Appendix B

Flood Potential Area Maps and Longitudinal Profiles

IDENTIFICATION OF FLOOD POTENTIAL AREA

There are already a number of studies that served as sources of data/information for the preparation of inundation maps of the 19 target river basins, among which are the following:

(1) The Hazard Mapping and Assessment for Effective Community-Based Disaster Risk Management or the READY Project, implemented by the Office of Civil Defense (OCD) in collaboration with the National Disaster Coordinating Council (NDCC), now known as National Disaster Risk Reduction and Management Council (NDRRMC). The Collective Strengthening on Community Awareness on Natural Disaster (CSCAND) agencies are the member agencies, such as MGB, NAMRIA, PAGASA and PHIVOLCS, from 2006 until 2011;

(2) The Study on the Nationwide Flood Risk Assessment and the Flood Mitigation Plan for Selected Areas in the Republic of the Philippines (JICA-FRIMP), undertaken by CTI Engineering International Company Ltd., under the assistance of JICA, in 2008;

(3) The Project for Strengthen of Flood Forecasting and Warning System for Dam Operation (FFWSDO), undertaken by Nippon Koei Co. Ltd., under the assistance of JICA, in 2012; and

(4) The Geohazard Mapping and Assessment Program undertaken by the Department of Environment and Natural Resources (DENR) and being implemented by the Mines and Geoscience Bureau (MGB).

The table below provides a list of river basins covered by each project mentioned above:

Availability of Flood Potential Area Maps (1/2)

River Basin	READY Project	JICA- FRIMP	Former JICA-TCP	MGB
Cagayan	○	○	×	○
Agno	×	○ (U)	×	○
Pampanga	○	○ (U)	○ (D)	○
Pasig-Laguna	○	○ (U)	×	○
Bicol	×	○	×	×
Abulog	×	○	×	○
Abra	○	○	×	○
Panay	×	○	×	○
Jalaur	×	○	×	○
Ilog-Hilabangan	×	○	×	○
Agusan	×	○ (U)	×	○
Tagaloan	×	○	×	○
Cagayan De Oro	×	○	×	○

Source: Ready Project, JICA- FRIMP, JICA-FFWSDO, and MGB
Legend: O – map is available, x – map is not available
(U) – available only in the upstream area, (D) – available only in the downstream area

Availability of Flood Potential Area Maps (2/2)

River Basin	READY Project	JICA- FRIMP	Former JICA-TCP	MGB
Agus	×	○	×	○
Tagum(saug)-Libuganon	×	○	×	×
Davao	×	○	×	×
Mindanao	×	○	×	○
Buayan-Malungun	×	○	×	×
Mandulog	×	○	×	○

Source: Ready Project, JICA- FRIMP, JICA-FFWSDO, and MGB
Legend: O – map is available, x – map is not available

Background on Related Studies

(a) READY Project

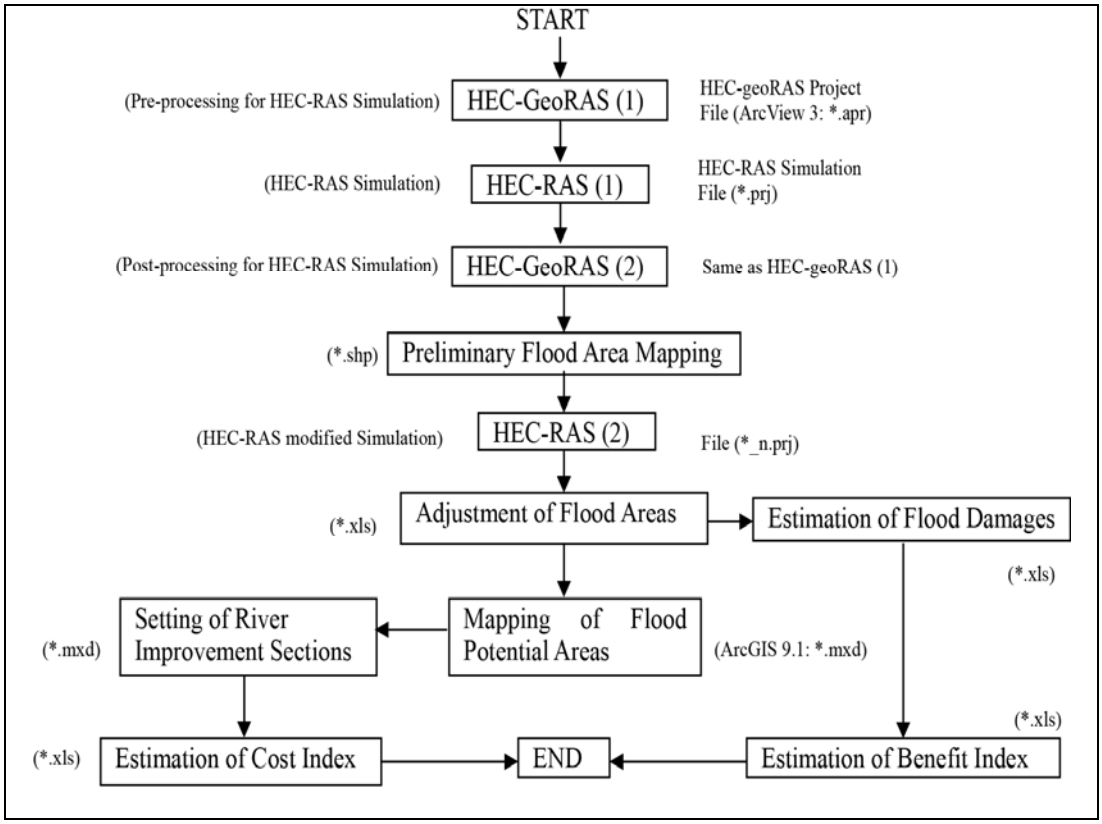
The READY Project is a multi-hazard mapping and assessment project undertaken by then NDCC, now known as the NDRRMC, in partnership with key CSCAND agencies such as PHIVOLCS, PAGASA, MGB, NAMRIA and other concerned agencies. It is built on existing structures and provides the environment for stakeholders to work together with clear roles and responsibilities to perform.

The Project focuses on high-risk areas which were selected based on population size and the number of hazards to which they are vulnerable. It marks the first attempt to approach disasters in a multi-hazard fashion. The goal of strengthening the capacity of key stakeholders sits well in terms of creating an enabling environment in the communities. The project encompasses the Disaster Risk Reduction and Management (DRRM) process, to include community-based early warning system and information, education, and communications (IEC) activities. The data and information generated from the Study are utilized by the sectoral agencies and Local Government Units (LGUs) for disaster risk management and planning**.**

Currently, the READY Project covers four of the 19 target river basins covered by this Study, namely Cagayan, Pampanga, Pasig-Laguna De Bay, and Abra. Unfortunately, the rest of the other river basins are not within the scope of the READY Project.

(b) JICA-FRIMP Study Project

The CTI conducted the Study on two screening stages to select priority river basins in order to identify flood potential areas. In both stages, a scoring of evaluation indexes using GIS technique was carried out to identify the priority river basins, taking into consideration several parameters such as socio-economic conditions, natural conditions, economic efficiency, and strategically significant river basins. As a result, 120 river basins were selected during the first screening. A second screening was conducted for these 120 river basins considering the cost and benefit indexes together with the scores on the first screening. In the course of estimating the cost and benefit indexes, HEC-RAS and HEC-GeoRAS models were utilized and flood prone areas were mapped out. The figure in the succeeding page shows the flowchart for this procedure.



Source: JICA-FRIMP

HEC-RAS/ GeoRAS and Mapping of Flood Potential Areas

HEC-GeoRAS (1) was utilized in order to obtain the cross-section data from the digital elevation model (DEM). HEC-RAS (1) was then utilized in order to calculate the water level in the river, and HEC-GeoRAS (2) to map out the preliminary flood area. Based on this preliminary flood area mapping, HEC-RAS (2) was utilized again in order to improve the accuracy of the model, which was mainly realized through:

- Upgraded accuracy of sub-basin area using 1/50,000 scale maps
- Improved accuracy of estimated design discharges using the specific discharge formula

Based on the results of HEC-RAS (2), flood area was adjusted by comparing the extent of preliminary flood area and the results of HEC-RAS (2). Following this adjustment, the preliminary flood area was modified and the flood potential upstream area was mapped out.

(c) JICA-FFWSDO Study Project

The JICA-FFWSDO Project targeted six dam sites, namely Ambuklao, Binga, San Roque, Angat, Pantabangan and Magat which are located in three major river basins (covering a total of 41,180 km^2 watershed area with 15.3 million people as beneficiaries) and the surrounding areas of the dam sites. One component of this Project is the conduct of flood inundation analysis in Pampanga River basin. The inundation analysis selected the recent major flood event that occurred in the area, i.e., Typhoon Pedring that occurred in September 2011, for its primary simulation period.

MIKE FLOOD, an inundation analysis tool, was applied in the Study. It is a dynamic mathematical modeling software for integrating one-dimensional (1-D) river model (based

on MIKE 11 HD) and two-dimensional (2-D) floodplain model (based on MIKE 21 HD). The software can also simulate hydrodynamic conditions of both river and floodplain. The hydrological analysis or rainfall-runoff model (based on MIKE NAM) is a component 1-D river modeling. The said model can be interlinked with 1-D River model to provide upstream boundary condition as well as sub-basin runoff contribution to river flow hydraulics.

The following key issues were identified during the Study:

- Identification of flood hazard area with depth and duration analysis
- Verification of water level and discharge in the river at un-gauged locations
- Verification of the flood water propagation through floodplain

The inundation analysis study covered the entire basin of the Pampanga River, covering a total of 10,434 km^2. This, however, is further divided into three sub-basins namely: 1) Pampanga main river basin with a catchment area of 7,978 km^2, 2) Pasac River basin with an area of 1,371 km^2, and 3) Angat River basin with an area of 1,085 km^2.

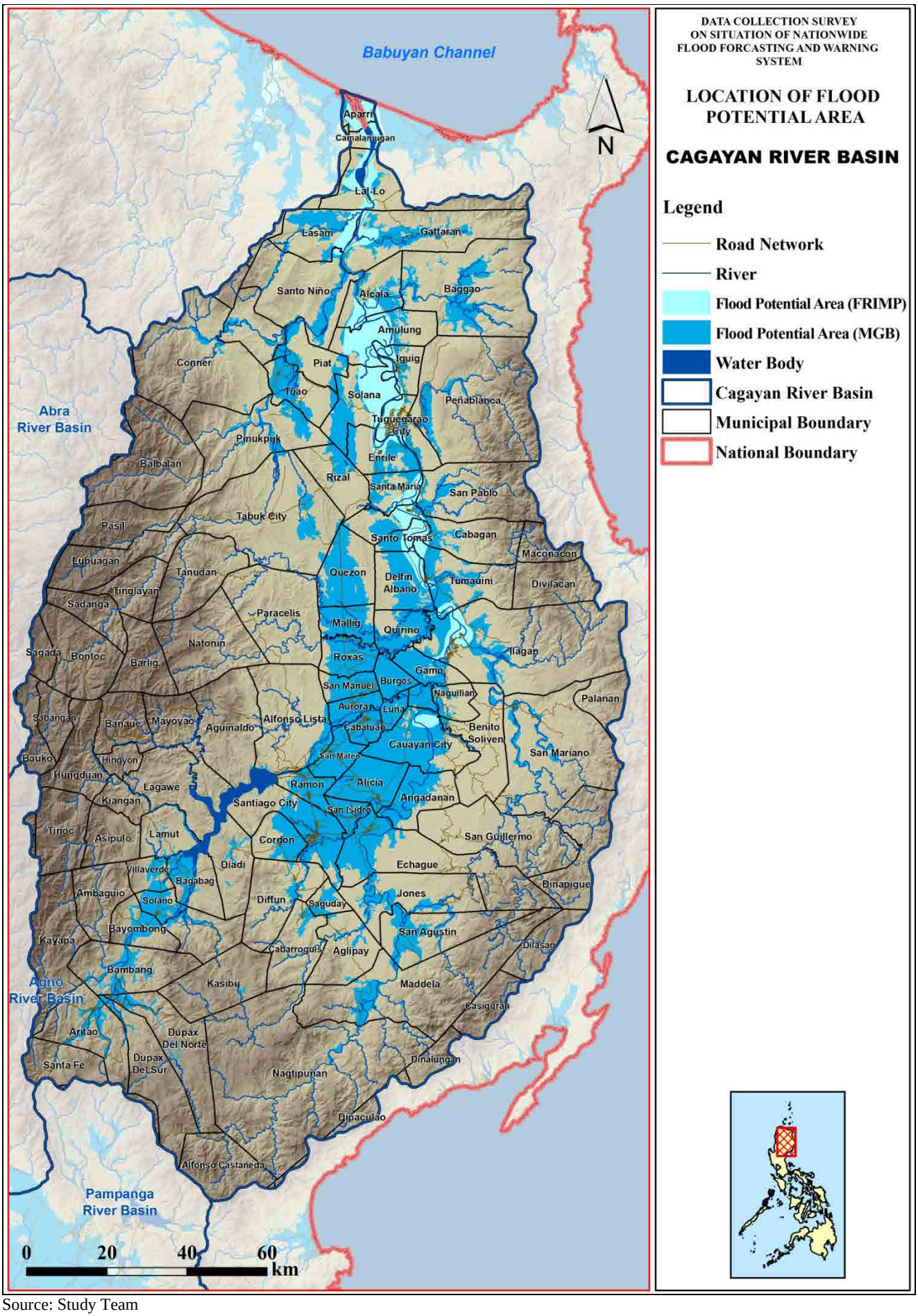
In this Study, the flood potential area identified by the JICA-FFWSDO Project for the Pampanga River basin will be utilized. This is because the detailed flood inundation modeling for the entire river basin was undertaken by the said Study, as mentioned earlier in this section.

(d) Geohazard Mapping and Assessment Program

This is a Program undertaken by the DENR and being implemented by the MGB. The main objectives of the program are to identify areas in the country that are susceptible or vulnerable to various geologic hazards and increase public awareness to lessen or mitigate the impacts of these events. Major activities were carried out under this program, which include the following:

- Geohazard Mapping at 1:50,000 scale and detailed Geohazard Mapping at 1:10,000 scale,
- Conduct of province-and-municipal-wide information and education campaign,
- Provision of geohazard maps and issuance of information/advisories to LGUs identified as prone to geohazards,
- Identification of relocation sites, and
- Establishment of community-based early warning system.

The geohazard maps included two major hazards, namely landslides and floods. The flood susceptible map does not cover four river basins, namely, Bicol, Tagum(saug)-Libuganon, Davao, and Buayan-Malungun. GIS analysis was used mainly as the methodology for the identification/assessment of the geohazard maps. The study was able to come up with geohazard maps of most of the regions and provinces in the Country and these can now be accessed at the website of MGB and Philippine Information Agency (PIA) as well.



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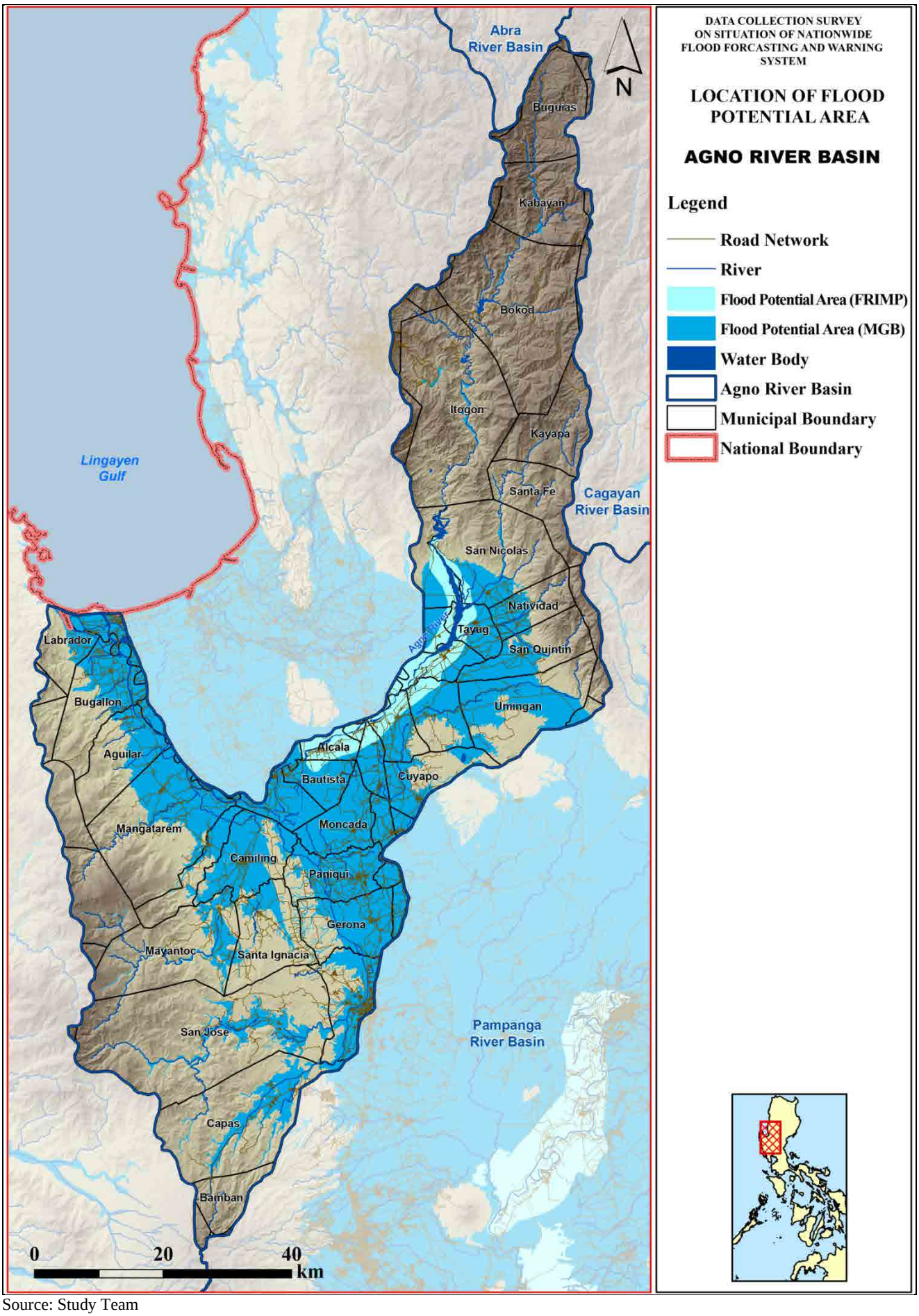

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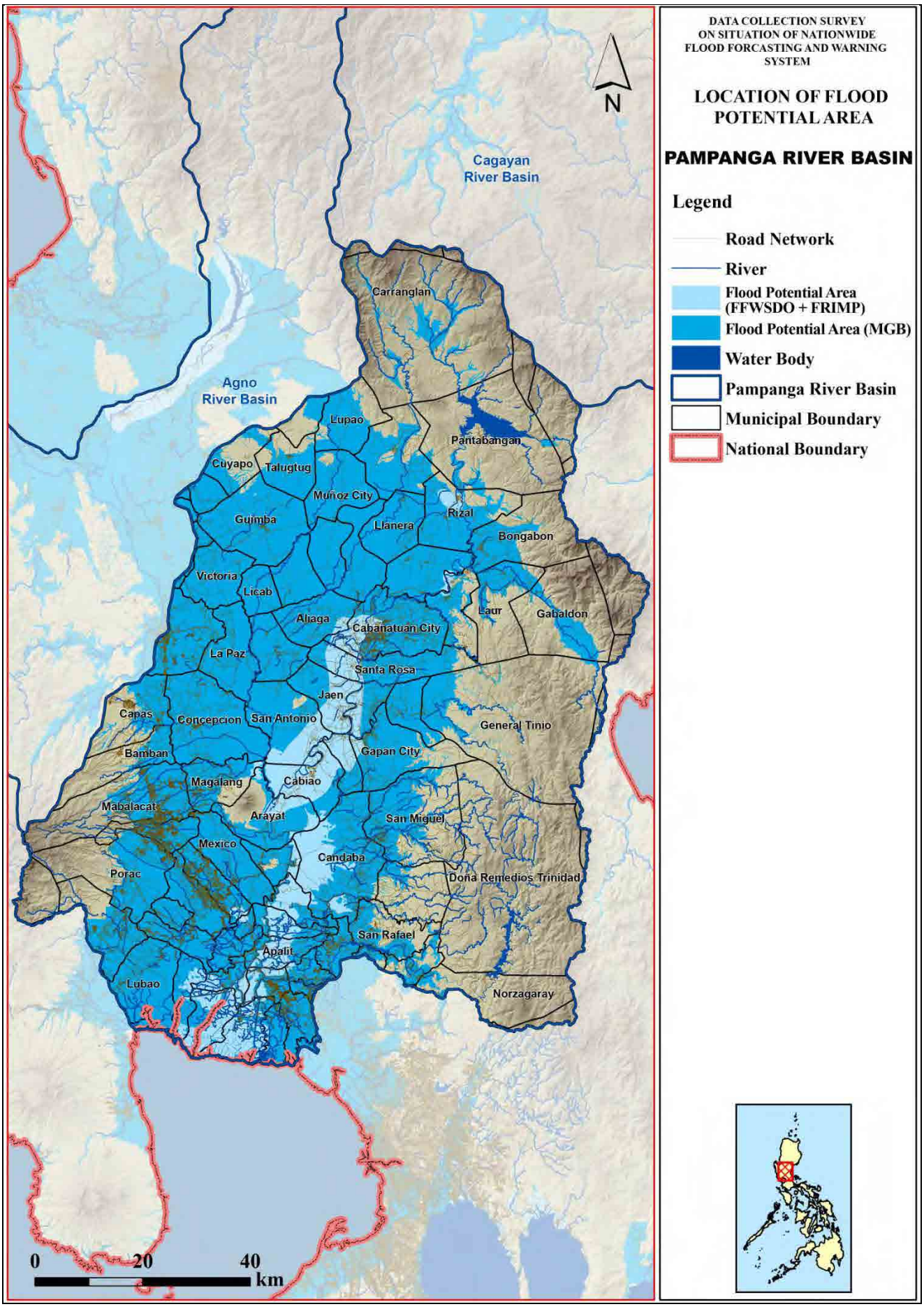
DATA COLLECTION SURVEY
ON SITUATION OF NATIONWIDE
FLOOD FORCASTING AND WARNING
SYSTEM
LOCATION OF FLOOD
POTENTIAL AREA
PAMPANGA RIVER BASIN
Legend
Road Network
River
Flood Potential Area
(FFWSDO + FRIMP)
Flood Potential Area (MGB)
Water Body
Pampanga River Basin
Municipal Boundary
National Boundary
N
Cagayan
River Basin
Agno
River Basin
Carranglan
Lupao
Pantabangan
Cuyapo
Talugtug
Muñoz City
Rizal
Guimba
Llanera
Bongabon
Victoria
Licab
Laur
Gabaldon
Aliaga
Cabanatuan City
La Paz
Santa Rosa
Jaen
Capas
Concepcion
San Antonio
General Tinio
Bamban
Gapan City
Magalang
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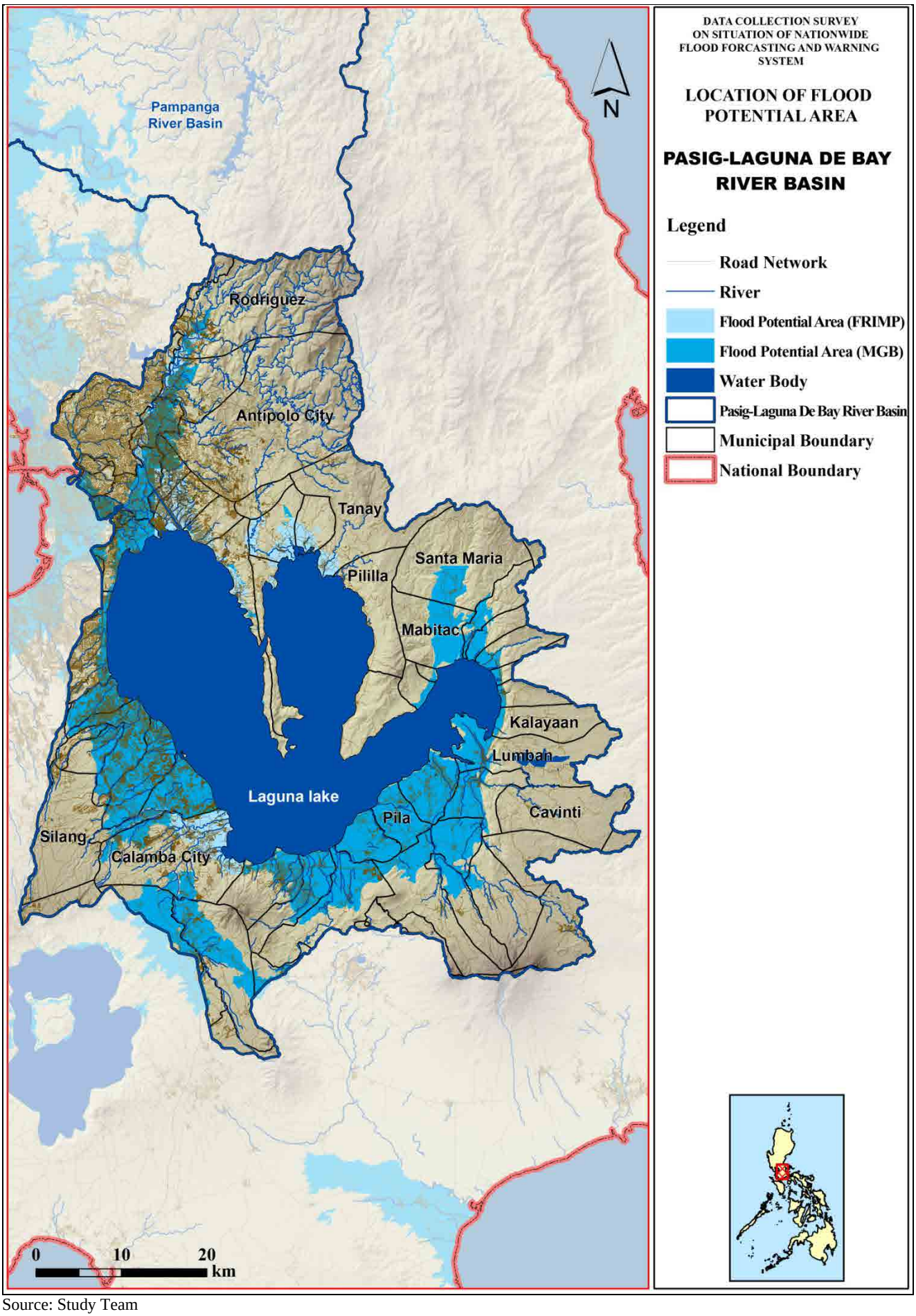

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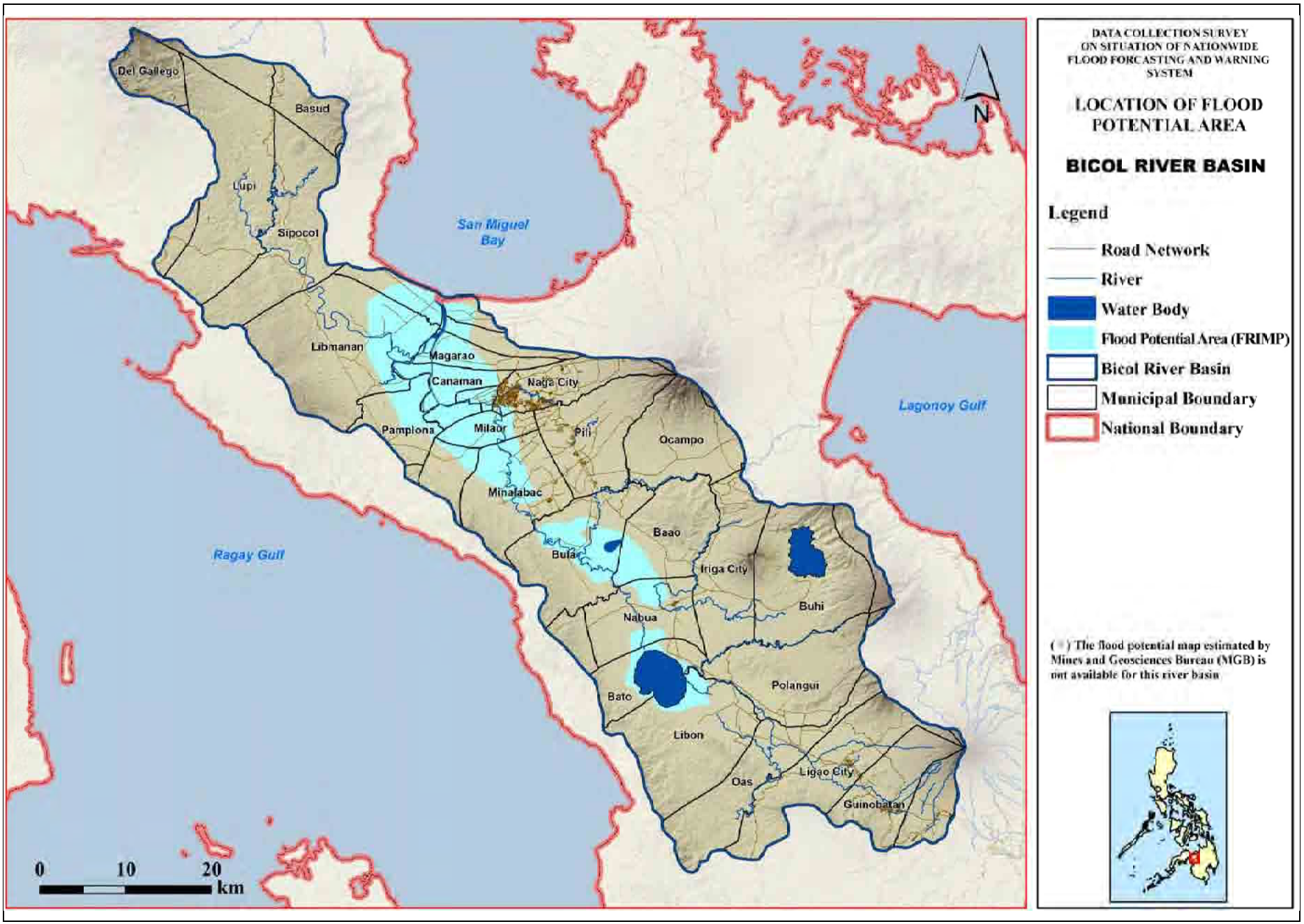

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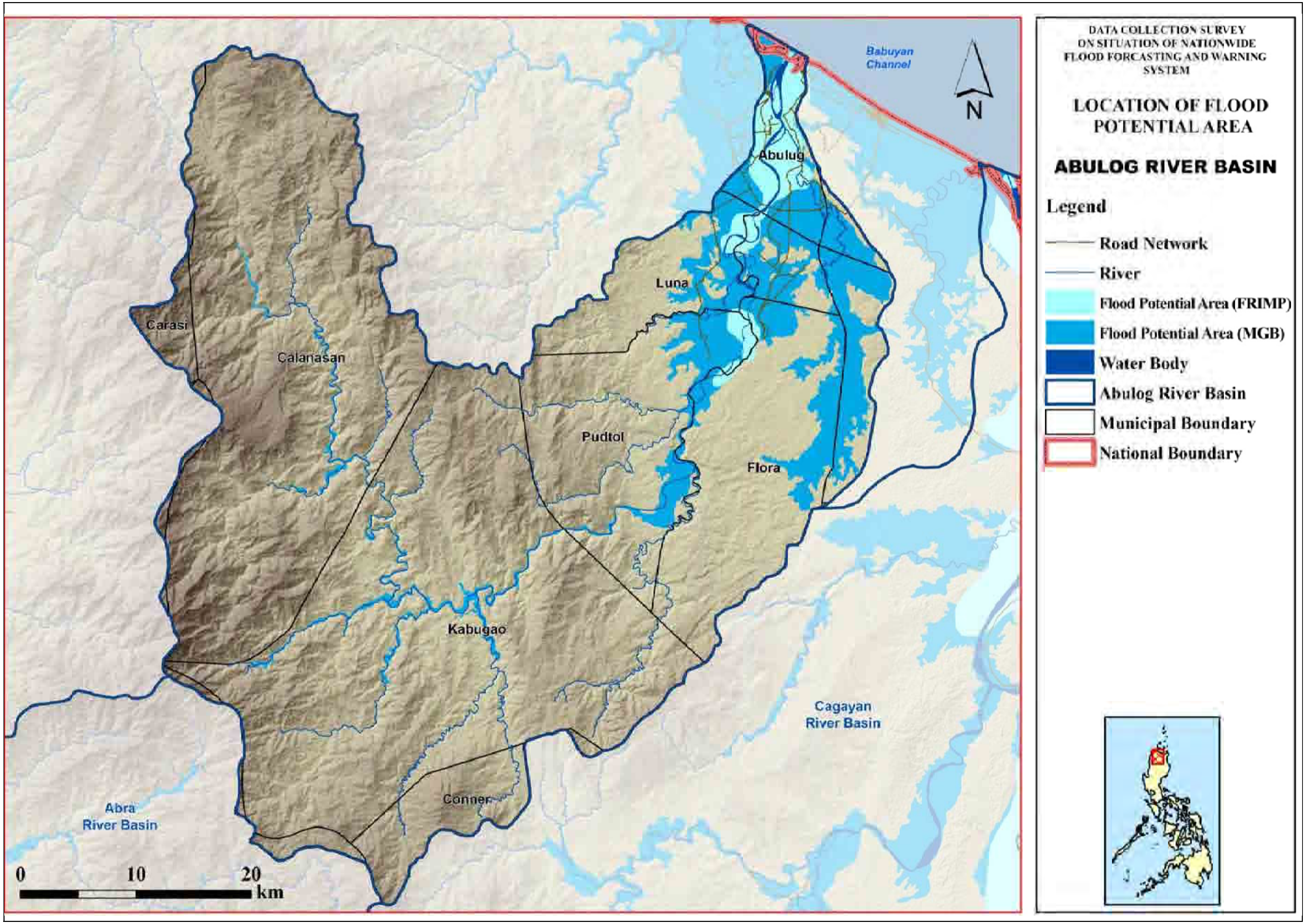

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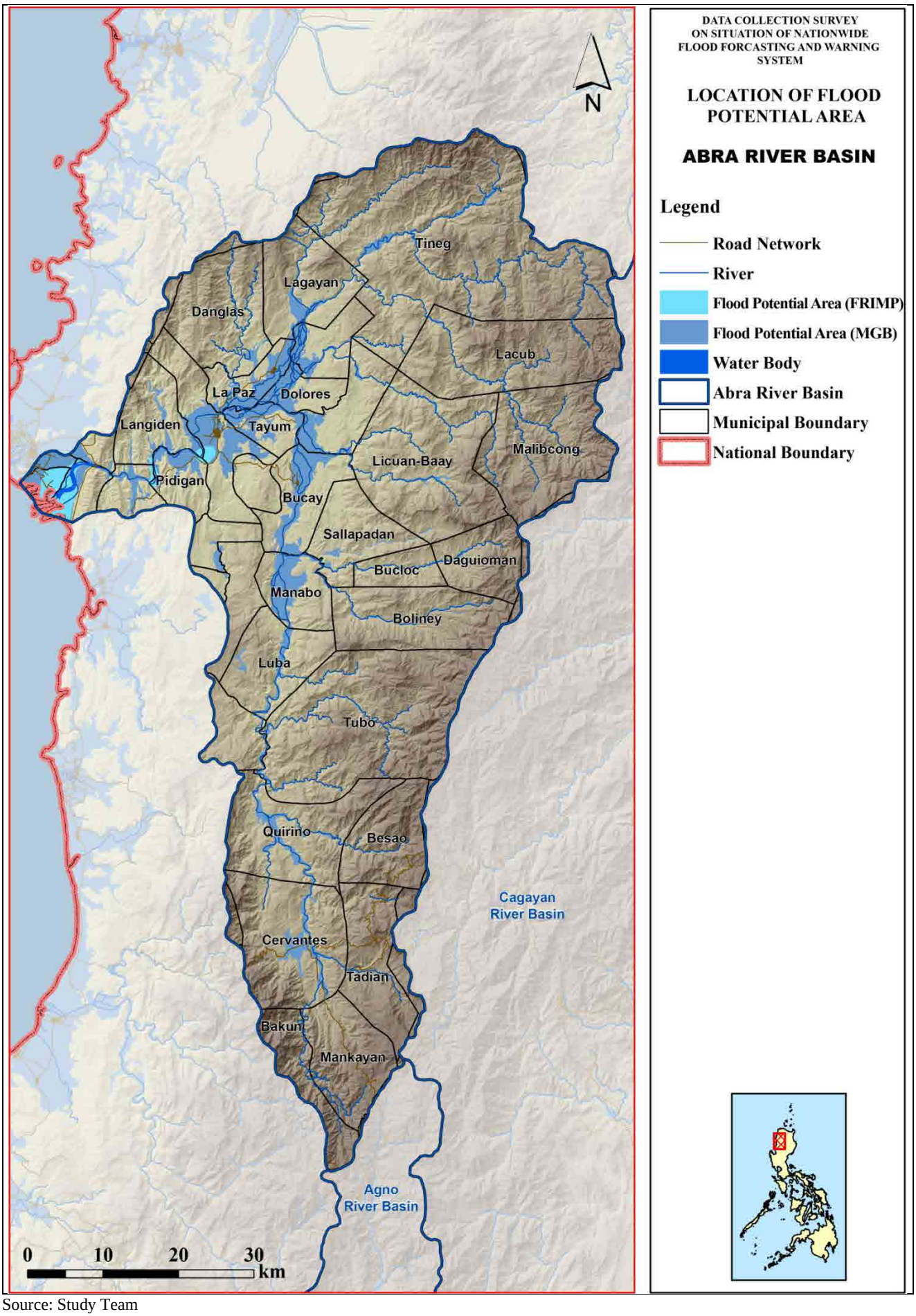

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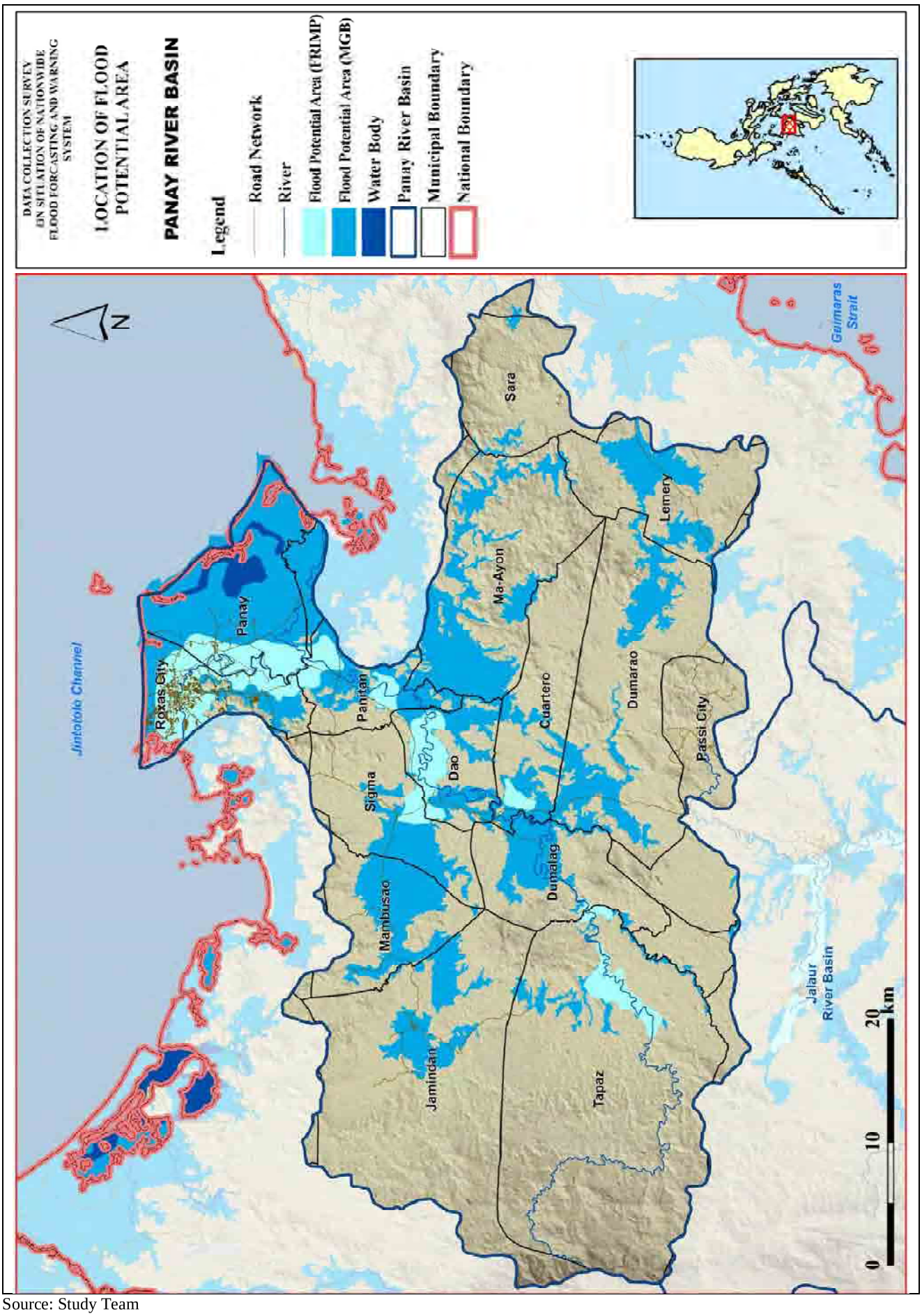

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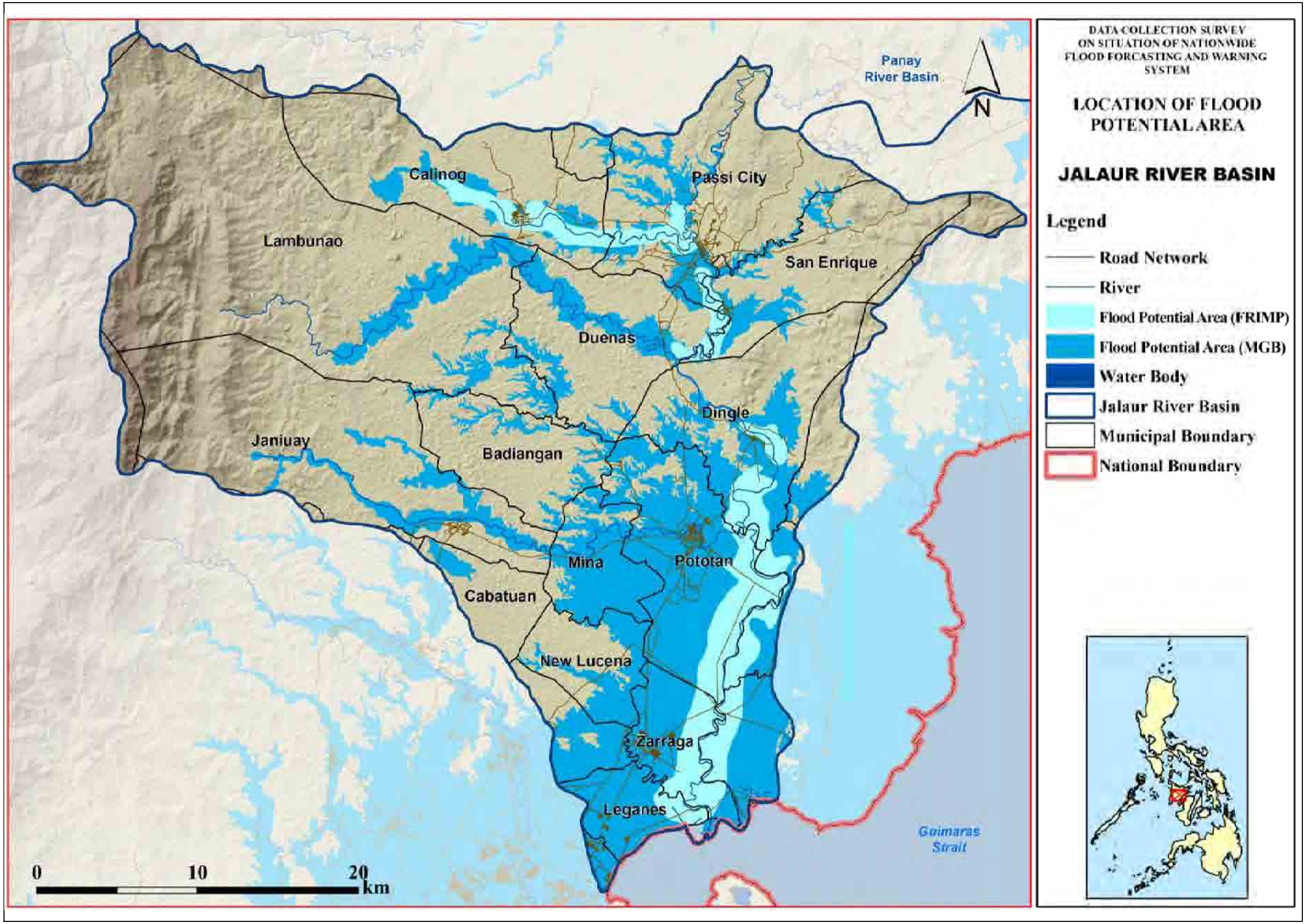

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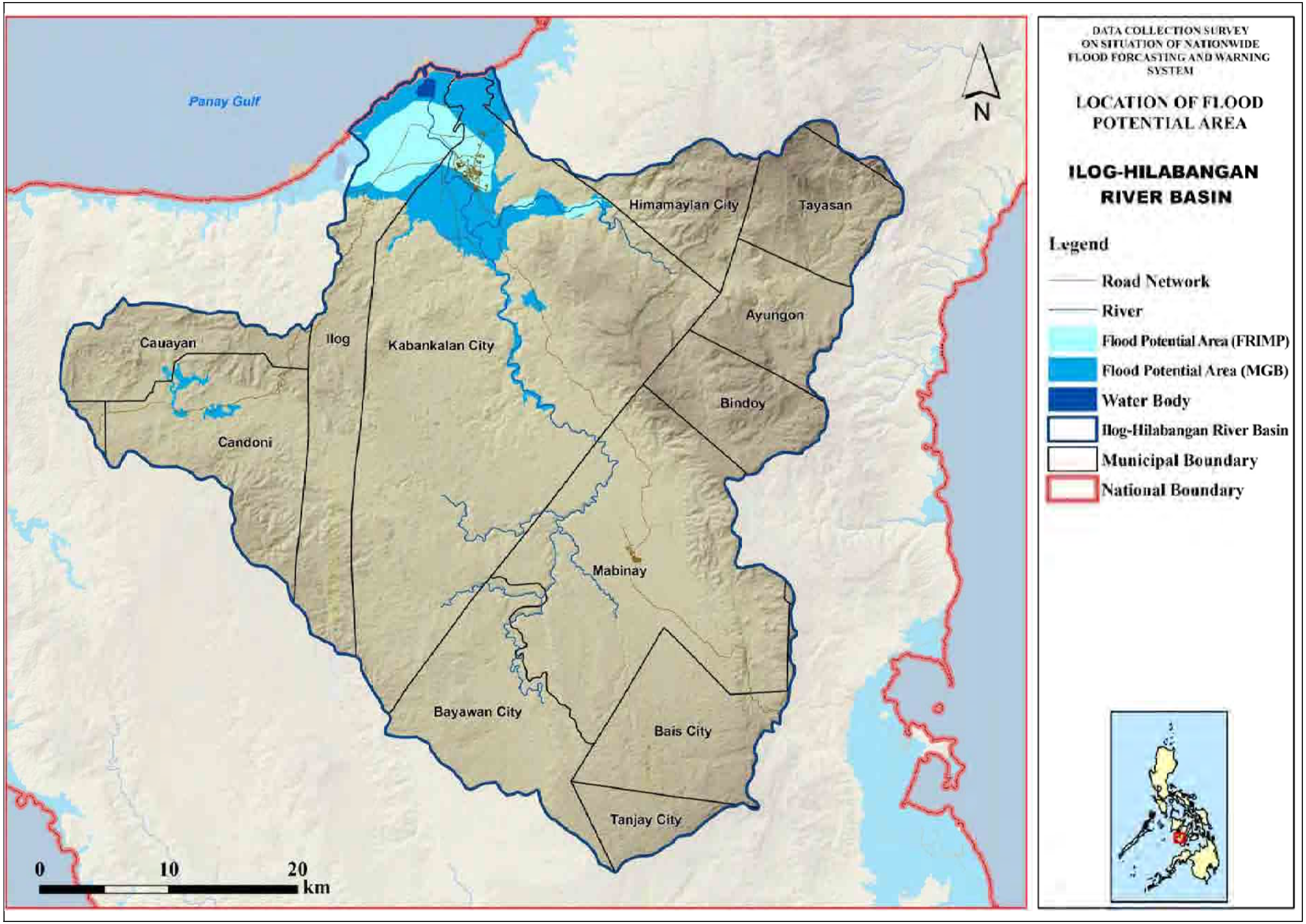

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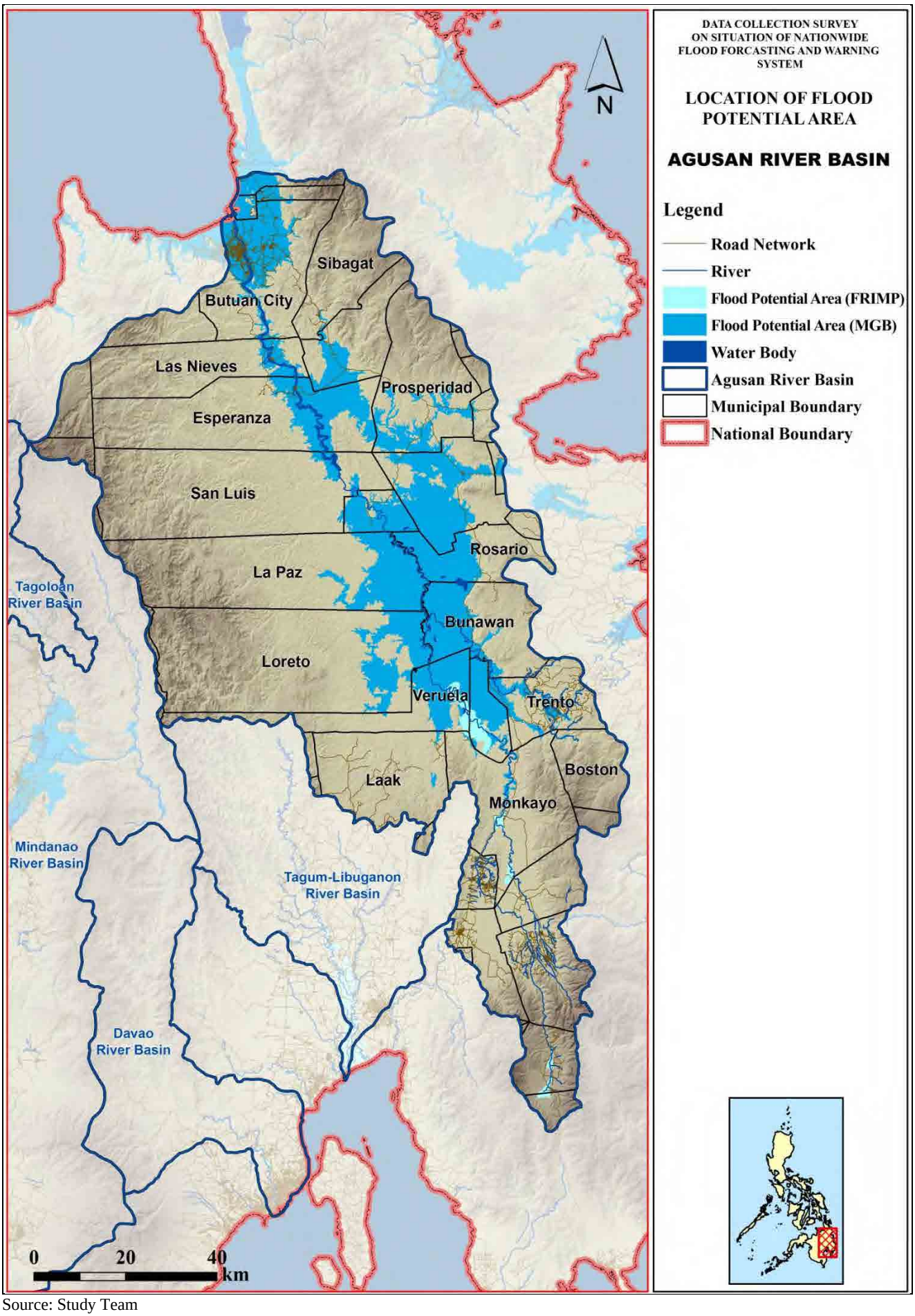

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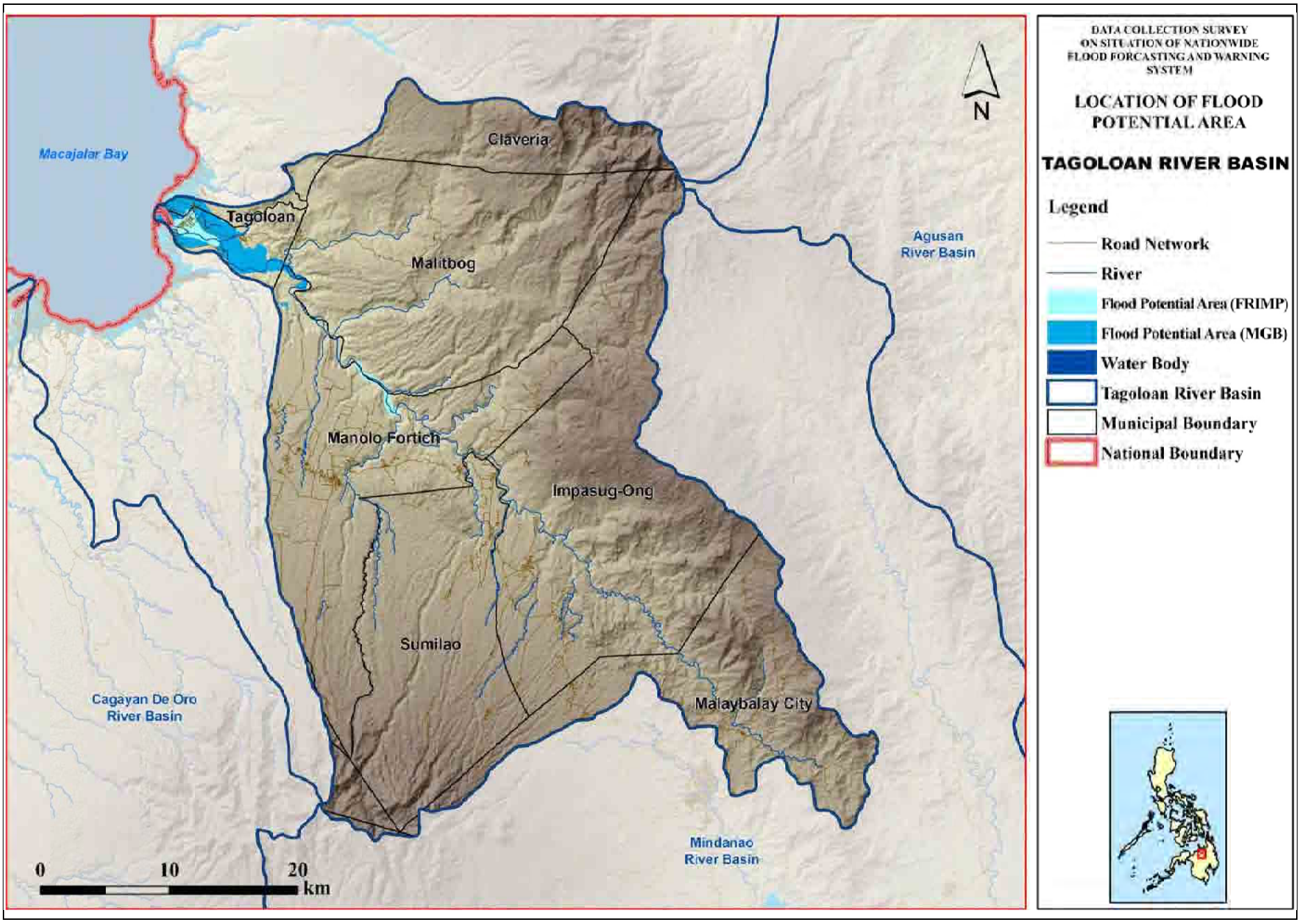

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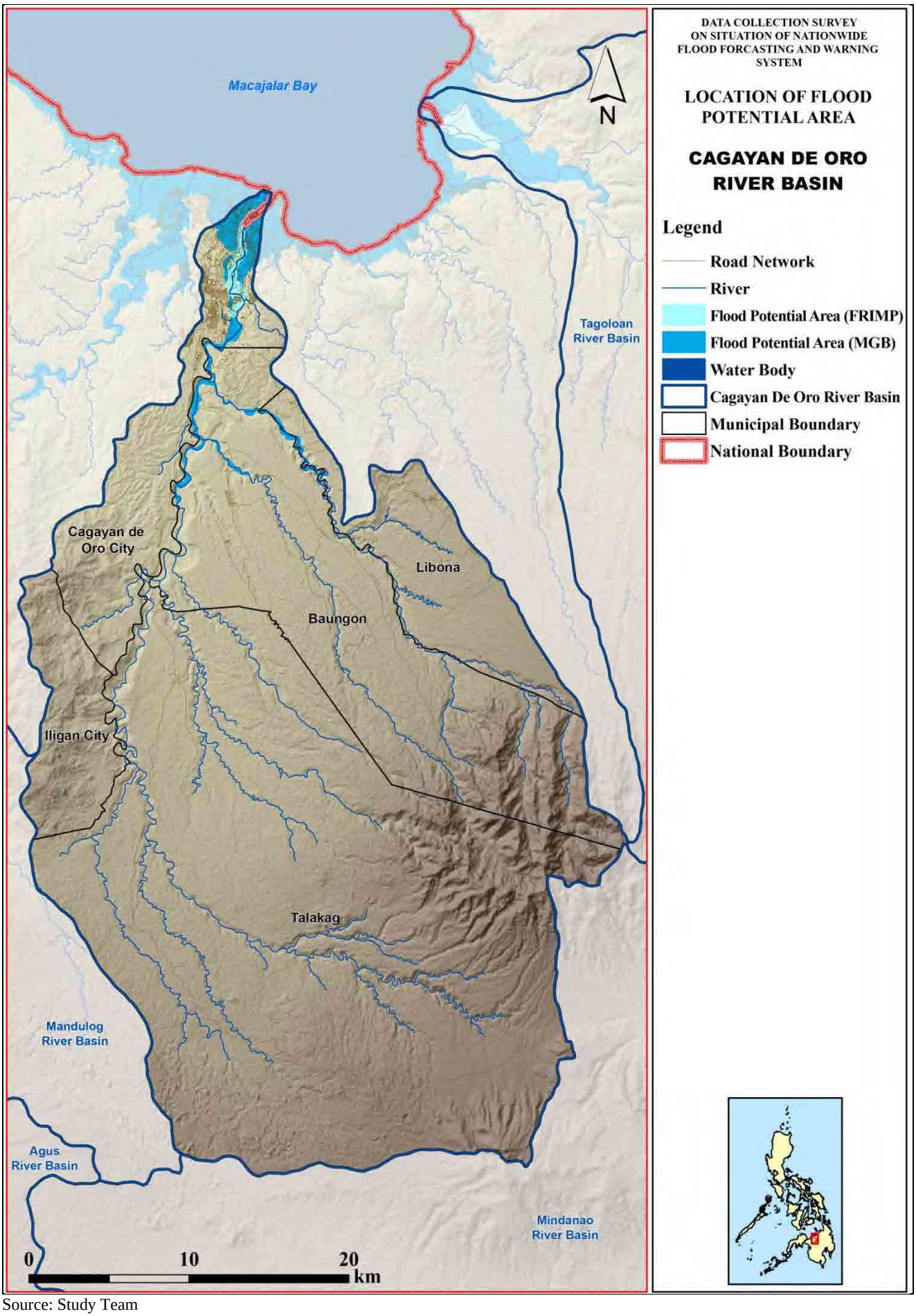

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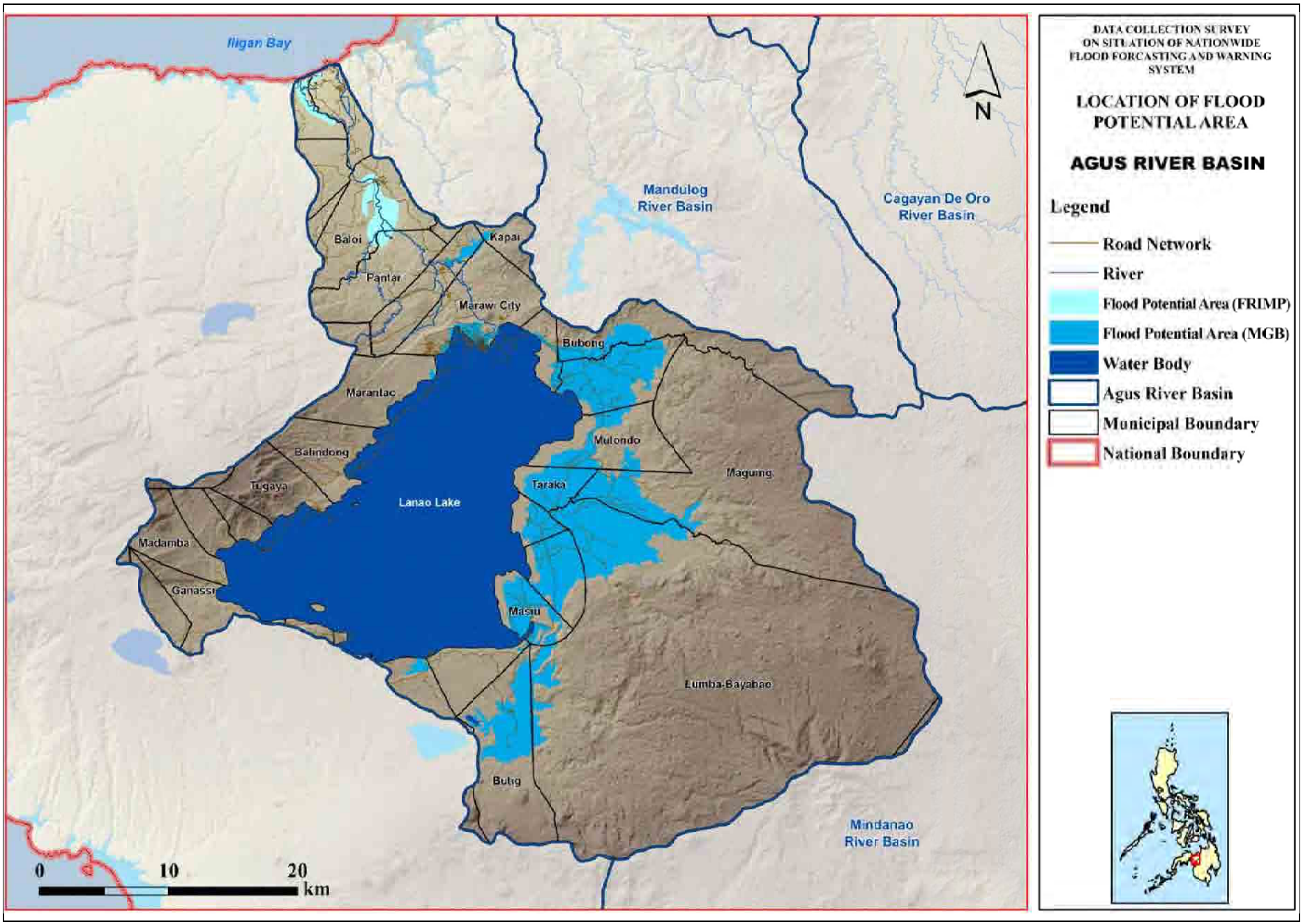

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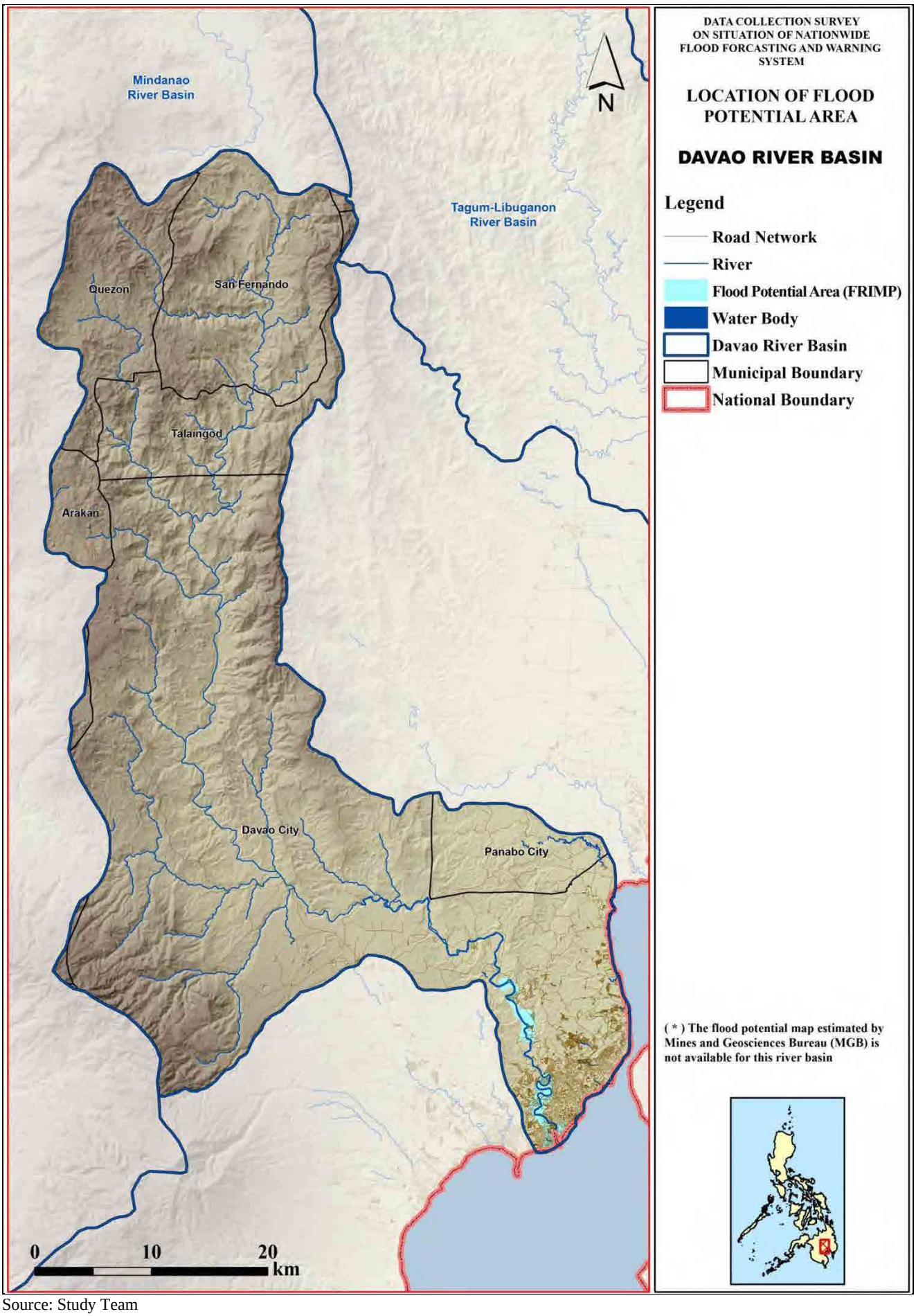

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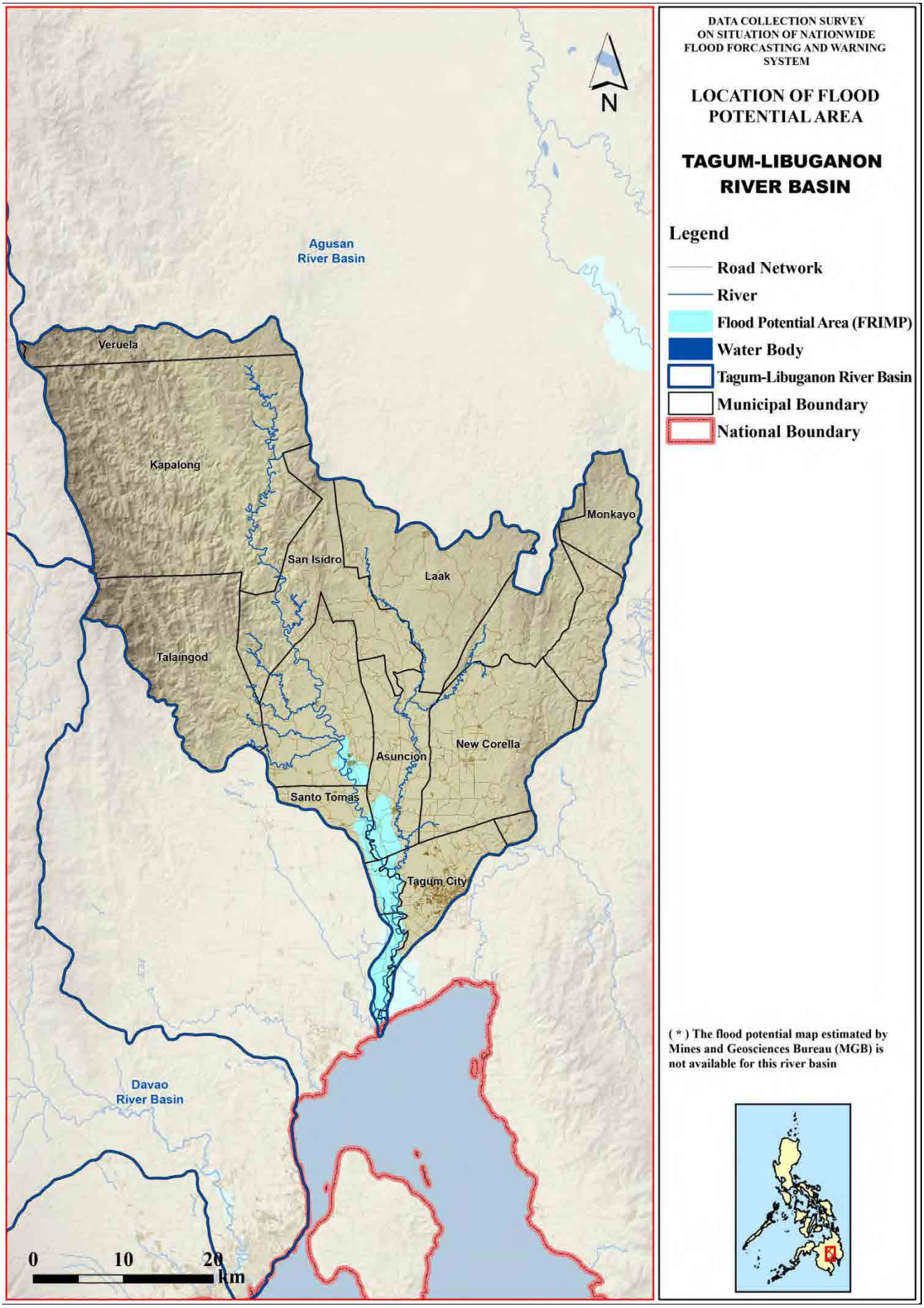

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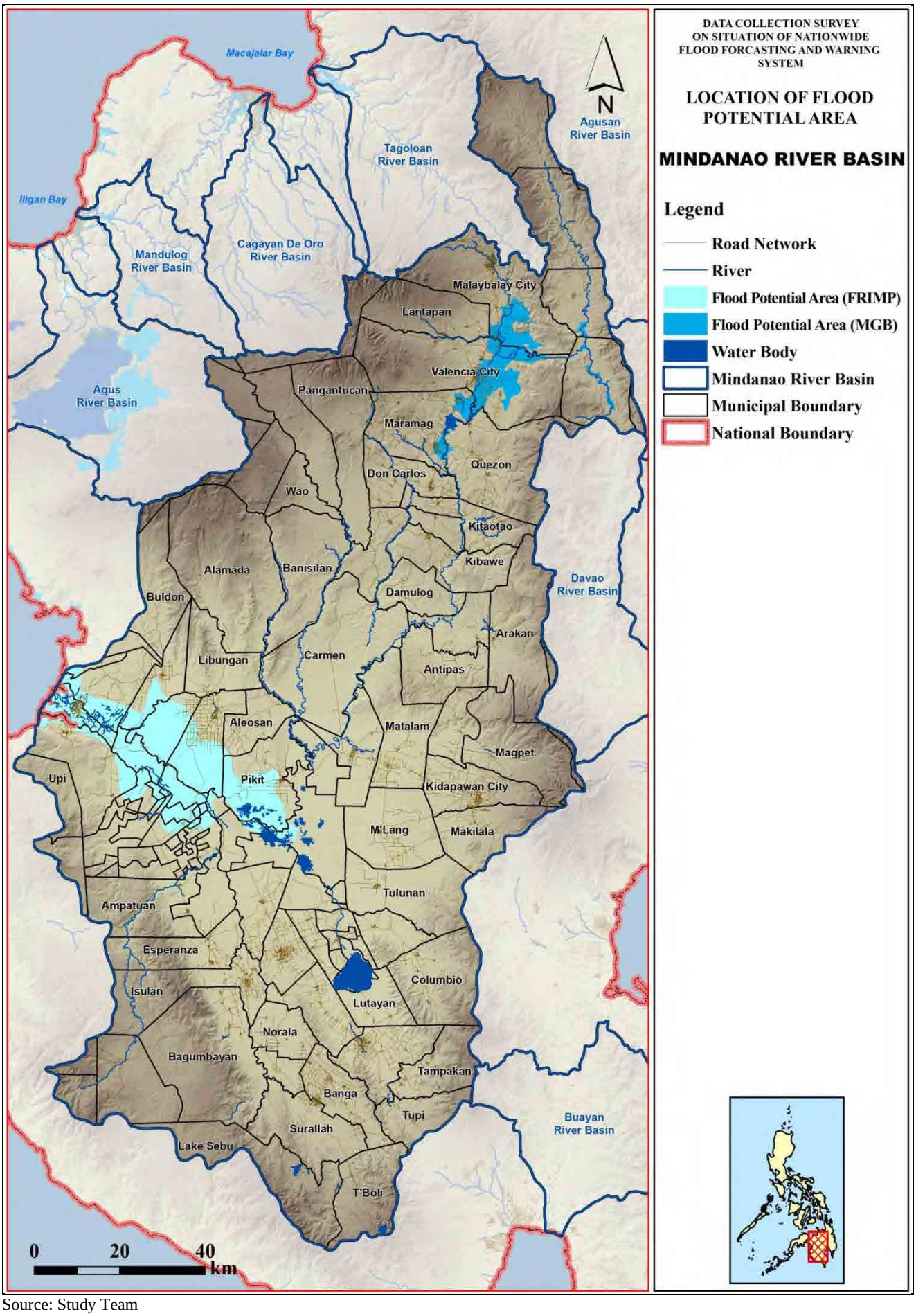

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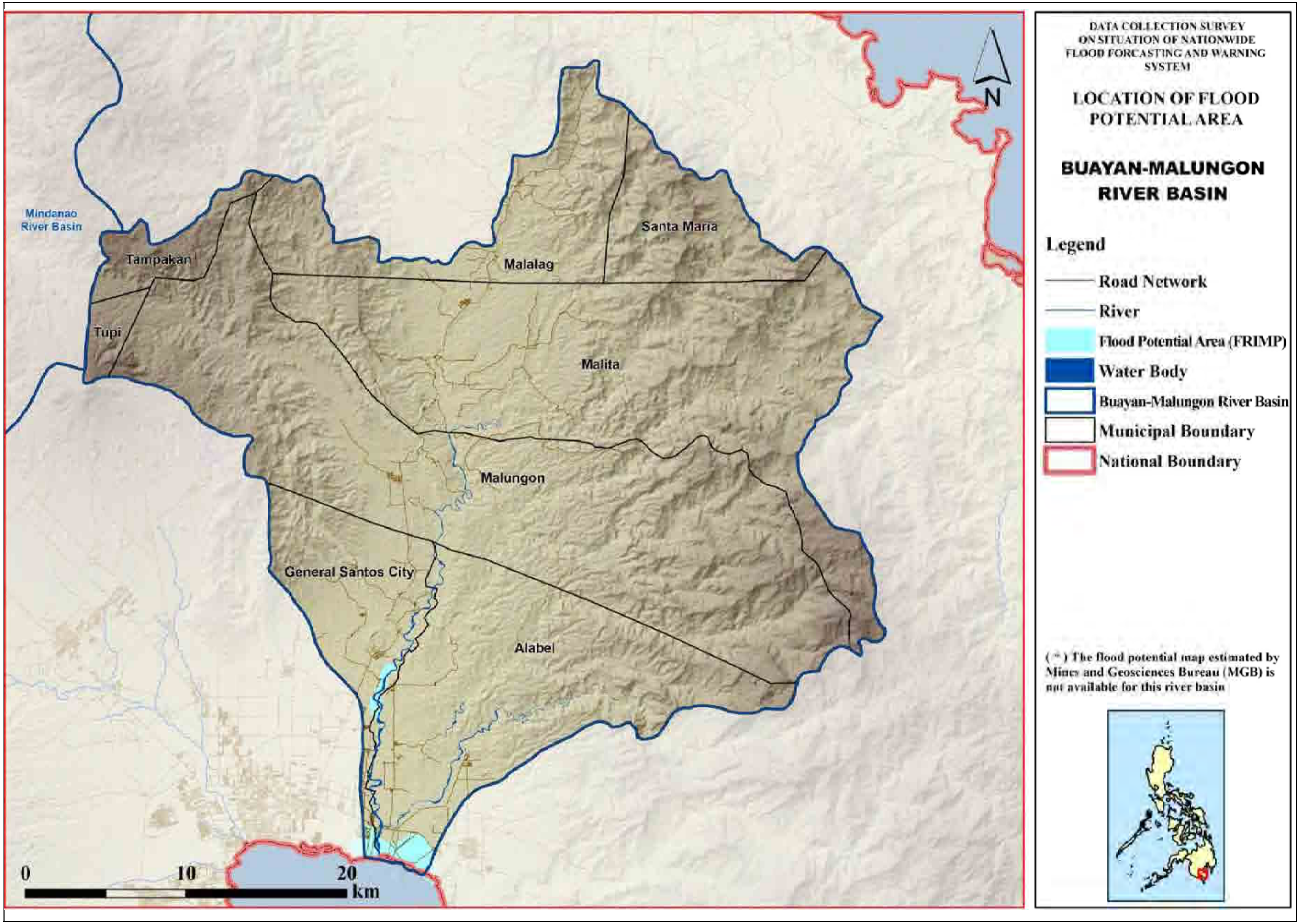

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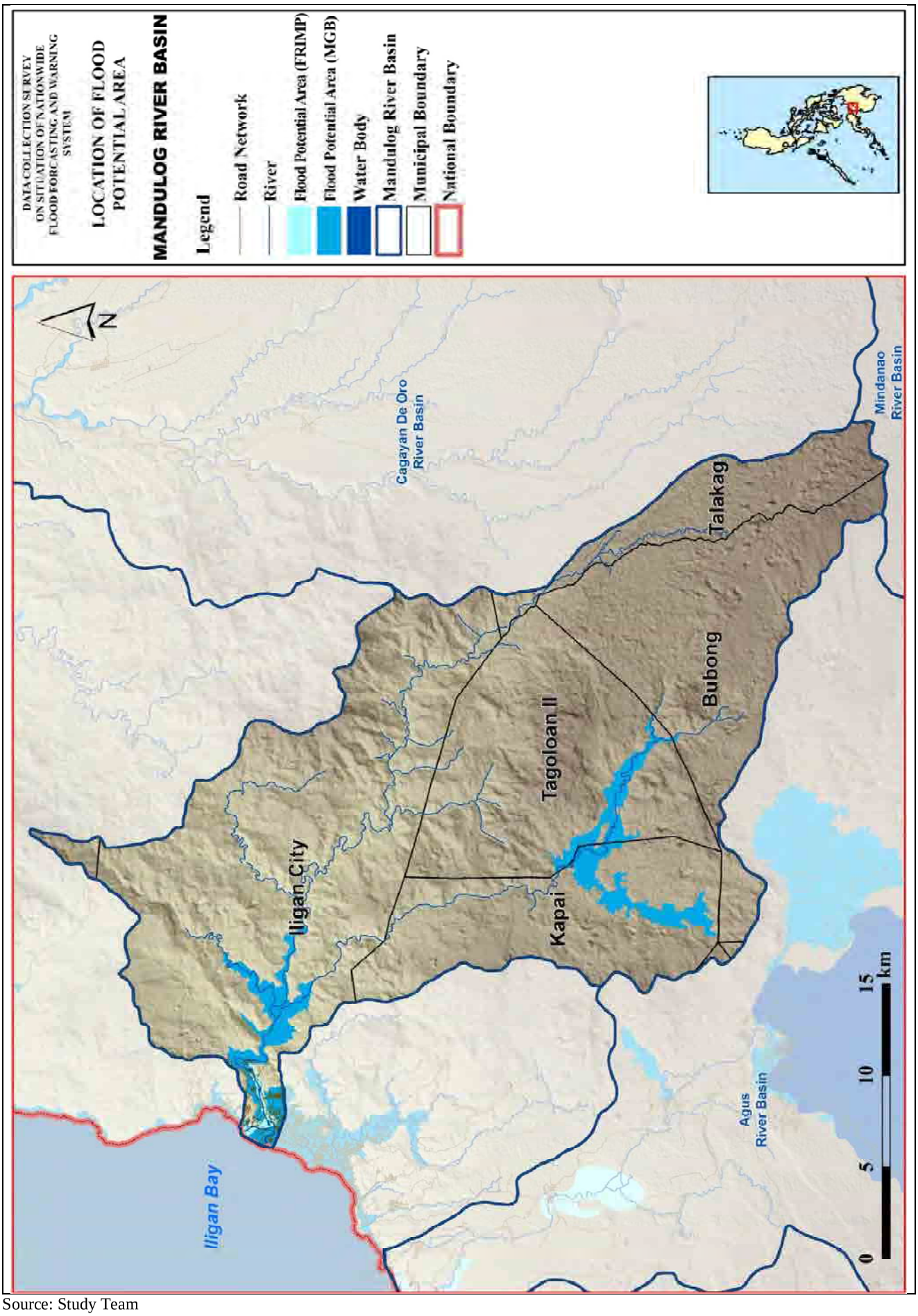


Source: Study Team

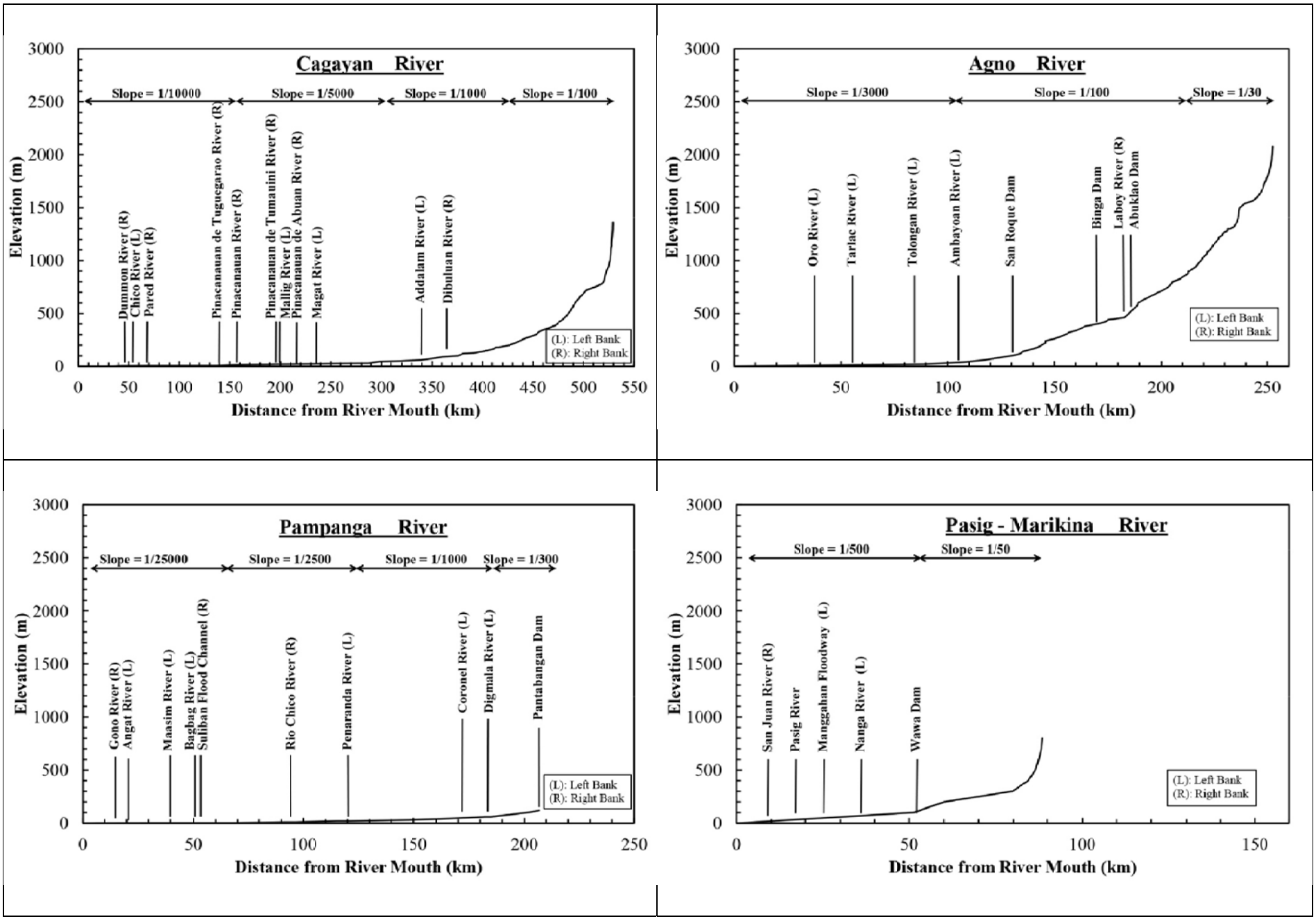
LONGITUDINAL PROFILES OF TARGET RIVER BASINS

The longitudinal profiles of the main streams have been created for the 19 target river basins. This can help in understanding the characteristics of each river by knowing the elevation of the river's source as well as the river's length. The longitudinal profiles were extracted from NAMRIA topographic sheets scales 1:250,000 and 1:50,000. The main tributaries were also identified for each river, taking into account the sides in which the tributaries have intersected with the main river whether from the right side or the left side in the downstream direction.

The information required to create a river profile are elevation and horizontal distance. A point shapefile data has been created to extract the longitudinal profiles. Using GIS, any profile can be reduced to a simple data table with two columns of X and Y values. The horizontal distance is placed in the X column, while the elevation data is placed in the Y column.

The collected points were plotted using MS. Excel to create longitudinal profile for each river basin. The slope has been calculated for each river when there are significant changes in the river slopes. The values of slopes can help in understanding the hydraulic characteristics of the rivers. At the final stage the rivers have been integrated together in one chart in order to understand the differences among the rivers in terms of scale, length, and hydraulic characteristic.

For example, the longest rivers available in the target river basins are Cagayan, Mindanao and Agusan, respectively, while the shortest rivers are Mandulog and Agus. On the other hands, the shallowest rivers or the rivers located in low elevations areas are Ilog-Hilabangan, Bicol, and Pampanga, whereas the steepest rivers over short distances are Buayan-Malungon, Cagayan de Oro, and Jalaur, Abra, and Agno.



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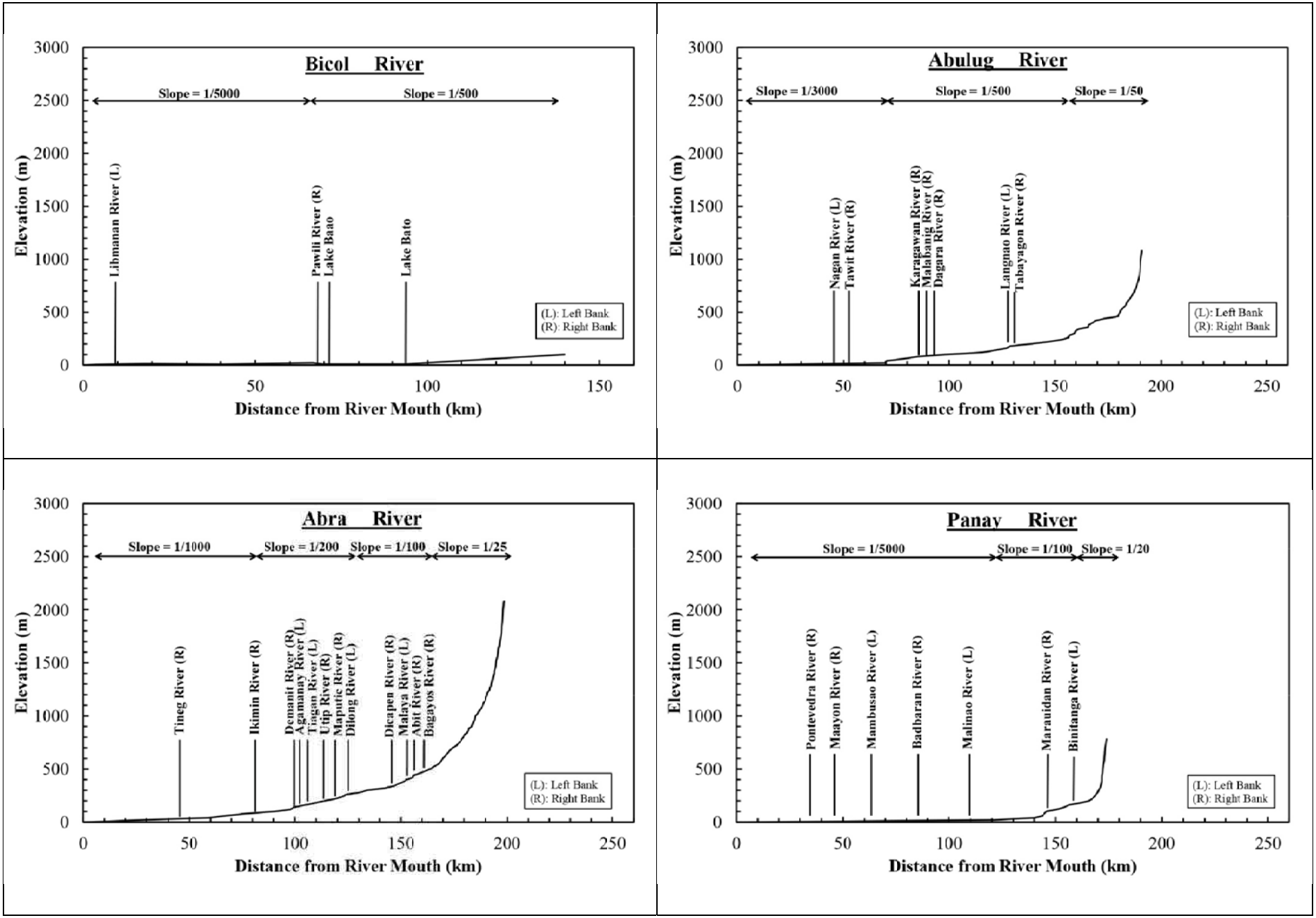

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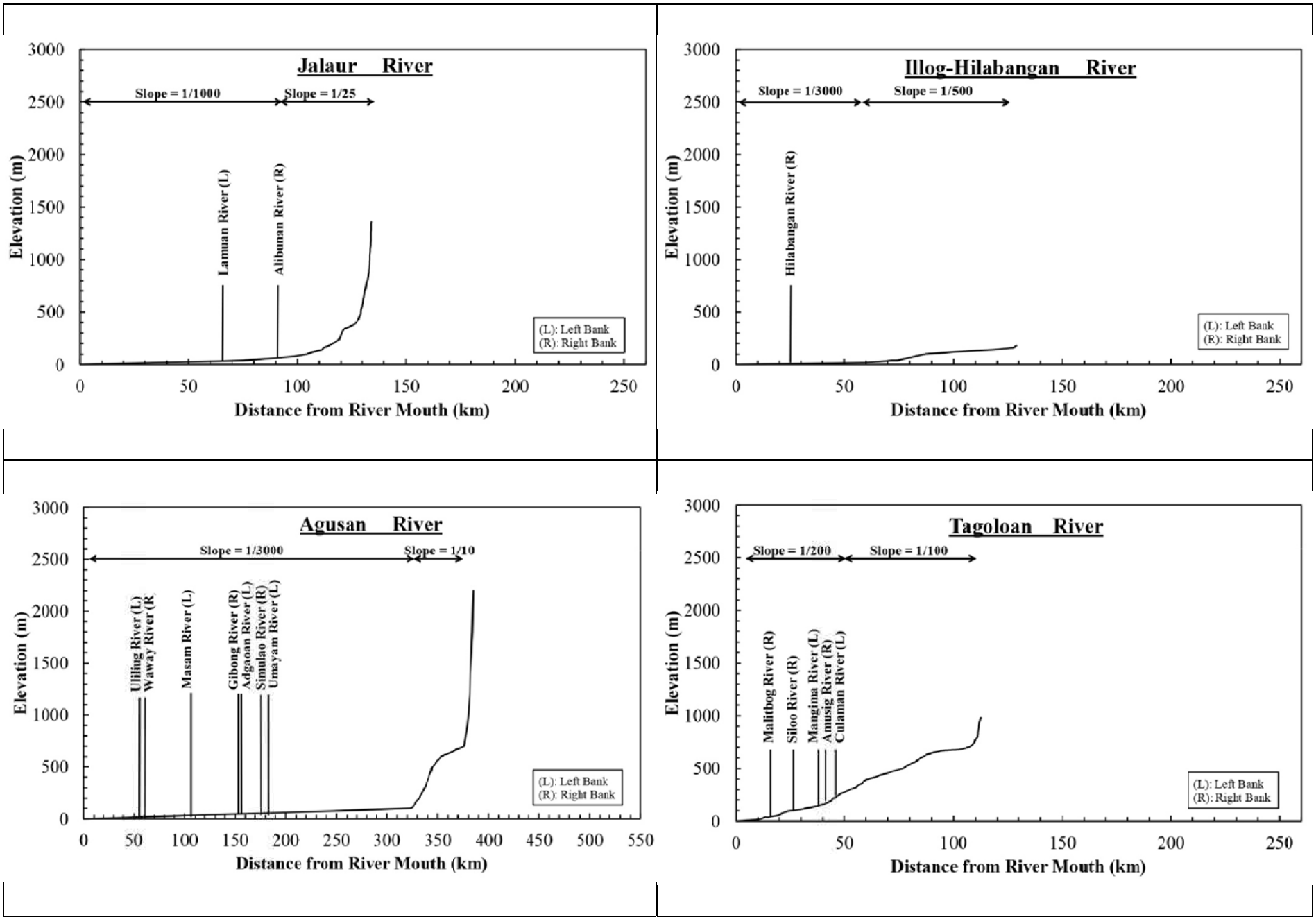

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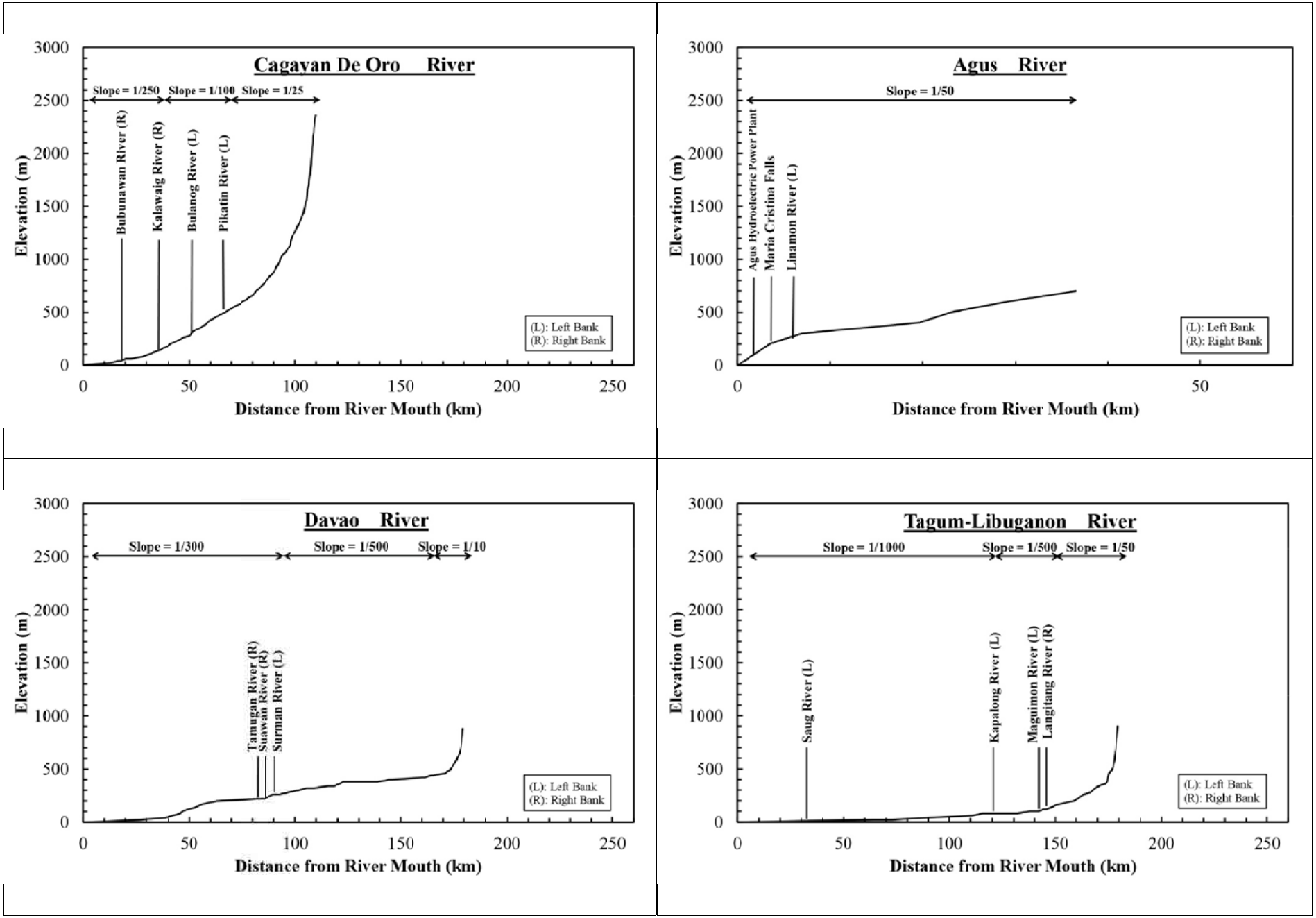

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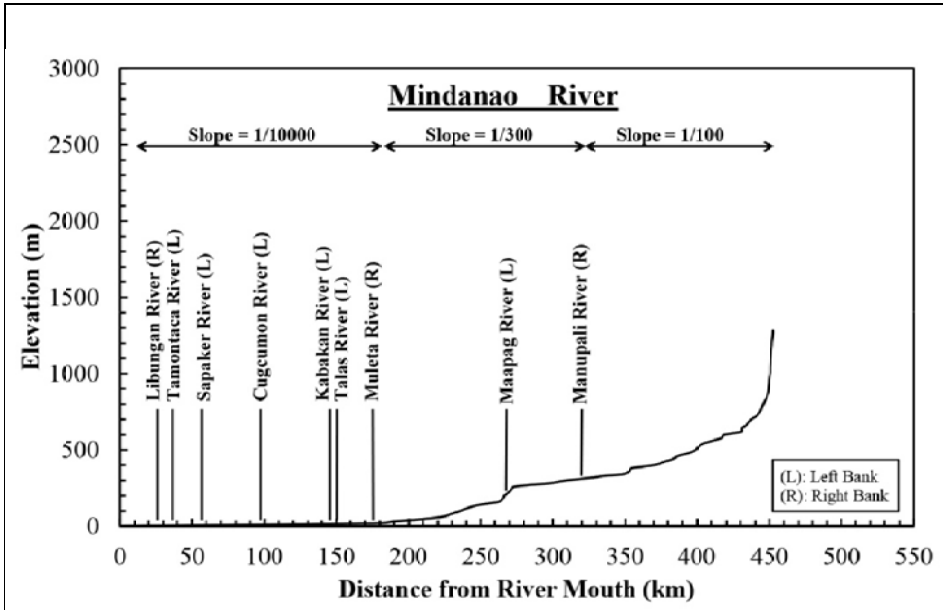

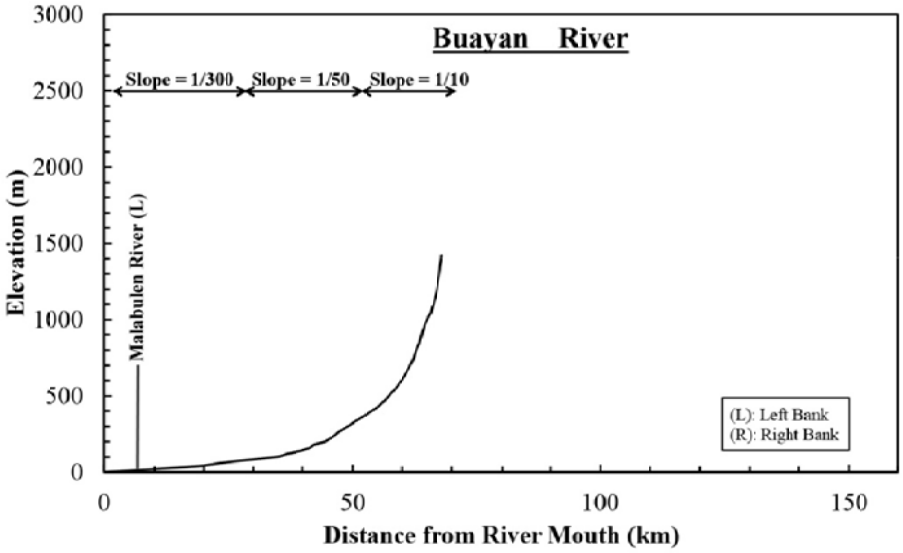

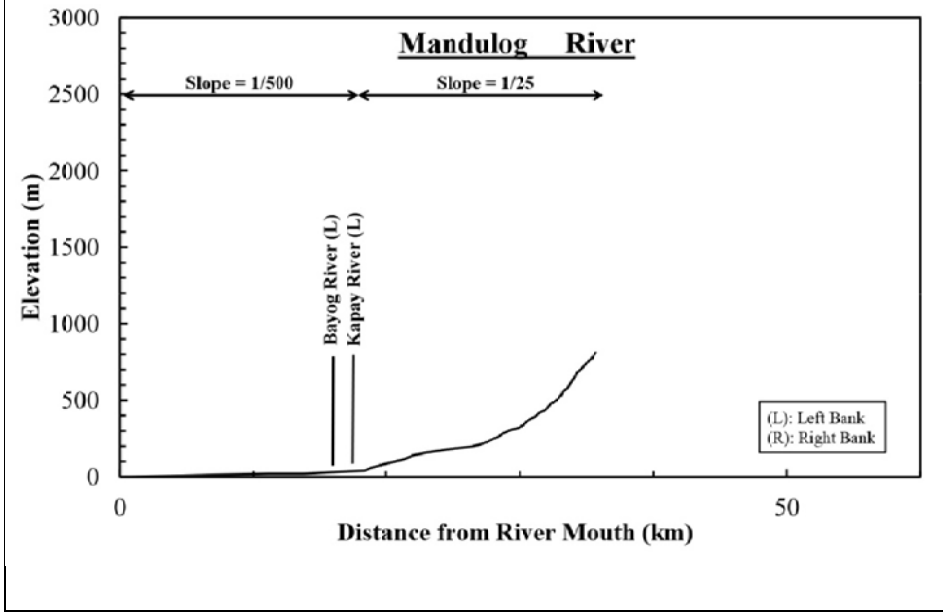

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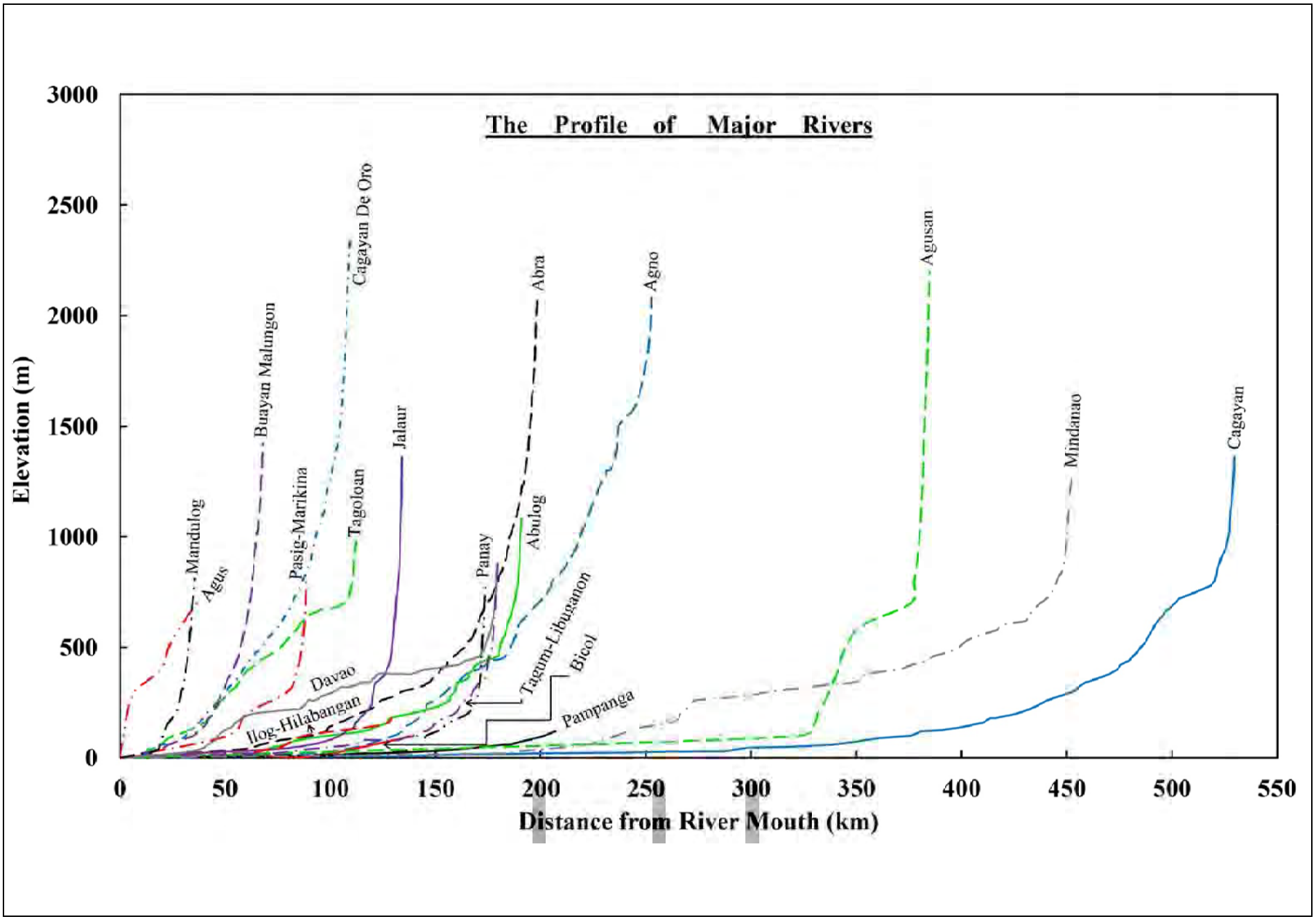

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