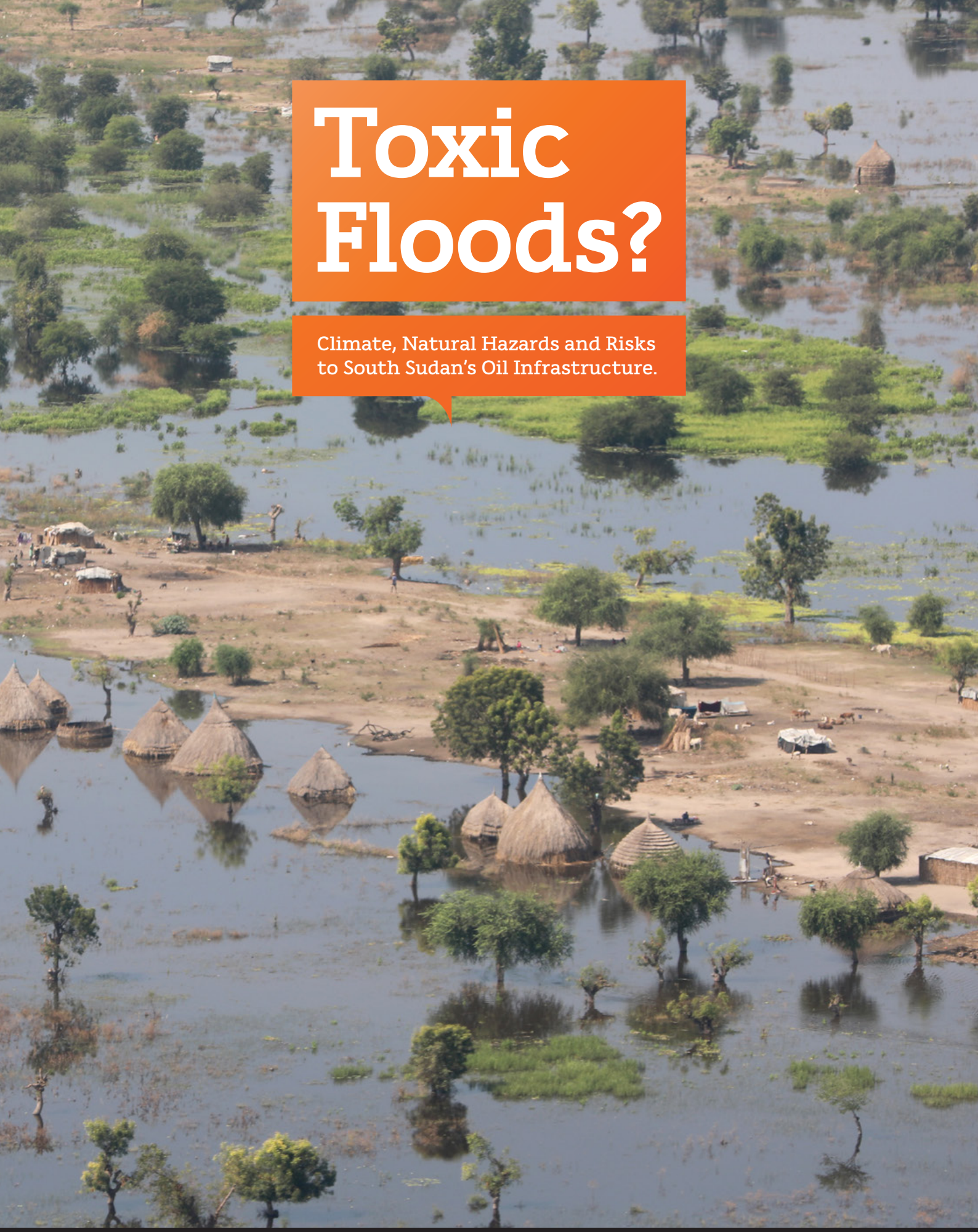

Toxic Floods?

Climate, Natural Hazards and Risks to South Sudan's Oil Infrastructure.

PAX
www.paxforpeace.nl

A remote sensing and hydrological model analysis by PAX, with contributions from Utrecht University

Colofon
May 2023

PAX means peace. Together with people in conflict areas and concerned citizens worldwide, PAX works to build just and peaceful societies across the globe. PAX brings together people who have the courage to stand for peace. Everyone who believes in peace can contribute. We believe that all these steps, whether small or large, inevitably lead to the greater sum of peace.

If you have questions, remarks or comments on this report, you can send them to info@paxforpeace.nl

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Cover image: Flying over Bentiu in South Sudan, the view is a patchwork of glorious colour. But under this colourful quilt is a shocking reality – deep, murky waters full of waste, rotting animal carcasses swaying lifelessly as snakes slither through the debris. Seventy percent of Unity state is under water because of the worst floods in nearly a century. Climate change has caught up to the world's youngest country even as it battles intercommunal conflict, cattle raids, sexual violence, displacement and an economy that is in the doldrums. Photo by Francesca Mold/UNMISS

Content

Introduction: Past and Present of South Sudan's Oil Pollution

The discovery and subsequent exploitation of oil fields in South Sudan has brought the country both wealth and woes. Armed conflicts and civil wars fought over control of oil fields have led to the killing of thousands, with many more wounded and displaced. Meanwhile, these conflicts have also resulted in long-term environmental implications from damaged oil infrastructure, especially with regards to local pollutants in and around oil fields.[1] Following South Sudan's independence in 2011, national legislation for the country's oil industry, including environmental laws and standards, has faced serious problems due to lack of enforcement, a problem worsened by corruption.[2] This has resulted in persistent pollution issues caused by a lack of maintenance, oversight, and crumbling oil infrastructure.[3] Broken pipelines, leaking open-air oil waste pits, fires at wells, oil dumping and related chemical waste have all contributed to fears from local communities over the impact on their health, as ground and surface waters used for drinking and agricultural use are polluted.[4] The expansion of oil production has also resulted in the displacement of local communities, with farmers and herders driven off their lands by growing infrastructure projects. Earth observation analysis has demonstrated the land change in the major oil blocks as a result.[5]

Against this backdrop, climate change and its impact on precipitation and seasonal flood patterns can lead to an exacerbation of an already dire situation, particularly with the risks posed by flooding in and around the oil fields. In January 2021, PAX started mapping oil fields and related infrastructure in South Sudan with the expectation that floods would affect these locations, while also increasing the monitoring of flood plains during the rainy season. Current discussions over the fate and development of South Sudan's unique Sudd wetlands[6] is linked to new plans to drain the White Nile in order to reduce flooding impacts. However, this will also impact its tributaries and the Sudd wetland with severe environmental challenges.[7] In this broader discussion and analysis on the linked environmental and climate challenges around these floodings, there is a dire need to include the status of oil infrastructure in risk assessments to strengthen transparency and accountability over potential pollution incidents occurring at oil fields and production areas. This should also contribute to improved protection of civilians from the potential polluting ripple effects of the already serious humanitarian impacts caused by the floodings and could affect their health and livelihoods.

This joint research paper will use remote sensing analysis to explore how oil exploitation in the main oil blocks is a growing risk from flood hazard and why swift action by both the South Sudanese government and the (international) oil corporations operating in the area is needed to prevent further public and environmental health risks from climate change-induced extreme weather events. The results aim to inform the wider debate around conflict-sensitive areas, environmental governance and growing water security and energy transition challenges linked with the climate crisis.[8]

A significant part of South Sudan's oil blocks are located near rivers and in floodplains. There is little information available on the state of South Sudan's oil industry due to a lack of oversight on its environmental impacts. The limited information available is based on NGO reports and work carried out by international organizations such as Cordaid and PAX.[9] According to a 2018 UN Environment report, so-called 'drilling muds', and toxic produced water that result from oil extraction, contaminate the environment at the oil fields.[10] In January 2021, the government announced it would undertake an environmental audit of all oil fields,[11] but previous intentions to carry out such an assessment in the past have thus far gone unfulfilled.[12] Experts have called for the audit to be independent, transparent, and inclusive to ensure voices from affected communities are reflected, and, in turn, to be meaningful and effective.[13] Civil society groups are currently taking the government to court for its failure to protect communities from the environmental risks posed by the oil industry's pollution.[14] In September 2021, the UN Human Rights Council's Commission on Human Rights in South Sudan noted the environmental harm caused by national and international oil companies, listing various incidents and shortcomings by the government and the oil industry to deal with the crumbling oil infrastructure, while calling for full reparations in the form of restitution, compensation, and satisfaction to communities affected by oil pollution.[15]

Unfortunately, most of the oil profits do not benefit the general population of South Sudan, as the oil blocks are controlled by international oil corporations that take much of the profits from oil exploitation (as outlined by International Crisis Group).[16] The oil industry is further affected by weak management of the country's finances, making it prone to corruption as officials siphon off oil revenues, as the UN Human Rights Council documented in 2021.[17]

Thar Jath oil facility, Sudd Petroleum Operating Company Limited, 2014.

Seasonal Flooding, Climate Change, and Flood Risk of Oil Blocks

The impacts of climate change and related environmental degradation are already felt throughout South Sudan.[18] Every year, seasonal flooding results in the displacement of over 700,000 people, with huge humanitarian impacts.[19] The rainy season usually starts in June, intensifying in August and September,[20] but these seasons seem to be changing, with rain starting earlier and increasing in intensity.[21] 2021 witnessed above-average rainfall early in the season in the Upper Nile area,[22] with further heavy rains in late summer that worsened flooding downstream.[23] Beyond its direct health impact, flooding has also severely affected local livelihoods. According to the FAO assessment of the flooding, over 800,000 livestock were killed and over 37,000 tons of crops were destroyed.[24]

Lack of proper access to shelter, hygiene, and security is worsened by increased flooding as excess water may negatively affect crop production, further worsening the food security situation. The intensity and change in seasonal occurrence of flood events will likely increase in the future as a result of the climate crisis. One element that warrants further research is the extent to which oil infrastructure poses additional environmental health risks for communities living on or near oil fields.[25] Limited studies have already shown elevated exposure risks for the local population, and communities fear that growing instances of health issues are linked with oil pollution. If oil infrastructure is affected by flooding, oil and wastewater could further impact water sources, villages and agricultural lands. These floods will likely be amplified further as time goes on and the climate crisis deepens. The governor of South Sudan's Unity State, mr. Monytuil, warned of flood consequences for oil fields in November 2021, stating that "the environmental and health hazards that will occur should oil fields be flooded will be unprecedented and taint the lives of South Sudanese citizens for the foreseeable future."[26]

Environmental Health Risks from Oil Operations

There are long-standing concerns regarding various stages of oil production in South Sudan that contribute to environmental pollution. These include oil spills during drilling and extraction; oil processing; the storage of oil and treatment chemicals; and the transport of oil.[27] Numerous incidents of damaged pipelines have resulted in major spills, while unsafe practices of

handling wastewater pose serious risks to ground and surface water. Oil and waste products such as grease and treatment chemicals contain various contaminants, ranging from hydrocarbons to heavy metals, that can lead to toxic concentration in soil and water sources, as indicated in studies undertaken on the major oil fields in South Sudan.[28] One study from 2016 in Unity State also found high concentrations of heavy metals linked with oil resources in the hair of individuals living near the oil fields.[29] The findings imply the likely exposure of local communities to oil derivatives, primarily through water and air pollution.

Contaminants and heavy metals including lead (Pb), mercury (Hg), chromium (Cr) and sodium (Na) linked with wastewater spills pose serious health risks for civilians that face either sustained (through drinking contaminated water and affecting ground water reservoirs) or acute exposure to toxic chemicals from improperly managed and dumped treatment chemicals.[30] There are also longer-term environmental risks as these contaminants affect soil and vegetation, impacting local biodiversity and habitats. Reporting by the government of South Sudan to the Convention on Biodiversity in 2019 revealed that leaks from oil production sites affected groundwater aquifers, leading to adverse effects not only at the site of contamination but also in more distant areas.[31]

Oil waste leaking at on oil field in Unity State.

Community Concerns over Oil Pollution

There are long-standing concerns from local communities and civil society groups over the oil industry's impact. The European Coalition on Oil in Sudan (ECOS), an international joint initiative active from 2001 to 2013, coordinated by PAX and collaborating with local civil society groups, has documented these problems and produced reports on foreign investors and labor practices in the oil industry.[32] More recently, other initiatives such as the Nile Initiative for Health and Environment and the Sudd Institute have further documented spills that resulted in the exposure of livestock and the contamination of crop fields, with an increasing number of reports of diseases that local communities link with pollution, as well as growing frustration with the lack of response from the South Sudanese government.[33] A 2020 study by the Sudd Institute on community perceptions of the presence of oil companies painted a bleak picture, with locals describing the grave effects oil pollution has had on their livelihoods:

In the summer of 2021, communities in Upper Nile took to the streets and protested against the lack of progress in dealing with pollution from oil extraction,[35] building on similar protests over the last decade.[36] The government subsequently announced that oil companies that don't implement environmental protection policies would be expelled[37], yet few believe this threat to hold any force, considering that the vast majority of the country's GDP depends on oil revenues.

> "We are getting contamination from water, milk and food because of the petroleum pollution. Before the oil, there were no diseases. Oil has brought diseases."
>
> *- Traditional leader from Melut town.*[34]

An abandoned drilling chemicals storage yard in Gumry, Adar oilfield, South Sudan.
©The Nile Initiative for Health and Environment, 2017

Main Oil Infrastructure Risks

Flood-born pollution risks can be best understood by analyzing the different types of oil infrastructure that could be affected. Building on the previously mentioned reports from UNEP, the Sudd Institute, ECOS and Cordaid, and additional earth observation of the main oil fields, the following main risk locations can be identified:

- Refinery wastewater and evaporation ponds: These huge reservoirs are located near the main refineries at the oil fields, containing millions of cubic meters of toxic wastewater. These structures are generally well-built, though past incidents give reason for concern in the case of insufficient maintenance or sustained exposure to flood water, while there are also regular concerns over construction methods not meeting international standards. There is also a general lack of independent inspections to ensure the quality of their construction.
- Oil extraction wastewater pits: Small reservoirs seen near pumping jacks or oil derricks in a few of the larger oil fields, particularly around the Paluch field.
- Oil pipelines: The oil extracted is transported locally and regionally across tens of thousands of kilometers of oil pipelines. A combination of problems, including lack of maintenance and sometimes outdated construction materials and corrosion could create more risks of a rupture, leading to a risk of widespread pollution if not timely contained.
- Treatment chemicals storage: Oil extraction and transport involves using various hazardous chemicals present at the drill sites or dumped in waste pits. Large containers and barrels containing methanol, diesel, herbicides, paint thinners, lead-acid batteries and other chemicals are often used; see the Engineer's Guide to Oil Field Chemicals and Fluids.[38]

In case of flooding, crude oil, wastewater and chemicals poses acute and long-term risks to the local environment, depending on the amount, exposure type and impacted area. Direct exposure to these chemicals can pose acute health risks to civilians. Crude oil and wastewater can affect drinking water sources for communities and livestock as well as soil if not cleaned up and remediated properly. Flooding is likely to dilute small quantities of oil and wastewater, thereby lowering the risks of high exposure to various pollutants. Proper identification and monitoring of suspected contaminated sites is needed for a full risk assessment.

Methodology

To better understand the risks associated with growing flooding of the rivers near these oil fields, this Environment and Conflict Alert has used earth observation (EO) and remote sensing (RS) data together with the application of a hydrological model to analyze both current flooding and historic trends. From this analysis, potential pollution scenarios can be derived. The focus is on the four main northern oil fields, namely Block 2; Block 5 in Unity State; and the combined Blocks 3 and 7, located in Upper Nile State. This analysis can be used to develop an early warning system for the oil blocks and to design protective measures for the oil installations at risk.

Visual interpretation was done combining Landsat and Sentinel imagery with recent high-resolution satellite imagery from Zoom Earth, Google Earth and Planet Scope and Planet Skysat to map oil drilling installations, oil complexes and industrial blocks (i.e. refineries and larger plants), water treatment pools, main tubing and other key oil infrastructure. Observed villages and urban footprints were also mapped.

Considering the frequently occurring flooding and its grave humanitarian impacts, the UN Office for Coordination of Humanitarian Affairs (UNOCHA) developed a generalized flood hazard map in 2020.[39] This layer was used as a first approach on the potential flooding areas. Though helpful, a more detailed flood hazard layer was needed to combine properly with the focus of the study (the oil infrastructure). Based on image classification using the Landsat dataset, PAX has developed its own detailed historic flood extent maps. Flood extents for 2021 were based on Sentinel 2 while relevant drainages which were not present in available datasets were digitized. UNOSAT has also published flood extent layers for different periods in 2022, including a general map of the flooded oil blocks.[40] In some areas, however, the UNOSAT flooding map misidentified burned land with flooded land; PAX therefore carried out its own flood analysis of the area in Unity State.

Flooded town in Unity State, December 10, 2021. Photo by Francesca Mold/UNMISS

Flood mapping was based on the NASA Landsat dataset, which has had a consistent temporal coverage since the mid-1980s. The Thematic Mapper TM, Enhanced Thematic Mapper ETM & Operational Land Imager (OLI) data was acquired through the USGS Global Visualization Viewer (GloVis) and Earth Engine. Evidence of flooding was collected from more than 40 Landsat images, covering 26 years of flood events from 1984 through 2020. ESA Sentinel 1 and 2 (Level 2A and 1C, depending on availability) were used for specific inquiries and contrast when available. For the updated 2021 flood event, Sentinel 2 was complemented with Landsat OLI imagery.

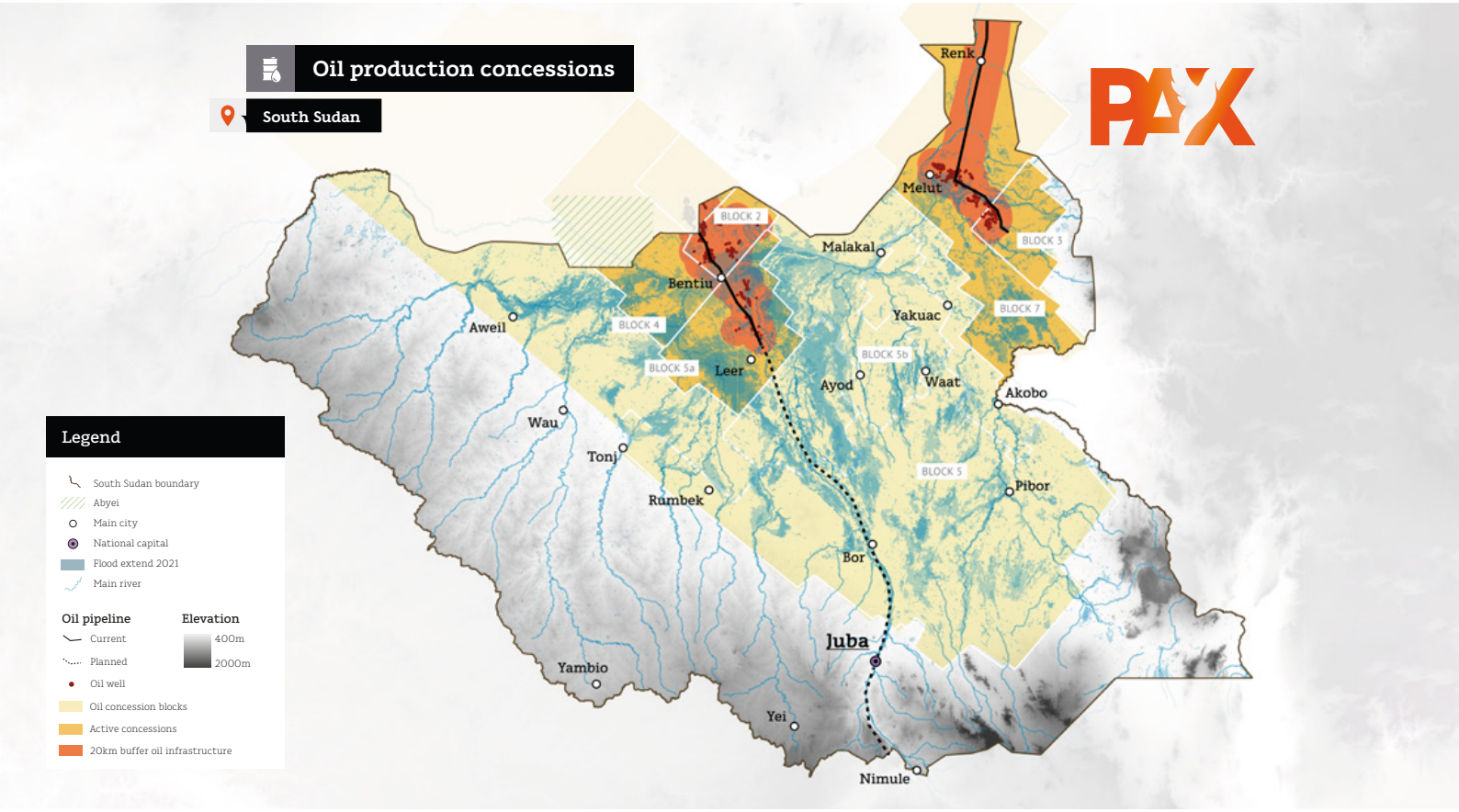
Additional open-source analysis was conducted through monitoring traditional news and social media sources for the locations of flood-affected areas and linked concerns over pollution from oil activities. PAX further consulted with local partners in South Sudan on the findings, and obtained an unreleased internal Environmental Impact Assessment, dated July 2018, of several GPOC oil blocks to further understand the various current issues associated with oil exploitation in South Sudan.

Machar Koang (47) posing for a portrait in front of his farm submerged by flood waters in Ding Ding, Unity state. October 6, 2022. WFP/ Gabriela Vivacqua

"This is the worst flood I ever saw in my life. Before we used to construct dikes and they would stop water from flowing into our homes. This time we constructed dikes, and all of them overflooded. We are surprised by these floods; we don't know where it is coming from."

Geography of the Oil Blocks

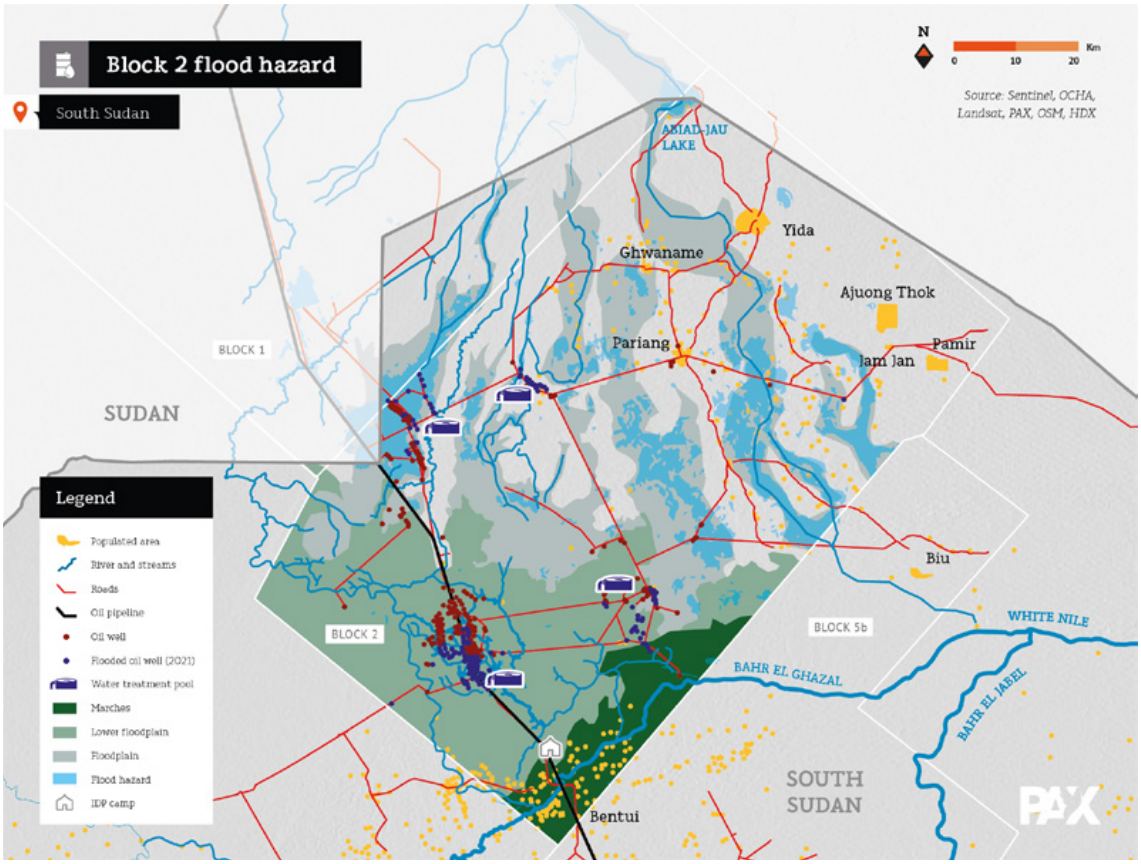
In South Sudan, oil extraction takes place in the lowlands in the north of the country. The existing oil infrastructure is located approximately between 300 and 390 meters above sea level (masl). The border of the oil concessions meets where the hilly terrain begins (around 450 masl). Extensive plains with a complex network of drainages dominate these flat landscapes. The lower parts of these plains flood regularly in the rainy season. The area of interest can be divided into three sections, according to the oil concession blocks, hydrology, and flooding pattern. The oil infrastructure and flood data is summarized for each concession block: block 2, block 5, and the combined blocks 3 and 7 (as they form one concession area). Block 1 corresponds mainly to Sudan and block 4 has no wells in the jurisdiction of South Sudan.



Block Hydrology – Water Source and Flood Moments in 2021

The development of the flooding patterns in 2021 showed how the different blocks and even sections within each block flood at different moments, due to the input of water from different source areas or catchments. Block 2 has two clear differences (the north and south parts): the lower floodplains of the southern part, around Unity and Munga, receive flood waters from the overflows of the Bahar el-Ghazal. The flooding dynamics of the northern section, comprising the areas around

El Toor, El Naar, Toma South and some areas above Munga, are determined by water flowing from a smaller catchment from the Nuba mountains and areas further north in Sudan. While the northern area showed average floods with a peak around mid to late August, the southern area showed the continuation of river floods into late October, continuing until the end of November in some places

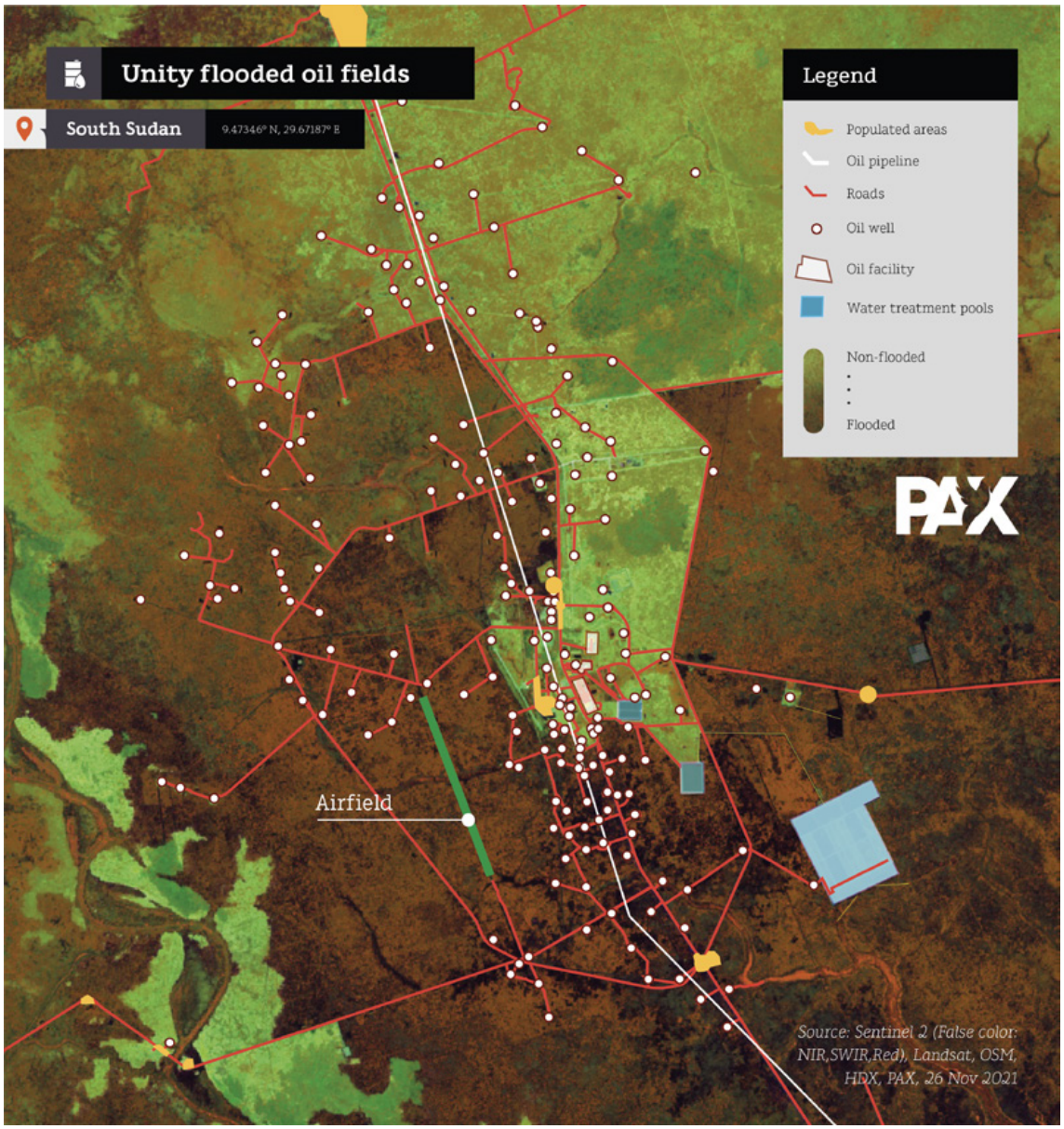


Unity State

Located near the border with Sudan, this State includes Block 5, one of the largest concessions. The area was heavily contested during the civil war that ended in 2005,[41] with thousands of civilians killed in fighting over control of the oil wells that displaced large farming and herding communities, with grave implications for agricultural production in the area.[42] During the war, the Sudanese army also received support and encouragement from foreign oil companies such as Sweden's Orrön Energy (then Lundin Oil/Petroleum), as documented by contemporary observers and more recently again by the Swedish Prosecution Authority. The outbreak of violence in 2013-14 halted work on the oil fields; extraction and further oil production resumed in mid-2021 by the Sudd Petroleum Operations Company (SPOC),[43] a consortium of oil companies with the Malaysian-origin Petronas having a majority stake. The restart of production would lead to an expected 45,000 barrels a day production by 2028.[44]

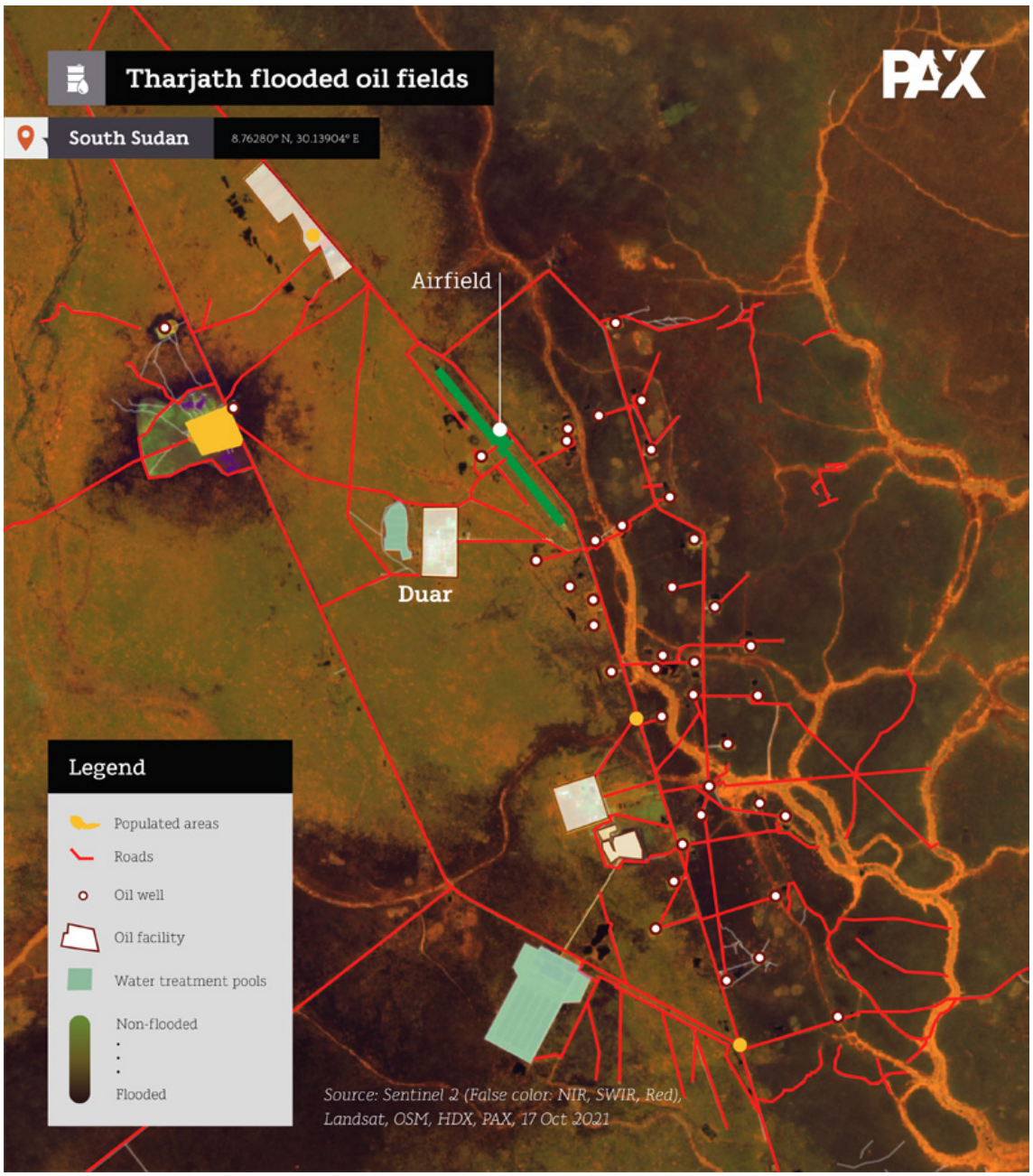
A significant part of these oil fields are located in the Sudd, Africa's largest tropical wetland and a likely a new UNESCO World Heritage site, with one of the world's largest freshwater ecosystems and known for its rich biodiversity.[45] With the White Nile flowing through it, the Sudd also hosts endangered species of mammals, rare birds, and large fish populations that depend on the unique

environmental conditions. The Sudd is already facing threats from an increase of development plans linked with agriculture that risk draining the water and impacting this important environmental region.[46] The increase of oil exploration in part of the Sudd in South Sudan, in particular Block 5A, could create further risks to its fragile ecosystems, particularly as there are no laws that protect the Sudd marshes.[47]



Flooding Impact

In block 2, there was no evidence of flooding prior to June. June was quite cloudy on satellite imagery and thus presumably quite rainy. Floods begin to appear in July in the block's northern section. By mid-August, the middle section around the Kadet (airstrip) was flooded. In early August, evidence of flooding is visible in the south, around the Tharjath and Rier oil fields. By the end of September, the Rier market was surrounded by floodwaters. The highest floods are visible between late September and mid-October. The block's northern section was heavily flooded in November. This section receives water overflow from the Bahr el Ghazal river, while the southern areas receive overflow from the White Nile, which flows along the west side of the fields. The central section is dominated by the Nile but is also impacted by overflows from the Bahr El Ghazal river.



In total, out of the **486** oil extraction points, flood water overflowed **233** wells. It was not clear how many of these wells are operational at the time of analysis. Flooding also impacted the territory of at least four wastewater ponds, but there are no indications of adverse effects as a result.

Upper Nile State

The Upper Nile river is the main water source in this region, with tributaries into the Machar marshes, a part of the Sobat basin. The wetlands are a habitat for diverse flora and fauna, with unique wildlife and also provide grazing land for rural herding communities, while tens of thousands of people depend on fishing along the many rivers in the basin.[48] Concerns over the impact of oil exploration were also put forward in a 2020 assessment of the Machar marshes, fearing pollution from wastewater and a lack of environmental regulations.[49] Blocks 7 and 3, the main oil fields in this area, are owned by Dar Petroleum Operating, a consortium consisting of China's National Petroleum Corporation, Petronas, and some smaller companies.[50] The fields produce 103,000 barrels per day since mid 2021, with the main location of oil facilities concentrated around Paluch.[51]

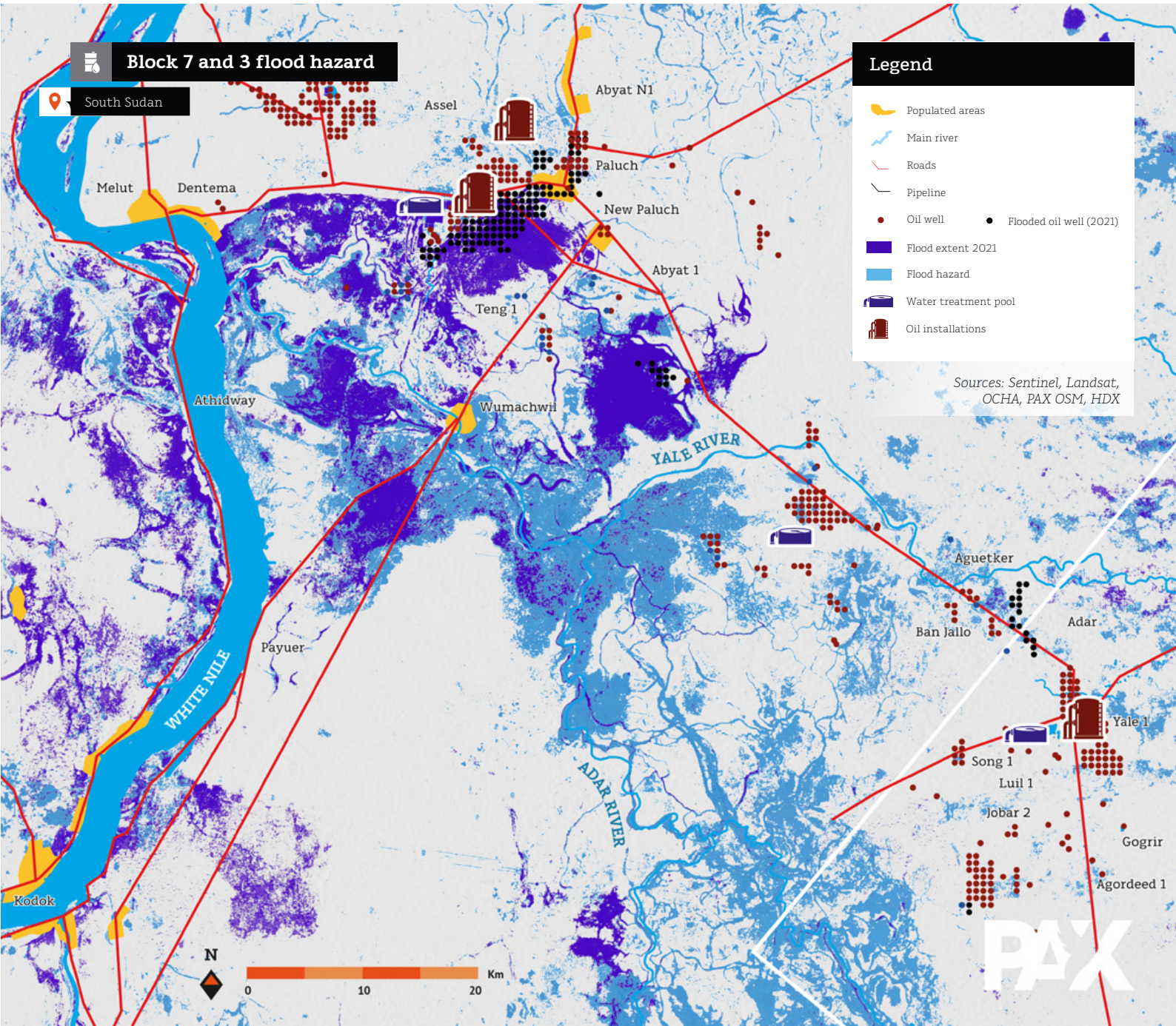
In the Melut basin, the increase of oil exploration resulted in severe impacts already before 2005. Over 100 villages were emptied of their inhabitants alongside the forced displacement of pastoralists, while there were major concerns over unsafe oil practices leading to environmental damage (detailed by the PAX-supported ECOS report).[52] A 2014 assessment by Cordaid further outlined problems with pollution,[53] and in early 2021, the Sudd Institute outlined a set of concerns over oil pollution's impact on human health in Melut, part of the block 7 and 3 oil fields.[54]

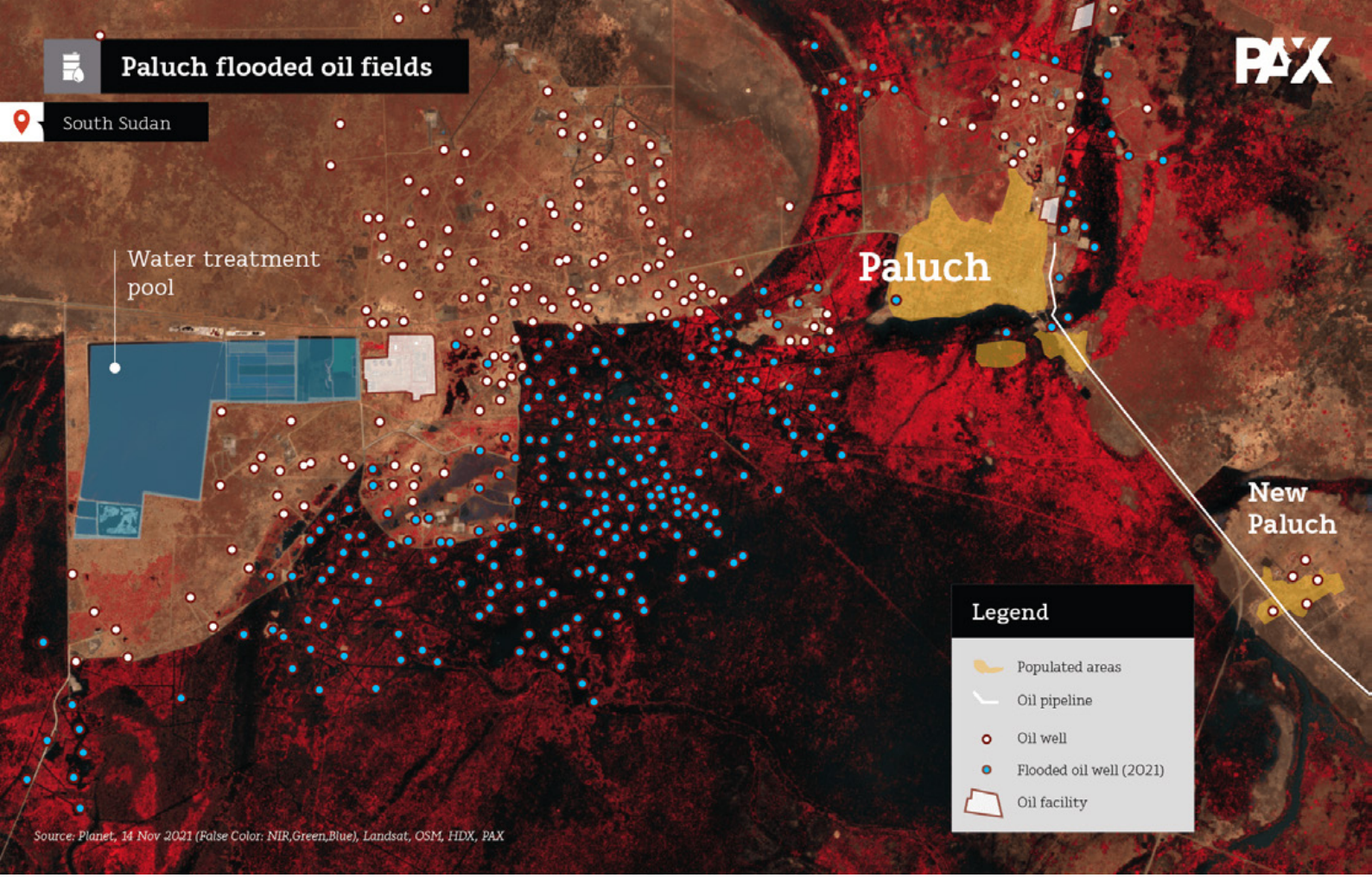
Flooding Impact

The Upper Nile and local rivers in block 7 and block 3 receive water from the hills and ridges bordering Ethiopia, forming the Adar and Yale rivers. When these reach the plains they spread and flood seasonally, going around, through and sometimes over well installations and ponds. The flood dynamics of the lower parts of block 7 also are controlled by the White Nile. (During the period of analysis, this location had the highest water level observed with a S-2 image on November 29, 2021) Floods in these blocks were observed in early 2021 and persisted through the year.

From the **533** observed flooded wells locations in the study area in 2021, block 2 had **159** flooded wells, compared to **74** for block 5b and **300** for Block 7/3. At the time of analysis, it was observed that a significant number of the wells were not in active use, as determined via Planet Skysat Very High Resolution imagery combined with Google Earth historical imagery.

Available altimetry data from the Database for Hydrological Time Series of Inland Waters (DAHITI) for three locations, two along the White Nile river and one for the Sobat river, in the study area (between block 5 and block 7/3) shows how flood seasons have been different in the last several years. Sentinel 2 satellite imagery also shows how 2021 began with the areas in question already wet, unlike past years where in the first months of the year the wetlands are generally dry. 2020 also shows a shorter dry period visible with satellite images and altimetry data. The altimetry data shows how each year after a high water or flood season, water levels eventually return to a normal level. For the last several years, however, the levels do not reach a 'normal' level, indicating the water bodies have not returned to their normal volumes and when they receive more water, they will overflow quicker. These recent changes in the flood season are not enough to claim climate change is responsible but still are a clear pattern change.

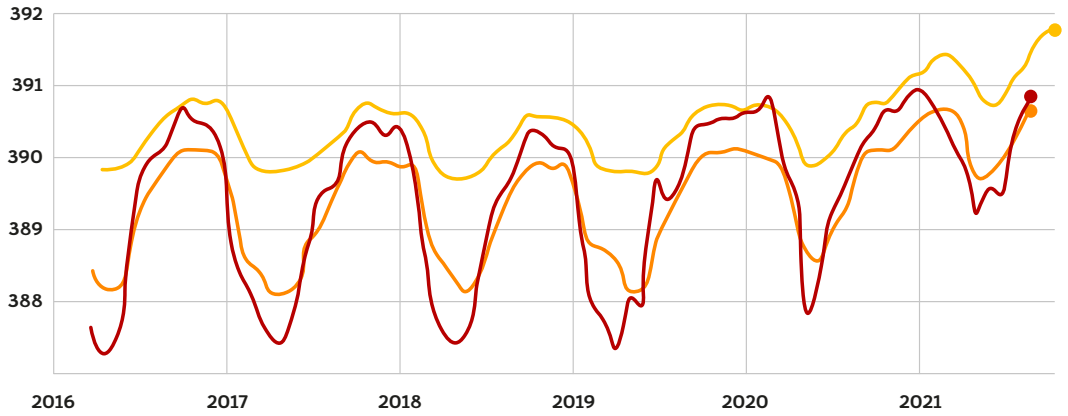


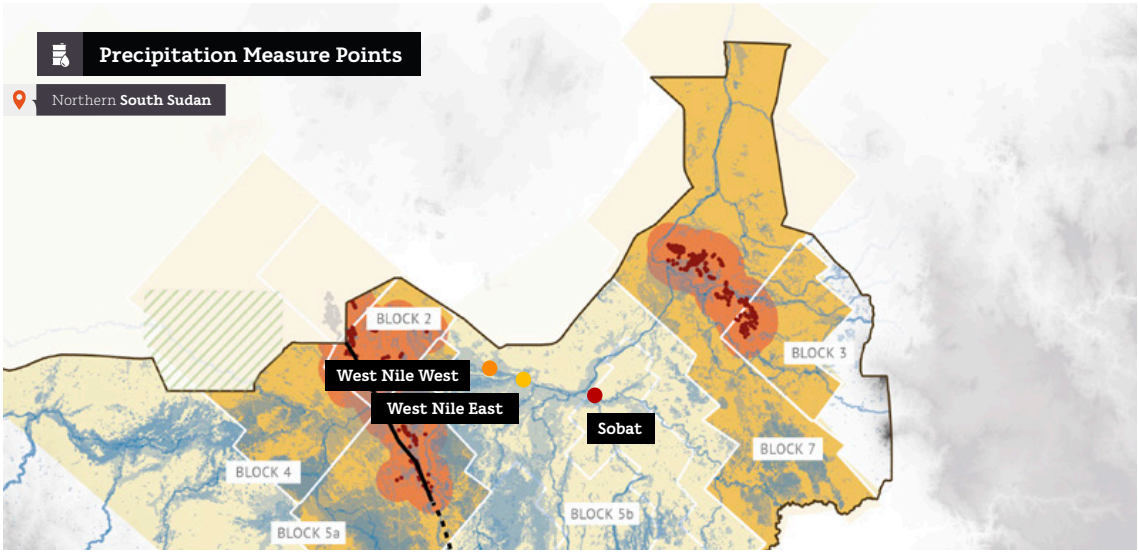

Paluch flooded oil fields
South Sudan
Water treatment pool
Paluch
New Paluch
Legend
Populated areas
Oil pipeline
Oil well
Flooded oil well (2021)
Oil facility
Source: Planet, 14 Nov 2021 (False Color: NIR,Green,Blue), Landsat, OSM, HDX, PAX


Paluch, Block 7 oil field, Upper-Nile State
South Sudan
10.44227° N, 32.49954° E
Oil drilling site
Flooded land
Oil waste pit
Source: MAXAR WorldView 2, December 22, 2022

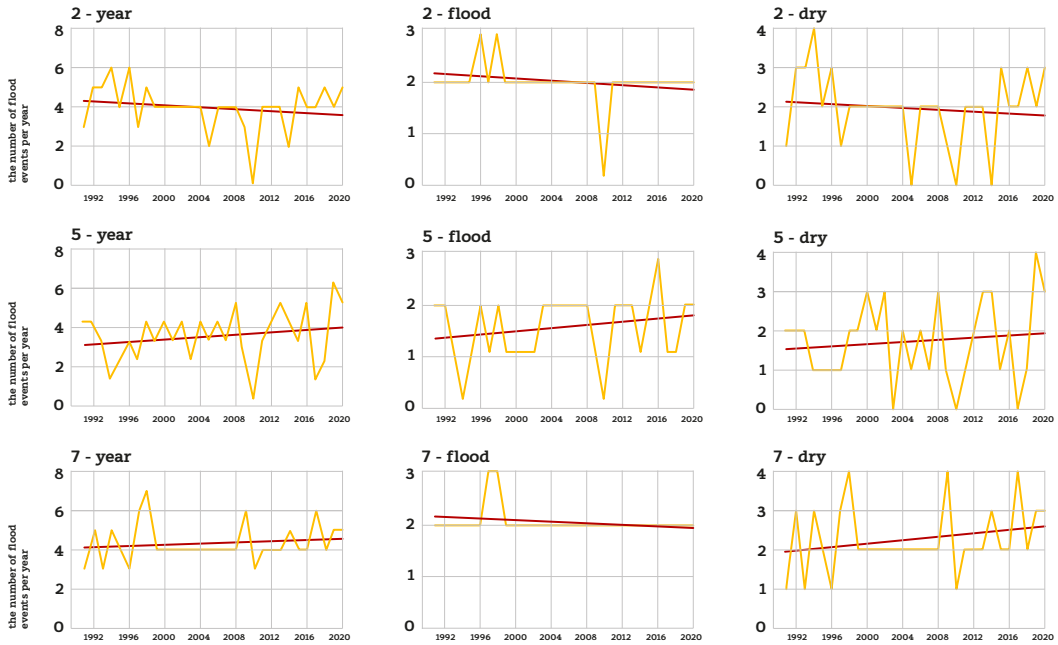
Historical Flooding Trend Analysis

Flood occurrence in block 2 continued to decrease over the past 30 years, both during the flood and dry season. To get a better idea how flood occurrence developed in the past, output from the hydrological model PCR-GLOBWB was used.[55] Per oil concession block 2, 5, and 7, the number of months with a flood event - here defined as the number of months in which the maximum flood depth exceeded 0.01 m - was derived. More specifically, the analysis was separately done for the flood season (August, September, November and December according to SIPRI), and the dry season (all remaining months).[56] The period 1990 - 2018 was taken into consideration for this study using the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) 2.0 precipitation dataset for precipitation input.[57]





Results indicate that for blocks 5 and 7 annual flood occurrence has increased over time. When attributing this change to wet or dry season, results show that this increase is driven by a higher flood frequency for both wet and dry season in block 5. In block 7, however, the change in flood occurrence is mainly driven by more frequent floods during the dry season. This indicates that changes in precipitation and temperature lead to a shift of flood occurrence and in turn shift of potential flood risk from the established flood season towards the dry season, posing additional challenges to flood management due to potentially lower awareness and preparation.

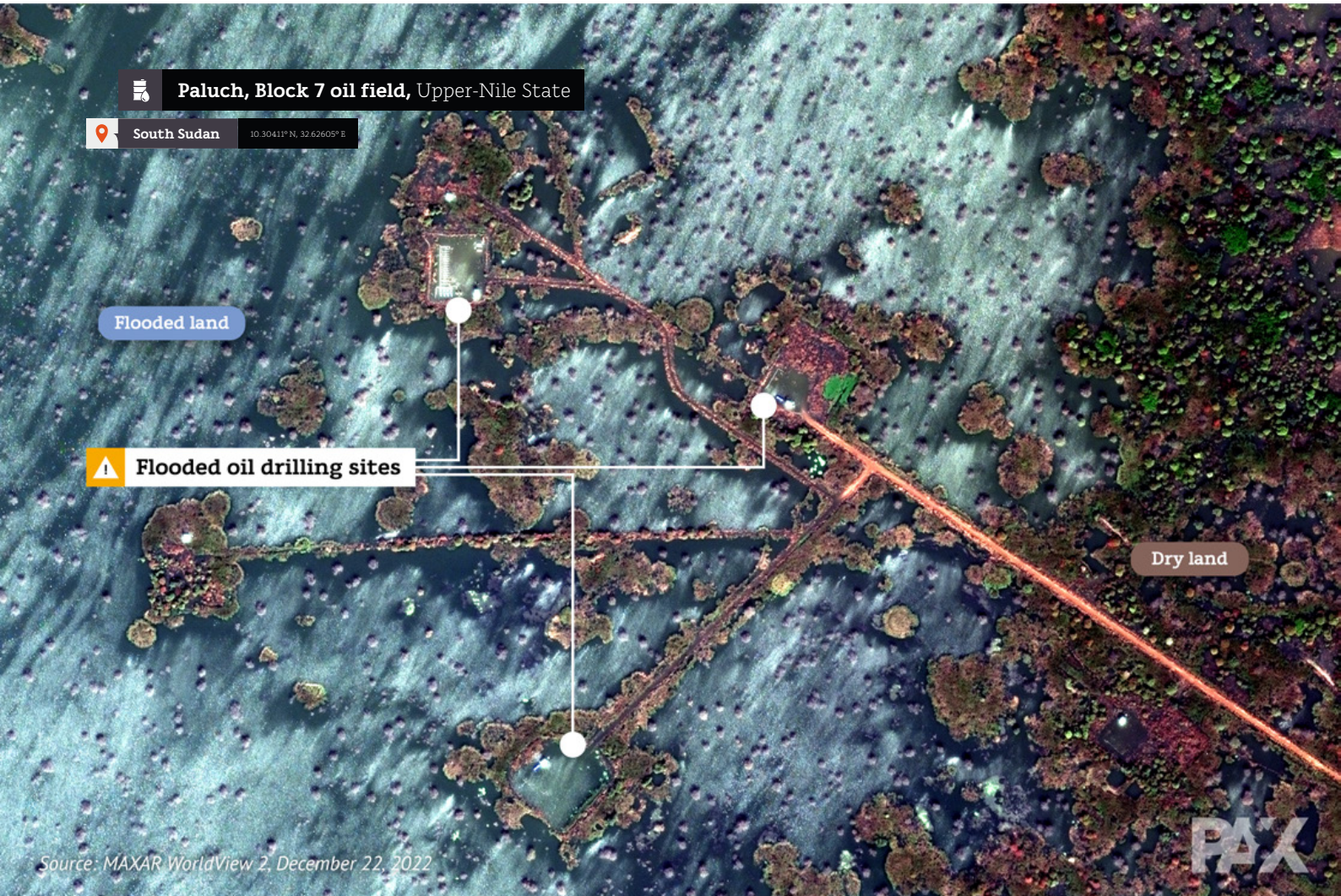


Alek Ngoar stands outsider her farm which has been submerged by floodwaters in South Sudan. October 27, 2022
© WFP/ Gabriela Vivacqua

Conclusions

Flooding in South Sudan continues to pose widespread and grave humanitarian consequences for over 700,000 people. The impacts of flooding will likely get worse as the climate and weather patterns become more erratic and extreme. Changes in precipitation, likely linked with the climate crisis, have resulted in more severe flooding scenarios and increased the risks to oil fields. The current oil infrastructure lacks adequate protection and often also proper maintenance. The humanitarian consequences of flooding are severely exacerbated by spills of oil products and toxic chemicals as a consequence of sub-standard industry practices. This adversely affects essential natural resources such as surface water and groundwater, as well as grazing lands that local communities and their livestock depend on.

The analysis in this report outlines the potential flood plains in the two main oil blocks in Unity State and Upper Nile State and precipitation data, combining this with data on oil infrastructure at risk. Based on the remote sensing assessment of the 2021 flooding by PAX, block 2 had 159 flooded oil wells, block 5b - 74 flooded wells, and block 7/3 - 300 flooded oil wells. If the proportion of flooded wells is taken as an indicator to classify the impact in an oil block, then block 5b in upper Unity State is the most heavily affected, with 74% of wells flooded. Block 2 had 41% of its wells flooded, while block 7/3 had 35% of its wells flooded.



The remote sensing analysis shows the amount of wells flooded, but at this stage it is unknown how many of these wells are active. More information from the oil industry and local authorities is needed to make a more detailed risk assessment of pollution originating from flooded oil fields. Thus far, there is no meaningful commitment from the South Sudanese government to carry out such an assessment, despite repeated promises.

Public reporting indicates ongoing concerns by communities over how the flooded oil blocks affect drinking water for villages, livestock and agricultural areas. These risks compound an already heavy humanitarian burden from flooding for the people of South Sudan, and are likely to be exacerbated with erratic weather patterns that can be linked with the climate crisis. The combination of poorly managed oil installations and a growing trend of extreme weather events is exacerbating climate-crisis linked environmental security risks. The conflict-affected oil industry lacks proper oversight and the comprehensive environmental impact assessment that the Petroleum Act of 2012 requires is yet to be carried out by the government of South Sudan. The Act's article that obliges companies to remedy any environmental and social adverse impacts remains ignored by both the government and the oil industry. Oil exploitation has restarted in block 5a and new oil exploitation agreements are in the making for areas along the White Nile, without indications that this time the law or international industry best practices will be respected or that measures will be taken to manage the proven severe environmental risks of heavy flooding.Together with predicted changes in temperature and precipitation, it can be assumed that floods will occur more frequently in the future in the study area, with its change being strongly influenced by increasing carbon emissions.[58] It should be noted that flood occurrence is not an indicator of flood magnitude (i.e. the severity of flooding) and the associated risk of a flood event. A 2018 study suggests, however, that future flood risks will increase worldwide compared to current day situations.[59]

Endnotes

1 For an overview of the work of PAX on oil extraction in South Sudan, see https://paxforpeace.nl/what-we-do/programmes/oil-extraction-in-south-sudan

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