***Meteorological Data Profiles***. The meteorological data of Pina-anan River from the telemetry station of Tagoloan HPP which is located at Impasugong Bukidnon with latitude 8.328403° and longitude 125.017313°. The profiles in Figure A and Figure B show the 6-month precipitation and water level data from January 27, 2020 to June 30, 2020 that is based on a 24-hour monitoring of rainfall data (in millimeter unit) and water level data (in meter unit). The precipitation data (Fig. A) revealed high readings of 25.2mm and 22.5mm on May 30, 2020 at 3:00PM and March 6, 2020 at 6:00 PM, respectively. Consequently, the highest water level (Fig. B) record is 3.71m on June 18, 2020 with a mode value of 1.5m.

**Figure A.** Pina-anan River Precipitation Profile from January 2020 to June 2020

**Figure B.** Pina-anan River Water Level Profile (January 2020 to June 2020)

The combined plot of rainfall and water level profile is shown in Figure C. This profile revealed two high records of data values, namely: (1) March 6, 2020 with precipitation of 22.8mm and water level of 2.227m; and (2) May 30, 2020 with 25.2mm of precipitation and a water level of 1.70m. Moreover, there was a series of rainfall from June 9 to June 19 period with accumulated precipitation value of 16.6mm on June 11 and accumulated water level of 3.56m on June 18. Finally, results revealed raining season from June 6 – June 29 with an average rainfall value of 0.44mm.

**Figure C.** Pinan-anan River Water Level and Precipitation Plot (January 2020 to June 2020)

***Metrological Data Analysis.*** Figure D show the Pinan-anan River Precipitation Profile. The data is an hourly profile January 1, 2020 – June 30, 2020 of Pina-anan River gauging from telemetry station of Tagoloan HPP located at Impasugong Bukidnon (8.328403°, 125.017313°). There are erroneous rainfall data *from May 18, 2021 to June 30, 2021* with highest rainfall of 1.15 mm and least rainfall value of 0.008 mm. The rainfall Data starting on May 18 to June 30 is insignificant for the Hyeto-Hydrograph since it formulates of an inaccurate trend for the Rainfall and Water Level*.* On the other hand, data revealed that the highest rainfall on May 10, 2021 (1:00pm) with a precipitation value of 33.20 mm and April 14, 2021 (6:00PM) with a precipitation value of 20.4 mm

**Figure D.** Pinan-anan River Precipitation Plot (January 2021 to July 2021)

**Figure E.** Pinan-anan Water Level Plot (March 2021 to June 2021)

**Figure E** show the hourly water level data of Pina-anan River from telemetry station in Tagoloan HPP located at Impasugong Bukidnon (8.328403°, 125.017313°). The hourly data is recorded from March 1, 2021 to June 30, 2021 with the highest water level (April 23) value of 3.56 m and a mode value of 1.7026m.

**Figure F.** Pinan-anan River Water Level and Precipitation Plot

There are erroneous rainfall data from May 18, 2021 to June 30, 2021 (Figure F) with highest rainfall of 1.15 mm and lowest rainfall of 0.008mm. Based from observation, the data record from May 18, 2021 does not coincide with the trend i.e. rainfall data and water level. The highest precipitation were found last March 10, 2021 at 33.20mm with a water level measurement of 1.965m and last April 14, 2021 at 20.4mm with a water level measurement of 2.20m. Also, series of rainfall from April 14 to April 20 with a highest rainfall value of 20.4mm generate the highest water level of the four months with a value of 3.56m on April 23, 2021.

Data Correlation

**Figure D.** Tagoloan Rating Curve 2015 to 2020.

Figure E shows the Tagoloan Rating Curve from 2018-2020. The highest correlation between the stage and flow was found between the year 2018-2019 (R² = 0.49). generally, has been considered to be the most representative data for estimation of Tagoloan Hydrograph for the preceding months. The graph shows a variance of 88% of its correlation for the last three years of water level & flow measurement.

**Figure E.** Tagoloan Rating Curve (2018-2020)

Figure F shows the Flow Measurement Timeline of the Pina-anan Rain Gauge station. Due to the pandemic, a flow measurement was taken during Feb 4 and Feb 11 for the year 2020 whereas only two samples were formulated during the year 2020. There are restrictions to the accuracy for the formulation of the rating curve due to the limitation of the data particularly in the flow measurements especially when a series of rainfall events had been observed for the preceding months.

**Figure F.** Flow Measurement Time Line(Pina-anan )

*Feb 11,2020 10:49 AM & 10:49 AM*

*Feb 4,2020 10:50 AM & 11:03 AM*

Theory /Methodology

Rating Curve is expressed as an equation of the following form in the Agency’s hydrometric archive system;

*Q* = *C* (*h* + *a*) *β*

where *C*, *a* and *β*, are coefficients that do have a physical significance as they were originally derived from hydraulic theory. The coefficient C increases as river cross-sectional area and slope increase, but decreases as roughness increases. It can be shown that for simple geometries the *β* coefficient is constant where *β* coefficient should remain unchanged. *a* is related to the elevation of the bed, and should also remain unchanged whereas the rating can be simplified into a power type of equation of

*Q* =*aSb*

where *a* and *b* are parameters that are fit using a power regression, *S* is stage height in meters and *Q* is the discharge in m³/s.

**Figure G.** Rating Curve 2018 -2020

Taking logarithms of the power type equation results in a straight line relationship of the form.

log(*Q*) = log(*a*) + *b* log(*S*)

Fit a linear line to the log-log data as shown in Figure H.

**Figure H.** Rating Curve 2018 to 2020 (log-log)

The sets of discharge (Q) and the effective stage *S* are plotted on the double log scale, they will represent a straight line. Coefficients Aand B of the straight-line fit are functions of *a* and *b*. Since values of *a* and *b* can vary at different depths owing to changes in physical characteristics (effective roughness and geometry) at different depths, one or more straight lines will fit the data on a double log plot.

Extract the coefficients

Therefore, the rating curve is expressed into a power equation of

Figure I shows the correlation of Observed vs Simulated Flow from 2016 to 2020.Correlation of the observed flow on 2016-2020 and simulated flow has an average error of 0.121 and RMSE of 1.90. This implies that the equation can be somehow used to simulate the hydrograph based on the observed water level from the telemetry. Since it has a limitation of the data and is based on the given data, there are rapid changes of its coefficients and parameters as time goes by.

**Figure I.** Correlation Observed vs Simulated Flow (2016-2020)

**Rating Curve**

The investigation of the rating curve used two sample-flow measurements from the preceding months. Presented in Figure J is the plot of the water level (WL) and the simulated flow base from the derive power equation (i.e. following months). The results revealed that the simulated hydrograph base from the derived equation is proportional to the water level at the given time. The highest flow levels were observed on June 18, 2020, with a flow rate of 293.36 cms which has also the highest water level of 3.71m. In contrast, the lowest water levels were observed on May 3, 2020, & May 8, 2020, which has a flowrate of 7.12cms and a stage of 1.34 m.

**Figure J.** Hydrograph at Pinan-anan (Jan 27,2020 1:00 AM - Jun 30,2020 11:00 PM)

MARCH 2020

**Figure N.** Pinan-anan River Hyeto-Hydrograph (March 2020)

-The highest flow levels in simulation were observed in March 6,2020 with a flowrate of 22.8 cms and has highest rainfall value of 22.8mm of the month

**Figure O.** Pinan-anan River Rating Curve (March 2020)

* highest flow rate: 47.14 cms with a stage of 2.25m
* lowest flow rate: 7.59 with a stage of 1.3618
* average flow of the month: 11.84 cms
* mode value for water level. 1.516m

APRIL 2020

**Figure P.** Pinan-anan River Hyeto-Hydrograph (April 2020)

- The highest flow rate simulation were observed in April 20,2020 with a flowrate of 26.16 cms and has highest rainfall value of 6mm on April 18

**Figure P.** Pinan-anan River Rating Curve (April 2020)

* highest flow rate: 26.16 cms with a stage of 1.917m
* lowest flow rate: 7.59 cms with a stage of 1.3618 m
* average flow of the month: 9.98 cms
* mode value for water level. 1.4638

MAY 2020

**Figure Q.** Pinan-anan River Hyeto-Hydrograph (May 2020)

-The highest flow rate simulation were observed in May 12,2020 with a flowrate of 70.62 cms and has highest rainfall value of 25.2 mm on May 30

**Figure R.** Pinan-anan River Rating (May 2020)

* highest flow rate: 70.62 cms with a stage of 2.51m
* lowest flow rate: 7.12 cms with a stage of 1.344 m
* average flow of the month: 13.76 cms
* mode value for water level. 1.4638

JUNE 2020

**Figure S.** Pinan-anan River Hyeto-Hydrograph (June 2020)

The highest flow rate simulation were observed in June 11,2020 with a flowrate of 293.36 cms and has highest rainfall value of 16.6 mm on June 11

**Figure T.** Pinan-anan River Rating Curve (June 2020)

* highest flow rate: 293.36 cms with a stage of 3.7088m
* lowest flow rate: 9.16 cms with a stage of 1.4399 m
* average flow of the month: 29.72 cms
* mode value for water level. 1.5592

**Figure U.** Pinan-anan River Rating Curve (March 2020 to June 2020)

* lowest flow rates were observed on the Month of May with a flow rate value of 7.12 cms and Highest flow rate value were observed on the month of June with a flowrate value 293.6 cms.
* Base from the meteorological data the month of July have an accumulated rainfall value of 287.40mm and an average value of rainfall of 0.09 which shows that the month of June is describe as rainy season from the 4 months
* **Figure V.** Pinan-anan River Monthly Rating Curve (April 2021 to June 2020)
* The rating curve express into a polynomial trendline to shows the differences of the distinct behavior of the rating curve for the 4 months
* It indicates there is prompt changes of characteristics that happen within the area. It shows that there is an increase of base flow for every month whereas 1.28% flow rate from the month of May to June.
* It shows the Month of June has the highest grade of its curve which emphasize a volatile flowrate within the month. And the month of April has less series of rainfall that happen in the 4 months.

**Results and Discussion**

**Figure W.** Pinan-anan River Hyeto-Hydrograph (March 2021)

Shown in Figure W is the Hyeto-Hydrograph at Pianan-an River for the month of March which shows the highest flow levels observed in March 14, 2021 with a flowrate of 68.2cms and highest rainfall value of 16.4mm on March 10, 2021. Shown in Figure X is the Rating Curve at Pinan-anan for March 2021 with the highest recorded flowrate at 68.2cms and a stage of 2.49m. In contrast, the lowest recorded flowrate is 12.96cms with a stage of 1.583m. Meanwhile, the average flow of the month is 18.98cms with modal water level value is at 1.7026 m.

**Figure X.** Pinan-anan River Rating (March 2021)

Shown in Figure Y is the Hyeto-Hydrograph at Pinan-anan for April 2021 where the highest flow levels were observed in April 23, 2021 with a flowrate of 253.91cms and has highest rainfall value of 20.4mm on April 14, 2021. The April month Rating Curve in Figure Z revealed that the highest recorded flowrate is 253.9cms with a stage of 3.56m. In contrast, the lowest recorded flowrate is 10.63cms with a stage of 1.50m. Meanwhile, the average flow of the month is 23.61cms. Furthermore, the modal water level value is at 1.83m.

**Figure Y.** Pinan-anan River Hyeto-Hydrograph (April 2021)

**Figure Z.** Pinan-anan River Rating Curve (April 2021)

**Figure AA.** Pinan-anan River Hyeto-Hydrograph (May 2021)

Shown in Figure AA is the Hyeto-Hydrograph at Pinan-anan for May 2021. The highest flow levels in simulation were observed in May 26, 2021 with a flowrate of 181.4cms and has highest rainfall value of 33.2mm on May 10, 2021.

Shown in Figure \_ is the Rating Curve at Pinan-anan for May 2020. The highest recorded flow rate is 181.84 cms with a stage of 1.61 m. In contrast, the lowest recorded flowrate is 13.69 cms with a stage of 1.61 m. Meanwhile, the average flow of the month is 28.6 cms. Furthermore, the modal water level value is at 1.70 m.

**Figure AB.** Pinan-anan River Rating Curve (May 2021)

* highest flow rate: 181.84 cms with a stage of 3.25m
* lowest flow rate: 13.69 cms with a stage of 1.61 m
* average flow of the month: 28.6 cms
* mode value for water level. 1.70 m

Shown in Figure \_ is the Hyeto-Hydrograph at Pinan-anan for June 2020. The highest flow levels in simulation were observed in June 22 2021 with a flowrate of 196.94 cms and followed by a flowrate of 131.64 cms on June 1, 2021.

**Figure AC.** Pinan-anan River Hydrograph (June 2021)

-The highest flow levels in simulation were observed in June 22 2021 with a flowrate of 196.94 cms and followed by a flowrate of 131.64 cms on June 1, 2021

Shown in Figure R is the Rating Curve at Pinan-anan for June 2021. The highest recorded flow rate is 196.94 cms with a stage of 3.33 m. In contrast, the lowest recorded flowrate is 23.85 cms with a stage of 1.87 m. Meanwhile, the average flow of the month is 41.85 cms. Furthermore, the modal water level value is at 2.01 m.

**Figure AD.** Pinan-anan River Rating Curve (June 2021)

* highest flow rate: 196.94 cms with a stage of 3.33m
* lowest flow rate: 23.85 cms with a stage of 1.87 m
* average flow of the month: 41.85 cms
* mode value for water level. 2.01 m

Figure \_ shows the Rating Curve at Pinan-anan from March to June 2021. lowest flow rates were observed on the Month of April with a flow rate value of 10.63 cms and Highest flow rate value were observed on the month of April with a flowrate value 253.91 cms. Mode value for water level (stage) for the 4 months is 1.70 which comprehends a base flow of 31.256 cms.

**Figure AE.** Pinan-anan River Rating Curve (March 2021 to June 2021)

* lowest flow rates were observed on the Month of April with a flow rate value of 10.63 cms and Highest flow rate value were observed on the month of April with a flowrate value 253.91 cms.
* mode value for water level (stage) for the 4 months is 1.70 which comprehends a base flow of 31.256 cms

Figure \_ shows the comparative analysis of for the monthly rating curve at Pinan-anan River. The rating curve express into a polynomial trendline to shows the differences of the distinct behavior of the rating curve for the 4 months. It indicates there is prompt changes of characteristics that happen within the area. It shows that there is an transition of base flow for every month whereas above 1.70 m flow rate for the month of March & April and above 1.80 for the month of May June which there is an 0.10 cms fluctuations of base flow in every month . It shows the Month of June has the highest grade of its curve which emphasize a volatile flowrate within the month. And the month of April & March have less series of rainfall that happen in the 4 months.

**Figure AF.** Pinan-anan River Monthly Rating Curve (March 2021 to June 2021)

* The rating curve express into a polynomial trendline to shows the differences of the distinct behavior of the rating curve for the 4 months
* It indicates there is prompt changes of characteristics that happen within the area. It shows that there is an transition of base flow for every month whereas above 1.70 m flow rate for the month of March & April and above 1.80 for the month of May June which there is an 0.10 cms fluctuations of base flow in every month .
* It shows the Month of June has the highest grade of its curve which emphasize a volatile flowrate within the month. And the month of April & March have less series of rainfall that happen in the 4 months.

Figure \_ shows the comparative analysis for the March 2020 and March 2021 Rating Curve. Comparing the highest flow rate between the two months, there is a 44.67 percent increase on its highest flow rate with 21.06 cms added to March 2021 from the previous year. In contrast, comparison of the lowest flow rate between the two months show a 71.50 percent increase with 5.37 cms added to March 2021 from the previous year. Moreover, the data shows a 60.30 percent, or an additional 7.14 cms, increase of average flow compared with the data from the previous year. Finally, there is a 12.31 percent, or an additional 0.187m increase, on the average stage of the river.

**Figure AG.** Pinan-anan River Rating Curve (March 2020 vs March 2021)

* Increase of 44.67% on its highest flow rate (21.06 cms added)
* Increase of 71.15% on its lowest flow rate: (5.37 cms added)
* Increase of 60.30% on its Average flow month: (7.14 cms added)
* Increase of 12.31% on its Averag flow month: (0.187 m added)

Figure \_ shows the comparative analysis for the April 2020 and April 2021 Rating Curve. Comparing the highest flow rate between the two months, there is a 870.6 percent increase on its highest flow rate with 227.75 cms added to April 2021 from the previous year. In contrast, comparison of the lowest flow rate between the two months show a 40.05 percent increase with 3.04 cms added to April 2021 from the previous year. Moreover, the data shows a 136.57 percent, or an additional 13.63 cms, increase of average flow compared with the data from the previous year. Finally, there is a 25.01 percent, or an additional 0.366m increase, on the average stage of the river.

**Figure AH.** Pinan-anan River Rating Curve (April 2020 vs April 2021)

* Increase of 870.6% on its highest flow rate (227.75 cms added)
* Increase of 40.05% on its lowest flow rate: (3.04 cms added)
* Increase of 136.57% on its Average flow month: (13.63 cms added)
* Increase of 25.01% on its Average flow month: (0.366 m added)

Figure \_ shows the comparative analysis for the May 2020 and May 2021 Rating Curve. Comparing the highest flow rate between the two months, there is a 157.49 percent increase on its highest flow rate with 111.22 cms added to May 2021 from the previous year. In contrast, comparison of the lowest flow rate between the two months show a 92.28 percent increase with 6.57 cms added to May 2021 from the previous year. Moreover, the data shows a 107.84 percent, or an additional 14.84 cms, increase of average flow compared with the data from the previous year. Finally, there is a 16.14 percent, or an additional 0.2362m increase, on the average stage of the river.

**Figure AI.** Pinan-anan River Rating Curve (May 2020 vs May 2021)

* Increase of 157.49% on its highest flow rate (111.22 cms added)
* Increase of 92.28% on its lowest flow rate: (6.57 cms added)
* Increase of 107.84% on its Average flow month: (14.84 cms added)
* Increase of 16.14% on its Average flow month: (0.2362 m added)

Figure \_ shows the comparative analysis for the June 2020 and June 2021 Rating Curve. Comparing the highest flow rate between the two months, there is a 32.87 percent decrease on its highest flow rate with 96.42 cms added to June 2021 from the previous year. In contrast, comparison of the lowest flow rate between the two months show a 160.37 percent increase with 14.69 cms added to June 2021 from the previous year. Moreover, the data shows a 40.81 percent, or an additional 12.13 cms, increase of average flow compared with the data from the previous year. Finally, there is a 28.91 percent, or an additional 0.451m increase, on the average stage of the river.

**Figure AJ.** Pinan-anan River Rating Curve (June 2020 vs June 2021)

* Decrease of 32.87% on its highest flow rate (96.42 cms deducted)
* Increase of 160.37% on its lowest flow rate: (14.69 cms added)
* Increase of 40.81% on its Average flow month: (12.13 cms added)
* Increase of 28.91% on its Average flow month: (0.451m added)

Limitations & Recommendations

-Flow measurements are so much limited due to pandemic.

-additional of RG for meteorological measurement particularly within the basin and nearly the area.

- Provide/Gathered more sample of flow measurement in order to establish a precise rating curve (for more accurate flow measurement, a use of Digital flow meter to determine an minutes/hourly/daily velocity rate)

-establish a cross-section survey to emphasize the left and right banks of the cross-section which can indicates for a bank-full scenario. And integrated the cross-section profile with the establishment of water surface level on the given time from the surveyed.

- Establish an Hydrologic Modelling which makes an accurate measurement of flow and good information for the assessments for the observed data with respect to long terms trends.

- Erroneous of data which affect the analysis of the rating curve. Time to time, data must be evaluated if it is substantial to accurate figures of data and device must be evaluate if it still working or calibrated.

Flow measurements are limited due to the pandemic. It is recommended to gather additional Rain Gauge data for meteorological measurement particularly within the basin and nearly the area. Moreover, by gathering more flow measurement samples, it is possible to establish a more precise rating curve which in turn would give a more accurate representation of the river. (for more accurate flow measurement, use of digital flow meter to determine in minutes/hourly/daily velocity rate)

It is further recommended to establish a cross-section survey to emphasize the left and right banks of the cross-section which can indicate a bank-full scenario, integrating the cross-section profile with the establishment of water surface level on the given time from the surveyed.

Lastly, it is recommended to establish a Hydrologic Modelling that makes accurate measurement of flow and good information for the assessments for the observed data concerning long terms trends.