SITUATION OVERVIEW

Jur River County Climatic Shocks and Resilience Assessment

March 2023 | South Sudan - Western Bahr el Ghazal State

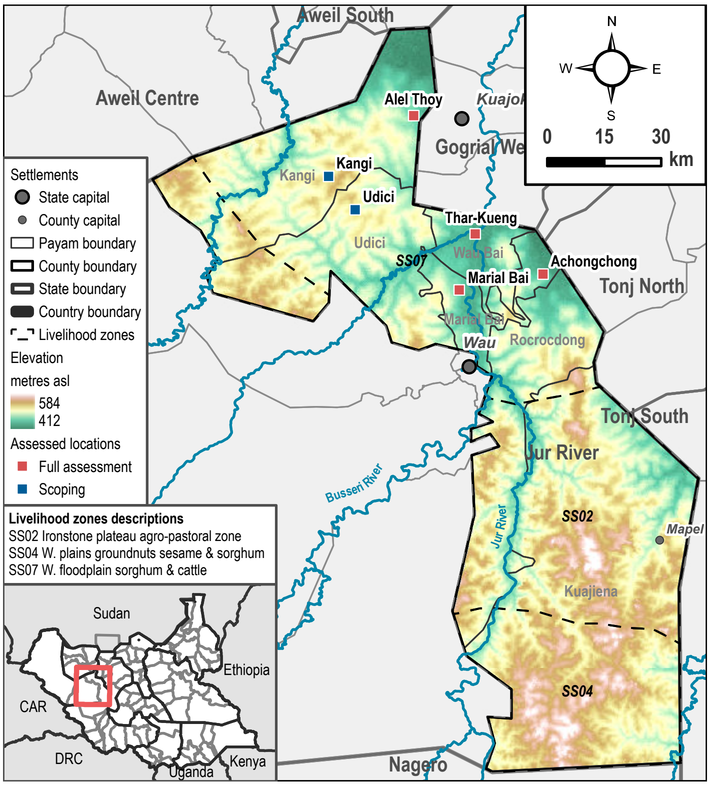
CONTEXT & RATIONALE

Western Bahr el Ghazal State and other parts of South Sudan have experienced abnormally high levels (and changing patterns) of rainfall and flooding in recent years. Due to a combination of abnormally high upstream flows on the Jur River and other tributaries, and the aforementioned heavy rainfall in the immediate area, water levels in the lowlands were higher than usual at the time of the assessment in October 2022, and many populated areas along the Jur River and surrounding tributaries had been flooded.

Given the regular recurrence of flooding across the county and the county's relative stability, Jur River County is a suitable location to implement disaster risk reduction (DRR) activities. In order to understand the current extent of DRR infrastructure and community perceptions across the county, REACH conducted a qualitative assessment and mapping exercise between the 13th and 20th October 2022.

Note that this assessment did not assess all potentially relevant locations and used a qualitative methodology, and as such, findings are indicative only. See page 2 for a methodology overview, and the Terms of Reference for more information.

Map 1: assessed locations and elevation, Jur River County



KEY MESSAGES

- Much of Jur River county is exposed to flooding. Flood exposure may be underestimated by national-level remote sensing analysis due to prevalence of flooding in vegetated areas and the cyclic short-term nature of rainfall flooding.
- Flooding in 2022 impacted many parts of the county, including in particular the flood plains adjacent to Jur River north of Wau, as well as the lowlands in Udici, around Achongchong, and around Alel Thoy.
- Many respondents reported that flood impacts were worse in 2022 because flooding occurred earlier than usual, i.e. before harvests, leading to extensive crop damage.
- In some assessed communities, community-managed disaster risk reduction (CMDRR) activities were in operation, supported by an INGO operating in the area. Flood and DRR assistance was otherwise limited.
- CMDRR activities involved establishment of CMDRR committees, development of community action plans, and support to develop flood control structures, with water channels being the most preferred structure.
- KIs and many FGD respondents reported flood control infrastructure was insufficient to cope with 2022 flooding, whilst others mentioned they were concerned about maintenance and sustainability.
- Assessed communities did not report having access to formal early warning systems, except for radio forecasts. These were generally low precision and many reported not having access to radios, nor being willing to act on forecasts.
- Many households reportedly employed a range of coping mechanisms including building platforms in their compounds, or moving to higher ground. However, many were unwilling to move due to lack of a place to stay.
- Building flood infrastructure was deemed a women's role due to it relating to the house, meaning there was greater burden on women during flood events. Also, limited access to markets to purchase menstrual pads, and damage to toilet infrastructure due to flooding led to inability to maintain menstrual hygiene.

METHODOLOGY OVERVIEW

REACH visited six locations in Jur River County, selected based on purposive sampling of locations where high flood risk was identified (Map 1), and locations reported to have been affected by flooding in 2022. REACH conducted 15 focus group discussions (FGDs) and two individual interviews (IIs). Three to four FGDs were conducted per location. Each FGD included 3 - 8 participants, with a moderator, translator and interviewer. Groups were gender-segregated and split into displaced and non-displaced groups where relevant. Ten key informant interviews (KIIs) were conducted with local leaders and NGO representatives with knowledge of the area and disaster risk reduction initiatives. Additionally, REACH physically assessed locations, to ground-truth flood risk maps and to map key affected infrastructure.

Figure 1: cattle in Marial Bai Payam. Photo: REACH

1. Background and context

1.1. Traditional livelihoods

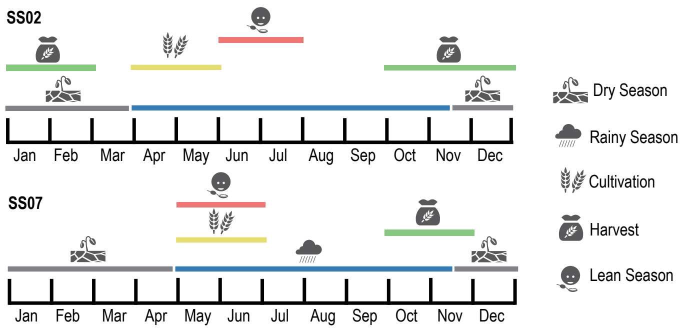
The north of Jur River county, approximately the area to the north of Wau, is situated within the **Western floodplain sorghum and cattle livelihood zone (SS07),** whilst the **Ironstone plateau agro-pastoral zone (SS02) covers the southern portion of the county (Map 1).**[1] Note that assessed locations all fall to the north of Wau, and therefore within zone SS07 - the Western floodplain sorghum and cattle zone.

Livelihoods in the SS07 zone are a combination of **crop production, cattle rearing, fishing and hunting, as well as gathering wild foods and bush products.**[2] Eighty percent of households are estimated to own cattle, which agrees with FGD and KI respondents who also mentioned the **main sources of livelihoods were from cattle and crop farming.** The zone is production-deficit, and is heavily reliant on imports from Sudan for its staple foods.

The **agro-climatic conditions of this zone are most suitable for growing sorghum, although other crop varieties can also grow well.** Seven KIs reported agriculture as the main livelihood activity in the county, with sorghum being the main staple crop. However, okra, pumpkin, groundnuts, cassava and maize were also mentioned. **Sorghum cultivation takes place at the start of the rainy season between April and June, whilst harvests usually take place towards the end of the rainy season from October onwards** (Fig. 2). Note that the sorghum harvest season is shorter than in SS02, likely meaning floods would have a greater impact on food availability here.

Cattle rearing was mentioned by three KIs, who reported **migration took place in December from Gogrial and Kuajok (Warrap State).** Cattle reportedly stay and graze in Jur River county for around four months, before returning to Warrap. It should be noted that **during the flooding season, the proportion of people participating in fishing livelihoods increased considerably** according to FGD respondents, especially in lowland areas. In highland or forest areas, **collection of firewood and charcoal was also mentioned,** an activity particularly undertaken by women, and at the time of the assessment (October 2022), some FGD respondents reported they would increase this activity in coming months (see section 7.2 on coping strategies).

Figure 2: seasonal Calendar for livelihood zones SS02 and SS07, Jur River county. Sorghum cultivation and harvest period shown.



1.2. Climate and environment

As shown in Map 1, Jur River County is characterised by undulating topography ranging from approximately 400 to 600 metres in elevation. Higher ground is found in the south and northwest of the **county, whilst the Jur River basin forms a narrow floodplain that widens to the north of Wau.**[3]

The Jur River is a tributary within the wider Nile Basin and runs downstream from the highlands near the border with the Democratic Republic of the Congo, through the western side of Jur River County, where there is a confluence with the Busseri River to the east of Wau. From there, Jur River continues to flow north and then northeast, joining the Bahr el Ghazal River, and eventually flowing into the White Nile near Lake No. **Another tributary flows through Kangi payam, flowing into the Bahr el Ghazal River** and an extensive herbaceous wetland zone near Aweil.[4]

A single rainy season occurs from May to October (sometimes into November), and generally peaks in

August. The county receives an average of approximately 1055 mm of rainfall per year.[5] Temperatures in the county range from an average of 25°C between July and September, rising to an average of 30°C in March and April.[6] **The dry period peaks between January and April when competition for water and pasture is critical.**[7]

Stretching down from Western Equatoria to Wau, lies the Ironstone Plateau, which is characterised by shallow moderately fertile and recognisably red soils.[8] Due to the **low water retention capacity of these soils and the sloping terrain, most run-off drains into the floodplains and lowlands to the north of the county.**[9] Soils in the lowland areas around Jur River to the north of Wau are **high in clay content,**[10] **further making them more prone to flooding.**[11]

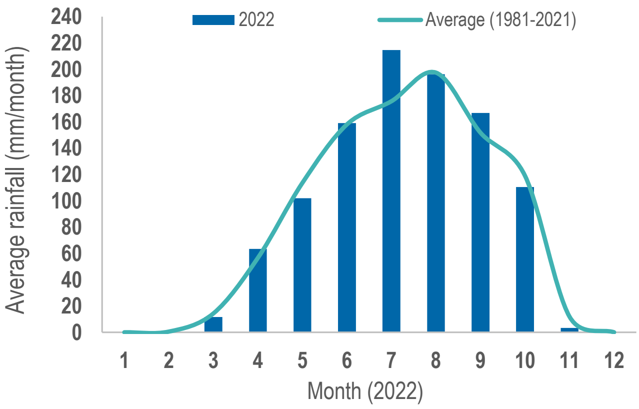
2. Climatic shocks

2.1. Flooding

Flooding was the most commonly reported shock to have occurred in the past year (2021-22), mentioned in all FGDs and by the majority of KIs. In addition, flooding was reported to have occurred in **2021 and to be a common occurrence in many assessed locations across the county.**

Figure 3 shows average rainfall in Jur River county in 2022, as well as the monthly historic average.[12] Notably, rainfall was below average in March, and normal in April, before an apparent dry spell occurred in May. Following this, rainfall **increased again in June, reaching above average levels in July.**

Figure 3: rainfall (mm) in Jur River County - 2022 vs average



According to the majority of FGD respondents, the rains started between April and June 2022, whilst many reported that a **dry spell occurred early in the rainy season, followed by heavy rainfall,** which corresponds with findings from the climatic data described above.

Whilst flooding was widely reported to occur annually in Jur River county, most respondents reported that the 2022 flooding was the worst in recent years. Many FGD respondents specifically mentioned that flood impacts were worse in 2022 than in 2021, because of the dry spell mentioned above, followed by heavy rain. **The timing of this heavy rain and flooding occurred before crops were due to be harvested, which reportedly led to widespread destruction of crops.** Conversely, FGD respondents reported that flooding usually occurred after staple crops such as sorghum had been harvested, and thus usually had a less significant impact on livelihoods.

Figure 4: flooding in Marial Bai payam. Photo: REACH, 2022.

2.2. Drought and dry spells

Drought and dry spells were also mentioned as shocks occurring in the past year (2021-22) by many KI and FGD respondents, although by a smaller number than those who reported flooding. As mentioned, most FGD and KI respondents reporting drought referred to a **short period of below average rainfall at the start of the 2022 rainy season.** This appears to be more characteristic of a dry spell, which relates to a shorter-term drop in rainfall, often during the normal rainy season.[13]

The **occurrence of heavy rainfall immediately following a dry spell, as reported in 2022, is known to exacerbate flooding** as dry, cracked soils repel rather than absorb water, increasing runoff and the risk of flooding.[14] Such conditions often increase crop damage, agreeing with findings from assessed FGDs and KIs.

Whilst the definition varies regionally, drought usually refers to longer-standing rainfall anomalies, often leading to more substantial impacts on vegetation and crop health, as well as surface water and groundwater storage.[15] Similar conditions were mentioned by one KI to have occurred in the past, where **people reportedly had to travel long distances to get water as water levels in wells were so low.**

2.3. Disease and other secondary shocks

Diseases were mentioned in many FGDs and KIIs across assessed settlements. Most of the **reported diseases were mentioned to have occurred as a result of the flooding, and thus can be considered "secondary shocks".** For example, the flooding reportedly led to **large increases in mosquitoes and incidences of malaria,** whilst many respondents claimed they did not have mosquito nets. In addition, some respondents claimed to sleep outside on raised platforms (a local community coping strategy, see Fig. 7) during flooding, **heightening their risk of malaria. Some health centres, specifically in Manyang and Tarqueny, were reported to be closed because of flood damage.**

Many others reported that they would **drink from dirty floodwater due to the absence of clean water sources, often resulting in illness.** Observations during the field assessment indicated that some wells had been flooded (Fig. 9), whilst **ailments such as diarrhea and coughing were reported.** In addition, large numbers of displaced residents were observed in buildings acting as evacuation centres, for example in Marial Bai, where almost **60 displaced people were residing at the time of the assessment. Such close-confinement could lead to poor hygiene conditions and subsequent transmission of diseases.**

The arrival of IDPs was mentioned as a shock by two KIs. Conflict due to the flooding was not reported, although some respondents claimed they **would not move to highlands to avoid conflict with neighbouring communities.** Finally, cattle raiding was mentioned by one KI, which is seasonally common with the normal cattle migration from Warrap.

3. Flooding Causes and Perceptions

Three main types of flooding were identified by participants. These were **river (fluvial) flooding; flooding due to heavy rainfall (pluvial); and flooding which involved water "coming up from the ground"- this is likely to be groundwater flooding**[16] (Fig. 5). Sometimes flooding was reported as resulting from a combination of both high rainfall and high water levels in rivers, and many FGD respondents and KIs reported this led to the **greatest damage to crops and shelters.**

River flooding is caused by excessive rainfall over an extended period of time and leads to rivers overflowing their banks.[17] Pluvial flooding on the other hand occurs due to **heavy rainfall where the terrain or geology is unable to absorb floodwater rapidly enough,** and does not necessarily occur close to major waterbodies.[18]

Pluvial flooding can occur as a flash flood, resulting in a short-lived but rapid increase in water levels. Flash floods can be highly destructive and often lead to loss of life, whilst fluvial flooding develops more gradually, but is highly likely to lead to property damage in exposed areas.[19] Often, fluvial flooding can be slow to recede, whilst further rainfall can lead to further increases in water levels, agreeing with reports from KIs and FGD respondents, as well as direct observations, that **flood levels remain high in many areas throughout the rainy season, and fluctuate according to rainfall patterns.**

The third type of flooding mentioned by some participants involved water "coming up from the ground." This is likely to be **groundwater flooding, which is caused by a gradual**

Figure 5: types of flooding identified by KIs and FGD respondents.

increase in the level of the water table, eventually reaching above the surface, due to prolonged rainfall.[20] This was reported most frequently in Achongchong, but also in Marial Bai and Alel Thoy. In Achongchong, FGD respondents mentioned this type of flooding led to the greatest damage to shelters.

Various terms were given to different types of flooding in the local languages, Luo and Dinka, providing insights into community awareness of flooding types and causes. Some respondents mentioned they used different terms for different levels of flood severity. Understanding prevalent flooding types and severity is critical to develop suitable infrastructure and mitigation measures from a community based approach.

4. Flood risk and exposure

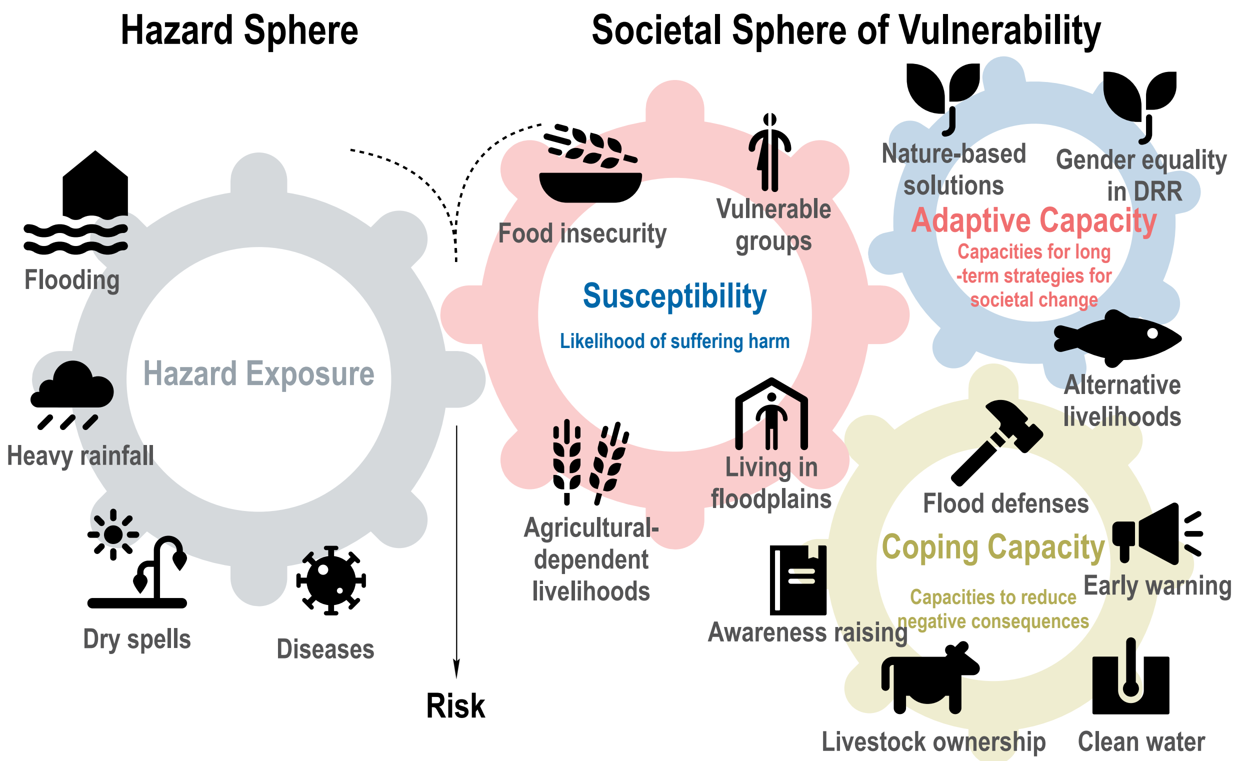
To understand flooding impacts on populations and infrastructure, it is important to first understand flood exposure. This gives an indication of who and what is actually exposed to the hazard. **A natural hazard alone cannot lead to a disaster, only when people or assets are affected.**

Map 2 shows the flood exposure across Jur River County and includes a flood hazard layer overlaid with population density and major roads, representing the exposure. The flood hazard layer is based on a number of indicators which are outlined in the annex, as well as a description of the way in which these indicators contribute to flood hazard and the weightings used.

Risk on the other hand involves incorporating both hazard exposure and vulnerability of the exposed population. Based on the World Risk Index methodology,[21] there are three major factors influencing population vulnerability; these are susceptibility, coping capacity and adaptive capacity. Whilst there was not enough vulnerability data available to create a flood risk map, Figure 6 shows the climate-induced risk concept for Jur River County. Some of the factors that may influence each of these components of risk in Jur River county are shown.

FGD and KI respondents most frequently mentioned that **women and children were more likely to suffer as a result of flooding.** Reportedly, this is due to unequal burdens placed on women and reduced safety of children during flooding due to increased risk of drowning. These vulnerable groups are likely to be more susceptible to

Figure 6: climate-induced risk concept, Jur River county: both hazard exposure and vulnerability together create disaster risk.



suffering harm from climatic hazards. Note that women and minority groups are not all equally vulnerable, and there is a need for an **inclusive and intersectional perspective in order to understand the multiple intersecting marginalised identities of vulnerabilities.**

As Map 2 indicates, **the flood plain surrounding Jur River itself, particularly north of Wau up to the border with Kuajok has the highest population density in the county** Due to proximity to the main river channel, low-lying and relatively flat terrain, as well as clay-rich soils, **this area is one of the most prone to flooding.** However, depressions and areas close to tributaries or drainage networks throughout the county are also prone to flooding. For validation, the map shows flooded settlements identified by KI and FGD participants, as well as verified flooded locations from field work.

By living in floodplains, people become exposed to flood hazards. However, there are many reasons why people choose to live in these areas. **One reason mentioned by FGD participants was that the floodplains were more suitable for crop farming**. Whilst conflict was not explicitly reported as an influencing factor, some FGD respondents reported that they felt tied to their land as it is their ancestral home, and that they could not move to the highlands as this area is occupied by a different ethnic group, which could lead to disagreements.

In terms of infrastructure, schools, health centres, and other critical facilities located in flood plains and without suitable flood protection will be highly prone to flooding. Bridges on the other hand are highly vulnerable to the impact of flooding, yet critical for maintaining network connectivity, especially in countries with low road density such as South Sudan. Damage can lead to disruption to market and essential service access. **In Raja county for example, a key bridge (Sofo Bridge) connecting Raja county to Wau collapsed due to flooding in October 2022, cutting the county off from supplies, including medical and nutritional supplies.**[22]

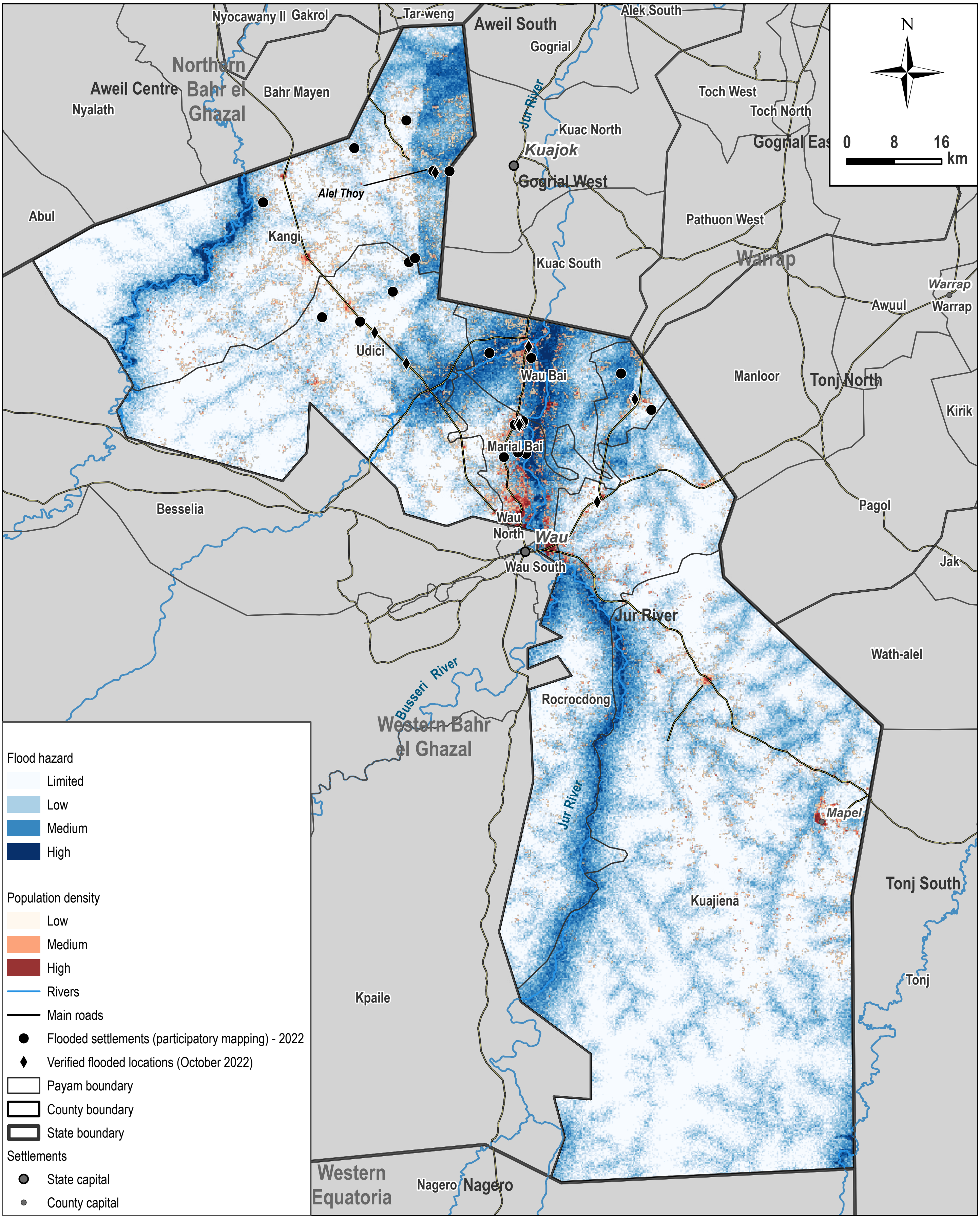
5. Disaster Risk Reduction (DRR)

Disaster risk reduction (DRR) is a policy objective aimed at preventing new and reducing existing disaster risk, as well as managing residual risk, to support resilience building.[23] **The focus of DRR is on reducing hazard exposure and vulnerability to limit the impact of potential disasters.** Specifically this means addressing the drivers of risk, such as poverty and inequality, economic and development practices, environmental degradation, and climate change.[24] **Disaster risk management, which refers to the application of DRR policies and strategies, involves preparedness, mitigation, response and recovery**. This report primarily focuses on the pre-disaster steps, i.e. preparedness and mitigation.

5.1. Preparedness and Mitigation

A range of flood control infrastructure were reported and observed across the county. Some of these were built with the support of international non-governmental organisations (NGOs), whilst others were developed at the household or community level. An international NGO operating in the area supported setting up **community-managed disaster risk reduction (CMDRR) committees in many of the assessed settlements.** DRR activities included development and implementation of community

Map 2: flood exposure map for Jur River County, indicating areas of high flood hazard and population density data to understand population exposure. To help validate the map, locations that were verified as flooded at the time of assessment (October 2022) are indicated, as well as settlements mentioned by FGD and KII participants to have been flooded in 2022.



action plans, disbursement of mitigation funds and construction of CMDRR resource centres.
Assessed settlements where an international NGO had set up CMDRR committees were located in Marial Bai, Wau Bai, Achongchong and Udici. However, despite many participants being aware of these activities in other areas, **there was no CMDRR committee present in Alel Thoy, whilst some assessed FGD respondents from near Tharqueny claimed there was no CMDRR present** in their village.

The CMDRR committees reportedly have around 20 members, usually including 10 men and 10 women, and through the disbursement of mitigation funds, construct flood control infrastructures in their settlement. It was noted that **despite male FGDs and KIs reporting equal gender participation, none of the CMDRR leaders were female.**

5.2. Flood control infrastructure

The most common flood control infrastructure reported and observed in assessed settlements across the county were water channels. Meanwhile, some communities reported building dykes, whilst one community in Tarqueny reported that they used the mitigation funds provided under the CMDRR committees mentioned above to construct boats to transport people to the village from the other side of the river. Shallow wells were reportedly built in some drought-affected areas, such as Nyiwara in Kuajena payam.

Whilst many respondents understood the **efficacy of the flood control infrastructure, many reported that it was not sufficient to withstand flooding in 2022.** Many FGD respondents indicated water channels were not deep enough and had overflowed or been destroyed by heavy rainfall in 2022. Some FGD participants were concerned that there was **limited support to maintain infrastructure, including if it had been destroyed by floods,** whilst many respondents reported they needed more tools to build infrastructure.

FGD respondents in Achongchong claimed that water channels were diverting floodwater to neighbouring communities leading to flooding there. This reportedly caused some disagreements, especially as this community was not aware of the benefits of water channels. In addition, another community in Alel Thoy, notably that is not covered by CMDRR activities, reported that they had limited knowledge about building water channels. **This highlights the importance of education and awareness raising in DRR.** Some studies have even found that awareness raising and disaster risk education can be **more effective than structural approaches to flood risk management, especially in low population density floodplains in rural Africa.**[25]

The **preference for water channels is most likely related to the fact that pluvial (rainfall) flooding is common in the county**, helping drain surface water from populated areas. **Dykes on the other hand were most commonly reported in Marial Bai and Wau Bai, probably given the proximity of these locations to the main Jur River channel,** and the fact that dykes are most effective at protecting river banks from fluvial (river) flooding.[26] Despite prevalence of water channels, some FGD respondents in Alel Thoy indicated water channels were ineffective as floodwater was coming from the ground (groundwater flooding).

5.3. Household flood mitigation strategies

Communities reportedly practiced a number of mitigation measures at the household level. This included **constructing raised platforms from compacted soil, which were reported and observed in many assessed locations.** Usually these were located in the centre of homesteads, providing an area of refuge in case of flooding (Fig.7), whilst tukuls (traditional house as seen in Fig.8) themselves were often positioned at ground level and residents reported they still became flooded, **forcing occupants to sleep outside on the platform during floods, exposing them further to malaria.**

Along the Jur River floodplain in Marial Bai and Wau Bai, some residents were observed to have raised their tukuls on wooden stacks (Fig. 8). These **shelter-based approaches could provide effective solutions for households dwelling in floodplains and unable or unwilling to move to higher ground during flood events.** A report in neighbouring Warrap State reviewed different shelter design approaches, and concluded that raised foundations were more effective and had a lower environmental impact because of the requirement for large amounts of good quality wood to construct an elevated platform.[27] However, further research would be required to understand suitable designs and specific needs in Jur River County.

Figure 7: examples of flood mitigation structures utilised by communities - a) water channels built by CMDRR committee with support of an INGO in Achongchong; b) raised platform in private compound, Marial Bai disaster risk.

Other FGD respondents reported digging small water channels around their homesteads, whilst some participants mentioned building small dykes around their homes. However, dykes were often reported to fail as flooding occurred due to heavy rainfall, and usually dykes are most effective as a barrier against fluvial flooding. Household mitigation structures were generally **built by the youth and one elderly women interviewed claimed she was unable to build one on her compound as she did not have any able relatives to build it for her.** This again highlights how certain groups may be more vulnerable to the impacts of flooding.

5.4. Early warning systems and forecasts

Forecasts assess risk and provide an estimate of potential flooding based on climatic and environmental evidence. This may include data on heavy rainfall or knowledge of the water basin.[28] A flood early warning system (EWS) meanwhile is a system that issues warnings for an imminent flood, or one that has already begun.[29]

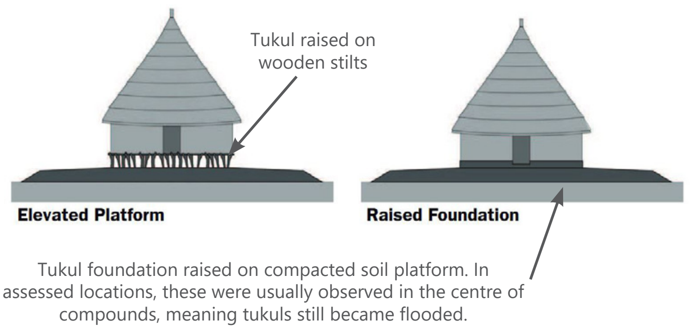
Despite KIs and FGD respondents reporting there were no formal EWSs in place, **assessed communities reported utilising a range of methods to identify an impending flood at various timescales.** For example, some respondents reported that local radio stations provided forecasts. These included the following stations: Eye Radio, Voice of Hope, and Radio Miraya (operated by the United Nations Mission in South Sudan).

Most respondents reported there were **barriers to receiving radio forecasts and that only some people were able to listen to them.** Reportedly, those accessing forecasts had access to radios or were able to listen to radio on their phones, as well as more educated people able to speak English or Arabic. However, many communities mentioned they did not have access to radios, that network was poor in their area or were unable to understand English or Arabic in the more rural areas. Additionally these **forecasts were reported to only provide general information, with low accuracy on timings and locations of flooding.**

Many FGD respondents indicated that they would look to **environmental signs to provide warnings for heavy rainfall and flooding.** For example, some FGD respondents claimed they expected rain in the afternoon if it was hot in the morning, whilst others reported to know that flooding was likely if water levels were high in the river, or if there had been an extended period of heavy rain. Two female FGDs meanwhile reported that flooding comes with a "demon in the form of a rainbow". This suggests there is a community belief that some of the impacts of flooding are spiritual which needs sensitisation on causes of flooding with consideration to cultural beliefs. Finally, a small number of groups reported people in some locations relied on "rainmakers" to bring on rain at the end of the dry season.

Although **formal EWSs were reported to be lacking, some FGD participants acknowledged their potential effectiveness,** with one group claiming a system providing information related to shocks and ways to mitigate

Figure 8: flood mitigation in tukul design[31]



Box 1. Community-based Early Warning Systems

As mentioned, fluvial flooding (due to overflow of river banks) was frequently reported in the main floodplains, such as around Marial Bai and Wau Bai. EWS for this type of flooding have been implemented in many river basins across Africa and globally.[32] Sensors can measure water levels upstream, whilst a community-based communication network ensures information reaches downstream communities when water levels increase.

Community-based early warning systems (CBEWSs) can be highly effective in rural areas. Community participation is essential for any EWS. An effective CBEWS is people-centred, timely and relies on simple low-cost technology.[33] They require a number of key components:[34]

1. **Risk knowledge:** mapping flood hazards and gathering information on assets and populations exposed, as well as the vulnerability of these populations.
2. **Local hazard monitoring:** monitoring when river levels rapidly increase or reach a critical point, usually done using stream gauges, and may be automated or require manual data collection.
3. **Flood risk dissemination and communication:** sharing information with affected communities so that they can act. Usually this means transmitting information to focal points downstream who can immediately pass information on to at-risk households.
4. **Community response capacity:** this is a critical component of any CBEWS which requires that the community are accepting and responsive to act on EWS and that local institutions have the capacity to support.

CBEWS may be more challenging to implement in areas affected by rainfall (pluvial) flooding. However, some research has identified methods that have been effective in rural areas of Niger, for example, which combine scientific and local knowledge.[35] Local hazard monitoring in the case of pluvial flooding should instead focus on use of hazard maps and monitoring of rainfall in the area to at least understand risk areas and triggers.

their impact would be useful. A higher number of **FGDs responded that they would not act on early warnings,** with many claiming they would not believe forecasts until they see flooding with their own eyes. Others claimed that they would not move as they would not know where to go or have any shelter on higher ground. Others said they would be unwilling to leave due to cultural reasons.

These findings suggest that **more awareness-raising on the effectiveness of EWSs is needed to get community "buy-in", in addition to development of suitable evacuation plans and centres.** Male respondents in Alel Thoy were the only groups that explicitly claimed they would act on forecasts, and some of them had in fact reportedly moved this year to cultivate on higher ground after receiving forecasts on the radio.

Whilst some FGD respondents reported that those with access to forecasts would share information with them, respondents in one FGD in Alel Thoy claimed that community leaders would not inform them because they do not want people to leave.

5.5. The role of women and Girls in DRR

Gender division of household duties affects the way women and girls interact with the environment around them. However, their ability to access and interact are affected by systematic inequities and bias in land ownership, access to resources, and social contextual norms of resource management.[30]

Womens' ability to access and utilise environmental resources is pivotal to sustaining their family. However, this does not appear to have been translated to DRR and resilience to climatic shocks in Jur River County. This assessment found that **women in almost all female-only FGDs reported they were the main ones responsible for building flood control structures, despite only being half the representatives in the CMDRR groups, and usually not in positions of leadership in these groups.**

One female FGD reported "**duties are divided here, making dykes is for women, men build walls" - this is likely to be related to gender division of roles** and despite the importance of flood control structures, this responsibility falls upon women due to it being considered part of the "household". Findings from male FGDs on the other hand suggested these **responsibilities were equal and men also take part in constructing DRR infrastructures.** One male KI did however attest with the female FGDs that it was considered a female duty.

6. Climate and Environmental Change

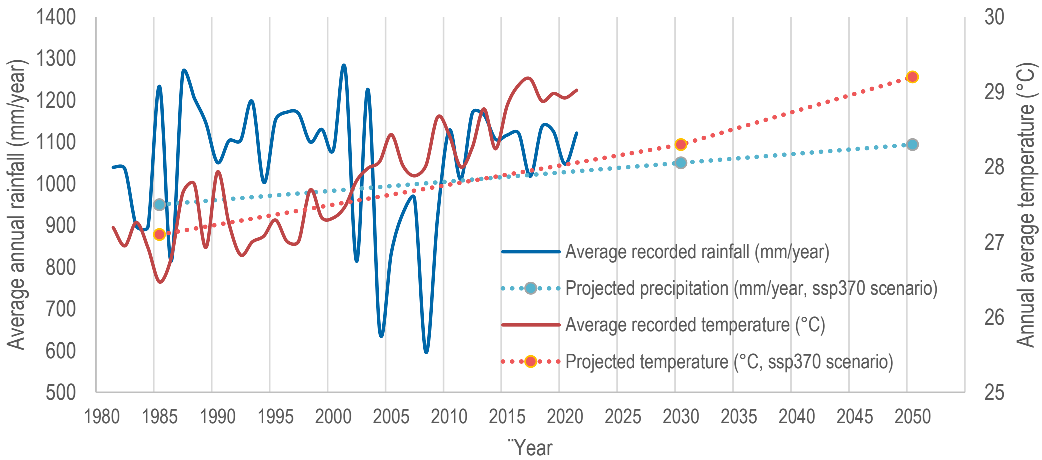
Historic climatic data indicates that in the past few decades, **annual average temperatures in Jur River County have steadily increased** (Fig. 10). Data indicates that precipitation has increased but **inter-annual rainfall variability has been relatively erratic, with a significant drop in 2004 and 2008,** when the county received almost a 50% reduction from the average annual rainfall (Fig. 10).

Whilst some FGD participants reported they had noticed increases in rainfall and temperatures over time, a much clearer trend was in the number of participants stating that **flooding in 2022 was the worst they had experienced, and that overall, flooding had worsened in recent years.** Part of this appears to be related to the early timing of the flooding, which could indicate increased unpredictability and variability in rainfall patterns, as suggested by rainfall data.

Future climate projections based on the Shared Socioeconomic Pathway (SSP) 370 scenario suggest there will be **significant increases in both precipitation and temperature across the county over the coming decades.**[36] This includes a 13% annual average increase in rainfall (approximately 144mm/year) from between 1970-2000 to between 2040 and 2050, and a 2.1°C (7%) increase in annual average temperature over the same period. In addition, **precipitation could increase by an average of 70mm in the wettest month in Jur River County,** which is significantly higher than the mean across South Sudan as a whole (50mm/month). Precipitation variability is also predicted to increase.[37]

Increased precipitation could lead to higher severity flooding in future, whilst the **increased precipitation variability is likely to result in increased extreme conditions such as periods of acute heavy rainfall or dry spells.** Increasing temperatures may further exacerbate the

Figure 10: recorded climatic trends (1981-2021) in Jur River County, including future projections based on SSP 3702 climate change scenario (1985, 2030, 2050).



intensity of dry spells due to increased evapotranspiration.[38] The combination of dry spells and flooding makes rain-fed agriculture particularly vulnerable, given its reliance on regular rainfall patterns.

From an environmental perspective, **many FGD participants reported cutting down trees for firewood and charcoal production.** Increased deforestation could **increase runoff and therefore the amount of water reaching lowland areas.** On the other hand, deforestation in floodplains will **reduce the natural capacity of the vegetation to absorb impacts of river flooding.**[39,40] Map 3 shows deforestation identified from satellite data[41] in the past two decades.

It was observed that a number of new feeder roads were recently built in the area, including near flooded areas. These roads were built with the assistance of NGOs and are important in terms of connectivity and transportation. However it would be important to be mindful of where the roads are located given that deforestation affects flooding, as previously mentioned. **It would therefore be recommended that environmental impact assessments are conducted.**

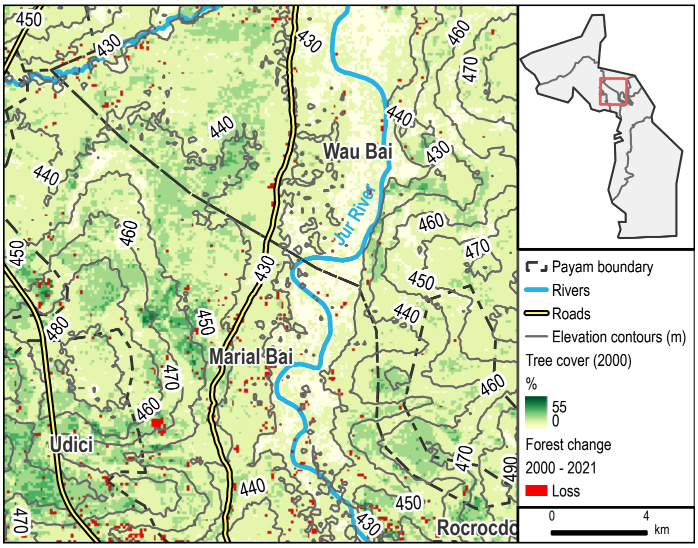
Finally, further population displacement could occur as a result of conflict with cattle herders, as it has done in the past. This may result in people becoming displaced into areas prone to flooding, thus exposing more of the population to flooding in future.

6.1 Implications for DRR and nature-based solutions

Given the projected changes in climate and environment in the next few decades, DRR measures in the county should account for potentially more extreme and more frequent climatic shocks. As this assessment found, some infrastructure was reportedly insufficient to cope **with flooding in 2022. However, with increased rainfall due to climate change, larger events can be expected in future,** especially in the case of further deforestation and environmental degradation.

Figure 9: flooding of well, and collapsed shelter damaged by flooding, near Alel Thoy

Map 3: elevation and forest cover, showing deforestation around Marial Bai



Nature-based solutions (NBSs) to DRR, which focus on conservation and restoration of the natural ecosystem have been found to have positive effects on reducing flooding impacts in the long term. NBSs tend to be economically effective and take advantage of the environment's natural ability to absorb and attenuate flood and rain water. They also take advantage of nature's ability to adapt and regenerate. Examples of NBSs include reforestation in floodplains and upland areas, wetland restoration, and vegetated stream banks.[42] Hybrid mitigation strategies, which combine nature-based solutions with more traditional solutions such as water channels and dykes could further enhance DRR effectiveness in Jur River.

7. Impacts of climatic shocks on livelihoods

FGD respondents reported that crops and cultivation were their primary source of livelihood in assessed settlements. However, FGD findings suggest **crops were destroyed in 2022 because heavy rainfall and flooding occurred atypically before the harvesting period.**

Traditionally, vegetables, which provide nutritional balance and diversity, grow after the rainy season. Preliminary findings from a recent REACH Standardised Monitoring and Assessment of Relief and Transitions (SMART) nutrition survey[43] suggest that reliance on **staple cereals and sorghum was not affected significantly and opportunities for fishing improved. Despite the higher abundance of fish, there is a reported lack of nutritional diversity due to the damage to vegetable crops.** Furthermore, the abundance of fish reportedly provided opportunities for engaging in the markets, but several FGDs reported some barriers to access, either due to distance or being blocked by flooding.

Six FGDs reported having to engage in casual labour to compensate for normal livelihood activities being disrupted due to flooding. Findings from FGDs suggest some families had to move to larger towns in search of work, and others noted a gender divide in the types of casual labour people engaged in. Women reported engaging in the market or selling tea to ensure income generation. This can pose some **protection and exploitation concerns as people are having to move away from their homes.**

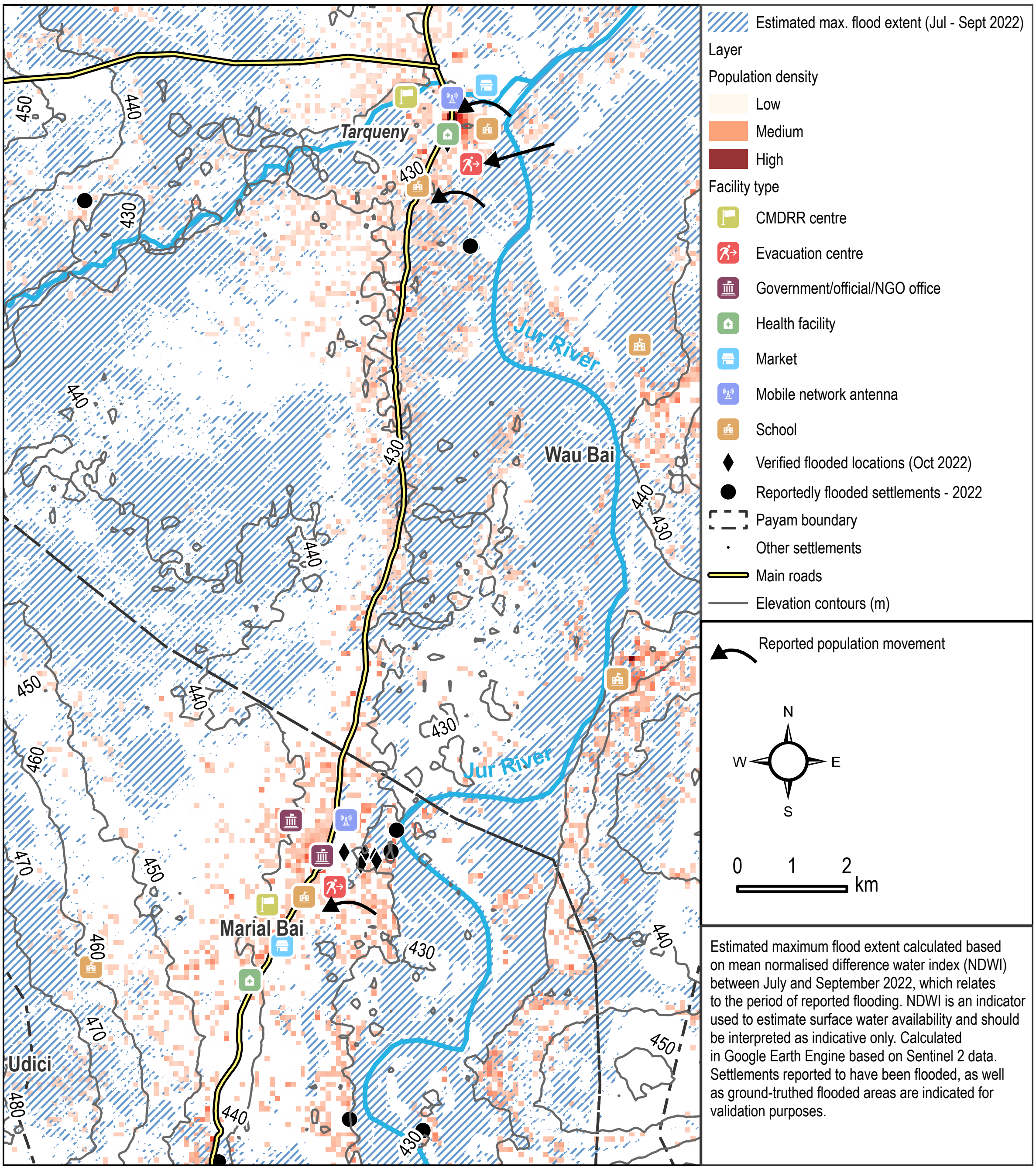
The northern part of Jur River County sits on the Western floodplain sorghum and cattle livelihood zone and many are reliant on livestock rearing. **Three FGDs reported that they were unable to move and take care of their livestock adequately, due to flooding disrupting paths of movement.** A significant amount of shelter damage was also identified, as well as damage and flooding of water points (Fig. 9). Map 4 shows 2022 estimated flood extent, key infrastructure, and population movement in the Marial Bai area.

7.1. Gendered impacts

Climatic shocks disproportionately affect women globally. Women will often have unequal burdens when it comes to climatic shocks and often must manage multiple tasks. This was reported in female FGDs in areas affected by flooding in Jur River.

To grasp the full impact of climatic shocks based on gender, it is necessary to understand the social and cultural context in which gender inequality occurs, under patriarchal systems based on domination and gender discrimination.[44] In South Sudan, almost half of women are married before the age of 18,[45] and during periods of conflict, women are often left behind to carry the day-to-day burden of caring for their families,[46] leaving them more vulnerable.

Map 4: flood impact and reported population movement, Marial Bai. Infrastructure locations mapped using GPS; population movement mapped during FGDs and KIIs.



Furthermore, some women reported **increases in domestic abuse during floods due to the increased demand on them to meet hunger gaps, repair structures, continued domestic chores, and building DRR structures, all of which culturally falls upon the responsibility of women.** As mentioned previously, FGD findings suggest this has cultural components as to why women had to take responsibility of DRR structures as "it's the job of women not men, because it is to do with the house". This suggests there are deeply ingrained gender roles, and DRR structures such as platforms and dykes are related to this division of roles.

Findings from two FGDs suggested women struggled to maintain hygienic menstruation practices; often, the stagnant flood water which is used to defecate in is the same water used to clean themselves, even during times of menstruation. This is because they reportedly do not have access to necessary female hygiene products. This had led to **some women reporting sickness and infections related to female health as a result.**

Respondents from three female FGDs reported that risk of drowning was a concern for themselves and their children. This suggests the unequal burden on women is further exacerbated as they must pay more attention to childrens' safety, taking them away from their normal livelihood activities. **At the time of the assessment, it was reported that over 3,000 children were missing school due to flooding.**[47] One FGD reported this, noting that this can further impact the vulnerability of women and girls to flooding as women are then responsible for looking after the children at home. Furthermore, girls can miss out on vital nutrition and protection services from aid organisations which are often operated in schools.

Data indicates that access to services for women decreased during flooding. Gendered roles are prominent in South Sudan particularly when it comes to accessing resources; four FGDs reported that women were unable to access wild food, firewood or crops as a result of excess rainfall and flooding but were having to engage in more casual work in the markets as a result if able to access the market. **This suggests women were having to pick up extra work, travel further, and/or spend more time in search of resources to ensure they are able to sustain their families. This can amplify their risk to snake bites, sexual and gender-based violence (SGBV), and exploitation.**

7.2. Coping Strategies and Barriers

The ability of a community to cope and react to climatic shocks directly relates to their coping capacity and vulnerability. In Jur River, several coping strategies were reportedly employed to ensure families could be sustained after a flood shock. **The main strategy, reported by twelve FGDs, was to move to higher ground, usually temporarily.** Some FGD respondents reported moving in with another family in different areas until the water levels receded. **Many people were reportedly forced to move to higher ground on an annual basis, and reported to often sleep in healthcare buildings or NGO grounds. This was reported and observed in Marial Bai.**

FGD findings suggest that after some amount of time, **many people were requested to leave such temporary grounds due to a lack of capacity and support from actors.** At the time of the assessment, partners reportedly had not yet responded to affected people, though some planning to respond was reportedly underway. **Respondents from one FGD mentioned a potential movement barrier was the result of land ownership issues; they feared that if they leave, their ancestral home may be taken over or claimed by other groups.**

Findings from the FGDs suggest that **people in Jur River who are affected by climatic shocks engage in seasonal livelihood activities, from reliance on crops during the dry season to engaging** in markets and casual labour during the period of heavy rainfall and flooding.

Ten FGDs reported engaging in casual labour such as selling tea or food items in the market which poses potential protection issues and can leave the person in a vulnerable situation; for example they may not be paid or be forced to work late hours. However, given the reduction in diversity of crops available due to flooding, market prices may be pushed down, which may affect the willingness of sellers to engage in markets. Additionally damage to market stalls was observed, for example in Alel Thoy (Fig. 10).

8. Conclusion

Given the recurrent and increasingly severe climate change-driven flooding affecting Jur River county, findings suggest that the county is a location that would benefit from further DRR investment. Existing CMDRR activities were generally reported to be effective, but frequently unable to withstand flooding in 2022. With increased rainfall projected in coming years, this suggests they may not be adapted to climate change.

Many communities not currently benefiting from CMDRR activities reported they would be useful. Findings suggest that early warning systems could be a useful addition to DRR activities, although findings suggest that further awareness raising would be required to ensure community "buy-in" and leadership. Additionally, the environmental impact of activities such as road construction (e.g. deforestation or changes in topography) should be considered, particularly in flood prone areas, with further investment in nature based solutions to DRR.

International NGOs are reportedly undertaking similar CMDRR activities to those mentioned in Jur River county in Wau county, as well as in Unity State. Findings suggest activities could be extended to other parts of the region such as neighbouring Raja county, whilst Aweil South, Aweil East, Aweil North and Aweil Center could may also be suitable locations given their relative political stability.

As mentioned previously, unprecedented flooding in Raja county led to the collapse of a bridge, disrupting a critical road link to this remote region. This highlights the vulnerability of this area and the importance of improved infrastructure here to prevent a similar scenario in future. The possible impact affects not only connectivity, but transportation of goods and people, which can have negative impacts on markets and food security.

Furthermore, the finding of the assessment highlights the importance of gender in CMDRR activities. As previously mentioned, women are significantly more vulnerable to climatic shocks, and the findings suggest the DRR activities related to flooding are predominantly the responsibility of women. However, women are often left out of the decision making process and reportedly not included in the leadership positions related to CMDRR. This highlights the importance of sensitisation to prevent further unequal burden on the basis of gender within DRR activities in the future.

Figure 10: market stall in Alel Thoy damaged by flooding in 2022.

Recommendations

- **Further development and investment into flood control infrastructure, including maintenance, and further expansion of CMDRR activities to additional communities.**
- **Given that many residents reported they would be unwilling to leave their homes during flooding, further research into shelter-based mitigation measures would be beneficial.**
- **DRR measures should be climate change-adaptive and include nature-based solutions, whilst environmental impact assessments should be conducted in flood plains prior to road construction, limiting deforestation where possible.**
- **Increase development of hazard maps, and improve availability of evacuation plans and centres.**
- **Improve access to forecasts, and develop early warning systems for flooding. These should capitalise on community knowledge and resources, whilst increased awareness raising would be required to ensure greater participation.**
- **Engage in anticipatory action such as providing materials such as mosquito nets to improve resilience to disease after floods, raise the walls of wells, and create water point platforms to prevent inundation and ensure clean water access. Providing water purification tools and usage information could also be beneficial.**
- **Ensure drought mitigation measures are in place in drought prone areas, noting that climate change predictions indicate increased temperatures and increased precipitation variability, which may lead to more droughts in future.**
- **Targeted action to increase womens' access to gender responsive early warning systems, services and finance, and resilient infrastructure, livelihoods, and businesses.**
- **Technical support and bridging services to increase womens' leadership and gender equality in CMDRR activities and resilience coordination mechanisms.**
- **Sensitisation training for CMDRR groups to place women in the center of response and share burden of DRR structures.**
- **Need for an inclusive and intersectional perspective in order to understand the multiple intersecting marginalised identities of vulnerabilities.**

ANNEX - FLOOD HAZARD CALCULATION

The flood hazard layer indicated in Map 2 was created by conducting a multi-criteria analysis in Geographic Information System (GIS) software, involving weighting and summing a number of layers representing key indicators, to produce a hazard index. The input indicators used were elevation, slope angle, flow accumulation and distance from tributaries, areas flooded in previous years, soil type, and land cover type.

Table 1: indicators used to develop flood hazard layer shown in Map 2. Each of these layers were rescaled between 0-100, weighted and summed so that the final hazard layer had values between 0 (no hazard) and 100 (very high hazard).

Indicator	Explanation	Weighting	Data source
Elevation	Lower elevation terrain is more prone to flooding as surface water naturally flows downslope under the force of gravity.	15%	SRTM Digital Elevation Model (DEM)
Slope angle	Lower slope angles are more prone to flooding as runoff will flow downslope faster on higher slope angles.	15%	Slope angles derived from SRTM DEM
Flow accumulation	Zones of high flow accumulation and areas close to known tributaries will be more susceptible to flooding.	20%	Flow accumulation derived from SRTM DEM. Tributaries from HydroSheds
Past flooded areas	Areas which have flooded on multiple years in the past are statistically more likely to flood again.	15%	UNOSAT flood extent data
Soil type	Soils with higher clay content are generally more susceptible to flooding as they have poor drainage capacity.	20%	FAO soil map
Land cover type	Areas of bare ground and sparse vegetation are more susceptible to flooding than dense vegetation and forest, which are better able to absorb water.	15%	ESA land cover

ENDNOTES

1 Famine Early Warning Systems Network (FEWSNET). Livelihood Zone Map and Descriptions for the Republic of South Sudan. Issued August 2018.
2 ibid.
3 Google Earth Engine. Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) 30m.
4 Google Earth Engine. ESA WorldCover v100. 2020.
5 Google Earth Engine. ERA5 Daily Aggregates - Latest Climate Reanalysis Produced by ECMWF / Copernicus Climate Change Service.
6 Google Earth Engine. CHIRPS Daily Rainfall Data. 2021.
7 Famine Early Warning Systems Network (FEWSNET). Livelihood Zone Map and Descriptions for the Republic of South Sudan. Issued August 2018.
8 Barbour, K.M., 1961. A Geographical Analysis of Boundaries in Inter-Tropical Africa. Essays on African Population. Taylor & Francis.
9 Food and Agriculture Organisation of the United Nations (FAO). The Digital Soil Map of the World. Version 3.6. Completed January 2003.
10 Basri, H. et al, 2022. Floods and their problems: Land uses and soil types perspectives. IOP Conference Series: Earth Environ. Sci. 951 012111
11 Google Earth Engine. CHIRPS Daily Rainfall Data.
12 Google Earth Engine. CHIRPS Daily Rainfall Data.
13 Mathlouthi, M. and Lebdi, F., 2012. Characterization of the Events of the Dry Spell in a Basin Northern Tunisia. Human and Social Dimensions of Climate Change.
14 University of Reading, 2022. Drought: heavy rain now might be a serious problem for the UK's parched landscape. 2022.
15 National Integrated Drought Information System. What is drought?
16 Geological Society Ireland. What is groundwater flooding?
17 Intermap, 2014. Three common types of flood explained.
18 ibid.
19 Puroclean, 2020. Five common types of flooding explained.
20 Geological Society Ireland. What is groundwater flooding?
21 University of Stuttgart. World Risk Index.
22 South Sudan: Flooding Snapshot No. 2 (As of 11 October 2022).
23 Prevention Web, 2015. Disaster risk reduction & disaster risk management.
24 ibid.
25 Lumbroso, D., 2020. Flood risk management in Africa. Journal of Flood Risk Management 13 (3).
26 Practical Action. Spurs and dykes for flood water protection.
27 REACH, 2013. Flood vulnerability and contingency plan - Warrap State, South Sudan: Mapping and Assessment Report.
28 Science Direct, 2016. Flood forecasting.
29 Risk Info, 2020. Flood early warning systems.
30 UN Women, 2022. Putting women's needs on the disaster risk reduction agenda is crucial.
31 REACH, 2013. Flood vulnerability and contingency plan - Warrap State, South Sudan: Mapping and Assessment Report.
32 Perera et. al. 2019. Flood Early Warning Systems: A Review Of Benefits, Challenges And Prospects. UNU-INWEH Report Series 08. United Nations University.
33 International Centre for Integrated Mountain Development (ICIMOD), 2023. Community based flood early warning system.
34 Climate Change Adaption Technologies for Water. Early warning systems for floods.
35 Tarchiani, V. et al., 2020. Community and Impact Based Early Warning System for Flood Risk Preparedness: The Experience of the Sirba River in Niger. Sustainability 12 (5).
36 WorldClim. Bioclimatic variables.
37 ibid.
38 Ayugi, B. et al, 2022. Review of Meteorological Drought in Africa: Historical Trends, Impacts, Mitigation Measures, and Prospects. Pure and Applied Geophysics 179: 1365–1386.
39 European Environment Agency, 2015. Forests can help prevent floods and droughts.
40 Phys.org, 2022. Deforestation increases risk of flash flooding in fast-growing West African coastal cities.
41 Google Earth Engine. Hansen Global Forest Change v1.9 (2000-2021).
42 Global Facility for Disaster Risk Reduction (GFDRR). Nature-based solutions for disaster risk management.
43 REACH, 2023. Standardised Monitoring and Assessment of Relief and Transitions (SMART) nutrition survey - Jur River County (preliminary findings).
44 United Nations Environment Programme. Gender equality and the environment: a guide to UNEP's work.
45 UNICEF South Sudan. Some things are not fit for children - marriage is one of them.
46 Al Jazeera, 2017. A woman's burden in war-torn South Sudan
47 Radio Tamazuj, 2022. Jur River: Over 3,000 school-ongoing children miss out on learning.