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RESEARCH PROPOSAL

I. BASIC INFORMATION

Program/Project/Study Title:

Quantitative Analysis of Hydrometeorological Forcing on Surface Water Body Geomorphology in Leyte Island

Program/Project/Study Leader(s):

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Implementing Unit:

Department of Meteorology
Department of Civil Egineering
Department of Geodetic Engineering
Department of Statistics

Cooperating/ Collaborating Agency(ies):

PAGASA-DOST
Mines and Geosciences Bureau, DENR
Bureau of Soil and Water Management, BSWM

Location:

Climate and Weather Studies Laboratory (CLAWS Lab), Department of Meteorology

Duration:

18 months

Proposed Budget:

Php780,000

Discipline:

Climate Change, Water Resources, Land-cover, and Land-use change

Classification:

Basic and Applied Research

II. TECHNICAL INFORMATION

A. Rationale

The Philippines is a tropical country and experiences significant rainfall throughout the year. The amount of rainfall can vary depending on the location and time of year. In general, the country experiences a rainy season from June to October, with the heaviest rainfall occurring in August and September (Akasaka, 2010; Bagtasa, 2020; Villafuerte et al., 2020). Water is one of the basic commodities humans will struggle living without. The archipelagic nature of the Philippines makes water resources abundant, yet most homes rely on rain as the main source of water for domestic use. Rainfall is one of the atmospheric variables greatly affected by climate change and its scarcity and abundance also greatly affects landscapes (Fathian et al., 2016a; Xiao et al., 2022).

Rainfall is a primary source of water for many human activities, including agriculture, industry, and domestic use. Rainwater can be collected and stored for later use, or it can be directly used for irrigation, livestock, and other purposes. Overall, rainfall plays a crucial role in supporting human activities by providing water resources, but it is also important to manage this resource sustainably to ensure that there is enough water for everyone, now and in the future. Climate change and population growth are increasing the pressure on water resources; hence it is important to implement water management strategies to ensure the availability of water for human activities (Black, 1972; Verstappen, 1997).

Water is a fundamental driver of landscape change, shaping the Earth's surface through various processes such as erosion, sedimentation, and deposition. The amount, distribution, and timing of water can have a significant impact on the landscape, creating diverse and dynamic environments. Water erosion is one of the most important processes that shape the landscape (Yang & Zhang, 2019). The movement of water over the land surface can cause the removal and transportation of soil and rock particles, leading to the formation of channels, valleys, and other landforms. Rivers, for example, can carve deep canyons and create wide floodplains through the erosion of the surrounding landscape (Rapant & Kolejka, 2021a).

Climate change and human activities can also exacerbate the impact of water on the landscape, leading to changes such as desertification, sea level rise, and increased flood risk (Madsen et al., 2014). Understanding the role of water in shaping the landscape is crucial for managing and conserving natural resources, mitigating risks, and planning for sustainable development.

Changes in the landscape can have a significant impact on water resources management. Some ways landscape changes can affect water resources management are (Black, 1972):

1. Alteration of runoff patterns: Changes in the landscape can affect the way water flows over the surface, altering the patterns of runoff and recharge of aquifers. For example, deforestation can increase runoff and reduce the amount of water that infiltrates into the ground, leading to a decline in groundwater resources (Shi et al., 2014).
2. Increase in flood risk: Landscape changes can increase the risk of flooding. For example, urbanization can lead to the paving over of natural surfaces, reducing the amount of land that can absorb water, and increasing the risk of flash floods (Jordan et al., n.d.).

3. Impact on water quality: Landscape changes can affect water quality. For example, agricultural activities can lead to the erosion of soil, which can increase the amount of sediment and nutrients in water bodies, leading to eutrophication and other water quality problems (Black, 1972; Kumar Rai et al., 2017; Shi et al., 2014).
4. Impact on aquatic ecosystems: Landscape changes can affect aquatic ecosystems. For example, the construction of dams can lead to the fragmentation of rivers, affecting the migration of fish and other aquatic species (Fathian et al., 2016a).
5. Impact on water availability: Changes in the landscape can affect water availability. For example, desertification caused by land use changes can lead to a decline in water resources and make it more difficult to sustain human activities (Verstappen, 1997).

Managing and conserving water resources requires understanding the complex interactions between water and the landscape. This understanding is essential for sustainable water resources management.

B. Objectives

The study aims to investigate surface water body geomorphology by quantifying the response of the Leyte Island landscape to the changes in rainfall patterns. The study aims to achieve this through the following specific objectives:

1. Establish a spatio-temporal rainfall pattern using comparative analysis of in-situ (i.e., PAGASA-DOST stations and automated rain-gauges) and remotely sensed data (i.e., Satellite-based Observation and Weather Radar Observation).

2. Analyze the hydrological connectivity of freshwater body geomorphology and rainfall using Soil and Water Assessment Tool (SWAT Model).

3. Characterize the spatio-temporal geomorphic response surface water bodies in Leyte Island as a function of hydrometeorological input using GIS technologies.

C. Logic Framework

Project Description	Performance Indicators	Means of Verification	Assumptions
GOAL Quantify the geomorphic response of river basins and other freshwater bodies in Leyte Island to changes in rainfall patterns.	• Improved understanding of freshwater body geomorphology as influenced by rainfall patterns.	• Establish spatio-temporal maps and data on freshwater body geomorphology as applied to agriculture, water resources management, and flood hazard and risk assessment	• Presently no high resolution spatio-temporal maps showing how freshwater bodies in Leyte Island evolved through time as a function of changing rainfall patterns • Established maps and data will be utilized by concerned Government Institution for their policy making and project implementation activities
PURPOSE Evidence-based and time-bounded water preservation measures using hydrometeorological and climatological inputs.	• Evidence-based policies on freshwater preservation and consumption	• Delineate the effect of hydrometeorological and climatological input to changes in the surface water features across time • Assess the effects on surface water availability for domestic use.	• Cooperation of the different agencies in providing the necessary data • Cooperation of the community members, barangay officials and other people concerned.
OUTPUTS 1. Spatio-temporal map of rainfall patterns 2. Hydrometeorological model of freshwater body geomorphological response to rainfall patterns 3. Mapping of freshwater body geomorphology across time 4. Climatological projection of freshwater body geomorphology	• Accuracy of the spatio-temporal map of rainfall patterns • Efficacy of the hydrometeorological model • Accuracy of freshwater body geomorphology • Accuracy of climatological projections as input	• Sensitivity Analysis and Bias correction • Ground-truthing	• Availability of data, software and hardware resources.

using different climate change scenarios	to geomorphological projection		
ACTIVITIES 1. Data gathering a. in-situ data of river basin morphometric characteristics b. remotely sensed data (i.e., weather radar data and satellite-based data) 2. Hydrometeorological modelling 3. GIS Analysis 4. Climate change projection 5. Research output manuscript writing 7. Presentation to conferences 8 Publication of research outputs	• Number of data gathered • Quality of data gathered • Model performance • Presentations to conferences • Submission to Calls for Paper	• Data quality and control mechanism/s • Model sensitivity analysis and correction algorithm • Quality of Conference and Indexing of Journals	• The research study conduct is on schedule.

D. Review of Literature

Ensemble rainfall data from in-situ and remotely sensed data

An ensemble of rainfall data using synoptic/agrometeorology stations, automated rain gauges, satellite and weather radar refers to a method of combining multiple sources of rainfall information to produce a comprehensive and reliable estimate of rainfall over a specific area. This approach can improve the accuracy of rainfall estimates by compensating for the strengths and weaknesses of individual data sources (Peralta et al., 2020; Veloria et al., 2021).

Ground based rainfall observation

Ground-based rainfall measurement involves collecting data on precipitation by installing rain gauges or other measurement devices on the ground (Bagtasa, 2020; Cayanan et al., 2011; Villafuerte et al., 2020). This type of measurement provides direct and detailed information about precipitation, including the amount, intensity, and duration of rainfall, which is critical for understanding and managing water resources.
There are several types of ground-based rainfall measurement devices, including:

1. Tipping bucket rain gauges: This type of gauge uses a funnel to collect rain into a bucket, which tips when a certain amount of rainfall is collected, counting the number of tips and providing a measure of the amount of rainfall.
2. Weighing precipitation gauges: This type of gauge uses a scale to weigh the amount of precipitation collected, providing a direct measurement of the amount of rainfall.
3. Sonic rain gauges: This type of gauge uses acoustic technology to measure the velocity of falling raindrops and calculate the amount of rainfall.

Ground-based rainfall measurements are widely used in hydrology, meteorology, and water resources management. They provide critical data for understanding and managing water resources, including quantifying the amount of rainfall, calculating streamflow, and developing and validating hydrometeorological models. However, it is important to note that ground-based measurements can be subject to measurement errors and uncertainties, and it is important to ensure that the measurement devices are properly maintained and calibrated (Ramos et al., 2016).

Weather radar data for rainfall pattern analysis

Weather radar data can be a useful tool for studying rainfall patterns. Radar systems emit a beam of microwave energy into the atmosphere and can detect the reflection of that energy from precipitation particles. By analyzing the radar data, scientists can determine the location, intensity, and movement of precipitation in each area (Deng et al., 2014; Lang et al., 2007; Parker & Ahijevych, 2007).

In rainfall pattern studies, radar data can be used to create precipitation maps, which show the distribution and amount of precipitation over a specific area. These maps can be used to identify areas of high and low rainfall, as well as to track the movement of storm systems. Additionally, radar data can be used to estimate the amount of rainfall that has fallen over a specific period of time (Kunz, 2007; Llasat et al., 2005). This information can be used to improve predictions of flooding and help with water resource management.

It's worth noting that radar data has some limitations, such as not being able to distinguish between rain, snow and sleet, and being affected by atmospheric conditions like temperature and wind, which can lead to errors in the data (Rigo & Llasat, 2004; Steiner & Houze, n.d.). To overcome this limitation, ground-based measurements and remote sensing techniques are also used to validate the radar data.

Satellite data for rainfall pattern analysis

Rainfall pattern analysis using satellite-based data involves analyzing precipitation patterns using data from satellite-based sensors. This type of analysis can provide valuable information about precipitation patterns and distribution, particularly in regions where ground-based data is limited or not available(Ramos et al., 2016).

There are several methods for analyzing rainfall patterns using satellite-based data, including:

1. Passive microwave remote sensing: This method uses microwave radiation to measure the amount of water vapor in the atmosphere, which can be used to estimate precipitation.
2. Infrared remote sensing: This method uses infrared radiation to measure the temperature of the Earth's surface and the atmosphere, which can be used to estimate precipitation based on the temperature difference between the surface and the atmosphere.
3. Combined methods: This involves combining data from multiple satellite-based sensors, including passive microwave and infrared, to provide a more comprehensive understanding of precipitation patterns.

These methods can provide valuable information about precipitation patterns in areas that are difficult to access or monitor, such as remote regions or disaster zones. This information can be used to support decision-making in the fields of water resources management, agriculture, and disaster risk reduction (Aryastana et al., 2022).

It is important to note that satellite-based data can have limitations, including measurement errors and uncertainties, and it is often necessary to validate the data using ground-based observations (Veloria et al., 2021).

Hydrometeorological Modelling

A hydrometeorological model is a mathematical model that simulates the interactions between water and the atmosphere. These models are used to predict and understand the dynamics of the water cycle, including precipitation, evaporation, runoff, and groundwater recharge(Yang & Zhang, 2019). Hydrometeorological models can be used for a variety of applications, including weather forecasting, water resources management, and flood and drought prediction (*Geomorphological Parameters of River Basins*, n.d.).

There are different types of hydrometeorological models(Pareta & Pareta, 2012), including:

1. Distributed models: These models simulate the water cycle at a high spatial resolution, allowing for the representation of small-scale features such as hills and valleys. They are often used for catchment-scale applications, such as predicting runoff and groundwater recharge.
2. Regional models: These models simulate the water cycle at a larger scale, such as for a region or a country. They are often used for applications such as drought and flood prediction, and for water resources management.

3. Global models: These models simulate the water cycle at a global scale and are used for climate modeling and research.

Hydrometeorological models are complex and require a large amount of data, such as weather observations and measurements of water levels, to be run and calibrated (Pullen et al., 2015). They also require a good understanding of the physical processes that govern the water cycle, as well as the ability to represent these processes in a mathematical form (Kourgialas et al., 2010; Li et al., 2022).

It's also worth noting that hydrometeorological models are always being improved to have more accuracy, especially with the increasing availability of observational data, remote sensing, and high-performance computing. They are also coupled with other models, like hydrological, ecological, and even economic models to assess the impacts of natural and human-induced changes on various sectors and ecosystem services (Torrefranca et al., 2021).

Statistical Analysis in Hydrometeorological Modelling

Statistical analysis is commonly used in hydrometeorological modeling to analyze and interpret the large amounts of data that are used to calibrate and run the models. Some examples of statistical methods used in hydrometeorological modeling include (Aparna et al., 2015; Kourgialas et al., 2010; Talampas & Cabahug, 2015):

1. Time series analysis: This method is used to analyze patterns and trends in time series data, such as precipitation and streamflow data. Time series models, such as ARIMA, are used to forecast future values of the data.
2. Regression analysis: This method is used to analyze relationships between variables, such as the relationship between precipitation and streamflow. Regression models, such as linear and multiple regression, can be used to predict streamflow from precipitation data.
3. Principal component analysis (PCA): This method is used to reduce the dimensionality of data and identify patterns in the data. PCA can be used to identify the main drivers of variability in the data, such as precipitation and temperature.
4. Bayesian statistics: These methods are used to update the probability of model parameters given new data. It is often used in the process of model calibration, where the model's parameters are adjusted to match the observed data.

These statistical methods are used in combination with the physical models to improve the predictions and understanding of the system. They are also used to estimate the uncertainty of the model predictions, which is important for decision making and risk management.

River basins and watersheds geomorphic response to rainfall patterns

The geomorphic response of river basins and watersheds to rainfall patterns refers to the way the shape and structure of the land changes in response to variations in precipitation. Rainfall patterns play a critical role in shaping the landscape through the processes of erosion, sediment transport, and deposition (Raj Saxena, n.d.; Rapant & Kolejka, 2021b; Sokol et al., 2021).

1. Erosion: Rainfall can cause erosion by dislodging soil and rock particles and moving them downstream. High intensity, short duration rainfall events can cause flash floods that can erode riverbanks and hillslopes, leading to channel incision and widening, and landslides (Hong & Naranjo, 2006).

2. Sediment transport: Rainfall can also cause sediment transport by moving soil and rock particles downstream. High intensity, short duration rainfall events can cause increased sediment transport, leading to channel aggradation and formation of alluvial fans and delta (Atienza & Hipolito, 2010).
3. Deposition: Rainfall can also cause sediment deposition by dropping the soil and rock particles downstream. Low intensity, long duration rainfall events can cause decreased sediment transport, leading to channel degradation and formation of floodplains and terraces (Shi et al., 2014).
4. Channel morphology: Rainfall patterns can affect the shape and structure of the river channels. High intensity, short duration rainfall events can cause the formation of steep, narrow channels, while low intensity, long duration rainfall events can cause the formation of wide, shallow channels (Fathian et al., 2016b).
5. Watershed response: Rainfall patterns can also affect the overall shape and structure of watersheds. High intensity, short duration rainfall events can cause the formation of steep, narrow watersheds, while low intensity, long duration rainfall events can cause the formation of wide, shallow watersheds (Genson Torrefranca et al., 2021; Pareta & Pareta, 2012).

It's worth noting that the geomorphic response of river basins and watersheds to rainfall patterns is a complex process that depends on various factors such as soil type, vegetation, topography, and human land use. Also, the rainfall patterns are not only affected by the amount of precipitation but also its temporal and spatial distribution. Therefore, accurate characterization of the rainfall patterns is crucial for understanding and predicting the geomorphic response of river basins and watersheds.

GIS Analysis on freshwater body geomorphology

GIS (Geographic Information Systems) analysis is a powerful tool that can be used to study the geomorphology of freshwater bodies, such as rivers, lakes, and lagoons. GIS analysis can be used to integrate, visualize, and analyze a variety of data types, including topographic, hydrological, and meteorological data, to understand the processes that shape and control the morphology of these water bodies (Fischer et al., 2008; Neussner et al., 2012).

1. Hydrological modeling: GIS can be used to create digital elevation models (DEMs) of the study area, which can be used to calculate hydrological parameters such as drainage density, stream order, and stream length-to-drainage area ratio. These parameters can be used to understand the processes that shape the river network, such as erosion and sediment transport (Sokol et al., 2021).
2. Sediment transport: GIS can be used to analyze the sediment transport in a river by using data from bathymetric surveys, topographic maps, and remote sensing imagery. It can also be used to calculate sediment transport rates, which can be used to understand how sediment is transported within a river and how it affects the river's morphology.
3. Flood analysis: GIS can be used to analyze the potential flood hazard within a river basin by using data on land use, topography, and hydrological models. Flood hazard maps can be generated and used to identify areas at risk of flooding and to develop flood management plans (Yumul et al., 2011).
4. Watershed management: GIS can be used to analyze the hydrological and geomorphological characteristics of a watershed, and to identify the factors that control the water cycle and the water quality within the watershed. It can also be used to

support land use planning and to develop sustainable management strategies for freshwater resources (Raj Saxena, n.d.).

5. Remote sensing: GIS can be used to analyze remote sensing data, such as satellite imagery and aerial photos, to study the geomorphology of freshwater bodies and their catchment areas. This can be used to identify changes in land cover, vegetation, and land use, and to monitor the effects of human activities on the water bodies (Fischer et al., 2008; Kumar Rai et al., 2017; Neussner et al., 2012).

Overall, GIS analysis can provide valuable insights into the geomorphology of freshwater bodies and can support decision-making for sustainable management and conservation of these important resources.

E. Expected Output

The outputs of river basin geomorphology studies can vary depending on the specific objectives and scope of the study, but they can generally include:

1. Maps and Spatial Data: River basin geomorphology studies can produce maps and other spatial data that provide a detailed understanding of the physical features and characteristics of river basins, including river channels, floodplains, and topography.
2. Hydrologic and Geomorphic Characterization: River basin geomorphology studies can provide detailed information on the hydrologic and geomorphic processes that shape river basins, including erosion, sediment transport, and river channel dynamics.
3. Flood Hazard and Risk Assessment: River basin geomorphology studies can provide information on the risk of flooding, including floodplain mapping, flood frequency analysis, and the development of early warning systems.
4. Water Resources Management: River basin geomorphology studies can inform decisions about water resources management, including the distribution and use of water for various purposes such as irrigation, hydropower, and domestic consumption.
5. Environmental Management: River basin geomorphology studies can provide information on the impact of human activities on river basins, including land-use change and water pollution, and inform decisions about the protection and preservation of important ecosystems, habitats, and species.
6. Infrastructure Development: River basin geomorphology studies can inform decisions about the development of infrastructure projects, including the construction of dams, levees, and other structures, by providing information on the potential impacts of these projects on the environment and local communities.
7. Climate Change Adaptation: River basin geomorphology studies can provide information on the potential impacts of climate change on river basins, including changes in the timing, distribution, and intensity of rainfall, and inform decisions on climate change adaptation and resilience.

In conclusion, the outputs of river basin geomorphology studies can provide important information for a wide range of stakeholders, including water resource managers, environmental managers, infrastructure developers, and policy-makers, and can inform decisions on water resources management, environmental management, infrastructure development, disaster risk reduction, and climate change adaptation.

The research study projects publication of research output especially the spatial data and maps generated from the study. Also, publication of the characterization of the geomorphic response of freshwater bodies in Leyte Island that will be beneficial in water resources management especially for agricultural, industrial, and domestic use. Another is the publication on Flood Hazard and Risk Assessment of different freshwater bodies and the respective localities they belong to. Lastly, with all the outputs of the study, infrastructure development is one aspect that is eyed to be one that will benefit the most since measures are to be taken to mitigate the effects of climate change.

F. Potential Impact

River basin geomorphology studies can have a significant impact on various aspects of society, including:

1. Water Resources Management: By understanding the geomorphology of river basins, it is possible to improve the management of water resources, including the distribution and use of water for various purposes such as irrigation, hydropower, and domestic consumption.
2. Flood Management: River basin geomorphology studies can provide important information on the risk of flooding and help to inform decisions on flood management, including floodplain mapping and the development of early warning systems.
3. Environmental Management: Understanding the geomorphology of river basins can help to inform decisions about the protection and preservation of important ecosystems, habitats, and species, as well as the management of land-use activities that impact river basins.
4. Infrastructure Development: River basin geomorphology studies can inform decisions about the development of infrastructure projects, including the construction of dams, levees, and other structures, by providing information on the potential impacts of these projects on the environment and local communities.
5. Disaster Risk Reduction: River basin geomorphology studies can help to identify areas that are at risk of natural disasters, such as landslides and flash floods, and inform decision-making on disaster risk reduction and management.
6. Climate Change Adaptation: River basin geomorphology studies can provide important information on the potential impacts of climate change on river basins, including changes in the timing, distribution, and intensity of rainfall, and inform decisions on climate change adaptation and resilience.

In conclusion, river basin geomorphology studies have the potential to inform a wide range of decisions related to water resources management, environmental management, infrastructure development, disaster risk reduction, and climate change adaptation, and thus, have a significant impact on society.

G. Methodology/ Workplan

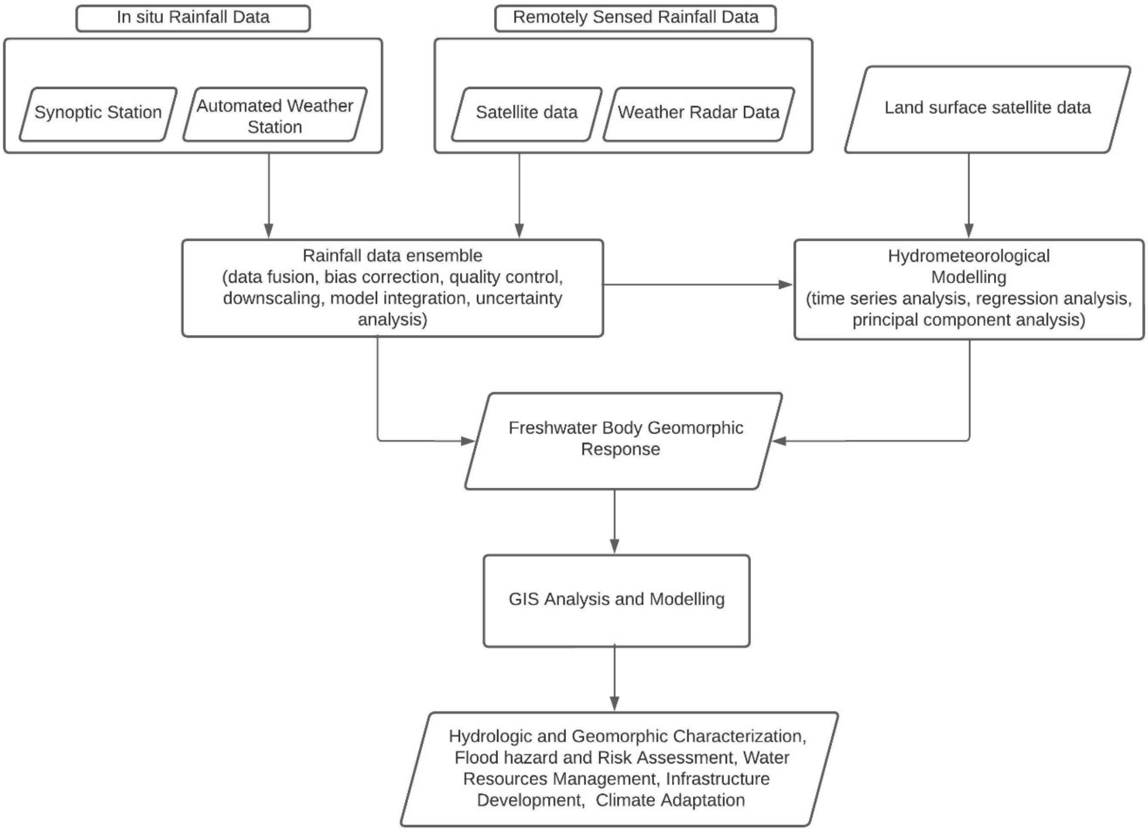

Figure 1. The Methodological Framework

Making an ensemble of rainfall data from station observation, satellite, and weather radar involves combining data from multiple sources in order to produce a more accurate and complete estimate of rainfall. The following are some of the methods that can be used to create an ensemble of rainfall data (Peralta et al., 2020; Rollenbeck & Bendix, 2011; Veloria et al., 2021):

1. Data Fusion: This involves combining rainfall data from multiple sources into a single estimate using statistical methods, such as averaging or weighting (Ramos et al., 2016).
2. Bias Correction: This involves correcting any systematic errors in the rainfall data from each source by comparing the data to a reference dataset, such as rainfall station observations.
3. Quality Control: This involves checking the rainfall data from each source for errors, inconsistencies, or missing values, and correcting or removing any problematic data (Hirose & Nakamura, 2005; Peter et al., n.d.).
4. Downscaling: This involves transforming the large-scale satellite or radar rainfall data to a finer resolution that is more appropriate for the local area of interest.
5. Model Integration: This involves incorporating the rainfall data from each source into a hydrological or meteorological model in order to simulate the rainfall and its impacts on the environment.

6. Uncertainty Analysis: This involves evaluating the uncertainty associated with each component of the ensemble rainfall data, including the measurement errors, the model uncertainties, and the sources of variability in the rainfall patterns.

These methods are often used in combination to produce a high-quality ensemble of rainfall data that can provide a more complete picture of rainfall patterns and help to inform decision-making in the fields of water resources management, agriculture, and disaster risk reduction (Kunz, 2007; Llasat et al., 2005; Steiner & Houze, n.d.).

The Soil and Water Assessment Tool (SWAT) is a widely-used hydrological model developed for predicting the impacts of land use and management practices on water resources and water quality. It is a physically-based, distributed-parameter model that simulates the movement of water, sediment, and nutrients through watersheds and river basins (Palao et al., 2013).

SWAT is designed to be flexible and can be used for a wide range of applications, including:

1. Water resources management: SWAT can be used to simulate the impact of different land use and management practices on streamflow, groundwater recharge, and water quality, and to inform decisions about water resources management and allocation (Guiamel & Lee, 2020).
2. Agriculture: SWAT can be used to simulate the impact of different agricultural practices, such as tillage, irrigation, and fertilization, on soil moisture, runoff, and nutrient losses, and to inform decisions about sustainable agricultural practices (Palao et al., 2013).
3. Environmental management: SWAT can be used to simulate the impact of different land use and management practices on water quality, including the impacts of non-point source pollution, such as sediment and nutrient runoff from agricultural fields (Guiamel & Lee, 2020; Nauman et al., 2019).
4. Climate change: SWAT can be used to simulate the impact of climate change on water resources, including changes in precipitation, temperature, and evapotranspiration, and to inform decisions about climate change adaptation and resilience (Graciela et al., 2018).

SWAT is widely used in academic, government, and private sectors for hydrological modeling and has been applied in many countries around the world. It is a flexible tool that can be customized to the specific needs of different watersheds and can be used in combination with other models and data sources to provide a comprehensive picture of water resources and water quality (Graciela et al., 2018; Guiamel & Lee, 2020; Nauman et al., 2019; Palao et al., 2013).

Hydrometeorological modeling involves using mathematical models to simulate and understand the behavior of water in the environment (Braud et al., 2014; Issakhov, 2014; Verbunt et al., 2006). The following are some of the common analyses used in hydrometeorological modeling:

1. Time series analysis: This involves analyzing time series data of precipitation, streamflow, evapotranspiration, and other hydrometeorological variables to identify trends, patterns, and cycles in the data (Verbunt et al., 2006).
2. Spatial analysis: This involves analyzing the spatial patterns of precipitation, streamflow, evapotranspiration, and other hydrometeorological variables across a watershed or river basin to identify regional differences and to understand the influence of topography and land use on water resources (Thakur et al., 2018).

3. Statistical modeling: This involves using statistical models to predict the behavior of hydrometeorological variables based on past data and to understand the relationships between different variables (Chiang & Chang, 2009; Vergnes et al., 2020).
4. Physical modeling: This involves using physical models to simulate the flow of water in the environment and to understand the processes that control the movement of water, sediment, and nutrients (Black, 1972; Shi et al., 2014).
5. Uncertainty analysis: This involves evaluating the uncertainty associated with the predictions of hydrometeorological models, including the measurement errors, the model uncertainties, and the sources of variability in the data (Chiang & Chang, 2009).
6. Climate change impact analysis: This involves using hydrometeorological models to simulate the impacts of future climate change on water resources and water quality and to inform decisions about climate change adaptation and resilience (Vergnes et al., 2020).

These analyses are often used in combination to provide a comprehensive understanding of the behavior of water in the environment and to support decision-making in the fields of water resources management, agriculture, and disaster risk reduction.

H. Milestone

Objectives	Expected Output	Activities	2023		2024			
			3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1. Establish a spatio-temporal rainfall pattern using comparative analysis of in-situ and remotely sensed data (i.e., Satellite-based Observation and Weather Radar Observation).	1. Time series of PAGASA statin and automated rain gauge data (ARG). 2. Time series of Satellite based data 3. Time series of weather radar data 4. Comparative analysis of datasets 5. Established rainfall pattern	1. Communicate and request data from PAGASA (station, ARG, and weather radar data) 2. Perform data quality and interpolation of missing data 3. Perform Time series analysis on time-generated data 4. Perform ensemble of data and comparative analysis	✔	✔				
2. Analyze the hydrological connectivity of river basin geomorphology.	1. Input spatio-temporal map of rainfall to hydrological model 2. Establish connectivity of rainfall patterns to surface water body geomorphology	1. Assimilate produced rainfall patterns to Hydometeorologica l Model, and; 2. Perform simulation on rainfall pattern to geomorphology connectivity 3. Perform correlation analysis		✔	✔	✔		
3. Characterize the geomorphic response of river basins in Leyte Island as a function of hydrometeorolog ical input.	1. Geomorphic response map of surface water body to climatological forcing 2. Geomorphologic al projections based on climatological scenarios.	1. Create geomorphic response map of surface water body 2. Simulate future geomorphological conditions of surface water bodies given different climate scenarios and projections.			✔	✔	✔	✔
4. Manuscript writing	1. Quarterly and Annual report	1. Quarterly and Annual report						

	2. Manuscripts for publications	writing and submission 2. Preparation of manuscripts for publication		✔	✔	✔	✔	✔
5. Conference proceeding presentation and publication	1. Research outputs and products	1. Presentation of results and information, education and communication campaign.			✔	✔	✔	✔

I. Users/ Target Beneficiaries:

Evidence-based water resources management refers to the use of scientific data and research to inform decisions about the management of water resources. The main beneficiaries of evidence-based water resources management are:

1. Community: Evidence-based water management can help to ensure that water resources are used in a sustainable and equitable manner, benefiting the communities that rely on them for drinking water, agriculture, and other needs.
2. Environment: By using scientific data to inform water management decisions, it is possible to minimize the impact of water use on the environment, including water-related ecosystems, habitats, and species.
3. Government: Evidence-based water management can help governments to make informed decisions about water resources and ensure that they are used in a manner that is consistent with national and international policies and regulations.
4. Business: Evidence-based water management can provide businesses with the information they need to make informed decisions about water use, including water sustainability and efficiency, and help them to reduce the impact of their operations on the environment.
5. Scientists and researchers: Evidence-based water management provides an opportunity for scientists and researchers to contribute to decision-making by providing the latest scientific data and research on water resources.

Overall, the beneficiaries of evidence-based water resources management include the communities that rely on water resources, the environment, the government, businesses, and the scientific and research community. By using scientific data and research to inform decisions about water management, it is possible to ensure that water resources are used in a sustainable and responsible manner, benefiting all stakeholders.

J. Budget Requirement

The following table details the pricing for delivery of the goods and services outlined in this proposal.

Budget Items	Unit	Unit Cost (Php)	No. of units (months)	Unit Total (Php)	Total (Php)
I. Personal Services					
A. Salaries and Wages					
Research Assistant	Month	20,000	18	360,000	360,000
Student Assistant	Day	100	18	2,000	36,000
Laborer	-	-	-	-	-
II. MOOE					
A. Travel and Communication	Call, texts, and data plan	500	18	9,000	9,000
	Travel Expenses (Transportation and accommodation of Meetings, Seminars, and Workshops)	-	-	-	40,000
B. Field Laptop	Laptop, 13.6", 8-core M2 Chip, 8GB RAM with Microsoft Office 2021 Professional Plus Perpetual License	120,000	-	120,000	120,000
C. Computer System Unit	Desktop Computer, Core i9 12th Gen, 32GB RAM, RTX 3070Ti, no Monitor	160,000	-	160,000	160,000
D. Computer Monitor	34" Ultra-Wide Curve 21:9 1440p Monitor	40,000	-	40,000	40,000
E. Miscellaneous	Incidentals	-	-	-	15,000
III. Total Cost					780,000

Disclaimer: The prices listed in the preceding table are an estimate for the goods and services discussed. This summary is not a warranty of final price. Estimates are subject to change if project specifications are changed or costs for outsourced services change before the project is executed.

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K. References

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Operational Definition of Terms:

Title – The identification of the program/ project and the projects/ component/ studies (as defined by DOST)

Program – consists of interrelated or complimenting R&D Projects on a multi-disciplinary approach to meet established goals within a specific time frame (as defined by DOST)

Project - a set of interrelated studies to meet pre-determined objectives within a specific time frame (as defined by DOST)

Study -

Leader – the one in-charge to take the lead in program/ project/ study implementation (as defined by DOST)

Researcher – refers to person working in those capacities, who uses or creates scientific knowledge and engineering and technological principles (as defined by DOST)

Cooperating/ Collaborating Agency(ies) – agencies participating in the R&D work

Duration – number of months the program/project/study will be implemented. To include date of implementation and completion

Classification – indicates whether the program/ project is a Research (basic, applied), Development or Extension program/ project/ study (as defined by DOST)

Basic Research – an experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view(as defined by DOST)

Applied Research – is an original investigation undertaken in order to acquire new knowledge directed primarily towards a specific aim or objective (as defined by DOST)

Development – is a systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices, installing new processes, systems and services and improving substantially those already produced or installed

Discipline – the specific field to be studied

Users/ Target Beneficiaries – refers to the clientele

Personal Services (PS) – total requirement for wages, salaries, honoraria, additional hire and other personnel benefits (as defined by DOST)

Maintenance and Other Operating Expenses (MOOE) – total requirement for supplies, materials, travel expenses, communication and other services (as defined by DA-BAR)