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Catalogues of Hydrologic Analysis for Hydro-Resilient Asia Pacific Region

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Purpose of collaborative research

In the Asia-Pacific regions, various hydrologic analysis methods have been applied for designs of hydraulic structures, river improvement works, rainfall-runoff predictions, flood and inundation prediction and so on. These hydrologic analysis methods have different characteristics in terms of climate, topography, development history of the catchments, etc. To develop a platform to share these hydrologic analysis methods is quite helpful to improve the ability for estimating water-related hazard risks and reduce the damage of disasters; however, most of researchers and engineers do not have knowledge of analysis methods used at the other countries and sectors in the Asia-Pacific region.

To improve this situation and enhance the risk estimation ability in Asia-Pacific region research and engineering communities, we form a research team and develop a hydroinformatics platform in the Asia-Pacific region for realizing hydrohazard resilient Asia. Specifically, to enhance the ability for evaluating water-related disaster risks, we develop a Catalogue of Hydrologic Analysis, CHA with the collaboration of researchers and engineers in the Asia-Pacific region.

Outline and progress of research

The purpose of CHA is to collect documents and software for various hydrologic analysis methods from practical use to advanced studies for short-term rainfall prediction, rainfall-runoff prediction, flood and inundation prediction, hydrologic frequency analysis, and eco-hydrology, which will be freely accessed through the CHA home page. Developing CHA and share the knowledge through the CHA, we provide a platform to improve the ability for evaluating water-related disaster risks, which will strengthen the cooperation among researchers, governmental agencies and private sectors; serve to reduce the damage of water-related disasters; and will be a local contribution to achieve targets of SDGs and UNESCO IHP-VIII.

CHA website is shown in Figure below. The address is <http://hywr.kuciv.Kyoto-u.ac.jp/ihp/rsc/cha.html>

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IHP RSC for Southeast Asia and the Pacific

UNESCO International Hydrological Programme

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Catalogue of Hydrologic Analysis for South East Asia and Pacific

In the Asia-Pacific regions, various hydrologic analysis methods have been applied for designs of hydraulic structures, river improvement works, rainfall-runoff predictions, flood and inundation prediction and so on. These hydrologic analysis methods have different characteristics in terms of climate, topography, development history of the catchments and so on. To develop a platform to share these hydrologic analysis methods is quite helpful to improve the ability for estimating water-related hazard risks and reduce the damage of disasters; however, most of researchers and engineers do not have knowledge of analysis methods used at the other countries and sectors in the Asia-Pacific region.

To improve this situation and enhance the risk estimation ability in ASEAN research and engineering communities, we form a research team and develop a hydroinformatics platform in the Asia-Pacific region for realizing hydrohazard resilient Asia. Specifically, to enhance the ability for evaluating water-related disaster risks, we develop a Catalogue of Hydrologic Analysis, CHA with the collaboration of researchers and engineers in the Asia-Pacific region. The Catalogue will collect documents and software for various hydrologic analysis methods from practical use to advanced studies for short-term rainfall prediction, rainfall-runoff prediction, flood and inundation prediction, hydrologic frequency analysis, and eco-hydrology, which will be freely accessed through the CHA home page. Developing CHA and share the knowledge through the CHA, we provide a platform to improve the ability for evaluating water-related disaster risks, which will strengthen the cooperation among researchers, governmental agencies and private sectors; serve to reduce the damage of water-related disasters; and will be a local contribution to achieve targets of SDGs and UNESCO IHP-VIII.

Development of Hydroinformatics Platform for Hydrohazard Resilient Asia

- Develop a Catalogues of Hydrologic Analysis, CHA for students, engineers, and researchers;
- Enhance cooperation among researchers, policy makers and private sectors in the Asia-Pacific region through development of the CHA;
- Improve abilities to evaluate water-related disaster risks in the region using the CHA; and
- Contribute to SDGs and IHP-VIII from the Asia-Pacific region through the development of CHA.



CATALOGUE OF HYDROLOGIC ANALYSIS

October 22, 2016

Theme 1: Water-Related Disasters and Hydrological Change

Flood runoff analysis

- Flood prediction using a distributed flow routing model, 1K-FRM (Y. Tachikawa and T. Tanaka, Japan)
 - [document](#)
 - [related information](#)
- Rainfall-runoff and flood inundation predictions using RRI model (T. Sayama and Y. Iwami, Japan)
 - [document](#)
 - [related information](#)

Water and heat balance analysis

- Estimation of monthly potential evapotranspiration using Thomthwaite method (K. Kobayashi, Japan)
 - [document](#)
 - [Exoell sheet for calculation](#)

Hydrologic frequency analysis

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<http://hywr.kuciv.Kyoto-u.ac.jp/ihp/rsc/cha.html>



The UNESCO-IHP Regional Steering Committee
for Southeast Asia and the Pacific



Development of Hydroinformatics Platform for Hydrohazard Resilient Asia

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SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD



IHP-VIII
WATERSECURITY
Responses to Local, Regional and Global Challenges
[2014-2021]



CATALOGUE OF RIVERS FOR SOUTHEAST ASIA AND THE PACIFIC

Volumes I to VI

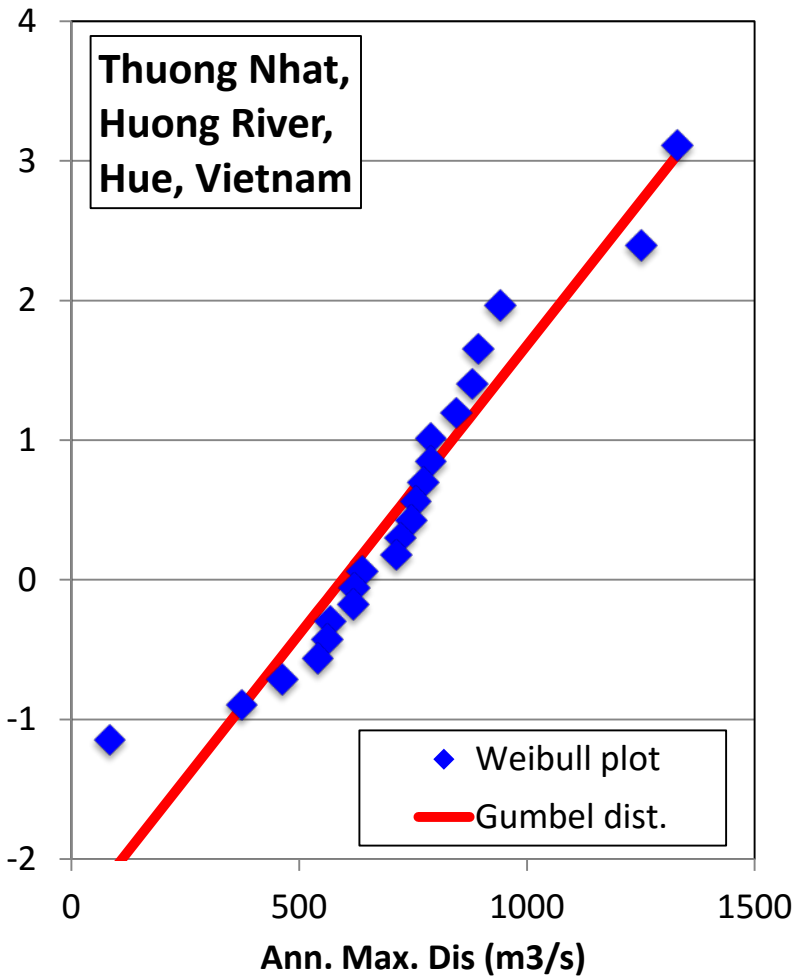
- **Volume I**, October 1995, edited by K. Takeuchi, A. W. Jayawardena and Y. Takahasi
- **Volume II**, December 1997, edited by A. W. Jayawardena, K. Takeuchi, and B. Machbub
- **Volume III**, May 2000, edited by H. Pawitan, A. W. Jayawardena, K. Takeuchi, and Soontak Lee
- **Volume IV**, March 2002, edited by R. Ibbitt, K. Takara, Mohd. Nor bin Mohd. Desa, and H. Pawitan
- **Volume V**, May 2004, edited by Y. Tachikawa, R. James, K. Abdullah and Mohd. Nor bin Mohd. Desa
- **Volume VI**, March 2012, edited by H. Chikamori, L. Heng and T. Daniell



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for Southeast Asia and the Pacific

Example of frequency analysis of discharge (by Chikamori)

- Huong River in Hue, Vietnam -



Gumbel probability paper

4.5 An
At Thuong

Year									
1981									
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990	9.18	745	5	3.17	2001	10.21	568	8	3.46
1991	11.26	84.0	8	2.20	2002	10.6	561	7; 8	2.33

1), 2) Discharge rated according to manual observation of water level.

Applying Gumbel distribution to annual maximum discharge

Return Period	Quantile (m ³ /s)
10	1138.23
20	1312.12
50	1537.21
100	1705.88

Study area

Chapter 3: Evapotranspiration

Thornthwaite Method

Study Area

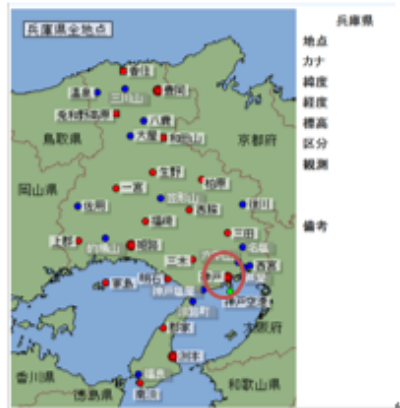


Figure 1: Study area. The red circle indicates Kobe city where the temperature data used in the example is measured.

Data

Table 1 shows mean monthly temperature of Kobe city for the year of 2013. Estimate the monthly potential evapotranspiration of Kobe city using Thornthwaite method.

Table 1. Mean monthly temperature of Kobe city for 2013

Mean monthly temperature (°C) for 2013	
Kobe city: lat. 34.7, lon. 135.2	
Jan.	1
Feb.	2
March	4.5
April	9.5
May	2.5
June	3.5
July	11.5
Aug.	16.5
Sep.	11
Oct.	6.5
Nov.	5
Dec.	6

Data

Result:

Thornthwaite (1948) derived a set of equations to estimate monthly potential evapotranspiration. The equations are expressed as follows:

$$E_p(i) = 0.533 D_0(i) \left(\frac{10t_i}{J}\right)^\alpha \quad (1)$$

where $\alpha = 6.75 \times 10^{-7} J^3 - 7.71 \times 10^{-5} J^2 + 1.79 \times 10^{-2} J + 0.492$

(2)

$$J^{\frac{1}{3}} = \sum_{i=1}^{12} \left(\frac{t_i}{5}\right)^{1.514} \quad (3)$$

where $E_p(i)$ is the potential evapotranspiration (mm/day) of the i th month, t_i the mean monthly temperature (°C), $D_0(i)$ the mean monthly sunshine hour (12hour/day).

From Table 1 and Equation (3), then Equation (2), J and α can be estimated:

$$J^{\frac{1}{3}} = \sum_{i=1}^{12} \left(\frac{t_i}{5}\right)^{1.514} = \left(\frac{1}{5}\right)^{1.514} + \left(\frac{2}{5}\right)^{1.514} + \left(\frac{4.5}{5}\right)^{1.514} + \left(\frac{9.5}{5}\right)^{1.514} + \left(\frac{2.5}{5}\right)^{1.514} + \left(\frac{3.5}{5}\right)^{1.514} + \left(\frac{11.5}{5}\right)^{1.514} + \left(\frac{16.5}{5}\right)^{1.514} + \left(\frac{11}{5}\right)^{1.514} + \left(\frac{6.5}{5}\right)^{1.514} + \left(\frac{5}{5}\right)^{1.514} + \left(\frac{6}{5}\right)^{1.514} = 21.50$$

$$\therefore \alpha = 6.75 \times 10^{-7} J^3 - 7.71 \times 10^{-5} J^2 + 1.79 \times 10^{-2} J + 0.492 = 0.85$$

$D_0(i)$ can be calculated using the following equations:

$$D_0(i) = \frac{2H}{0.2618} \quad (4)$$

$$\sin\left(\frac{H}{2}\right) = [A / \cos \theta \cos \delta]^{\frac{1}{2}} \quad (5)$$

$$A = \sin\left(\frac{\pi}{4} + \frac{(\theta - \delta + r)}{2}\right) \sin\left(\frac{\pi}{4} - \frac{(\theta - \delta + r)}{2}\right) \quad (6)$$

where θ is the latitude of the observation point (rad), δ the solar declination (rad), H hour angle (rad) from the sunrise to culmination considering horizontal refraction r ($=0.01$). The solar declination δ is expressed as:

$$\delta = 0.33281 - 22.984 \cos(wf) - 0.34990 \cos(2wf) - 0.13980 \cos(3wf) + 3.7872 \sin(wf) + 0.0325 \sin(2wf) + 0.07187 \sin(3wf) \quad (7)$$

where $w = \frac{2\pi}{365}$, in bissextile year $w = \frac{2\pi}{366}$ and J the number of the days from the New Year's Day.

As the result, the estimated monthly potential evapotranspiration is shown in the right

Result (cont.)

where ϕ is the latitude of the observation point (rad), δ the solar declination (rad) from the sunrise to culmination considering horizontal angle ($=0.01$). The solar declination δ is expressed as:

$$\delta = 0.33281 - 22.984 \cos(wJ) - 0.34990 \cos(2wJ) - 0.13980 \cos(3wJ) + 3.7872 \sin(wJ) + 0.0325 \sin(2wJ) + 0.07187 \sin(3wJ) \quad (7)$$

where $w = \frac{2\pi}{365}$, in bissextile year $w = \frac{2\pi}{366}$ and J the number of the days from the New Year's Day.

As the result, the estimated monthly potential evapotranspiration is shown in the right hand side column of Table 2.

Table 2. Mean monthly evapotranspiration of Kobe city estimated for 2013

Month	Temperature (°C)	Evaporation (mm/day)
Jan.	1	0.23
Feb.	2	0.45
March	4.5	0.99
April	9.5	2.04
May	2.5	0.70
June	3.5	0.97
July	11.5	2.61
Aug.	16.5	3.35
Sep.	11	2.19
Oct.	6.5	1.28
Nov.	5	0.94
Dec.	6	1.04

References:

- Brutsaert, W.: Hydrology: An Introduction, Cambridge University Press, 2005
 Ikebuchi, S., Shiiba, M., Takara, K., and Tachikawa, Y. : Ace Hydrology, Asakura Press, 2006

The format of the reference book will be carefully discussed among member countries as it was so in the catalogues of rivers.

References

Final Report of the 22nd RSC meeting for Southeast Asia and the Pacific (Yogyakarta, Indonesia, 13-14 November 2014)

The final report of the 22nd RSC meeting for Southeast Asia and the Pacific states as follows:

- *Mr. Hidetaka Chikamori and Mr. Kenichiro Kobayashi presented a “Proposal of Catalogue for Hydrologic Analysis” which output would be a reference book with target practitioners and university students. He presented the example of table of contents with 5 themes of IHP VIII and example of format including map of study area, data, dataset and calculation.*
- *Vietnamese delegate, Mr. Tran Thuc, supported the proposal and recommended to account for the history of the data records from the catalogue and carrying on updating it.*
- *The chairman, Mr. Kaoru Takara, suggested updating the data of the previous Catalogue of Rivers and including them in the new initiative.*
- *Australian delegate, Mr. Trevor Daniell, also proposed that the Australian Rainfall-Runoff project of 9 books (already available) can assist in some examples.*
- *The Rep. of Korea delegate, Mr. Soontak Lee, stated that the proposal is a very good idea and should be implemented through a consultative process by sending the format template to all members a.s.a.p.. All delegates are requested to send back comments by the end of November. Mr. Chikamori and Mr. Kobayashi should incorporate these comments into the format and if a draft is ready on time, it would be very good to have it presented at the RSC session in the 7th WWF.*

Final Report of the 22nd RSC meeting for Southeast Asia and the Pacific (Yogyakarta, Indonesia, 13-14 November 2014)

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- *The RSC Secretariat, Mr. Shahbaz Khan, asked about the timeline and what was already ready. He further proposed the use of CONNECT-Asia with some regular courses on this initiative should also be considered.*
- *Mr. Chikamori stated that the timeline depends on the way this initiative can be supported, the format can be circulated and comments taken in account.*
- *The RSC Secretariat, Mr. Shahbaz Khan, asked if there was a need for funding. If yes, then there is a need to work together to put a proposal through MEXT and first draft should be produced within the next 6 month.*
- *Mr. Chikamori stated the needs of funds depends on what will be produced. If it is, 200-300 printed books with CD of the program and publishing e-book through website then funds are necessary. Mr. Chikamori will send an assessment of how much is necessary.*
- *Mr. Soontak Lee urged that if the members agreed to launch this during the 7th WWF then it should be addressed in very URGENT manner. Proposed to launch a demo version as the first draft in 7th WWF.*

Draft Report of the 23rd RSC meeting for Southeast Asia and the Pacific (Medan, Indonesia, 19-20 October 2015)

The “draft” report of the 23rd RSC meeting for Southeast Asia and the Pacific states as follows:

- *Mr Chikamori reported on the situation of the Catalogue of Hydrological analysis. Consultation on the format and level of target user was circulated to the committee members during January 2015. Only two responses were received and it was reported the level of user should be beginner also a format was proposed and the floor opened for discussion.*
- *Mr Tabios inquired about the difference between the catalogue of hydrologic analysis and the atlas that was developed 6 years ago on the general status of water resources as well as AP_FRIEND activities.*
- *The chairperson explained this new catalogue is about using data collected in the six volumes of catalogue of rivers in an online format. It is a collection of analysis method including software and the discussion in this item point should be about the format of this new catalogue.*

- *Mr Daniell* commented on *the high value of this new catalogue as a teaching tool* and suggested it should: • have a label system with several levels (Beginner, Advanced/Graduate and Practitioners), • be open source software based or freely available • Include a list of topics to be covered.
- *The secretariat* reported the *new proposed JFIT funded IHP project, WISER* (Water Informatics for Sustainability and Enhanced Resilience in Asia and the Pacific) focuses on hydroinformatics and DRR and *has received a positive response from the government of Japan.*
- *It was reported there is a need for standardized method but this was very challenging.* Also there is a need to give a clear identity to this new catalogue that shows why this new catalogue is developed, what are the differences of RSC hydrological methodology compared to already shared ones and *the demarcation could be based on AP region geophysical characteristics including humid tropic region and snowmelt runoff countries.*
- *Ms Yan called for action.*
- *It was agreed to form a technical sub-committee (Action point 3) for which chair and members of the sub-committee should be selected.*

Draft Report of the 24th RSC meeting for Southeast Asia and the Pacific (Ulaanbaatar, Mongolia 24-26 October 2016)

Kenichiro Kobayashi introduced the background of the Catalogue of Hydological Analysis (CHA) which was proposed at the 22nd RSC meeting in Yogyakarta. Since then the following activities were undertaken:

- *In December 2013, the first regional call for contributions was made.*
- *At ICWRER2016, the first technical coordination meeting took place during the session with IDI and IFI and UNESCO Jakarta (June 2016)*
- *A Japanese coordination meeting took place in August 2016*
- *The latest regional call for contributions was made at the region at Bali meeting (July 2016)*
- *The website prototype was presented to the RSC. It comprised : 1) module from Prof Tachikawa and 2) module on RRI from Prof Sayama, 3) evapotranspiration module from Prof Kobayashi and 4) a page on “how to contribute to CHA?” with a word document with the format on how to send contribution to CHA.*
- *The RSC members discussed on 1) if the name “Catalogue of Hydrological Analysis” was appropriate, 2) what CHA was trying to achieve. The CHA Japanese team underlined CHA is not intended to be a Japanese initiatives but all RSC members were encouraged to participate and contribute what they can or want. It was concluded:*

Draft Report of the 24th RSC meeting for Southeast Asia and the Pacific (Ulaanbaatar, Mongolia 24-26 October 2016)

Contd.

- *A “task force team” has to be formed and the current technical sub-committee can be the initial task force team*
- *There is a need for the task force team to conduct some kind of literature review in order to assess if there is any other existing initiative with the same purpose*
- *A regional call for contributions will be resent to all RSC members by a task force and all RSC members are highly encouraged to consider what they can contribute and commit.*
- *In the light of the received commitments, the name as well as the purpose of the current CHA will be redefined.*

New proposal (by Tachikawa, Kobayashi and Sayama) being considered this year!

As the results

- Title: CHA
- Contents : Water related disaster (forecasting, hazard map), Water resources management (drought, groundwater use), eco-hydrology (water quality, water environment preservation) etc. which are related with IPH 8th Phase.
- Editorial board: RSC chairperson, secretary, CHA responsible personnel (according to the theme) × 3 = approx. 5 persons) which will be requested to all the countries.
- Schedule: Every 2 years
- 2017: Proposal of the revised plan
- 2018: Decision of the proposal (e.g. hazard map). The due date is 2019
- 2019: Start of the editorial process after the collection of the hazard map manuscripts. To be completed by 2020.
- 2020: Discussion of the 2nd phase plan, decision and request of the 2nd phase

New proposal (by Tachikawa, Kobayashi and Sayama) being considered this year!

As the results

Water related hazard (flood, inundation forecast)

Title: Flood warning in the Yodo River basin

- (1) (Yodo river basin overview) : The citation from River Catalogue is expected.
- (2) (System) : flood warning system including meteorological warning system. System and legal framework. Information to the public (e.g. evacuation information) will be described.
- (3) (Technology) : Introduction of meteorological forecast, flood forecast.
(Theory) Theory of the analysis, basic equation
(Tool) e.g. RRI.
- (4) (Example) Good practice of the past events. When the warning is made and how was the reaction etc.
- (5) (References) if possible

We welcome your support!