Research Note

CLASS A PAN EVAPORATION VERSUS POTENTIAL EVAPOTRANSPIRATION AT SEVEN LOCATIONS IN PUERTO RICO[1,2]

Shih[3,4] has estimated monthly potential evapotranspiration (PET) at seven locations in Puerto Rico. He used six PET models: namely Penman with albedo (α) of 0.05, Penman with α of 0.23, Blaney-Criddle USDA-SCS, Blaney-Criddle modified by Shih, Blaney-Criddle modified by FAO, and Thornthwaite. The parameters[6] in each model are indicated below:

1. *Penman (PM)*: air vapor pressure, net radiation, wind speed, latent heat of vaporization of water, average air temperature.
2. *Blaney Criddle (BCSCS)*: crop growth coefficient, annual daylight hours, average air temperature.
3. *Blaney Criddle (BCSH1H)*: Crop growth coefficient, monthly incoming solar radiation, average air temperature, annual incoming solar radiation.
4. *Blaney Criddle (BCFAO)*: climatic factor, annual daylight hours, average air temperature, average monthly minimum relative humidity related to saturation vapor pressure at dewpoint and air temperature, monthly and annual incoming radiation.
5. *Thornthwaite* (THRNTH); monthly average daytime hours, mean monthly temperature.

Several investigators[5] have related estimated PET with evaporation data to see if a model is suitable for a particular location. The objective of this study was to develop linear relationships among PET with various methods versus class A pan evaporation. Estimations by Shih[4] and monthly class A pan evaporation at seven locations in Puerto Rico were used. The locations were the agricultural experiment substations at Adjuntas, Corozal, Fortuna, Gurabo, Isabela, Lajas and Río Piedras. The geographical description for these locations is given by Goyal et al.[6]

Table 1 indicates linear regression relationships: $Y = A + B \times X$, where Y = monthly PET with each model, (mm/month) X = monthly class A pan evaporation (mm/month), A and B = regression coefficients, R^2 = coefficient of determination and r = coefficient of correlation. Table 1 also shows the ranking of each PET model based on values of r. All regression coefficients and coefficients of correlation were significant at

[1]Manuscript submitted to Editorial Board 13 April 1989.

[2]This study was conducted under Southeast Regional Project S-143 (H326), "Trickle Irrigation in Humid Regions—Puerto Rico," and C-411, "Bioclimate of Puerto Rico." Authors thank administrators of agricultural experiment substations, University of Puerto Rico, for providing class A pan evaporation data.

[3]Shih, S. F., 1987. Irrigation Requirement Estimation in Puerto Rico—Evapotranspiration. Unpublished report by University of Florida, Gainesville.

[4]Shih, S. F. and K. S. Cheng, 1988. Evapotranspiration estimation in Puerto Rico. ASAE Paper No. 88-2509 at the 1988 Winter Meeting of American Society of Agricultural Engineers, Chicago-Ill.

[5]Goyal, M. R. and E. A. González, 1988. Riego por goteo: evapotranspiración. No. IA72 Serie 14, o Servicio de Extensión Agrícola, Universidad de Puerto Rico, Río Piedras, P.R.

[6]—— and ——, 1988. Requisitos de riego para plátano en siete regiones ecológicas de Puerto Rico. *J. Agric. Univ. P. R.* 72 (4): 599-608.

TABLE 1.—*Relationships among evapotranspiration by various methods (Y) versus class A pan evaporation (X) for seven locations in Puerto Rico*

Location	Y[2]	Regression coefficients[1]				
		A	B	R^2	r	rank
Adjuntas	PM 0.23	15.33	0.77	0.94	0.97**[3]	1
	PM 0.05	18.05	0.63	0.94	0.97**	1
	BCSCS	16.41	0.73	0.74	0.86**	5
	BCSH1H	33.84	0.46	0.90	0.95**	2
	BCFAO	78.02	0.61	0.82	0.91**	4
	THRNTH	10.37	0.70	0.61	0.78**	6
	ALL	26.67	0.65	0.87	0.93**	3
Corozal	PM 0.23	25.86	0.62	0.95	0.93**	2
	PM 0.05	27.38	0.50	0.86	0.93**	2
	BCSCS	24.70	0.77	0.85	0.92**	3
	BCSH1H	48.02	0.36	0.57	0.75**	5
	BCFAO	73.70	0.58	0.87	0.93**	2
	THRNTH	3.06	0.97	0.74	0.86**	4
	ALL	33.79	0.63	0.91	0.95**	1
Fortuna	PM 0.23	8.05	0.60	0.90	0.95**	1
	PM 0.05	11.91	0.50	0.90	0.95**	1
	BCSCS	22.07	0.55	0.64	0.80**	4
	BCSH1H	28.40	0.36	0.83	0.91**	3
	BCFAO	78.50	0.48	0.85	0.92**	2
	THRNTH	0.95	0.74	0.48	0.70**	5
	ALL	24.98	0.54	0.84	0.91**	3
Gurabo	PM 0.23	50.09	0.25	0.93	0.97**	1
	PM 0.05	49.21	0.16	0.88	0.97**	1
	BCSCS	25.72	0.67	0.77	0.88*	2
	BCSH1H	97.50	−0.06	0.21	−0.45 NS[4]	6
	BCFAO	91.19	0.24	0.65	0.80**	4
	THRNTH	11.60	0.79	0.60	0.77**	5
	ALL	54.21	0.34	0.74	0.86**	3
Isabela	PM 0.23	1.13	0.81	0.91	0.95**	1
	PM 0.05	2.89	0.68	0.90	0.95**	1
	BCSCS	18.45	0.67	0.56	0.75**	5
	BCSH1H	11.33	0.56	0.80	0.90**	2
	BCFAO	78.46	0.57	0.70	0.83**	4
	THRNTH	18.68	0.67	0.38	0.61*[3]	6
	ALL	21.83	0.66	0.73	0.86**	3
Lajas	PM 0.23	36.94	0.47	0.87	0.93**	1
	PM 0.05	36.79	0.38	0.84	0.93**	1
	BCSCS	45.23	0.48	0.62	0.79**	4
	BCSH1H	53.96	0.24	0.60	0.77**	5
	BCFAO	99.50	0.37	0.74	0.86**	2
	THRNTH	36.65	0.57	0.44	0.67*	6
	ALL	51.51	0.42	0.72	0.85**	3
Río Piedras	PM 0.23	35.45	0.60	0.93	0.97**	1
	PM 0.05	40.00	0.47	0.94	0.97**	1

TABLE 1.—(Cont.)

Location	Y[2]	Regression coefficients[1]				
		A	B	R^2	r	rank
	BCSCS	31.22	0.66	0.72	0.85**	5
	BCSH1H	61.64	0.22	0.88	0.94**	2
	BCFAO	100.61	0.43	0.77	0.88**	4
	THRNTH	18.70	0.81	0.54	0..73**	6
	ALL	47.94	0.53	0.81	0.90**	3
Overall Average	PM 0.23	45.17	0.43	0.58	0.76**	2
	PM 0.05	42.31	0.36	0.53	0.76**	2
	BCSCS	49.42	0.47	0.58	0.76**	2
	BCSH1H	62.18	0.20	0.45	0.67**	5
	BCFAO	92.76	0.41	0.54	0.74**	3
	THRNTH	29.84	0.63	0.53	0.72**	4
	ALL	53.61	0.42	0.68	0.82**	1

[1]Regression coefficients were significant at P = 0.05.

[2]Using estimated values by S. F. Shih, University of Florida and Epan at 7 locations in Puerto Rico. PM = Penman at α of 0.23, PM = Penman at α of 0.05, BCSCS = Blaney-Criddle USDA-SCS method, BCSH1H, Blaney-Criddle modified by Shih, BCFAO = Blaney-Criddle modified by FAO, THRNTH = Thornthwaite, ALL = average of all PET models.

[3]** = P > 0.01.

[4]NS = non significant

[5]* = P > 0.05.

P = 0.05 at all locations and for all models except at Gurabo and for BCSH1H.

For all 7 locations the coefficient of correlation (r) range was = 0.93 to 0.97 for Penman, 0.75 to 0.92 for BCSCB; 0.67 to 0.95 for BCSH1H, (Gurabo was not considered); 0.80 to 0.93 for BCFAO; 0.61 to 0.86 for THRNTH. Shih used incoming solar radiation at Gurabo with a multple regression method and data of other locations in Puerto Rico. This may not be true and because of this the *r* value is nonsignificant for BCSH1H at Gurabo. The ranking based on *r* values (in descending order) was

Adjuntas = PM > BCSH1H > ALL > BCFAO > BCSCS > THRNTH;

TABLE 2.—*Estimated potential evapotranspiration (mm/year) and class A pan evaporation in Puerto Rico*

Location	Epan	PM 0.23	PM 0.05	BCSCS	BCSH1H	BCFAO	THRNTH
Adjuntas	1280	1173	1029	1128	989	1717	1021
Corozal	1390	1171	1021	1367	1075	1686	1390
Fortuna	2144	1383	1213	1454	1104	1981	1590
Gurabo	1578	995	849	1368	1073	1480	1392
Isabela	1671	1371	1176	1340	1067	1897	1337
Lajas	1803	1297	1123	1403	1088	1867	1470
Río Piedras	1585	1375	1224	1419	1092	1891	1503

Corozal = ALL > PM/BCFAO > BCSCS > THRNTH > BCSH1H;
Fortuna = PM > BCFAO >ALL/BCSH1H > BCSCS >THRNTH;
Gurabo = PM >BCSCS >ALL >BCFAO > THRNTH;
Isabela = PM >BCSH1H > ALL > BCFAO >BCSCS >THRNTH;
Lajas = PM >BCFAO > ALL > BCSCS > THRNTH;
Río Piedras = PM >BCSH1H > ALL > BCFAO > THRNTH;
Island P. R. = ALL > PM/BCSCS > BCFAO > THRNTH > BCSH1H.

The Penman method gave the best estimates of PET. PET estimates with BCSH1H for Gurabo may not be used. Annual PET estimates (mm/year) by Shih[3] and class A pan values are given in table 2. It is advisable to estimate PET with each model and come up with a monthly PET range and average PET (sum of PET with each model/no. of models). No single method is suitable for all locations. Selection of each method is based on the type of climatic data available.[7]

Carmela Chao de Báez
Associate Statistician
Statistics Section
Megh R. Goyal
Agricultural Engineer
Department of Agricultural Engineering

[7]Jensen, M. E., 1980. Design and Operation of Farm Irrigation Systems. ASAE Monograph #3 by Am. Soc. Agric. Engineers, St. Joseph - MI. Pages 189-225.