Regulated and Unregulated River Reach Perception Through Geoinformatic Public Domain Model Particularized Upon The Chaophraya Tributaries

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ABSTRACT

Vigorously influenced to Thai researcher, GAME-T data base has been successively persuasive produced such enormous research projects. Public domain system modeling is one of them thus were producible created under GAME-T / GAME-Chaophraya project.

Prototype areas were basically researched on unregulated steep slope and hilly area basins upon Ping and Nan river basins, while other comparable prototype was on Pasak regulated reach. Those huge drainage areas occupied 1,500, 10,156 and 14,520 square kilometers respectively. Two of them, situated in mountainous area, were unregulated studiousness while the largest basin was regulated by Pasak Cholasit dam site.

Essential hydrological data approached from GAME-T data base were, two stations at Ping river, nine stations at Nan river and eleven stations at Pasak river. Spatial analysis through 1:50,000 topology of geoinformatic system were much convenient for federation and assessment.

Hydrologic Respond Unit (HRU) together with stream flow Hydrograph Separation and Analysis Program (HySeP), were intensified for flood hydrograph and base flow methodology. Continual rainfall investigation with sufficient number of stations would imply admirable correlation efficiency. Nevertheless, public domain SWAT/GIS 2000 model has been proved and recommended to basis calibrate up to five hundred basins to perform the best result. According to model calibrations and verifications, admissible results with ninety seven percentage of correlation efficiency performed an ensuing accuracy in these appropriations. Innovative geoinformatic system execution could perform and illustrate precisely synchronism with this public domain model.

Keywords: GAME-T data base, Geoinformatic System, Soil and Water Assessment Tools, Stream flow Hydrograph Separation and Analysis Program, Standard Query Language

INTRODUCTION

The Chaophraya river basin has been dominant influenced to mostly Thai agriculture, agro-economy, industry, communication, society and etc., which was regional regime characterized by monsoon, spatial and intensive heavy rainfall. Increased mean rainfall intensity attitude as rainfall variations with plenitude, caused floods, landslide and debris flow. Inundation simulation which major causes of water-related extreme event, which was attempted to structure and verify public domain SWAT/GIS 2000 model. Data analysis interface has been modified by data analysis programming and data access approached on access basic SQL (Standard Query Language). Base flow severance methodology was selected studiousness on stream flow hydrograph separation and analysis program (HySeP) which was leashed by sliding interval methodology.

METHODOLOGY

SWAT / GIS principle has been designed to assess continuous incidents and long time periods of both natural and au-natural activities which could be applied to large and small basins. It was physically based requiring specific inputs for weather, soil, topography, vegetation, land management practice and watershed, which would be essential partitioned into hydrologic response units (HRU). These HRU sub-watershed or sub-basins severely based on land uses, soil types, channels, ponds or reservoirs. Hydrology simulation was separated into land phase and stream phase, while land phase controlled main channel transportation on water, sediment and agricultural chemicals but stream phase would be transported through channel grid into basin outlet. Model was tenuous simulated upon tropical precipitation in Thailand, whose local impact on regional scale of tropical deforestation. Intricacy and simplicity model as SWAT/GIS2000, public domain model in water resource with continuous time, basin scale and geoinformatic system interface, has been advantageous employed to formulate and calibrate from small to very large basins.

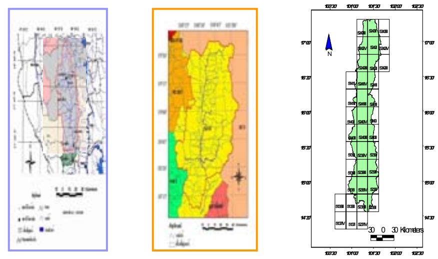
DATA ASSIMILATION

Chiangmai and Nan river basin topography were both major by mountainous and hilly features, which occupied 1,500 and 10,156 square kilometers respectively, while Pasak river basin was mountainous on upper part and slope down to dam site outlets, occupied 14,520 square kilometers as shown in Figure1. Selected rain-gage stations under responsibility of the Royal Irrigation Department (RID) were stations number:

28013 at amphour Muang, 28032 at amphour Na Noi, 28042 at amphour Pua, 28053 at amphour Thung Chang, 28073 at amphour Tha Wang Pha, 28102 at amphour Chiang Klang, 28111 at amphour Sa,19052 A.Chai BaDan, 19092 Pattananicom, 19113 A.BauChum, 19342, 19351 Ban Thayiam, 19360, 19411, 25132, 25172 Klang Ong Teak Plantation, 25272, 25470, 25612, 36013 A.Maung, 36023 A.LomSak, 36032 A.LomKoa, 36043 .WichianBuri, 36052, 36062 Nai Chun Farm, 36082 Caoksaard School, 36092 A.Nongpai, 36104, 36122 Nam Ron and 36192 A.Bung Phan.

Thailand Meteorology Department (TMD) responsibility were stations
327008 at amphour Oomkoi, 327027 at amphour Hoa, 376203, 331008 at Doi Phuka National Park and 331009 at amphour Songkwae.

Agro-meteorological Station were 28142 at amphour Nan, 28152 at amphour Mae Charim and 19342 at Chai Badan.



a. Chiangmai b. Nan c. Pasak

Figure 1. Study Area
(a.Chiangmai basin , b.Nan basin, c.Pasak basin).

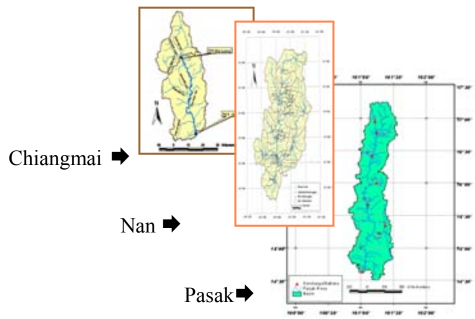
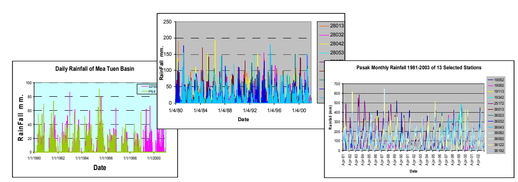


Figure 2. Hydro-informatics station

Table 1. GIS data for SWAT/GIS model.

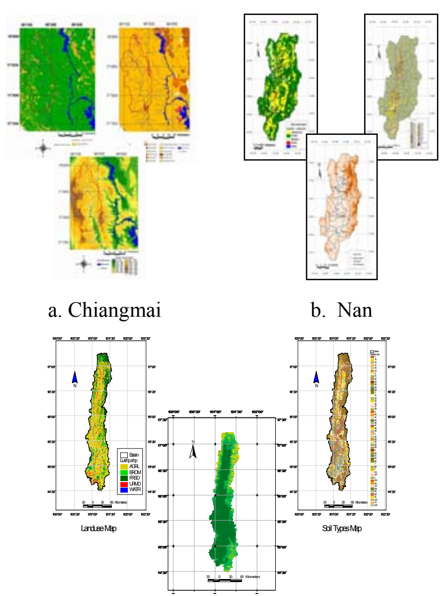
Data Type	Resource Department	Scale
Topography	Royal Survey Thailand Department	1:50,000
Land Cover	Land Development Department	1:50,000
Soil	Land Development Department International	1:50,000
	Geosphere–Biosphere Programe(IGBP-DIS)	N/A
Weather	Thai Meteorology Department (TMD)	N/A
	Royal Irrigation Department (RID)	
Stream Flow	Royal Irrigation Department (RID)	N/A

According to precipitation from 1980 to 2003 at Chiangmai, Nan and Pasak provinces, rainfall analysis in September and October 1995 were normally high as rainy season of Thailand. Topography, soil, land cover and river system were used together with GIS interface to equalize digital data and convert to model format. The most essential GIS data base, had to be available for initial model calibration. All initial information were shown in Table 1and Figure 2 to Figure 5.



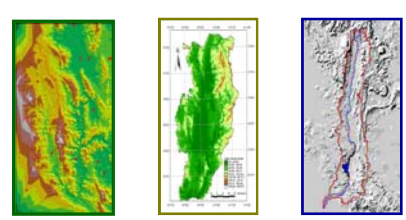
a. Chiangmai(1990-2000) b. Nan(1980-2001) c. Pasak(1982-2003)

Figure 3. Hydrologic information



a. Chiangmai b. Nan c. Pasak

Figure 4. Spatial analysis linkage informatics

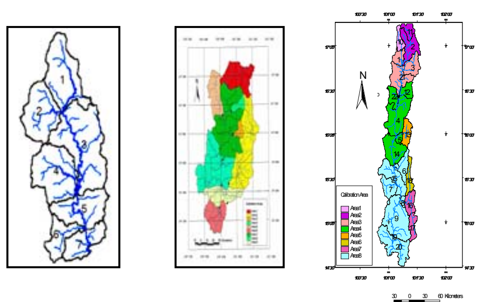


a. Chiangmai b. Nan c. Pasak

Figure 5. Digital Elevation Model

CALIBRATION

Mostly calibration had greatly improved accuracy of model. Same as the frontal calibration upon observed stream flow data from gauge stations of RID. Those are stations number P64 and PN8 for Chiangmai, N.17, N.42, N.49, N.50, N.51, N.63, N.1, N.13A and N.35 for Nan basins, while S.4B, S.9, S.10, S.12, S.13, S.14, SM.1, and SM.2 for Pasak basins . Theirs were investigated along periods 1990 to 2000 AD. for Chiangmai, 1980 to 2001 A.D. for Nan and 1982 to 2003A.D. for Pasak. which was illustrated to calibrate basin as shown in Figure 6.



a. Chiangmai b. Nan c. Pasak

Figure 6. Calibrated basins in SWAT model.

SWAT model was separately calibrated against both observed surface flow and base flow between two gauge stations which covered entire period of interest. Stream flow had two primary sources, surface runoff and ground water where base flow was separated from daily stream flow using a method adapted from USGS program HySeP hydrograph Separation as shown in Figure 7.

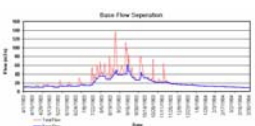


Figure 7. Base flow separation

Hydrological sub basin was basically on the following formula. Surface runoff duration time could present with

$$N = A^{0.2} \quad \ldots(1)$$

where N = Number of days with no runoff , A = Drainage area in square-miles.

Water balance equation was

$$SW_t = SW + \sum (R_i - Q_i - ET_i - P_i - QR_i) \quad \ldots(2)$$

where SW = Soil water content 15 Bar, t = time (days), R = Daily precipitation, Q = Daily runoff, ET= Daily evapotranspiration, P= Daily percolation and QR = Daily return flow.

SCS curve number method was for infiltration determination as follows:

$$Q = \frac{(R - 0.2s)^2}{R + 0.8s}, R > 0.2s \quad \ldots(3)$$

$$Q = 0.0, R \le 0.2s \quad \ldots(4)$$

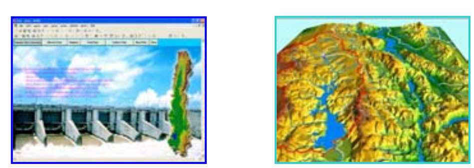
$$s = 254(\frac{100}{CN} - 1) \quad \ldots(5)$$

where Q = Daily runoff, R = Daily rainfall, s =Retention parameter and CN = Curve number. Assigned based on soil type, land cover and initial moisture conditions.

DATA ANALYSIS PROGRAM

Digital data base with spreadsheet software have capability to use macro script for both data calibration and chart representation. Access Basic and SQL was mainly developed utilization in order to convenient digitally calibrate and analyze in SWAT/GIS 2000 model.

Figure 8. was shown data analysis program frontal which was developed for SWAT / GIS 2000 model.



Frontal DEM & Flood Animation

Figure 8. Frontal & DEM analysis program.

RESULTS:

Caliber correlation efficiency indicated best significant on mild slope river basin and good relation on steep slope river basin where regulated methodology denoted up to ninety seven percentages and unregulated indexed over seventy percentages. Consequence, comparison and correlation at outlet verified features, pointed out that SWAT model could perform best on large mild slope basin without observed rainfall investigation, were shown in Figure 9. Table 2. were summarized on periods, basin area, base flow, surface flow and total flow of simulated and observed of those basins. Table 3. had contained results in slope, a mount of rain gauge intensity and correlation coefficient between simulated and investigated flow.

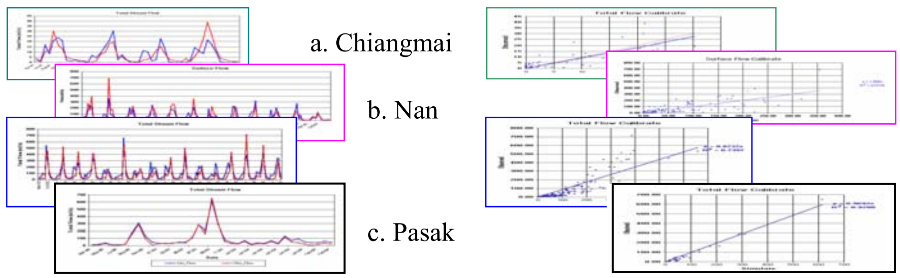


Figure 9. Observed and simulated flow comparisons and correlations.

Table 2. Correlation efficiency on calibrated basins.

station	Period	Basin Km^2	Slope	No. Rain Gauge	Simulated			Observed		
					Total flow	Surface runoff	Baseflow	Total flow	Surface runoff	Baseflow
PN.64	1990-1994	487.18	0.27	1	7.41	2.16	3.58	7.46	2.14	5.32
PN.8	1990-2000	1567.67	0.30	1	22.44	6.91	3.48	21.83	6.95	14.88
N.17	1980-1988	1091.15	0.31	0	22.667	6.067	16.6	23.949	5.92	18.029
N.42	1980-1988	2047.11	0.30	2	38.558	16.086	54.644	39.557	16.488	56.236
N.49	1987-1992	153.16	0.32	0	2.931	1.482	1.449	6.348	2.311	4.037
N.50	1987-1992	194.61	0.32	0	3.989	2.801	1.188	5.854	2.255	3.598
N.51	1980-1987	758.53	0.24	1	14.295	4.572	9.723	14.383	4.643	9.74
N.63	1991-2000	776.05	0.20	1	4.169	2.112	2.056	4.171	2.107	2.064
N.1	1988-1994	4495.06	0.24	8	70.608	27.219	43.389	65.321	21.26	44.061
N.13A	1988-1994	8566.91	0.24	8	124.941	46.168	78.773	114.259	40.53	73.729
N.35	1988-1992	10156.01	0.23	11	132.176	46.47	85.706	121.863	41.075	80.787
S.10	1983-1991	300.79	0.10	0	2.36	1.20	1.16	2.31	1.16	1.15
SM.1	1992-1999	1132.7	0.25	2	10.93	0.19	10.74	11.54	0.24	11.30
S.4B	1995-2001	332.1	0.18	3	21.73	7.42	14.31	19.79	7.97	11.83
S.12	1983-1998	476.11	0.23	0	3.81	1.65	2.17	4.01	1.72	2.29
SM.2	1992-1998	7329.49	0.16	6	65.46	11.23	54.23	48.87	10.02	38.85
S.13	1983-1998	395.25	0.10	0	2.73	1.13	1.60	2.74	1.16	1.13
S.14	1990-1997	1252.77	0.09	0	5.75	3.66	2.09	5.20	3.25	1.95
S.9(un)	1982-1997	14323.8	0.07	13	106.55	29.52	77.04	75.11	21.81	53.31
S.9(Re)	1999-2003	14323.8	0.07	13	87.99	27.33	60.66	75.14	21.11	54.02

Table 3. Correlation on calibrated basin.

Calibration Area	Stream Gauge	Basin Area Km^2	Basin Slope	No. of Rain Gauge	Coefficient of Correlation (R^2) Total Flow
Area1	P.64	487.18	0.266	1	0.5795
Area2	PN.8	1567.67	0.299	1	0.5361
Area3	N.17	1091.15	0.306	0	0.3512
Area4	N.42	2047.11	0.296	2	0.6219
Area5	N.49	153.16	0.317	0	0.4784
Area6	N.50	194.61	0.324	0	0.4775
Area7	N.51	758.53	0.240	1	0.5284
Area8	N.63	776.05	0.202	1	0.4099
Area9	N.1	4495.06	0.241	8	0.6008
Area8	N.13A	8566.91	0.237	8	0.7045
Area10	N.35	10156.01	0.230	11	0.7008
Area11	S.10	300.79	0.100	0	0.6037
Area12	SM.1	1132.70	0.248	2	0.7585
Area13	S.4B	3321.00	0.181	3	0.8285
Area14	S.12	476.11	0.230	0	0.5450
Area15	SM.2	7329.49	0.158	6	0.8089
Area16	S.13	395.25	0.100	0	0.7182
Area17	S.14	1252.77	0.087	0	0.8572
Area18	S9.(Un)	14323.80	0.068	13	07397
Area19	S9.(Re)	14323.80	0.068	13	0.9708

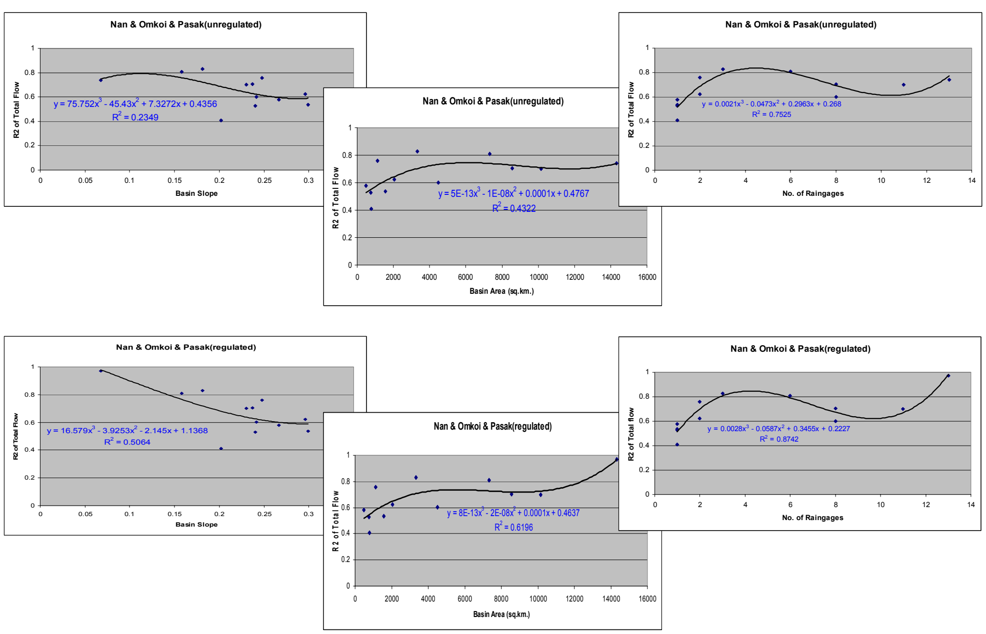


Figure 10. Correlation coefficient of flows, number of basin rain gauge and basin slope.

CONCLUSONS:

Digital data base and public domain system model have been executed on most methodology in this decade, which become more and more standardize to the technological world. SWAT/GIS 2000 has been assessed on unregulated and regulated areas, affirmable best arbitrated on large scale-mild slope potentiality and un-implied in both continual rainfall investigation and sufficient number of stations. Admirable correlation efficiency in large tropical basin of both unregulated steep slope and regulated mild slope basins were shown in Table 3. and Figure10. The model candid to basis calibrate up to five hundred basins to perform the best result on selected basin. Differences were permissible for both surface runoff and base flow fractions since investigated values are on large scale verification. Data analysis program development has been much efficient investigation to operate, calibrate and verify the model while digital elevation model was combined to become essential assistant on decision supporting system.

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