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Geoinformatic Public Domain System Model " SWAT " in Thailand

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ABSTRACT

The Chaophraya river basin has been supremely presumed to regime characterize central plain area. Prototype domains were researched with the SWAT model on medium and huge areas of both unregulated and regulated reaches upon steep slope, hilly and plain features on the Chaophraya tributaries in northern Thailand. 1,500 and 10,200 sq. kilometers domains situated in mountainous feature were unregulated studiousness, the other largest research domain of 14,500 sq.kilometers was regulated by Pasak Cholasit reservoir. Essential hydrological data inquiry was two stations at Ping river, nine stations at Nan river and eleven stations at Pasak river. 1:50,000 geoinformatic system was much conveniently spatial analyzed for federation and assessment. Base flow severance was stream flow hydrograph separation and analysis program was assembled by sliding interval methodology. Data analysis interface was modified by data analysis programming and data access methodology was approached by basic standard query language. This appropriate model calibrations and verifications, admissible ensued on above ninety percentage of correlation efficiency and affirmable best arbitrated on large scale-mild slope potentiality together with un-implied in both continual rainfall investigation and sufficient number of stations.

Key words: SWAT, soil and water assessment tools, geoinformatic system, stream flow hydrograph separation and analysis program, standard query language

INTRODUCTION

While most popular water resource models employed in Thailand, were costly licensed, Thai researchers had composed several models but still repelled. Nowadays, an innovative SWAT(soil and water assessment tools) has been a rather renowned public domain model in water resource which is updated to geoinformatic system model (Bahram,1992). Whereas the Chaophraya regime had been regional characterized by monsoon, spatial and intensive heavy rainfall increased mean rainfall intensity attitude as rainfall variations with plenitude that could cause floods, landslide and debris flow (Vathananukij, 1998). This inundation simulation which mainly caused of water-related extreme event (Micheal,1998; Muttiah and Allen, 1999), was attempted to structure and verify through standard public domain SWAT/GIS model to the Chaophraya tributaries.

METHODOLOGY

Public domain SWAT model

SWAT the "Soil and Water Assessment Tools", a model in water resource with continuous time, basin scale and geoinformatic system

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interface, has been capably counseled maxima to five hundred drainage basins calibration. Adequate hydro-meteorology continuance investigation might insinuate reliable correlation coefficient while SWAT model provided contingent spontaneous precipitation (Srinivasan *et al*., 1995; Rosenthal *et al*.,1995; Srinivasan *et al*., 1996). Thus model 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 grids into basin outlet (Sloto and Crouse, 1996; Steven, 1998). Flood hydrograph and base flow analysis employed hydrologic respond unit together with stream flow hydrograph separation and analysis program (HySeP) (Vathananukij and Thanasiriyakul, 2002). Hydrological sub basin was basically on the following formulae.

Surface runoff duration time could present with

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

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

Water balance equation was

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

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 (infiltration determination) as follows:

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

$$Q = 0.0, R < 0.2s \qquad \ldots(4)$$

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

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.

The SWAT model was principaly designed to assess continuous incidents and long time periods of both natural and au-natural activities which could advantageously employed to formulate and calibrate from small to very large basins. This research was proved that local geoinformatic system execution could perform and illustrate precisely synchronism with this public domain model (Vathananukij, 2003a; 2004 a).

Data assimilation

Intricacy and simplicity model as SWAT/GIS has been tenuous simulated upon tropical precipitation in Thailand (Vathananukij, 2003b). Figure 1 shows three different prototype domains at Ping(Chiang Mai), Nan and Pasak river basins whose topography with mainly mountainous and hilly features. Two domains occupied 1,500 and 10,156 square kilometers while other comparable prototype, Pasak river domain, was mountainous on upper part and slope down to dam site outlets, occuping 14,520 square kilometers.

Selective hydro-informatic data from precipitation gauge stations under responsibility of the Royal Irrigation Department (RID) were stations number: 28013, 28032, 28042, 28053, 28073, 28102, 28111, 19052, 19092, 19113, 19342, 19351, 19360, 19411, 25132, 25172, 25272, 25470, 25612, 36013, 36023, 36032, 36043, 36052, 36062, 36082, 36092, 36104, 36122, 36192 while Thailand Meteorology Department (TMD) responsibility were stations

Figure 1 Prototype domains.

numbers: 327008, 327027, 376203, 331008, 331009 and Agro-meteorological stations were numbers: 28142, 28152 and 19342. According to sufficient precipitation from 1980 to 2003 at Chiang Mai, Nan and Pasak provinces, rainfall consistency and analysis are illustrated in Figure 2 (Chow, 1988; Vathananukij and Paewpisakul, 2003a).

Geoinformatic system (George, 1997) which illustrated topography, soil, land cover and river system is used as interface to equalize digital data and converted to model format(Craig,1981), thus became the most essential availability for model initiation, calibration and verification occurrence (Vathananukij, 2003a; 2004 b). All digital information commencement and concern were recommended as presented in Table1. Figure 3 shows those substantial digital information on these three prototype domains (Vathananukij, 2005).

Calibration

Streamflow investigation by RID gauging stations (P64 and PN8 along periods 1990 to 2000 A.D. for Chiang Mai prototype; N.17, N.42, N.49, N.50, N.51, N.63, N.1, N.13A and N.35 from 1980 to 2001 A.D. for Nan prototype; S.4B, S.9, S.10, S.12, S.13, S.14, SM.1 and SM.2 from 1982 to 2003 A.D. for Pasak prototype) have been calibrated and verified through SWAT model (Vathananukij, 2002; 2003b; 2004b). Most calibration consequence greatly affirmed model consistency. Substantial calibrated domains were shown in Figure 4.

DATA ANALYSIS PROGRAMMING

Programming was principled on stream flow with two principal sources; surface runoff and ground water, where base flow was separated from daily stream flow using sliding interval method adapted from USGS program named “HySeP” (Arnold *et al*., 1995). SWAT model was separately calibrated against both observed surface flow and base flow between two gauge stations which covered entire period of interest. Base flow hydrograph separation is shown in Figure 5. Digital data base with spreadsheet software have capability to use macro script for both data calibration and tabular presentation (Ling, 1996; Mauro *et al*., 1998; Vathananukij, 2003). Data access basic software and standard query language were mainly developed for substance utilization in order to convenient digitally calibrate and analyze SWAT model. Results are illustrated in Figure 6.

RESULTS

Overwhelm simulation majorly caused water-related normal to extreme event, was attempted to structure and verified the geoinformatic public domain SWAT model. Comparison outcome on correlative efficiency illustrated the best presage on mild slope feature and good relation on steep slope feature where regulated prototype signified above ninety seven percent and unregulated prototype index over seventy percent. Table 3 shows results in feature slope, a number of rain gauge intensity and correlation coefficient between simulated and investigated surface flow.

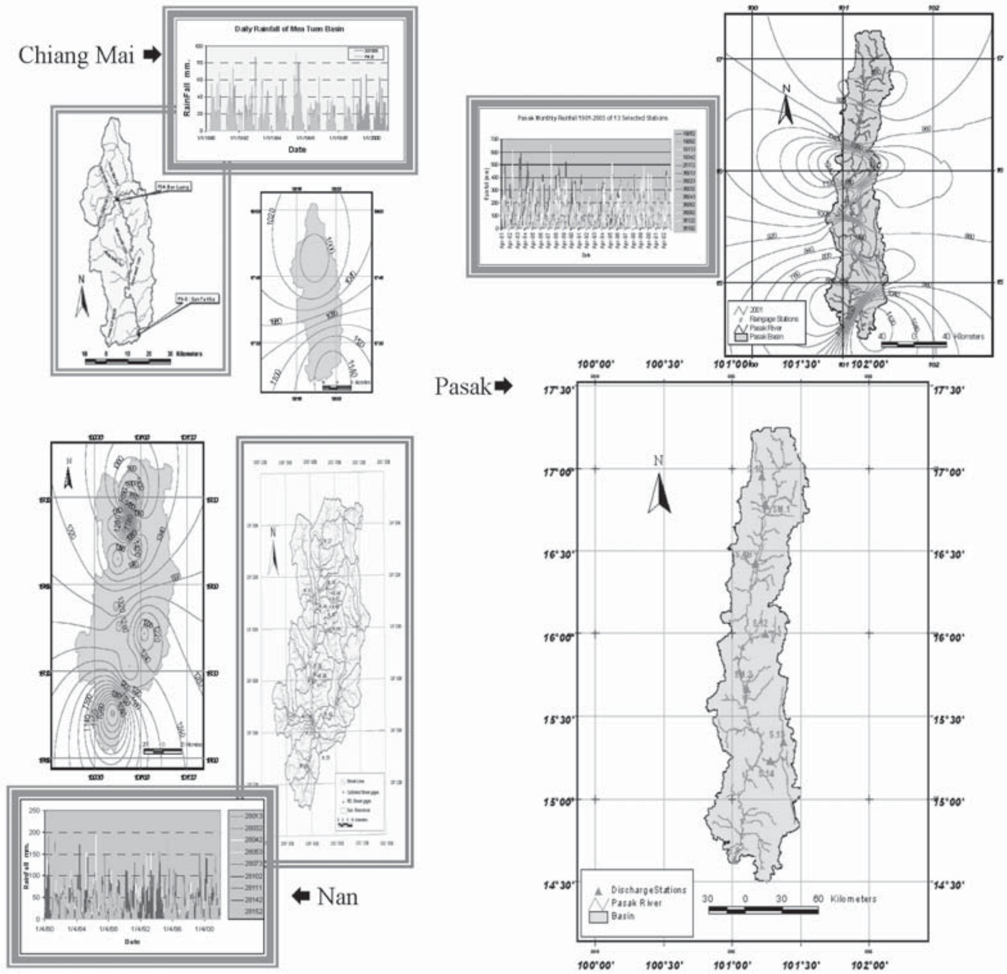

Figure 2 Hydro-informatics location and consistency analysis.

Table 1 Geoinformatic system information for SWAT 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	1:50,000
	International Geosphere–Biosphere Programe (IGBP-DIS)	
Weather	- Thai Meteorology Department (TMD)	N/AN/A
	Royal Irrigation Department (RID)	
Stream Flow	- Royal Irrigation Department (RID)	N/A

DISCUSSION

Consequences indicated that SWAT model (the first standard geoinformatic public domain model which exercised through Thailand hydroinformatic system) which could perform basis calibration up to five hundred sub-basins, has been standardized and affirmable best arbitrated (62~97 % efficiency)on both normal to large scale area (1,000 to 14,000 squared kilometers domains) and mild slope potentiality although un-implied and insufficient in continual precipitation observation.

In addition to data analysis program development which was much efficient investigation to operate, calibrate and verify through SWAT model.

Open source SWAT model assessment did essentially employ on geoinformatic system and digital elevation model capability. Furtherance could be more concerned in integration and management together with decision supporting system automation program.

Figure 7 illustratively indicated both

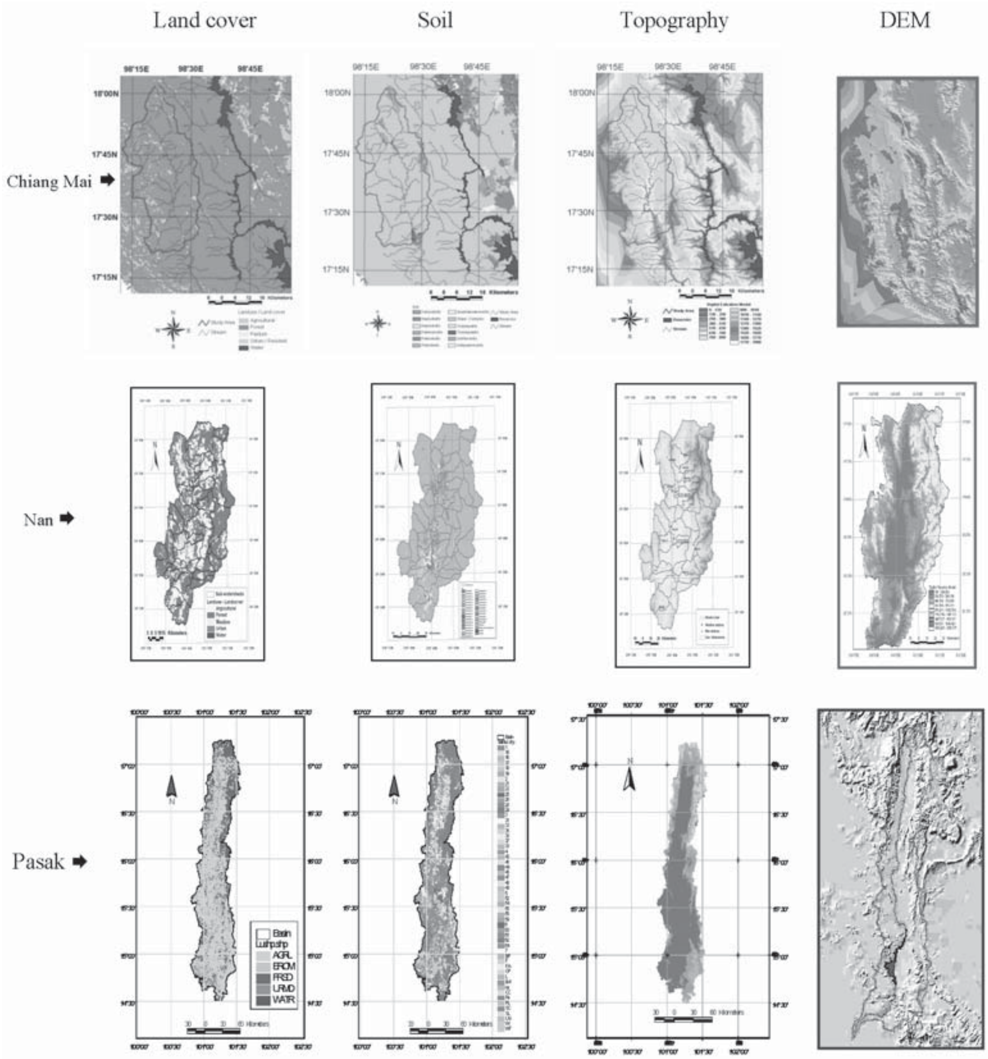

Figure 3 Geoinformatic system analysis linkage and performance.

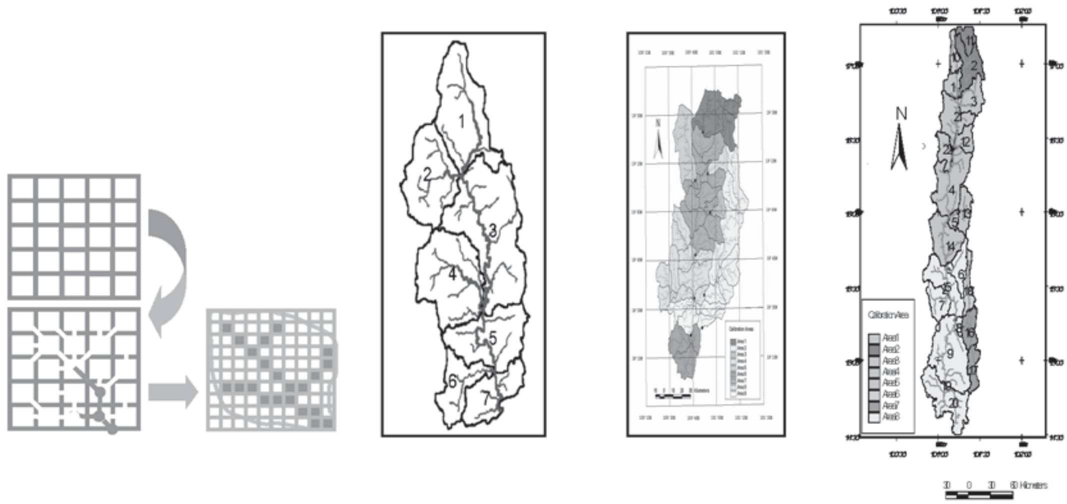

Figure 4 Threshold stream network and calibrated domains.

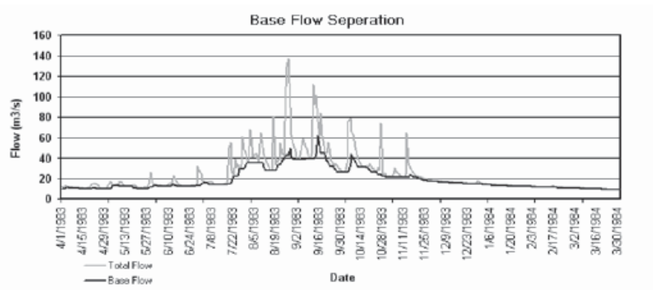

Figure 5 Base flow separation.

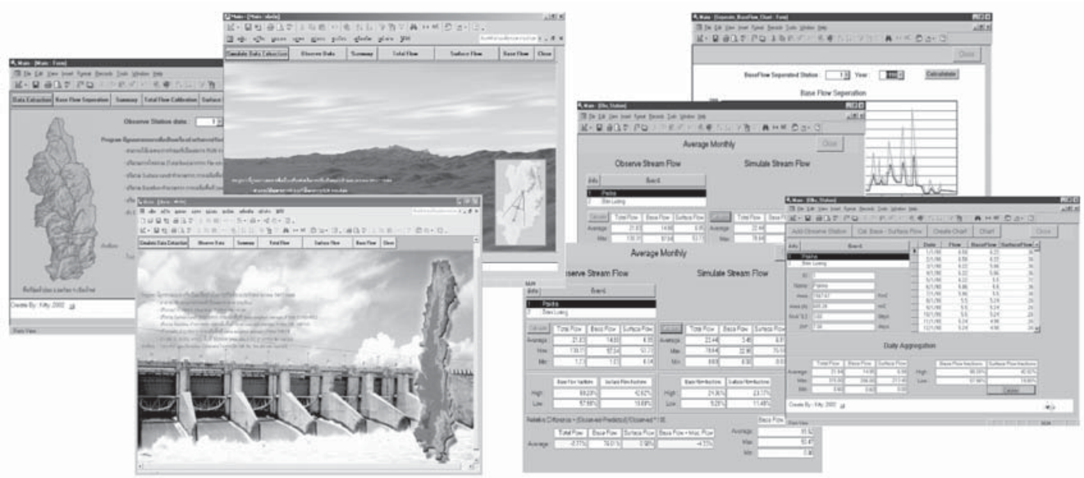

Figure 6 Data analysis program for model calibration.

Table 3 Correlation on calibrated basin.

Calibration area	Stream gauge	Basin area Km^2	Basin slope	Rain gauge intensity	Correlation coefficient (R^2) total flow
Area1	P.64	487.18	0.266	1	0.5795
Area2	PN.8	1,567.67	0.299	1	0.5361
Area3	N.17	1,091.15	0.306	0	0.3512
Area4	N.42	2,047.11	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	4,495.06	0.241	8	0.6008
Area10	N.13A	8,566.91	0.237	8	0.7045
Area11	N.35	10,156.01	0.230	11	0.7008
Area12	S.10	300.79	0.100	0	0.6037
Area13	SM.1	1,132.70	0.248	2	0.7585
Area14	S.4B	3,321.00	0.181	3	0.8285
Area15	S.12	476.11	0.230	0	0.5450
Area16	SM.2	7,329.49	0.158	6	0.8089
Area17	S.13	395.25	0.100	0	0.7182
Area18	S.14	1,252.77	0.087	0	0.8572
Area19	S9.(Un)	14,323.80	0.068	13	0.7397
Area20	S9.(Re)	14,323.80	0.068	13	0.9708

comparison and correlation at outlet verified features (Chiang Mai basin, upper Nan basin, regulated & unregulated Pasak basin).

CONCLUSON

Public domain system model SWAT, has been executed on most water resource freeware in this decade, which become more and more standardize to technological contemporary. The advantages of SWAT model basely calibrate up to five hundred basins, could perform best results on these selected domains. Differences were permissible for both surface runoff and base flow fractions since investigated values are on large scale verification. The SWAT model has been elective appraised on both unregulated and regulated prototypes, which their issuances had confirmative best allied on large scale-mild slope potentiality and un-implied in both continual rainfall investigation and sufficient number of stations. Bondage correlation efficiency in large tropical basin of both unregulated steep slope and regulated mild slope basins were illustrated in Table 2, Figure 7 and Figure 8. Data analysis program development has been much efficiently investigated to operation, calibration and verification the model while digital elevation model was combined to become essential assistant on water resource decision supporting system.

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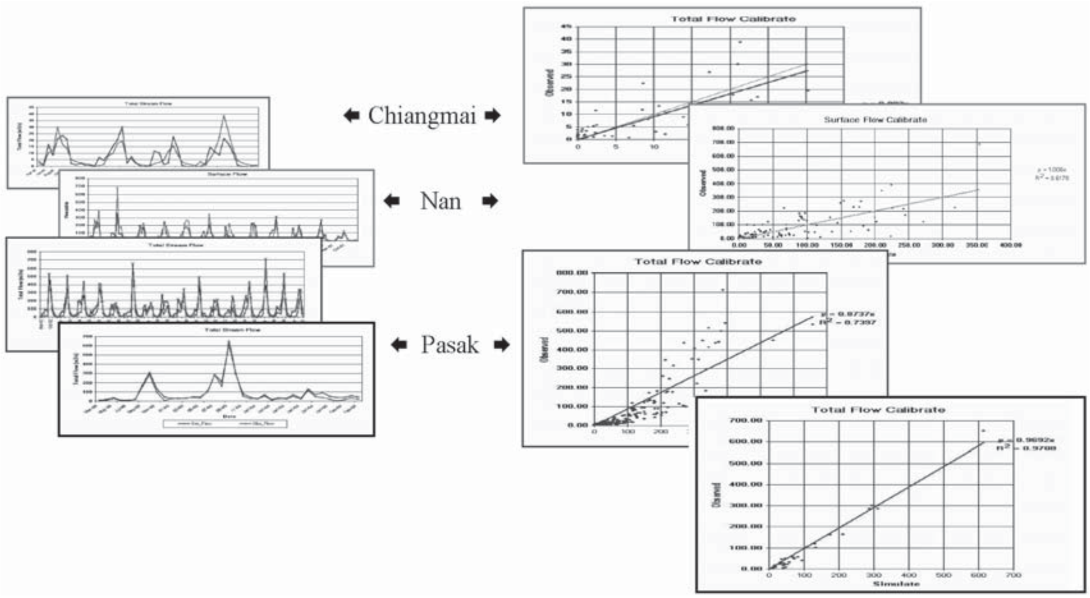

Figure 7 Surface flow comparisons and correlations.

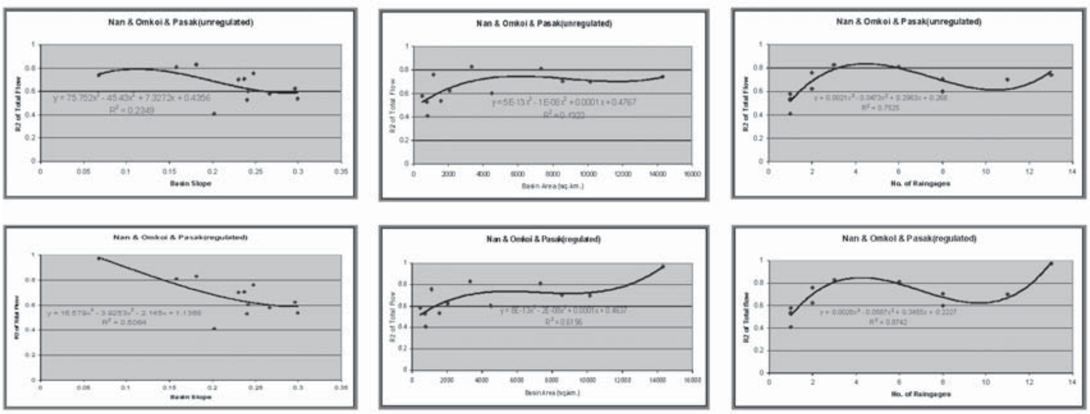

Figure 8 Correlation of flows, number of basin rain gauge and basin slope.

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