ITALIAN AGENCY FOR DEVELOPMENT COOPERATION

cima RESEARCH FOUNDATION

Drought impact based Early Warning System for Sudan

APIS project "Climate Change Early Warning and civil protection for floods and droughts in Sudan"
funded by AICS - AID 12465

INTRODUCTION

Drought is a complex, progressive phenomenon characterized by a prolonged reduction in water availability that produces significant impacts on water quantity, quality, and demand. It is not merely a meteorological event: drought arises from the interplay of climatic factors—such as low precipitation, high evapotranspiration, and anomalous snowmelt—and human activities, including unsustainable withdrawals, land-use practices, and territorial management.

As drought persists, water-resources management plays an increasingly decisive role in either mitigating or amplifying its effects. For this reason, drought must be regarded as a **systemic risk**, also shaped by political, economic, and social decisions.

Its impacts cut across all key sectors—agriculture, health, energy, water supply, ecosystems, transport, and industry—and can overlap with other extreme events, compounding their consequences.

Addressing drought requires an **integrated risk-management approach** capable of capturing interconnections among sectors and territories and of guiding responses in a proactive rather than emergency-driven manner. Adaptation strategies must reflect the complexity of the systems involved, taking into account non-linear dynamics, feedback loops, cascading effects, and uncertainties. This implies:

- Intersectoral coordination for water-resources management
- Use of forecasting tools to develop future scenario
- Promotion of social equity and climate justice

CONTEXT

Globally, between 2000 and 2023, droughts accounted for only 3% of recorded disasters, yet they affected over one-third of the world population exposed to extreme events. The most vulnerable segments of the population suffer disproportionately, exacerbating inequalities and undermining progress toward the Sustainable Development Goals (SDGs).

In Africa, drought is among the most severe and frequent environmental threats. In Sudan in particular, drought risk is intensified by structural and contingent factors: food insecurity[1], pressure on water resources, agricultural water needs, and —since 2023 — the internal armed conflict, which has compromised institutional capacity and triggered massive population displacements. More than 8.1 million people have been displaced, and over half the population requires humanitarian assistance (OCHA, February 2024).

In this scenario, droughts not only reduce water and agricultural productivity, but also undermine the capacity of communities and institutions to respond and adapt.

The lack of local data, weak infrastructure networks, and disruption of meteorological services further hamper prevention, response, and mitigation efforts.

Against this backdrop, the project "**Climate Change Early Warning and civil protection for floods and droughts in Sudan – APIS**," funded by the Italian Agency for Development Cooperation, aims to strengthen national climate-risk management capacities. The project encompasses the development of monitoring and forecasting tools, technical training, and interinstitutional coordination to restore early-warning systems even in compromised operational contexts, supporting the ongoing humanitarian emergency.

In particular, the CIMA Foundation has developed a comprehensive methodology for drought-risk monitoring, analysis, and mapping, intended to feed impact-based early-warning systems that enable anticipatory and proactive drought-risk management and impact mitigation.

[1] https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1159433/?iso3=SDN

METHODOLOGY

The methodology employed by the CIMA Foundation rests on the well-established framework in which risk is the product of three fundamental components:

RISK =
Hazard × Exposure × Vulnerability

Hazard

The drought hazard was analyzed separately for three sectors: agriculture, livestock, and human consumption (civil uses).

Agricultural and pastoral areas: the hazard was quantified by integrating multiple environmental data sources:

- Precipitation accumulation over the previous 1–3 months

- Soil moisture over the preceding 10 days

- Vegetation development status observed in the prior month

These indicators allow for the precise identification of areas under water stress, dynamically representing hazard evolution over the short and medium term.

Human consumption and civil uses: the hazard was assessed using the Standardized Precipitation Index (SPI) at long aggregation periods (SPI-12), a statistical index capable of detecting precipitation anomalies over various time scales. This enables simultaneous analysis of hydrological drought phenomena and thus water availability and variability:

- Flow of minor watercourses

- Soil saturation status

- Groundwater recharge capacity

These variables serve as key indicators for understanding the hazard state related to water availability.

Exposure

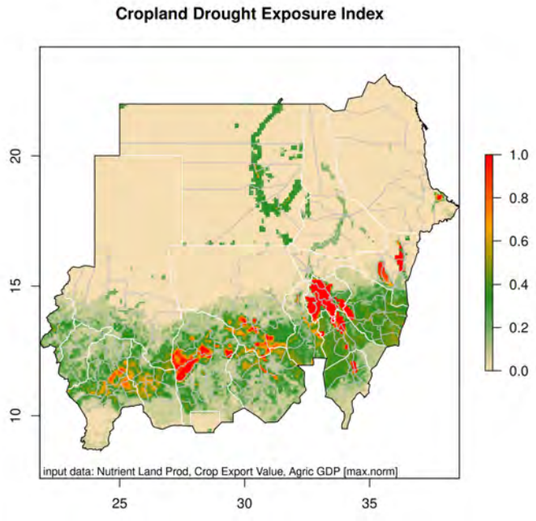
Exposure was evaluated based on the geographic distribution and strategic importance of resources and populations potentially affected by drought, following a sectoral approach.

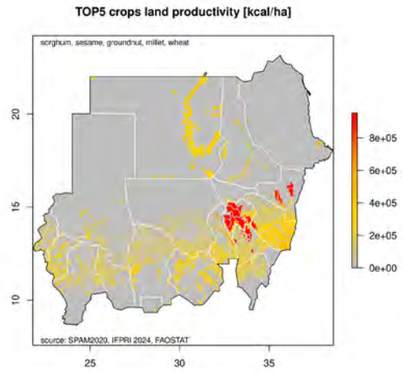
In the agricultural sector, exposure was calculated by considering:

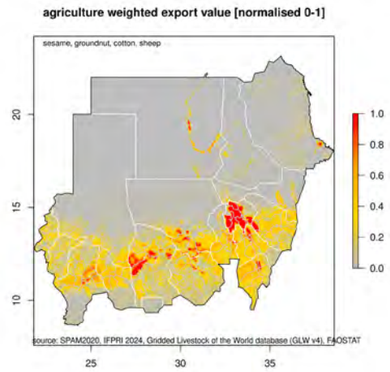
- the extent of the main crops (sorghum, sesame, peanuts, millet, and wheat)

- the nutritive productivity of cultivated land, expressed in kcal per tonne per ectare, to highlight the subsistence component of griculture

- the economic value of agricultural exports, an important factor even if scaled down due to the ongoing conflict.



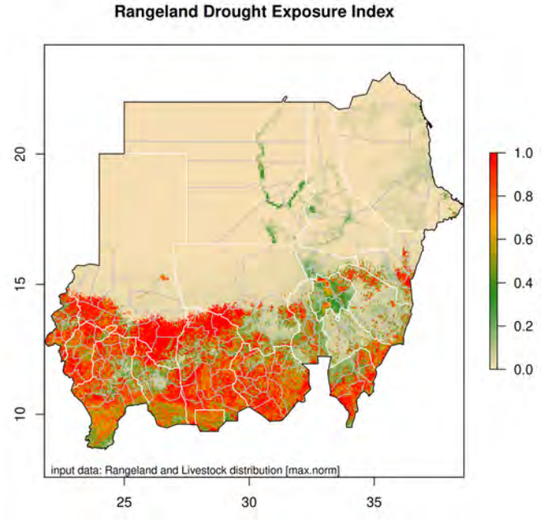


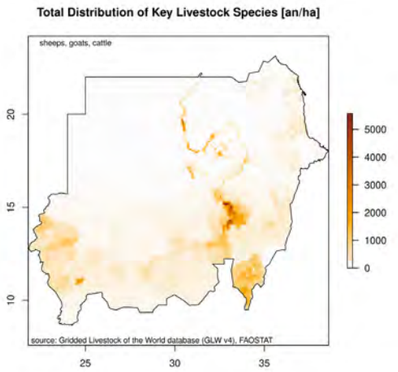


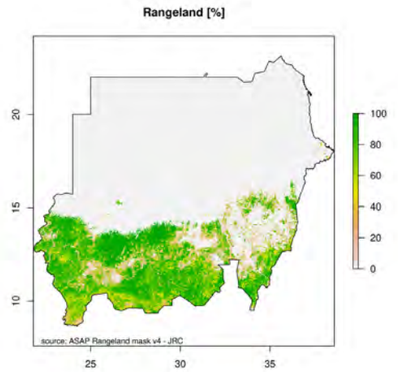
In the case of agropastoral activities, exposure was estimated through:

- the spatial distribution of the main livestock categories present in the country (sheep, goats, cattle, and camels)

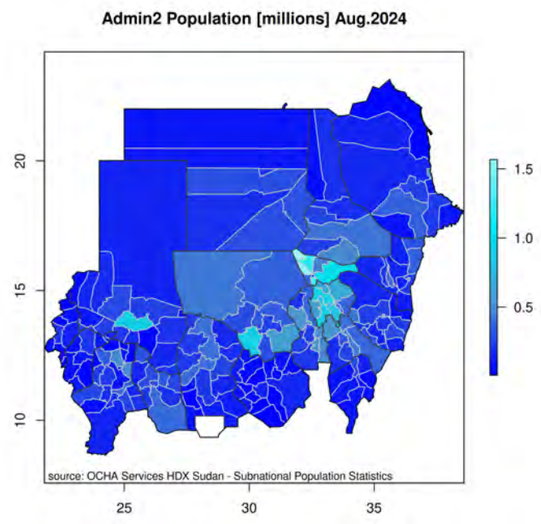
- their economic and social significance for local communities.







For human consumption and civil uses, exposure was measured by analyzing the population distribution. Since the available population data were only updated to 2020, they were supplemented and updated to August 2024 using datasets provided by OCHA (United Nations Office for the Coordination of Humanitarian Affairs), which account for conflict-related internal migration flows.

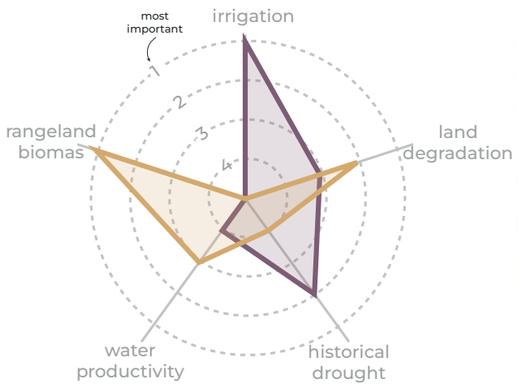


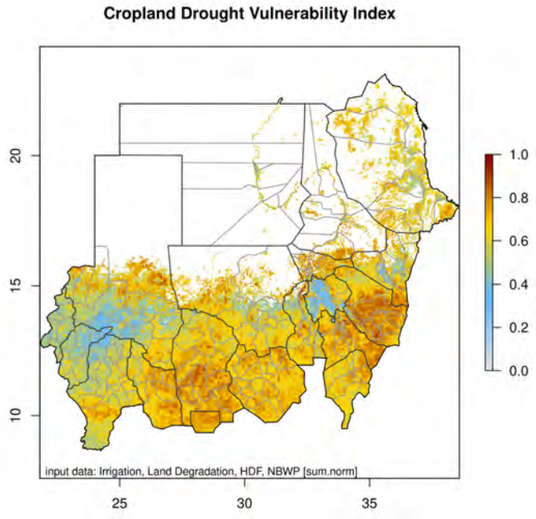
Vulnerability was interpreted as the capacity of the sectors considered (agriculture, livestock, and human consumption) to withstand the negative impacts of drought. The most relevant factors were identified through **surveys conducted with key Sudanese stakeholders, coordinated by the National Civil Protection Council and the meteorological agency**, which enabled the selection of shared, sector-specific indicators.

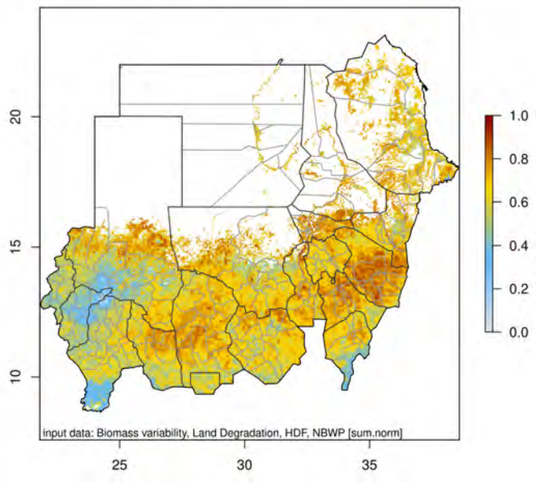
For agriculture and rangelands, five factors were considered—three common to both sectors and one unique to each sector. For each indicator, specific maps were produced using validated data sources.

Indicators Identified by the survey

- croplands
- rangelands



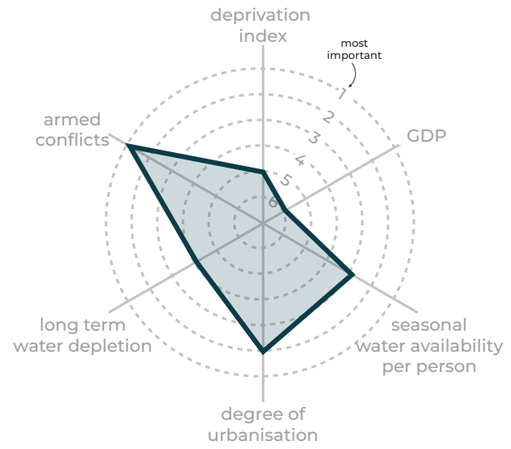


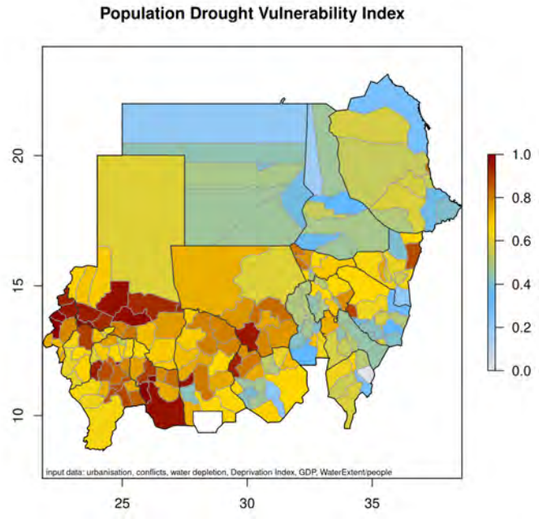


The vulnerability of human consumption and civil uses was assessed through a set of socioeconomic and environmental indicators, also identified in consultation with local stakeholders. In this case as well, a specific map was developed for each factor, then aggregated into a single representation of population vulnerability.

Indicators Identified by the survey

- human consumption and civil uses



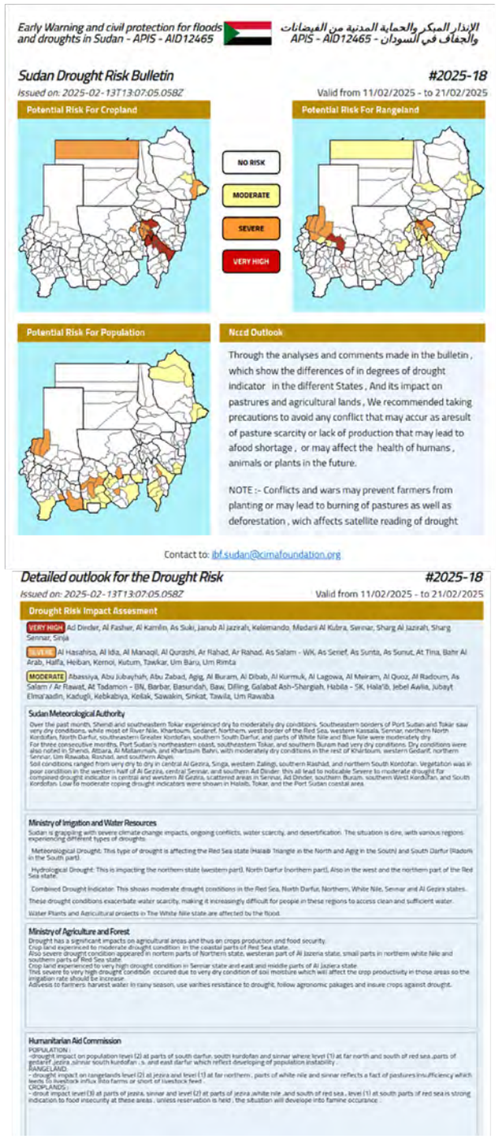


OPERATIONAL RESULTS

All information generated through the methodology is integrated into the **myDEWETRA.world** platform for web GIS visualization, designed for real-time monitoring and forecasting of natural hazards and their impacts. In the Sudanese context, the platform is used by the Port Sudan Civil Protection Situation Room to produce monitoring bulletins, updated every ten days, to assess drought risk across the three sectors considered: **agriculture, livestock, and civil uses**.

The maps offer a clear depiction of the most critical areas, enabling local and international institutions and humanitarian actors to pinpoint precisely where to focus prevention, mitigation, and adaptation efforts. These maps form the operational core of the **Sudan Drought Risk Bulletin**, which is issued every ten days and **distributed by email to national authorities and humanitarian organizations** active in the country.

The bulletin is based on outputs from numerical meteorological and hydrological observation models and on satellite data. In addition to hazard information, it integrates data on population exposure and vulnerability, including the locations of internally displaced persons (IDPs). This structure makes the bulletin an action-oriented, **impact-based monitoring** tool capable of supporting real-time operational decisions, even in complex scenarios.



Early Warning and civil protection for floods and droughts in Sudan - APIS - AID12465

الإنذار المبكر والحماية المدنية من الفيضانات والجفاف في السودان - APIS - AID12465

Sudan Drought Risk Bulletin #2025-18

Issued on: 2025-02-13T13:07:05.058Z

Valid from 11/02/2025 - to 21/02/2025

Potential Risk For Cropland

Potential Risk For Rangeland

NO RISK

MODERATE

SEVERE

VERY HIGH

Potential Risk For Population

Nccd Outlook

Through the analyses and comments made in the bulletin , which show the differences of in degrees of drought indicator in the different States , And its impact on pastrures and agricultural lands , We recommended taking precautions to avoid any conflict that may accur as aresult of pasture scarcity or lack of production that may lead to afood shortage , or may affect the health of humans , animals or plants in the future.

NOTE :- Conflicts and wars may prevent farmers from planting or may lead to burning of pastures as well as deforestation , wich affects satellite reading of drought

Contact to: ibf.sudan@cimafoundation.org

Detailed outlook for the Drought Risk #2025-18

Issued on: 2025-02-13T13:07:05.058Z

Valid from 11/02/2025 - to 21/02/2025

Drought Risk Impact Assesment

VERY HIGH Ad Dieder, Al Fasher, Al Kamlin, As Suki, Janub Al Jazirah, Kelimando, Medani Al Kubra, Sennar, Sharg Al Jazirah, Sharg Sennar, Singa

SEVERE Al Hasahisa, Al Ida, Al Manaqil, Al Quraishi, Ar Rahad, Ar Rahad. As Salam - WK. As Serief, As Sunta, As Sunut, At Tina, Bahr Al Arab, Hufra, Heiban, Kernoi, Kutum, Tawkar, Um Baru, Um Rimta

MODERATE Abassiya, Abu Jubaybah, Abu Zabad, Agig, Al Buram, Al Dibab, Al Kurmuk, Al Lagowa, Al Mairam, Al Quoz, Al Radoum, As Salam / Ar Rawat, At Tadamon - BN, Barbar, Basundah, Baw, Dilling, Galabat Ash-Shargiah, Habila - SK, Hala'ib, Jebel Awlia, Jubayt Elma'aadin, Kadugli, Kebkabiya, Kelkak, Sawakin, Sinkat, Tawila, Um Rawaba

Sudan Meteorological Authority

Over the past month, Shendi and southeastern Tokar experienced dry to moderately dry conditions, Southeastern borders of Port Sudan and Tokar saw very dry conditions, while most of River Nile, Khartoum, Gedaref, Northern, west border of the Red Sea, western Kassala, Sennar, northern North Kordofan, North Darfur, southwestern Greater Kordofan, southern South Darfur, and parts of White Nile and Blue Nile were moderately dry.

For three consecutive months, Port Sudan's northeastern part, southeastern Tokar, and southern Buram had very dry conditions. Dry conditions were also noted in Shendi, Atbara, Al Mallanmiah, and Khartoum Bahri, with moderately dry conditions in the rest of Khartoum, western Gedaref, northern Sennar, Um Rawaba, Rosheid, and southern Abyei.

Soil conditions ranged from very dry to dry in central Al Gezira, Singa, western Zalingi, southern Rashad, and northern South Kordofan. Vegetation was in poor condition in the western half of Al Gezira, central Sennar, and southern Ad Dinder. this all lead to indicate Severe to moderate drought for composed drought indicator in central and western Al Gezira, scattered areas in Sennar, Ad Dinder, southern Buram, southern West Kordofan, and South Kordofan. Low to moderate coping drought indicators were shown in Halaib, Tokar, and the Port Sudan coastal area.

Ministry of Irrigation and Water Resources

Sudan is grappling with severe climate change impacts, ongoing conflicts, water scarcity, and desertification. The situation is dire, with various regions experiencing different types of droughts:

- Meteorological Drought: This type of drought is affecting the Red Sea state (Halaib Triangle in the North and Agig in the South) and South Darfur (Radom in the South part).
- Hydrological Drought: This is impacting the northern state (western part), North Darfur (northern part), Also in the west and the northern part of the Red Sea state.

Combined Drought Indicator: This shows moderate drought conditions in the Red Sea, North Darfur, Northern, White Nile, Sennar and Al Gezira states.

These drought conditions exacerbate water scarcity, making it increasingly difficult for people in these regions to access clean and sufficient water.

Water Plants and Agricultural projects in The White Nile state are affected by the flood.

Ministry of Agriculture and Forest

Drought has a significant impacts on agricultural areas and thus on crops production and food security.
Crop land experienced to moderate drought condition in the coastal parts of Red Sea state.
Also severe drought condition appeared in nortern parts of Northern state, westeran part of Al Jazeria state, small parts in northern white Nile and southern parts of Red Sea state.
Crop land experienced to very high drought condition in Sennar state and east and middle parts of Al Jazeira state.
Also severe drought condition occurred due to very dry condition of soil moisture which will affect the crop productivity in those areas so the irrigation rate should be increase.
Address to farmers harvest water in rainy season, use varities resistance to drought, follow agronomic pakages and insure crops against drought.

Humanitarian Aid Commission

POPULATION :
-drought impact on population level (2) at parts of south darfur, south kordofan and sinnar where level (1) at far north and south of red sea ,parts of gedarif ,jezira ,sinnar south kordofan , s, and east darfur which reflect developing of population instability .
RANGELAND.
- drought impact on rangelands level (2) at jezira and level (1) at far northern , parts of white nile and sinnar reflects a fact of pastures insufficiency which leads to livestock influx into farms or short of livestock feed .
CROPLANDS :
- drout impact level (3) at parts of jezira, sinnar and level (2) at parts of jezira ,white nile ,and south of red sea , level (1) at south parts of red sea is strong indicaion to food insecurity at these areas . unless reservation is held , the situation will develope into famine occurance .

CONCLUSIONS

The methodology developed by the CIMA Foundation for assessing drought risk in Sudan stands out for its multidimensional scientific approach, which coherently integrates environmental, socioeconomic, and territorial data. The combination of the three fundamental risk components—hazard, exposure, and vulnerability—enables the production of reliable, operational, and easily updatable analyses.

Implementing this methodology, visualizing the results through the myDEWETRA.world platform, and translating them into the Sudan Drought Risk Bulletin represent a concrete example of an impact-based early-warning system capable of supporting timely, community-focused protection decisions.

Despite relying on global datasets selected for their accessibility and continuity, the system has proven both effective and replicable. Its added value lies in its ability to adapt to different contexts and integrate local sources and knowledge.

A crucial element in this process has been international cooperation: collaboration among the CIMA Foundation, the Italian Agency for Development Cooperation, and the member institutes of Sudan's National Civil Protection Council enabled the joint identification of key risk factors, even in an unstable and complex context.

Of particular importance has been the role of the regional centers established under the AMHEWAS project. To prepare and operate the bulletin, Sudanese experts were hosted at the ICPAC Disaster Operations Center in Nairobi and at the African Union's Continental Situation Room in Addis Ababa. Thanks to the principle of subsidiarity, this regional network provided the tools and conditions needed to sustain Sudan's national early-warning system, which had been severely damaged by the ongoing conflict.

This experience demonstrates how a robust scientific framework, combined with the development of equitable and enduring partnerships, can strengthen local drought-preparedness and response capacities, concretely reducing risk and promoting sustainable adaptation strategies.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