International Conference on Global Water Security and Sustainable Development

ABSTRACTS

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GLOBAL WATER SECURITY IN THE DIGITAL AGE

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Global water security is a multi-dimensional and enduring human goal, which is inevitably affected by the growing dependence of society on digital information. Access to this information helps better manage water-related hazards, improve water utility performance, and improve water management for agricultural production, to name but a few of the advances associated with digital technologies. In this abstract, we address the various dimensions of global water security and associated challenges and offer potential directions for addressing them.

WATER, SUSTAINABLE DEVELOPMENT, NATURE AND CLIMATE CHANGE

Mark Fletcher
Arup

According to the UNFCCC, more than 90% of the impacts of climate change are felt through the water and extreme weather events, natural resources crises and large-scale environmental damage are in the top 10 global risks identified by the World Economic Forum in 2022-2023.
In this session, Dr Mark Fletcher will explore how to tackle the wicked problems facing water: climate change, urbanisation and declining water environments. Using case studies, he will highlight the value of adopting systems-thinking, resilience and adaptive approaches and regenerative solutions coupled with strong understanding of governance. He will also set out the routes to scaling including policy, approaches and toolkits and sharing knowledge and experiences.

CLOSING IN ON ANSWERS TO SUSTAINABILITY ISSUES

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For a water utility to be operationally sustainable, it has to do more with less. It has to use less energy and generate less waste. The holy grail is to be energy self-sufficient, carbon neutral, and generate no waste products. PUB's view is that technological innovation and international collaboration will allow us to get closer and eventually achieve this goal.

SPONGE CITIES 2.0: TOWARDS THE NEXT LEVEL OF CLIMATE RESILIENCE OF URBANIZING CATCHMENTS AND DELTAS

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TuDelft and IHE delft

Cities across the globe are increasingly suffering from flooding by extreme rainfall, drought and related heat stress. Climate change, ongoing urbanization and aging/decay of existing water management infrastructure together are the major drivers of this process. New approaches to integrated urban water management (IUWM) are continuously being tested and revised to address these challenges in an effective way, such as Water Sensitive Urban Design and the Sponge City approach. These approaches all foster the widespread deployment of multi-beneficial nature-based, blue-green infra solutions for creating protection up to a certain service level, while maximizing ecosystem services and other benefits provided by these solutions. One of these emerging approaches is the Three Points Approach (adapted from Fratini et al, 2012). This approach provides a basis for integrative planning and design of urban, regional and river basin water management interventions (Geldof and Kluck, 2008; Fratini et al., 2012). The 3PA (see Figure below) divides stormwater management into three domains: 1) Design domain; 2) Extreme domain; 3) Everyday domain.

The 3PA approach also calls for a shift in focus from adapting to slow changing drivers and preparing for singular, extreme events to (also) anticipating trends in these type of events. This change of focus is inherently coupled with large uncertainties about how the physical (climate change) and economic conditions will change, what research and innovation will bring, how societal preferences will develop etc. Moreover, long lead times of urban transformation to a water sensitive city are prompting (city) governments to take a long-term horizon.

Governments are increasingly aware of these implications to be relevant not in the long-term, but already for decisions they have to make today. It is becoming increasingly clear that a switch is needed from an adaptive planning (incremental) to an integrated, planned adaptation (transformational) approach. This requires envisioning a desired future beyond the transition and thus callsfor a renewed attention for (spatial)design both as a method and a product in urban planning. In this context it aims to complement the current, traditional largely model-based approaches by visualizing desired futures, including the spatial translations and consequences from multiple (incl. bottom-up) perspectives, which allows identifying sustainable pathways leading to these futures.

In this keynote I will address the question of “What are the major features and challenges of taking along-term perspective assuming that climatic conditions will drastically change in the future and what are the implications of present actions and policies? And what does the 3PA approach bring and how to operationalize this approach?”

International experience such as from The Netherlands will be presented and challenges and opportunities for the Sponge City program of China will be briefly touched upon.

QUANTIFYING WATER SECURITY – STATE-OF-THE-ART AND CHALLENGES

Eelco van Beek
Deltares

Addressing the too much, too little and too dirty water issues ask for an integrated, multi-disciplinary approach. The concept of Integrated Water Resource Management (IWRM) was introduced about 40 years as a process to deal with these water issues. The concept is now globally accepted and included in the Sustainable Development Goals. IWRM focuses on the process to improve water management but it does not become specific what it aims to achieve, what the end goal is. That end goal is to achieve water security. Although the general paradigm of water security has been used for a long time, we only started about 15 years ago to define water security, to quantify it and use it as a framework to access management practices.

UN-Water (2013) defines water security as the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. This definition shows the multi-disciplinary elements of water security. Much attention, also by IAHR, is given to the individual dimensions of water security. The challenge is to bring them together and quantify the full picture.

The Asian Water Development Outlook (AWDO) is the most widely recognized tool for assessing this full picture. It is published by the Asian Development Bank (ADB) and provides a comprehensive overview of the state of water resources, water management, and water security in the Asian region, expressed in 5 key-dimensions: rural household water security, economic water security, urban water security, environmental water security, and water-related disaster security. AWDO enables the comparison of the water security between countries and the development over time. Quantified information on the water security in Asia and the Pacific is available for the years 2013, 2016 and 2020.

Much valuable academic work is being done on the concept of water security. However, as important is the uptake of the concept by actual water managers. Many countries have included water security now in the objective of their water policies and have carried out country water security assessments. The UN has used the AWDO approach to assess the 2023 Global Water Security Report, presented at the UN-Conference in New York. The World Bank has developed a Water Security Framework to support their water resource assessment activities.

The concept keeps evolving and many efforts are on-going to enrich it. Challenges are to link the concept with the SDGs (in particular Goal 6 and target 11.5), to make the concept more inclusive and to make it more forward looking, for example by including the vulnerability to climate change.

TRANSFORMATIVE CHANGE IN WATER RESOURCE MANAGEMENT IN BANGLADESH

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Bangladesh is a developing country currently facing many challenges in water resource management. These include floods, erosion, water scarcity, salinity intrusion, cyclones, and much more. In the past, water management initiatives undertaken in Bangladesh primarily focused on Flood Control Drainage and Irrigation (FCDI) projects, which had detrimental effects on other sectors. Unfortunately, these initiatives lacked the foresight required to address future uncertainties, which made them unsustainable in the long run. For this reason, current risk reduction efforts prioritize transformational change through integrated and long-term approaches in plans and policies. This approach is critical to achieving global water security and sustainable development goals.

VIRTUAL WATER CONSIDERATIONS ON WATER SECURITY IMPACTS

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The Virtual Water (VW) approach, which takes into account the value of every unit of water for various consumption purposes, can be nominated as an excellent approach for improving the conditions of water stressed/challenged environments through redistribution and revision of the share of different activities such as agricultural practices. The desiccating Lake Urmia, once the largest lake within Iranian borders plays a vital role in the economic and social life of the north-western region of the country. Insufficient attention to Integrated Water Resources Management (IWRM) is believed to be the most important practical reason for its severe condition. Here, with the aid of an allocation model of the region based on IWRM principles, the recommended solutions for different water management scenarios based on the VW approach have been investigated. A comparison of the scenarios, reveals the unfavourable condition of local agricultural practices at present both in terms of water consumption and in terms of financial revenues, feared to eventually lead to severe water scarcityand insecurity problems in the region.

INDIRECT EFFECT OF CLIMATE CHANGE ON GLOBAL WATER AVAILABILITY THROUGH ADJUSTMENTS IN TERRESTRIAL VEGETATION

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Climate change alters surface water availability (precipitation minus evapotranspiration, P–ET) and consequently impacts agricultural production and societal water needs, leading to increasing concerns on the sustainability of water use. Although the direct effects of climate change on water availability have long been recognized and assessed, indirect climate effects occurring through adjustments in terrestrial vegetation are more subtle and not yet fully quantified. To address this knowledge gap, here we investigate the interplay between climate-induced changes in leaf area index (LAI) and ET and quantify its ultimate effect on water availability during the period 1982-2016 at the global scale, using an ensemble of data-driven products and land surface models. We show that ~44% of the global vegetated land has experienced a significant increase in growing-season-averaged LAI and climate change explains 33.5% of this greening signal. Such climate-induced greening has enhanced ET of 0.051±0.067 mm yr-2(mean±s.d.), further amplifying the ongoing increase in ET directly driven by variations in climatic factors over 36.8% of the globe, and thus exacerbating the decline in water availability prominently in drylands. These findings highlight the indirect impact of positive feedbacks in the land-climate system on the decline of water availability, and call for an in-depth evaluation of these phenomena in the design of local mitigation and adaptation plans.

QUANTIFYING THE EFFECT OF URBANIZATION ON EXTREME PRECIPITATION IN GUANGDONG–HONG KONG–MACAO GREATER BAY AREA, CHINA

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As one of the most developed areas in China as well as the world, the Guangdong–Hong Kong–Macao Greater Bay Area (GBA) has been experiencing rapid urbanization. Meanwhile, urban flooding, mainly due to extreme precipitation, cause huge economic losses, thus becoming one of the most focused public safety issues. Therefore, how the extreme precipitation respond to urbanization and global warming deserves our investigation, to prepare for the future extreme events. Databases including the annual China Land Cover Dataset (CLCD) and the China Meteorological Forcing Dataset (CMFD) were used to monitoring the impervious area dynamics and extract time series of extreme precipitation indicators during the period of 1985-2018. Three urbanization stages were divided based on the impervious area changes. Then, multiple statistical methods including Mann-Kendall Test, Bivariate Moran's, and the Spearman Correlation Coefficient were adopted to detect the response of various extreme precipitation indicators to the impervious area during each urbanization stage, with the spatial variations discussed. Most Extreme Precipitation Indicators show significant increasing trend in the urbanized areas and their periphery, indicating significant impacts from urbanization on the intensity and frequency of extreme precipitation. In addition, trends of indicators including Number of Wet Days (NW), Consecutive Dry Days (CDD) and Simple daily intensity index (SDII) reveal that more intense rainfall occurred in less rainy days, which might be attributed to global warming. The results not only contribute to our understanding of extreme precipitation trends in the GBA, but also provide informative references to other regions under different urbanization stages.

DETECTION AND ATTRIBUTION OF CHANGES IN TERRESTRIAL WATER STORAGE ACROSS CHINA: CLIMATE CHANGE VERSUS VEGETATION GREENING

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Whether or not large-scale vegetation restoration will lead to a decrease in regional ter-restrial water storage is a controversial topic. This study employed the Geodetector model, in con-junction with observed and satellite hydro-meteorological data, to detect the changes in terrestrial water storage anomaly (TWSA) and to identify the contributions of climate change and vegetation greening across China during the years 1982–2019. The results revealed that: (1) during the period of 1982–2019, TWSA showed a downward trend in about two thirds of the country, with significant declines in North China, southeast Tibet, and northwest Xinjiang, and an upward trend in the remaining third of the country, with significant increases mainly in the Qaidam Basin, the Yangtze River, and the Songhua River; (2) the positive correlation between normalized vegetation index (NDVI) and TWSA accounts for 48.64% of the total vegetation area across China. In addition, the response of vegetation greenness lags behind the TWSA and precipitation, and the lag time was shorter in arid and semi-arid regions dominated by grasslands, and longer in relatively humid re-gions dominated by forests and savannas; (3) furthermore, TWSAs decreased with the increase in NDVI and evapotranspiration (ET) in arid and semi-arid areas, and increased with the rise in NDVI and ET in the humid regions. The Geodetector model was used to detect the effects of climate, vegetation, and human factors on TWSA. It is worth mentioning that NDVI, precipitation, and ET were some of the main factors affecting TWSA. Therefore, it is essential to implement rational ecological engineering to mitigate climate change's negative effects and maintain water resources' sustainability in arid and semi-arid regions.

INTELLIGENT IDENTIFICATION OF CHLOROPHYLL-A DIURNAL VARIABILITY IN SHALLOW LAKES BASED ON TIME SERIES CLUSTERING

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Changes in cyanobacteria colonies on a short-term basis are related to the vertical migration of cyanobacteria and are readily influenced by environmental factors. The occurrence of cyanobacterial blooms in the majority of lakes is marked by substantial temporal and spatial heterogeneity. However, the majority of current research focuses on the seasonal or interannual characteristics of phytoplankton, whereas the short-term variation of chlorophyll-a (Chla) concentration is crucial for the short-term prediction of algal blooms. This paper designed a method for automatic recognition of Chla diurnal concentration change patterns in large shallow lakes based on highly time-resolved monitoring data. By capturing the characteristics of time series to identify the pattern of the change of daily Chla concentration on the surface of Taihu Lake, the daily change rule of Chla concentration was fully investigated, and the effect of environmental change pattern on the daily change of Chla was analyzed. The results demonstrated that the Chla concentration on the surface of Taihu Lake can fluctuate in four modes per day, which can be interpreted as the cyanobacteria's vertical migration mode. It suggested that Chla concentrations peaked at various periods of the day throughout the entire lake area, and that these change pattern were readily affected by wind speed and air temperature. The vertical migration of cyanobacteria is readily altered by strong winds, high temperatures, or large environmental changes within a single day. The analysis of temporal and spatial change characteristics of short-term change modes is useful for optimizing lake water management and monitoring. In addition, it can provide a new perspective for small-scale (diurnal) cyanobacterial harmful water bloom observation prediction.

STUDY ON THE WATER TEMPERATURE DISTRIBUTION AND INFLUENCE ON LARGE RIVER-LAKE SYSTEM

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Lakes are important regulators and indicators of global climate change, and understanding the lake surface water temperature distribution characteristics of lakes not only contributes to a deeper understanding of lake ecosystems but also allows researchers to investigate the potential influence of water temperature on the distribution characteristics of aquatic organisms. Poyang Lake, the largest freshwater lake in China, differs from previous lake water temperature investigations in that it is a river-lake system with dynamic seasonal expansion and contraction. Based on hydroclimatic and other lake area data, this paper develops a hydrodynamic model with coupled heat flux exchange to investigate the spatial and temporal variation of water temperature in Poyang Lake from 2016 to 2018 using a coupled heat flux exchange. The model accurately simulates water level and temperature, with RMSE values of 0.177 – 0.369 meters and 1.425 – 2.001℃, respectively. After separating the lake's boundaries using remote sensing, the model was calibrated to evaluate the lake's spatial and temporal distribution of water temperature. The relationship between water temperature patterns and external organisms (fish) was subsequently determined using redundancy analysis. The results indicate that the water temperature distribution of Poyang Lake is characterized by the southern lake area being warmer than the northern lake area and the eastern lake area being warmer than the western lake area throughout the entire year. The water temperature difference reaches its maximum (0.9–5.6°C) during the cold season (10°C) and its minimum (0.7–3.2°C) during the warm season (>30°C), and its spatial and temporal variability is strongly correlated with the season. In terms of fish distribution, the main channel and northern lake area are better suited for fish that prefer low water temperatures, whereas the south-central lake area is better suited for fish that prefer higher water temperatures. This study found that the temperature distribution of Poyang Lake is consistent with the distribution of typical fish behavior, and the results can serve as a quantitative reference for the hydrological department and fishery department of the region.

FORECASTING OF SURFACE CURRENTS AT COASTAL AREAS BASED ON HIGH FREQUENCY RADAR OBSERVATIONS

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Sea currents forecasting is not only important content of marine meteorological research, but also a key scientific issue to be solved in coastal engineering construction. In this research, temporal and spatial characteristics of sea surface currents for the Guangdong- Hong Kong- Macao Greater Bay Area and West Coast of Ireland were analyzed firstly; then short-term sea surface currents forecasting models were established based on machine learning algorithms and shore-based High Frequency radar observations. A random forest algorithm was applied to assess importance of variables when establishing the short-term forecasting models. A number of sensitivity tests and comparisons were undertaken. The results indicate that the machine learning forecasting models developed can produce accurate outputs of surface velocity components, which are simpler and less computationally expensive than numerical models. These findings will provide a scientific basis and an important reference for marine engineering construction, disaster prevention and reduction and coastal rescue activities.

PROJECTION OF FUTURE EXTREME PRECIPITATION IN MAINLAND SOUTHEAST ASIA

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In recent decades, the global climate change has led to unprecedented transformations, impacting both the Earth's natural systems and human lives. Characterized by its diverse ecosystems, dynamic economies, and dense population centers, Southeast Asia is currently witnessing a heightened occurrence of climate extremes. These extreme events are reshaping the region's environmental and socioeconomic fabric. The greenhouse gas emissions are on an upward trajectory because of human activities, potentially leading to more frequent and impactful alternations in extreme weather conditions. To tackle this concern, numerous research efforts have turned to general circulation models (GCMs) to forecast potential climate shifts. These models explore various scenarios involving greenhouse gas emissions and economic activities. The most recent GCMs are under the Coupled Model Intercomparison Project Phase 6 (CMIP6), offering more comprehensive and diverse climate projections by amalgamating the representative concentration pathways (RCPs) with shared socioeconomic pathways (SSPs) bolstered by improved spatiotemporal resolutions. The projection of future extreme precipitation in Southeast Asia stands as a critical area of study in the face of evolving global climate patterns. As climate change continues to influence weather systems worldwide, understanding how precipitation extreme might change in the future is fundamentally important. The Southeast Asia region, characterized by its diverse geography and growing population centers, is particularly vulnerable to the consequences of shifting precipitation patterns under threatening of climate change effects. Approximately 30% of the land in Southeast Asia is occupied by agricultural zones, playing a significant role in driving the region's economy. Therefore, any alterations in precipitation patterns could potentially influence agricultural output, as well as the economic landscape of the area. The detailed information regarding extreme precipitation in Southeast Asia has not yet been adequately explained and is still lacking. Hence, the main aim of this research is to assess the reliability of past climate datasets in mainland Southeast Asia (MSEA). Additionally, we delve into the influence of shifting climate patterns on instances of intense wet and dry weather in this region. This is achieved by employing accurate, high-resolution climate projections that have been corrected for biases.

HYDRODYNAMIC RESEARCH OF THE TAIHU AND RIVER NETWORK REGION BASED ON WATER QUANTITY, QUALITY AND FRACTION MODEL

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Based on water quantity, quality and fraction model of the Taihu Basin, numerical simulation and rehearsal of the flow movement tracks of main rivers for water supply were evaluated. In order to analyze the flow migration characteristics of the Taihu and river network, different discharge effects on water exchange and hydrodynamic for sluices along the Yangtze River and the Taihu were compared. The results demonstrated that (1) The water supply of Yongchangjing and Yechangjing located on the east side of the Wangyu River increased 48.4m^3/s, and the outflow discharge of Yangchenghu increased 9.65m^3/s. Part of the outflow from the Yangchenghu flowed into Liuhe in the north direction, part of the outflow was diverted to the east through Suzhouhe, while the rest of the outflow entered the Taipuhe and Huangpujiang in the south direction through the Lanlugang. When Yongchangjing and Yechangjing increased the water diversion, while the Liuhe sluice began to drainage to the Yangtze River, and the water ratio of Loulu section on the Liuhe reached to 50 percent. (2) The discharge of Taipu Sluice increased from 60 m^3/s to 100 m^3/s, the Taihu water ratio of Jinze and Songpudaqiao section increased significantly. The average percentage of clear water from Taihu in Jinze section increased from 26 percent to 41 percent after September 30th, while the average percentage of clear water from Taihu in Songpudaqiao section increased from 8 percent to 13 percent after October 5th. With the increasing discharge of Taipu Sluice, the concentration of ammonia nitrogen for Jinze section was reduced from 0.16 mg/L (the water quality was type II) to 0.14 mg/L (Type I) while the concentration of ammonia nitrogen for Songpudaqiao section was reduced from 0.12 mg/L (Type I) to 0.11 mg/L (Type I). (3) The water diversion from the Yangtze River through the Xinmenghe had increasing effects on water stage and inflow of the Taihu. The average Taihu water stage increased 0.03 m, and representative water stage of river network for Huxi subbasin increased 0.03m to 0.19m. The inflow of the Taihu for Huxi sub-basin increased 32 m^3/s, including fenshuiqiao inflow increasing 21 m^3/s, the Chengdonggang inflow increasing 8 m^3/s, and the Wuxiqiao inflow increasing 3 m^3/s. (4) After the water diversion from the Yangtze River through Jiepai hydro-junction on the Xinmenghe, it took 2 days to arrive the Benniu hydro-junction, 4.5 days to arrive the crossing section of Xinmenghe and Beiganhe, and 7.5 days to arrive Fenshuiqiao. Part of the water flowed eastward to the Wuyi Canal, and it took 6 to 6.5 days to arrive Fenshuiqiao through Taige Canal. The water diverted from the Yangtze River into the Taihu through the Xinmenghe, had influence on the Zhushan flow field with flow direction from north to south, and had little influence on the flow field for the East Taihu. The water ratio from Fenshuiqiao section increased 15 percent for the northern part of the Zhushanhu, and 8 percent for the southern part. The research results provided decision support for opening up water supply river network from the Taihu to the Chenhang Reservoir, and guaranteeing water supply security for the Taipuhe and upstream of Huangpujiang.

EFFECTS OF CLIMATE CHANGE AND DAM CONSTRUCTION ON SALINITY AND WATER RESOURCES IN LOWER BANG PAKONG BASIN, THAILAND

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Climate change is main factor of water level increment in the sea that affects all over the world and the gulf of Thailand to confront with problem of salinity intrusion in estuaries. Much damage from this problem, such as, management for industrials, agricultural and domestic water had been increased continuously. The purpose of this research aims to investigate hydraulic behaviors and assessment effect of salinity intrusion during dry season in Bang Pakong Basin by using MIKE11 model. It was found that roughness coefficient Manning's n = 0.025 - 0.030, R^2= 0.80-0.99, IA = 0.54 - 0.98, RMSE = 0.16 - 0.31 for Hydrodynamic (HD) module. Advection Dispersion (AD) module, dispersion coefficients Df = 100 - 2000 m^2/s, R^2= 0.80 - 0.99 IA = 0.54 - 0.98, RMSE = 0.16 - 0.31. By applied to study the effects of dam construction and raw water diversion to the Eastern Economic Corridor (EEC) under the climate change situation. It was found that salinity will encroach to the river estuary longer distance than in the present, and will be impact on agricultural productivity and biodiversity in the future. Results from this study can use to estimate risk area from salinity, guidelines and adaptation plan for management of water resources and agriculture in Lower Bang Pakong Basin.

UNDERWATER CRACK PIXEL-WISE IDENTIFICATION AND QUANTIFICATION FOR DAMS VIA LIGHTWEIGHT SEMANTIC SEGMENTATION AND TRANSFER LEARNING

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Remotely operated vehicles (ROVs) with cameras provide a solution for dam underwater information acquisition, but problems like massive high-dimensional data processing and effective damage-related information extraction also occur. This paper thereby proposes a real-time pixel-level dam underwater crack automatic segmentation and quantification framework using the lightweight semantic segmentation network LinkNet and two-stage hybrid transfer learning (TL). With the combination of in-domain and cross-domain TL, the modeling cost and computational burden can be significantly reduced by transferring knowledge learned in relevant domains to the target domain. The proposed method shows strong identification capability in complicated underwater scenarios (motion blur, uneven illumination, and obstacle blocking), achieving performance with 0.8924 mIOU, 0.9444 precision, 0.9151 recall, and 0.9295 F1-score in the test set. Combined with infrared laser-assisted ranging systems, the geometric features and physical sizes of cracks are quantified using the proposed method. Finally, a visual GUI software with both offline and online detection patterns is developed to perform real-time detection in practice.

TRANSBOUNDARY RIVERS, INTERNATIONAL WATER LAW AND WATER SECURITY IN THE 21ST CENTURY: TIME FOR A NEW SOLUTION FROM A CHINESE PERSPECTIVE - "A WATER COMMUNITY WITH A SHARED FUTURE."

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The global water crisis today around the world is at a tipping point. Increased pressure on a finite supply of freshwater from climatic shifts in temperatures around the globe, increased population movement with an increase in urbanization in the name of economic development, are stretching water treaties between riparian countries sharing a transboundary river basin to a breaking point. The challenges then, are how to effectively resolve water resources conflicts, while preventing new water conflicts from starting, in transboundary river basins around the world where an uneven distribution of water resources exists. Furthermore, how to improve the water resource utilization efficiency while achieving sustainability under the realization that major theoretical, cultural and political differences exist among different stakeholders in transboundary river basins along with a decreasing water supply is crucial. This paper will examine some key reasons for transboundary river basin conflicts today and present an idea to solve these conflicts from China's perspective of building "A Community with a Shared Future for Water" based on the concept of "A Shared Community for Mankind" as put forward by President Xi Jinping. We analyze the importance of "A Community with a Shared Future for Water" as well as interpret the concept and significance of "A Community with a Shared Future for Water." Aspects of water diplomacy and water cooperation have put forward the content of "Water with a Shared Future" from different points of view. First, the initial distribution of water should be based on fairness. Second, an efficiency-based adjustment mechanism to permit flexibility in transboundary river agreements is necessary to reduce the chances of water conflict. Third, an efficiency mechanism comparing and contrasting equitable water allocation and benefit sharing is necessary. Fourth, a guarantee mechanism for "A Water Community with a Shared Future" should be built from three aspects: Management and cooperation models, legal and institutional foundations, coordination and supervision mechanisms. This guarantee mechanism provides pertinent information for the management of water resource conflicts in transboundary rivers while constructing "A Water Community with a Shared Future."

PERSONAL FACTORS AFFECT THE HUMP-SHAPED RELATIONSHIP BETWEEN PUBLIC PREFERENCE AND WILDNESS OF URBAN LAKE AREAS IN FRANCE AND CHINA

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The public exhibits certain degrees of liking for urban ecosystems. These preferences for urban ecosystems may vary with increasing biodiversity. Previous studies of urban green spaces have evidenced that it might present a hump-shaped relationship, i.e., the preference first increases, peaks at the intermediate level, and decreases with increasing biodiversity. However, the driving factors of this relationship are not clear. Using a photograph-based method, we analyzed this relationship along a wildness gradient in three urban lake areas of Tours, France, and Wuhan, China. We collected 120 and 295 questionnaires in Tours and Wuhan, respectively. We found that medium wild urban lake areas were the preferred choice in both cities, because such urban lake areas are neat, safe, well-maintained, and could facilitate recreational activities. Respondents who indicated a higher visit frequency were likely to prefer wilder urban lakes. Notably, in Wuhan, respondents who preferred wilder urban lakes were likely to be older, which may be attributed to the older respondents having a memory of natural lakes before the rapid urban development. This study suggested a hump-shaped relationship between public preference and wildness in urban lake areas, which was driven by the public's infrequent visits to the urban lakes and probably lack of memories of natural lakes. Therefore, we recommend encouraging the public to engage with wilder urban green-blue spaces more frequently to foster familiarity with wilder settings; additionally, increasing their wildness from low to medium or high wildness to improve the attractiveness to urbanities and enhance the habitat quality for biodiversity.

A NOVEL METHODOLOGY TO IDENTIFY AND QUANTIFY DEEPWATER-RENEWAL PROCESSES DURING WINTER COOLING IN A LARGE, DEEP LAKE (LAKE GENEVA)

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We propose a novel methodology – heat budget decomposition – to identify and quantify different deepwater-renewal processes during a very cold spell in 2012 in a large, deep lake (Lake Geneva, 309-m depth). Combined with field observations and numerical modeling, we find that 1D convective cooling only reached 200-m depth. Instead, cooling of the lake's deepest layers was due to lateral advection of cold water, revealing the important role of 3D processes during winter deepwater renewal.

THE INCREASING RISK OF FUTURE SIMULTANEOUS DROUGHTS OVER THE YANGTZE RIVER BASIN BASED ON CMIP6 MODELS

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Drought projection is critical for water resource planning and management, as well as disaster prevention and mitigation. As a strategic national water source for China, the Yangtze River Basin (YRB) plays a vital role in the connectivity of rivers and economic development, flowing through 11 provincial administrative regions and is injected into the East China Sea, with a total length of 6,397 kilometers. The watershed covers an area of 1.8 million square kilometers, accounting for about 1/5 of China's total land area. However, frequent droughts have caused water shortages in the YRB in recent years. Based on observed meteorological and hydrological data, the CMIP6 model and SPEI (standardized precipitation evapotranspiration index) drought models were used to elucidate the risk of future simultaneous droughts in the upper and mid-lower reaches of the YRB from 2015 to 2100. SRI has been used based on SWAT model to study the transfer process of meteorological drought to hydrological drought. The results indicated that, 1) The average of 10 CMIP6 models showed a good verification of historical precipitation and temperature for drought predictions. The MMK and Sen’s slope demonstrated consistency for historical and future droughts in the YRB. From a historical perspective (1961-2019), the middle reaches of the YRB experienced intensifying drought frequency with the highest total drought (Moderate and above drought events) frequency (>17%); 2) In the future (2020 – 2100), the higher emission signifies higher moderate and total drought frequency, intensity, and scope of the YRB in FF, lower in NF. The ratio of autumn severe and extreme droughts would increase in mid-21st century; 3) Severe drought risk encounters were projected in the upper and meanwhile in the middle-lower reaches in YRB, especially in the 2030-2040 period. Under all three scenarios, severe droughts occurred more frequently with SPEI close to -2. The middle-lower reaches of the YRB are forecast to witness the largest scope and highest intensity of drought under the SSP1-2.6 scenario.; 4) The future runoff in the YRB during the dry period varied less, but in May and June during the main flood season the runoff under SSP1-2.6 would be the largest. Maximum decrease in runoff in the mid-lower reaches under the SSP2-4.5 scenario would be 2045, reaching 13.9%. Extreme flooding events and extreme meteorological droughts would happen accompanying with hydrological droughts would occur more frequently and severely under different scenarios. More attention and improved strategies should be brought to bear to address future simultaneous droughts in the upper and mid-lower YRB.

ACCUMULATED ECOLOGICAL AND HYDROLOGICAL EFFECTS OF THE LARGEST CASCADE RESERVOIRS OVER THE YANGTZE RIVER BASIN

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That the Baihetan Hydropower Station started commencement of operations in June 2021 marked the formal establishment of the Yangtze River's primary giant reservoir cascade, which also stands as the world's largest cascade reservoir group. How do the construction and operation of the four major downstream reservoirs on the Jinsha River (Xiluodu, Xiangjiaba, Wudongde, and Baihetan) influence hydrological characteristics downstream? What are the ecological and hydrological impacts of the jointed operation of these four Jinsha River reservoirs with the Three Gorges Dam on the Yangtze River mainstem? Existing studies have predominantly centered on scenario simulations, utilizing relatively dated time series data. Currently, there is a dearth of contemporary research on the actual operational dynamics of the four downstream Jinsha River reservoirs. Leveraging the latest and lengthiest observed hydrological data series, this study categorizes the research period into three phases: 1950-2011, 2012-2019 and 2020-2022, utilizing the initiation of operations at the four Jinsha River reservoirs as the benchmark. The study investigated the accumulative ecological-hydrological effects arising from the operation of the largest cascade reservoir group on the Yangtze River mainstem, from the perspectives of hydrological alterations, ecological deficits and surpluses, as well as ecological risks. The result revealed that the influence of the giant reservoir group on downstream hydrological conditions is shaped not only by factors such as proximity, reservoir capacity, and the quantity of reservoirs but also by the interplay among neighboring reservoirs; reservoir scheduling and operation not only substantially amplify annual ecological deficits but also adversely shift their intra-annual distribution; the disparities in ecological risks engendered by the reservoir group across the individual reservoirs are not statistically significant, necessitating further investigation and analysis to elucidate the precise underlying causes.

CLIMATE CHANGE IMPACT ON WHEAT YIELDS IN THE TASHKENT REGION OF THE REPUBLIC OF UZBEKISTAN UNDER DIFFERENT CLIMATE SCENARIOS

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Climate change has a significant impact on wheat production. Studies have shown that in some regions, wheat accessions demonstrated high plasticity and stability of productivity, indicating their ability to adapt to changing environmental conditions. This study focuses mainly on wheat yields because wheat products are an essential part of the Uzbek people's lives, and have been of strategic importance in terms of food security in Uzbekistan since independence. Therefore, the fate of wheat yield is significant. The Tashkent region, which is the focus region of our research, is a region of rapid modernization and industrialization since independence (1991). Given that Uzbekistan is developing under an agro-industrial state, both sectors' development is essential. In this study, the climate data (precipitation, maximum temperature, minimum temperature, mean temperature) were analyzed using homogeneity tests, autocorrelation tests (Durbin-Watson), and Mann-Kendall tests. Furthermore, after accurate issues, productivity analysis was performed using the Agricultural Production Systems Simulator (APSIM).First, the predictions of population change in the next hundred years was calculated because population forecasting is an important tool for addressing the challenges brought by population growth. Various methods and models have been used to predict future population. For predicting the population growth in our study, the calculation method based on the growth rate and using the JMP16 model was used. The next task was to compare this study' results with the information provided by the "World Data" statistical database. In Uzbekistan, wheat is considered a necessity staple food, and efforts are needed to reduce the demand and supply gap through innovative production techniques and increasing domestic production. The rising prevalence of celiac disease (CD) worldwide has been associated with increased wheat consumption, showing a high positive correlation between wheat consumption and CD prevalence. Therefore, it is necessary to consider the consumption of wheat. A survey related with wheat consumption was conducted, and it included the consumption of more than 80 families in our study area. Based on this, getting an average of 4.72 tons of wheat from one hectare of wheat field will be enough for our population, considering the increase in population. In order to select climate parameters, which are the main source of our research we used CMIP6 data base. We compared 12 GSM's climate data with the observed climate data during 1950-2000 by using statistical indicators. As a result, 6 out of 12 GSMs (CanESM5, CMCC-ESM2, INM-CM4-8, IPSL-CM6A-LR, MPI-ESM1-2-HR, NorCPM1) gave a positive result with the observed data between 1950-2000. Our study confirms that climate data have shown positive results. In terms of homogeneity of climatic data, Pskem hydro meteorological station showed 90.8%, Almalyk meteorological station 92.3%, and Yangiyul meteorological station 92.9%. The next stage was a trend test, which showed a relatively higher trend, mainly in September and April. In the next process, we determined the yield based on 60 years of climate data using APSIM, and according to that, an increase in productivity found in the territory of all stations. In particular, 18% increase in Pskem station area, 12% in Almalyk station area, and 15% in Yangiyul station area.

DISCHARGE COEFFICIENTS SPILLWAYS LABYRINTH ACCORDING TRANSITIONAL HYDRODYNAMIC UPSTREAM WALLS FORMS AT THE APPROACH CANAL.

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In the last times the canals, weirs and others hydro-structures designers starts to use labyrinth weirs in spillways. Today climate change affects the performance of original water structures; as a consequence their designs results insufficient. The implementation of labyrinth has been indicated as beneficial elements in water reservoir or water conducts because increase the discharge in high events. This characteristic is an advantage because can increase the body´s normal level of water to replace losses while maintaining the same level of "high water". This structure can be use in a new design too. Some important characteristic in labyrinth weirs is the flow approach conditions over the spill weirs, and the flow condition However, many aspects of the functioning of these structures have not been investigated. The labyrinth weirs can present some problems because the upstream canal hydrodynamic adaptation to the water flow attends to construction requirements. In previous structures that use these elements, it has been found nape interference over the crest and disturbance flow zones along the weir. For this reasons it is necessary implement several characteristics like specific shapes and long apex. The purpose of this research is to implement a upstream hydrodynamic hydraulic wall to get down the nape interference effects and increase the discharge. For this reason we resorted to the study of this device as an equivalent to physical geometric scale of a labyrinth weir. The values obtained from measurements of hydraulic head and flow transited, processed to obtain the coefficients of discharge.

DUAL SECURITY CRITERIA OF RELIABILITY AND ROBUSTNESS FOR REGULAR AND BACKUP WATER RESOURCES PLANNING

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The annual total depths of precipitation in Taiwan is 2,507 mm by the records from 1949 to 2020, which is over twice of the global average. Since more than 60% of the total rainfall occurs during mid-May to the end of October, reservoirs are required to store the surplus floodwaters for steady water supply. The floodwaters are primarily brought by the invasions of typhoons, which normally occur 3 to 4 times per year. The absence of typhoon invasion will inevitably lead to inadequate reservoir storage and impose severe risks of water shortage for the ensuing dry season. This is the reason for the recent drought with 100-years return period during 2020 to 2021. Several districts in Taiwan experienced water rationing and fallow. The shortage continued until the end of May in 2021, when the plume-rain front brought significant rainfall and resolves the drought. This extreme event exposes the urgency of pursuing water security in Taiwan.

According to the definition by the UN-Water, water security is the "capacity to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and social-economic development, for ensuring protection against water-borne pollution and water related hazards, and preserving ecosystem in a climate peace and political stability." This extends its umbrella to cover almost all water-related affairs. For example, the Taiwanese "Forward-looking Water Environment Infrastructure Developing Program", with slogans as "shortage-less", "flooding-less", "potable quality", and "environmentally accessible" water, also share similar visions with the above definition.

The development of hydraulic and water resources infrastructures requires specifying the level of protections or services to determine the developing capacity. Enhancing water security implies needs to reevaluate the designing criterion for more robust protections or services. This requires more financial investments, which may lead to thriving economics, higher efficiency of public services, cost reduction, disaster prevention, enhanced sustainability of society and environment, and national development. All these factors are site-specific and not easy to quantify. Thus "to which level can a system be deemed as secure" remains an unanswered question.

Following the discussions from Mays (2010) regarding water sustainability, the authors believe water security also have to be considered on a local, regional, national, and international basis. While most previous studies investigate the relationship between water investment and economic development on the national or international scale, this study focuses on the regional scale to address the problem of water security in terms of adequate quantity. A pair of indices of water shortage are proposed, which are the annual reliability based on the tolerable shortage of public demand and the maximum annual deficit-percent-day respectively. The first of which specifies the yield of the system under normal condition, while the last reveals the vulnerability of the system during extreme droughts. By assigning acceptable thresholds for these indices, the status of the system can be evaluated and classified as being secure, unreliable but robust, reliable but unrobust, and unreliable and unrobust. The last three of which require development of regular and backup water resources

to secure water supply. The proposed framework could be utilized to evaluate the effectiveness of water resources development scenarios, specify risks of water shortage and provide a basis for future studies to investigate the relationship between economic growth and water security.

OPTIMIZING DISCHARGE COEFFICIENTS SPILLWAYS LABYRINTH IMPLEMENTING TWO HYDRODYNAMICS FORMS DEVICES IN THE UPSTREAM

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Nowadays dams start to use labyrinth weirs to replace structures due to the fact that the original structures are insufficient. As a consequence, the volume of discharge in a situation of high event increases the body's normal level of water to replace losses of dam volume while maintaining the same level of high water attending the security of the Dam. These losses happen because of sedimentation. The hydrodynamic device influences the increase of the discharge, and it is well known that as more water is placed above this structure, far from the effects of the channel walls, the coefficient increases. The numerical specification (discharge coefficient) of their operation is important to implement in any design or rehabilitation. Using labyrinth weirs are an increasing practice in spillways reservoirs, needed to raise the level of normal water, keeping the same free edge of prey, which is very important when do not have an adequate volume for flood control. The main focus is test two devices design, considering constructive requirements. Previous some hydrodynamic forms design was testing, but others in side requirements consider new designs.

ENHANCED HYDRO-EPIDEMIOLOGICAL MODELLING USING A NOVEL BACTERIA DECAY APPROACH

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Water quality plays an important role in global water security. Microbial contamination is a big threat to water security and public health. Faecal Indicator Organism (FIO) are widely used to assess microbial contaminations by various directives, such as the EU revised Bathing Water Directive. Hydro-epidemiological modelling provides a strong tool in management and assessment of microbial contamination and fate and transport of FIOs. One of the main parameters in hydro-epidemiological modelling are the FIOs decay rates. Improvements to a FIO decay model for nearshore coastal waters are proposed and tested in Swansea Bay, UK. While the improved models did not always improve FIO prediction accuracy, the models correctly reproduced measured FIO decay rates. This study also highlights the need f or experimental study on FIO decay rates.

AN APPROACH FOR WATER QUALITY RESTORATION IN TROPICAL RIVERS

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This work deals with an approach for the water quality restoration with emphasis on the removal of organochlorine pesticides and eutrophic conditions in tropical rivers, causing influence on the management of the central-regional aqueduct, as a source of water supply for human consumption (4 million people) and industrial production in the states of Carabobo, Cojedes and Aragua, Venezuela, testing the phytoremediation techniques through Vetiveria zizanioides (VZ) species and coupled bioreactors, Sequencing Batch Reactor (SBR) followed by an Upflow Anaerobic Filter in Three Separate Stages (UAF-3SS). Five rivers are involved known as Chirgua, Paito Guacara, Ereigüe and Tucutunemo, whose waters have been classified as hypereutrophic, and containing organochlorine pesticides (OCPs). As a sample, for Tucutunemo River, OCPs included to DDT (dichlorodiphenyltrichloroethane) and its isomers and DRINs (Aldrin, Endrin and Dieldrin) dissolved in water and sorbed on sediments, which were measured during the dry and rainy seasons in the period 2013 to 2016, in three monitoring stations distributed in a reach of 15 km. The results indicated that p.p'-DDT concentration dissolved in water was increased up to 10 times from rainy to dry seasons, indicating that a permanent use of it is being carried out by farmers in the agricultural activity development. Steady concentrations of the DTT isomers (e.g. p.p'-DDD and p.p´-DDE) and Aldrin isomers (e.g. Dieldrin) demonstrated that the anaerobic and aerobic biodegradation processes occurred along the river and between climatic seasons. At experimental scale, VZ hydroponic system developed over a period of six months for the removal of nutrients demonstrated moderately low to high removal efficiencies. With respect coupled bioreactors, each bioreactor has been experimentally tested, demonstrating satisfactory performance in Chemical Oxygen Demand (COD) removal from industrial wastewater containing recalcitrant and inhibitory substances (46-98%), which was estimated in the influent ranging from 3,500 to 5,500 mg/L, evidencing that coupling of bioreactors might lead to an effluent COD complying with environmental regulations.

IN SITU AND EX SITU BIOREMEDIATION PROPOSAL FOR TROPICAL AQUIFER CONTAMINATED WITH HYDROCARBONS

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The work is focused on testing a new bioremediation method in a tropical aquifer contaminated with hydrocarbons, whose contamination was caused by fuel leaks from underground tanks sited in the area of a fuel service station located in Valencia, Venezuela, sharing boundaries between residential and industrial uses. Ex situ remediation proposal will be developed to laboratory scale. For soil treatment, two coupled bioreactors are proposed consisting of a Soil-Slurry Sequencing Batch Reactor (SS-SBR) and Upflow Anaerobic Filter separated in three phases (UAF-3SS), which will treat soils containing hydrocarbons sorbed in concentration upper to international regulations allowing the occurrence of mass transfer processes to the air (volatilization) present in soil empty spaces in the vadose zone and groundwater (sorption-desorption) in the saturated zone. For groundwater treatment, bioreactors involve SBR-UAF-3SS. Each bioreactor was experimentally tested, demonstrating satisfactory performance in Chemical Oxygen Demand (COD) removal from industrial wastewater containing inhibitory substances (46-98%). In-situ remediation proposal will be tested in pilot scale in the subsoil within fuel service station in order to compare the kinetic coefficients of indigenous microbial performance with ex situ bioremediation treatment, by implementing air sparging system in the saturated zone and soil vapor extraction system in the unsaturated zone. Both systems will be installed in two soil cross sections comprising fifteen monitoring wells where the highest Benzene, Toluene, Ethylbenzene and Xylenes (mixed) and Total Petroleum Hydrocarbons concentrations were determined in strata comprising the interface between the saturated and unsaturated zones at depths between 3 and 8 m below ground surface.

DEVELOPMENT OF HYBRID AND COUPLED MODELS FOR THE DESIGN OF UPFLOW ANAEROBIC FILTERS THROUGH MULTIPLE SEPARATE STAGES IN THE REMOVAL OF ORGANIC MATTER FROM SANITARY LANDFILL LEACHATES

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In this paper, the formulation, calibration and validation of hybrid and coupled models for the design of upflow anaerobic filters in multiple separated stages were developed for organic matter removal from sanitary landfill leachates. The formulation, calibration and validation of mathematical structures of hybrid models and five coupled models are proposed for UAF-2SS and UAF-3SS reactors. The hybrid models are based on the law of mass conservation, with the organic matter transformation component within the UAF-2SS and UAF-3SS reactors, being estimated from empirical equations that have been tested in aerobic culture reactors, adapted to the experimental factors, including among these, those under a non-stationary - advective conditions based on Velz's Law, Phelps's Law and Monod’s equation. The coupled models combine the components of the molecular transport by biosorption and molecular diffusion processes, with adaptations of the Stack’s equation and Fick's Law, as well as transformation of organic substrates by biomass, whose kinetic coefficients contributes to explain the fraction, in which, the processes of mobility and biochemical transformation of the organic matter are occurring in the biomass within the bioreactors.

KINETIC MODELING OF ORGANIC MASS AND NITROGEN REMOVAL BY GRANULAR AND SUSPENDED BIOMASS IN A SEQUENCING BATCH REACTOR

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In this paper, a kinetic modeling is carried out for estimating the sequencing batch reactor (SBR) performance parameters due to the Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN) and ammonium (NH4-N) removal by granular and suspended biomass from tannery wastewater, under conventional and simultaneous nitrification-denitrification (CND and SND). The novelty consists of determining the highest performance for SBR operated by single (oxic) and combined sequencing biological in two (anaerobic-oxic) and three (anoxic I-oxic-anoxic II) phases. The COD removal rate was increased as the biological phases were increased from single oxic phase (-60 mg L-1 h-1), anaerobic-oxic phases (-100 mg L-1 h-1) to the anoxic I –oxic-anoxic II phases (-250 mg L-1 h-1). The suspended biomass reached the highest performance in the COD removal. The TKN and NH4-N removal rates were significant in the first anoxic and the oxic phases of SBR, respectively, which was observed both CND and SND.

DIFFUSION-ADVECTION PROCESS MODELING OF ORGANOCHLORINE PESTICIDES IN TROPICAL RIVERS

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This paper deals with the diffusion-advection process modeling of organochlorine pesticides (OCPs) dissolved in a topical river. The novelty consists of proposing a mathematical expressions that allow to estimate the physical and biochemical coefficients of OCPs advection-diffusion combined to biochemical transformation processes. The OCPs involved are DDTs (p.p'-DDT, o.p'-DDT, p.p'-DDD, p.p'-DDE, o.p'-DDE) and DRINs (Aldrin, Dieldrin and Endrin). Four scenarios for simulating the OCPs transport are proposed: 1) molecular diffusion, 2) biochemical transformation, 3) advection-diffusion 4) advection-diffusion with biochemical transformation and sorption/desorption processes. The proposed scenarios predict in a good approach of the spatio-temporal distribution of OCPs concentration into an interval until 1.5 standard deviation regarding the mean of difference between OCPs observed and simulated. The scenario N°4 associated to a coupled model offers a suitable prediction of physical and biochemical coefficients such as molecular diffusion, substrate utilization rate and sorption/desorption processes for a tropical river.

MUNICIPAL MODEL FOR PROVIDING DRINKING WATER AND SANITATION SERVICES IN DEVELOPING COUNTRIES

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In this study, models for the provision of drinking water and sanitation services, were evaluated for the San Joaquin Municipality, Carabobo State, Venezuela, represented in the Municipal Autonomous Institute of Water of San Joaquin (IAGUASANJO, in Spanish) through three management indexes proposed in an integrated manner for drinking water and sanitation, a model index for the provision of drinking water services and model index for the provision of sanitation services. IAGUASANJO has oriented 65% of the activities towards the provision of sanitation services and 35% of the actions for the provision of the drinking water service in the period 2018-2021.

MANAGEMENT MODELING OF A TROPICAL WETLAND

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This article presents, as a novelty, a proposal for management modeling of a tropical wetland. The model is based on the combination of the components and criteria established in the 4th Strategic Plan 2016 – 2024 of the RAMSAR Convention on Wetlands with Bloom's Taxonomy. The results of the qualitative analysis contributed to establishing the scope of the degree of commitment of Latin countries through the proposed WMSP and its implementation demonstrated at the 13th Meeting of the Conference of the Contracting Parties. The proposed wetland management model constitutes a tool to contribute with an integral wetland management model index, resulting of the weighting of the indexes associated with the Bloom Taxonomy in five levels that include knowledge, comprehension, application, evaluation and creation, which are influenced by the implementation in the Latin-countries of targets linked to the goals of a RAMSAR-WMSP.

METHOD FOR FLOOD RISK PREDICTION IN A TROPICAL BASIN

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This study proposes a method for flood risk estimation in a tropical basin. The novelty consists of linking the effective rain with the exceedance probability on the occurrence of the effective rain and weather events during the service life of the hydraulic structure that would be designed to mitigate the flood risk. The precipitation time series used occurred during the months of the rainy season in the period 2015-2017. Precipitation is estimated using the method of ordinary Krigging applied over 25 gauging stations in the environment of the basin. Two dynamic factors are included, which are the precipitation and the land use and land cover (LULC), monitored using sensors of precipitation data in real time, as well as multispectral images produced by remote sensing technology installed in satellite. This method provides spatio-temporal information that allows decisions to achieve preventive measures contributing to the protection of life and properties.

CALIBRATION AND VALIDATION OF MODELS FOR THE WATER YIELD OF A CONFINED AQUIFER IN A TROPICAL REGION

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This article deals with the calibration and validation of models for the water yield of a confined aquifer in a tropical region. The novelty consists in converting into coefficients those parameters associated with the well function proposed by Theis for the non-stationary flow to a well in a confined aquifer. Based on the analysis of 28 lithological profiles provided by the Ecosocialism Ministry of Venezuela, clay and fine to coarse sand strata were found at depths varying between 43 and 96 m below the ground surface, which confirms the condition of a confined aquifer. From 2015 to 2019, 20 pumping tests for variable flow were carried out measuring flow rate and water level in the wells. The determination coefficients obtained in the statistical adjustment of proposed models are satisfactory; they varied between 76 and 85%. The complete validation stage requires models to be tested with a greater number of data.