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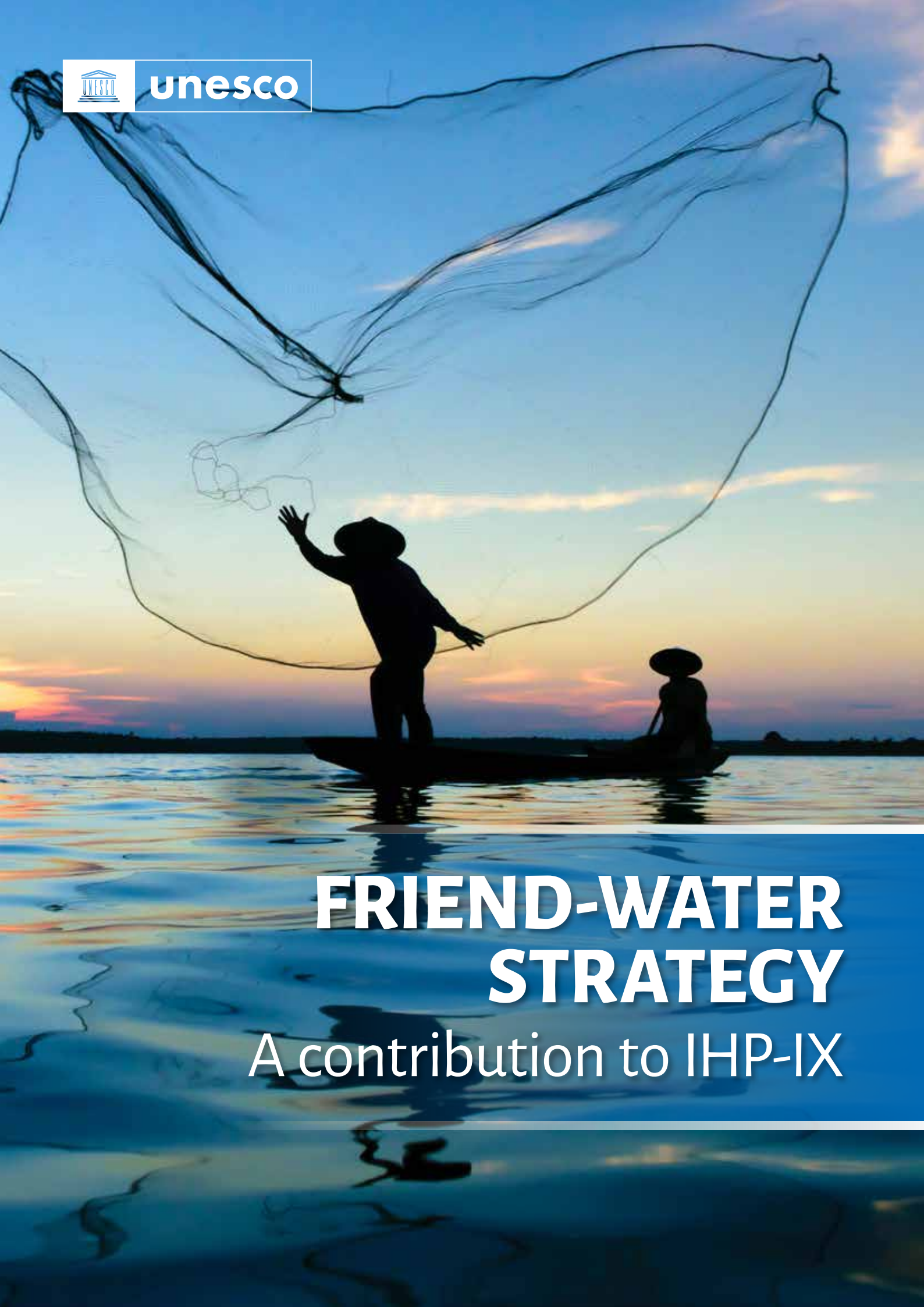
Flagship Initiative Strategy

FRIEND-Water Strategy: A Contribution to IHP IX



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FRIEND-WATER STRATEGY

A contribution to IHP-IX

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1. THE FRIEND-WATER FLAGSHIP INITIATIVE

1.1. Towards a new FRIEND-Water Strategy

FRIEND-Water (Flow Regimes from International Experimental and Network Data) is a flagship initiative of the Intergovernmental Hydrological Programme (IHP) of UNESCO, founded in 1985. FRIEND-Water seeks to facilitate, promote, and foster collaborations across borders between scientists (hydrologists and related disciplines) to conduct studies on shared river basins. FRIEND-Water is one of the fifteen Flagship Initiatives approved by the Intergovernmental Council of IHP, based on the needs of UNESCO Member States. Flagships work on long-term crosscutting themes related to hydrology and water management issues and their global aim is to enhance the management of water resources through science-based recommendations, education and capacity building. Involving researchers from over 150 countries, the FRIEND-Water programme evolved into regional groups spread around the world, focusing on Europe, the Mediterranean, Central and South America, West and Central Africa, Asia-Pacific, Southern Africa, Congo, Nile and Hindu-Kush basins.

Since its inception in 1985, the activities of the FRIEND-Water Programme (FWP) have also evolved significantly, with urgent topics such as climate change leading to a promotion of collaborative research agendas across borders on rivers and aquifer basins. Given the above, a growing interest in common shared data and science emerged. Upcoming activities of this Flagship Initiative will present an opportunity to think about how to respond to the triple planetary crisis, which includes climate change, pollution and biodiversity loss, and how the FRIEND-Water Programme can contribute to addressing these global challenges through new practices in science development.

Such activities will be aligned with the objectives of the 9th phase of IHP 'Science for a Water Secure World in a Changing Environment'. IHP-IX (2022-2029) represents a methodological response towards transdisciplinarity to achieve a water-secure world in today's complex context. Its strategic plan addresses these ambitions through five priority areas: 1) Scientific Research and Innovation; 2) Water Education in the Fourth Industrial Revolution including Sustainability; 3) Bridging the Data-knowledge Gap; 4) Integrated Water Management Under Conditions of Global Change; and 5) Water Governance Based on Science for Mitigation, Adaptation and Resilience. The IHP-IX programmatic content is organized into 34 outputs to maximize the support to Member States in achieving SDG6 targets and its related UN SDG6 Global Accelerator Framework, UN-Water Decade for Action (2018-2028) and other water-related goals and targets, by generating scientific knowledge and strengthening data availability to support informed decision-making.

1.2 Previous FRIEND-Water Achievements

During the latest reporting period of 2014-2022, FRIEND-Water was active across its eight regional programmes, implementing numerous workshops, meetings, and conferences. Over 90 events were organised, gathering other 900 participants from 150 countries. Conferences include the Global FRIEND conference in Montpellier (2014) and Global FRIEND conference in Beijing (2018), as well as a series of conferences on the Hydrology of African Large River basins, held in Hammamet (2015), Dakar (2016), Alger (2018) and Cotonou (2021). FRIEND-Water was also active in sessions at EGU and AGU meetings, as well as IAHS events notably the 2022 General Assembly in Montpellier. Training courses and workshops covering topics such as Hydrological Modelling and Modelling Applications, Water Quality and Emergent Pollutants, and Integrated Basin Management were organised across the programmes globally.

Scientific and academic activities in the network led to hundreds of scientific articles from individual researchers and research groups associated with the FRIEND-Water programme. Over 350 papers were

published in indexed journals, and over 1000 communications were prepared by the FRIEND-Water groups. Two special issues in the Proceedings of IAHS were published following the FRIEND-Water conferences in Cotonou and Beijing. Further detail on these achievements of the FWP can be consulted in the publication "FRIEND-Water – A Global Perspective 2014-2022. Facts and Figures" published in 2023 by UNESCO and openly accessible at UNESDOC[1].

Two main issues challenged the implementation of FRIEND-Water activities: the security of financial support and the difficulties posed by the COVID-19 pandemic. To address the former, there was an effort to develop synergies with other IHP initiatives, such as Ecohydrology, G-WADI, ISI, WLRI, IDI and some regional groups. In 2020, the Covid-19 pandemic prevented almost all scheduled events from taking place as planned. Some were converted into online meetings, such as the EURO FRIEND project groups held in a virtual format during the Assembly of the European Geophysical Union (EGU2020: Sharing Geosciences Online). Even during these challenging times, under the framework of FRIEND-Water dozens of meetings took place worldwide. Some events were merged with other conferences, such as the IAHS General Assembly in Montpellier (2022), and FRIEND-Water was also present at the World Water Forum, held in Dakar on 22-26 March 2022, after being postponed one year.

The FRIEND-Water programme now possesses a dedicated Secretariat to coordinate the programme in close cooperation with the UNESCO-IHP Secretariat. The International Center for Interdisciplinary Research on Water Systems Dynamics (ICIREWARD) in Montpellier, France, a Category II Centre under UNESCO's auspices, was endorsed in 2020 to become the global secretariat for the FRIEND-Water programme.

A new chair of the FRIEND-Water Intergroup Coordination Committee (FIGCC) was appointed at the beginning of 2023. A call to renew Regional and Thematic Coordinators was launched in 2024 to align the FRIEND initiative with the IXth phase of the IHP programme. In 2023, the 9th FRIEND-Water Global Conference was held in Dakar gathering over 100 participants from 24 countries for scientific and training sessions and allowing the global FRIEND community to meet and exchange once again face-to-face.

1.3 Identified Knowledge Gaps, Needs and Opportunities

FRIEND-Water has shown to be a very solid and active Flagship Initiative (FI). This was confirmed by the Flagship Initiatives performance evaluation by UNESCO-IHP, or the resolution made by the UNESCO-IHP Intergovernmental Council in April 2022 regarding this FI. As for the other UNESCO Flagships, FRIEND-Water was reviewed by the IHP Council in 2018, which is also in charge of planning, defining priorities and supervising its execution.

FRIEND-Water was assessed in 2018, based on its reported activities. This FI obtained a relevance score of 1.6, above the average of 1.3 for all FIs, meaning that this initiative has significant relevance within the activities of IHP. The visibility score of 1.7 (against the average of 1.3) should also be highlighted. The main outcomes and recommended actions, particularly relevant from FRIEND-Water extracted from the IHP Flagship Evaluation Report are listed below:

- **Effectiveness/achievement of Objectives:** All FIs have issued publications (i.e., scientific articles, implementation reports based on case studies, training manuals, etc) and practically all FIs have actively participated in conferences, presentations or workshops. However, some FIs, including FRIEND-Water, have reported less than 13 activities in a 5-year report.
  - **Action 1:** The Assessment Report recommends FRIEND-Water to organize more events. *This was anticipated by the FIGCC Chair and Regional Coordinators and the number of activities increased after 2018 as highlighted in the previous section.*
- **Visibility:** Nine FIs have independent websites aiming at reinforced visibility, while six others have an entry on the IHP or other partners' websites.

1 https://unesdoc.unesco.org/ark:/48223/pf0000384838?posInSet=10&queryId=b59d7f9c-aa0f-4237-b3be-3be6d63b3fe4

- **Action 2:** The webpage of FRIEND-Water needs to be updated to keep the visibility of the programme. *This task had been postponed several times and has been addressed thanks to the support of the newly established secretariat of the FRIEND-Water programme (the UNESCO Cat II Centre ICIREWARD)*

- **Action 3:** FRIEND-Water logo should be updated. This could be subject to a call within the regional programmes.

- **Action 4:** Keep expanding the FRIEND-Water community. *With the support of the new secretariat and the renewed Coordination team, FRIEND is now working to strengthen and broaden the FRIEND network globally.*

After the 2018 evaluation of flagship initiatives, the IHP Council endorsed Resolution XXV-3 "Continuation of the Flagship Initiatives during IHP-IX" and decided that the FRIEND-Water Programme was recommended to continue given its satisfactory performance during IHP-VIII. At the same time, the council requested all Flagship Initiatives to follow the new Flagship Initiative Framework and to align their strategy with the approved strategic framework of IHP-IX – as reflected in this Implementation Plan.

Moving forward, with water assuming an increasingly central role in climate change discussions, it is also expected that the FWP objectives become aligned with the goals defined in the Paris Agreement, the 2030 Agenda and the Sustainable Development Goals, supporting each region in the path to achieve a resilient and sustainable water management. It is highly recommended the deepening of connections with other water-related Flagship Initiatives of UNESCO to take improved advantage of the vast experience among the UNESCO Water Family.

During the past evaluation period, some regional programmes experienced greater difficulties in developing activities and mobilising regional networks. These resulted partly from limited funding and led the Hindu-Kush Himalayan group to be merged into the Asian-Pacific regional programme in 2018. In 2024, as part of the new strategy of this Flagship Initiative, it was decided to merge the Nile group with the Southern Africa programme to become the East and Southern Africa regional group. Likewise, the West Africa and Congo regional groups were redefined to become a single West and Central Africa group. These changes seek to have groups of sufficient size to enhance the visibility and strength of respective regional groups, increase funding opportunities, and facilitate reporting under the current IHH-IX phase (2023-2029).

2. OBJECTIVES OF THE FRIEND-WATER PROGRAMME

The UNESCO FRIEND-Water Flagship Initiative is an international research programme whose aim is to help set up regional networks **to improve the understanding of the impacts of global changes on hydrological regimes and their extremes in small and large (transboundary) basins and to encourage the development of Open Data Systems for increased knowledge and data sharing.**

As a cross-cutting initiative of UNESCO's Intergovernmental Hydrological Program (IHP), FRIEND-Water notably contributes to research on regional water resources (long-term variability, IWRM, Nexus, socio-hydrology), water-related disasters (floods, droughts), global change and the water cycle, and water education and capacity building. Activities focus on i) stimulating research and training activities carried out by regional researchers in hydrology, related topics and shared databases and ii) promoting dialogue and knowledge exchange between scientists, local communities and policymakers. These activities seek to encourage UNESCO Member States to adopt and use tools and methodologies developed under the framework of the FRIEND-

Water initiative to support better understanding and adaptation to the impacts of global change, in small and large (transboundary) basins. FRIEND-Water is notably involved in water education and capacity building to support young researchers and relevant stakeholders of hydrological services, with a strong presence across the global South.

IMPACT	UNESCO Members States adopted and use tools and methodologies developed under the framework of the FRIEND-Water initiative, towards the improved understanding of the impacts of global changes on hydrological regimes and their extremes in small and large transboundary basins and the development of Open Data Systems for increased knowledge and data sharing.			
OUTCOMES	Member States have endorsed and adopted FRIEND-Water methodologies and tools for **collecting and sharing data** on freshwater resources	Member States are equipped and trained in methods and tools to better predict the impacts of **global change on hydrological regimes and their extremes**	Multiple stakeholders in member states are equipped with knowledge and tools to measure the impact on the **WEFE Nexus** of **river basin trajectories** in small and large transboundary basins	Member states are provided with **interdisciplinary educational** approaches and learning materials for holistic water education
FRIEND-WATER EXPECTED RESULTS (OUTPUTS)	**Expected Result 1** Tools and methods have been developed to increase the **monitoring of freshwater resources and data sharing**, based on novel, low cost approaches exploiting field and **Open Access data including Earth observations**	**Expected Result 2** Advanced modelling tools and methodologies have been developed to increase the **prediction of global change impacts on hydrological regimes and their extremes** (floods, droughts) and disseminated to support development of local EWS/DRR	**Expected Result 3** Advanced modelling tools and interdisciplinary approaches on **water-society interactions** have been developed to support fair and **equitable water management** between multiple stakeholders	**Expected Result 4** **Interdisciplinary educational resources and programmes**/ diplomas to support research in monitoring, modelling and sharing knowledge on freshwater resources
CORRESPONDING IHP-IX OUTPUTS	Output 3.1, 3.2, 3.3 Output 1.9	Output 1.6, 1.7	Output 1.5, 1.7	Output 2.3
ACTIVITIES	Data rescue Experimental Basins RS, citizen science OA platforms, IHP-WINS	Modelling tools and EWS Publications Trainings International conferences	Sociohydro modelling & DSS International conferences Publications Interdisciplinary training	Operational support MSc courses MOOC

FIGURE 1 FRIEND-WATER THEORY OF CHANGE DIAGRAM

To achieve these overarching goals, the FRIEND-Water initiative is based on four main pillars:

1) Collecting and sharing data on freshwater resources;

2) Understanding and predicting the impacts of global change on hydrological regimes and their extremes;

3) Understanding and predicting the impacts on the water-environment-food-energy nexus of river basin trajectories in small and large (transboundary) basins;

4) Developing interdisciplinary educational approaches and learning materials for holistic water education.

The outcomes and outputs of the programme for the current IHP-IX phase (2023-2029) are presented in the Theory of Change Diagram (Figure 1).

3. IMPLEMENTATION PLAN

The FRIEND-Water Strategic Framework and Theory of Change are accompanied by a detailed Implementation Plan, describing the specific objectives and activities this flagship initiative seeks to address in the course of the 9th phase of IHP (2023-2029). The FRIEND-Water Implementation Plan is divided into four Expected Results which encompass specific key activities, aligned with the IHP-IX Strategic Programme, as described below:

1. EXPECTED RESULT 1: INCREASED HYDROCLIMATIC DATA COLLECTION AND SHARING

Expected Result 1.1.: Raising availability and exchange of field observations in hydrology

In line with FRIEND's objectives since its inception in 1985, several activities of the Flagship Initiative seek to improve the collection and sharing of hydroclimatic data across all FRIEND-Water regions. Sound understanding of hydrological processes and large-scale variations requires long-term observations from field observation networks, however, the availability of reliable, accurate ground observations has declined in many basins across the world, notably in Africa. Activities under Result 1.1. focus on i) the rescue of existing field data and archives; ii) supporting/consolidating the collection of experimental research data and iii) supporting/improving the exchange of hydrological data through open-access platforms.

Substantial amounts of hydrometeorological data are available across databases and archives around the world and remain unavailable to the wider water community. Activities will focus on data rescue tools to digitize historical data in paper (e.g. Nunieau), inventorying/compiling/collecting data spread across national databases from WMO/GRDC global databases, and supporting the upload of additional data from national, research and other databases and observations in line with initiatives such as WMO HydroSOS, IAHS Rehydrate and CEH ROBIN. Flow data from European rivers will for instance be regularly updated, as part of the further development of information systems such as the Global Runoff Data Centre (GRDC) and other relevant data centres, and observational networks of the Global Terrestrial Network for Hydrology (GTN-H). Activities will centre on data collection but also capacity building of national services as well as publications (research papers, policy briefs) on the importance and value of open access hydrological data, as well as guidelines on data quality standards and best practices. Though focussed on hydrometric data, these activities will across certain regions include data related to groundwater and water quality issues.

In parallel, the ongoing collection of hydrological data from ground observation networks must be encouraged and supported to consolidate long-term data collection in hydrology. An inventory of existing Experimental Research Basins and partner networks will be conducted and support sought to reactive ERBs and develop additional long-standing experimental networks. In line with the interdisciplinary nature of FRIEND, these observatories must focus on acquiring hydrometeorological ground observations but also additional variables and processes/dynamics relevant to Ecohydrology and Socio-hydrology disciplines.

Furthermore, activities will seek to improve data sharing and exchanges through OA platforms. Following the philosophy of Open Science, the use of Open Data and Open Software Tools must be encouraged to promote/support increased dissemination and access to hydrological data. Experimental data and historical data collected must be integrated within OA initiatives for easiness of access and improved dissemination and use by all relevant stakeholders (academic and operational). A dedicated survey to review Open and Free hydrology practices within the water community will be carried out, before recommending and implementing an adequate strategy for the FRIEND community. A user manual as well as a dedicated workshop will be organised to promote best practices. Available platforms notably include IAHS Digital Water Globe and the UNESCO-IHP's Water Information Network System (IHP-WINS)[2] as well as other initiatives such as ROBIN, SIEREM, and Datasuds. Launched in 2017, WINS is an open-access platform for sharing, accessing and visualizing water-related information; promoting the connection amongst water stakeholders to support decision-making and policy recommendations; and building capacity for a science-based water resources management. WINS provides maps, reports and graphs covering the entire water cycle, which can be combined to create new, customized outputs. Compatibility between, or merging of, national-scale datasets is planned to be further investigated to contribute to large-scale databases.

Expected Result 1.2.: Improved monitoring of resources and hydroclimatic variables through the increased access and uptake of EO and citizen science

In parallel to the decline in field observations, new sources of hydroclimatic data have emerged. Activities of FRIEND notably centre on the i) development and application of Earth Observations in multiple environments, and ii) the contribution of citizen science.

The rise in availability of freely accessible earth observations at rising spatial and temporal resolutions provides increased opportunities in multiple applications of hydrology, notably in data-scarce environments and at large spatial scales. Products from NASA, ESA/Copernicus notably provide gridded rainfall, ET observations, DEM/topography, land use classifications, and a growing number of products including those from the SWOT mission provide altimetric data suitable for estimating water levels across rivers and lakes. EO data will be inventoried and compared to ground observations to explore their value and accuracy but also to adapt, and calibrate geoprocessing methods and optimize their use in multiple settings and applications. These include direct monitoring of lakes, wetlands and small water bodies, and have become essential inputs into hydrological modelling, fuelling lumped and conceptual models used in the study of floods, basin water management, agricultural water availability, but also water quality issues. Links between the FRIEND community and EO communities of practice will also be strengthened through participation in RS conferences including ESA events, EO-Africa and designated sessions in FRIEND conferences. Training on RS methods and applications as well as the production and sharing of data papers, and code (Google Earth Engine scripts, Jupyter notebooks, etc.) will also be supported.

Another result/activity relates to the use of Citizen Science in hydrology. Citizen Science engages volunteers to collect (and sometimes analyse) water data, fostering a collaborative/participatory, field-based approach to understanding water systems. CS enhances data collection in data-scarce environments, but the participatory approach also favours greater understanding and investment by local stakeholders in water issues, empowering communities to contribute to scientific research and decision-making processes. Individuals can monitor water quality, track changes in water levels and rainfall over time, and record flood levels and damages. Citizen science is particularly relevant in the context of hydroclimatic risks (droughts, floods), bridging the gap between scientists and the public and helping both generate essential knowledge of hydrological phenomena while increasing

2 WINS available at: https://ihp-wins.unesco.org/

local understanding of the water resources variability and risks and helping local populations prepare and adapt to these. Best practices for CS data collection will be shared and the contribution of innovative technologies such as IoT and low-cost sensors for river flow and rainfall monitoring will be tested.

Expected Result 1.3: Strengthened communication and outreach of FRIEND-Water initiative

These activities rely on the quality and breadth of the collaborations within the FRIEND initiative. In parallel to all activities above, the FRIEND will be strengthened through i) improved communication between FRIEND regions and ii) better connections with the wider water family to strengthen its role as a Global network for data and knowledge exchange in hydrology.

A key activity is to promote the communication between FRIEND-Water Regional Groups, which shall be achieved through regular meetings between FRIEND-Water Regional Coordinators, and the increased data and knowledge sharing between regions. The introduction of Thematic Coordinators will also serve to encourage collaborations and exchanges between regions on four designated themes (Data, Extremes, Water-Society, and Water Education). Cross-regional events will be organised through sessions at scientific conferences (EGU, IAHS), the FRIEND Conferences on African Hydrology and in 2027 (tentatively) the 10th FRIEND-Water Global Conference shall be held to share and promote activities developed in Regional Group and foster collaborations. Additional collaboration through the implementation of joint research (and development) projects will be strongly encouraged. As for the previous reporting periods, a publication on the FRIEND-Water achievements in 2022-2029 shall be developed and disseminated.

In parallel, FRIEND will continue to strengthen its links/relations with partners including IAHS, WMO and UNESCO IHP notably the World Large Rivers Initiative, G-Wadi and Ecohydrology groups. Joint scientific events will be organised, and FRIEND will collaborate directly with initiatives, such as the IAHS HELPING working groups, the IAHS Africa Regional Committee, etc. FRIEND will also update its online presence (website, social media, webinars) to ensure effective communication and outreach of the FRIEND-Water Initiative and encourage new members to join, notably more early-career, female researchers.

2. EXPECTED RESULT 2: INCREASED UNDERSTANDING OF THE IMPACTS OF GLOBAL CHANGE ON HYDROLOGICAL REGIMES AND THEIR EXTREMES

Expected Result 2.1: Raised understanding of the impact of climate changes on hydrological regimes and their extremes

FRIEND has progressively reinforced its role in exploiting the vast databases produced to analyse and better understand regional hydrology dynamics. Substantial progress has been made in the detection and projections of hydrological extremes, and research activities in the network will continue to focus on exploring historical variability and impacts of climate change on hydrological regimes. Climate change has been shown to alter the frequency, intensity, and spatial distribution of rainfall events, raising the likelihood of extreme events, including droughts and floods.

Detection of climate indices and large-scale patterns directly from hydrological data is required. As catchment characteristics play a dominant role in filtering out climate variability on river flow, including hydrological extremes, efforts need to focus on improving the representation of key hydrological processes on a large scale and accounting for the role of groundwater, land use and human activities vs climate variations. Attribution studies on the cause and processes leading to extreme events (floods, droughts) require improved knowledge of how weather anomalies drive hydrological extremes, as well as process-based hydrological models capable of representing dynamic changes in environmental conditions. In parallel, rainfall and evapotranspiration projections under climate scenarios produced by several GCM models from CMIP5/CMIP6 and downscaled RCMs will be compared across several FRIEND regions. Improved hydrological models will help forecast the amplitude and frequency of hydrological extremes and guide disaster risk reduction and early warning systems.

Reflecting the interdisciplinary nature of hydrology, impacts of extremes on socio-economic and environmental conditions will also be considered. Furthermore, understanding compound extremes is crucial for assessing and managing risks associated with climate change and variability. Compound extremes in hydrology refer to concurrent or sequential occurrences of multiple extreme hydrological events, such as floods, droughts, heatwaves, or storms. These events can have interconnected impacts on water resources, ecosystems, infrastructure, and human communities, often exacerbating the severity and complexity of their effects. For example, a drought followed by heavy rainfall can lead to flash floods and landslides, posing significant challenges for water management and disaster risk reduction.

Hydrological forecasts under global change will also be used to drive a global update of the datasets and guidelines (rules, formulae) used to calculate flow return periods and define hydrological standards (norms) in engineering. Understanding flow return periods helps water resource managers, engineers, and planners design infrastructure, establish floodplain management policies, and assess the potential risks associated with different flow magnitudes. It allows them to make informed decisions about flood protection measures, land use planning, and emergency preparedness strategies. These norms must be updated to account for the shift in climate over the past 50 years (non-stationarity) and design suitable water infrastructure to meet the demands of the planning, agriculture and energy ministries.

Research activities will be carried out in close collaboration with a network of universities and research institutes around the world. Academic training and supervision of early career scientists (PhD, postdocs) will contribute to increased capacities and knowledge on innovative tools and methodologies, while additional training on modelling tools and data analysis will be provided to operational partners. Outputs will be shared through scientific publications and communications at international conferences, and contributions to policy briefs (including COP/IPCC reports).

Expected Result 2.2: Reducing hydroclimatic vulnerability and supporting adaptation and preparedness of populations

Outputs from research activities detailed above will contribute to the development and implementation of Early Warning Systems with local stakeholders to support adaptation and preparedness of affected populations. Early warning systems in hydrology exploit near real-time data and predictive models to forecast the impact of hydrological extremes such as floods and droughts. These systems can incorporate various monitoring technologies, including remote sensing and sensor networks, to detect changes in water levels and precipitation patterns and issue short to medium-range forecasts of water levels or availability. Integration with communication networks ensures that warnings reach vulnerable communities, enhancing disaster resilience and response capabilities, and ultimately reducing risks to lives and property. Research activities seek to combine classical bottom-up approaches, which use hazard, exposure and vulnerability as a basis, with top-down approaches including forecasting to change from reactive to pro-active risk management. The suitability of available global tools such as the Copernicus GloFAS or the WMO HYDROSOS forecasting capabilities will be evaluated and compared with site-specific tools developed in FRIEND regions (West Africa, Europe). A critical appraisal of indices and indicators provided by these approaches will be developed, as well as a review of the effectiveness of reactive and proactive strategies by local governments in addressing extreme events, notably in West Africa.

3. EXPECTED RESULT 3: INCREASED UNDERSTANDING OF WATER-SOCIETY INTERACTIONS IN SMALL AND LARGE TRANSBOUNDARY BASINS

Expected Result 3.1: Raised understanding of water-society interactions within watersheds

Water demand is constantly growing due to economic development and population growth, raising the need for joint planning and management based on sound research and data. The development of large dams,

for example in Asia and Africa to meet growing demands for hydropower and irrigation, introduce major hydrological changes, reducing the amplitude of annual floods of large rivers, and their associated ecosystem services. Understanding these changes and evaluating the trade-offs for the Water-energy-food-ecosystems (WEFE) nexus requires a detailed understanding of the hydrological and human dynamics and their impacts across these interconnected sectors. Working on several large transboundary river basins of the world (Nile, Congo, Hindu-Kush, Mekong, Niger, Senegal, Amazon, Plata…), FRIEND-Water continues to play an active role in i) raising understanding of water-society interactions; ii) improving inclusive governance of water resources in large, transboundary basins but also smaller shared basins.

Research notably focuses on modelling water use trajectories, global change impacts on the WEFE nexus, the management of river basin resources and the operation of dams and reservoirs. More widely, the recent surge in scientific literature on socio-hydrology highlights the growing recognition of the importance and difficulties in studying the mutual interactions in human-water systems (i.e. human influences on water systems and vice versa). The broad, complex interactions and retroactions of coupled human-water systems require new interdisciplinary approaches, capable of incorporating the approach and viewpoints of other disciplines, rather than simply combining their results. These help address water and society issues from a different perspective, allow new topics and new questions to be investigated and generated, and feed into wider socio-hydrological modelling research. Research within the FRIEND network will seek to review the advances in socio-hydrology and help promote interdisciplinary approaches, whilst highlighting suitable frameworks and guidelines and identifying remaining challenges. In addition to publications, FRIEND will develop training on interdisciplinarity, and suitable tools and models, and share results through dedicated sessions and conferences. The value of collaborative living labs as demonstrative case studies will also be explored. Links with the Ecohydrology group will also seek to better understand ecological characteristics and processes within river basins and promote nature-based solutions to better manage water resources.

Expected Result 3.2: Improved, inclusive, governance of water resources

Research results will be employed to support stakeholders in the operational management of water resources within small, and large transboundary basins. Working alongside river basin agencies, FRIEND notably provides data and models and assists in the development of decision support systems (DSS). These tools serve for instance to visualize the impacts of river basin development choices on multiple sectors in the basin through a series of user-defined indicators, maps and dashboards. FRIEND will accompany river basin agencies in developing scenarios and selecting optimal river basin planning pathways in line with the objectives of the basin countries and stakeholders. This is achieved through a series of participative workshops (serious games, scenario development workshops), the development of models, tools and guidelines, as well as dedicated training to operational partners. FRIEND also contributes to modelling reservoirs and dams and supports the operational management of reservoirs, dams and other hydraulic infrastructure (weirs, irrigation perimeters, etc.) through the provision of tools and training.

To build capabilities and enhance cooperation amongst partners in shared basins, training will focus on hydrological tools but also wider aspects, related to transboundary water governances, water laws and conflicts, hydro-diplomacy, gender and institutional aspects. These are essential in large transboundary basins where FRIEND operates as river basin management is confronted with ambitious national development plans and complex political dynamics.

4. EXPECTED RESULT 4: RAISED ACCESS TO INTERDISCIPLINARY, EDUCATIONAL RESOURCES AND PROGRAMMES FOR CAPACITY BUILDING OF THE WATER SCIENCE COMMUNITY

Expected Result 4.1: Raised access to educational programmes, training and mobilities

FRIEND actively collaborates with numerous academic partners across all regions including several from the global South. The FRIEND secretariat has since 2020 ensured by the UNESCO Cat II Centre ICIREWARD,

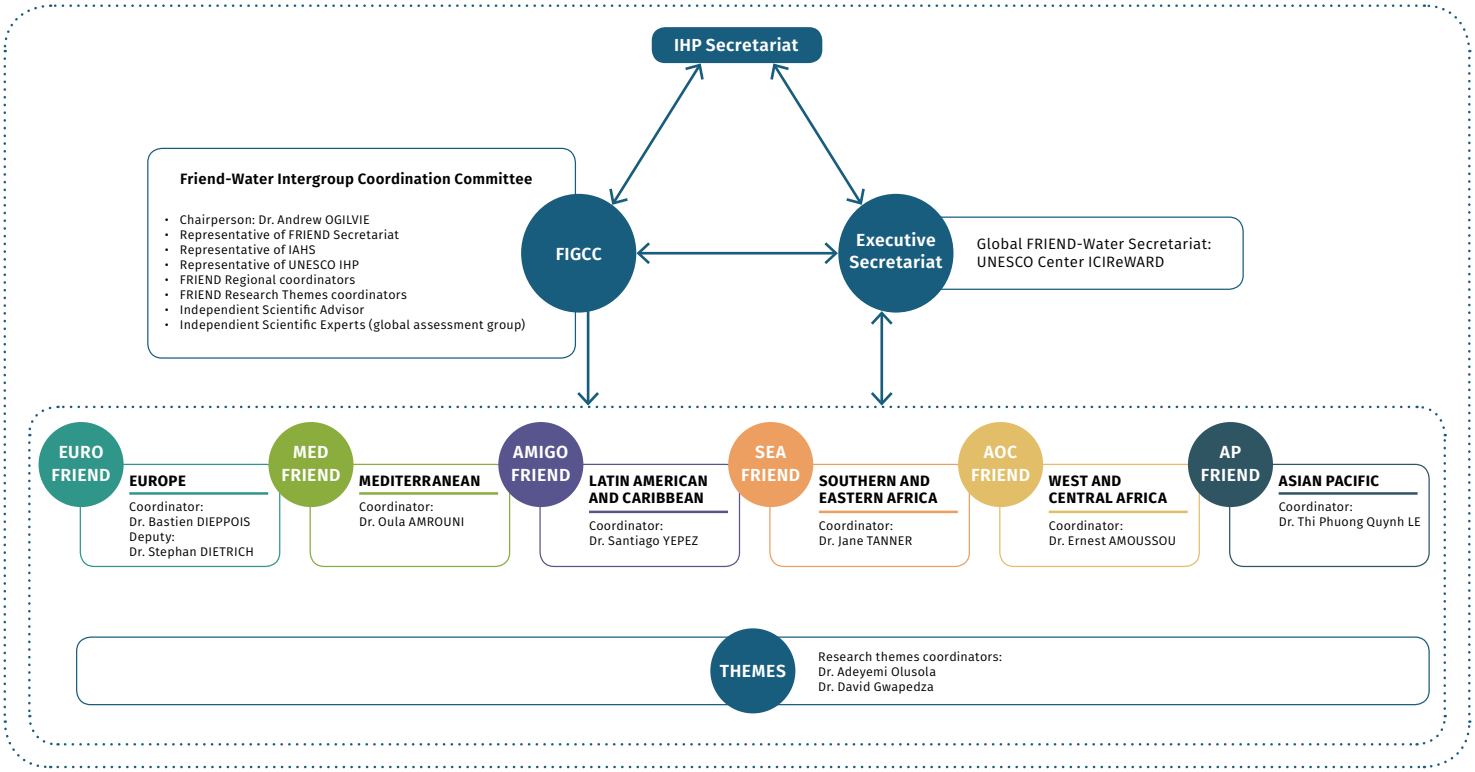
which brings together 13 partner academic and training institutes in Montpellier and surroundings (IRD, CIRAD, CNRS, University of Montpellier, INRAE, etc.) providing increased opportunities to educational and training possibilities for the FRIEND initiative. Activities of the FRIEND group will continue to actively support the supervision and training of students at the university level (MSc, PhD, postdoctorate) whilst also contributing to the development of interdisciplinary academic content. This includes co-creating a Master's degree on complex societal challenges in the face of global changes associated with CHARM-EU to engage the experts within the FRIEND network and train students from several FRIEND regions. Workshops in design thinking, serious games, and low-cost instrumentation will be organized, as well as summer schools on early warning systems and hydrometry. Mobilities between countries and institutes will also be supported, to encourage south-south collaboration and networking, in collaboration with existing programmes (One Planet, MOGPA, IAHS, etc.).

Expected Result 4.2: Greater availability and access to Open Access educational resources

Contents produced by the FRIEND network will be shared freely, online where possible to promote Open Access to educational resources. These include the series of online seminars organised by EURO-FRIEND and shared on a YouTube channel, as well as the development of a knowledge-sharing platform on interdisciplinarity. The possibility of developing a dedicated MOOC (Massive open online course) related to FRIEND activities in hydrology will also be explored with UNESCO and ICIREWARD.

4. GOVERNANCE

The governance structure behind the FRIEND-Water Programme is summarised in Figure 2.



4.1. Global FRIEND-Water Secretariat

In close cooperation with the IHP Secretariat, the FRIEND-Water Secretariat supports the implementation of this Flagship Initiative as defined in this Implementation Plan. During the FRIEND-Water Intergroup Coordination Committee (FIGCC) meeting, held on 25 November 2020, the International Centre for Interdisciplinary Research on Water Systems (ICIREWARD) in Montpellier, France, a Category II Centre under the auspices of UNESCO, has been endorsed as the Global FRIEND-Water Secretariat. Its tasks include the planning, delivering and reporting of FRIEND-Water activities in collaboration with regional groups and guided by FIGCC. In addition, the secretariat also develops and implements the outreach and communication strategy for the global FRIEND-Water network and is responsible for managing the FRIEND-Water webpage and for the preparation of brochures and informative materials. Finally, the secretariat is the lead organiser of the FRIEND-Water Global Conference, to be held every four years.

4.2. FRIEND-Water Regional Coordinators (FWRC)

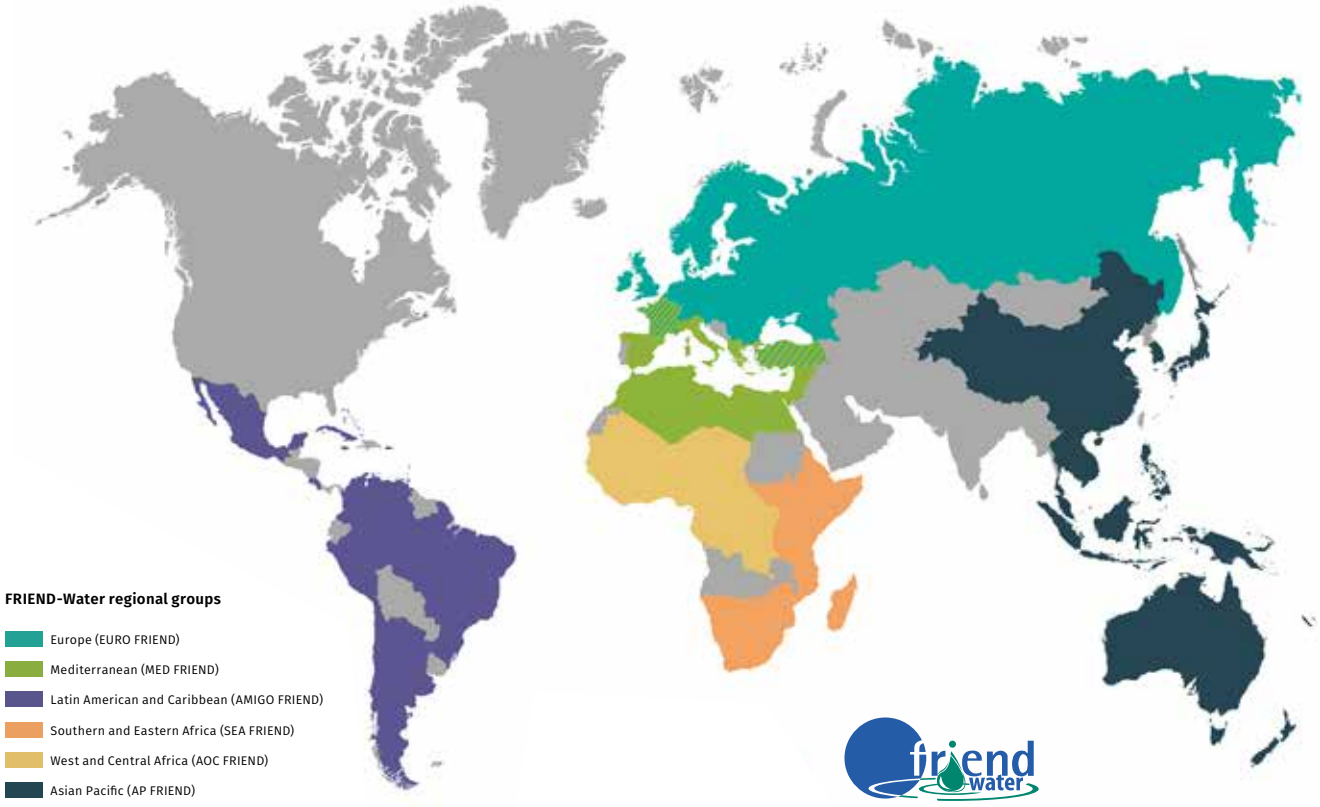
The FRIEND-Water Regional Coordinators (FWRC) are nominated and appointed by the FRIEND Intergroup Coordination Committee (FIGCC) through an application process. The Regional Coordinator nominations are effective for 4 years, with the possibility of extension for an additional 4 years. Regional Coordinators are seconded in the implementation of their tasks by a Deputy Regional Coordinator who is appointed by the FIGCC in consultation with the FWRC.

The FWRC's main role is to develop and coordinate a regional network of water scientists, whilst leveraging opportunities to increase the scientific activities of the regional FRIEND-Water group. Within each FRIEND-Water regional group, research themes are defined by the regional coordinator in close cooperation with the FIGCC and members of the group based on their experience and knowledge of regional research priorities in water sciences. Research priorities and activities should also be aligned with the strategic action plan of UNESCO IHP ongoing phase (currently Phase-IX 2022-2029). The FWRC should drive the organization of international conferences, seminars and workshops, international training, the edition of books and proceedings and other knowledge-sharing activities in their regions. The FWRC must report to the FIGCC, the FRIEND-Water secretariat and at UNESCO's request, providing written reports summarizing activities conducted within the region and participating in regular meetings. A final report summarizing the activities conducted within the region in the 4 years and at the end of the IHP phase is required. All FWRCs are expected to attend the periodic Global FRIEND-Water Conference to discuss the general strategy and future activities of the FRIEND-Water programme. The discussions should also lead to the identification of future directions for the programme at global and regional levels so that the FWP can continue to contribute to the generation of relevant and adapted scientific knowledge in addressing water-related challenges at different scales. The different FWRCs are strongly encouraged to raise additional financial support for their regional activities, which can be sourced from research programmes, national or international funding agencies, or any other opportunities that may arise. Cooperation with other UNESCO programmes or initiatives is equally encouraged.

4.3. FRIEND-Water Intergroup Coordination Committee (FIGCC)

The FRIEND-Water Intergroup Coordination Committee (FIGCC) has the role of supporting regional activities, including their connection with other programmes or initiatives, either IHP-related (e.g. G-WADI, ISI, IDI, IFI, Ecohydrology, etc) or from other academic institutions (e.g. IAHS, EGU, AGU, among others). The FIGCC should also facilitate the dissemination of papers presented during the conferences and their inclusion in special issues of academic journals. The FIGCC is composed of acknowledged specialists on water-related research topics, who are appointed for 4 years as well, with the possibility of a single extension of an additional 4-years. The Committee meets every 4 years, back-to-back with the Global FRIEND-Water Conference, whose organization it should also support by nominating editors for the conference proceedings.

The FIGCC Chair is appointed by the FRIEND secretariat in agreement with the IHP Secretariat at the Global Conference, following a call for applications. Research Themes Coordinators (Thematic Coordinators) can also be appointed by the FIGCC to support the implementation of the FRIEND-Water activities.



4.4. Key partners and network members

The FWP has an active network of members and partners that play a key role in the initiative activities, including individual water experts or organizations working on themes related to the fundamental areas of action of FRIEND-Water. These include academic partners across all FRIEND regions as well as institutional partners such as WMO, IAHS and other members of the Water family. Members of the network contribute to the organization and/or participate in workshops, conferences and trainings, as well as publications and other outreach activities. Their engagement takes place through the work of the Regional Coordinators and specific working groups.

Background information on the 6 FRIEND regional groups in 2024:

- **EURO FRIEND:** EURO FRIEND was started in 1985 by the IHP Committees of the UK, Germany, the Netherlands and Norway, who seconded full-time scientists for three years to collaborate in an international project group based at the Centre for Ecology and Hydrology (formerly the Institute of Hydrology), Wallingford, UK.
- **MED FRIEND:** MED FRIEND was launched in 1991. Cemagref (La Recherche pour l Ingénierie de l Agriculture et de l Environnement) in Lyon, France, hosted the AMHY (Alpine and Mediterranean Hydrology) FRIEND Secretariat up until December 1998. In 1999 the Secretariat moved to the Institut de Recherche pour le Développement (IRD) in Montpellier, France.
- **FRIEND AOC:** The project for West and Central Africa was established in 1992 in Ouagadougou, Burkino Faso with support from UNESCO and the Institut de Recherche pour le Développement (IRD), France. The Congo group created in 2018, has been less active, so it has been integrated to the FRIEND AOC group in 2024.

- **Asian Pacific FRIEND:** Initiated in 1997, Asian Pacific FRIEND is organised by the IHP Regional Steering Committee for Southeast Asia and the Pacific. Currently thirteen countries are participating: Australia, Cambodia, China, Indonesia, Japan, Republic of Korea, Lao People's Democratic Republic, Malaysia, New Zealand, Papua New Guinea, the Philippines, Thailand, and Vietnam. In 2018, the Hindu-Kush regional group was merged into the AP FRIEND programme.

- **FRIEND AMIGO:** The FRIEND AMIGO project for Mesoamerica and the Caribbean began in 1999 with the support of the Regional Office of Science and Technology of UNESCO for Latin America and the Caribbean ROSTLAC - and the active participation of experts from Chile, Argentina, Brasil, Perú, Colombia, Venezuela, Cuba, Jamaica, Mexico, Puerto Rico and Costa Rica.

- **SEA FRIEND:** The Southern and Eastern Africa FRIEND group was established in 2024 and combines the Southern Africa and Nile regional groups. Building upon the former Southern Africa group created in 1991 and which gathered up to 13 countries, SEA FRIEND expands its scope to encompass a broader range of countries and water-related themes.

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