



Adaptation to Drought
and El Niño Effects in
the Central Highlands
of Vietnam

Drought-ADAPT

– Results Summary –





DROUGHT-ADAPT PROJECT

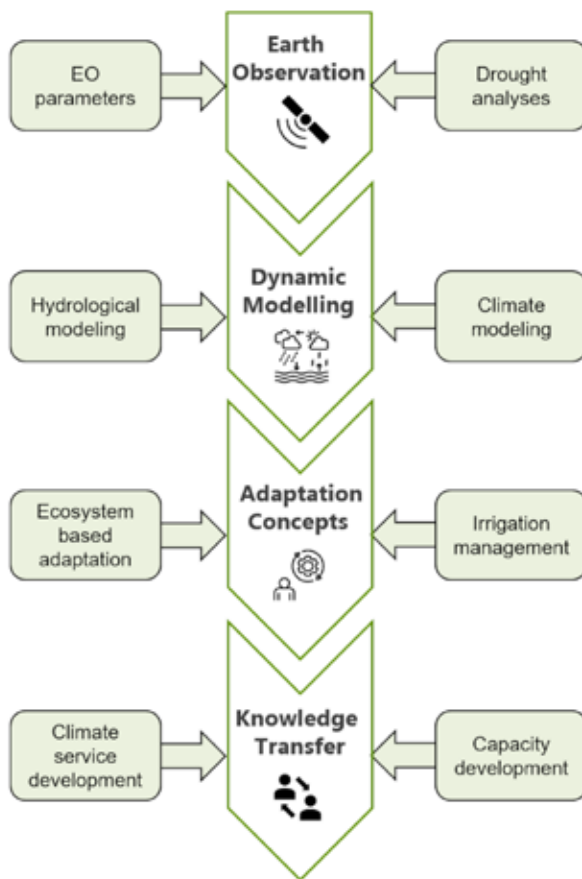
Vietnam is already one of the countries most affected by climate change - extreme events such as El Niño and the resulting droughts particularly affect the Central Highlands, one of the country's most important agricultural regions. In order to develop suitable adaptation measures, accurate and up-to-date information is needed on future regional climate conditions, water availability, sustainable irrigation techniques and infrastructure for climate-adapted agriculture, as well as improved information mechanisms - before, during and after drought events. The German Federal Ministry of Education and Research (BMBF) funded the Drought-ADAPT project from June 2021 to December 2024 to promote the generation of knowledge and the development of adaptation measures in German-Vietnamese cooperation.



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RESEARCH OVERVIEW



The Drought-ADAPT project worked on several spatial scales and with 3 main objectives:

On the one hand, **scientific analysis** aimed to provide a framework for the project and generate information that is unprecedented in this level of detail, from the local to the regional scale.

On the other hand, **engineering support** aimed to result in adapted developments for selected project sites in Dak Nong - exemplary for one of the Highlands provinces.

One of the major innovations of the project is the co-development of a climate service for the Central Highlands. At least one prototype was planned to be developed to test and validate the application of the **climate service** in the region and its acceptance - e.g. a seasonal drought warning system by linking the results of the project contributors, developed according to user requests and needs.

SUMMARY OF RESULTS

The final results include the climate service available online (see individual QR codes). The innovation is that the service has not been available for the province of Dak Nong – the project's focus in the region. Sustainability will be covered by providing this service for the following at least 2 years in cooperation with the Vietnamese collaborators, also after project will be finished.

Other objectives, such as the development of hydrological models and drought forecast, which are not yet freely available, as well as engineering concepts and tools, have been trained at the Vietnamese partner institutions, at the cooperating company and on the project sites.

Selected results are summarized in the following pages. A large part has been published in scientific conferences and well-cited journals (see individual QR codes).



Impact of drought on a pepper plant

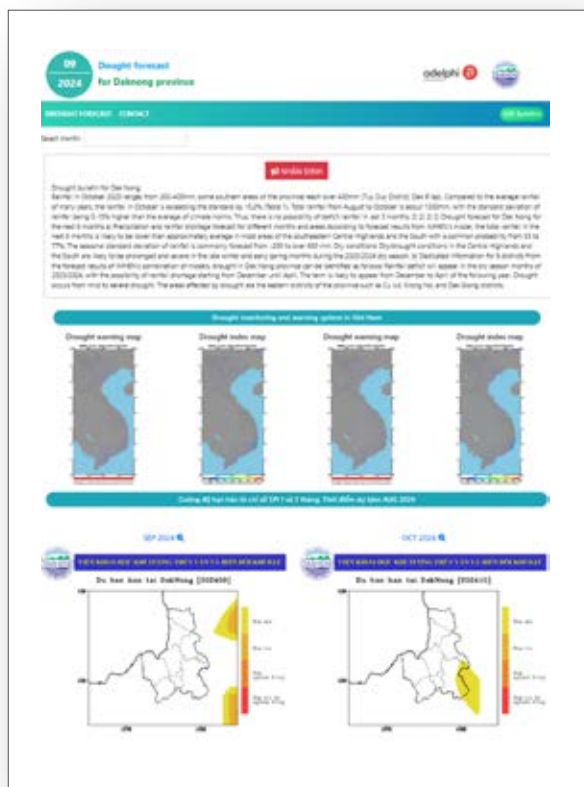
CLIMATE SERVICE: DROUGHT BULLETIN



The bulletin provides a six-month drought forecast for Dak Nong Province based on hydrological models and dynamic forecasting systems. It will be distributed on a monthly basis to beneficiaries in Dak Nong, including local authorities (e.g. the Department of Agriculture and Rural Development (DARD) at provincial and district level), the Weather and Climate Forecasting Centre, the Farmers Union and ultimately the farmers themselves.

The bulletin provides an overview of climate conditions over the past few months (e.g. rainfall) and gives both a meteorological and hydrological drought forecast for the eight districts in Dak Nong.

This climate service makes a valuable contribution to drought forecasting in Dak Nong Province, where no comparable service has existed until now. By using the drought bulletin, planting and harvesting practices can be adapted to local conditions, minimising the damage caused by climate change and achieving the best possible yields.



By using the monthly drought bulletin planting and harvesting practices can be adapted to local conditions

SEASONAL HYDROLOGICAL DROUGHT FORECAST



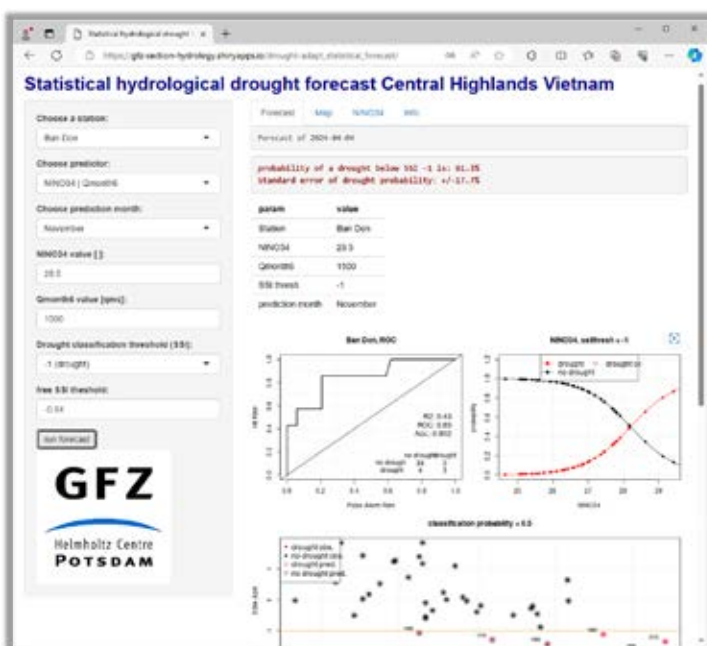
The management of the water resources during the dry season is vital for the economy, agriculture and the livelihood of the population. Thus a reliable forecast of droughts in the dry season January-April with sufficient lead time for making decisions and taking action is essential. However, the existing operational forecasts water resources, here streamflow, have a lead time of up to a few weeks only. Within Drought-Adapt a statistical forecast tool using climatological indexes (ENSO) and antecedent streamflow (Qante) as predictors. Predictions are made for the existing river gauging stations in the Srepok and Sesan (2S) basin.

An evaluation of the results showed that reliable forecast of drought events are able up to a lead time of

6 months and 3 months for ENSO and Qante, respectively, with highest skills for Qante in the 2 months prior to the dry season. The ENSO forecast can thus serve as an early warning, with refined forecasts for decision in the period just before the dry season.

In order to maximize the usability of the developed forecast model, e.g. in the National Centre for Hydro-Meteorological Forecasts (NCHMF), a web-based application has been developed.

This open-source model is currently developed further to suit the needs and demands of the NCHMF, with this the ultimate goal to implement it in the existing forecasts routines of the NCHMF.



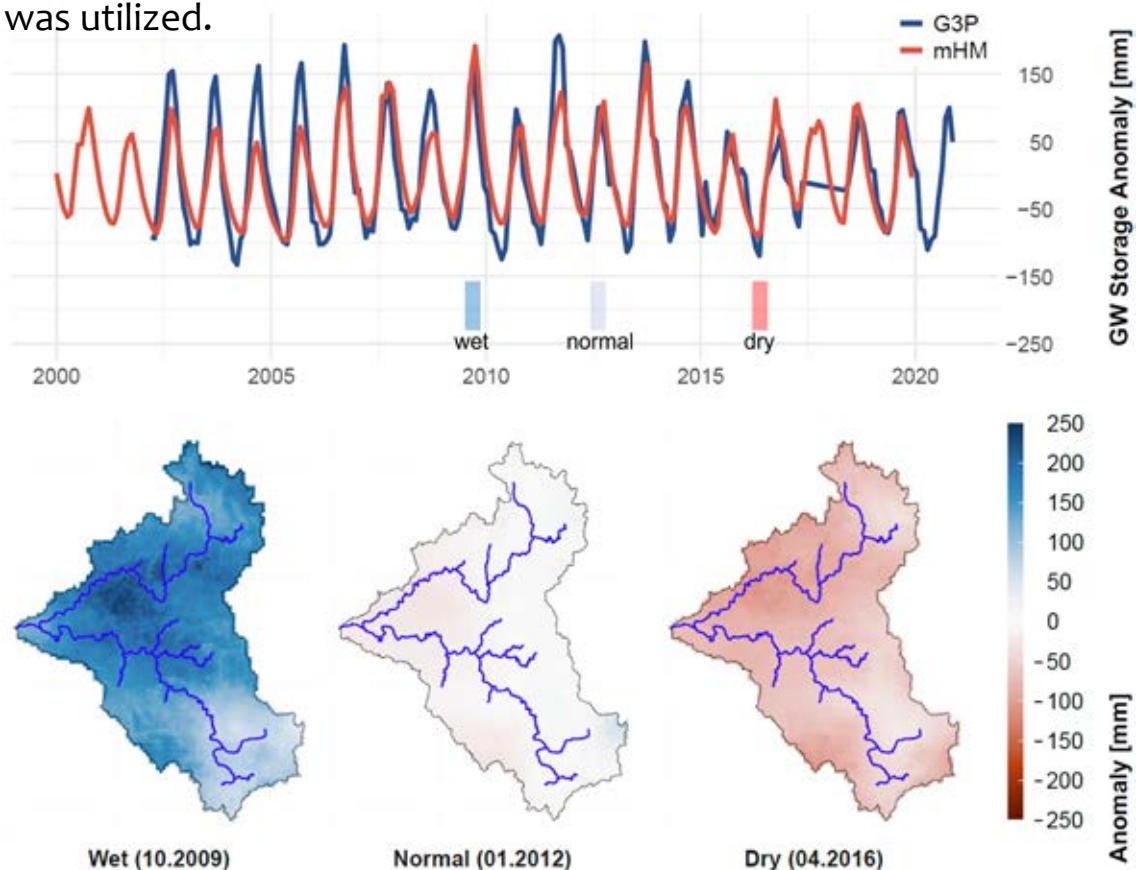
Webtool for statistical seasonal hydrological drought forecasts

GROUNDWATER RESOURCES IN THE CENTRAL HIGHLANDS



Groundwater (GW) is a major water resource in the Central Highlands during the dry season. However, information on GW storage and variation is scarce, particularly on a large scale. In order to provide actionable quantitative data on GW resources, Drought-Adapt developed a detailed open-source hydrological model (mHM) to simulate the whole water budget in the Srepok and Sesan river basin (2S), including the major reservoirs. Additionally the novel satellite-gravimetry based groundwater product G3P to quantify the state and changes in GW resources was utilized.

The mHM model results provide the associated spatially detailed picture of GW deficiencies & excesses at daily resolution. This information is vital for the planning of the water resources management in the districts in the 2S basin. Moreover, the model will be used in an operational seasonal forecast mode to provide forecasts of water resources availability including GW. These quantitative forecasts can serve as the basis for water management decisions in the Central Highlands.



EFFECT OF CLIMATE CHANGE ON TEMPERATURE IN DAK LAK AND DAK NONG UNDER THE BUSINESS AS USUAL SCENARIO RCP8.5



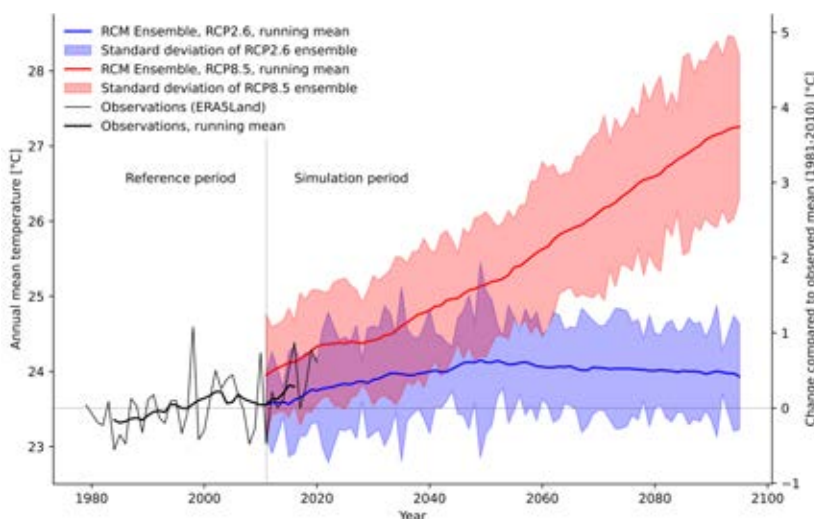
Anthropogenic climate change poses major challenges for the Central Highlands. In order to better assess the consequences of climate change for the provinces of Dak Lak and Dak Nong, we evaluated simulations of high-resolution (25 km x 25 km) regional climate models from CORDEX-SEA and created a multi-model ensemble (red line).

Based on the business-as-usual scenario RCP8.5 (Representative Concentration Pathway), we conclude that by the middle of the century it could become about 2°C warmer compared to the observed average of the years 1981-2010 (horizontal dashed line) based on ERA5Land (black lines, 1979-2020).

Towards the end of the century, there is the possibility of a warming of around 4°C. The red area shows the standard deviation of the individual simulations and thus represents the uncertainty in the ensemble.

On the other hand, it also shows the physically possible event space of a temperature increase of approx. 1-3°C by the middle and 2.5-5°C by the end of the century.

In terms of precipitation, a slight increase of around 150 mm on average is projected. Looking at droughts, however, it is to be expected that the higher temperatures and the resulting increase in evaporation will lead to drier conditions overall and, consequently, more severe and longer droughts.



Projected temperature under RCP2.6 (blue) and RCP8.5 (red) in Dak Lak and Dak Nong



Investigation Site

The Dak Nag Reservoir and irrigation area, located within Krong No District, has been investigated in relation to optimization of irrigation technology and demand, reservoir capacity and adaptation solutions to drought events.

Agricultural Adaptation Measures

- Extensive Land Use Management: optimized cropping patterns to reduce water demand (Rice, cash crop, coffee/maize/bean; 70% of rice areas changed to sweet potato in winter/spring season; no tillage)
- Field Buffer Strip along streams to minimize sedimentation
- Combined measures can increase reservoir volume by 15% in dry season.

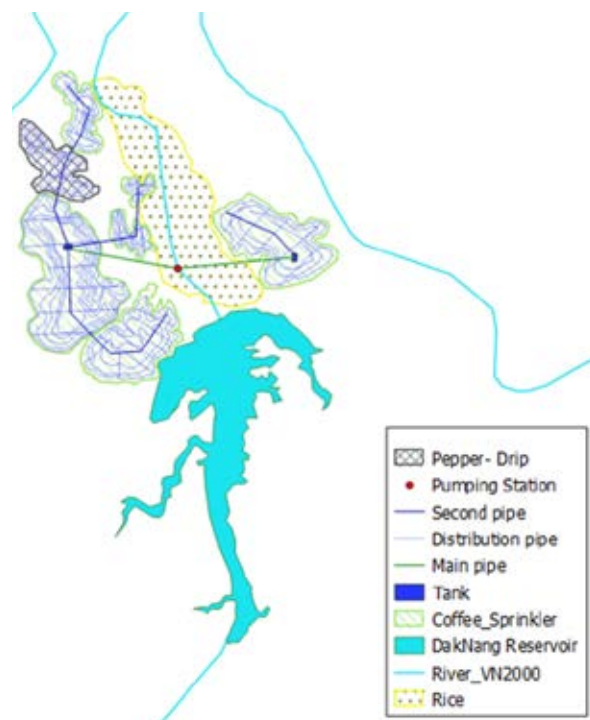
Engineering Technologies

Smart Water Saving Irrigation System (SWIS):

- Centrifugal Pumping Station
- Water Tanks & Pipe System
- Emmitter: Sprinkler / Drip
- Solar-powered wireless soil moisture sensor
- Reservoir water level monitoring

Results of SWIS

Irrigation schedules for different crops can be derived from SWIS monitoring. This will optimize water consumption for irrigation. For coffee, the recommended monthly irrigation period is 25 days per month (every 1.2 days), with irrigation amounts of 34 to 43 liters per irrigation.



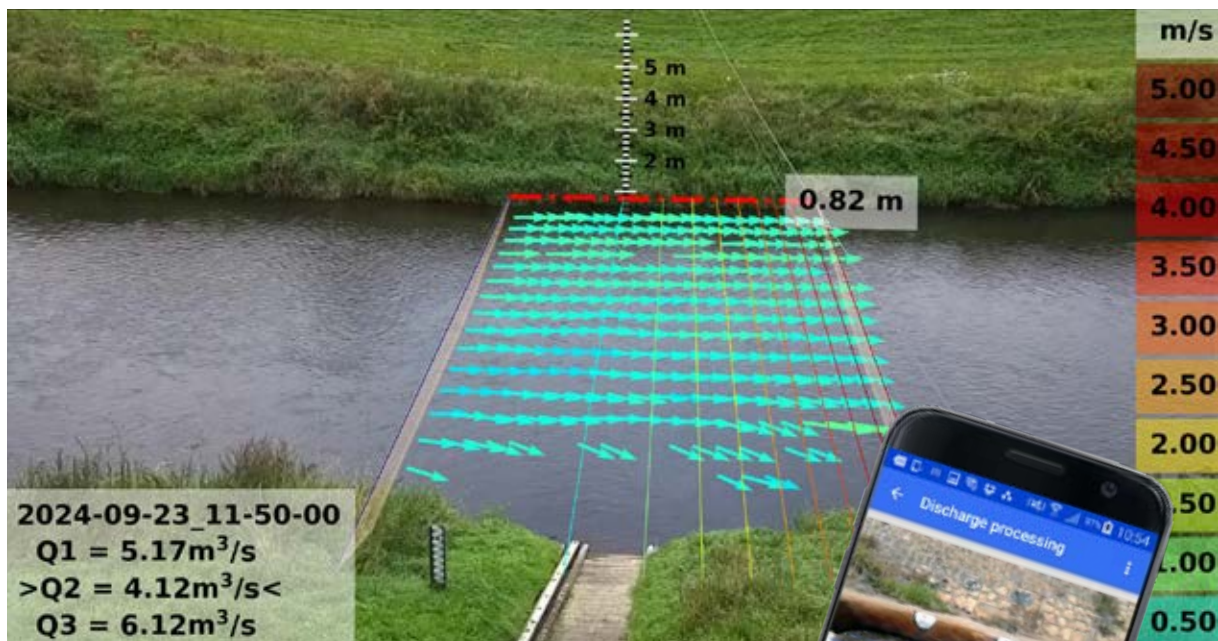
Designed water saving irrigation system for coffee and pepper (Source: Hydroplan)

INNOVATIVE HYDROMETRIC MEASUREMENT TECHNOLOGIES



A new modern generation of the SEBA modem product type SlimCom 4G has been developed as part of the project. The SlimCom 4G is a remote data transmission module with autonomous power supply. One of the advantages of the new 4G modem is the applicability of the device under tropical measurement conditions in Vietnam (high temperatures and high humidity).

Furthermore, a workshop including a training of trainers on the SEBA DischargeApp was held in Vietnam this year. The DischargeApp is an innovative camera-based solution for flow and discharge monitoring using a smartphone-app. The DischargeApp is a low-cost, user-friendly smartphone application and can be very beneficial to be used in Vietnam, in the hydrology and irrigation sectors, in places where no flow measuring systems are installed.



SEBA Discharge App

EbA BEST PRACTICE REPORT
AND POLICY BRIEF



Ecosystem-based adaptation (EbA) emerges as a promising approach in adapting existing agricultural practices in response to intensifying climate change in the Central Highlands of Vietnam. It entails the implementation of strategies that integrate ecosystem services and biodiversity into the planning and management of natural resources, with the primary goal of enhancing the resilience of local communities. The “EbA Best Practice Report” serves as an orientation for EbA practices in Vietnam, shedding light on its various benefits and practical application within the context of drought events in the Central Highlands. It thoroughly explores the domains of agriculture, forestry and water management, providing in-depth descriptions and assessments of existing EbA initiatives in Vietnam.

Building on the report, the “Policy Brief: EbA for drought resilience in Vietnam’s Central Highlands” gives four recommendations for further mainstreaming EbA in Vietnam to upscale its implementation at both regional and national level (see recommendations page).

With these two knowledge products, the project contributes to the knowledge base about EbA practices in Vietnam and provides valuable guidelines for decision-makers, practitioners and policy makers.



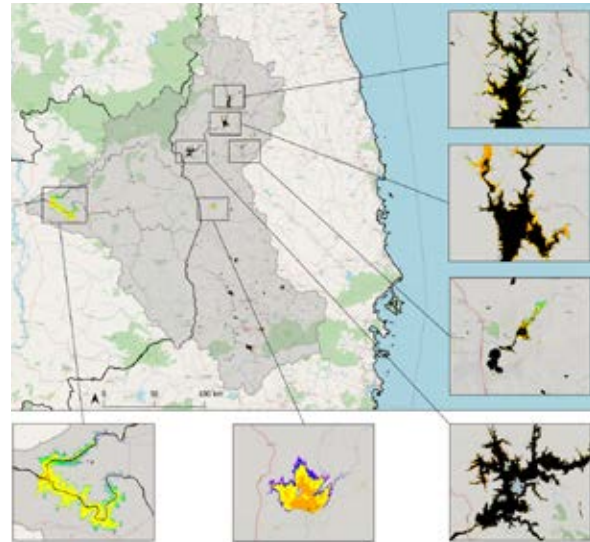
EARTH OBSERVATION ANALYSES OF DROUGHT IMPACT



Time series data analyses have been carried out for mainland South-east Asia, looking at the impact of drought on vegetation in general and on agricultural land, compared with precipitation anomalies and temperature. For the study period, 7 particularly drought-prone years are identified - 2000, 2004, 2005, 2010, 2016, 2019 and 2020.

In contrast to the larger spatial scale analyses, the regionally-adapted work is based on locally-adapted land cover information and showed different results for the project site in the Central Highlands. Earth observation based time series for the years 2000 to 2022 consistently show the years 2005, 2014, 2015 and 2016 to be significantly affected by drought.

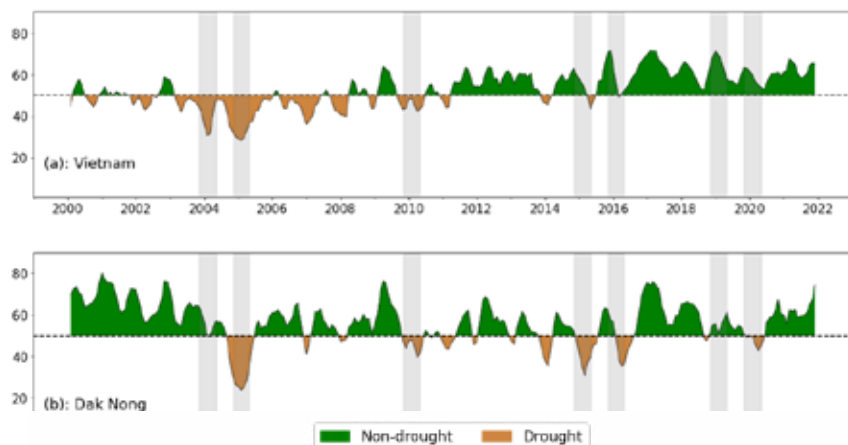
In addition, an inventory of water reservoirs covering the 2S catchment area has been produced.



Water reservoir analyses for 2S catchment based on high-res EO data

A remote sensing assessment of water bodies for the years 2016 to 2022 was carried out using high spatial resolution EO data. The aim was to determine whether new water reservoirs have been created in these areas outside the Vietnamese project sites and, in particular, whether drought-related phenomena can be detected from satellite data.

Analysing the effects of drought on vegetation in a comparison between Vietnam and Dak Nong Province – based on satellite time series information from 2000-2022





RECOMMENDATIONS

To summarize, the successful realization of the Drought-ADAPT project after 3.5 years has produced a large number of results that are ideally suited for appli-

cation in the Central Highlands region of Vietnam. Contacts with local institutions and companies should enable further implementation and new collaborations.

Drought Forecasting

Drought management requires timely forecasts. Hydrological droughts can be predicted with several months lead time based on ENSO and antecedent discharge. The developed forecast models thus add to the ensemble of drought forecasting tools and support effective drought management.

Climate Change Scenarios

Climate change is expected to exacerbate drought conditions in the Central Highlands. The detailed climate change projections developed for the Highlands should be used as the quantitative basis for long-term planning of drought adaptation and mitigation measures in the region.

Mainstreaming EbA

Recommendations for mainstreaming EbA include 1) raising awareness and capacities; 2) mobilizing local investment for change; 3) restructuring local markets to adapted products; 4) coordinating multiple government authorities for multi-sectoral drought adaptation action.

Drought Bulletin

The Drought Bulletin, produced on a monthly basis, is a valuable contribution to drought management in Dak Nong Province. It is used by both local authorities and farmers to monitor drought and respond to local weather and climate conditions, thereby maximising the results of agricultural production.

Hydrological Resources

Vital surface and groundwater resources can be quantified by the satellite gravimetry-based G3P product and the mHM hydrological model. These quantitative estimates of the available water resources provide the basis for an adapted water resource management and sustainable use of water resources.

Data and Information

When using satellite-derived information, it is recommended that locally tailored data and information be used. Our analyses of the effects of drought on vegetation have shown that information tailored to the Central Highlands can address the problem of drought much more accurately.

IMPRESSUM

The German Federal Ministry of Education and Research (BMBF) funded the project Drought-ADAPT (Grant No. 01LZ2002A-F) from 06/2021 to 12/2024 in the framework of the strategy “Research for Sustainability” (FONA) under the funding measure “CLIENT II - International Partnerships for Sustainable Innovations”.

Disclaimer: The opinions expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the funding organization.

More information about the project:

<https://bmbf-client.de/en/projects/drought-adapt>

Publication date: December 2024



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