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Study on environmental and socio-economic issues arising from the improper disposal of drill cuttings

Identification and characterisation of potential hot spot areas in BMZ partner countries and stakeholder consultations

Imprint

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Abbreviations

API	American Petroleum Institute
Barcelona Convention	Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean
BGR	Federal Institute for Geosciences and Natural Resources
BMZ	Federal Ministry for Economic Cooperation and Development
BOD	Biochemical Oxygen Demand
BP	British Petroleum
DPR	Nigerian Department of Petroleum Resources
EEAA	Egyptian Environmental Affairs Agency
EGASPIN	Environmental Guidelines and Standards for the Petroleum Industry Nigeria
EGAS	Egyptian Natural Gas Holding Company
EGPC	Egyptian General Petroleum Corporation
EPA	United States Environmental Protection Agency
ESMI	Nigerian Environment and Safety Management Institute
EU	European Union
FMPR	Nigerian Federal Ministry of Petroleum Resources
FWT	Fichtner Water & Transportation GmbH
GIS	Geographic Information System
HSE	Health Safety and Environmental Standards standards
HELCOM	Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area
HYPREP	Hydrocarbon Pollution and Remediation Project
LBEG	Lower Saxony State Office for Mining, Energy and Geology, Germany
LGA	Local Government Area
MoM	Minutes of Meetings
m	Meter
m^3	Cubic meter
mSv	Millisievert
MAP	Mediterranean Action Plan
MEMAC	Marine Emergency Mutual Aid Centre
MPMR	Ministry of Petroleum & Mineral Resources

NDDC	Niger Delta Development Commission
NEMA	National Environmental Management Authority Uganda
NESREA	Nigerian National Environmental Standards and Regulations Enforcement Agency
NIBIS	LBEG Web Map Services
NORM	Naturally Occurring Radioactive Mineral
OERF	Ogoniland Environmental Restoration Fund
OMPADEC	Oil Minerals Producing Areas Development Commission
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAHs	Polycyclic Aromatic Hydrocarbons
PAU	Petroleum Authority of Uganda
PSA	Production Sharing Agreements
PSC	Production Sharing Contracts
R & D	Research and Development
SEA	Strategic Environmental Assessment
SINTEF	Stiftelsen for Industriell og Teknisk Forskning
t	Metric ton
TC	Technical Cooperation
TENORM	Technically Enhanced Naturally Occurring Radioactive Minerals
TDS	Total Dissolved Substances
THC	Total Hydrocarbon Content
UNEP	United Nations Environmental Programme
USA	United States of America
VOC	Volatile Organic Compounds

Summary

On behalf of the Federal Ministry for Economic Cooperation and Development (BMZ), the Federal Institute for Geosciences and Natural Resources (BGR) commissioned a study on the improper handling and management of residues originating from the oil and gas industry, in particular drill cuttings. The study has a regional focus on Egypt, Nigeria and Uganda, all three of them partner countries of the German state development cooperation (BMZ partner countries). Drill cuttings are small rock fragments of various sizes which are, during exploration and production drilling, absorbed by the drilling fluid and brought to surface. As drill cuttings may contain various different organic and inorganic pollutants, the improper handling and disposal of drill cuttings and residual drilling waste in general may cause severe environmental pollutions. This in consequence can have serious negative effects on the livelihoods of people in terms of, for example, human health threats, devastation of soils as well as of ground and surface waters.

In the first part of the present study, common international practice are summarised and analysed for both, the technical and operational handling and management of drill cuttings as well as the corresponding legal and regulatory aspects, deemed required for an environmentally sustainable handling (incl. re-use und recycling) and proper disposal of drilling wastes. To this end, legal and regulatory mechanisms in countries with well-developed extractive industry/petroleum sectors were examined and summarised, among them Germany, Australia (Queensland) and the United States of America (USA).

The European Union (EU) has made significant efforts in the development of technical standards for industry practices and waste management procedures in the past ten to twenty years. This includes the EU-wide harmonisation of the corresponding legal and regulatory requirements (see e.g. Wood Environment & Infrastructure Solutions 2019). These requirements and standards are defined through the national mining laws, the environmental protection and immissions control laws, as well as the waste and recycling legislation and related regulations. The latter provides the general legal and regulatory framework, often in line with transnational or supraregional standards, stipulated in protection conventions such as the OSPAR, Barcelona, HELCOM or MEMAC Conventions.

On a national level, federal states often maintain their own rules and requirements for the management of drill cuttings (e.g. in the USA, Germany, Nigeria). Subsequently, specific regional respectively local or project related issues are supervised by designated competent federal state authorities (e.g. federal state mining authorities).

Concerning the handling and management of drill cuttings, predominantly treated as waste material, many jurisdictions require a precise physical and chemical characterisation and transportation monitoring including detailed information about the whereabouts. With high technical/operational standards and environmental protection measures applied in many technically-developed oil and gas sectors, environmental risks are nowadays comprehensively addressed.

Despite well-established environmental protection standards, a worldwide problem still exists with abandoned and disposal sites often polluted by cutting residues. These sites often originating

from gas and oil exploration activities commenced before the turn of the millennium, when technical standards and legal requirements for environmental protection were low or even not existent.

The second study part focuses on the potential issue of improperly disposed drill cuttings in the three BMZ partner countries Egypt, Nigeria and Uganda. Hereby, a special emphasis is given to the review of the legal, regulatory and institutional frameworks with regard to the management of oil and gas wastes. For that purpose, an extensive literature research was not only performed on statutory documents, but also on any other publicly assessable sources to identify and collect documented evidence of improper handling and disposal of drill cuttings. Complementary, in total 30 stakeholder, representing governmental institutions, private sector entities and the civil society, were identified and invited for remote interviews. Of the invited stakeholders, five were available to share their views, knowledge and experience as well as other valuable information about petroleum waste management and associated likely negative environmental and socio-economic impacts. The stakeholder consultations helped to identify valuable approaches for potential future activities of technical cooperation (TC).

As a result of the conducted research, the following main findings could be concluded: In Egypt, significant oil and gas operations were carried out since the 1970s. In the scientific literature, indications are given concerning contaminations of onshore and offshore environments caused by the petroleum industry. And while no factual sites contaminated through the improper disposal of drill cuttings are officially confirmed, statements from stakeholders as well as research conducted in the course of the present study indicate that remnants of improperly disposed drill cuttings are existent in the four major oil and gas production provinces. The consulted stakeholders believe that the given legal framework sufficiently addresses the key requirements for environmental protection in oil and gas operations. Therefore, environmental protection laws and regulations are in place and in most cases in accordance to international standards, but are sometimes not stringently followed, as there is a strong need to exploit the existing national resources. International oil and gas companies operating in Egypt are working as prescribed by the national laws and regulations, but not necessarily in line with common international practice. Authorities are advised putting more emphasis on environmental sustainability in oil and gas projects, e.g. during permit approval procedures. In this regard, groundwater resources, and in particular the non-rechargeable fossil water aquifers in the arid Sahara region, which could be negatively impacted through the underground disposal of petroleum wastes should be strictly protected. The stakeholder interviewed recommended institutional strengthening and capacity building for environmental authorities towards a more stringent control and implementation of environmental protection measures to be performed by the petroleum industry. To this end, the Egyptian Environmental Affairs Agency (EEAA) is considered as a potential partner for measures targeting at improvements in the authority's regulatory and monitoring functions as well as environmental trainings for the EEAA-staff.

The Niger Delta in Nigeria is one of the largest oil and gas production areas worldwide. In the past decades, in the region several thousands of oil and gas wells were drilled on- and offshore. But the Niger Delta is also home to the indigenous Ogoni people with their vulnerable livelihoods and characterised by diverse and hence extremely worth protecting ecosystems such as mangrove forests. Hence, it is even more dramatic that nowadays, the Niger Delta region, and here especially the Ogoniland, a region covering approximately 100,000 square kilometres in the Nigerian Rivers State, is one of the most polluted and devastated areas, suffering from negligent and improper oil and gas operations undertaken in the past. According to the stakeholders interviewed, environmental protection as well as remediation and clean-up measures to be implemented by both, the regulators and the responsible petroleum company, namely a Nigerian subsidiary of Royal Dutch Shell Nigeria, are considered as insufficient. Environmental pollution with its associated health risks and socio-economic impacts is still negatively affecting the livelihoods of local indigenous communities in Ogoniland. Petroleum waste management in the Nigerian oil and gas sector in general are supervised by the Nigerian Department of Petroleum Resources (DPR) and the

Nigerian Ministry of Environment. Their mandate comprises as well the clean-up works of oil contamination in the Ogoniland. Though the stakeholders consider the DPR as sufficiently equipped with appropriate capacity to control the fulfilment of environmental and waste management standards by ongoing and future oil and gas operations, it is deemed insufficiently effective in the fulfilment of its regulatory functions. Accordingly, the DPR was proposed as a partner of potential future TC activities. In addition, the stakeholders recommend TC activities to the benefit of the local communities and organisations directly representing the interests of the local people affected, e.g. the "Movement for the Survival of the Ogoni People".

As stated by the stakeholders, improper and non-compliant disposal of drilling wastes in Nigeria is facilitated through the lack of a comprehensive national waste management system, which includes and regulates the systematic determination, handling, processing and utilisation/disposal of petroleum wastes. At present, the final fate (transportation and disposal) of drilling waste is still left to the discretion of the petroleum industry. Against this backdrop, a better coordination and cooperation between the oil and gas companies and regional recycling companies is as required as the implementation of countrywide standards and technical guidelines for a systematic handling and processing of drilling wastes. In general, the stakeholders in this study engaged consider future TC activities as very helpful and appreciated.

In Uganda, oil and gas operations were commenced recently in a few areas adjacent to Lake Albert (Albertine Graben) and first commercial oil and gas productions are expected to start soon. A limited number of oil and gas wells were drilled so far and no factual evidence of improper cutting disposal could be found in public sources. Still, stakeholders mentioned a few cases of non-compliant waste dumping or oil spills were recorded during recent years. Considering the recent commencement of the oil and gas operations in Uganda, technical cooperation may facilitate the mitigation of non-compliant practices of drilling waste disposal.

With the legal and regulatory framework in place, Uganda, for one thing, seems to be well prepared for the coming challenges involved in operations control and environmental protection. Nevertheless, revisions and amendments to the legal framework are demanded by stakeholders and partly already underway. Amongst others, this includes more detailed technical standards and operational guidelines for a systematic management of petroleum wastes. Also, the technical and managerial experience among the competent authorities, in charge of controlling the new-born petroleum sector, could benefit from further strengthening measures. With regard to this, the National Environmental Management Authority (NEMA) was proposed as a candidate potential partner for institutional strengthening (technical capacity building) measures, targeting at an improved fulfilment of its control and environmental monitoring functions.

On the global scale, well-developed and evolving petroleum sectors, including those in developing and transitional countries achieved significant improvements and adopted legal frameworks towards a more stringent and sustainable management of petroleum wastes. Anyhow, 20 years ago, environmental protection regulations were either not that stringent or not available, as it is nowadays deemed necessary for sustainable environmental protection. Among the current BMZ partner countries (60), 39 countries commenced oil and gas drilling activities for the purpose of field exploration and development before the year 2000. This year is interpreted as the approximate time when the majority of countries worldwide amended their petroleum regimes towards a more stringent environmental protection, including the management of drilling wastes. Until today 23 BMZ bilateral partner countries (Afghanistan, Albania, Algeria, Bangladesh, Benin, Bosnia and Herzegovina, Cameroon, Colombia, Ecuador, Egypt, Ethiopia, Georgia, Ghana, Ivory Coast, Jordan, Morocco, Namibia, Nigeria, Pakistan, Senegal, Tunisia, Ukraine and Uzbekistan) are probably impacted through an improper or disputable drilling waste management applied in the past. In eight more BMZ 'Global Partner' countries (Brazil, China, India, Indonesia, Mexico, Peru, South Africa and Vietnam) as well as eight BMZ 'Nexus' and 'Peace Partner' countries (Chad, Iraq, DR Congo, Libya, Sudan, South Sudan, Syria and Yemen) similar inherent environmental burdens may be existent.

As a conclusion of the study, improperly disposed drill cuttings pose a major and world-wide present environmental and socio-economic challenge. Since the turn of the millennium, more than a million oil and gas wells were drilled worldwide, producing an approximate drilling cutting mass in the order of a three-digit million ton figure.

1. Introduction

As a major energy and chemical industry resource, hydrocarbons are among the world's most important natural resources. On the other hand, this means enormous amounts of various different wastes are produced through the exploration and production of hydrocarbons, which in turn form a major source of environmental problems. Starting with exploration drilling, wastes including contaminated drilling fluids as well as solids (cuttings) are produced at the drilling site.

Drill cuttings – Definition (Wood Environment & Infrastructure Solutions 2019; Abdul Razak Ismail et al. 2017; ICF Consulting 2000):

Broken bits of solid material (crushed rocks, sand, silt and clay) generated through rotary, percussion or auger drilling and removed from a borehole and brought to the surface as part of the drilling mud. Cuttings are produced in boreholes drilled for various exploration and production targets such as oil and gas and geothermal energy; but also for mineral exploration. Brought to surface, cuttings are separated from the drilling mud and used for sampling, examination and characterisation of the actually drilled geological formation. Cuttings may contain various kinds of pollutants, including hydrocarbons, chemicals additives, salts as well as main and trace elements including heavy metals and radionuclides.

Drilling sites exist in all different terrestrial and marine areas and environments worthy of protection, including on land, continental shelf regions[1] and also offshore regions[2]. Accordingly, significant costs are borne by operators in order to manage (re-use, recycle) and/or dispose these various wastes in accordance with the relevant laws and regulations applicable in the operational area (e.g. country, federal state, or convention area). Table 21 gives a short summary of the most relevant wastes produced in oil and gas operations.

In offshore drilling operations, cuttings are often re-used, re-injected, released to the seabed or brought ashore for subsequent treatment and disposal. The release to the seabed, however, is highly restricted or even prohibited in many jurisdictions, due to associated negative impacts on the marine environment.

Onshore as well as offshore exploration drilling may cause various different environmental impacts that result from waste production, emissions and other discharges. A few to be mentioned here are: excessive water consumption, noise, vibrations, emissions, extraneous light, liquid discharges of contaminated muds and waters, heat from flaring and general disturbance of the wildlife and benthic sea flora and fauna by vessels (Commission Implementing Decision 2020/248). Other threats to human life originating from improper waste handling, including leaching (e.g. from a reserve pit) and contamination of drinking water resources, may be caused by the influx of toxic chemicals included drilling muds, contaminated waters and cuttings or the accumulation of chemicals in the local food chain (e.g. fish, vegetables, grain, etc.) (Rana 2008).

1 Thus, the part of the sea reaching from the shoreline until the edge of the continental shield, marked by the continental slope (Schlumberger 2021a).

2 Those parts of the sea adjacent to the continental shelf and beginning with the continental slope, usually from depth deeper than 200 m (Schlumberger 2021b).

On a global scale, improper management and disposal of drill cuttings often leads to severe environmental and socio-economic impacts. Originating from improper handling and disposal of cuttings, contaminations occur in soil, water and air and may thus jeopardise the livelihoods of local people. Additionally, uncontrolled offshore disposal of drilling wastes (e.g. cuttings and muds) into the sea may endanger marine life existing in and near the seabed.

Table 1: Waste types produced in the course of oil and gas exploration and production

Type of waste	Main components	Possible environmentally significant constituents
Waste lubricants	Lube oil, grease	Heavy metals, organics
Spacers	Mineral oil, detergents, surfactants	
Hydrocarbons	Polycyclic aromatic hydrocarbons, alcohol, etc.	PAHs, carcinogens such as benzene, naphthalene
Spent/contaminated water based muds (including brine)	Whole mud, mineral oil, biodegradable matters	Heavy metals, inorganic salts, biocides, hydrocarbons, solids/cutting, organics
Water based muds and cutting	Formation solids, water based muds mineral oil	Heavy metals, inorganic salts, biocides, hydrocarbons, solid/cutting, radionuclides
Spent/contaminated oil-based muds	Whole mud mineral oil	Hydrocarbons, heavy metals, inorganic salts, solids, organics, surfactants, radionuclides
Oil based mud cuttings	Formation solids, oil based muds	Heavy metals, inorganic salts, hydrocarbons, solids/cuttings, radionuclides
Spent bulk chemicals	Cement, bentonite, barite, viscosities, thinners, fluid-loss reducers, speciality product	Heavy metals, hydrocarbons, organics, solids, acids, corrosion inhibitors,
Spent special products	H2S scavengers, defoamers, tracers	Zinc carbonates, iron oxides, hydrocarbons, silicon oils, potassium salts, radioactive materials

(Source: Sharif et al. 2017; Rana 2008).

Extractive industry operations in general and the exploration and production of hydrocarbons in particular are both technically and economically challenging. Business success in the extractive industry requires strong technical as well as financial capacities. Since investments in the development of extractive industry projects commonly amortise only after ten years or even later, operational sustainability and full compliance with the legal and regulatory framework are of upmost priority.

Besides or operational accidents, the improper management of cuttings may arise from various reasons and backgrounds. Based on the study author's international experience, these reasons and backgrounds often include the following circumstances:

- In many cases, the legal framework is insufficient or ambiguous and does not provide clear guidance regarding the minimum environmental standards or the validity and ap-

plication of international technical and environmental standards. Economically driven, the operating company in most cases fulfils the minimum legal requirements. This may lead to belated negative environmental and socio-economic impacts, e.g. after closure and abandonment of all facilities.

- Strong authorities for mining inspection and environmental protection with executive powers are also essential. They must be capable to temporarily shut down certain operations, even against the interest of the government who claims being investor friendly and desires formerly agreed earnings (royalties, shares of a production sharing agreement, etc.).

- In some countries, the competent authority is weak or limited in institutional capacity including experienced staff, staff capacity in general and financial resources. Often, the competent authority is also lacking the required legal capacity to interfere in improper business operations, non-compliant to laws and regulations.

- The closure, remediation and long term monitoring of former mining or oil and gas production sites may cost several hundreds of million euros. Without any stringent liability and appropriate financial assurance, the government and the local communities are faced with the risk of postponed or improper remediation. Such financial assurance (guarantee) has to be provided in the early beginning of a project and has to be controlled and adjusted by the competent authority.

- In order to ensure full compliance with the laws and regulations, companies must be obliged to execute their operations pursuant to a formerly agreed operating plan. Such an operating plan must also consider the closure and remediation activities in the aftermath as well as affiliated social and environmental impact assessments.

In many countries, which dispose of an oil and gas industry applying state-of-the-art technologies, these and other weak points have already been improved. Improvements were and are still achieved through a step-wise process based on long-term experience, addressing technical aspects as well as the legal and regulatory framework. This is also the case in developed oil and gas/mining sectors such as Western Europe, the USA, Canada or Australia, where the issue of orphaned disposal sites has not been solved completely up until today.

2. Scope, objectives and methodology

On behalf of the Federal Institute of Geosciences and Natural Resources BGR (in the following BGR), Fichtner Water & Transportation (hereinafter the authors) was assigned to execute a baseline study on environmental and socio-economic issues arising from the improper disposal of drill cuttings including a regional focus on selected BMZ partner countries.

As part of the focus chapter, the following BMZ partner countries were studied in detail: Egypt, Nigeria and Uganda. While Uganda recently commenced its oil and gas operations, Egypt and Nigeria have mature hydrocarbon sectors. For the research on the respective countries covered in this study, also remote interviews with relevant stakeholders were conducted.

Within the scope of the assignment, the study was conducted in two action steps (in the following "Part 1" and "Part 2"):

- Part 1: Desktop study on several BMZ partner countries, identification of potential hot spot areas of improperly disposed drill cuttings produced by the oil and gas industry. Preparation of a summary on practical examples of international legal/regulatory and technical/operational practices for the management and disposal of drill cuttings in other countries with significant extractive industries sectors.

- Part 2: Conduction of remote interviews with relevant stakeholders familiar with the issues that arise from improperly disposed drill cuttings in the selected BMZ partner countries.

Complemented by specialist contributions from BGR experts, the results of both action steps were subsequently brought together in an overall study.

The primary objective of the study was the identification of areas within selected BMZ partner countries potentially impacted through an improper (non-compliant) handling and disposal of drill cuttings produced by the oil and gas industry. In this regard, so called potential "hot spot" regions were to be identified, which are environmentally and/or socio-economically negatively affected.

In parallel to the identification of hot spot areas, the legal and regulatory framework of the selected BMZ partner countries was to be analysed and summarised, in order to identify potentially existing deficits. To this end, common international practices were analysed for both, the technical/operational management (handling, re-use and deposition) of drill cuttings (Chapter 4.1) as well as for the legal and regulatory management (Chapter 4.2).

Additionally, potential hot spot areas identified in the selected BMZ partner countries were to be summarised and described in tables and illustrated via overview GIS based maps.

In the second part of the assignment and based on the results and findings of part one, stakeholders/actors were to be identified and invited to remote interviews. In the course of these interviews, the current situation as well as approaches and potential hurdles for potential TC activities were identified, targeting at the mitigation of negative environmental and socio-economic impacts related to improper drilling waste management.

In total 30 institutions from the regulatory sectors (government ministries, agencies and regional au-

thorities), the private sector (oil and gas companies, environmental service companies) and the civil sector (non-governmental organisations, community representatives, universities, etc.) were invited to remote interviews.

All stakeholders/actors identified in the three BMZ partner countries were contacted via specific and dedicated invitation letters and provided with a letter of credence from the BGR, a tentative agenda and a questionnaire.

During the interviews, the study author gave a short introduction to the ongoing assignment, including its objectives and targets. All stakeholders were given the opportunity to share their thoughts and recommendations to the subject of the study.

All inputs and recommendations provided by the stakeholder/actors were kept confidential and all contributing stakeholders were given the right (through the sharing of Minutes of Meetings (MoMs) to decide on the utilisation (publication) of their inputs in this report.

3. Common international practice in the management, handling and disposal of drill cuttings

This chapter summarises common international practice in terms of technical and operational as well as the legal and regulatory aspects for the management and disposal of drill cuttings. In addition, prominent technical, operational and regulatory key aspects, representing common international practice as implemented in countries or federal states with well-regulated oil and gas sectors were synthesised.

Amount of drilling waste

Around the world, hydrocarbon exploration and production operations generate large volumes of waste. This includes, amongst others, produced water, drilling waste (cuttings and drilling muds) and other associated wastes.

Since the turn of the millennium, more than 50,000 oil and gas wells were drilled each year (Veazey 2020), making more than 1 million wells in the past 20 years alone. In consideration of the approximate mass of cuttings per well, the cumulative amount of cuttings produced in the past 20 years is in the range of a three-digit million ton figure.

In the USA, the amount of solid drilling waste material annually produced amounts to estimated 140 million barrels (University of Colorado at Boulder 2014). According to a study performed by the American Petroleum Institute (API) in 1995, at that time most of these drilling wastes (approx. 68%) were either buried or evaporated and thus left orphaned at the drill site (Sustainability Accounting Standard Board – SASB 2014).

Drilling waste handling costs

In general, drill cuttings can form different kinds of waste material requiring a dedicated systematic classification, processing and handling (SASB 2014). This can result in technically challenging and costly management and disposal processes, especially for cuttings originating from offshore drilling operations (SASB 2014). The average specific disposal costs for drilling waste are estimated at between USD 7 and 10 per barrel of waste (ICF Consulting 2000).

Drill cuttings and related environmental risks

Depending on the drilling technology applied, the drilling fluids and additives used, the traversed geological strata and its likely hydrocarbon content, the drill cuttings may contain various hazardous substances. Deep formation waters as well as hydrocarbons encountered during drilling may contain various harmful chemical elements and minerals, including naturally occurring radioactive minerals[3] (NORMs). During drilling and production, these compounds accumulate, amongst others, in production tubings, pumps, separators and storage tanks in the form of scales (Ali et al.

3 These NORMs may compose of radionuclides such as 226Ra, 228Ra, 222Rn, 210Pb and 40K (Ali et al. 2019).

2019). Such accumulations are called technically enhanced naturally occurring radioactive minerals (TENORMs).

Improperly disposed drill cuttings may pose various environmental and corresponding socio-economic risks, as they possibly contain, amongst others, the following environmentally harmful components (Garbarino 2018 et al.):

- Total hydrocarbon content (THC), accommodated or adhered to cutting material, posing a contamination risk to soils and waters;
- Volatile organic compounds (VOCs), posing the risk of air contamination;
- Total dissolved substances (TDS), incl. various chemicals added to the drilling fluid, posing the risk of water contamination;
- Heavy metals and NORMs, as part of the produced formation water and adhered to cuttings, posing an immediate or long term risk to groundwater, soils and human health.

3.1 Technical and operational aspects

Since more than a decade, the management and disposal of waste produced in the extractive industry sector is a prominent topic among regulators, the industry, scientific community and other stakeholders. The environmental impacts of drilling waste disposal as well as the applicability of new technologies aiming on mitigation and reuse of drill cuttings are therefore an object of ongoing research.

Concerning environmental and natural resource protection, the management of extractive industries' wastes demands additional investigation and research on ancient deposits and pits. Many of the latter absorbed drilling fluids and cuttings, which need to be examined for their contaminant content and related environmental risks.

In the following, common international practice in the management and handling of drill cuttings is summarised.

3.1.1 Management and handling of drill cuttings

In oil and gas drilling operations, a solid control system, installed nearby the drilling rig, separates the drill cuttings of various sizes from the drilling fluid and mud. Following this, the drilling fluid is processed (e.g. circulation) for re-use (Sharif 2017 et al.). A standard solid control system (cf. Fig. 1) comprises several components such as shale shakers, degassers, desanders and desilters for finer particles. Subsequently, the mud processing unit separates gases and other components. Drill cuttings and other solids are collected in a temporary storage facility for subsequent treatment and final disposal. In offshore operations, this means either being transported ashore or discharged into the sea (Sharif 2017 et al.),

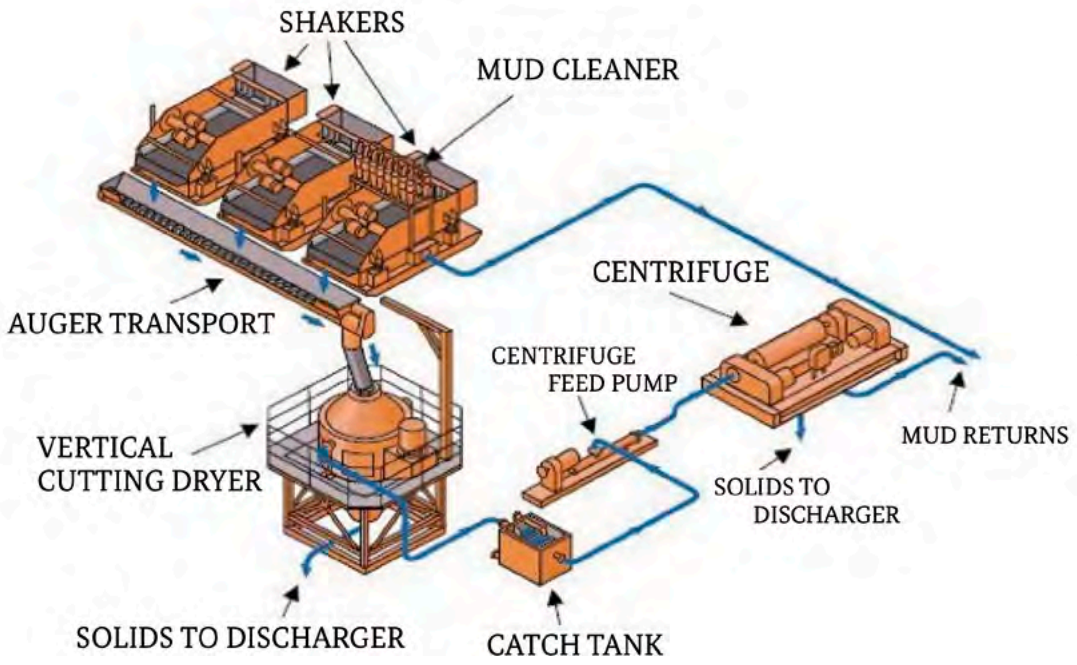

Fig. 1: A standard solid control system (Sharif et al. 2017)

Together with other by-products, drill cuttings gathered from onshore drillings are classified according to the pollutant content. Subsequently, they can be either thermally[4] or biologically treated[5] or directly disposed on special landfills (Commission Implementing Decision 2020/248; Ministry for Environment, Energy, Construction and Climate Protection of Lower Saxony – MU 2016).

3.1.2 Recycling and re-use of drill cuttings

Re-use as construction material

In many countries, the building sector is faced with a lack of certain construction raw materials such as sand, clay or limestone. The re-use of drill cuttings as a concrete aggregate might offer a feasible alternative to this shortage and is therefore subject of ongoing research. Amongst others in the USA, where the shale gas boom resulted in a significant increase in drilling waste volumes (Foroutan et al. 2018; Foroutan 2017).

Recent research (e.g. Foroutan et al. 2018; Mostavi et al. 2015) questions the suitability of cuttings to replace significant shares of cement, as such substitutes are reducing the compressive strength (deemed critical for construction applications) of the concrete. However, such deficits could be possibly mitigated through other additives like fly ash and silica fume (Mostavi et al. 2015).[6]

3.1.3 Disposal of drill cuttings

Three major options for the disposal of drill cuttings exist, including a.) offshore disposal, b.) onshore disposal (land spreading, landfill) and c.) re-injection into a suitable underground reservoir formation (Gaurina-Međimurec et al. 2020; Abdul Razak Ismail et al. 2017).

4 Options for thermal treatment can be the desorption or incineration through heating, combustion and oxidizing of hydrocarbons (Commission Implementing Decision 2020/248).

5 e.g. degradation through micro-organisms (Commission Implementing Decision 2020/248)

6 Assessment of the author: Even after washing and processing, depending on the traversed geological strata, drill cuttings are unique in their mechanical, mineralogical and chemical composition. That is why prior to any larger-scale industrial application, a sort of homogenisation and standardisation of the cuttings material is deemed to be required. Additionally, there are waste materials of other origin (e.g. fly ash, glass, recycled concrete, etc.) that can be potentially processed and used as a concrete additive. In a similar manner, drill cuttings could be, after cleaning and processing, re-used as well.

In offshore operations, cuttings not posing any environmental risk[7] are often, due to economic reasons, discharged into the sea using a dedicated pipeline called "downcomer", or treated and disposed in certified in landfills (Commission Implementing Decision 2020/248; World Bank Group 2015).

For on-land operations in most European countries including Germany as well as the USA and Australia, drilling fluids and cuttings, classified according to different disposal classes, are generally disposed in certified landfills. Before its disposal, each kind of waste including drilling mud or cuttings requires a dedicated processing and treatment in order to meet the landfills' technical and operational requirements.

3.2 Legal and regulatory aspects

Commonly, the management and disposal of drilling waste is regulated at the national or alternatively federal level, supplemented by inter- and supranational legal provisions (e.g. directives and regulations issued by the European Union). At international level, several supranational conventions provide complementary guidelines for the disposal on a voluntarily basis agreed by the ratifying countries. Among those, the following, facilitating the implementation of common international practice, are most important:

3.2.1 Supranational conventions for the protection of marine environments

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) was ratified in 1992 by the members of the Oslo- and Paris Convention[8].

The OSPAR Convention aims at mitigating the negative impacts on the marine environment of the North-East Atlantic. The OPSAR Convention allowed the underground storage of carbon dioxide (CCS) in geological formations under the seabed, but prohibited the storage in deep sea water basins (OSPAR Commission 2020).

Barcelona Convention

What is known today as the 'Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean' (Barcelona Convention) entered into force in 1978 as the 'Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft', adopted earlier in 1976. Following an amendment and renaming in 1995, the present version of the Barcelona Convention and its seven Protocols entered into force in 2004. As part of the Mediterranean Action Plan (MAP) it forms the main legally binding Multilateral Environmental Agreement (MEA) for the Mediterranean region. The Barcelona Convention requires the 22 contracting parties to protect the Mediterranean marine and coastal environment and to develop further national policies in terms of environmental protection and sustainable development. Its several protocols aim on the protection of the Mediterranean environment, inter alia by dealing with environmental impacts arising from land-based sources and industries (the "Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources and Activities") or pollutions originating from offshore exploration and exploitation (the "Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from the Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil") (EC 2021a; UNEP 2021a, 2021b).

HELCOM Convention

Based on the version ratified in 1974, the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM Conven-

7 Cuttings not posing any environmental risk are mostly those recovered via water-based fluids (Commission Implementing Decision 2020/248; World Bank 2020).

8 Contracting parties are Belgium, Denmark, the European Union (EU), Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom of Great Britain, Northern Ireland, Luxembourg and Switzerland (OSPAR Commission 2020).

tion) was adopted in 1992. At present, nine littoral states of the Baltic Sea[9] and the European Union have ratified the HELCOM Convention. Its aim is to protect the Baltic Sea from all sources of land-based, air-borne and water-related pollution. The underlying protection strategy is closely linked with those of the European Union, supporting the preservation and recovery of the Baltic Sea environment, as well as its safety and accessibility (EC 2021b).

MEMAC Convention

The Marine Emergency Mutual Aid Centre MEMAC is a regional intergovernmental organization, founded in 1982 in Manama, Bahrain. Its primary objective is the protection of the marine environment environment through cooperation to mitigate pollution related to oil and gas but also other activities. Its member states comprise the Kingdom of Bahrain, the Sultanate of Oman, the Islamic Republic of Iran, the State of Qatar, the Republic of Iraq, the Kingdom of Saudi Arabia, the State of Kuwait and the United Arab Emirates (Marine Emergency Mutual aid Centre – MEMAC 2021).

3.2.2 Practical examples for cuttings treatment and disposal

The common international practice for the release of drilling fluids and cuttings into marine environments differs from those on land. It should be regulated in due consideration of the actual type, composition and pollution grade of the drilling waste. Many jurisdictions require an individual and project-related approval issued by the competent licence authority (Abdul Razak Ismail et al. 2017). The offshore re-injection of drilling fluids and milled cuttings through a disposal well into an isolated reservoir formation is considered as a viable, low cost and environmentally less negative alternative. Thus, this method is applied in the North Sea area, Ireland, Alaska, the Gulf of Mexico, Canada, Venezuela and Indonesia (SLR Consulting Ireland 2010; Abdul Razak Ismail et al. 2017; Commission Implementing Decision 2020/248).

Despite common rules and guidelines applied on a supranational level, many countries disposing about an established oil and gas sector have their own guidelines and regulations for the management of waste produced by the oil and gas industry. Examples are:

- Scotland: SEPA Guidance. Regulation of Offshore Oil and Gas Waste (WST-G-059, Version 1 2018),
- Canada: Offshore Waste Treatment Guidelines (2010),
- Queensland, Australia: Environmental Protection Act 1994 and the Waste Reduction and Recycling Act 2011 (Department of Environment and Science, Queensland – DLS 2019),
- United States of America: Guidelines for Commercial Exploration and Production Waste Management Facilities (API Order No. G00004 2001).

In the European Union, the EU Directive 2006/21/EC "on the management of waste from extractive industries and amending Directive 2004/35/EC" (EU Mining Waste Directive) aims at preventing adverse effects on the environment and human health caused by extractive industries' wastes, including tailings and other waste rock materials (Council Directive (EC) 2006/21/EC). Supplementary to the EU Mining Waste Directive, the EU issued comprehensive and detailed technical guidelines for the inspection of mining wastes in 2018. The technical guidelines comprise all relevant technical and managerial aspects addressing inherent environmental risks and especially contamination and pollution. Furthermore, common practice guidelines are set out for the prevention, processing, recycling, re-use and disposal of various mining wastes, including drilling fluids and drill cuttings (Garbarino et al. 2018; Commission Implementing Decision (EU) 2020/248).

In response of the Deepwater Horizon accident, the EU commissioned studies on liability regulations in case of offshore accidents. A focus was put on the determination of the liabilities towards the aggrieved parties. This included the question

9 These are by now: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russian Federation and Sweden (HELCOM Convention 1992).

how to ensure that the determined liable parties have sufficient financial capacities for appropriate compensation for damages caused by them and how the compensations shall be disbursed in due time to the legitimate claimants. At the end of this process, the EU Directive 2013/30/EU "on safety of offshore oil and gas operations and amending Directive 2004/35/EC" (EU Offshore Safety Directive) was passed. Pertaining the liability, the EU Offshore Safety Directive determines the compensations and financial assurances to be provided by offshore oil and gas operators. This provides an EU-wide framework for emergency prevention and also response in case of major accidents and makes licensees strictly liable for any environmental damage resulting from their operations (Council Directive (EU) 2013/30/EU; EC 2015).

3.2.3 Legal and regulatory issues and fundamentals – discussion

In the past decades, numerous bad examples in terms of improper handling and disposal of drilling wastes occurred worldwide. Due to steadily rising demands for energy resources, the oil and gas industry expanded more and more into remote and ecologically sensitive areas around the world. In the course of these developments, often neither the concerned national legal or regulatory framework is sufficient, nor are the stakeholders involved provided with the necessary capacities to protect their legitimate interests. Weak legal and regulatory frameworks as well as the hardly involved communities, if at all, leave room for the disregard respectively violation of internationally accepted environmental protection standards.

The development, implementation and maintenance of a well-functioning legal and regulatory framework is considered as challenging and usually based on long-lasting, often negative experiences. Not least because the legal and regulatory framework should be also in line with the strategic, both socio-ecological and -econmic, development targets of the country concerned. Accordingly, there is no single rule or standard for common international practice and each country has to find its individual strategy, policy and implementation measures. As an example, Norway discretionarily decides on the requirement for financial assurance to be deposited by the licensee. Also a demolition, abandonment and/or closure plan is only to be issued towards the tail-end of a production operation and not in the beginning of a project. By contrast, the province of Catamarca, Argentina requires the lodgement of a financial guarantee in the early beginning of a project and requires a periodically update of closure and remediation plans.

Based on the author's experience in ongoing and past projects, the following fundamentals are deemed important:

- An explicit, unambiguous and comprehensive legal framework;
- Requirements for state-of-the-art technical and operational standards, covering also new production technologies, including the use of harmful chemicals, that may be applied to all currently extracted natural resources;
- A clear regulation on closed material cycles, including material re-use and a clear definition of waste materials;
- Stringent requirements for environmental protection, maintained e.g. through independent environmental impact assessments and the protection of other natural resources like soils, groundwater and air;
- Powerful and competent authorities, acting transparently and non-discretionary, stringent in inspection and monitoring and authorised to sanction non-compliant operators, e.g. through shutdowns or withdrawal of production licenses;
- A division share of functions and competences among the mining cadastre (license management and awards), the mining authority (inspection, monitoring, sanctioning) and the geological survey (provision of data and supporting exploration);
- Definition of regulations and procedures for the management of environmental damages and pertaining liabilities, including the "polluter pays" principle;

- Regulation regarding the issuance of financial assurances, for example through bank guarantees, surety bonds, cash deposits or a trust fund (cf. Sassoon 2009), covering the costs for closure, abandonment and remediation as well as operational incidents and hazards.

In the following chapters, some practical examples are described in the form of country/federal state case examples.

3.3 Country examples

In the following chapters, some practical examples are described in the form of country/federal state case examples.

3.3.1 Germany

Exploration and production of hydrocarbons started in the 1850s, and to date, several tens of thousands deep exploration and production drillings were carried out. Dependent on the time of execution and implementation of at that time applicable technical and operational standards, dif-ferent drilling methods and drilling fluids (drilling muds) were used. In earlier times, drilling fluids, muds and cuttings were stored in various pits that served as temporary or final storage of drill-ing muds and products such as cuttings (State Parliament of Mecklenburg-West Pomerania – LTMV 2016). Since the 1980s, such pits were only temporarily operated and remediated prior to the end of the operations (MU 2016). Cuttings and spent drilling muds were deposited in ded-icated landfills.

In the following years, the legal and regulatory framework for the operational handling of drilling wastes was subjected to significant improvements, which finally led to the technical standards applied nowadays.

In Germany's petroleum sector, the onsite recycling and re-use of the drilling fluid (including solids, cuttings) is common practice (Kögler 2016). The overall emission rates must be kept as low as possible, especially in consideration of alternative options that require transportation to and interim storage at centralised waste processing facilities.

3.3.1.1 Management of environmental burdens and orphaned drilling sites in Germany

Numerous contaminated sites that originate from historic oil and gas drilling activities, depend-ing on the federal state approximately 1990 and earlier, are currently subject to a public and po-litical debate. In consequence, containment sites were studied and inventoried by the federal state governments of e.g. Lower Saxony (see e.g. Lower Saxony State Office for Mining, Energy and Geology – LBEG 2017; ENGESER ET AL. 2015; MU 2021), Schleswig-Holstein (see e.g. Mull und Partner Ingenieurgesellschaft 2017), Mecklenburg-West Pomerania (see e.g. LTMV 2016) and Hesse (see e.g. Hesse State Office for Nature Conservation, Environment and Geology 2019; State Parliament of Hesse 2016). Information about contaminated sites and related research activities are publicly accessible, for example through the NIBIS Map server operated by the federal state of Lower Saxony (see Fig. 4-2) (LBEG 2021).

3.3.1.2 Legal and regulatory aspects in Germany

Drilling of exploration and production wells is governed by the German Federal Mining Law (Bundesberggesetz) and its amending regulations. As a prerequisite to any approval of an op-erating plan, the Federal Mining Law requires proper recycling and/or deposition of all wastes produced during oil and gas operations (Bundesberggesetz (BBergG) 1980).

Moreover, the Water Resources Act (Wasserhaushaltsgesetz), the Federal Soil Protection Act (Bundes-Bodenschutzgesetz) and other environmental protection laws, such as the Federal Immissions Control Act (German Bundes-Immissionsschutzgesetz), set further requirements and limits for the handling of drilling wastes (Bundesverband Erdgas, Erdöl und Geoenergie e.V. – BVEG 2021). According to the Federal Emission Control Act, only certificated waste facilities are authorised to recycle or process extractive industries' wastes (Kögler 2016). For the pro-cessing and re-use, the waste producer, so the drilling company or field owner, is obliged to analyse and characterise the waste according to standard waste classes based on kind and amount of contaminants and their physical and chemical properties. The drilling fluids then can either be transported to a stationary processing facility, including transportation and interim storage, or can be processed on-site at the drilling site, with the latter being nowadays the common practice.

The disposal of drilling wastes (including cuttings) is regulated by the Circular Economy Act (Kreislaufwirtschaftsgesetz) (MU 2016). This law considers drill cuttings as mineral waste (Kögler 2016), requiring a more detailed classification prior to any subsequent storage, use or disposal. Pursuant to the German Recycling Law, in theory certain drilling fluids or muds, classified as non-harmful waste, could be placed on certain land areas that are not foreseen or used for any agricultural or livestock farming purposes. Although such waste utilisation is allowed in general and deemed admissible on international level (cf. Commission Implementing Decision 2020/248), it finds rare application due to the unclear legal situation and the low public acceptance of such practices (Kögler 2016). Moreover, the German Circular Economy Act regulates the general mitigation of waste in terms of its: reduced total amount, content of harmful substances, total or partly re-use, utilisation for a different purpose and final disposal. The Circular Economy Act distinguishes the following individual or legal entities (Kögler 2016):

- Waste producer (the field owner or operating company),
- Waste owner (the drilling company),
- Waste collector (collecting waste for a different purpose),
- Waste transporter (transporting company).

In Germany, radioactive wastes originating from oil and gas operations are regulated through the Radiation Protection Regulation (Strahlenschutzverordnung). In accordance with this regu-lation, the handling and disposal of waste materials produced by the oil and gas industry is gov-erned and controlled on the federal state level by the regional authorities for mining, energy and geology. In some cases, the authorities of several federal state have merged their administra-tion activities in this area (State Parliament of Lower Saxony – LTN 2017). The regulation fore-sees various chemical and physical processing measures including for example concentration, washing, water separation, drying and thermal treatment are applied. By this means, either the separate treatment of drill cuttings for the purpose of re-use through recycling of certain com-ponents or their final landfill disposal is facilitated (Kögler 2016).

It should be mentioned that special handling of NORM-bearing waste material in the German oil and gas sector is not common, as the lower threshold value (1 mSv/year) is rarely exceeded (Richter and Hosemann 2012). Also there exists no official register for NORM-bearing waste produced in Germany.

In the area of German coastal waters and the continental shelf, the management, utilisation and disposal of drill cuttings is additionally regulated through restrictions in line with international conventions (cf. Änderungsverordnung zu bergrechtlichen Vorschriften im Bereich der Küstengewässer und des Festlandsockels 2016).

3.3.1.3 Conclusive summary and discussion

Governed through the mining operations plan procedure (Betriebsplan-Verfahren) valid for on-shore and offshore oil and gas operations, in Germany the handling and management of drill cuttings is well regulated towards recycling, re-use, waste reduction/mitigation. In compliance with the legal and environmental requirements, economically viable solutions are envisaged and applied. However, numerous laws and regulations, including those protecting adjacent natural and nature resources require due consideration. Here only a few key aspects of the legal and regulatory frameworks could be addressed in the scope of this study.

On a project level, the German Federal Mining Law transfers duties to the respective responsi-ble federal state authority. The federal authorities follow a step-by-step approval, the so-called operating plan procedure, with an on-demand engagement of other local or federal environmen-tal authorities. The operation plan procedure is considered as functioning with leaving room for project-specific particularities as well as for the engagement of other authorities and local stakeholders. Despite its comprehensiveness and given applicability, the German legal regime is considered as complex, especially for foreign operators or investors. Moreover, it requires a well-developed and functioning administrative regime within both, the national and federal state levels.

3.3.2 Queensland/Australia

The federal state of Queensland has a vital petroleum sector, mainly based on onshore pro-duction. In 1900, the first gas field was discovered in Roma and the first gas pipeline was built in 1969. To date, some 14,450 exploration and production wells were drilled, approximately 11,000 of them for the production of coal seam gas and 3,450 conventional wells (GasFields Commission Queensland 2018).

3.3.2.1 Legal and regulatory aspects in Queensland

The key legislation for the petroleum sector is formed through the Petroleum Act 1923, the Pe-troleum and Gas (Production and Safety) Act 2004, the Water Act 2000 and the Environmental Protection Act 1994. The legal and regulatory framework for waste management and disposal is based on the Waste Reduction and Recycling Act of 2011 including subordinate legislation as well as on the Environmental Protection Act 1994 (DLS 2019).

Queensland's environmental protection regulation classifies wastes produced by the oil and gas industry in terms of their solid materials, inherent components and associated environmen-tal risks. In general, cuttings are defined as 'regulated waste', if certain risky or harmful ele-ments or contents are included (DLS 2019). The regulation further requires to record and track wastes produced, handled or transported by various entrepreneurs. Prior to transportation, a specific characterisation for drilling wastes, including drilling fluids and solid materials (cutting), with regard to acidic or alkaline solutions, inorganic sulphides, mineral oils, non-toxic salts, oil/water emulsions, organic solvents, phenols, surface active agents is required. It follows a subsequent assessment of contaminants and associated environmental risks due to the chemical composition, chemical-physical properties, eco-toxicity, biodegradation and others. Moreover, drilling operators are required to assess cuttings against criteria stated in the National En-vironment Protection Measure to determine whether the material is suitable for any (re-) use (e.g. road spreading, construction materials), or to be disposed at a dedicated landfill (National Environment Protection (Assessment of Site Contamination) Measure 1999).

3.3.2.2 Conclusive summary

Queensland facilitates the extractive industry sector through a liberal, investor-friendly, but stringent waste management and environmental protection policy. Authorities are well equipped and developed.

3.3.3 United States of America

The USA are among the world's largest producers and consumers of oil and natural gas (BGR 2019). In 2018, oil and gas production was at 698.4 million tonnes of oil and 863 billion m^3 natural gas, respectively (BGR 2019). Hydrocarbon production takes

place onshore (central and eastern USA) as well as offshore (east coast and Gulf of Mexico). Since about 15 years, the production of both, crude oil and natural gas experienced a significant increase due to the de-velopment of unconventional oil and gas resources.

3.3.3.1 Legal and regulatory aspects in the United States of America

The US Environmental Protection Agency EPA is the competent authority in charge of environmental protection and monitoring. Under the Resource Conservation and Recovery Act (RCRA) the EPA recently established a national framework for the management of solid. The RCRA authorises the EPA to control hazardous wastes, including its generation, transportation, treatment, storage and disposal. The federal states have in general the primary authority over the disposal of non-hazardous wastes within their territories wastes (EPA 2021a, 2021b).

In coordination with state governments, the EPA administers the Federal Water Pollution Control Act (Clean Water Act) that laid the legal ground for the Deepwater Horizon litigation process, originating from a massive oil spill in the Gulf of Mexico in April 2010 (James and Pulman 2020).

Different from regulations and practices in Europe, the construction and use of sludge pits and reserve pits for the temporary storage of production fluids and solid wastes are still common practice in the USA (3,426 active pits in Colorado in 2019). Whereas the application of a closed circulation system to handle drilling fluids and to separate solid wastes, though it is considered as best feasible, is not mandatory in all states such as North Dakota (Backman 2016). The ac-tual design of these pits, e.g. the need for liners to mitigate soil infiltration, varies in conjunction with federal states requirements. According to a survey conducted by the American Petroleum Institute (API) in 1995, about 68% of drilling wastes were left buried or evaporating at the drilling site. Only approximately 25 % of the wells at that time were drilled using a closed mud system without any reserve pits to store and dispose used drilling muds and cuttings (ICF Consulting 2000).

Albeit the EPA states that effects on the soil quality or productivity resulting from the disposal of cuttings on surficial soils to promote decomposition are still unknown, this is a common form of re-use of solid drilling wastes in the USA (EPA 2019). Concerning this, the federal states may impose restrictions regarding the type of waste used in such applications. Non-hazardous waste materials may be otherwise utilised, for example as road base, concrete additives or road applications. Corresponding requests are submitted to the responsible state agency that either approves or rejects the proposed utilisation on a case-by-case basis.

Moreover, operators can deposit their solid drilling wastes in dedicated landfills. Such landfills are often subject to restrictions on transport distances. Usually the distance between drilling site and landfill must not exceed 70 miles (EPA 2019) if the other options mentioned above are deemed feasible. Drilling wastes envisaged for landfill deposition have to meet certain chemical and physical acceptance criteria.

3.3.3.2 Conclusive summary and discussion

The extractive industry sector in the USA is known to be liberal concerning the extraction of natural resources. Major laws regulating the production of hydrocarbons as well as environ-mental protection are issued on national level, while there are differences on federal level, e.g. for the implementation of temporary drilling mud pits or the re-use of drill cuttings. However, there is no policy on the mitigation of waste, as it exists in Europe.

As demonstrated in the Deepwater Horizon lawsuit, authorities, especially those responsible for environmental protection, are stringent and powerful in sanctioning guilty parties. In the claims settlement process following the Deepwater Horizon catastrophe, British Petroleum (BP) was found guilty and paid approximately USD 70 billion until now (Nocera 2020) in compensations to residents and businesses, suits settlements, fines and clean-up.

3.3.4 Summary of country examples

Common practice in extractive industries' waste management is in general well defined and ap-

plied in many countries, located in the northern Atlantic region (USA, Canada, Europe) as well as in Australia and the Arabic Peninsula. Still, technical standards in countries and regions differ due to geological, geographic but also political, economic and development reasons such as other industry sectors interfering with the oil and gas business. For example, possibilities for the re-use and further utilisation of cuttings depend on the availability of infrastructure (Oil In-dustry International Exploration and Production Forum and UNEP Industry and Environment 1997), business environments and the overall status of technical capacities. On the other hand, environmental protection regulations have made significant improvements in terms of securing protected goods such as groundwater, soils and air. In this regard, the risk-based assessment approaches as well as long-term monitoring studies, accompanied by positive and negative op-erational experience helped defining appropriate guidelines and measures for environmental protection.

From the legal and regulatory perspective, explicit up-to-date laws, also covering new exploita-tion methods like fracking or lithium brine mining, just lay the ground for competent authorities to govern and control the extractive industry sector. Successful authorities need clear administra-tive functions and competences in their area of responsibility as well as a definite mandate and authorisation for execution including sanctioning. To be sufficiently strong in terms of resource capacity to discuss and regulate on an equal footing with the operators provides the basis to this. Operators' compliance with technical standards and regulations is only maintained through continuous frequent technical, managerial, financial and environmental control and inspection work.

In general, the agreement on supranational standards stated in various environmental protec-tion conventions support the further development and application of technical best feasible practices.

To put the existing legal foundations into practice, good coordination and cooperation among different authorities (e.g. the mining/petroleum authority and the environmental agency) is deemed indispensable, for example in the execution of operating permit procedures. To strengthen in turn the authorities' legitimation among the population, community representatives and other local stakeholders should be engaged in the approval procedures. All engaged agen-cies need to follow a formally agreed development and protection strategy aiming at a sustaina-ble protection of all natural resources.

A sufficient legal framework must also regulate the responsibilities that arise from abandoned drilling, production and processing sites, regardless whether the entrepreneur is still existent or liable. That is why the legal and regulatory framework shall regulate the return of land owner-ship and associated responsibilities to the state or a suitable third party. In addition, environ-mental burdens through contaminations inherent to abandoned sites are to be investigated case-by-case and, if required, remediated.

Especially in risky businesses like oil and gas exploration and development, the operator or li-cense holder must be kept liable for all potential damages until the site is closed and remediated according to common international practice. In case of a transfer of an exploration or produc-tion license, the initial licensee should be kept liable for the whole project cycle. On a project base, the requirement of a financial assurance, covering the costs for comprehensive site abandonment/closure and remediation, is deemed best feasible practice (MonTec 2008) and thus, demanded in many jurisdictions.

Independently of the costs, operational aspects should involve the application of best available technologies to mitigate (negative) environmental impacts as far as possible. In this context, the decision about technical and financial viability remains at the discretion of the investor. This procedure in general facilitates technically and financially strong and responsible companies in acquiring licenses while technically and financially weak companies fail to meet the set require-ments and standards. In order to grant licenses to an appropriate entrepreneur, a transparent license management system should be adopted, that awards licenses on a factual basis and without discretionary decisions, encouraging corruption, or politically induced preference or un-fair competition in general.

Here, the agreement on supraregional standards stated in various environmental protection conventions can support the sustainable management of the sector including the application of technical best feasible practices.

In many jurisdictions, state participation through production sharing contracts/agreements se-cures governments certain rights and revenues related to a project. Notwithstanding this, con-flicts of interest may arise within the government, either towards an increased recovery and thus higher revenues, or towards environmental protection and sustainable community en-gagement.

4. Case examples on regions in BMZ partner countries

During the last decade, Africa's oil and gas sector continued growing (in terms of reserves and production) and attracted international investors, especially from China and India (Graham and Ovadia 2019). In several African countries, including Chad, Cote d'Ivoire, Ghana, Liberia, Senegal, Sierra Leone, Togo, as well as in the Central African Republic, Uganda, Tanzania, Kenya and Mozambique significant new hydrocarbon resources were discovered. The existence of numerous, per date undiscovered resources is deemed probable.

In this chapter, the results and findings regarding the improper handling and disposal of drill cuttings and drilling wastes in a broader sense in Nigeria, Uganda and Egypt are presented.

4.1 Egypt

4.1.1 Introduction

In Egypt significant oil resources were discovered in 1908 in the Eastern Desert and during the late 1930s along the Gulf of Suez. Economically significant hydrocarbon volumes were produced since the early 1970s. In 2018, Egypt produced 32.7 million tonnes of oil and 62.3 billion m^3 of natural gas (BGR 2019; African Development Bank – ADB and the African Union – AU 2009). Egypt has the third largest gas reserves in Africa. Major production areas exist offshore in the Nile Delta (natural gas, onshore and offshore) as well as in the Gulf of Suez (oil), the latter making up 50% to 70% of total production, the Sinai Peninsula (8% of total production (Agwa et al. 2012) and in the south-east part of the Mediterranean Sea. Onshore hydrocarbon production is conducted in the Western Desert (north and east of the Quattara Depression, ca. 16% of total oil production) and in the Eastern Desert region (8 % of total oil production) (see Fig. 5-1; Kitchka et al. 2015).

Fig. 2: Major oil and gas production areas in Egypt (MPMR n.d.)

4.1.2 Legal and regulatory framework for the hydrocarbon sector

The Egyptian Environmental Affairs Agency (EEAA), a subordinate of the Ministry of Environment is the competent authority for environmental protection (EEAA 2021). Pursuant to the Law 4/1994 on the Protection of the Environment, the EEAA was restructured and assigned with new mandates to represent the executive arm of the Ministry of Environment.

The two laws with key relevance for environmental protection are Law No. 4/1994 (main framework law), its executive regulations on environmental protection (specific standards and guidelines on emissions, discharges, etc.) and Law No. 9/2009 (EcoConServ et al. 2010). Complementary, the EEAA issued specific environmental impact assessment guidelines for the oil and gas sector (Environmental Impact Assessment. Guidelines for the Oil and Gas sector 2001). The guidelines require operators to develop a waste management plan as well as a classification (pollutant content, etc.) of the waste material.

The institutional control of the Egyptian Petroleum sector is highly centralized. The Ministry of Petroleum & Mineral Resources (MPMR) is responsible for the regulations of all activities along the oil and gas value chain. Its strategic objectives include the execution of the two key laws: The Ministry of Petroleum Decision on Hazardous Waste (Ministry of Petroleum Decision on Hazardous Waste 2007) and the Disposal of Hazardous Substances Resolution (Disposal of Hazardous Substances Resolution 673 in 1999). In addition, it is responsible for the enforcement of environmental standards, the promotion of sustainable development and modernisation of the petroleum sector, as well as the assurance of optimum value-adding of natural resources (International Associations of Oil and Gas Producers – IOGP 2017 MPMR 2021).The supervision of the implementation of international and regional conventions covering environmental management is another main responsibility of the Petroleum Ministry.

In Egypt, petroleum activities are in general executed through joint ventures, concluded through production sharing contracts (PSCs) or production sharing agreements (PSAs) (Beardsworth Jr. and Stuart 2019), with one of the three national oil

companies: Egyptian General Petroleum Corporation (EGPC), the Egyptian Natural Gas Holding Company (EGAS) or the Ganoub El Wadi Petroleum Holding Company (GANOPE) (IOGP 2017).

Regarding site closure or abandonment and environmental remediation, there is little experience in the Egyptian hydrocarbon sector and the current legislation does not include any detailed provisions for decommissioning activities. Besides operators in Egypt should comply with the Barcelona convention on a voluntary basis, for the management of drill cuttings, therefore handling, re-use and disposal, no explicit regulation is available (EC 2021; IOGP 2017).

4.1.3 Potential hot spot areas of improperly disposed cuttings

As a result of oil and gas operations including exploration, production, transport and refining, in Egypt a large number of contaminated sites are likely to exist on- and offshore (see e.g. Agwa et al. 2012; Farahat and El-Gendy 2008). In consequence, numerous environmental programs for mitigation and environmental protection were initiated. However, no actual site, impacted through pollutions originating from oil and gas drillings, could be identified by the authors in publicly available sources.

Also, no information could be found about the total number of oil and gas wells drilled in Egypt. But according to the number of oil and gas fields developed in Egypt (e.g. Kitchka et al. 2015), an estimated few thousand deep oil and gas wells were drilled to date.

One Egyptian stakeholder from the academic sector interviewed for this study claimed, Egypt should, due to its geographic and climatic conditions, be more cautiously with the disposal of petroleum wastes into underground reservoirs. Across the Egyptian territory, there is a strong need to protect the national groundwater resources, amongst others the supranational Nubian Aquifer, which extends over parts of Egypt, Libya and Chad. In addition, the Red Sea area is a strategically and ecologically highly sensitive area, with various economic sectors in place such as hydrocarbons and tourism (Hegazy and Effat 2010).

According to the same stakeholder's perception, environmental protection laws and regulations are in place and in most cases in accordance to international standards. But in spite of their existence, present regulations are sometimes not stringently followed, as there is a strong need to use and exploit the existing national resources.

Concerning operational standards applied by the oil and gas industry, the stakeholder believes that international oil and gas companies operating in Egypt are working in compliance with the national laws and regulations, but not necessarily in line with common international practice. To this end, better and more stringent controls and monitoring by the competent authorities are considered valuable.

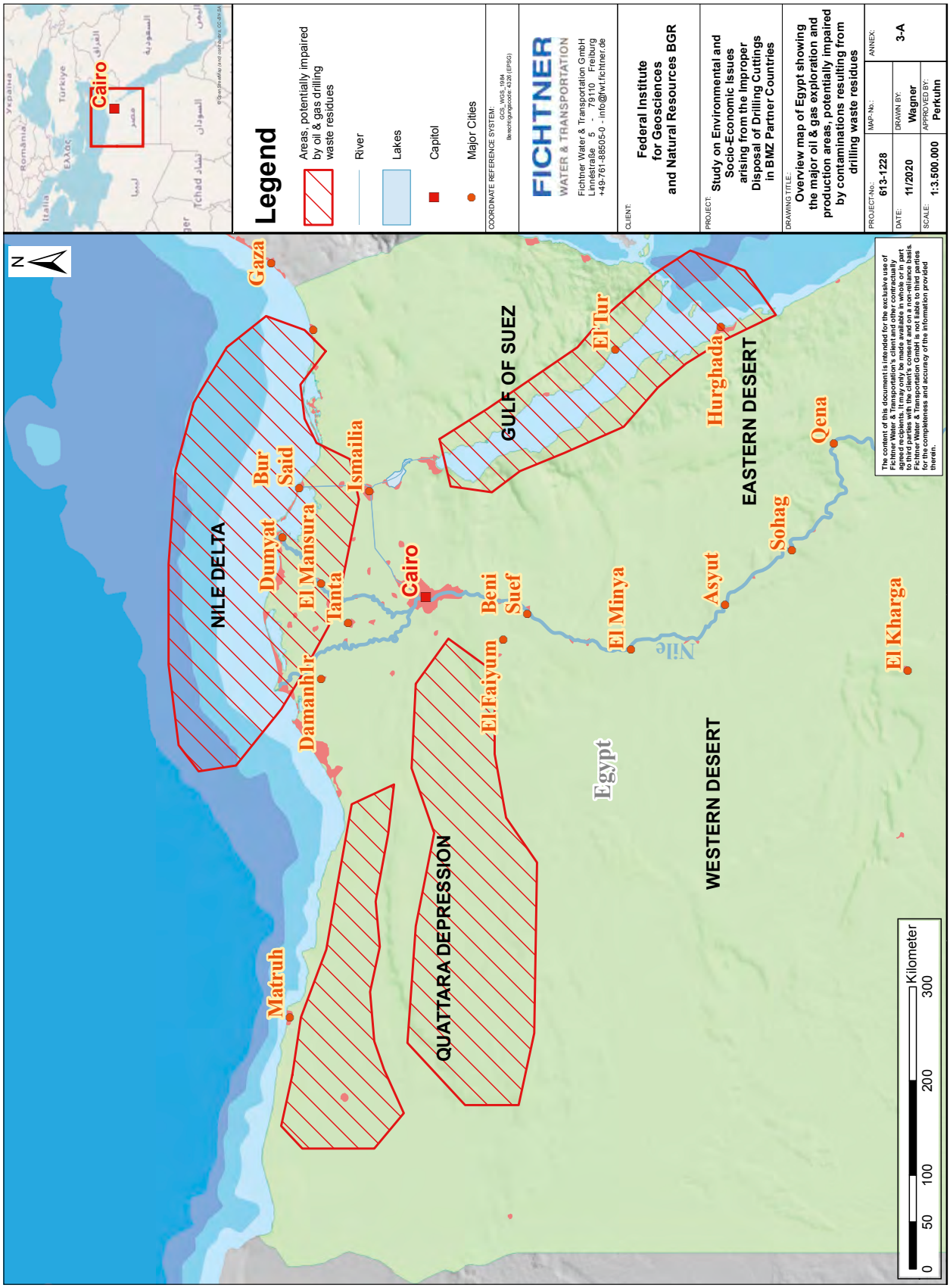

Fig. 3: Egypt: regions, potentially affected by improperly disposed residues of oil and gas drilling waste. (Own illustration, Fichtner 2020)

4.1.4 Potential entry points for international cooperation

From the stakeholder's perspective, institutional strengthening of the EEAA in respect of approval procedures and a stringent implementation and execution of the existing laws and regulations is necessary. Secondly, the stakeholders recommend allocating financial resources towards improvements in the actual fulfilling of the authority's regulatory and monitoring functions, (e.g. in state-of-the-art laboratory equipment, vehicles and other required facilities), as well as in continuous education and environmental staff training.

4.1.5 Summary and conclusion

Commercial oil and gas production in Egypt dates back to the early 1970s, a time when stringent regulations for environmental protection were worldwide practically non-existent. Accordingly, improper disposals of drill cuttings, especially in remote areas including offshore environments are deemed likely. Nevertheless, as a result of the study, no factually contaminated site could be identified where drilling residues had been improperly disposed. Here political reasons could be at least partly the reason, why Egypt authorities may have opposed against any transparent communication of environmental damages caused by the oil and gas sector.

As recommended by the stakeholders, competent authorities should – in general - not ban large scale industrial projects, but instead should strengthen the application of international environmental protection standards.

4.2 Nigeria

4.2.1 Introduction

Nigeria, Africa's biggest oil exporter, has also the continent's largest natural gas reserves. In 2018, Nigeria produced 98.4 million tonnes of oil and is ranked 12th among the most important global oil producers. An additional 44.3 billion m^3 of natural gas were produced in 2018, putting Nigeria at rank 18 of the largest gas producers in the period 2013 to 2018 (BGR 2019).

Alongside considerable earnings from oil and gas exports, Nigeria is facing several challenges, including the need to rebuild social infrastructure, to develop strong and effective institutions with a robust public financial management system and to reduce economic dependence on oil.

Since the late 1960s, oil is continuously and commercially produced (ADB and AU 2009) and since the 1970s oil revenues account for the biggest share in the state revenues (Ebeku 2020). Revenues from the extractive petroleum sector make up some 80% of the total state's revenues and contribute significantly to the national gross domestic product (Anderson 2019). It exists a strong dependency on tax/royalty incomes from the petroleum sector and the distribution of revenues within the country remains a perennial political issue.

The federal government holds the titles (rights) of the domestic natural resources (Aladeitan et al. 2019), but in the enactment and implementation of petroleum laws, the federal states act autonomously. Accordingly, the authorities on the national level have minor influence on the fiscal levies on extractive industry activities in the country. Similar, Nigeria's federal government is reported as being disempowered in various federal states to enforce environmental protection laws and regulations for the extractive industries. This has led to political upheavals in political, environmental and socio-economic aspects (Anderson 2019).

State participation in terms of production sharing agreements are common in Nigeria, while the contractors (operators, investors) bear the major shares of the exploration risk (Beardsworth Jr. and Stuart 2019).

4.2.2 Legal and regulatory framework for the hydrocarbon sector

The Nigerian Petroleum Act and accompanying regulations provide the general legal framework for oil and gas operators and their activities in the field of exploration, production and transportation of crude oil (Aye et al. 2013). The Directorate of Petroleum Resources (DPR) under the Nigerian Federal Ministry of Petroleum Resources (FMPR) in turn is the competent authority in charge of ensuring compliance with petroleum laws, regulations and

guidelines for upstream and downstream activities (DPR 2021). Therefore, the DPR has to ensure that all operations are compliant with the national health, safety and environment regulations and international best feasible oil field practice. Also, oil companies operating in the Niger Delta region are required to adopt common international standards of oil-field disposal practices as approved by the DPR (Onwukwe and Nwakaudu 2012).

According to the Environment and Safety Management Institute (ESMI), a stakeholder consulted in the course of this study, the DPR controls and monitors the handling and management of petroleum waste material. Although the DPR is considered as theoretically disposing of appropriate/sufficient capacities and means to control ongoing and future oil and gas operations, it is yet assessed as being insufficiently effective in fulfilling its regulatory functions. This includes especially the management and oversight of handling and further processing the drilling waste materials. Thus, the DPR is recommended by the ESMI as a potential target institute for institutional strengthening measures.

For any drilling operations, an environmental permit must be issued by the DPR, which includes the maritime discharge of drilling wastes as well as its treatment and disposal (Ofuani 2011). In 2019, the DPR finally put into force the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), which have been issued already in 1991 (Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) 1991). EGASPIN generally seeks to adopt principles of common practice, using methods and guidelines in line with international standards. It seems more that transparency and accountability in its interpretation and implementation remain a weak point of EGASPIN (Olawuyi and Tubodenyefa 2018).

When interviewed, the representatives of ESMI claimed, many operators disregard common international practices in environmental protection and sustainable waste management. According to ESMI, with its endorsement the EGASPIN guidelines are used by the DPR to assess compliance of operations by the oil and gas operators including drilling waste management. In the EGASPIN, however, a clear and explicit definition of drill cutting material (as a petroleum waste) and the corresponding detailed guidelines for handling, processing and disposal are still missing.

In face of its strong financial dependency and potential tax revenue losses, the government is criticised of fearing the implementation of strict laws and regulations. Moreover, legal inconsistencies or conflicts, including overlapping regulatory functions between the National Environmental Standards and the Regulations Enforcement Agency NESREA, a subordinate of the Federal Ministry of Environment, and other agencies are known on the federal state level.

The National Environmental Standards and the Regulations Enforcement Agency (NESREA) is responsible for environmental protection and development, conservation of biodiversity and sustainable development of Nigeria's natural resources. Key functions of NESREA (NESREA 2021) are:

- Enforcement of compliance with laws, guidelines, policies and standards;
- Enforcement of compliance with the provisions of international agreements, protocols, conventions and treaties on the environment;
- Enforcement of compliance with policies, standards, legislation and guidelines on water quality, environmental health and sanitation, including pollution abatement (including amongst others oil and gas, chemicals, hazardous wastes);
- Liaison and coordination of stakeholders within and outside Nigeria on matters of environmental standards, regulations and enforcement;
- Implementation of environmental audits and regulatory and enforcement mechanisms of environmental standards other than in the oil and gas sector;
- Creation of public awareness and provision of environmental education on sustainable environmental management, promotion of private

sector compliance with environmental regulations.

In order to secure the sustainable development of the Niger Delta area, the Oil Minerals Producing Areas Development Commission (OMPADEC) was established in 1992 (Ebeku 2020). The OMPADEC holds the primary functions and powers to a.) rehabilitate and develop further oil mineral producing areas, b.) mitigate ecological problems that arise from oil exploration, c.) consult with federal and state government authorities on the control and mitigation of problems arising from oil pollution and d.) liaise with the various oil companies on matters of pollution control.

OMPADEC was dissolved in 1999 due to negligible regional improvements and other still existing deficits such as the lack of transparency, accountability and community engagement, poor overall project performance, political interference in the operations of the agency and conflict of interests. In 2000, its successor agency, the Niger Delta Development Commission (NDDC), a subordinate of the Ministry of Niger Delta Affairs, was assigned with a similar mandate (Ebeku 2020).

In 2016, the University of Halifax conducted a critical assessment of the legal and regulatory framework for Nigeria's petroleum sector (Ibeawuchi 2016). As a result, the following deficits were revealed: The majority of enacted environmental laws were assessed as obsolete and inadequate and partly outdated to protect Nigeria's environment. For the closure/abandonment and environmental remediation of former oil and gas facilities, there are substantial shortcomings in the legal framework (Kingston and Okere 2019; Kingston and Adangor 2018; Ibeawuchi 2016; UNEP 2011) concerning:

- the decommissioning of facilities (abandonment and remediation plans),
- any kind of financial assurance for closure and remediation,
- the re-utilisation, innocuous disposal of dismantled equipment and
- a model for remediation of the polluted environment, with regard to the timing and decision for decommissioning and for any post closure/abandonment monitoring.

Thus, it is at the discretion of the operator when and to what extent closure and remediation is actually performed. In addition, several critical though internationally common practices were deregulated to a voluntary basis. Among them the handling of drill waste including offshore release to the seabed or gas flaring (Ofuani 2011). The enforcement of the laws and associated sanctioning were assessed as being weak. For example, the identified regulators' lack of experience in environmental protection measurements adversely affects an effective implementation of policies and laws (Ofuani 2011; UNEP 2011). Also, corruption was mentioned as a critical problem within the regulatory bodies (Ebeku 2020; Ibeawuchi 2016).

The legal requirements actually allow the offshore discharge of drill cuttings from water based muds without any treatment, provided it does not contain any free oil as determined by a visual sheen on the receiving water surface (Nwinee 2018). Oil based drill cuttings must not be discharged into offshore waters, unless treated to a residual oil content below 1%. ESMI informed that about 15 % of the drill cuttings material originating from oil and gas drillings in the Niger Delta area are oil-contaminated and require further analysis and treatment.

On the other hand, improvements in the legal and regulatory framework were achieved. For example regarding the overall transparency, including the dissemination of information (World Bank 2020), as well as the enactment of the Environmental Impact Assessment (EIA) Act of 1991. Since the latter concerns only projects commissioned after 1991, older orphaned sludge pits containing improperly treated drill cuttings were not subjected to any environmental impact assessment (Kingston and Okere 2019). This leaves a weak point and a revised EIA-act, broadened in its time scope, could be a big contribution in detecting and categorizing abandoned disposal sites of drill cuttings.

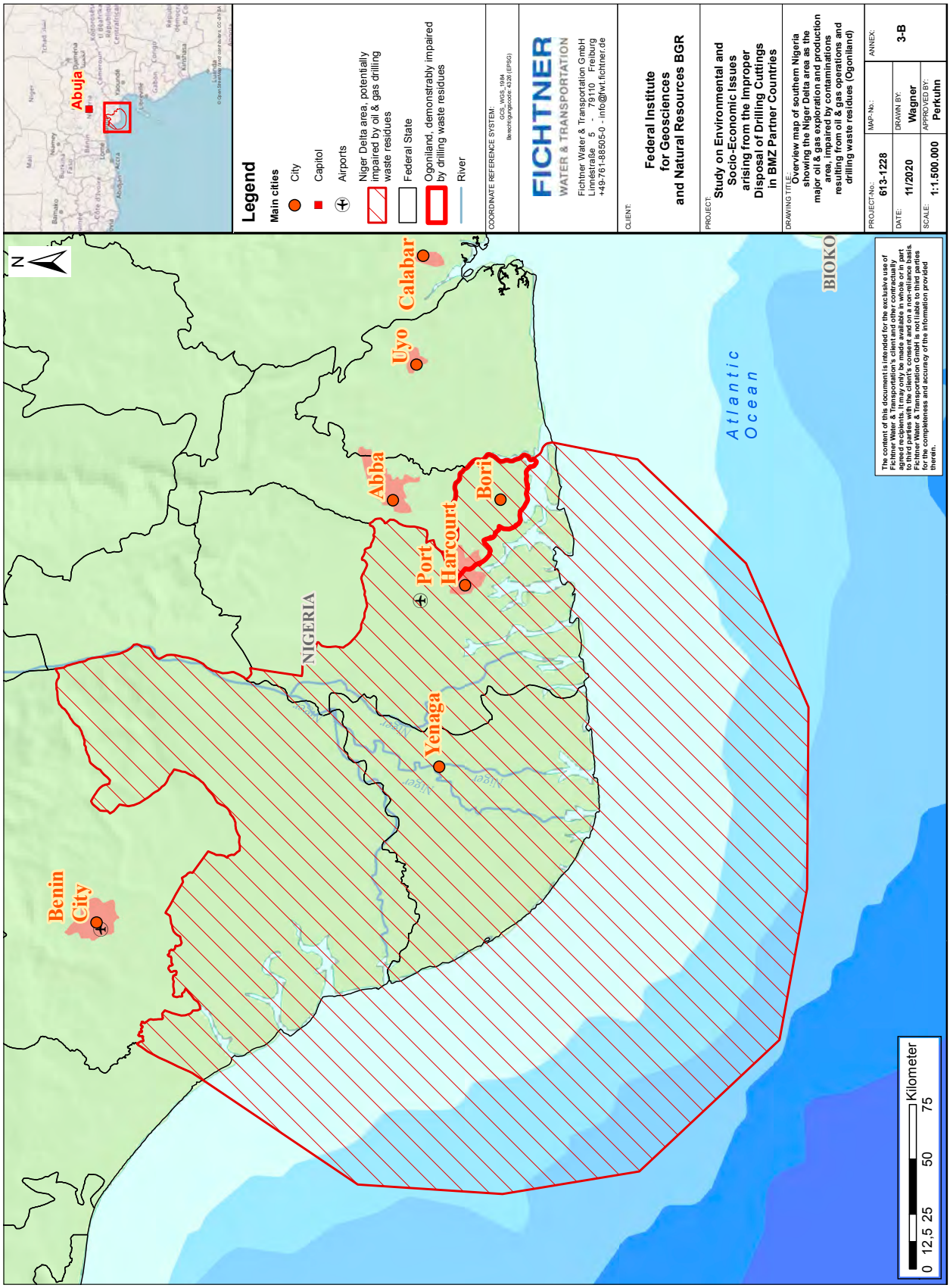

Fig. 4: The Niger Delta: regions, potentially and evidentially affected by improperly disposed residues of oil and gas drilling waste. (Own illustration, Fichtner 2020).

4.2.3 Improper disposal of cuttings in the Niger Delta

The Niger Delta, located in the south of Nigeria, covers an area of approximately 70,000 km2 (7.5% of Nigeria's land territory). It extends over territories of the nine federal states Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers (see Fig. 4).

In the area east of Port Harcourt in the Rivers State, oil exploration and production started in 1950. The area consists mainly of tropical rainforest and mangrove swamps, forming the typical Niger Delta environment.

Since the discovery of significant oil and gas resources, about 1,182 exploration wells were drilled onshore and offshore in the Niger Delta basin until 2009 and about 400 oil and gas fields of various sizes were found until the same year (Ite et al. 2013). According to the Nigerian Department of Petroleum Resources (DPR 2019), 1,022 wells were drilled between 2010 and 2018, of which approximately two thirds are offshore with 417 wells being situated on land/swamp, 383 wells shallow offshore and 218 wells categorized as deep offshore. In total, to date approximately 5,284 wells were drilled in the Niger Delta region (National Petroleum Investment Management Service 2021; Kadafa 2012). However, the real number of wells drilled on-land respectively offshore remained unclear to the author. The problem of potentially improper disposed drill cuttings may apply to all drill holes drilled until 2000 (or even 2010), because of the less strict requirements for environmental protection given at that time.

Most oil reservoirs in the Niger Delta occur at depths between 1,000 m and 4,000 m (Tuttle et al. 1999). Assuming an average reservoir depth of approximately 2,500 m and an average drill hole diameter ranging between 12 and 17 inch, the approximate volume of drill cuttings (Rachain 2009) is in the order of 160 to 340 m^3 or 350 to 750 tonnes per well, respectively. Assuming some 5,300 wells drilled in the Niger Delta, the appraised cumulative amount of cuttings ranges between 1.8 and 4.0 million tonnes of cuttings material.

In many cases, and due to the lack of good waste management practice, former operations caused severe environmental damages and contaminations of surface and coastal waters, groundwater, soils and the marine ecosystems in the Niger Delta.

As concluded from the reviewed literature (DPR 2019; Ite et al. 2013; UNEP 2011; Tuttle et al. 1999) and confirmed by the ESMI, onshore pollution originates predominantly from oil spills, resulting from the deterioration of the exploration, production and transportation infrastructure. Oil spills caused significant negative impacts on the environment, including the agricultural sector. Oil contaminations are lethal to soil microorganisms as well as to aquatic life occurring in rivers and in the sea. According to ESMI, insufficient environmental protection measures are performed among the regulators as well as in the oil and gas industry.

In consideration of the lack of stringent environmental protection requirements, each of the more than 1,000 drill holes may have one or more orphaned mud pits, including oil sludge and drill cuttings.

4.2.4 The Ogoniland as a hot spot area of improperly disposed cuttings

Located in the eastern part of the Niger Delta in the Rivers State, the Ogoniland, a region named after the Ogoni people who account for the majority of its population, covers an area of approximately 1,000 km^2. Oil explorations and productions in the Ogoniland were finally stopped in 1993 due to protests of local communities and all so far installed production, transportation and processing facilities (12 oilfields, 205 wells and 5 flow stations) were not decommissioned, but left simply orphaned (UNEP 2011).

In 2011, the United Nations Environment Programme's (UNEP) report "Environmental Assessment of Ogoniland" (UNEP 2011) drew worldwide attention to the tragic history of pollution in the Ogonliand, caused by oil spills, oil well fires and non-compliant/uncontrolled deposition of petroleum wastes. These pollutions originated from the operations of two companies: Shell Petroleum Development Company Nigeria Ltd. (in charge of

upstream operations) and the Nigerian National Petroleum Company (UNEP 2011).

In its EIA, UNEP performed a comprehensive survey of the disastrous environmental damage in terms of crude oil contaminations of land, sediments and soils, of ground- (41 sites with groundwater pollutions through hydrocarbons), surface and drinking water as well as vegetation and air pollution. All of it resulting from insufficient or negligent industry practices and the given weak legal and institutional framework (UNEP 2011).

As a result of the UNEP survey (UNEP 2011), hundreds of industrial packing bags were found, containing 1,000 to 1,500 m^3 of waste, recorded as drill cuttings, dumped in an unlined former sand mine in Oken Oyaa in the Eleme Local Government Area.

Based on the findings in its EIA, UNEP recommended urgent remediation actions including in-depth studies and environmental risk assessments. In 2020, Royal Dutch Shell, identified as key actor, is still under pressure and blamed for failure in terms of insufficient remediation and decontamination activities (Amnesty International 2020; Amnesty International et al. 2020). ESMI stated that the UNEP-EIA was acknowledged by the Nigerian government. Corresponding comprehensive clean-up programs including remediation works, the first of its kind ever commenced in Nigeria, were initiated. At present, seven contaminated sites were remediated and the responsible authorities are currently in charge of assessing the success of these works.

The Hydrocarbon Pollution and Remediation Project (HYPREP), the clean-up and restauration program mentioned by ESMI, was set up by the Nigerian government in response to the UNEP-EIA in 2017. Funded by the USD 1 billion Ogoniland Environmental Restoration Fund (OERF), lounged in 2016, the program aims on the realisation of the recommendations stated in the UNEP-EIA to restore the ecosystem as well as the livelihoods of communities in Ogoniland. Experts expect that the clean-up and remediation work could last around 25 years to be completed (Reed 2021; Shell 2018; UNEP 2017). Promising subsequent steps were made in 2017 with the ground-breaking ceremony of the Integrated Contaminated Soil Management Centre (Shell 2018).

Despite these governmental initiatives, the achievements and their effectiveness remain disputed. In January 2020, an in-depth report published by four NGOs[10] and based on on-site investigations, questioned the successful implementation of the 2011 UNEP-EIA key recommendations through HYREP and OERF. The report concludes that as by the end of 2019 not a single of the contaminated sites documented in the EIA have been completely remediated. And with merely 11% of the sites being subject to any remediation work at all, not more than 5% were actively cleaned-up by the time the report was published (Amnesty International et al. 2020). It was not verifiable to the author if the difference in numbers of entirely cleaned-up sites, as stated during the interviews by ESMI and in the report, is due to remediation works have been successfully concluded between end of 2019, only before the publication of the report, and autumn 2020, when the interviews for this study were conducted. Latest numbers, issued by HYREP in January 2021, stated that in total 11 sites have been remediated completely with the remaining are completed for 90% (Reed 2021).

Other findings listed in the report are the insufficient implementation of 'emergency measures' as demanded by the UNEP-EIA. This includes the lack of drinking water for local communities as the realisation of emergency measures on the provision of drinking water and health protection failed. Similarly failed the aim to establish a health and environmental monitoring system which involves the local communities (Amnesty International et al. 2020). The establishment of 'community based security and surveillance systems' in conjunction with public health provisions was a key pillar of the on-site recommendations outlined in the UNEP-EIA (UNEP 2011). Allegedly there is also no reporting system in place, making information on the USD 31 million spent from the OERF since 2018 publicly available. Finally, out of 16 companies entrusted to undertake the remediation work by the end of 2019, only five have been classified as being

10 These were Amnesty International, Friends of the Earth Europe, Friends of the Earth Nigeria/Environmental Rights Action and Milieudefensie,

suffcient competent. A problem reinforced by the fact that the terms of reference issued for the contractors did not contain specialist prerequisites for ground water remediation (Amnesty International et al. 2020; Essen 2020).

Findings, concurring with the claims stated by the 2020-report, were made by ESMI following their investigations at oil wells located in two Nigerian federal states. According to ESMI most of the studied waste material including cutting material was not properly disposed (e.g. in a dedicated landfill) but dumped into the environment, causing environmental pollution and contaminations.

Fig. 5: Improperly disposed drill cuttings in Ogoniland (1.2 km southeast of Ejama and about 4 km north of Onne) (UNEP 2011a)

An international non-governmental organisation, protecting the rights of non-represented people and interviewed for this study, confirmed the immense devastation of natural resources and the livelihoods of indigenous people. According to this stakeholder, Royal Dutch Shell is accused of being the main actor responsible for the current severe situation. During the long lasting oil and gas production that caused the above mentioned environmental damages, Royal Dutch Shell was continuously collaborating with the Nigerian Government. The company is still accused to evade from its responsibility related to the remediation of environmental and socio-economic damages, caused by a decades-lasting denying of responsibility in interaction with a lack of proper response on the governmental side. The stakeholder informed that there are still ongoing litigation processes against Royal Dutch Shell in the Netherlands and other jurisdictions. The affected community is still waiting for appropriate clean-up measurements on their territory and compensation. The stakeholder also claimed that considerable mistrust exists among the indigenous people against the government, causing intensifying socio-economic problems and conflicts. Communities are affronted and disillusioned by the lacking response on side of the Nigerian government, e.g. the Niger Delta Development Commission, which is considered as still acting in favour of the national government and ignoring the requirements of the local people.

4.2.5 Shortcomings of petroleum waste management in Nigeria

According to ESMI, and due to the lack of a legally binding national framework for waste management, a broad and systematic cooperation between

the multinational oil and gas companies and regional recycling companies is still missing in Nigeria. Although a national waste management regulation is in place, significant differences exist on the federal state level. The existing laws and regulations are insufficiently stringent. In the current Nigerian Recycling Law, petroleum wastes are treated differently from civil wastes; and thus, not yet included in the national waste management system. For the re-use or recycling of petroleum wastes, applicable, verified and countrywide valid standards are required, promoting alternative solutions such as the, in some countries already practiced, utilization for agricultural purposes (incl. bacterial degradation of harmful substances). To the knowledge of ESMI, cuttings are in general neither properly characterised through laboratory tests nor properly treated. In cases of cuttings materials released to the seabed, negative impacts on the marine environment are still known as common.

ESMI further informed that appropriate state-of-the-art technical guidelines for a systematic handling and processing of drill cuttings are urgently required, including detailed standards for technical processes such as fluid and solids separation as well as thermal treatment of cutting materials. Moreover, administrative deficits exist in the management of petroleum wastes. Implementing authorities acting on sub-national level are considered as weak and not authorised to control the handling of petroleum wastes, as this falls under the competence of the national government. In practice, only a few recycling plants exist in the country.

4.2.6 Potential entry points for international cooperation

Referring to the aforementioned issues and deficits stated by ESMI, future international cooperation could foster the development and implementation of technical/operational standards and guidelines determining the systematic and comprehensive handling of petroleum wastes. This should especially include already existing and improperly discharged drill cuttings and drilling waste materials, attributed to historical oil production activities. Furthermore, these processes, standards and procedures need to be aligned and integrated into the national waste management system, covering various types of industrial and domestic wastes produced in the country. In order to facilitate implementation, the oil and gas companies need to cooperate with regional recycling and waste disposal companies. The DPR, currently in charge of controlling petroleum wastes, may benefit from technical assistance towards the implementation of the required technical standards and guidelines as well as from a systematic integration of petroleum wastes into the broader recycling and waste management stream. To this end, the EGASPIN is in the need of additional amendments including a clear and systematic definition of drilling waste materials. Further, it would have to be brought in line with explicit guidelines towards a systematic handling, characterisation, processing and possible utilisation.

In addition and as recommended by the ESMI, the DPR could benefit from institutional strengthening measures (e.g. staff training, enhancement of laboratory capacities), aiming at an enhanced efficiency and effectiveness of its regulatory and site monitoring functions.

According to an international non-governmental organisation interviewed for this study, future technical cooperation is urgently needed and may help mitigating the high frustration level among the affected communities. At present, the communities are still lacking appropriate support to solve the pressing environmental and socio-economic problems. As already recommended by the 2011 UNEP-report, the stakeholder urgently recommends to empower the affected community to take primary control in clean-up works in the Ogoniland, e.g. through direct employment of local people. This approach is thought to directly address the needs of the impacted local people and allow staff training of community members. Against this backdrop, potential partners of technical cooperation should be the community rather than a central governmental entity that is, in the stakeholder's opinion, considered responsible for the current mismanagement and lack of appropriate support measures.

In addition, prominent local organisations representing the traditional structure of the Ogoniland should be engaged. Stakeholders specifically mentioned here the "Movement for the Survival of the Ogoni People" and the "Ogoni Development Au-

thority", a new organisation still under development, as potential partner institution.

Finally, the stakeholder considers political measures, e.g. from the German government or the European Union, as valuable in order to secure effectiveness of the possible future technical cooperation activities.

4.2.7 Summary and conclusion

Ogoniland as well as other regions within the Niger Delta are known as highly vulnerable regions tremendously affected by non-compliant and negligent oil exploration and production measures and showcase for reckless environmental pollution. Since 1993 until 2011 and even later on, the exploration and production infrastructure and facilities including drill cuttings were left orphaned, resulting in ongoing devastation of the environment and the livelihoods of local people.

Two oil and gas producing companies, Royal Dutch Shell with its national joint venture partner, the Nigerian National Petroleum Company as well as the Nigerian Government are still considered as responsible for not taking appropriate actions towards remediation, clean-up and compensation. Still today, the environmental and socio-economic issues, failures and consequences are debated and subject of heated disputes.

Several legal and regulatory shortcomings were identified and confirmed by the engaged stakeholders. These include, amongst others, the appropriate handling, treatment and disposal of petroleum wastes (including drill cuttings) and the lack of corresponding comprehensive technical standards and guidelines.

As stated by ESMI, petroleum wastes need to be integrated into the national waste management system and processed accordingly. In this matter, the legal and regulatory regime governing the handling and disposal of petroleum wastes needs to be revised.

Regarding future activities of technical cooperation, affected communities in the Ogoniland as well as the DPR were identified as potential partners for technical assistance and institutional strengthening measures.

4.3 Uganda

4.3.1 Introduction

The Ugandan conventional energy resources amount to approximately 300 million tonnes of respectively 340 million tonnes of oil reserves and approximately 14 billion m^3 of natural gas reserves respectively 90 billion m^3 natural gas resources (BGR 2019). To date, there is minor to no continuous hydrocarbon production. Several foreign petroleum companies, amongst others Total E&P Uganda (France), the Chinese National Offshore Oil Corporation CNOOC (China) and Tullow Oil Uganda (Ireland) have acquired several exploration and production licenses and are in the process of field development. Crude oil production is scheduled for 2023 (Ratcliffe 2019; Akello 2014).

Hydrocarbon discoveries in Uganda were first recorded in 1925 and a first well (Waki-B1, the sole well until 2002) was drilled in 1938 in the Butiaba area, Masindi district, in the western part of the country. Based on present knowledge, hydrocarbon resources (mainly oil) occur in the Albertine Graben region, which forms parts of the western Great Rift Valley system in East Africa. The Albertine Graben, including its five national parks, forms an ecologically highly sensitive area (Akello 2014). It extends from the northern border between Uganda and South Sudan to Lake Edward in the south over a length of more than 500 km and a width of up to 45 km, covering also of the Democratic Republic of Congo. Presently, hydrocarbon exploration and development takes place in the western part of Uganda close to the border to the Democratic Republic of Congo, in the Rhino Camp Basin, the Packwach Basin, the Northern Lake Alberta Basin, the Hoima Basin and the Semliki Basin, of which all surround Lake Edward (see Fig. 6).

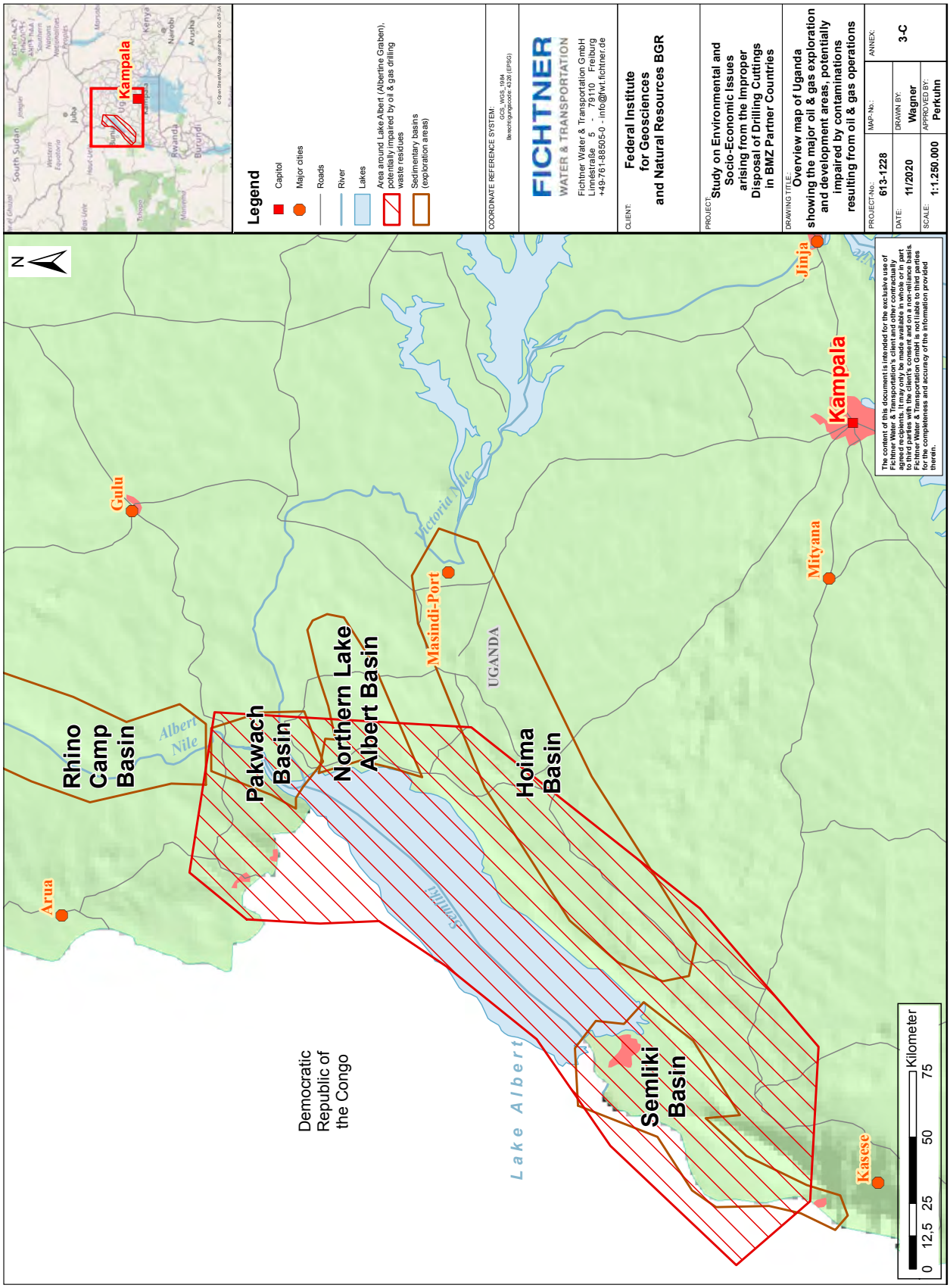

Fig. 6: Map of western Uganda showing the location of hydrocarbon fields and corresponding license areas along the Albertine Graben structure (R304).

4.3.2 Legal and regulatory framework for the hydrocarbon sector

The two most relevant authorities in charge of regulating and controlling the petroleum sector are the Petroleum Authority of Uganda (PAU) (PAU 2019) and the National Environmental Management Authority (NEMA), a semi-autonomous authority subordinate to the Ministry of Water and Environment (NEMA 2021). The PAU is regulating all upstream and midstream activities of the petroleum sector. Its responsibilities include licensing, regulation, supervision of exploration, production, hydrocarbon transportation, refining and accounting.

The Directorate of Environment, Health, Safety and Security, a subordinate of the PAU, fulfils, amongst others, the following strategic objectives (PAU 2021):

- Implementation and maintenance of the legal and regulatory framework required for sustainable environmental protection;
- Ensuring that oil and gas operations are undertaken in an environment-appropriate manner;
- Inspection and controlling of all explorations, development and production operations and related provisions of adequate resources (e.g. financial and staff) and facilities (e.g. laboratories, vehicles, equipment);
- Securing compliance with the effective laws, regulations and standards as well as the implementation of international established operational practices;
- Implementation of necessary measures to prevent incidents, hazards and accidents.

NEMA advises government and coordinates the development of environmental policies, laws, regulations, standards and guidelines relevant for environmental protection and management (NEMA 2021). This includes the supervision of setting rules on the management of drilling wastes (Akello 2014), including the treatment, re-use and disposal of wastes originating from the petroleum sector (e.g. including land spreading and farming, re-injection of wastes, stabilization and solidification, thermal and biological treatment, onsite burial).

When interviewed, Oxfam stated that the legal framework was recently subjected to several amendments to sufficiently cover and control the recently commenced oil and gas operations. Between 2011 and 2012, the primary regulations for petroleum waste management were issued. At present, the legal framework is still in revision and in some areas, detailed legal requirements are not yet put into force. Certain legal requirements for environmental protection set forth for the operating companies need to be revised towards clearness and comprehensiveness.

In 2012, a strategic environmental assessment (SEA) of the oil and gas activities in the Albertine Graben was jointly conducted by NEMA and the Ministry of Energy and Mineral Development (Ministry of Energy and Mineral Development and National Environment Management Authority 2013). The SEA provides the fundamental basis for the legal and regulatory requirements for the petroleum sector.

Among the legal instruments governing the Ugandan petroleum sector including the handling and management of drilling wastes, the following are most important (Golder Associates 2017):

- National Environment Management Act of 1995;
- Petroleum (Exploration, Development and Production) Act of 2013;
- National Environment (Waste Management) Regulations of 1999, regulating the storage and disposal of hazardous waste (including its transportation within the country as well as into neighbouring countries), as well as the management of waste disposal facilities, landfills, sanitary fills and incinerators;
- Petroleum (Exploration, Development and Production) Regulations (2016), setting the rules for the issuance of operating permits, in-

cluding the handling and management, characterisation and classification of petroleum operations waste (drilling fluids, muds, cuttings and other wastes). Besides, the Petroleum Regulation require a financial security (for cases of non-compliance, bankruptcy, sudden closure) covering the cost for closure, decommissioning and remediation, monitoring and aftercare of sludge pits and landfills.

– The Petroleum (Waste Management) Regulations (2019) setting more detailed rules on the production, transportation, storage (including the construction and operation of petroleum waste management facilities), the treatment and/or disposal of petroleum wastes. It also keeps the licensee responsible for its petroleum waste management and remediation actions (in case of any incidents/accidents).

Similar to several other countries, the state participates via production sharing agreements in hydrocarbon production, executed through the Uganda National Oil Company (Beardsworth Jr. and Stuart 2019; Uganda National Oil Company 2020).

4.3.3 The area around Lake Albert as a potential hot spot area of improperly disposed cuttings

At present, hydrocarbon exploration and development activities take place around the Lake Albert in western Uganda. Although research on water contaminations arising from hydrocarbon exploration are performed (e.g. Kiraye 2016), no factual information about any non-compliant disposal of drill cuttings (or drilling waste in a broader sense) could be identified in the public media. According to Oxfam, one incident case was reported: A non-compliant/improper petroleum waste dumping at a farm near Mwoya in 2011 to 2013. The origin, the final fate as well as the subsequent site monitoring and waste management procedures by the competent authorities remained unclear to the stakeholder.

The PAU stated towards the authors that about 50,000 tonnes of petroleum waste (including drill cuttings) were produced until 2020 and handled in accordance to the laws and regulations, especially the Petroleum Waste Management Regulation. A first commercial hydrocarbon discovery was made in 2006, and in the period 2006 to 2011, some 120 exploration and development wells were drilled. During that time, 90% of the produced drilling waste was consolidated and put in a controlled interim storage. In parallel, the legal and regulatory framework was amended towards detailed requirements for the management of such wastes and the required infrastructures and processing facilities were constructed. Former interim storage sites were then cleaned-up, remediated and subjected to on-site environmental monitoring.

Regarding the re-use of cutting materials, PAU mentioned a past pilot project performed in Uganda on the utilisation of some 500 tonnes of cuttings materials for road construction and other purposes. But up to know little experience is available in this area due to limited analytical lab capacity that is required for a risk-based characterisation (toxicity) of drilling waste materials.

In accordance to the regulations, the waste generation as well as the subsequent handling and storage are kept traceable in terms of duration as well as volumes. Petroleum wastes are physically and/or chemically treated and deposited in a coordinated manner, transported and deposited by licensed/certificated operators.

With regard to probable environmental burdens which can be traced back to drilling wastes disposed approximately 20 years ago or earlier, the PAU stated that there is no present knowledge about such. Oxfam stated similar, saying that the drilling waste was neither examined nor considered at all by the authorities. Nevertheless, PAU categorized all recently performed exploration drillings as being sufficiently controlled. As far as known to the author, only one deeper well (Waki B-1, 1938) was drilled before the year 2002.

Consequently, the area around Lake Albert was identified as an area without significant or systematic non-compliant handling of drilling wastes.

4.3.4 Potential entry points for international cooperation

The regulatory framework for the petroleum sector established in Uganda is a promising sign that the country wants to mitigate the problematic issue of improperly disposed drill cuttings right from the beginning.

When being interviewed for this study, this impression seemed to be shared by PAU as well as Oxfam. Even though, both stakeholders stated the need for further amendments in the existing legal framework and especially of the Petroleum Waste Management Regulation and the corresponding compliance monitoring. In this context, additional technical standards or guidelines, detailing technical processes and operational procedures, are deemed to be required.

PAU sees additional need for institutional strengthening measures for national agencies, which could benefit from capacity building and training in the field of petroleum waste management. Through such measures, national institutions like the PAU or NEMA could be strengthened in the fulfilment of their control and monitoring functions on petroleum industry operations. According to Oxfam, NEMA is required to increase and strengthen its staff capacity and financial resources, especially in regional branch offices, in order to perform stringent and periodic site inspections and environmental compliance monitoring. At present, parts of NEMA's environmental management functions are performed by contracting third parties as the authority is lacking sufficient human resources to perform all its duties self-dependently. To enforce environmental protection effectively, Oxfam considers Uganda as being over-centralised by the federal government. In this sense, local governments should be better engaged in the monitoring and verification of environmental compliance.

4.3.5 Summary and conclusion

Uganda's petroleum sector is in its developing phase, as several oil fields along the Albertine Graben are still under exploration and development. Against this background and the needs for legal and regulatory improvements identified approximately ten years ago (International Alert 2011), the fundamental legal and regulatory framework seems to be well-established. The common issues in connection with drilling and production waste are addressed in detail in the existing legislation and in line with common international practice. Still, additional amendments are recommendable and the effectiveness of the laws and regulations require verification and affirmation through continuous monitoring and field inspections.

Positively highlighted should be that competent authorities including PAU and NEMA are already required to demonstrate their managerial assertiveness and enforcement power in ongoing permit approval procedures. To further strengthen the national authorities in their fulfilment of regulatory and environmental compliance monitoring functions, two approaches seem promising: to either enhance the authorities' capacities, or to transfer certain duties to regional branch offices, for example periodic site inspections and environmental monitoring. The latter approach would address also the existing over-centralisation of the Ugandan administration, as mentioned by stakeholders, which allegedly impedes them to enforce environmental protection efficiently. As a conclusion, technical assistance and/or institutional strengthening is considered valuable in order to consolidate and maintain state-of-the-art procedures and technologies.

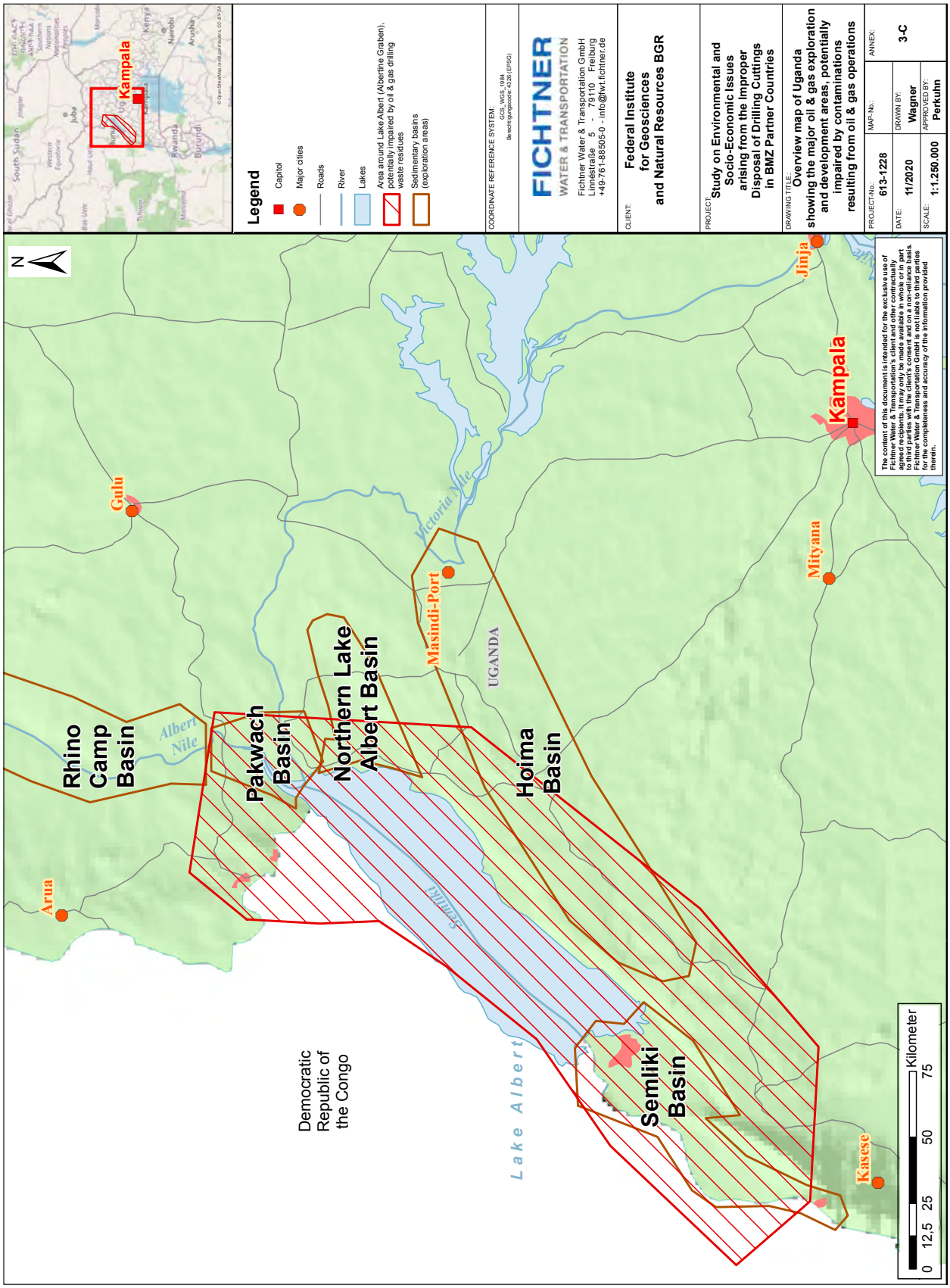

Fig. 7: Uganda: regions, potentially affected by improperly disposed residues of oil and gas drilling waste. (Own illustration, Fichtner 2020)

4.4 Other BMZ partner countries

In order to add a global perspective to the study, 60 countries currently defined as 'BMZ partner countries' (BMZ 2021), including 42 bilateral partners, 8 'global partners' and 10 'nexus' and 'peace partners', were reviewed with regard to their national oil and gas exploration and production history. In most of these countries, dedicated laws or regulations (primarily mining and petroleum laws, environmental protection laws, etc.), laying the ground for the general management, handling and disposal of drilling wastes, were enacted during the 1990s and 2010s. This supports the conclusion that drillings wastes produced earlier in these countries were most likely handled without due consideration of any negative environmental and corresponding socio-economic impacts.

In 39 BMZ partner countries, oil and gas exploration and production activities (for the purpose of field exploration and development) started before the year 2000. These include 23 bilateral partners (Afghanistan, Albania, Algeria, Bangladesh, Benin, Bosnia and Herzegovina, Cameroon, Colombia, Ecuador, Egypt, Ethiopia, Georgia, Ghana, Ivory Coast, Jordan, Morocco, Namibia, Nigeria, Pakistan, Senegal, Tunisia, Ukraine and Uzbekistan), 8 'global partners' (Brazil, China, India, Indonesia, Mexico, Peru, South Africa and Vietnam), and 8 BMZ 'nexus' and 'peace partners' (Chad, Iraq, DR Congo, Libya, Sudan, South Sudan, Syria and Yemen) (see Fig. 5-7).

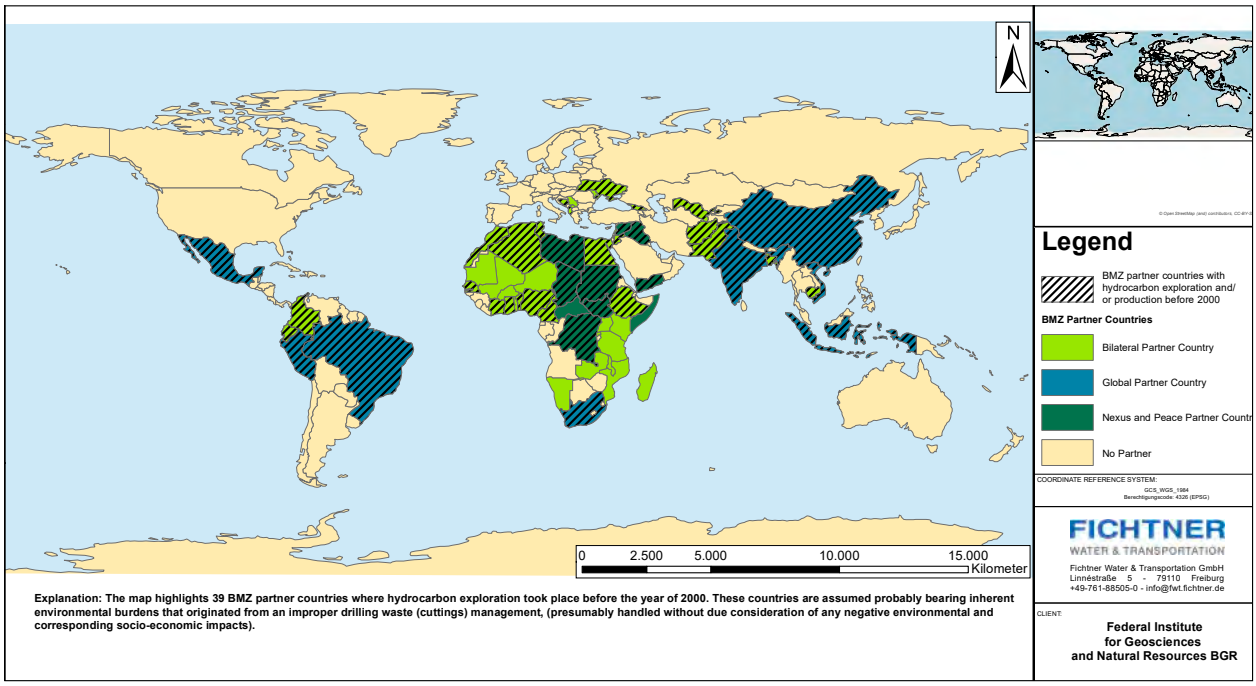

Fig. 8: BMZ partner countries with significant oil and gas drilling activities commenced before the turn of the millennium.

Based on oil and gas exploration and production activities before the year of 2000, these 39 BMZ partner countries were assumed bearing environmental burdens that originated from an improper drilling waste management. As a conclusion, the improper disposal of drilling waste (including the neglect or disregard of appropriate environmental protection measures) potentially poses a major and worldwide environmental and socio-economic problem, including several of the BMZ partner countries.

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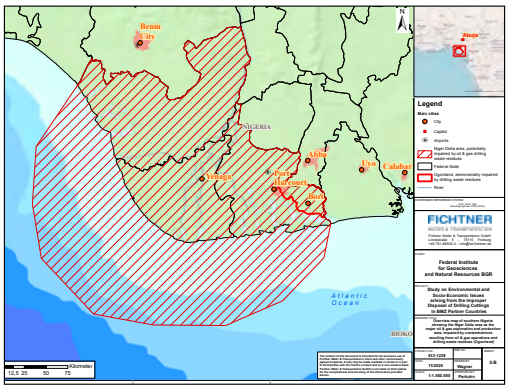
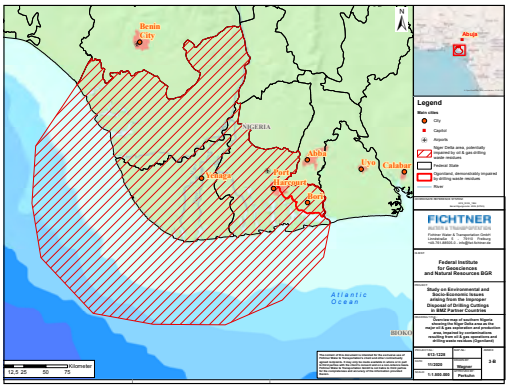
Annex

Summary of potential hot spot regions (location profiles)

No.	Criteria	Information	Reference
1	Name of the hot spot region	Niger Delta, embracing the federal states Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers (incl. Ogoniland)	Amnesty International 2020; Ite et al. 2013; Amnesty International et al. 2020; Okonkwo et al. 2015; Aye et al. 2013; UNEP 2011
2	Country, region, location	Nigeria, Niger Delta 	UNEP 2011
3	Engaged exploration and production companies	Shell Petroleum Development Company Nigeria Ltd. in charge of upstream operations and Nigerian National Petroleum Company	UNEP 2011
4	Originator/ polluter	Shell Petroleum Development Company Nigeria Ltd. in charge of upstream operations and Nigerian National Petroleum Company	UNEP 2011
5	Type of residue	Deteriorated drilling, production and oil transportation infrastructure, incl. sludge/ solid waste pits of approximately 3,000 drilled wells.	UNEP 2011
6	Approximate age of the residue	Drilling wastes in the region are of various ages, between approximately 1950 to 1991	Author's interpretation
7	Approximate number of individual residues	Approximately more than 3,000 wells (estimation according to the number of onshore wells drilled in the region). Besides, cuttings produced from offshore drillings may be dumped in the sea (presumably without previous treatment)	Author's interpretation
8	Type of improper deposition of the residue	Drill cuttings, partly oil bearing, and other wastes produced during drilling (fluids, muds, lubricants, etc.)	Author's interpretation
9	Type and severity of environmental and socio-eco-nomic impacts	Severe impact on environment and socio-econmic situation. Devastation of livelihoods, farmland, ground and surface waters, fish farming, etc.)	

10	Exemplary visualisation	(UNEP 2011b) 	UNEP 2011

No.	Criteria	Information	Reference
1	Name of the hot spot region	Ogoniland in the Rivers Federal State, Niger Delta, Nigeria	Amnesty International 2020; Okonkwo et al. 2015; Ite et al. 2013; UNEP 2011
2	Country, region, location	Individual site in Nigeria, Niger Delta, Ogoniland: 1.2 km southeast of Ejama and about 4 km north of Onne. 	Ite et al. 2013; UNEP 2011
3	Engaged exploration and production company	Shell Petroleum Development Company Nigeria Ltd. in charge of upstream operations and Nigerian National Petroleum Company	Ite et al. 2013; UNEP 2011
4	Originator/ polluter	Shell Petroleum Development Company Nigeria Ltd. in charge of upstream operations and Nigerian National Petroleum Company	Ite et al. 2013; UNEP 2011
5	Type of residue	Oil bearing drill cuttings, approximately 1,000 to 1,500 m^3, originating from an oil well outside Ogoniland	UNEP 2011
6	Approximate age of the residue	2010, at the time of conduction of the UNEP survey in the region	UNEP 2011
7	Approx. number of individual residues	Individual site location	UNEP 2011

8	Type of improper deposition of the residue	Big bags dumped in a former sand pit, without any underground insulation (clay or liner) and therefore disregarding legal requirements.	UNEP 2011
9	Type and severity of negative environm and socioecon. impacts	Local contamination (crude oil, heavy metals, etc.) of soils and groundwater, requiring site remediation and monitoring	UNEP 2011
10	Exemplary visualisation	(UNEP 2011a) 	UNEP 2011