in the hope that foreign investment will enable enhanced production from existing fields. Some of the first concessions released to international oil companies have been mature onshore fields in the Villahermosa region. Field maturity and unique geological characteristics in this region require specialised imaging techniques to be used.

Located in the southern most part of the Gulf of Mexico, Villahermosa and surrounding Tabasco province is Mexico's largest O&G producing region. Villahermosa is considered to be the 'Energy City of Mexico.' Within 200 km of the city more than 90% of Mexico's natural gas is produced. Over 95% of Mexico's crude exports originate from ports very close to the city. Villahermosa is a major technical hub for the national oil company PEMEX. Onshore exploration is focused on increasing production from existing fields while offshore exploration efforts are mainly focused on new finds.

Regional geography and climate

Villahermosa is located in the southeast of Mexico. The city and surrounding Tabasco province have a tropical monsoon climate. During extended periods of rain, rivers and the surrounding plains are prone to flooding. The region's geography mainly consists of low-lying plains having tropical savannah or wetland environments. Some mountains and valleys exist and these are typically covered with thick forest. Extensive logging has reduced forest to a fraction of their former size. Slashing and burning such wilderness to increase agricultural land is still widely practiced. Much of the region is dotted with freshwater lagoons, wetlands and rainforests. The coastal region of the Tabasco province is characterised by thick mangrove swamps and estuarine marshes.

Infrastructure

The O&G industry has provided a large income for the state government in Mexico. This has enabled the construction of extensive road, communication and transport networks. O&G export facilities along with deep-sea ports support the region's hydrocarbon dominated economy. Although well serviced with road infrastructure, the region still has large tracts of land which are made inaccessible by their remoteness or their challenging terrain (wetlands, forested mountains and valleys etc). There remains

in Tabasco, a large requirement for systems which reduce the risks and costs associated with field exploration and development - namely those that better facilitate seismic planning.

E&P status

The O&G industry in Villahermosa and much of Mexico is well developed. Its origins began in the early twentieth century with many oil finds made by American oil majors. Now entirely nationalised Mexican production is controlled by the national oil company PEMEX. The O&G industry is serviced by an extensive pipeline network that integrates production facilities with the downstream chemicals sector. Most of Mexico's operating assets are located onshore. However, large amounts of offshore exploration are yielding promising results.

EO applicability

With a relatively advanced O&G sector the priorities in Mexico (Villahermosa) for complementary imaging technologies such as EO are more limited than in 'frontier' countries. However, opportunities still exist where locating existing infrastructure, monitoring changing geology (locating rivers/ lagoons) and avoiding population centres is a concern.

In Mexico, EO technologies are noted to be most relevant in the early stages of field development - pre-licensing and exploration. Vast surveillance areas, inaccessible marsh and savannah land and extreme climate (typhoon events) give Earth Observing technologies a clear operational advantage over aerial surveillance aircraft and land-based monitoring techniques.

During the pre-licensing phase, prioritising concessions for seismic acquisition is a clear advantage. Although relatively flat, the region is dotted with lagoons and freshwater marshes that would pose significant challenges to seismic planners. This is true for projects exploring new fields and those seeking to redevelop existing hydrocarbon provinces. Having access to surface information indicating existing access points, location of water-bodies and geomorphology could expedite analysis leading to lower exploration costs and reduced project risk.

4 South Africa

Regional geography and climate

South Africa is a largely semi-arid country at the Southern tip of Africa that can suffer from periods of extreme drought, although the east coast could be described as having a more sub-tropical climate. It has a vast interior plateau that is surrounded by rugged hills and a narrow coastal plain. With regard to onshore O&G activity, the country is very much a frontier region.

Infrastructure

Much of the country's onshore infrastructure is associated with its offshore O&G sector (pipelines, refineries). There is currently no conventional onshore oil and gas exploration and shale gas exploration is only prospective, with the technically recoverable shale resource is estimated at 30-500 Tcf. Aside from PetroSA, the NOC of South Africa, operators such as Shell, Chevron, Falcon O&G and Bundu Gas have all publically declared their interest in the region's shale, whilst companies such as Sasol pursue CBM development.

E&P status

Onshore O&G activity in South Africa is associated with coal bed methane and shale gas, centred on the Karoo Basin. The Karoo is a unique region of high environmental significance - a factor that, coupled with water scarcity, continues to slow the development of its shale resource. In addition to this, water resource availability will play a key part in the development of this shale. Production technologies are currently very water intensive although R&D efforts are being undertaken to limit this intensity.

EO applicability

In South Africa EO has definite applicability for environmental monitoring, seismic surveys and subsidence monitoring. The CBM industry in the country is an EO ready market that could potentially use the technology to monitor mine depletion rates (assuming they were surface mines), potentially for competitor intelligence. Logistics concerns are likely to be less of an issue as the country is comparatively well established.

5 South Sudan

South Sudan gained independence from Sudan on 9 July 2011. It is ethnically and linguistically diverse and conflict between rival ethnic groups and rebel forces is common. Conflict and violence is particularly prevalent in the border regions of the Nuba Mountains (south east) and Abyei (north). South Sudan has a strained relationship with Sudan and disputes over border regions and the sharing of oil revenues are still very active. It is economically unstable - inflation peaked at 79% in May 2012 and a halt to oil production in 2012 reduced GDP by 55%.

Regional geography and climate

South Sudan is a land locked country boasting one of the richest agricultural areas in Africa. Its geography consists of expansive grassland, swamps and tropical rain forest straddling both banks of the White Nile which provides an abundant source of water. Swampland (The Sudd) accounts for 15% of South Sudan's area; more than 100,000 km². The terrain is formed from plains in the north and center, and highlands along the southern border with Uganda and Kenya. Other border countries include Sudan, Central African Republic, Democratic Republic of Congo, and Ethiopia.

Infrastructure

Despite its potential oil wealth, South Sudan is one of Africa's least developed countries. Industry and infrastructure are severely underdeveloped and poverty is widespread. Electricity is typically produced by diesel generators, running water is scarce and the country has only 60 km of paved road. However, the years since the 2005 peace accord ushered in an economic revival and investment in utilities and other infrastructure. The World Bank has estimated South Sudan's annual infrastructure funding gap at US\$ 879 million per year and it is therefore unlikely that it can catch up with its neighbours within the next 10 years. South Sudanese oil is exported through two pipelines that run to refineries and shipping facilities at Port Sudan on the Red Sea. A new pipeline to connect resources in the south (Juba) is also proposed.

E&P status

An estimated 75% of all the former Sudan's oil reserves are in South Sudan but the existing refineries and the pipeline to the Red Sea are in Sudan. South Sudan produces nearly three quarters of the former Sudan's oil output and oil revenue provides virtually all (98%) of South Sudan's budget. Prior to independence, South Sudan received 50% of the former united Sudan's oil proceeds but that arrangement expired with independence. Political tension between Sudan and South Sudan regarding the sharing oil revenues continues to impact production and led South Sudan to halt oil production between January 2012 and May 2013. South Sudan currently outputs approximately 240,000 bbl/day although prior to the 2012 shutdown, output was at 300,000 bbl/day. To date, most oil field development has occurred in the north east.

EO applicability

The needs of South Sudan's O&G sector are akin to that of the Democratic Republic of Congo. The development of an O&G sector has suffered dramatically as a result of the country's conflict ridden history and therefore, as a frontier region, EO has high applicability throughout the entire lifecycle of field development. However, there is a far reduced need for decommissioning in the short term. South Sudan's extensive swampland poses difficulties for seismic activities and logistics as well as for the development of infrastructure, both for access to oil fields and the transport of hydrocarbons from

source to demand (although there is a major existing trunk main to Sudan and the Red Sea). EO may offer significant advantages with regard to logistics and infrastructure planning. South Sudan has an abundance of environmentally sensitive areas including rainforests, swamplands and grass lands and consequently EO has huge potential for environmental monitoring.

A number of those interviewed also highlighted the potential value of EO as a security tool in South Sudan.

6 Tanzania

Regional geography and climate

Tanzania borders Burundi the DRC, Kenya, Malawi, Mozambique, Uganda Zambia and the Indian ocean. The coastal plains in the east of the country provide a tropical climate but in the highlands to the north and south it becomes more temperate. The central plateau is often subjected to flooding in the rainy season and drought in the dry season. Volcanic activity is also a geohazard in the country. The region is extremely bio-diverse and minimising or mitigating any environmental damages will be crucial to any oil company seeking to explore this country.

Infrastructure

Amongst other factors, political instability has limited the development of infrastructure networks in Tanzania. Only the primary road networks linking the key cities of Dar es Salaam to Tunduru, Dodoma, Tanga, and Arusha. The majority of roads are only dirt tracks and often become impassable during flood seasons. Rail connections with bordering countries do exist but are also in a poor condition. Aside from the logistical implications, rainy season also regularly causes power outages due the high percentage reliance of the national energy company on hydro-electricity.

E&P status

The O&G industry is a minor contributor to the Tanzanian economy but the government is keen to encourage E&P investment to generate income and diversify the country's energy mix. To date, the focus of the industry is on the production of small volumes of natural gas for domestic consumption. However, the country has the potential to become an LNG exporter in the future. Tanzania does not produce crude oil and there has not been a commercial oil discovery in the country recently.

The BG Group in partnership with Ophir Energy, and Statoil in partnership with ExxonMobil, have made several offshore natural gas discoveries since 2010, totalling 25 to 30 trillion cubic feet of recoverable gas resources. The onshore repercussions of these discoveries will be in the likely development of onshore LNG infrastructure near the coast.

EO applicability

EO is highly applicable in Tanzania, especially with regard to logistics planning (including for seismic surveys) and environmental diligence. Forested areas and cloud cover may impact the performance of the technology, but there is a clear demand for the information that EO can provide. Much of the application in the near future is likely to be associated with the offshore sector, but the construction of supporting infrastructure will undoubtedly impact the country as a whole.

7 Turkey

Turkey is dependent on imported O&G to meet 97% of its energy needs and in 2011 was the world's 9th largest importer of natural gas, importing 43.9 billion cubic meters.

Regional geography and climate

Turkey has a temperate climate, consisting of hot, dry summers and mild, wet winters. During summer months, water is a scarce resource and forest fires are known to occur. Its terrain consists of a high central plateau, narrow coastal plain and several mountain ranges. Northern Turkey can be subjected to severe earthquakes.

Infrastructure

Turkey generally has reasonable infrastructure including road, rail, air and sea transportation and an established (although not all encompassing) power grid. It has established facilities for conventional oil exploration and production (e.g. Baku-Tbilisi-Ceyhan pipeline, capable of transferring up to 1 million barrels per day from the Caspian to market) but there is less established infrastructure for gas production and a knowledge gap with respect to the development of unconventional reserves. Several gas pipeline projects have been proposed to help transport Central Asian gas to Europe through Turkey (by extension of the South Caucasus Pipeline) but these are yet to be constructed.

E&P status

Turkey has estimated shale gas reserves of 163 trillion cubic feet, 24 trillion cubic feet of which is estimated to be technically recoverable, in the Dadaş and Hamitabat Shale (Southeast Anatolian Basin near the border with Syria and the Thrace Basin near the border with Bulgaria). To date shale gas exploration has been predominantly offshore and most of Turkey's internal basins are still unexplored or under-explored. None of the inland formations have been tested with unconventional production techniques but the geological structure suggests there is huge potential. The Turkish Petroleum Corporation (TPAO) have identified the possibility that unconventional production techniques may be the future supply for Turkey. Shell and Transatlantic Petroleum are active in Turkish shale gas exploration.

EO applicability

Turkey has a relatively well established conventional O&G sector but exploration for onshore shale gas is embryonic and many onshore fields are under-explored, creating an opportunity for EO technology. The scarcity of water during summer months could pose a threat to shale production, so any EO technology capable of assessing the availability and location of water would be extremely beneficial. Turkey's terrain is mountainous in some regions and arid in others, making EO for logistics planning, infrastructure routing and seismic planning particularly suitable.

8 Uganda

Following a very volatile period throughout the 1970s and 1980s, during the 1990s and 2000s Uganda looked to be stabilising with democratic and economic reforms, together with the discovery of O&G reserves in the west of the country. However, more recently, there has been a perceived deterioration of governance and an increase in corruption which threatens Uganda's future development. Uganda is closely linked with Sudanese politics: its main export partner is Sudan.

Regional geography and climate

Uganda is a landlocked country and borders DRC, Kenya, Rwanda, South Sudan and Tanzania. It is largely fertile and well watered due to its tropical climate, although the northeast region may be described as semi-arid and there are two dry seasons (Dec-Jan; Jun-Aug). Deforestation coupled with the draining of wetlands for agricultural purposes is enhancing soil erosion issues in arid regions. Uganda's terrain is formed mainly of a plateau with mountainous border regions. The Bwindi National Park and Murchinson Falls National Park are contained within Ugandan borders.

Infrastructure

Following its stable development since the early 1990s, Uganda has been able to develop a reasonable infrastructure system, especially near Kampala, that compares very favourably to its neighbours. The government have also indicated their intention to invest heavily in infrastructure, potentially via Chinese government funding (to be paid in arrears from oil revenue). The Ugandan government is currently assessing the feasibility of transporting some of its crude oil to the coast through the planned Juba-Lamu pipeline, and has plans to build a refinery in order to provide a domestic fuel supply and potentially export to Rwanda, Kenya and Tanzania.

E&P status

Uganda's first commercial oil discovery was in 2006 and it has proved reserves are estimated at 1 billion barrels, contained within the Albertine Graben along Uganda's western border with DRC and southern border with South Sudan. It is estimated that only 40% of the Albertine Graben basin has been explored and other unexplored formations with the potential for reserves include the Hoima, Lake Kyoga and Kadam-Moroto basins. In 2011 there was zero crude oil production from Uganda and it imported 16,930 bbl/day of refined petroleum products to meet its domestic demand. Total have a presence (through acquisitions) in Uganda and are currently undertaking seismic analysis in the Nwoya district of Murchinson Falls National Park. Tullow Oil and China National Offshore Oil Company also have a presence in the country but development is centred around Lake Albert, on the border region with Kenya.

EO applicability

There is still a significant proportion of the country that remains unexplored and given the lush, fertile and environmentally valuable terrain of Uganda, EO technology is extremely applicable for pre-licence and exploration activity. Environmental monitoring and reducing HSE exposure are also areas where EO has a potential niche in Uganda. Total have recently identified unexploded ammunitions in an area in which they were undertaking seismic analysis - any EO technology that could identify articles of this nature would be of great benefit across a number of frontier regions. Furthermore, Total's seismic exploration of Murchison Falls National Park is being limited due to environmental concerns regarding the disturbance of habitat and species. Any non-invasive seismic analysis that could be undertaken by an operator to minimise disruption on the ground could be considered as a competitive advantage, potentially increasing the likelihood of an operator obtaining exploration blocks. Furthermore, with the investment in infrastructure from foreign donors looming, the potential for EO to be used for infrastructure routing is high. Decommissioning is less of a priority in Uganda as the first commercial oil production occurred in 2006 - decommissioning is unlikely to become relevant for 20 years.