Livestock Water Monitoring and Risk Management System

[ET – Monitoring]

https://et.waterpointsmonitoring.net/

Training of Trainers Manual and Guide

On

Water and Pasture Monitoring and Interpretation and use of ET – Monitoring Digital Platform for Climate Risk Management

The Alliance of Biodiversity International and International Center for Tropical Agriculture (CIAT), Ethiopian Agricultural Research Institute (EIAR) and Ministry of Agriculture

July 2024

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July 2024

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Acknowledgment

Preparation of this Training Manual and Guide is a result of the continued cooperation between the Alliance of Biodiversity International and International Center for Tropical Agriculture (CIAT), Ethiopian Agricultural Research Institute (EIAR) and Ministry of Agriculture. Their joint efforts seek to enhance proper utilization of science-based water and pasture monitoring and climate risk management advisory services tailored for the pastoral and agro-pastoral context in in Ethiopia. We wish to thank Tess Ruso for the technical support and coordination during the preparation of this document. We also extend special thanks to the Bill & Melinda Gates Foundation for their financial support that made the development of this document possible. Special recognition is extended to the team of experts: Sintayehu Alemayehu, Sintayehu Workneh, Getachew Tegegne, Liyneh Gebre among others, for spearheading the development of this manual and guide. Preparation of this "manual and guide" would not have been successful without the technical input from different Ministries, Departments, and Agencies (MDAs), research and training institutions, academia and farmers whose cooperation is highly appreciated.

Overview of Training Manual and Guide

1.1. Overview

Pastoralism and agropastoralism provide livelihoods for the more than 15 million Ethiopians who derive most of their income from keeping livestock, complemented with farming in the case of agro-pastoralists. The impacts of droughts on the population have pastoralists and agro-pastoralists been increasing exponentially from 1970s to date. Drought intensity coupled with climate change, have adversely affected the livelihood of many pastoral and non-pastoral communities in arid and semi-arid areas of Ethiopia. This has immensely affected water and forage availability for livestock, which is the main livelihood option. Pastoral communities mostly rely on traditional methods such as historical memory, cloud behavior at a given time of the year, and behavior of plants and animals to develop coping strategies during crisis situations. However, the frequency of floods and droughts in the region has greatly increased. Thus, near real time information about water and pasture is critical for pastoralists to enhance their adaptation strategies with adverse weather conditions. The lack of such information increases the dependence of pastoral communities on perennial sources, which often increases their vulnerability to climate risks and leads to competition and conflicts.

1.2. Purpose and Objectives of the Training Manual

The primary objective of this user's training manual is to enhance the knowledge and skills of regional and zonal-level water and livestock extension officers, as well as researchers from regional institutions, in effectively utilizing and implementing the outputs of the decision support system. The training will guide participants on how to access the system, navigate the data in the platform, evaluate the functionality of the system, and generate reports related to the early warning system and agro-advisory services. Through the training, participants will be equipped with a comprehensive understanding of the features and capabilities of the entire digital platform. The purpose of this user's training manual is to empower the participants to confidently access the system and generate timely early warning information and agro-advisory services. The overarching goal is to strengthen the capacity building initiatives and improve the skills of regional and zonal-level water and livestock management technicians, as well as regional institutions, in effectively utilizing and implementing the decision support system. This training manual will equip the trainees with the necessary knowledge and skills to optimally leverage the platform and accurately interpret the information provided. Additionally, the Alliance Bioversity International and CIAT Climate Action team is actively raising awareness and training pastoralist communities to effectively use the digital platform, while also establishing a community information center to facilitate ongoing engagement with the pastoralists. Ultimately, this training manual will guide users in accessing and utilizing the platform's predictive data and forecasts, enabling them to better fine-tune policy decisions and humanitarian interventions ahead of droughts and related disasters.

1.3. Structure and Content of The Training

The training module is organized into five sections.

- **Section 1:** Overview of the platform
- **Section 2:** Seasonal and sub-seasonal climate forecast
- **Section 3.** Waterpoint monitoring and forecasting
- **Section 4.** Pasture monitoring and forecasting
- **Section 5.** Climate risk management and advisory services

Section 1: Overview of the platform

2.1. Overview of the Digital Water Monitoring and Risk Management Platform

The user-centered livestock water and pasture monitoring and early warning system, **ET – Monitoring,** accessible at https://et.waterpointsmonitoring.net/monitoring serves as a critical tool for risk management by providing a range of essential water balance components of the waterpoint. This decision support system is designed with the user in mind, offering a platform that facilitates an understanding of waterpoints' water depth, allows for data downloads and sharing with decision-makers, supports water research, aids in the development of climate adaptation plans, facilitates the development of agro-advisory services, and assists in establishing early warning systems. The platform provide a near real time information on 1) geographical location of water-points, including geospatial information and characteristics of water-points; 2) rainfall; 3) evaporation; 4) scaled water depth; 5) condition of the water-points; 6) profile of waterpoints; 6) spatiotemporal pasture availability; 7) biomass per hectare; 8) seasonal and sub-season whether forecast; 9) livestock movement route and 10) pastoral specific agro-advisory services. This web-platform is also used to disseminate the information daily in near-real time base. Pastoral and agro-pastoral communities are highly vulnerable to climate variability and changes. Thus, this digital platform is a first in its kind and key decision support tools to manage climate risk and enhance pastoralists' and agro-pastoralists' adaptive capacity. The platform can also be used by governmental organizations, non-governmental organizations, and other stakeholders for early warning and decision making. Additionally, users can visualize the platform's outputs for each waterpoint spanning from 2001 to the present, enabling comprehensive analysis over time. Furthermore, users have the capability to download the generated information from the digital platform, allowing for manipulation and utilization in their own research or analytical endeavors. Primarily, the digital platform allows users to access and visualize water balance information, including precipitation, evapotranspiration, and water depths.

2.2. Platform Overview

2.2.1. Key Features and Functionalities

The key features and functionalities of the platform include: 1) Geographical location of waterpoints, including geospatial information and characteristics, 2) Rainfall data, 3) Evaporation data, 4) Scaled water depth, 5) Condition of the waterpoints, 6) Detailed waterpoint profiles, 7) Spatiotemporal pasture availability, 8) Biomass per hectare, 9) Seasonal and sub-seasonal weather forecasts, 10) Livestock movement routes, and 11) Pastoral-specific agro-advisory services. The platform provides site-specific information on the relative depth, rainfall, and evaporation levels of the water surface - vital data for pastoralists managing their herds. It also shows users the travel time to reach available resources, helping pastoralists anticipate forage shortages and move their cattle to areas with good resources. Perhaps most importantly, the platform provides up to six months of weather forecasts, giving pastoralists and government agencies an unparalleled ability to plan ahead despite the increasingly unpredictable weather patterns due to climate change. In summary, this comprehensive platform empowers pastoralist communities by providing them with crucial, real-time information on water, pasture, and weather conditions, enabling them to better manage their resources and adapt to the challenges posed by climate change.

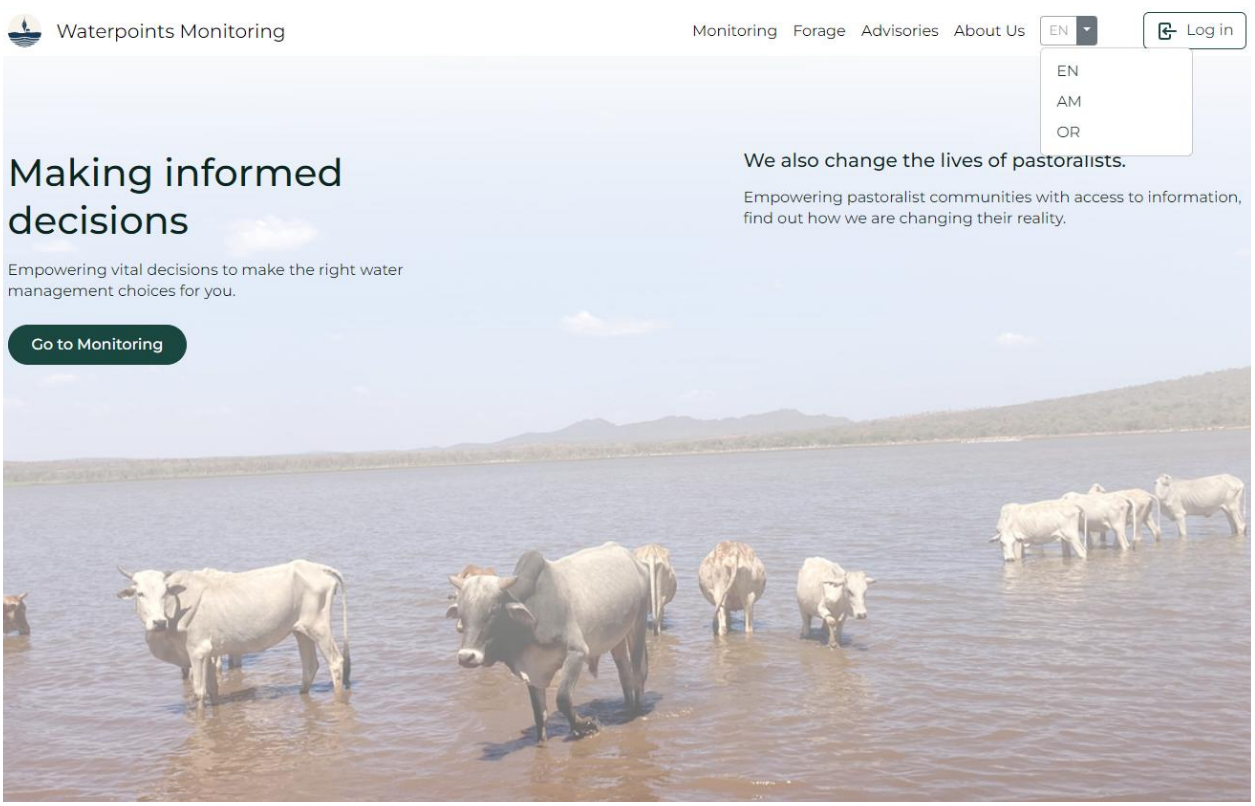
2.2.2. User Roles and Permissions

The digital platform has the potential to be adapted and used by a diverse range of stakeholders beyond the regional pastoralist community. Each sector can leverage the information provided by the platform to inform their unique perspectives and decision-making processes. To facilitate this, the user-centric design team aims to gather user profiles to understand the varied needs and preferences of the digital platform users. This information will guide the customization and optimization of the platform to effectively meet the demands of its diverse user base. Additionally, the user profiles will help the team optimize the information dissemination strategy and ensure efficient outreach and engagement with the targeted audience for the platform-generated content. The clear definition of roles and responsibilities is essential for an effective communications strategy. It ensures the efficient issuance of early warnings and the development of a supportive communications strategy to engage the relevant stakeholders. For instance, local leaders and emergency managers can prepare communities to manage incidents locally. The private sector is often responsible for large pieces of infrastructure and can aid in the distribution of early warnings through private telecoms and media companies. NGOs can mobilize supplies, share emergency information, provide responses, and offer training on emergency preparedness and required actions.

2.3. Getting Started

2.3.1. Opening the System

To open the system, open up Internet Explorer or Google Chrome after connecting to the Internet. Go to https://et.waterpointsmonitoring.net/. The homepage contains the welcome messages, the top menus to access the different components of the platform (Forage, Monitoring, Advisories and Language Dropdown box) to the top left of the page (Figure 1). The footer section has similar links to the components with additional privacy links and contact information to the project members. To ensure accessibility, the platform offers information in three languages: English (EN), Amharic (AM), and Afan Oromo (OR), catering to a diverse user base.



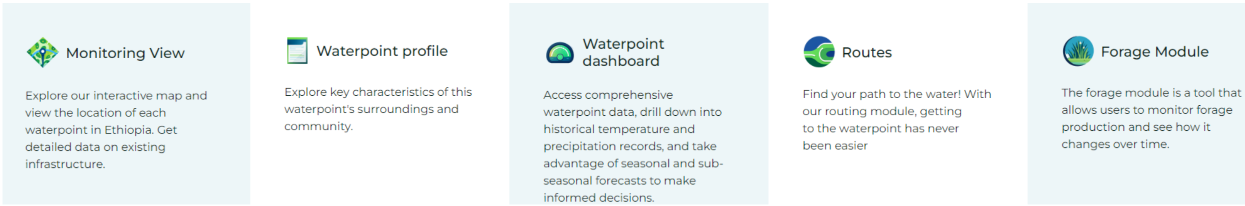


Figure 1. User-centered livestock water and pasture monitoring platform

2.3.2. Accessing the System Data

To access the digital platform's data and updates, users must first register or log in by selecting the "Log in" option located in the top right corner of the platform interface (refer to Figure 2). Upon clicking this section, users are prompted to enter their username (email) and password, as depicted in Figure 2, in order to proceed with the login process.

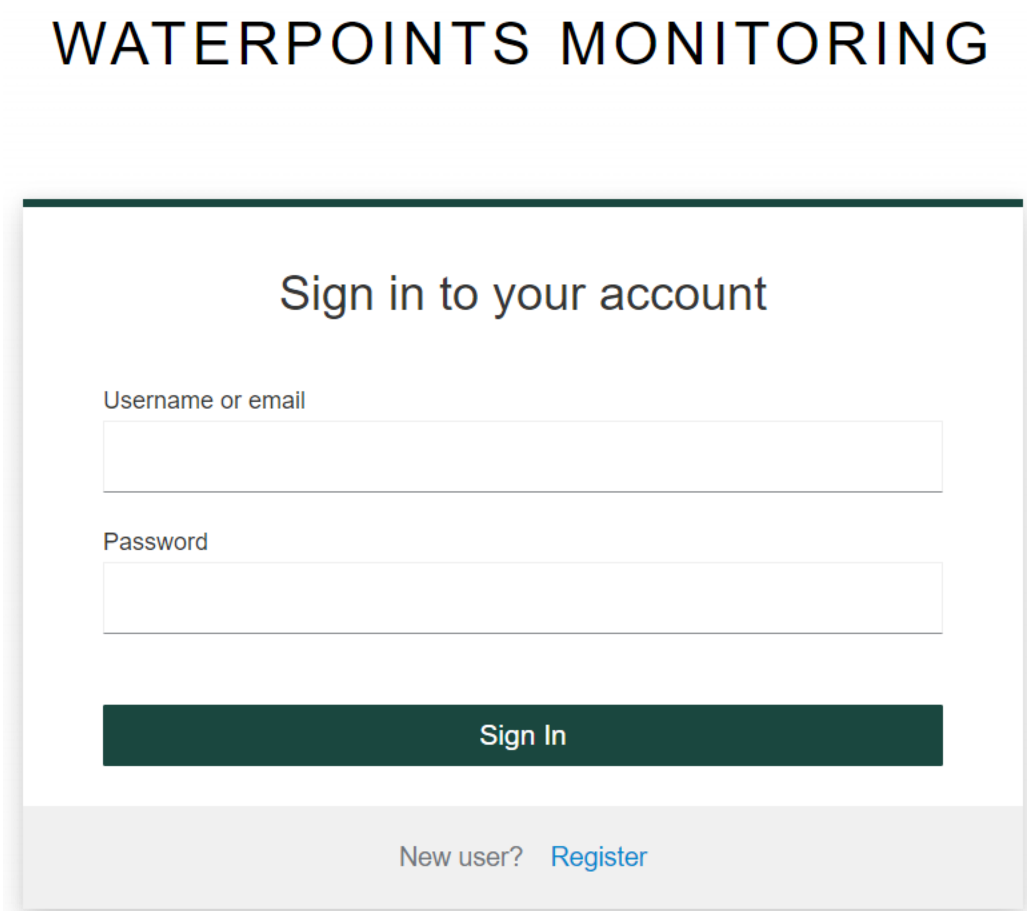


Figure *2*. User login to the digital platform.

2.3.3. User Registration and Login

New users must register on the digital platform (see Figure 3), which is freely accessible to the public. During registration, users are required to input their first name, last name, email, username, and password. Upon successful registration, users can log in by clicking the "Sign In" button.

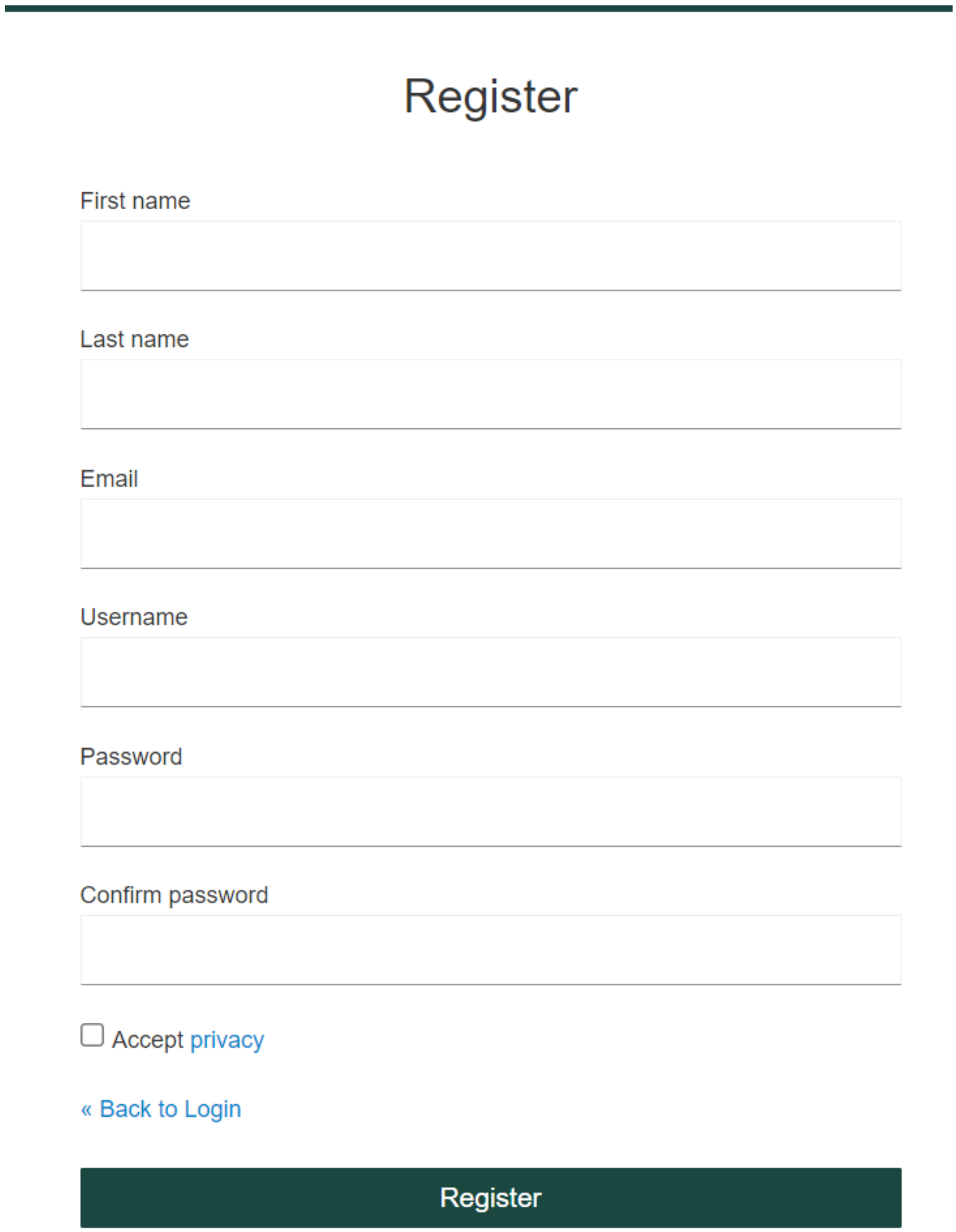


Figure *3*. User registration to the digital platform products.

2.4. Navigation and Dashboard

2.4.1. Navigating through the Platform

Users may navigate to the monitoring section (Go to monitoring), located on the main page (refer to Figure 4), to access a range of system outputs. These outputs include the conditions of waterpoints categorized as follows: good (indicated by green color), watch (yellow color), alert (gold color), near-dry (red color), and seasonally dry (dark-gray color) as illustrated in Figure 4.

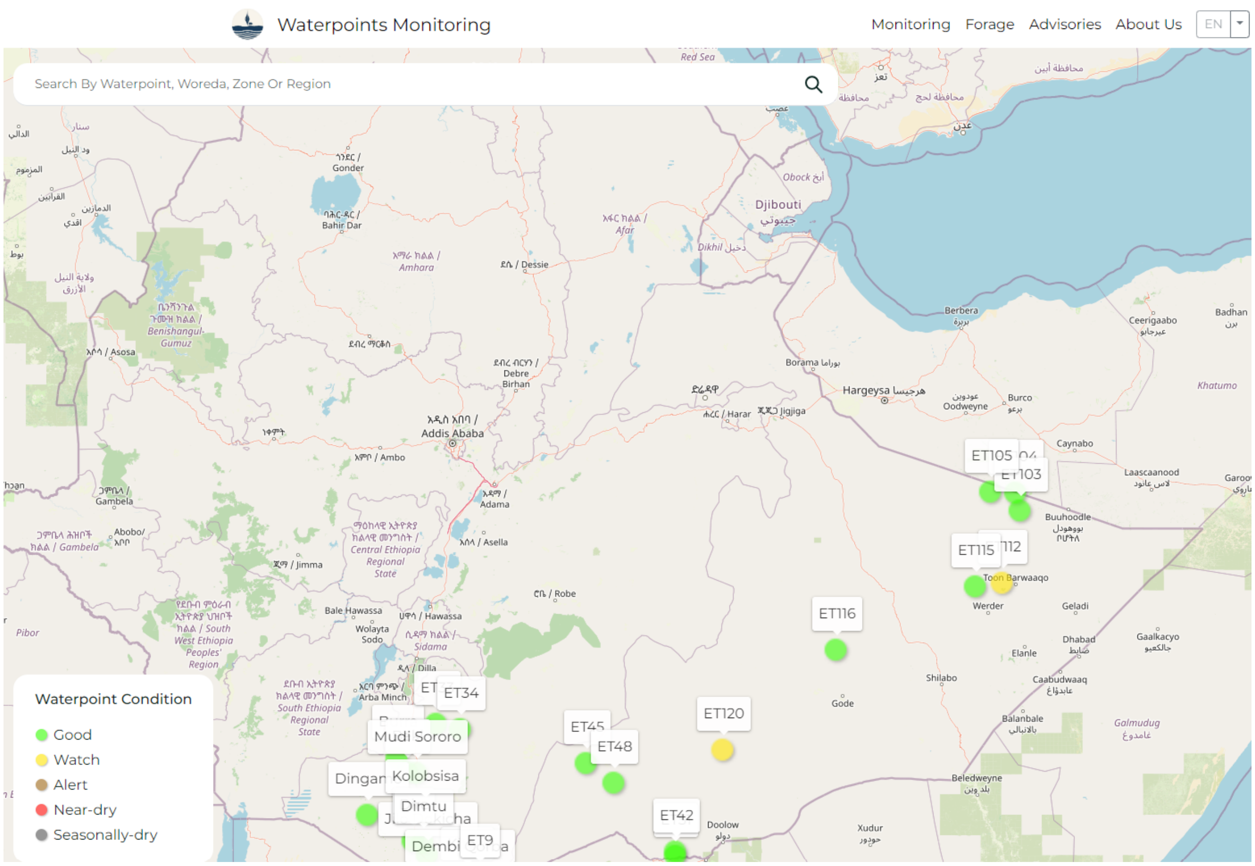


Figure *4*. View of the waterpoints conditions

2.4.2. Understanding the Dashboard Layout

Users can search for specific waterpoints based on their interests using the page depicted in Figure 5. For example, if a user wants to access information about the "Beki" waterpoint, they can either manually search for it by zooming in and out on the map or by typing the name "Beki" and selecting the suggested name provided by the system, as shown in Figure 5.

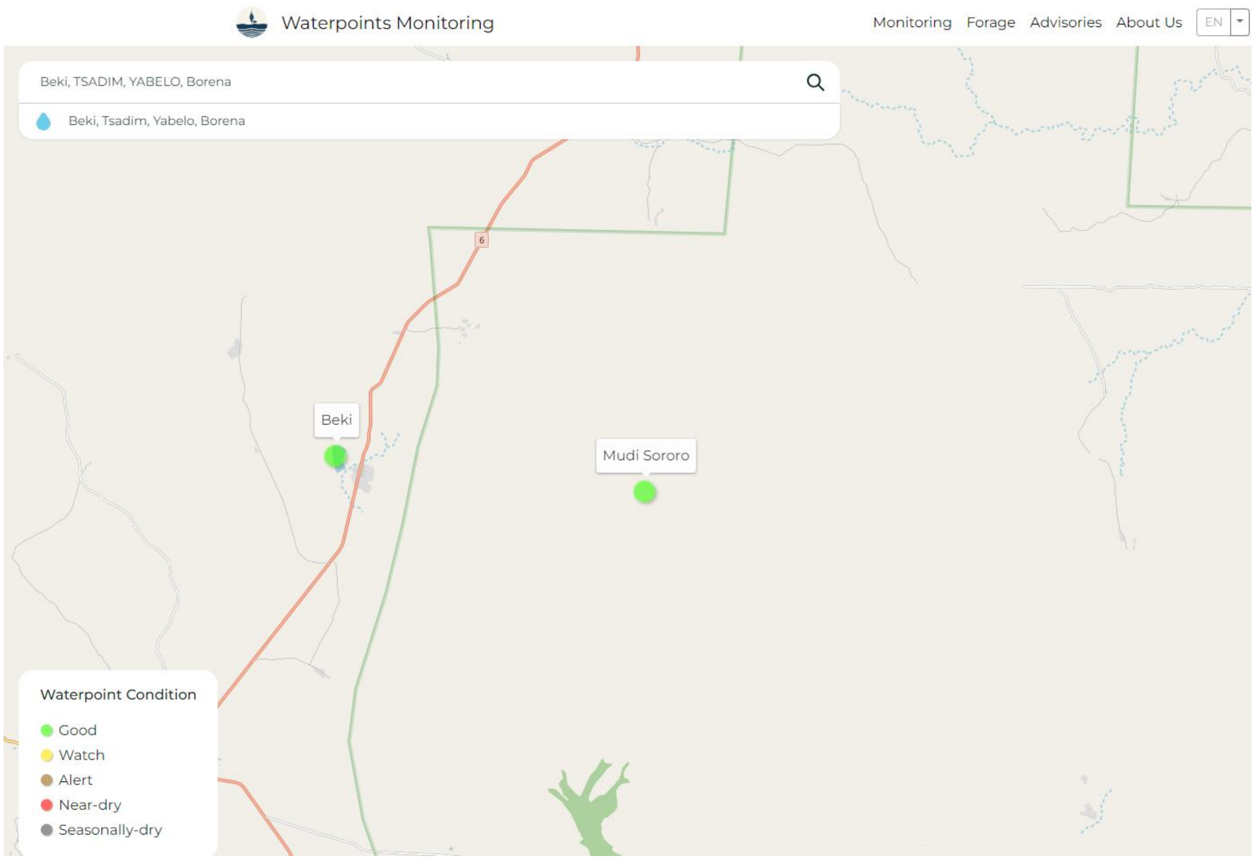


Figure 5. Searching for Beki waterpoint.

Users can select the point labeled "Beki" to access information about the Beki waterpoint, which includes the waterpoint profile map, data such as modeled depth, modeled precipitation, modeled evaporation, and scaled water depth, as well as climate forecast details (refer to Figure 6).

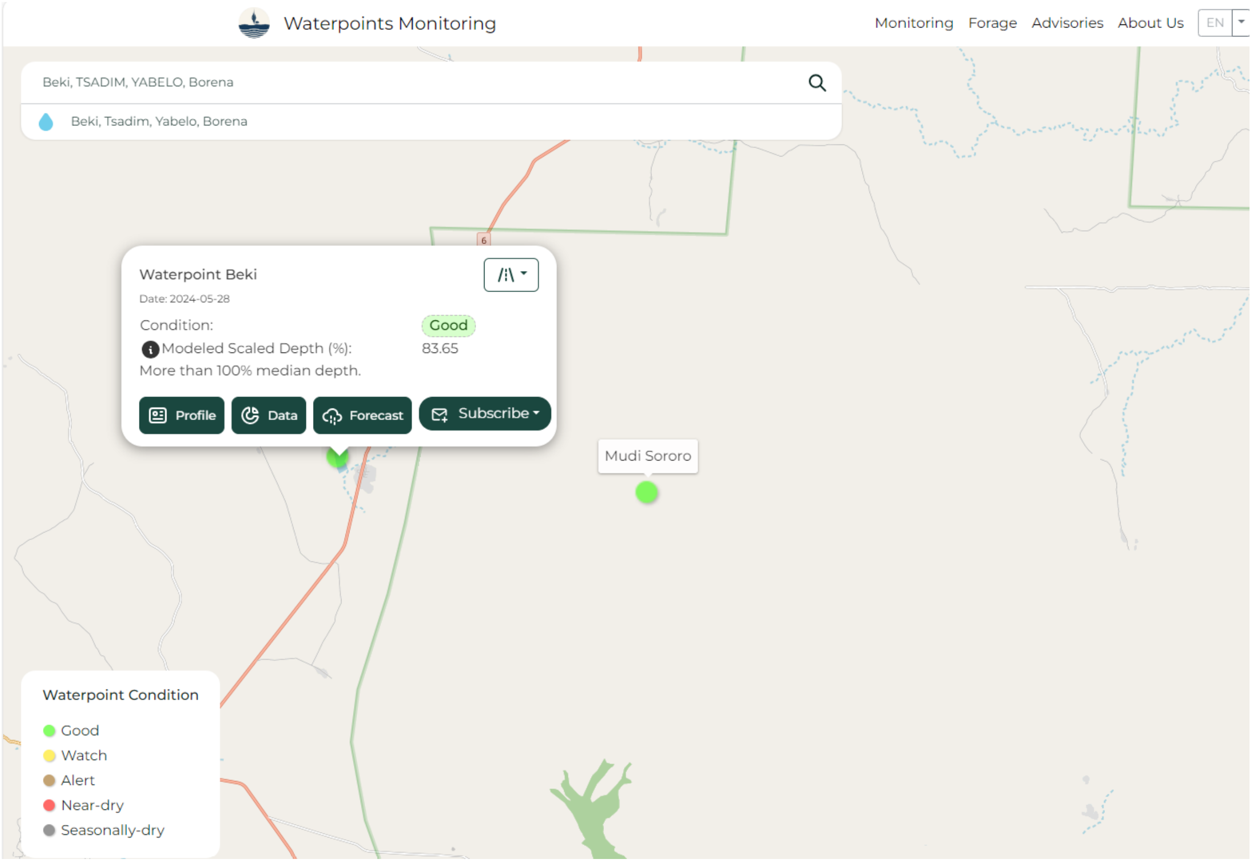


Figure *6*. Beki waterpoint information.

Section 2: Seasonal and Sub-seasonal Climate Forecast

The climate forecast is produced with NextGen approach using PyCPT tool which is developed by International Research Institute for climate and society (IRI). The tool utilizes a model output statistics approach based on hindcast and forecast data from state-of-the-art coupled ocean-atmosphere of the Global Climate Models (GCMs). The climate forecast is generated in a probabilistic tercile forecast which indicates the possible outcome of three categories (below-normal, normal, or above-normal). This tercile probabilities provide the likelihood of rainfall expected for the seasons in a specific area. The forecast is presented in two three-month periods as depicted in the bar graphs. API integration has been incorporated to retrieve seasonal and subseasonal forecasts from AClimate platform and update it to the waterpoint.

3.1. Climate Forecast

Users can click the "Forecast" button to access sub-seasonal and seasonal climate forecast details for the chosen waterpoint (Figure 7). View graphs and maps displaying sub-seasonal and seasonal climate forecasts will help to understand the climatological variables variability in the area of interest. This will help the decision makers to develop early warning and action systems ahead of climatological hazards.

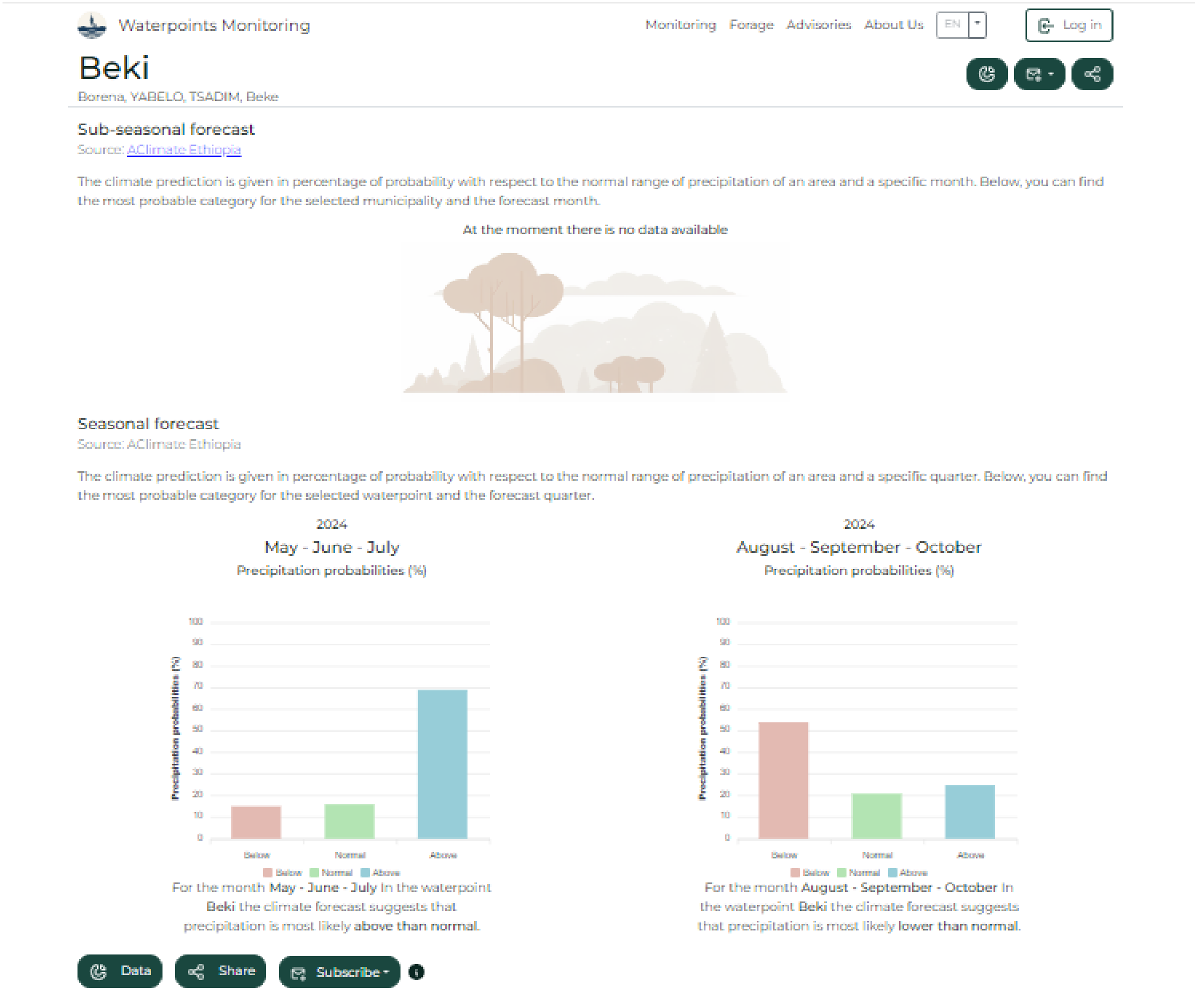


Figure 7. Graphs displaying sub-seasonal and seasonal climate forecast

3.2 Sub-seasonal Climate Forecast

Sub-seasonal forecasts offer climate predictions on weekly basis, from week1 to week4, aiding in short-term planning for livestock water management decisions. These forecasts provide the probability percentage relative to the normal precipitation range for a specific area and week. The system furnishes information on the likelihood of rainfall in the selected waterpoint area for the forecasted week.

3.3. Seasonal Climate Forecast

Seasonal forecasts provide valuable insights by offering climate predictions for the upcoming three months, thereby aiding in seasonal planning and preparation for potential water shortages or surpluses. These forecasts are particularly useful for anticipating and mitigating the impacts of changing weather patterns on water resources. The climate predictions provided in these forecasts are expressed as a percentage probability relative to the normal range of precipitation for a given area and specific quarter. This information enables users to gauge the likelihood of variations in rainfall patterns, helping them to make informed decisions regarding water management strategies. In Figure 8, the probability of rainfall occurring below normal, normal, and above normal levels for the selected waterpoint and the forecasted quarter is illustrated. This visualization allows users to assess the potential risk of drought or excessive rainfall, facilitating proactive measures to address water-related challenges effectively.

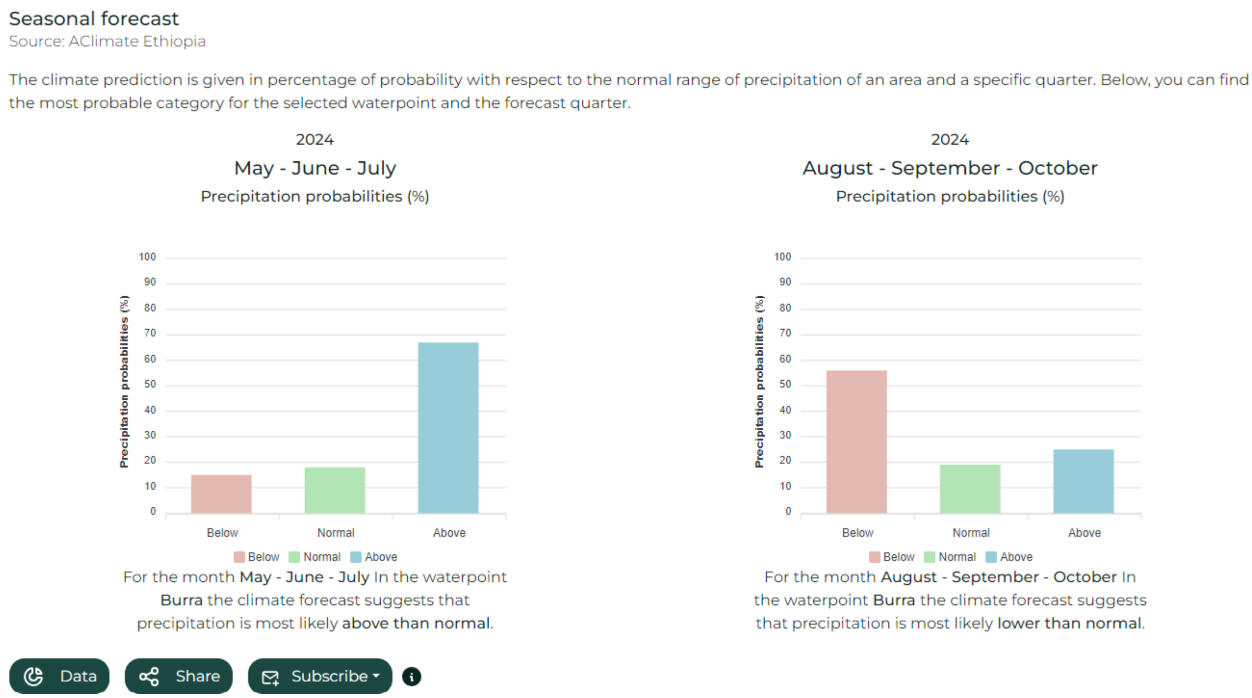


Figure 8. Graphs displaying seasonal climate forecast

Section 3: Waterpoint Monitoring and Forecasting

4.1. Guage Installation and Data Collection

Gauging stations have been strategically placed at various waterpoints to directly measure water levels in real-time. This data is used to fine-tune and validate the hydrological model's ability to accurately simulate water depths. Figure 9 is the picture taken during gauge site identification and installation. The key aspects of staff gauge installation involve: 1) thorough planning, coordination, and training; 2) equipment preparation and packing; 3) site surveys and preparation for installation; 4) secure installation of staff gauges, recording GPS coordinates, and testing stability/readability; and 5) comprehensive data collection to create detailed waterpoint profiles. Annex 1 depicts the full procedure for staff gauge installation, which includes: conducting site surveys to determine best locations, clearing and preparing the installation area, labeling staff gauge readings, inspecting and testing all equipment, securely installing the staff gauges, recording precise GPS coordinates, and verifying the stability and readability of the installed gauges. The measured water level data from these strategically placed gauging stations is critical for validating and improving the hydrological model's performance in accurately simulating water depths

Figure *9*. Identification of sites and staff gauge installation.

4.2. Surface Water Modeling

A water balance equation similar to the lake level modelling approach (Velpuri et al. 2012; Velpuri and Senay 2012) was used to simulate the water point level fluctuations. Assuming a rectangular cross section of the waterholes, the changes in depth in a waterhole are expressed as:

$$\Delta D = P + R_{in} + G_{in} - E - R_{out} - G_{out} - S$$

P represents the precipitation over the water point; Rin represents the modelled run-off contribution to the water point; Rout is the spill from the water point; Gout and Gin represent the groundwater inflows and outflows, respectively; E represents the evaporation over the water point; and S indicates seepage losses from the water point. The runoff contribution to each water point is computed using the equation:

$$R_{in} = \frac{\alpha \times P \times A_{ws}}{A_{wh}}$$

where Aws is the surface area of the watershed, Awh is the surface area of the water point, and α is the rainfall-run-off coefficient for each water point (α = 0.05). The water level for each water point was estimated using:

$$\omega_i = \omega_{i-1} + \Delta D_i$$

where subscripts i and i - 1 indicate the current and previous time steps, respectively, and ω represents the water level in the waterhole. When ω was discovered to be negative, the water level was set to zero. The general procedure followed in this project is depicted in Figures 10.

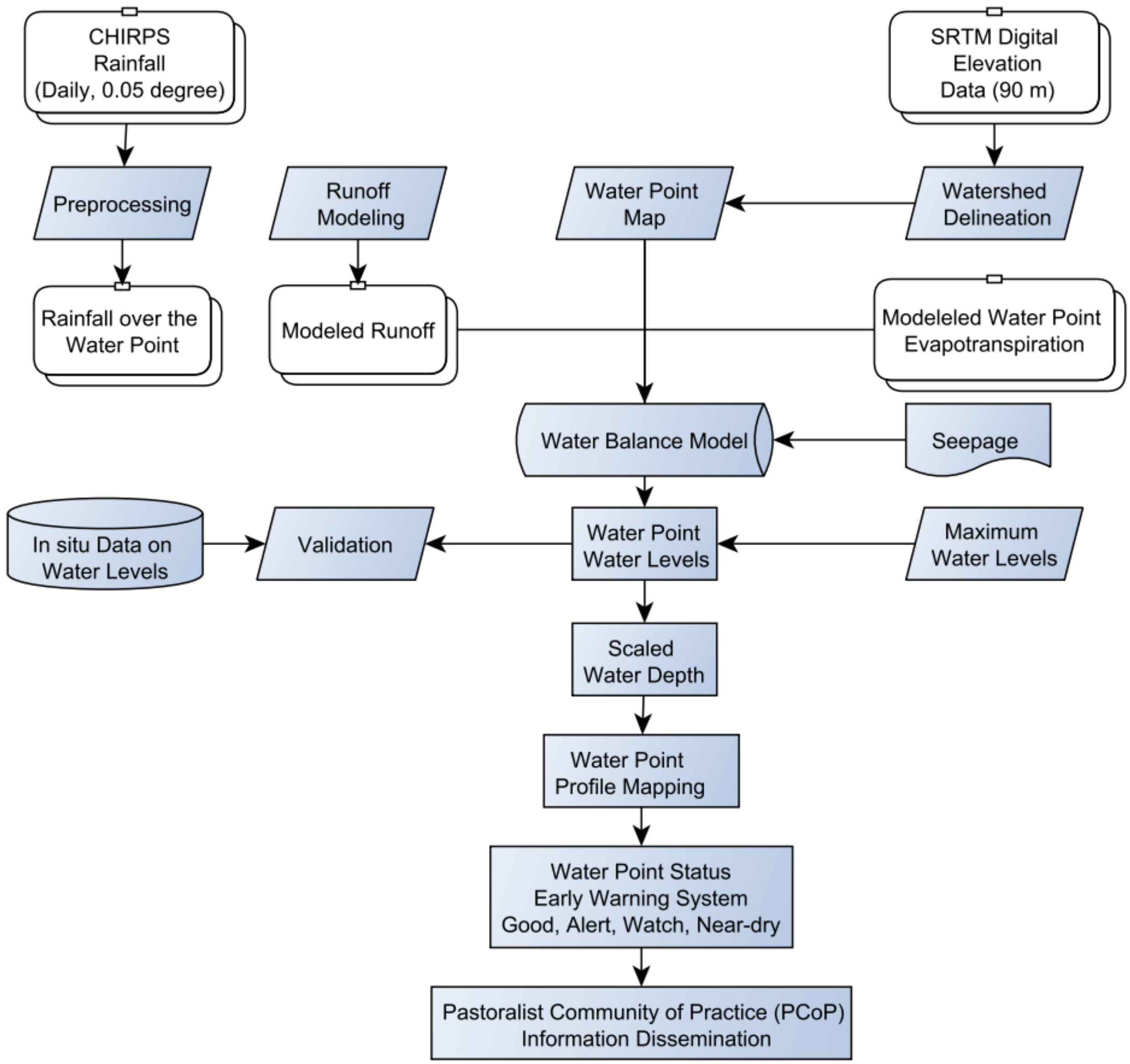


Figure *10.* Flow chart indicating a water point monitoring system and information dissemination approach.

After the model calibration, a regional hydrological model has been developed to extrapolate calibrated parameters from gauged sites to ungauged ones, expanding the platform's applicability across diverse geographical areas. By integrating state-of-the-art technologies with rigorous scientific methodologies, the waterpoints monitoring platform offers a comprehensive solution for monitoring, modeling, and managing water resources effectively and sustainably. Overall, the platform demonstrates exceptional performance in replicating field water level measurements, showcasing its effectiveness in simulating water depths using a combination of remote sensing data and advanced hydrological modeling techniques

4.3. Data Analysis and Reporting

Users may navigate to the monitoring section (Go to monitoring) located on the main page (refer to Figure 1) or directly go to https://et.waterpointsmonitoring.net/monitoring, to access a range of products. The products include the conditions of waterpoints, scale depth, historical rainfall, evaporation, profile of waterpoint, seasonal and sub-seasonal probabilistic climate forecast etc.

4.3.1. Waterpoint condition

The conditions of waterpoints are categorized as follows: good (indicated by green color), watch (yellow color), alert (gold color), near-dry (red color), and seasonally dry (dark-gray color) as illustrated in Figure 11.

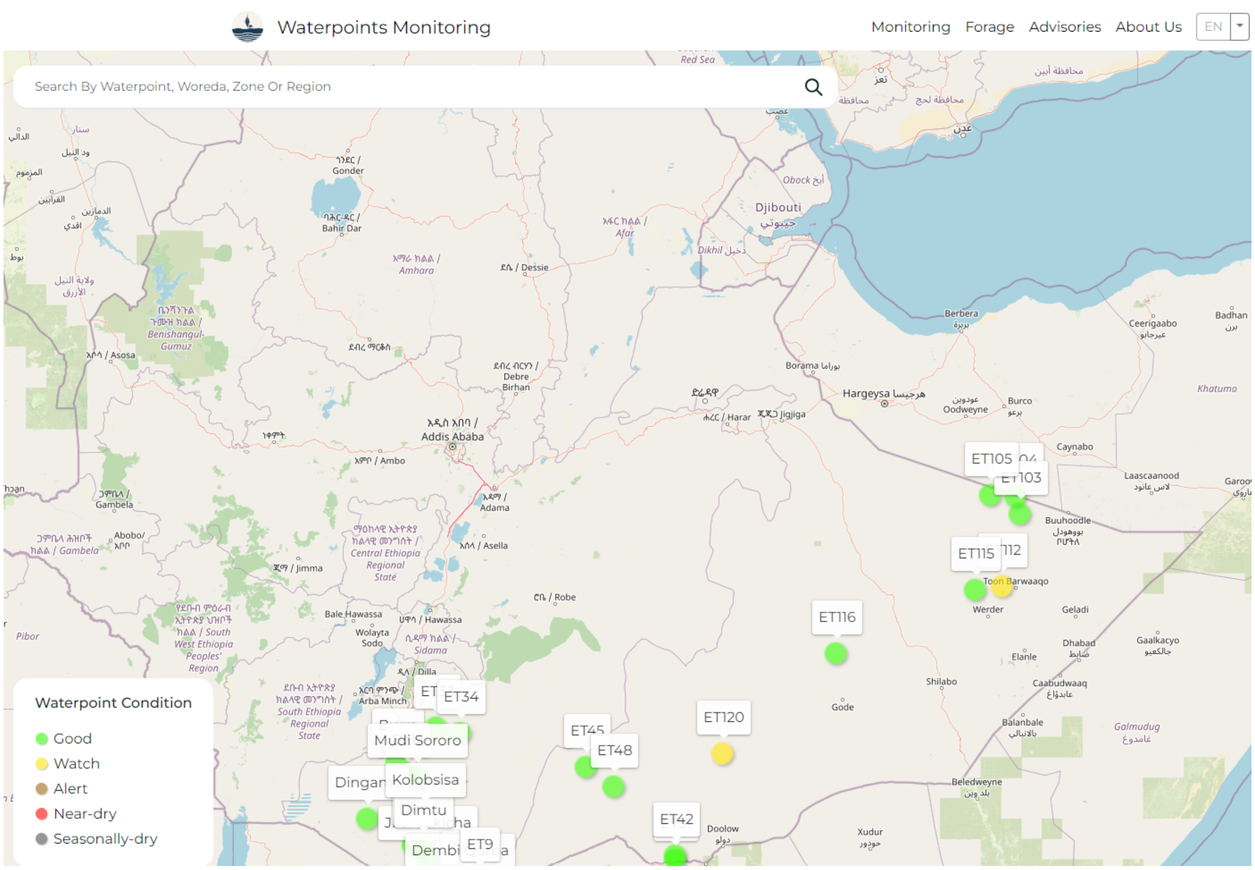


Figure 11. View of the waterpoints conditions

4.3.2. Searching for waterpoint

Users can search for specific waterpoints based on their interests using the page depicted in Figure 12. For example, if a user wants to access information about the "Beki" waterpoint, they can either manually search for it by zooming in and out on the map or by typing the name "Beki" and selecting the suggested name provided by the system, as shown in Figure 10.

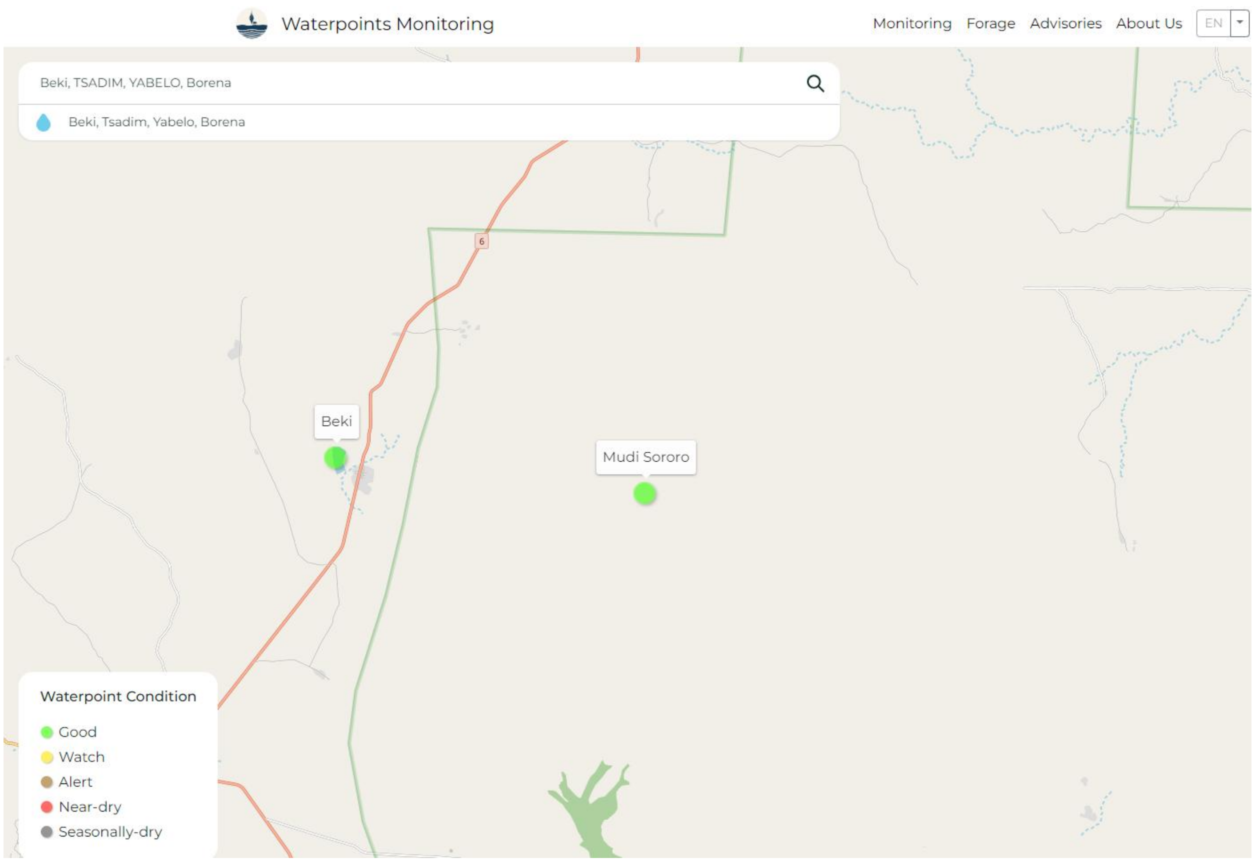


Figure 12. Searching for Beki waterpoint.

4.3.3. Access waterpoint information

Users can select the point labeled "Beki" to access information about the Beki waterpoint, which includes the waterpoint profile map, data such as modeled depth, modeled precipitation, modeled evaporation, and scaled water depth, as well as climate forecast details (refer to Figure 11).

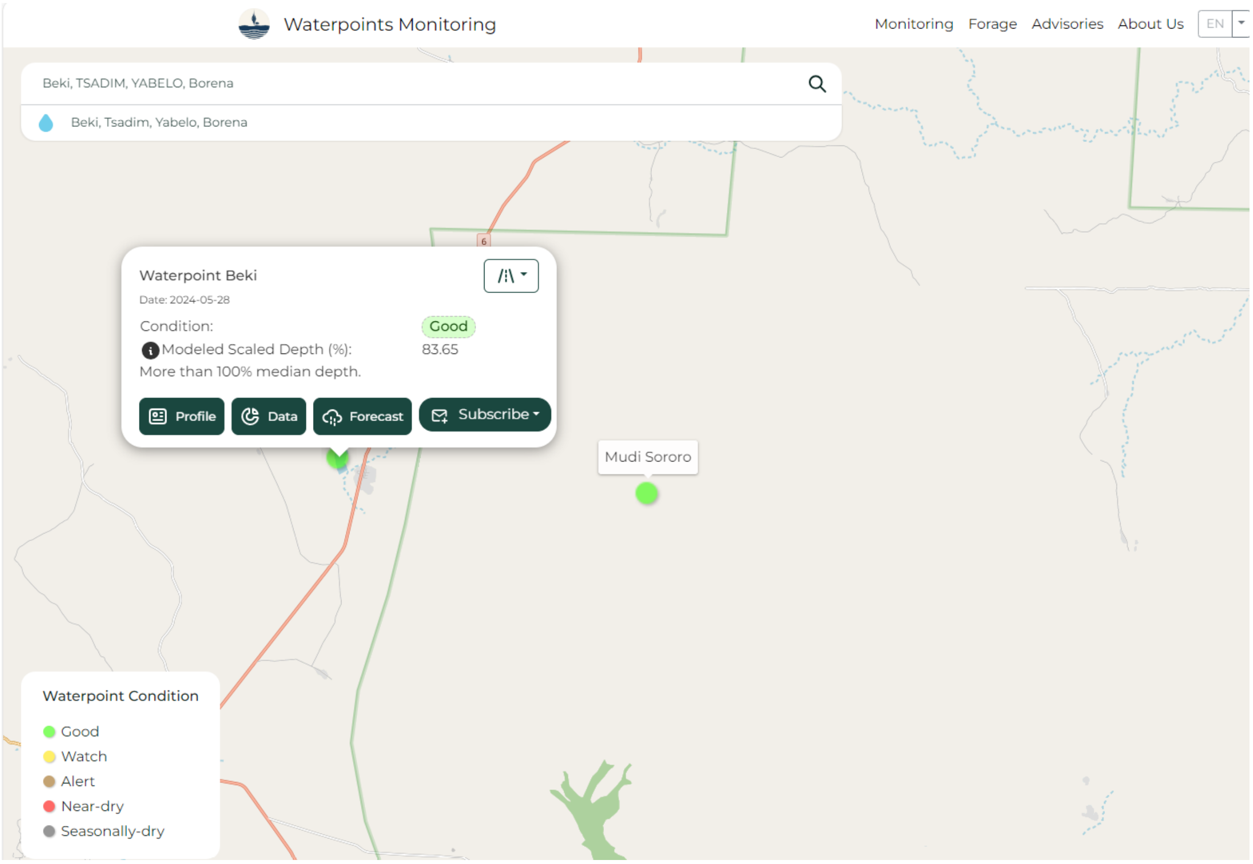


Figure 13. View of Beki waterpoint information.

4.3.4. Waterpoint profile

The profile contains detailed information about the watershed, livestock number and species, description and overview of watershed waterpoints, demographics and water use, management and challenges. To access the profile, click profile from the pop-up window as shown in Figure 14. The profile has a download button that allows you to download the profile as a PDF document. Profiles can be shared on social networks by clicking on the top right corner in Figure 14.

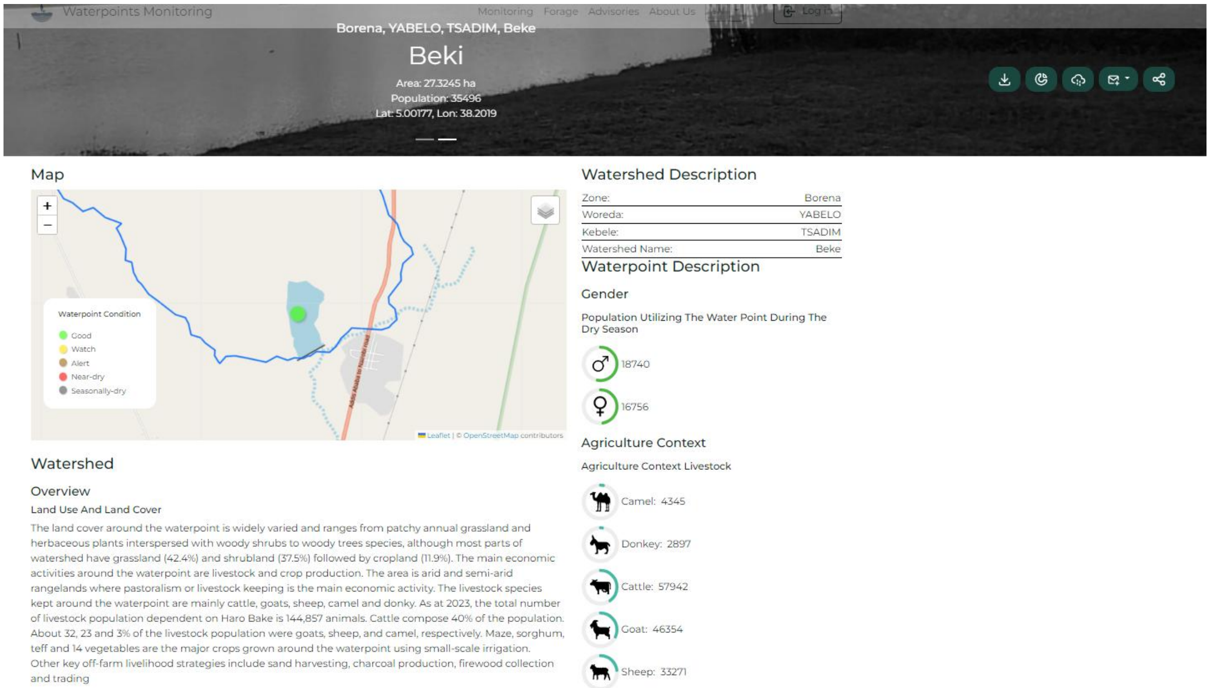


Figure 14. View of Beki waterpoint profile

4.3.5. Waterpoint Data

The data page is accessible from the monitoring page pop-up window (Figure 15). This page is also accessible from the profile page. The data page of platform offers 1) modeled water depths; 2) scaled water depths; 3) modeled precipitation and 4) modeled evaporation for each waterpoint (Figure 15). The dashboard has the functionality to filter data, view and compare with historic observation. It has also a downloading functionality to download the waterpoint data for further investigation of the waterpoint data.

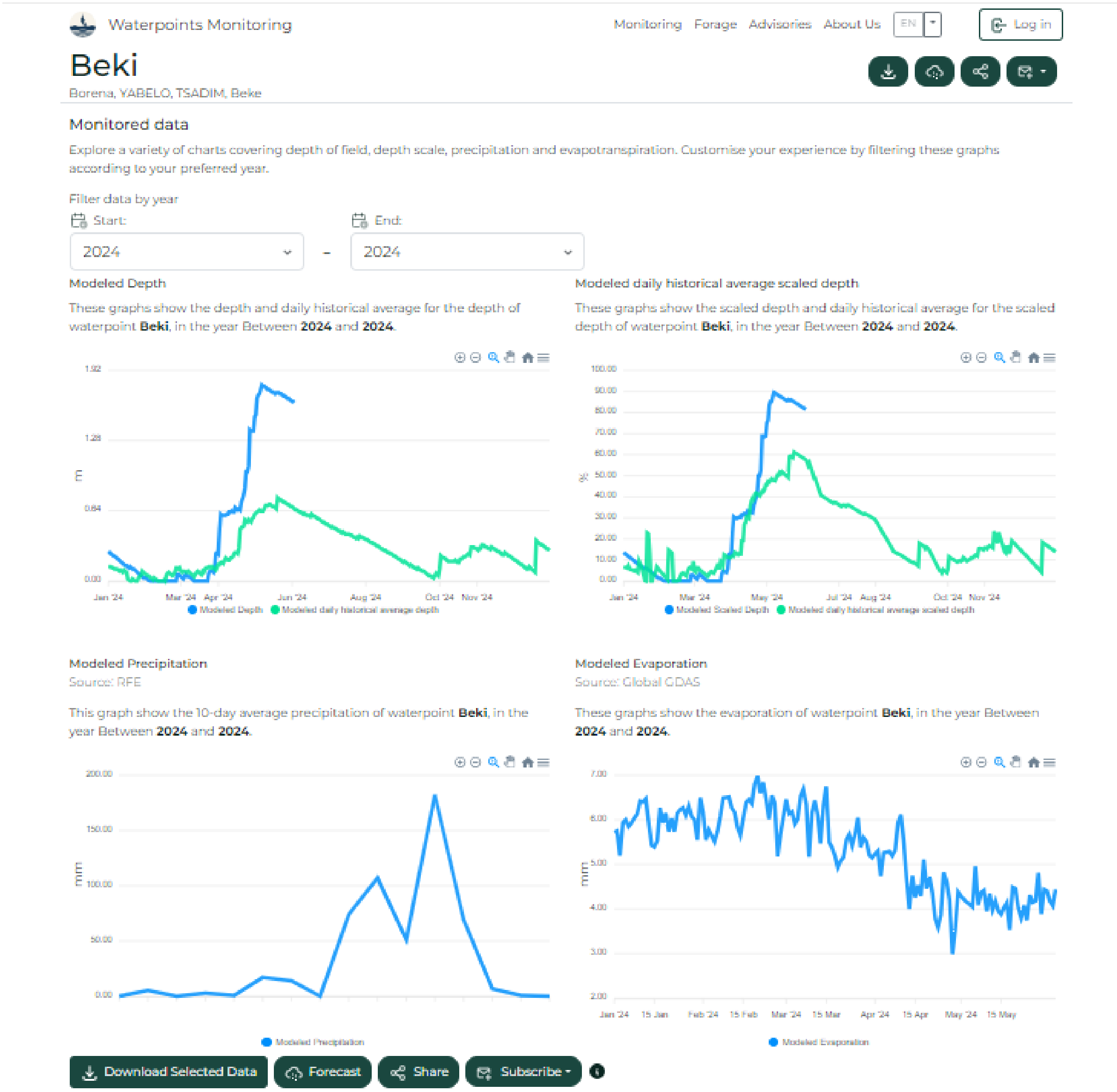


Figure 15. View of Beki data page

To ensure accuracy, the simulated water depths undergo calibration and validation processes through ground truthing methodologies. The hydrological model developed for this purpose simulates inflows to each waterpoint, providing a comprehensive understanding of the dynamics of water availability. Subsequently, a water balance equation is employed to estimate the water depths, integrating various factors such as precipitation, evaporation, and runoff. Additionally, the scaled water depth provides users with a comparative perspective by evaluating the current water depth relative to the historical maximum water depth. This calculation enables users to gauge the current state of water availability in comparison to past maximum water depth conditions, facilitating informed decision-making regarding water resource management strategies.

4.3.6. Visualizing Water Depth Data

The water depth of each waterpoint is determined through simulation utilizing a straightforward water balance model. To ensure the reliability of these simulated water depths, comparisons are made between field-measured data and the simulated results. This validation process underscores the accuracy of the model's predictions, affirming the suitability of the chosen hydrologic and water balance models for the project area. The modeled simulated water depth serves as a crucial source of real-time information regarding water levels across various waterpoints. These water level data play a pivotal role in the development of early warning systems and agro-advisory services, as they provide valuable insights into water availability at each specific location. Users can access both current and predicted water depth data through graphs and charts, facilitating real-time decision-making in water management endeavors. Figure 16 offers a visual representation of the modeled water depth and modeled daily historical average water depth spanning the period from 2001 to 2024, providing users with comprehensive insights into water depth trends over time.

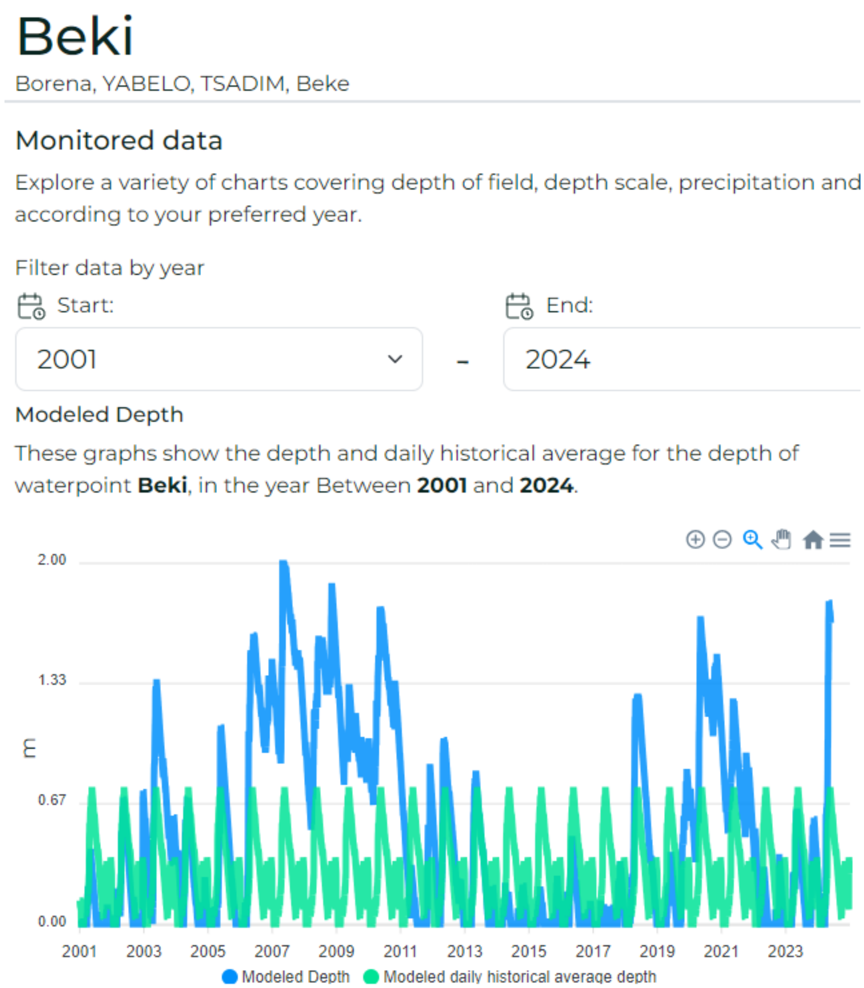


Figure 16. View of modeled depth and modeled daily historical average depth.

4.3.7. Scaled water depth

Figure 17 depicts the modeled scaled water depth and modeled daily historical scaled water depth amounts and patterns. Scaled water depth serves as a valuable metric for users to comprehend the current state of water resources in a normalized context by representing the relative depth compared to a historical maximum. This comparative approach enables users to gauge the current water depth in relation to the maximum depth recorded historically, offering a standardized measure of water availability. By contextualizing the current water depth relative to its historical maximum, scaled water depth provides users with insights into the extent of water availability at a given point in time. This normalization facilitates more informed decision-making regarding water resource management, as users can assess the current status of water resources against established benchmarks.

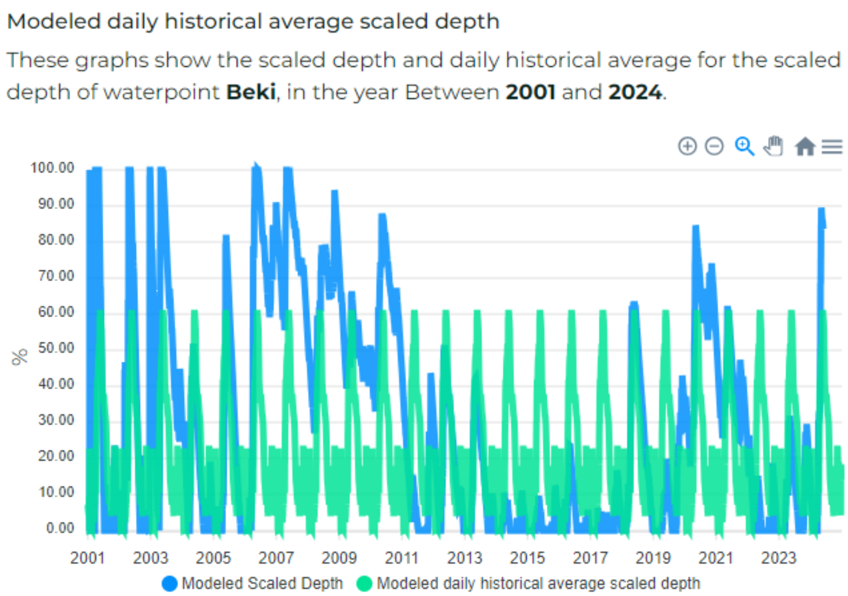


Figure 17. View of modeled scaled depth and modeled daily historical average scaled depth

4.3.8. Modeled precipitation

Modeled precipitation data is derived using satellite and remote sensing methodologies, providing an essential component of the water balance equation crucial for forecasting future water availability at each waterpoint. This data serves as a fundamental indicator for understanding precipitation patterns and their impact on water resources. The platform grants access to precipitation data spanning from 2001 to the present, allowing users to analyze precipitation amounts and patterns over specific timeframes. This information is invaluable for guiding water management strategies and facilitating informed decision-making.

Within Figure 18, users are provided with the option to access precipitation data. This action initiates the process of retrieving precipitation amounts and patterns. Once prompted, users can specify their desired timeframe by inputting both the start and end periods within the interface displayed in figure 8. Upon submission, Figure 18 showcases the precipitation pattern specifically for the year 2024, offering users a visual representation of precipitation trends throughout that period. This feature enables users to analyze and utilize precipitation data effectively for various planning and management purposes.

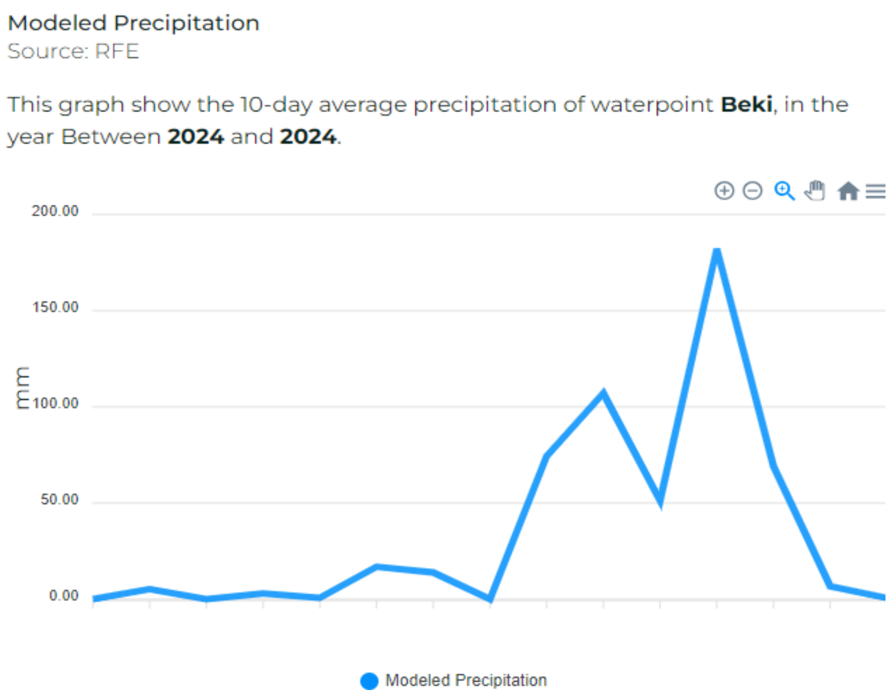


Figure 18. View of modeled precipitation of Beki waterpoint

Additionally, users have the option to access precipitation data spanning the entire available period, from the start year 2001 to the end year 2024, as demonstrated in Figure 19. By inputting these start and end years, users can retrieve comprehensive precipitation information covering the entirety of the platform's dataset. Once the desired period is specified, users can download the precipitation data for that selected timeframe by clicking on the "Download selected data" button. This facilitates the acquisition of a comprehensive dataset for further analysis and planning purposes. Moreover, users interested in receiving regular updates on precipitation data can subscribe to the service by clicking on the "Subscribe" button. This feature ensures users stay informed about any new data additions or updates, enabling them to maintain access to the latest information for ongoing monitoring and decision-making.

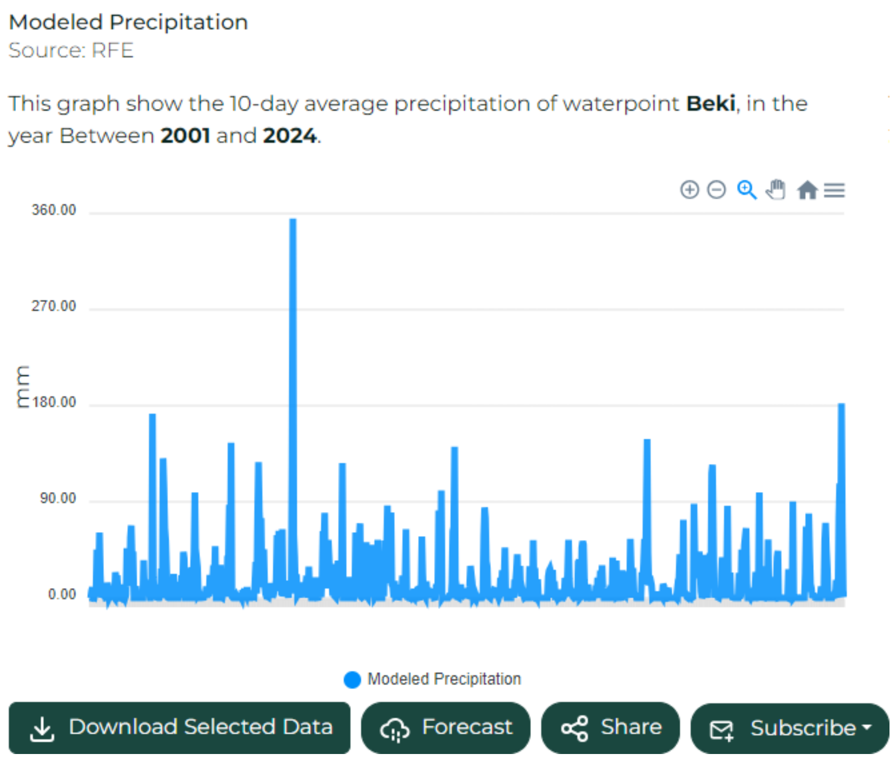


Figure 19. View of precipitation pattern for the period 2001 - 2024 in the Beki waterpoint.

4.3.9. Modeled evaporation

Evaporation is key to assess the volume of water lost from water bodies as a result of evaporation. This data plays a pivotal role in comprehending water retention dynamics across varied climatic conditions. Figures 20 and 21 present simulated evaporation rates, providing users with valuable insights into water loss patterns and facilitating the formulation of strategic water conservation measures. Understanding evaporation is essential as it constitutes a fundamental component of the water balance equation, aiding in the estimation of water depths at each waterpoint. This information is instrumental in assessing water availability and guiding resource management decisions effectively. Users keen on accessing evaporation estimates can do so by specifying their desired timeframe, inputting both the start and end periods in the provided space. This enables users to download evaporation data for different time periods, empowering them with the necessary information to make informed decisions regarding water management strategies.

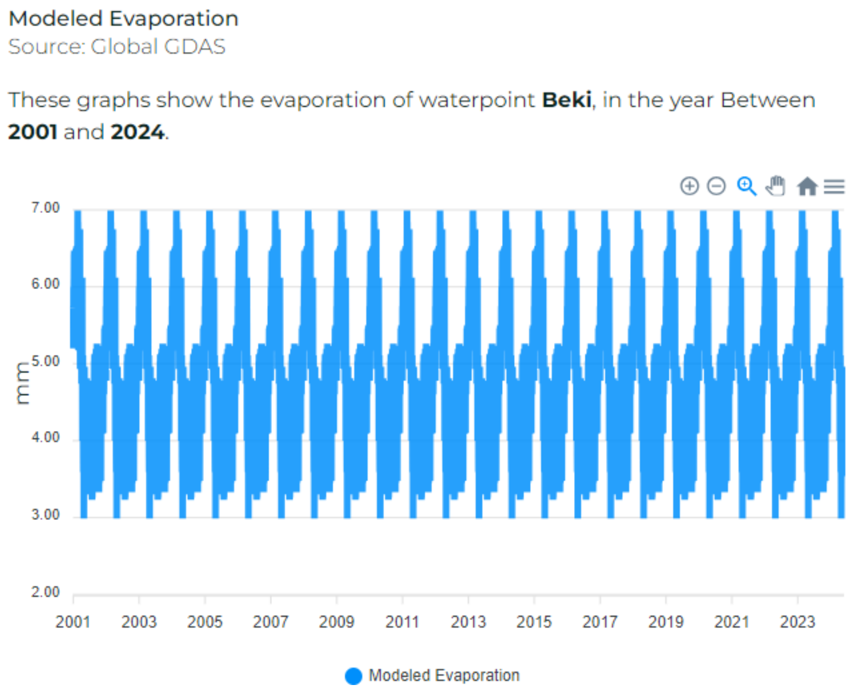


Figure 20. Graph displaying simulated evaporation rates for the period 2001 – 2024.

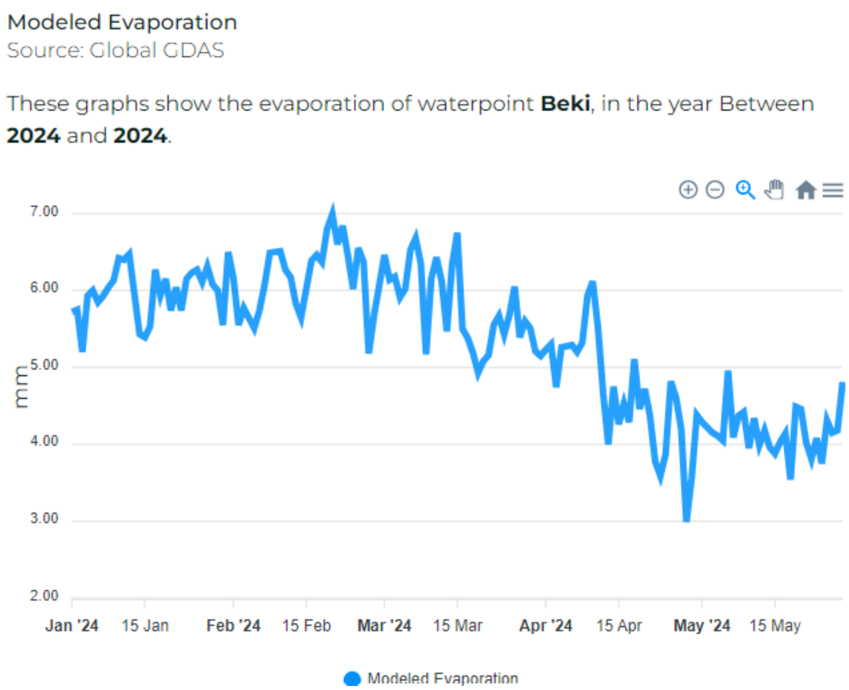


Figure 21. Graphs displaying simulated evaporation rates from January 2024 - May 2024.

Section 4. Pasture monitoring and Forecasting

5.1. Data Set Used and Preparation

Several data including Normalized Difference Vegetation Index, Rainfall, Temperature and Soil Moisture were used to model the forage in the lowland parts of Ethiopia. Detecting multicollinearity before developing a model is critical and removing the same improves model performance. The easiest way for the detection of multicollinearity is to examine the correlation between each pair of explanatory variables.

5.2. Forage Modeling

The geographically Weighted Regression (GWR) model was used to develop a prototype forage biomass prediction model (Fotheringham et al 2005).

$$Y_i = \alpha(U_i, V_i) + \beta(U_i, V_i)X_i + \lambda(U_i, V_i)Z_i$$

Where coordinates of location i are represented by U_i, and V_i. The symbols α, β, and λ are local parameters to be estimated particularly at location i. X and Z are independent variables.

The GWR technique is preferred over the Ordinary Least Square Regression (OLR) due to its capability of examining the existence of spatial non-stationarity in the relationship between a dependent variable and as set of independent variables.

Then the output from the prediction model was converted to pasture biomass in Kg/ha. This method was also used to convert observed maximum NDVI to pasture biomass following the method of Hobbs (1995).

5.3. Forage Spatial Map

Users can click the "forage" button to access detailed information regarding forage for the main page (Figure 22).

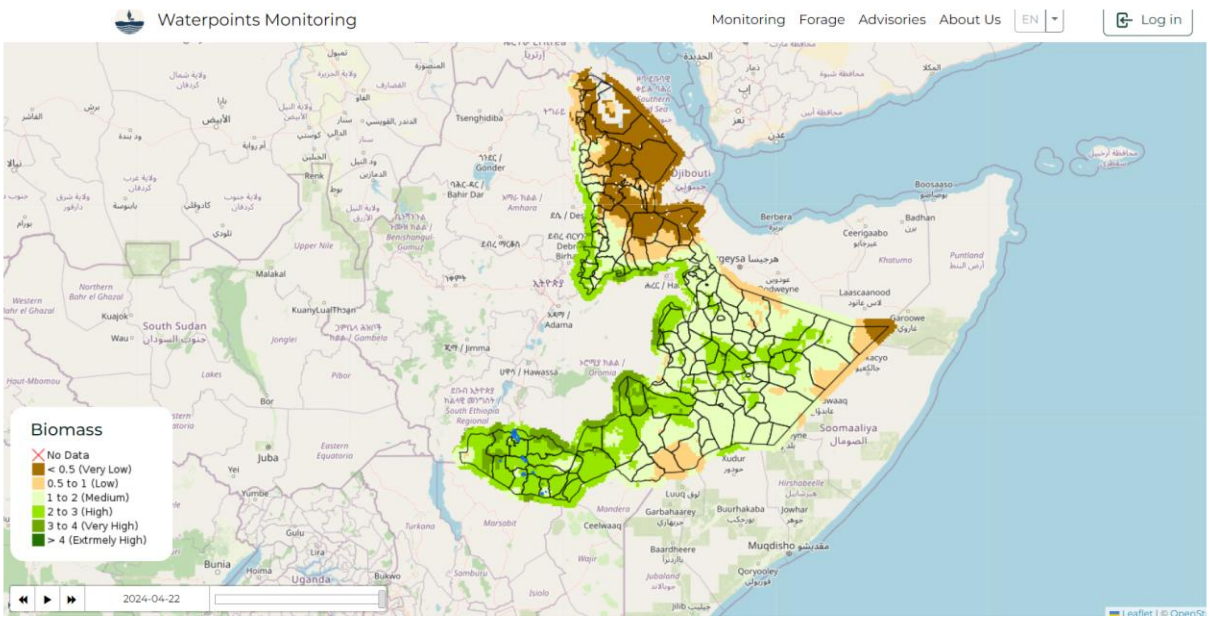


Figure 22. Graphs displaying forage information

Figure 23 shows the modeled pasture in the low land parts of Ethiopia. The modeled pasture is highly influenced by precipitation and water availability. This helps in managing grazing patterns and ensuring sustainable livestock feeding. Visualize the health and growth patterns of pastures, ensuring optimal grazing management and pasture sustainability. This feature is instrumental in managing grazing patterns effectively and ensuring sustainable feeding practices for livestock. Users can visualize the health and growth patterns of pastures through the platform, allowing for a comprehensive understanding of their condition. By monitoring these patterns, users can implement optimal grazing management strategies, ensuring that pastures are utilized in a sustainable manner to support livestock feeding needs. This visualization tool facilitates informed decision-making regarding pasture management, enabling users to adapt their grazing practices based on real-time insights into pasture health and growth dynamics. Ultimately, this promotes sustainable land use practices and contributes to the long-term health and productivity of grazing areas.

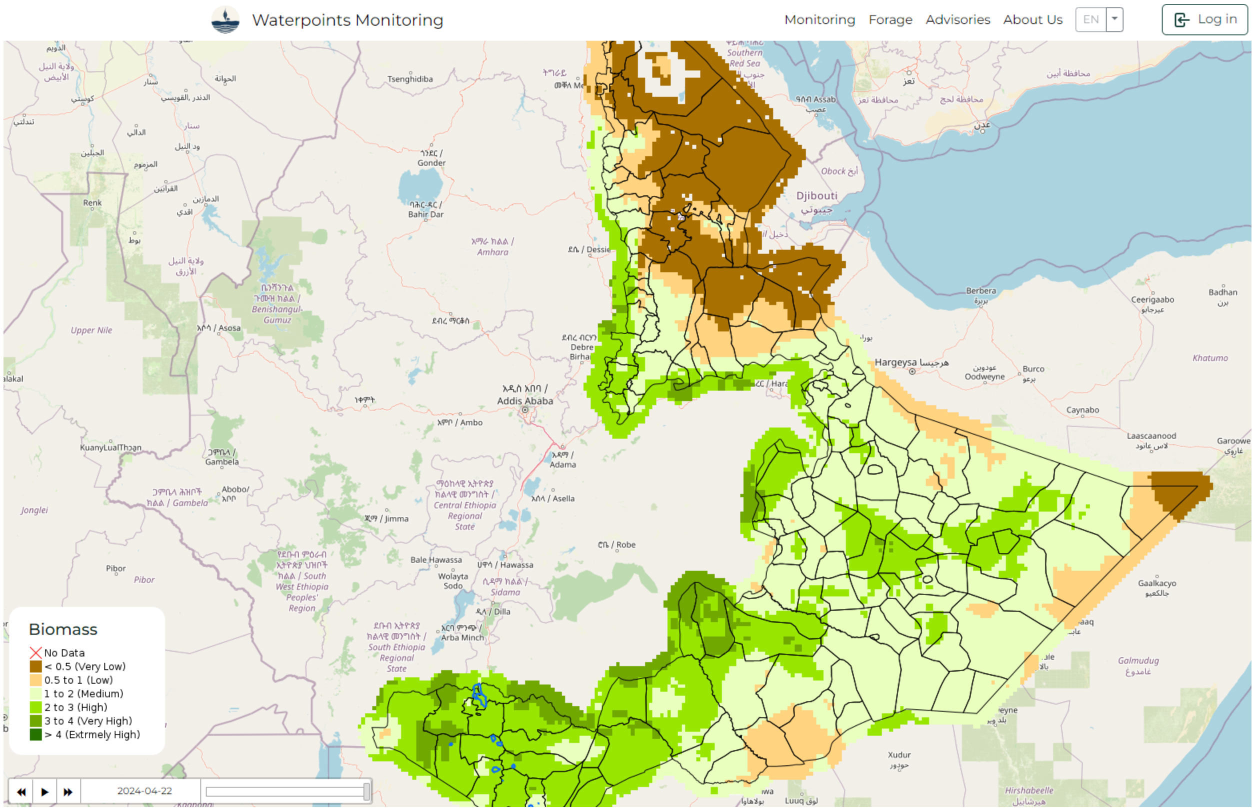


Figure 23. Graphs displaying simulated biomass for the day 22/04/2024.

Section 5. Climate Risk Management and Advisory Services

6.1. Risk Assessment and Identification

Ethiopian pastoralist communities have lacked access to a comprehensive livestock early warning system that could predict and provide information on water and pasture availability. This has limited the ability of pastoralists, the government, and development partners to address pressing climate challenges. The launch of the user-centered integrated water, pasture, and climate monitoring and forecasting system represents a significant step towards improving resilience for pastoralist communities in Ethiopia. This system allows for the identification of water availability risks using different color-coded alert levels: Green, yellow, gold, red, and black-grey colors represent different alert levels for each waterpoint (as shown in Figure 24). With these clear, color-coded alert levels, Ethiopia's pastoralists can more effectively plan for the unpredictable, safeguarding their livelihoods and the water security they provide for communities at large. This new integrated monitoring and forecasting system is a crucial development that empowers pastoralist communities to better navigate the challenges posed by climate change, by providing them with the comprehensive information they need to manage water and pasture resources.

Alert Levels

The user-centered digital early warning system chooses to customize the alert levels with green, yellow, gold, red and grey colors as they are simple, easy to understand and actionable.

Green – Good Condition

The GREEN alert level represents for the waterpoints with GOOD status when their mean scaled depth over the previous 10 days is greater than the long-term median depth. The waterpoints with GREEN alert level has adequate amount of water level.

Yellow - Watch Condition - Be Aware

The YELLOW alert level indicates for the waterpoints with WATCH status when their scale depth over the previous 10 days is between 50% and 100% of the long-term median depth. The waterpoints with YELLOW alert level has less adequate amount of water level at this time.

Gold - Alert Condition - Be Prepared

The GOLD alert level shows for the waterpoints with ALERT status when their scaled depth over the previous 10 days is between 3% and 50% of the long-term median depth. The waterpoints with GOLD alert level has inadequate amount of water level at this time. The issue of GOLD level warning implies that the pastoralists around this waterpoint should prepare themselves in an appropriate way for the anticipated conditions.

Red - Near Dry Condition - Severe Waterpoint Warning - Take Action

The RED alert level stands for the waterpoints with NEAR DRY status when their scaled depth over the previous 10 days is less than 3% of the median depth. The waterpoints with RED alert level has very small amount of water level at this time. The issue of RED level warning implies that the pastoralists around this waterpoint should take action in an appropriate way for the anticipated conditions. The pastoralist around this waterpoint with the RED alert level should take action to protect themselves and/or their properties; this could be by moving their livestock out of this waterpoint temporarily; by following the system livestock movement route or by other traditional approaches aimed at mitigating the effects of the waterpoint dryness.

Grey – Seasonally Dry Condition – No water Available - Take Action

The GREY alert level stands for the waterpoints with SEASONALLY DRY status when their scaled depth over the previous 10 days is almost zero due to the dry season with no rainfall. The waterpoints with GREY alert level has no amount of water level at this time.

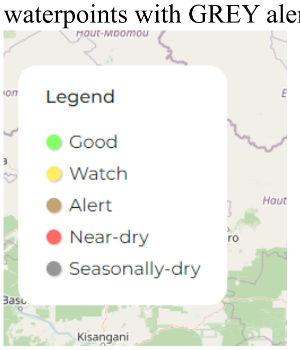


Figure *24*. Waterpoints risk identification alert levels.

6.2. Early Warning System and Agro-climate Advisory Service

The primary objective of the early warning system and agro-climate advisory services are to empower pastoralists to respond timely and appropriately to the risks associated with water availability in order to de-risk livestock loss and damage. Warnings need to get the message across and stimulate those at risk to take action. Thus, the user-centered digital platform helps to collect and analyze data, package and distribute early warnings, build appropriate processes and response matrixes to allow fast delivery, and share relevant information with stakeholders and actors to ensure pastoralists know what to do based on the waterpoints condition. The condition of waterpoints plays a pivotal role in facilitating the development of an effective early warning system, particularly beneficial for pastoral communities facing prolonged droughts. This system empowers decision-makers and pastoralists with the insights needed to employ strategies and interventions to mitigate water scarcity challenges, especially when waterpoints are marked with red and black-grey colors, indicating critical conditions. Pastoralists often practice seasonal migration, moving their herds to areas with better water availability and pasture during dry periods. They may have established customary routes and agreements with other communities for accessing water sources in different areas. Migration allows them to take advantage of spatial variations in rainfall patterns and access water and pasture resources in different locations. Generally, early warning system development can further enhance the resilience of pastoral communities in coping with water scarcity during prolonged droughts. In general, the waterpoint condition will be one of the following:

- *Beki waterpoint is in good status (Green color); you can continue using water as usual and manage the water consumption for other purposes.*
- *Beki waterpoint is in watch status (Yellow color); it is recommended to conserve water as there is a high probability of water shortage. Thus, reduce water consumption for other purposes and follow waterpoint manager instructions.*
- *Beki waterpoint is in alert status (Gold color); it is advised to seek alternative water sources for livestock and prioritize domestic and weak livestock water usage.*
- *Beki waterpoint is in near dry status; it is recommended to search for other water sources and prioritize domestic water use. Waterpoints A, B, C, etc., are in good status, and our suggested route will guide you there.*

- *Beki waterpoint is in seasonal dry status; it is recommended to search for other water sources. Please text "waterpoint" name to get the information about the waterpoints in good condition and our suggested route will guide you there.*

Based on the status of waterpoint different early action risk management interventions recommended to enhance pastoralists resilience and adaptation capacities (Table 1).

Table 1: Agropastoral and pastoral-advisory services to mitigate and adapt water-level changes

Waterpoint status	Scientific description	Definition towards local context	Proposed agropastoral and pastoral-advisory services
Good	The mean scaled depth over the previous 10 days is greater than the long-term median depth	Adequate amount of water level at this time	• Recommend using the water pond as usual as there is an adequate amount of water. • Continuously monitor water levels to ensure they remain within the optimal range. • There is a X% probability of no rainfall for month X week X; thus, reduce pond water consumption and conserve water for upcoming dry periods by promoting water-saving practices such as fixing leaks, avoiding excessive water usage, and recycling greywater for non-potable purposes. • Advise on regular maintenance of water ponds and purification methods to ensure clean water supply for household needs. • Educate farmers on the importance of clean water sources and proper sanitation to prevent waterborne diseases among livestock. • Recommended use of efficient irrigation techniques and crops • Regularly maintain and desilt the pond to remove accumulated debris, vegetation, and sediment that can reduce water volume and quality. • Involve local communities in pond restoration efforts through participatory planning, awareness-raising campaigns, and capacity-building workshops on water conservation and sustainable land management practices.

Watch	The scale depth over the previous 10 days is between 50% and 100% of the long-term median depth	Less adequate amount of water level at this time	• There is a X% probability of no rainfall for month X week X; thus, advise pastoralists and agro-pastoralists to use the water pond for domestic and livestock with optimizing livestock watering schedules. • There is a X% probability of rainfall for month X week X; thus, advise pastoralists and agro-pastoralists to use water ponds for all uses with irrigation schedules and focusing on high-value crops or drought-tolerant varieties to optimize water usage. • Suggest storing and preserving fodder to reduce the water requirements for the livestock feed during dry periods. • Regularly maintain and desilt the pond to remove accumulated debris, vegetation, and sediment that can reduce water volume and quality. • Involve local communities in pond restoration efforts through participatory planning, awareness-raising campaigns, and capacity-building workshops on water conservation and sustainable land management practices.
Alert	The scaled depth over the previous 10 days is between 3% and 50% of the long-term median depth.	Inadequate water level at this time	• There is a X% probability of no rainfall for month X week X; thus, advise pastoralists and agro-pastoralists to use the water pond for domestic and weak livestock with optimizing livestock watering schedules and use our movement route to identify water points with good status for other livestock. • There is a X% probability of rainfall for month X week X; thus, advise pastoralists and agro-pastoralists to use water ponds for domestic and livestock with optimizing livestock watering schedules. • Regularly maintain and desilt the pond to remove accumulated debris, vegetation, and sediment that can reduce water volume and quality. • Involve local communities in pond restoration efforts through participatory planning, awareness-raising campaigns, and capacity-building workshops on water conservation and sustainable land management practices.

Near dry	The scaled depth over the previous 10 days is less than 3% of the median depth.	Very small amount of water level at this time	• Prioritize domestic water needs for human consumption, cooking, and sanitation to safeguard public health and hygiene. • There is a X% probability of rainfall for month X week X; thus, advise pastoralists and agro-pastoralists to use water ponds for domestic and weak livestock with optimizing livestock watering schedules. • Alert households to impending water shortages and provide guidance on emergency water conservation measures such as limiting non-essential water use and storing emergency water supplies. • Initiate emergency measures such as rationing water, prioritizing livestock types and essential crops, and implementing water-sharing agreements among farmers. • Coordinate with local authorities or humanitarian organizations to facilitate access to emergency water sources. • Provide guidance on alternative water shortages coping strategies, such as selling non-essential livestock or adjusting herd sizes to match available water resources. • Suggest using our livestock migration route to the waterpoints with good status. • Regularly maintain and desilt the pond to remove accumulated debris, vegetation, and sediment that can reduce water volume and quality. • Involve local communities in pond restoration efforts through participatory planning, awareness-raising campaigns, and capacity-building workshops on water conservation and sustainable land management practices.

Seasonally dry	The scaled depth over the previous 10 days is almost zero due to the dry season with no rainfall.	No water available at this time.	• Suggest using our livestock movement route to the waterpoints with good status. Support pastoralists and agro-pastoralists in exploring alternative water sources such as groundwater wells, water trucking, community water supply schemes or accessing emergency livestock watering points to meet immediate water needs. • Recommend livestock destocking or relocation to areas with better water availability to reduce pressure on local water resources. • Coordinate emergency water supply interventions such as water trucking, and emergency borehole drilling. • Provide guidance on sanitation and hygiene practices to minimize health risks associated with no water availability in the water pond. • Conduct maintenance and repair work on waterpoints during dry periods to ensure they are ready to capture and store water when rainfall returns. • Regularly maintain and desilt the pond to remove accumulated debris, vegetation, and sediment that can reduce water volume and quality. • Involve local communities in pond restoration efforts through participatory planning, awareness-raising campaigns, and capacity-building workshops on water conservation and sustainable land management practices.

Implementing advisories through SMS services based on waterpoint conditions enables users to take proactive measures towards improved water management. Users can subscribe to the platform via the "Subscribe" button (Figure 25) to receive updates on waterpoint conditions and advisories. This service keeps users informed of any changes or developments, aiding in real-time decision-making regarding water management. The platform provides detailed information on each waterpoint, empowering users to make informed decisions in real-time regarding water management strategies, ultimately enhancing resilience and sustainability in pastoral communities.

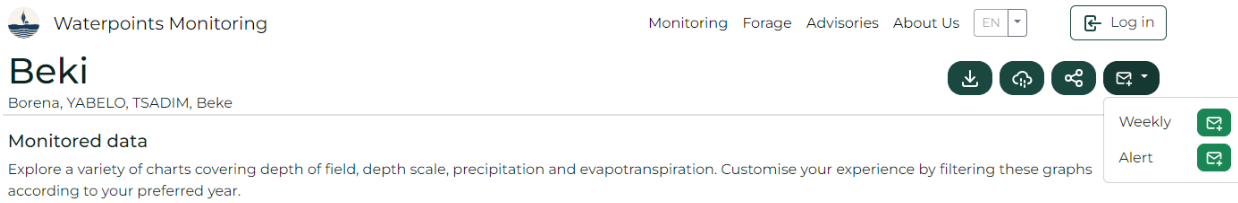


Figure 25. User subscription for weekly and alert information about the waterpoint of interest.

6.3. Climate Risk Management Advisory Service for Early Action

The agro-advisory service module (see also Table 1) will guide smallholder agro-pastoralists mitigating and adapting the changes in water availability and build resilience against water-related risks. The mitigation strategies and action plan based on the waterpoints status can be summarized as follows:

- ✓ *Pond X is in good status; you can continue using water as usual.*
- ✓ *Pond X is in watch status; it is recommended to conserve water as there is a high probability of water shortage.*
- ✓ *Pond X is in alert status; it is advised to seek alternative water sources for livestock and prioritize domestic water usage.*
- ✓ *Pond X is in dry status; it is recommended to search for other water sources. Ponds A, B, C, etc., are in good status, and our suggested route will guide you there.*

6.4. Data Analysis and Reporting

6.4.1. Generating reports

Researchers and extension service users can use the platform's generated data for further analysis. By using this user's training manual, users can leverage the platform's data effectively to make informed decisions regarding water management, grazing strategies, and livestock welfare. Moreover, researchers and extension service users are encouraged to:

- o *Compare current and forecasted water levels with historical averages to identify anomalies or deviations.*
- o *Utilize precipitation and evaporation data to forecast trends in water availability, aiding in proactive management strategies.*

- *Assess pasture health data to adapt grazing strategies and mitigate the risk of overgrazing, ensuring the sustainability of grazing areas.*
- *Incorporate climate forecasts to anticipate potential weather impacts on water sources and livestock, enabling proactive measures to be taken to mitigate risks and ensure resilience.*

Figure 26 illustrates the status of the Beki waterpoint within the view map interface, denoted by the color green, indicating a good water level condition. For a detailed classification of waterpoint statuses, users can refer to the advisory module, which categorizes waterpoints using different colors corresponding to their respective conditions. Upon quick inspection of the Beki waterpoint, it is noted that it is in a "Good" condition, highlighted with a green color. Additionally, the modeled scaled depth is reported as 83.65%, indicating a depth exceeding the median depth by more than 100%.

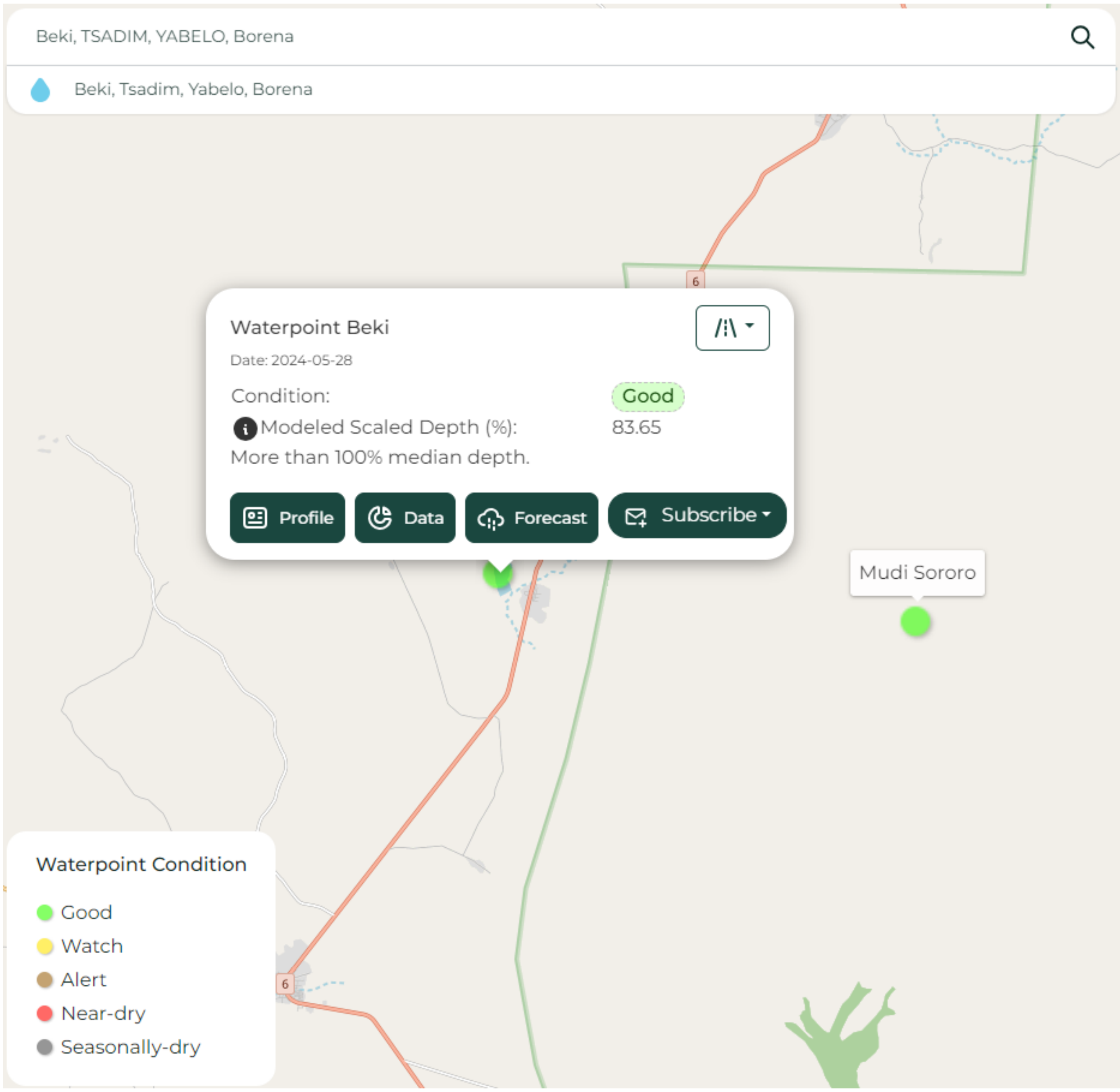


Figure 26. Graphs displaying a quick view of the Beki waterpoint condition.

6.4.2. Exporting and sharing data

The platform offers users the capability to export data in various formats, such as CSV, facilitating further analysis. Users have the flexibility to select the specific water balance components and timeframes they desire to export. This functionality enables users to download the data (as shown in Figure 27) for utilization in other analytical tools or software applications. The data download feature serves as a valuable resource for users, empowering them with the ability to conduct advanced analysis and integrate data with other datasets for comprehensive water resource management strategies. Upon downloading, the data is structured with each column representing specific parameters:

- *Date: The date corresponding to the data entry (first column)*
- *Modeled water depth: The simulated water depth value (second column).*
- *Water depth trend value: Trend value indicating the direction of change in water depth over time (third column).*
- *Scaled water depth: The scaled representation of water depth relative to historical maximum (fourth column).*
- *Scaled water depth trend value: Trend value indicating the direction of change in scaled water depth over time (fifth column).*
- *Modeled precipitation: The modeled precipitation amounts (sixth column).*
- *Precipitation trend value: Trend value indicating the direction of change in precipitation over time (seventh column).*
- *Modeled evaporation: The modeled evaporation rates (eighth column).*
- *Evaporation trend value: Trend value indicating the direction of change in evaporation rate over time (ninth column).*

By organizing data in this format, users can easily interpret and analyze the exported data, facilitating informed decision-making in water resource management endeavors.

date	depth	trend_valu	scaled_de	trend_valu	rain	trend_valu	evaporatio	trend_valu
1/1/2024	0.27	0.134906	13.49	6.745275	0	0	5.72	5.72467
1/2/2024	0.26	0.130533	13.05	6.52665	0	0	5.75	5.74544
1/3/2024	0.25	0.126434	12.64	6.321675	0	0	5.2	5.19839
1/4/2024	0.24	0.121969	12.2	6.09845	0	0	5.93	5.92931
1/5/2024	0.23	0.122872	11.75	7.221534	0	0	6	6.00252
1/6/2024	0.23	0.114024	11.3	5.896588	0	0	5.85	5.84796
1/7/2024	0.22	0.10858	10.86	5.428975	0	0	5.93	5.92832
1/8/2024	0.21	0.105899	10.41	5.294961	0	0	6.04	6.04326
1/9/2024	0.2	0.099492	9.95	4.974575	0	0	6.13	6.13302

Figure *27*. Download data format.

Maintenance and Troubleshooting

7.1. System Updates and Upgrades

The developer team is committed to continually enhancing the digital platform to provide you with the best possible user experience. As part of this ongoing improvement process, there may be times when the system undergoes updates or upgrades that temporarily impact data availability or functionality. To ensure the platform remains secure, stable, and up-to-date, we regularly schedule system maintenance and software updates. During these periods, certain features or data may be temporarily unavailable as the updates are implemented. We make every effort to minimize disruptions and schedule maintenance windows during off-peak hours to reduce the impact on users. However, you may occasionally encounter messages like "At the moment there is no data available" or other notifications about temporary service interruptions (see Figure 28 below).

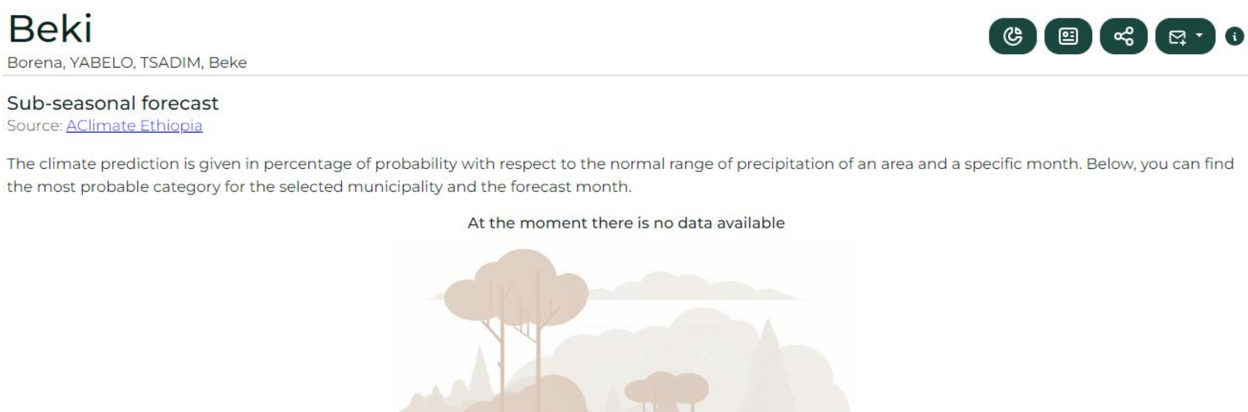


Figure *28.* Example of "No Data Available" Message

7.2. Contacting Support

The Alliance Bioversity International and CIAT climate action team are committed to continually improving the platform to better serve our users. Describe any difficulties you have faced in navigating or using the features of the platform. Please provide as much detail as possible so we can look into your feedback and work to enhance the platform. If you've encountered any challenges or have feedback, please let us know by emailing to S.Alemayehu@cgiar.org. We appreciate you taking the time to help us improve.

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Annex

Annex 1: Staff gauge installation user's guide

☐ **Planning, Coordination and Training on Staff Gauge Installation** **Main tasks:** • *Assign roles and responsibilities, and* • *Identify and gather necessary resources such as staff gauges.* **Specific tasks:** • *Hold a kickoff meeting with the team.* • *Review the target locations and logistical considerations.* • *Ensure all necessary permissions and permits are secured.* • *Prepare a detailed checklist of equipment and supplies needed (staff gauges, installation tools, GPS, data recording sheets, etc.).* • *Deliver training on how to install the staff gauges (theoretically)* • *Hold 3-4 hours training and capacity building program for the selected staff.* • *Implement safety protocols for working in remote areas (first aid kits and emergency plans).*
☐ **Equipment Preparation and Packing** **Main task:** • *Ensure all equipment is ready and in good condition.* **Specific tasks:** • *Label staff gauge reading.* • *Inspect and test all staff gauges and installation tools.* • *Pack the equipment in a manner suitable for transportation to remote areas.*

☐ **Travel to the First Remote Location** **Main task:** • *Transport team and equipment to the first target area.* **Specific tasks:** • *Coordinate transportation logistics (vehicles, fuel, routes).* • *Ensure the safety and security of the team and equipment during travel.*
☐ **Site Survey and Preparation for Installation** **Main task:** • *Assess the site conditions and prepare for installation.* **Specific tasks:** • *Conduct a site survey to determine the best locations for staff gauges.* • *Clear and prepare the area for installation, ensuring it's safe and accessible.*
☐ **Installation of Staff Gauges** **Main task:** • *Install staff gauges at identified site.* **Specific tasks:** • *Install staff gauges by ensuring they are securely anchored.* • *Record precise GPS coordinate of the installed gauge.* • *Test the stability and readability of the installed gauge.*
☐ **Data Collection for Waterpoint Profile Mapping** **Main task:** • *Waterpoint profile mapping* **Specific tasks:**

- *Ensure reliable communication methods (mobile phones) for remote areas.*
- *Keep detailed records of all activities, including site conditions, installation procedures, and data collected.*
- *Collect relevant data on livestock types and numbers for each waterpoint.*
- *Collect data on demographic characteristics and water use and management.*
- *Collect data on land cover/land use, and soil classes.*
- *Collect data on construction year of waterpoint, operation type, ownership, and maintenance and monitoring approach.*
- *Collect data on population number and socio-economic condition.*
- *Collect data on gender dynamics.*