C202

Optimization of Magat Dam Operation Rule for Flood Risk Management in Cagayan River Basin

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The Philippines is the 4th most vulnerable to natural calamities and ranked 3rd in disaster risks. Figure 1(a) shows the high number of cyclones that crossed the Philippines between 2011-2021, with an average of 10 typhoons/year. The most significant successive typhoons hit the Cagayan River Basin northern part of Luzon island, in the late summer. In addition, recent storms and flooding events have displaced many vulnerable communities and caused economic damages in the Philippines, as shown in Fig. 1(a). For example, torrential rains brought by Typhoon Tisoy in 2019 have affected over 70,000 people in the province of Cagayan alone, causing more than 900 million economic losses in 26 villages in Isabela and an estimated 600 million damages on school classrooms (Fig. 1b). The last is Typhoon Ulysses, which got devastating and unexpected flood heights in Isabela, Cagayan, and Ilagan city (Fig. 1c).

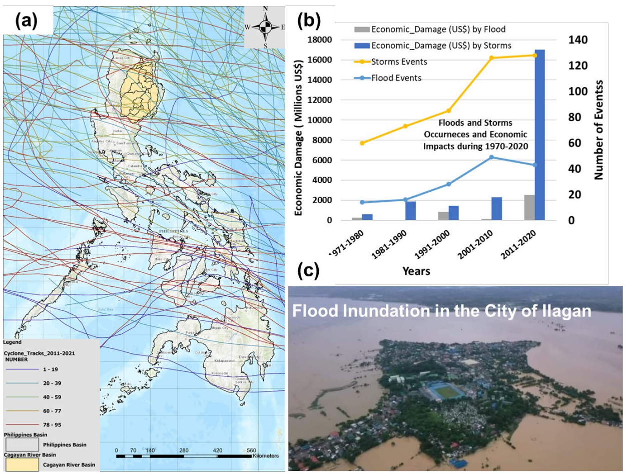

Fig. 1 (a) classified cyclones tracks that crossed the Philippines between 2011-2021; (b) number of flood occurrence and economic damages; (c) flood inundation in the Cagayan basin

Study area

The tropical river basin of Cagayan on Luzon Island in the Philippines has been known for prolonged and extensive floods from 1973 to the present. From November 9 to 12, 2020, typhoon Ulysses hit the basin and inundated large areas of Cagayan and Isabela. Figure 2 shows the flood inundation map based on measured depths during post-flood surveys by public residence (red circles), satellite data, and Google Earth Engine (Blue color).

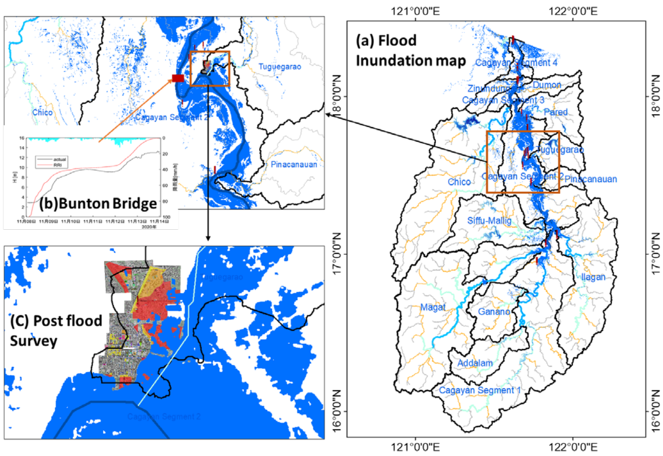

Fig. 2 Flood inundation map and post-flood surveys for typhoon Ulysses at specific locations (a, b) and participatory validation surveys (c)

The Cagayan River receives all discharges from 18 tributaries in a 27,281 km^2 catchment area. The active river channel is meandering and surrounding Tuguegarao city nearby the Buntun Bridge. Despite the basin's extensive catchment area and many tributaries, only Magat dam started operation as a multipurpose dam in 1983. Based on the JICA master

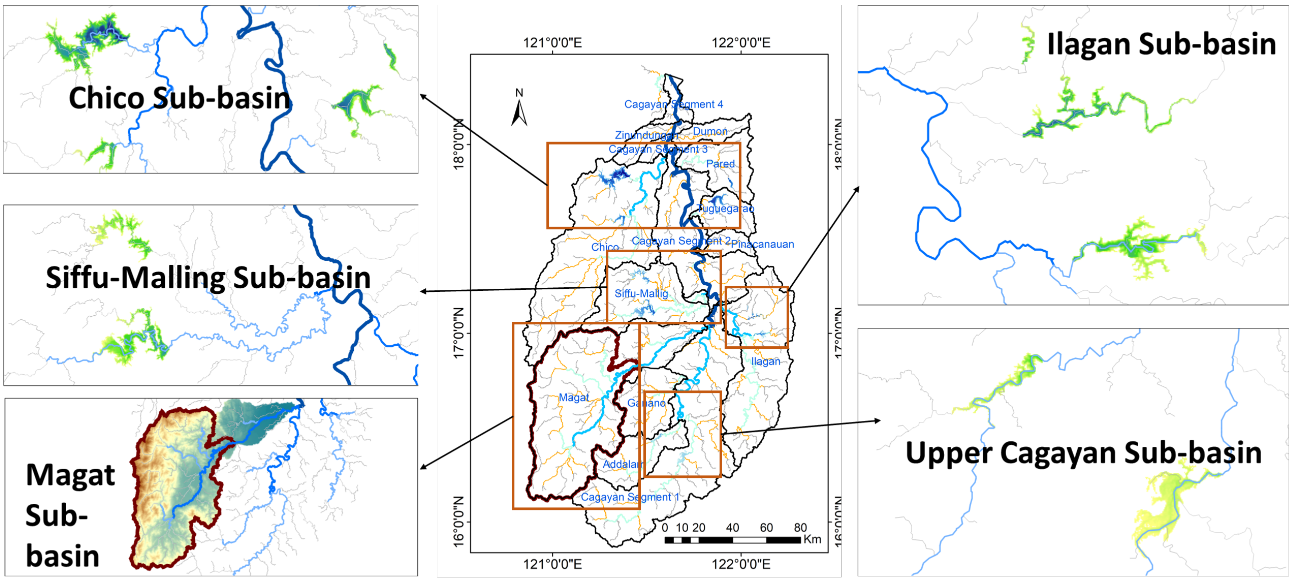

Fig. 3 Location map of Magat sub-basin and proposed structural mitigation measures at Upper Cagayan and Ilagan

plan study in 1987, several flood control dams and mitigation measures have to be implemented to reduce the flood in the lower Cagayan basin. Moreover, only Magat catchment is equipped with various hydrological monitoring stations among all basins. Magat reservoir receives its inflow discharges from Vizcaya and Ifugao province. Therefore, the main objective of this study is to assess the flood risk mitigation measures based on different dam operation rules and flood control structures. Furthermore, to understand the hydrological responses of each tributary and propose effective mitigation measures under successive typhoons.

Results

The Rainfall-Runoff Inundation (RRI) model was adopted to simulate the recent 2020 floods in Cagayan River Basin (Fig. 4). The analysis reveals that the consecutive typhoons hit Magat river catchment during the period from 13th of October to 13th of November 2020 almost during 1-month long-lasting rainfall effects with irregular spatial and temporal distributions and rainfall intensities. The model was calibrated and then several proposed scenarios were simulated, first, the sub catchment contributions (Fig. 4a). The analysis showed that the largest received flow

ico sub-basins and Parced. Accordingly, we have proposed a structural engineering solution for about 11 dams with different reservoirs capacities, as shown in Fig. 3. Then, the proposed dams in the upper Cagayan sub-basin (Fig. 4b) were added to support Magat Dam, and interestingly the flood depth was reduced by 1.5m, and the peak flood discharge was reduced 2000 m^3/s as shown in Figures 4d and 4c. We are still testing the other mitigation dams for better flood risk reduction downstream.

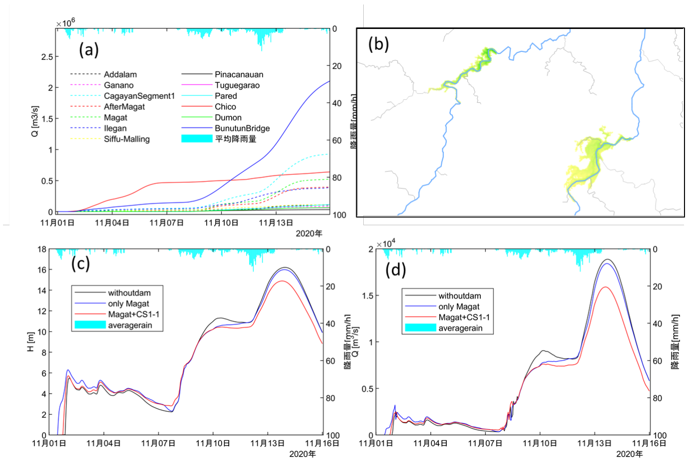

Fig. 4 (a) Accumulation flow discharge for the main sub-basins, (b) proposed dams at Upper-Cagayan, (c) flood depths, (d) flood discharges, of proposed simulated scenarios

Acknowledgment

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