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Performance Evaluation and Statistical Analysis of Solar Energy Modeling: A Review and Case Study

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Abstract

The main target of this research is a quantitative review of literature on global solar radiation (GSR) models available for different stations around the world. The statistical analysis of 400 existing sunshine-based GSR models on a horizontal surface is compared using 40-year meteorological data in the selected locations in Egypt. The measured data is divided into two sets. The first sub-data set from 1980 to 2019 was used to develop empirical correlation models between the monthly average daily global solar radiation fraction (H/H_0) and the monthly average of desired meteorological parameters. The second sub-data set from 2015–2019 was used to validate and evaluate the derived models and correlations. The developed models were compared with each other and with the experimental data of the second subset based on the statistical error indicators such as RMSE, MBE, MABE, MPE, and correlation coefficient (R). The statistical test of the correlation, coefficient (R), for all models gives very good results (above 0.92). The smallest values of t-Test occur around the models (M 272, M 261, M 251, and M 238). The accuracy of each model is tested using ten different statistical indicator tests. The Global Performance Indicator (GPI) is used to rank the selected GSR models. According to the results, the Rietveld model (Model 272) has shown the best capability to predict the GSR on horizontal surfaces, followed by the Katiyar *et al.* model (Model 251) and the Aras *et al.* model (Model 261).

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1. Introduction

Solar energy has remained the most dependable source of energy capable of supporting and maintaining all of the activities and cycles that support life on the planet for plants, creatures, and other material substances. Solar energy is generally acknowledged as a key energy hotspot for the future all over the planet due to the natural issues related to fossil fuels as well as their restricted stores. Different wellsprings of non-sustainable power cause perceptible ecological risks. Sustainable power sources, for example, geothermal, wind, sun-based and flowing, are harmless to the ecosystem since they have a lot lower natural effect than regular sources like petroleum derivatives. As a result, solar energy is widely regarded as the most promising and reasonable type of energy capable of resolving the natural issues that humanity will face in the future [1-3].

Sustainable power sources, for example, solar energy, can possibly moderate a few negative ecological issues, in-

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cluding environmental change brought about by concentrated petroleum derivative abuse. With quick mechanical advancement and decreasing costs, solar energy will play an important role in future energy frameworks. In the forecast, study, and planning of solar energy frameworks, information on solar radiation and its parts in a specific area is extremely fundamental. Global solar radiation on a level surface is the most fundamental piece of information used in the planning and forecasting of the display of a solar energy device at a specific location. Sun-based light can be assessed by handling pictures from satellites or by on-ground estimations with pyrometers in meteorological stations. Satellite radiation estimations are not exact in assessing ground solar power radiation since they require environmental models to gauge the solar radiation at ground level [4-8].

Solar radiation showing up on earth is the most basic and sustainable power source in nature. Solar energy, brilliant light, and people since antiquated times, utilizing a scope of truly advancing advancements, have bridled hotness from the sun. The energy from the sun could play a key part in de-carbonizing the worldwide economy through enhancements in energy efficiency and forcing costs on ozone-harming substance producers. In solar energy research, information on sun-powered radiation and its components in a given area is a significant contribution for sun-based energy applications such as photovoltaic, sun-based warm frameworks, sun-based heaters, and aloof sun-based plans. The information ought to be dependable and promptly accessible for plan, advancement, and execution assessment of nearby planet groups for a specific area.

The most effective way to decide how much worldwide sunlight-based radiation at any site is to introduce estimating instruments, for example, pyranometer and pyrheliometer, at that specific spot and to screen and record its everyday recording, which is actually an extremely drawn-out and expensive activity [5]. Regardless of the significance of sunlight-based radiation estimations, in many developing countries this data is not immediately accessible due to a lack of the ability to bear the cost of the estimating equipment and procedures involved. Hence, various relationships and techniques have been created to assess every day or monthly worldwide solar power radiation in view of the more promptly accessible meteorological information at a larger part of weather conditions stations.

Experimental models that have been utilize to work out sun-oriented radiation are normally find on the accompanying elements; Astronomical elements (sun based steady, earth-sun distance, sun based declination and hour point), Geographical variables (scope, longitude and height of the site), Geometrical elements (azimuth point of the surface, slant point of the surface, sun rise point, sun azimuth point), Physical elements (dissipating of air particles, water fume content, dispersing of residue and other climatic constituents like O_2, N_2, CO_2, O and so forth) and meteorological elements (extraterrestrial sunlight based radiation, sun-sparkle term, temperature, precipitation, relative stickiness, impacts of shadiness, soil temperature, vanishing, reflection of the environs, and so on) [5].

The number of connections that have been distributed and attempted to assess the monthly average global solar radiation is generally high, making it difficult to select the most appropriate technique for a specific reason and site. Choosing a suitable technique from different existing models depends on their information prerequisites and model exactness. Forecasts of monthly daily worldwide sunlight-based radiation for a large number of areas are being introduced in various research works. It is essential that every one of the proposed models contain exact constants, which depend upon the season and the topographical area of a specific spot. The models examined in this review article are sequentially introduced and thus valuable for choosing the suitable model to assess worldwide sun-based radiation for a specific spot of interest [5-7].

The first model to predict the worldwide solar powered radiation was developed by Angstrom, which relates the normal monthly worldwide solar powered radiation to crisp morning radiation and to the normal part of conceivable daylight hours [9]. Prescott [10] modified the Angstrom model. From that point on, numerous scientists have modified the Angstrom model by utilizing different boundaries, for example, daylight hours, minimum temperature, mean temperature, maximum temperature, relative moistness, elevation, scope, longitude, overcast cover, and so on, or blends of the boundaries. Nevertheless, the most broadly utilized boundary to date is the daylight hour.

Iziomon and Mayer [11] have presumed that the presentation of the daylight-based model is far superior to the meteorological boundary-based models. The most commonly used boundary up to this point is daylight length because it is accessible in many areas and can be effectively and consistently estimated [12, 13]. When the first request Angstrom, type relationship is examined, the second and third requests do not improve the precision to a significant level [14, 15]. In addition, Almorox and Hontoria [16] proposed the direct, quadratic, third degree, and the logarithmic relapse models for Spain and inferred that the third request gave the general best outcome, however, re-complimented to utilize the straight relapse model since the blunder between the straight and third request relapse models is extremely small. Angstrom's worldwide sunlight-based radiation model is one of the pioneering works in the field of solar radiation. In the long term, it tends to be seen that numerous scientists have generally utilized this relationship by adjusting coefficients for diversified areas (like [17-42] and some more).

Numerous scientists have modified the Angstrom model by utilizing different boundaries like daylight hours, scope, longitude, and height. Glover and McCullum [17] have proposed a relapse model that considers the effect of scope and reasoned that the worth of "a" will be an element of scope, though the worth of "b" is effectively consistent. Correspondingly, [42] was proposed for the relapse condition as far as scope and daylight hours, utilizing the metrological information of 40 areas (37 areas from Pakistan and 3 areas from India). Hussain *et al.* [19] have proposed a relapse model considering the scope effect, utilizing the meteorological information of 40 stations all over the planet, and presumed that alongside the elevation effect, the half-yearly apportionment of the year ought to be utilized. [20] used meteorological data from 40 different locations around the world as a component of scope, height, and the proportion of daylight hours, and concluded that the proposed model can be used in any region of the world with a 10% error. For the Kingdom of Saudi Arabia [43], the relapse model is a component of daylight length, scope, longitude, and elevation. Jin it *et al.* [21] proposed higher request relapse models based on meteorological data from 69 locations in China. A comparative review was finished by [22] for 86 different areas across China and proposed the higher request relapse model regarding scope, longitude and elevation. As of late, Gadiwala et al. [23], Onyango, and Ongoma [24] have proposed the relapse model for Pakistan and Kenya separately.

Bakirci [25] proposed the direct, quadratic, and third request relapse models for the Eastern Anatolia Region (EAR) of Turkey and inferred that the third request polynomial condition gives the best outcome. The temperature is based on Quansah et al. [26] for the Ashanti Region of Ghana, where the deliberate and determined values show excellent concurrence with one another. Likewise, the constants "a" and "b" are site-specific. Yaniktepe and Genc [27] have proposed a straight, quadratic, and cubic relapse model for Osmaniye. The exhibition of the proposed model was contrasted with nine different models left in writing utilizing measurable tests (MAPE, MABE, and RMSE).

It was inferred that the cubic relapse model performs better when contrasted with direct and quadratic models. Namrata et al. [28] proposed a straight relapse model for three different areas in Jharkhand, India. The exhibition of the proposed model has contrasted with the deliberate information and the relapse model proposed by Rietveld [29], Ogleman [30], Akinoglu [31], Glover [17] and Gopinathan [20]. It was inferred that the relapse consistent "a" and "b" does not shift with height and scope. It was seen that the amount of relapse consistent is practically the same for the three different urban areas (for example, Jamshedpur 0.717, Ranchi 0.700, and Bokaro 0.714). Das et al. [32] chose eleven nonlinear and six straight models accessible in writing to assess worldwide sunlight-based radiation over South Korea. It was presumed that the nonlinear models perform far superior to the straight models, likewise utilizing the normal Kriging strategy solar maps have plotted for South Korea. Using nine years' worth of meteorological data Hejase and Assi [33] fostered a direct, quadratic, cubic, dramatic, log-straight, and logarithmic model for the United Arab Emirates and presumed that the cubic model gives minimal blunders among the whole proposed model. The main objective of this paper is to evaluate and perform extensive global solar radiation (GSR) models available in the present research by using the statistical indicators and the most accurate models chosen in this study, and apply these models for case study using the available meteorological parameters

2. Methodology

The global solar radiation models are classified according to the basis of the input parameters they employ in correlating with the clearness index. The clearness index (k_t) shows the proportional depletion via the sky of the incoming photovoltaic radiation and consequently offers the stage of availability of photovoltaic radiation and adjustments in the atmospheric situation in a given environment [34]. Mathematically, the clearness index is the ratio of horizontal global solar radiation to the extraterrestrial solar radiation (H_o) on a monthly basis, principally calculated theoretically as given by [35].

$$H_0 = (24/\pi) I_{sc}[1 + 0.033\cos(360n/365)] \times[cos\varphi\cos\delta\sin\omega_s + (2\pi\omega s/360)\sin\varphi\sin\delta \quad (1)$$

I_{SC} is the solar constant, (φ) is the latitude of the location, (δ) is the solar declination, (ω_s) is the mean sunrise hour angle for the given month and n is the number of days of the year starting from firstly January. The solar declination (*deltaup*) and mean sunrise hour angle ($omegaup_s$) for a given month can be calculated using equations 2 and 3, respectively.

$$\delta = 23.45\sin[360(n + 284)/365] \quad (2)$$

$$\omega_s = \cos -1(-\tan\varphi\tan\delta) \quad (3)$$

It has been establish that world photovoltaic radiation is exceptionally affect by means of meteorological parameters, astronomical factors, geographical factors, and geometrical factors. This may want to be attribute to the strong point of nearby local weather in figuring out the meteorological and atmospheric parameters that exceptional match a given locality. This additionally relies upon on the availability of enter meteorological/ atmospheric parameter(s) that a given radiometric station or an person is successful of measuring robotically which in the end grew to become out to be the great enter parameter at the disposal of the researcher for predicting world photo voltaic radiation in that place [36-39].

3. Statistical indicators

The accuracy and performance of the derived correlations in predicting global solar radiation were evaluated because of the following statistical error tests; mean bias error (MBE), root mean square error (RMSE), mean percentage error (MPE), maximum absolute relative error (MARE), mean absolute error (MAE), root mean square relative error (RMSRE), coefficient of determination (R^2) and *t*-Test statistic. These error indices are defined as [36]:

$$\text{MBE} = \frac{1}{n}\sum_{i}^{n} = 1(H_{i,m} - H_{i,c}) \quad (4)$$

$$\text{RMSR} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(H_{i,m} - H_{i,c})^2} \quad (5)$$

$$\text{MPE} = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{H_{i,m} - H_{i,c}}{H_{i,m}}\right)x100 \quad (6)$$

$$\text{MARE} = max\left(\left|\frac{(H_{i,m} - H_{i,c}}{H_{i,m}}\right|\right) \quad (7)$$

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}|H_{i,m} - H_{i,c}| \quad (8)$$

Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
1	$H/H_0 = 0.365 + 0.351\ (S/S_0)$	El-Sebaii et al. [14]
2	$H/H_0 = 0.332 + 0.407\ (S/S_0)$	Raja et al. [40]
3	$H/H_0 = 0.280 + 0.493\ (S/S_0)$	Hay [41]
4	$H/H_0 = 0.412 + 0.211\ (S/S_0)$	Elagih et al. [42]
5	$H/H_0 = 0.272 + 0.384\ (S/S_0)$	Yao et al. [43]
6	$H/H_0 = 0.230 + 0.620\ (S/S_0)$	Glover et al. [17]
7	$H/H_0 = 0.361 + 0.366\ (S/S_0)$	Khogali [44]
8	$H/H_0 = 0.315+ 0.402\ (S/S_0)$	Khogali [44]
9	$H/H_0 = 0.278 + 0.467\ (S/S_0)$	Khogali [44]
10	$H/H_0 = 0.357 + 0.374\ (S/S_0)$	Khogali [44]
11	$H/H_0 = 0.433 + 0.271\ (S/S_0)$	Khogali [44]
12	$H/H_0 = 0.350 + 0.353\ (S/S_0)$	Khogali [44]
13	$H/H_0 = 0.339 + 0.359\ (S/S_0)$	Khogali [44]
14	$H/H_0 = 0.402 + 0.234\ (S/S_0)$	Khogali [45]
15	$H/H_0 = 0.211 + 0.572\ (S/S_0)$	Khogali [45]
16	$H/H_0 = 0.208 + 0.544\ (S/S_0)$	Khogali [45]
17	$H/H_0 = 0.460 + 0.208\ (S/S_0)$	Khogali [45]
18	$H/H_0 = 0.325 + 0.423\ (S/S_0)$	Khogali [45]
19	$H/H_0 = 0.325 + 0.356\ (S/S_0)$	Khogali [45]
20	$H/H_0 = 0.287 + 0.463\ (S/S_0)$	Khogali [45]
21	$H/H_0 = 0.341 + 0.446\ (S/S_0)$	Garg [46]
22	$H/H_0 = 0.309 + 0.482\ (S/S_0)$	Garg [46]
23	$H/H_0 = 0.302 + 0.464\ (S/S_0)$	Garg [46]
24	$H/H_0 = 0.327 + 0.399\ (S/S_0)$	Garg [46]
25	$H/H_0 = 0.293 + 0.459\ (S/S_0)$	Garg [46]
26	$H/H_0 = 0.291 + 0.464\ (S/S_0)$	Garg [46]
27	$H/H_0 = 0.330+ 0.453\ (S/S_0)$	Garg [46]
28	$H/H_0 = 0.286+ 0.467\ (S/S_0)$	Garg [46]
29	$H/H_0 = 0.279+ 0.514\ (S/S_0)$	Garg [46]
30	$H/H_0 = 0.340+ 0.399\ (S/S_0)$	Garg [46]
31	$H/H_0 = 0.393+ 0.357\ (S/S_0)$	Garg [46]
32	$H/H_0 = 0.334+ 0.444\ (S/S_0)$	Hussain et al. [19]
33	$H/H_0 = 0.217+ 0.593\ (S/S_0)$	Hussain et al. [19]
34	$H/H_0 = 0.308+ 0.407\ (S/S_0)$	Hussain et al. [19]
35	$H/H_0 = 0.292+ 0.473\ (S/S_0)$	Hussain et al. [19]
36	$H/H_0 = 0.300+ 0.359\ (S/S_0)$	Hussain et al. [19]
37	$H/H_0 = 0.291+ 0.454\ (S/S_0)$	Hussain et al. [19]
38	$H/H_0 = 0.283+ 0.469\ (S/S_0)$	Hussain et al. [19]
39	$H/H_0 = 0.314+ 0.421\ (S/S_0)$	Hussain et al. [19]
40	$H/H_0 = 0.292+ 0.433\ (S/S_0)$	Hussain et al. [19]
41	$H/H_0 = 0.274+ 0.470\ (S/S_0)$	Hussain et al. [19]
42	$H/H_0 = 0.310+ 0.400\ (S/S_0)$	Hussain et al. [19]
43	$H/H_0 = 0.312+ 0.418\ (S/S_0)$	Hussain et al. [19]
44	$H/H_0 = 0.296+ 0.554\ (S/S_0)$	Hussain et al. [19]
45	$H/H_0 = 0.375+ 0.350\ (S/S_0)$	Hussain et al. [19]
46	$H/H_0 = 0.170+ 0.590\ (S/S_0)$	Ibrahim [47]
47	$H/H_0 = 0.290+ 0.460\ (S/S_0)$	Ibrahim [47]
48	$H/H_0 = 0.220+ 0.550\ (S/S_0)$	Ibrahim [47]
49	$H/H_0 = 0.140+ 0.610\ (S/S_0)$	Ibrahim [47]
50	$H/H_0 = 0.230+ 0.540\ (S/S_0)$	Ibrahim [47]
51	$H/H_0 = 0.520+ 0.230\ (S/S_0)$	Ibrahim [47]
52	$H/H_0 = 0.700+ 0.030\ (S/S_0)$	Ibrahim [47]
53	$H/H_0 = 0.130+ 0.604\ (S/S_0)$	Srivastava et al. [48]
54	$H/H_0 = 0.126+ 0.600\ (S/S_0)$	Srivastava et al. [48]
55	$H/H_0 = 0.336+ 0.339\ (S/S_0)$	Srivastava et al. [48]

Continue on the next page

Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
56	$H/H_0 = 0.121 + 0.582\ (S/S_0)$	Srivastava et al. [48]
57	$H/H_0 = 0.105 + 0.569\ (S/S_0)$	Srivastava et al. [48]
58	$H/H_0 = 0.052 + 0.644\ (S/S_0)$	Srivastava et al. [49]
59	$H/H_0 = 0.093 + 0.632\ (S/S_0)$	Srivastava et al. [49]
60	$H/H_0 = 0.138 + 0.556\ (S/S_0)$	Srivastava et al. [49]
61	$H/H_0 = 0.491 + 0.263\ (S/S_0)$	Jemaa et al. [50]
62	$H/H_0 = 0.305 + 0.429\ (S/S_0)$	Khorasantzadeh et al. [51]
63	$H/H_0 = 0.133 + 0.647\ (S/S_0)$	Jin et al. [21]
64	$H/H_0 = 0.570 + 0.011\ (S/S_0)$	Suthar et al. [52]
65	$H/H_0 = 0.269 + 0.489\ (S/S_0)$	Marwal [53]
66	$H/H_0 = 0.228 + 0.311\ (S/S_0)$	Katiyar et al. [15]
67	$H/H_0 = 0.262 + 0.395\ (S/S_0)$	Katiyar et al. [54]
68	$H/H_0 = 0.223 + 0.512\ (S/S_0)$	Katiyar et al. [54]
69	$H/H_0 = 0.229 + 0.531\ (S/S_0)$	Katiyar et al. [15]
70	$H/H_0 = 0.228 + 0.509\ (S/S_0)$	Katiyar et al. [15]
71	$H/H_0 = 0.190 + 0.620\ (S/S_0)$	Soler [55]
72	$H/H_0 = 0.072 + 0.694\ (S/S_0)$	Hejase et al. [33]
73	$H/H_0 = 0.200 + 0.510\ (S/S_0)$	Flocas [56]
74	$H/H_0 = 0.657 + 0.023\ (S/S_0)$	Ahmad et al. [7]
75	$H/H_0 = 0.458 + 0.175\ (S/S_0)$	Ahmad et al. [7]
76	$H/H_0 = 0.177 + 0.692\ (S/S_0)$	Jain [57]
77	$H/H_0 = 0.175 + 0.552\ (S/S_0)$	Bahel et al. [58]
78	$H/H_0 = 0.360 + 0.340\ (S/S_0)$	Maduekwe et al. [59]
79	$H/H_0 = 0.347 + 0.352\ (S/S_0)$	Rehman [18]
80	$H/H_0 = 0.324 + 0.405\ (S/S_0)$	Ahmad et al. [7]
81	$H/H_0 = 0.222 + 0.652\ (S/S_0)$	Li et al. [60]
82	$H/H_0 = 0.170 + 0.680\ (S/S_0)$	Yohanna et al. [61]
83	$H/H_0 = 0.250 + 0.500\ (S/S_0)$	Gadiwala et al. [23]
84	$H/H_0 = 0.309 + 0.368\ (S/S_0)$	Chegaar et al. [62]
85	$H/H_0 = 0.367 + 0.366\ (S/S_0)$	Chegaar et al. [62]
86	$H/H_0 = 0.233 + 0.591\ (S/S_0)$	Chegaar et al. [62]
87	$H/H_0 = 0.175 + 0.712\ (S/S_0)$	Onyango et al. [24]
88	$H/H_0 = 0.180 + 0.620\ (S/S_0)$	Onyango et al. [24]
89	$H/H_0 = 0.278 + 0.648\ (S/S_0)$	Ezekwe and Ezeilo [63]
90	$H/H_0 = 0.260 + 0.431\ (S/S_0)$	Sambo [64]
91	$H/H_0 = 0.250 + 0.450(S/S_0)$	Jackson et a [65]
92	$H/H_0 = 0.291 + 0.306\ (S/S_0)$	Kuye et al. [66]
93	$H/H_0 = 0.242 + 0.641\ (S/S_0)$	Safari et al. [67]
94	$H/H_0 = 0.320 + 0.309\ (S/S_0)$	Tijjani [68]
95	$H/H_0 = 0.239 + 0.585\ (S/S_0)$	Ituen et al. [69]
96	$H/H_0 = 0.138 + 0.488\ (S/S_0)$	Isikwue et al. [70]
97	$H/H_0 = 0.220 + 0.430\ (S/S_0)$	Quansah et al. [26]
98	$H/H_0 = 0.110 + 0.790\ (S/S_0)$	Nwokoye et al. [71]
99	$H/H_0 = 0.249 + 0.566\ (S/S_0)$	Adaramola [72]
100	$H/H_0 = 0.422 + 0.128\ (S/S_0)$	Ampratwum et al. [73]
101	$H/H_0 = 0.267 + 0.475\ (S/S_0)$	Ulgen et al. [74]
102	$H/H_0 = 0.318 + 0.449\ (S/S_0)$	Togrul et al. [75]
103	$H/H_0 = 0.352 + 0.361\ (S/S_0)$	Aziz et al. [76]
104	$H/H_0 = 0.343 + 0.322\ (S/S_0)$	Bakirci [25]
105	$H/H_0 = 0.288 + 0.547\ (S/S_0)$	Sherif [77]
106	$H/H_0 = 0.244 + 0.415\ (S/S_0)$	Okonkwo et al. [78]
107	$H/H_0 = 0.183 + 0.530\ (S/S_0)$	Assi et al. [79]
108	$H/H_0 = 0.183 + 0.647\ (S/S_0)$	Assi et al. [79]
109	$H/H_0 = 0.495 + 0.593\ (S/S_0)$	Katiyar [15]
110	$H/H_0 = 0.215 + 0.527\ (S/S_0)$	Said et al. [80]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
111	$H/H_0 = 0.226 + 0.418\ (S/S_0)$	Tiris et al. [81]
112	$H/H_0 = 0.340 + 0.320\ (S/S_0)$	Veeran et al. [82]
113	$H/H_0 = 0.270 + 0.650\ (S/S_0)$	Veeran et al. [82]
114	$H/H_0 = 0.140 + 0.570\ (S/S_0)$	Lewis [83]
115	$H/H_0 = 0.313 + 0.474\ (S/S_0)$	Jain [57]
116	$H/H_0 = 0.307 + 0.488\ (S/S_0)$	Jain [57]
117	$H/H_0 = 0.309 + 0.599\ (S/S_0)$	Jain [84]
118	$H/H_0 = 0.241 + 0.488\ (S/S_0)$	Luhanga et al. [85]
119	$H/H_0 = 0.240 + 0.513\ (S/S_0)$	Jain and Jain [84]
120	$H/H_0 = 0.191 + 0.571\ (S/S_0)$	Khogali et al. [45]
121	$H/H_0 = 0.262 + 0.454\ (S/S_0)$	Khogali et al. [45]
122	$H/H_0 = 0.297 + 0.432\ (S/S_0)$	Khogali et al. [45]
123	$H/H_0 = 0.174 + 0.615\ (S/S_0)$	Alsaad [86]
124	$H/H_0 = 0.230 + 0.380\ (S/S_0)$	Hinrichsen [87]
125	$H/H_0 = 0.220 + 0.420\ (S/S_0)$	Hinrichsen [87]
126	$H/H_0 = 0.230 + 0.480\ (S/S_0)$	Page [88]
127	$H/H_0 = 0.307 + 0.312\ (S/S_0)$	Abdalla et al. [89]
128	$H/H_0 = 0.441 + 0.292\ (S/S_0)$	Ogolo [90]
129	$H/H_0 = 0.248 + 0.509\ (S/S_0)$	Ogolo [90]
130	$H/H_0 = 0.278 + 0.483\ (S/S_0)$	Ogolo [90]
131	$H/H_0 = 0.222 + 0.580\ (S/S_0)$	Ogolo [90]
132	$H/H_0 = 0.176 + 0.563\ (S/S_0)$	Rensheng et al. [22]
133	$H/H_0 = 0.206 + 0.546\ (S/S_0)$	Louche et al. [91]
134	$H/H_0 = 0.180 + 0.615\ (S/S_0)$	Newland [92]
135	$H/H_0 = 0.154 + 0.787\ (S/S_0)$	Gopinathan et al. [93]
136	$H/H_0 = 0.196 + 0.721\ (S/S_0)$	Gopinathan et al. [93]
137	$H/H_0 = 0.308 + 0.417\ (S/S_0)$	Aras et al. [94]
138	$H/H_0 = 0.275 + 0.039\ (S/S_0)$	Sivamadhavi et al. [95]
139	$H/H_0 = 0.300 + 0.415\ (S/S_0)$	Amoussa [96]
140	$H/H_0 = 0.238 + 0.522\ (S/S_0)$	Amoussa [96]
141	$H/H_0 = 0.279 + 0.416\ (S/S_0)$	Bakirci [25]
142	$H/H_0 = 0.228 + 0.527\ (S/S_0)$	El-Metwally [97]
143	$H/H_0 = 0.174 + 0.615\ (S/S_0)$	Alsaad [86]
144	$H/H_0 = 0.309 + 0.368\ (S/S_0)$	Chegaar and Chibani [62]
145	$H/H_0 = 0.367 + 0.367\ (S/S_0)$	Chegaar and Chibani [62]
146	$H/H_0 = 0.233 + 0.591\ (S/S_0)$	Chegaar and Chibani [62]
147	$H/H_0 = 0.340 + 0.320\ (S/S_0)$	Veeran and Kumar [82]
148	$H/H_0 = 0.270 + 0.650\ (S/S_0)$	Veeran and Kumar [82]
149	$H/H_0 = 0.267 + 0.475\ (S/S_0)$	Ulgen and Hepbasli [74]
150	$H/H_0 = 0.140 + 0.570\ (S/S_0)$	Lewis [83]
151	$H/H_0 = 0.180 + 0.620\ (S/S_0)$	Tiris et al. [81]
152	$H/H_0 = 0.217 + 0.545\ (S/S_0)$	Almorox and Hontoria [16]
153	$H/H_0 = 0.335 + 0.367\ (S/S_0)$	Raja and Twidell [40]
154	$H/H_0 = 0.215 + 0.527\ (S/S_0)$	Said et al. [80]
155	$H/H_0 = 0.242 + 0.501\ (S/S_0)$	Ulgen and Hepbasli [74]
156	$H/H_0 = -2.81 + 3.78\ (S/S_0)$	El-Sebaii et al. [14]
157	$H/H_0 = 0.324 + 0.405\ (S/S_0)$	Ahmed and Ulfat [98]
158	$H/H_0 = 0.133 + 0.647\ (S/S_0)$	Jin et al. [21]
159	$H/H_0 = 0.230 + 0.380\ (S/S_0)$	Akpabio and Etuk [99]
160	$H/H_0 = 0.332 + 0.311\ (S/S_0)$	Ampratwum and Dorvlo [73]
161	$H/H_0 = 0.242 + 0.356\ (S/S_0)$	Ampratwum and Dorvlo [73]
162	$H/H_0 = 0.180 + 0.600\ (S/S_0)$	Benson et al. [100]
163	$H/H_0 = 0.240 + 0.530\ (S/S_0)$	Benson et al. [100]
164	$H/H_0 = 0.180 + 0.660\ (S/S_0)$	Rietveld [29]
165	$H/H_0 = 0.200 + 0.600\ (S/S_0)$	Rietveld [29]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
166	H/H_0 = 0.220+ 0.580 (S/S_0)	Rietveld [29]
167	H/H_0 = 0.200+ 0.620 (S/S_0)	Rietveld [29]
168	H/H_0 = 0.240+ 0.520 (S/S_0)	Rietveld [29]
169	H/H_0 = 0.240+ 0.530 (S/S_0)	Rietveld [29]
170	H/H_0 = 0.230+ 0.530 (S/S_0)	Rietveld [29]
171	H/H_0 = 0.220+ 0.550 (S/S_0)	Rietveld [29]
172	H/H_0 = 0.200+ 0.590 (S/S_0)	Rietveld [29]
173	H/H_0 = 0.290+ 0.600 (S/S_0)	Rietveld [29]
174	H/H_0 = 0.170+ 0.660 (S/S_0)	Rietveld [29]
175	H/H_0 = 0.180+ 0.650 (S/S_0)	Rietveld [29]
176	H/H_0 = 0.276+ 0.648 (S/S_0)	Ezekwe and Ezeilo [63]
177	H/H_0 = 0.260+ 0.620 (S/S_0)	Ezekwe and Ezeilo [63]
178	H/H_0 = 0.210+ 0.490 (S/S_0)	Ezekwe and Ezeilo [63]
179	H/H_0 = 0.200+ 0.740 (S/S_0)	Arinze and Obi [101]
180	H/H_0 = 0.413+ 0.241 (S/S_0)	Sambo [64]
181	H/H_0 = 0.160+ 0.530 (S/S_0)	Folayan and Ogunbiyi [102]
182	H/H_0 = 0.263+ 0.374 (S/S_0)	Banna and Gnininri [103]
183	H/H_0 = 0.253+ 0.357 (S/S_0)	Banna and Gnininri [103]
184	H/H_0 = 0.271+ 0.300 (S/S_0)	Banna and Gnininri [103]
185	H/H_0 = 0.208+ 0.748 (S/S_0)	Falayi et al. [104]
186	H/H_0 = 0.018+ 1.139 (S/S_0)	Augustine and Nnabuchi [105]
187	H/H_0 = 0.295+ 0.306 (S/S_0)	Augustine and Nnabuchi [105]
188	H/H_0 = 0.191+ 0.433 (S/S_0)	Augustine and Nnabuchi [105]
189	H/H_0 = 0.278+ 0.331 (S/S_0)	Augustine and Nnabuchi [105]
190	H/H_0 = 0.290+ 0.420 (S/S_0)	Augustine and Nnabuchi [105]
191	H/H_0 = 0.290+ 0.253 (S/S_0)	Augustine and Nnabuchi [105]
192	H/H_0 = 0.336+ 0.247 (S/S_0)	Augustine and Nnabuchi [105]
193	H/H_0 = 0.219+ 0.638 (S/S_0)	Olayinka [106]
194	H/H_0 = 0.211+ 0.629 (S/S_0)	Olayinka [106]
195	H/H_0 = 0.163+ 0.806 (S/S_0)	Olayinka [106]
196	H/H_0 = 0.450+ 0.274 (S/S_0)	Olayinka [106]
197	H/H_0 = 0.320+ 0.308 (S/S_0)	Tijjani [68]
198	H/H_0 = 0.170+ 0.680 (S/S_0)	Yohanna and Itodo [107]
199	H/H_0 = 0.239+ 0.585 (S/S_0)	Ituen [69]
200	H/H_0 = 0.249+ 0.566 (S/S_0)	Adaramola [72]
201	H/H_0 = 0.300+ 0.530 (S/S_0)	Yakubu and Medugu [108]
202	H/H_0 = 0.287+ 0.547 (S/S_0)	Musa et al. [109]
203	H/H_0 = 0.138+ 0.488 (S/S_0)	Isikwue et al. [70]
204	H/H_0 = 0.239+ 0.717 (S/S_0)	Kolebaje and Mustapha [110]
205	H/H_0 = 0.258+ 0.612 (S/S_0)	Kolebaje and Mustapha [110]
206	H/H_0 = 0.250+ 0.643 (S/S_0)	Kolebaje and Mustapha [110]
207	H/H_0 = 0.286+ 0.537 (S/S_0)	Kolebaje and Mustapha [110]
208	H/H_0 = 0.318+ 0.513 (S/S_0)	Kolebaje and Mustapha [110]
209	H/H_0 = 0.310+ 0.540 (S/S_0)	Kolebaje and Mustapha [110]
210	H/H_0 = 0.194+ 0.398 (S/S_0)	Ohunakin et al. [111]
211	H/H_0 = 0.115+ 0.567 (S/S_0)	Solomon [112]
212	H/H_0 = 0.389+ 0.358 (S/S_0)	Gana and Akpootu [113]
213	H/H_0 = 0.417+ 0.316 (S/S_0)	Gana and Akpootu [113]
214	H/H_0 = 0.334+ 0.449 (S/S_0)	Gana and Akpootu [113]
215	H/H_0 = 0.416+ 0.317 (S/S_0)	Gana and Akpootu [113]
216	H/H_0 = 0.453+ 0.268 (S/S_0)	Gana and Akpootu [113]
217	H/H_0 = 0.386+ 0.360 (S/S_0)	Gana and Akpootu [113]
218	H/H_0 = 0.083+ 0.684 (S/S_0)	Afungchui and Neba [114]
219	H/H_0 = 0.286+ 0.579 (S/S_0)	Afungchui and Neba [114]
220	H/H_0 = 0.253+ 0.427 (S/S_0)	Afungchui and Neba [114]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
221	H/H_0 = 0.303+ 0.484 (S/S_0)	Afungchui and Neba [114]
222	H/H_0 = 0.314+ 0.479 (S/S_0)	Afungchui and Neba [114]
223	H/H_0 = 0.005+ 1.313 (S/S_0)	Sarsah and Uba [115]
224	H/H_0 = 0.244+ 0.415 (S/S_0)	Okonkwo and Nwokoye [78]
225	H/H_0 = 0.220+ 0.430 (S/S_0)	Quansah et al. [26]
226	H/H_0 = 0.288+ 0.547 (S/S_0)	Sheriff [77]
227	H/H_0 = 0.192+ 0.442 (S/S_0)	Ike [116]
228	H/H_0 = 0.045+ 0.051 (S/S_0)	Sani et al. [117]
229	H/H_0 = 0.010+ 0.750 (S/S_0)	Adesina et al. [118]
230	H/H_0 = 0.240+ 0.310 (S/S_0)	Olatona and Adeleke [119]
231	H/H_0 = 0.110+ 0.790 (S/S_0)	Okonkwo et al. [78]
232	H/H_0 = 0.295+ 0.532 (S/S_0)	Innocent et al. [120]
233	H/H_0 = 0.250+ 0.522 (S/S_0)	Boluwaji and Onyedi [121]
234	H/H_0 = 0.314+ 0.491 (S/S_0)	Boluwaji and Onyedi [121]
235	H/H_0 = 0.315+ 0.433 (S/S_0)	Boluwaji and Onyedi [121]
236	H/H_0 = 0.130+ 0.620 (S/S_0)	Coulibaly and Ouedoraogo [122]
237	H/H_0 = 0.210+ 0.450 (S/S_0)	Coulibaly and Ouedoraogo [122]
238	H/H_0 = 0.170+ 0.470 (S/S_0)	Coulibaly and Ouedoraogo [122]
239	H/H_0 = 0.210+ 0.460 (S/S_0)	Coulibaly and Ouedoraogo [122]
240	H/H_0 = 0.150+ 0.460 (S/S_0)	Coulibaly and Ouedoraogo [122]
241	H/H_0 = 0.180+ 0.530 (S/S_0)	Coulibaly and Ouedoraogo [122]
242	H/H_0 = 0.210+ 0.430 (S/S_0)	Coulibaly and Ouedoraogo [122]
243	H/H_0 = 0.230+ 0.400 (S/S_0)	Coulibaly and Ouedoraogo [122]
244	H/H_0 = 0.180+ 0.490 (S/S_0)	Coulibaly and Ouedoraogo [122]
245	H/H_0 = 0.219+ 0.614 (S/S_0)	Okundamiya et al. [123]
246	H/H_0 = 0.236+ 0.621 (S/S_0)	Okundamiya et al. [123]
247	H/H_0 = 0.479+ 0.246 (S/S_0)	Okundamiya et al. [123]
248	H/H_0 = 0.270+ 0.240 (S/S_0)	Ayodele and Ogunjuyigbe [124]
249	H/H_0 = 0.292+ 0.284 (S/S_0) +0.211 $(S/S_0)^2$	Katiyar et al. [15]
250	H/H_0 = -0.197+ 0.177 (S/S_0) -0.912 $(S/S_0)^2$	Katiyar et al. [15]
251	H/H_0 = 0.129+ 0.933 (S/S_0) -0.503 $(S/S_0)^2$	Katiyar et al. [15]
252	H/H_0 = 0.234+ 0.465 (S/S_0) -0.043 $(S/S_0)^2$	Katiyar et al. [15]
253	H/H_0 = 0.184+ 0.845 (S/S_0) -0.280 $(S/S_0)^2$	Almorox et al. [16]
254	H/H_0 = 0.181+ 0.895 (S/S_0) -0.361 $(S/S_0)^2$	Akinoglu et al. [125]
255	H/H_0 = 0.222+ 0.705 (S/S_0) -0.217 $(S/S_0)^2$	Ogelman [30]
256	H/H_0 = 1.111- 1.828 (S/S_0) +1.660 $(S/S_0)^2$	Ogelman [30]
257	H/H_0 = 0.168+ 0.835 (S/S_0) +0.320 $(S/S_0)^2$	Ogolo [90]
258	H/H_0 = 0.154+ 0.933 (S/S_0) +0.370 $(S/S_0)^2$	Ogolo [90]
259	H/H_0 = 0.719- 1.067 (S/S_0) +1.145 $(S/S_0)^2$	Ogolo [90]
260	H/H_0 = 0.339+ 0.287 (S/S_0) +0.119 $(S/S_0)^2$	Singh et al. [5]
261	H/H_0 = 0.154+ 1.172 (S/S_0) -0.705 $(S/S_0)^2$	Aras et al. [94]
262	H/H_0 = 0.100+ 0.874 (S/S_0) -0.255 $(S/S_0)^2$	Togrul et al. [126]
263	H/H_0 = 0.180+ 1.160 (S/S_0) -0.910 $(S/S_0)^2$	Said et al. [80]
264	H/H_0 = 0.348+ 0.320 (S/S_0) +0.070 $(S/S_0)^2$	Maduekwe et al. [59]
265	H/H_0 = 0.222+ 0.538 (S/S_0) +0.152 $(S/S_0)^2$	Ahmad et al. [7]
266	H/H_0 = 0.069+1.326 (S/S_0) - 0.667 $(S/S_0)^2$	Onyango et al. [24]
267	H/H_0 = -2.767+ 9.207 (S/S_0) -6.350 $(S/S_0)^2$	Safari et al. [67]
268	H/H_0 = -2.767+9.207 (S/S_0) -0.674 $(S/S_0)^2$	Tijjani [68]
269	H/H_0 = 0.025+ 1.125 (S/S_0) -0.308 $(S/S_0)^2$	Nwokoye et al. [71]
270	H/H_0 = 0.282+ 0.572 (S/S_0) -0.224 $(S/S_0)^2$	Bakirci [25]
271	H/H_0 = 0.100+ 1.020 (S/S_0) -0.440 $(S/S_0)^2$	Rietveld [29]
272	H/H_0 = 0.326+ 0.344 (S/S_0) +0.102 $(S/S_0)^2$	Rietveld [29]
273	H/H_0 = 0.692- 0.068 (S/S_0) +0.118 $(S/S_0)^2$	Sekhar et al. [40]
274	H/H_0 = 0.264+ 0.516 (S/S_0) -0.005 $(S/S_0)^2$	Sekhar et al. [40]
275	H/H_0 = 0.494+ 0.064 (S/S_0) +0.173 $(S/S_0)^2$	Sekhar et al. [40]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
276	H/H_0 = 0.273+ 0.468 (S/S_0) +0.018 $(S/S_0)^2$	Sekhar et al. [40]
277	H/H_0 = 0.263+ 0.514 (S/S_0) -0.008 $(S/S_0)^2$	Sekhar et al. [40]
278	H/H_0 = 0.403+ 0.788 (S/S_0) -0.224 $(S/S_0)^2$	Sekhar et al. [40]
279	H/H_0 = 0.279+ 0.037 (S/S_0) +0.009 $(S/S_0)^2$	Sekhar et al. [40]
280	H/H_0 = 0.285+ 0.036 (S/S_0) +0.002 $(S/S_0)^2$	Sivamadhavi et al. [95]
281	H/H_0 = -0.067+ 1.772 (S/S_0) -1.249 $(S/S_0)^2$	Sivamadhavi et al. [95]
282	H/H_0 = 0.635+ 0.097 (S/S_0) -0.026 $(S/S_0)^2$	Elagib et al. [42]
283	H/H_0 = 0.140+ 0.613 (S/S_0) +0.035 $(S/S_0)^2$	Assi et al. [79]
284	H/H_0 = 0.487+ 0.612 (S/S_0) -0.018 $(S/S_0)^2$	Jin et al. [21]
285	H/H_0 = 0.434+ 0.233 (S/S_0) +0.166 $(S/S_0)^2$	Katiyar et al. [15]
286	H/H_0 = -0.359+ 1.763 (S/S_0) -0.659 $(S/S_0)^2$	Jemaa et al. [50]
287	H/H_0 = 0.215+ 0.625 (S/S_0) -0.221 $(S/S_0)^2$	Hejase et al. [33]
288	H/H_0 = 0.748- 0.949 (S/S_0) +1.042 $(S/S_0)^2$	Togrul et al. [126]
289	H/H_0 = 0.231+ 0.463 (S/S_0) – 0.044 $(S/S_0)^2$	Ravichandran et al. [127]
290	H/H_0 = 0.189+ 0.845 (S/S_0) – 0.390 $(S/S_0)^2$	Okonkwo et al. [78]
291	H/H_0 = 0.388+ 0.580 (S/S_0) -0.407 $(S/S_0)^2$	Assi et al. [79]
292	H/H_0 = 0.086+ 1.158 (S/S_0) -0.556 $(S/S_0)^2$	Suthar et al. [52]
293	H/H_0 =-0.140+2.52 (S/S_0) -3.71 $(S/S_0)^2$+2.24$(S/S_0)^3$	Samuel [128]
294	H/H_0 =-2.43+11.95 (S/S_0) -16.75 $(S/S_0)^2$+7.96$(S/S_0)^3$	Ertekin and Yaldiz [129]
295	H/H_0 =0.230+0.380 (S/S_0)+0.469 $(S/S_0)^2$-0.366$(S/S_0)^3$	Almorox and Hontoria [16]
296	H/H_0 =0.81-3.34(S/S_0)+7.38 $(S/S_0)^2$-4.51$(S/S_0)^3$	Lewis [83]
297	H/H_0 =0.241+0.363(S/S_0)+0.459 $(S/S_0)^2$-0.371$(S/S_0)^3$	Ulgen and Hepbasli [130]
298	H/H_0 =0.152+1.133(S/S_0)-1.113 $(S/S_0)^2$+0.452$(S/S_0)^3$	Tahran and Sari [131]
299	H/H_0 =0.128+0.725(S/S_0)-0.229 $(S/S_0)^2$+0.184$(S/S_0)^3$	Jin et al. [21]
300	H/H_0 =0.483-0.616(S/S_0)+1.893 $(S/S_0)^2$-1.098$(S/S_0)^3$	Aras et al. [94]
301	H/H_0 =0.150+1.145(S/S_0)-1.474 $(S/S_0)^2$+0.963$(S/S_0)^3$	Rensheng et al. [22]
302	H/H_0 =0.631-0.725(S/S_0)+1.208 $(S/S_0)^2$-0.463$(S/S_0)^3$	Bakirci [25]
303	H/H_0 =0.171+0.026(S/S_0)+2.100 $(S/S_0)^2$-1.640$(S/S_0)^3$	Burari et al. [132]
304	H/H_0 =0.197+0.981(S/S_0)+0.053 $(S/S_0)^2$-1.317$(S/S_0)^3$	Kolebaje and Mustapha [110]
305	H/H_0 =0.231+0.548(S/S_0)+1.884 $(S/S_0)^2$-4.215$(S/S_0)^3$	Kolebaje and Mustapha [110]
306	H/H_0 =0.400+0.137(S/S_0)+0.001 $(S/S_0)^2$+1.139$(S/S_0)^3$	Kolebaje and Mustapha [110]
307	H/H_0 =0.306+0.464(S/S_0)+0.001 $(S/S_0)^2$-0.189$(S/S_0)^3$	Kolebaje and Mustapha [110]
308	H/H_0 =0.091+1.401(S/S_0)-0.928 $(S/S_0)^2$-0.001$(S/S_0)^3$	Kolebaje and Mustapha [110]
309	H/H_0 =0.851+0.869(S/S_0)+0.001 $(S/S_0)^2$-1.364$(S/S_0)^3$	Kolebaje and Mustapha [110]
310	H/H_0 =0.050+0.971(S/S_0)-0.200 $(S/S_0)^2$+0.001$(S/S_0)^3$	Nwokoye and Okonkwo [71]
311	H/H_0 =1.561-0.365(S/S_0)+0.037 $(S/S_0)^2$-0.001$(S/S_0)^3$	Sani et al. [117]
312	H/H_0 =0.25+0.38(S/S_0)-0.210 $(S/S_0)^2$+0.074$(S/S_0)^3$	Ayodele and Ogunjuyigbe [124]
313	H/H_0 =2.72-11.01(S/S_0)+ 17.43 $(S/S_0)^2$-8.654$(S/S_0)^3$	Katiyar et al. [15]
314	H/H_0 =1.38-6.33(S/S_0)+ 12.75 $(S/S_0)^2$-7.66$(S/S_0)^3$	Katiyar et al. [15]
315	H/H_0 =0.294+0.086(S/S_0)+ 0.77 $(S/S_0)^2$-0.436$(S/S_0)^3$	Katiyar et al. [15]
316	H/H_0 =0.512-0.993(S/S_0)+ 2.53 $(S/S_0)^2$-1.33$(S/S_0)^3$	Katiyar et al. [15]
317	H/H_0 =0.16+0.87(S/S_0)- 0.61$(S/S_0)^2$+0.34$(S/S_0)^3$	Bahel et al. [58]
318	H/H_0 =0.230+ 0.381(S/S_0)+ 0.469$(S/S_0)^2$- 0.366$(S/S_0)^3$	Almorox et al. [15]
319	H/H_0 =0.285+0.259(S/S_0)+0.617 $(S/S_0)^2$-0.483$(S/S_0)^3$	Ulgen et al. [130]
320	H/H_0 =0.179+0.981(S/S_0)-0.296 $(S/S_0)^2$-0.266$(S/S_0)^3$	Togrul et al. [126]
321	H/H_0 =0.475-0.898(S/S_0)+2.773 $(S/S_0)^2$-1.54$(S/S_0)^3$	Onyango et al. [24]
322	H/H_0 =0.400+0.214(S/S_0)+0.153 $(S/S_0)^2$+0.119$(S/S_0)^3$	Jemaa et al. [50]
323	H/H_0 =1.324-4.942(S/S_0)+8.714 $(S/S_0)^2$-4.549$(S/S_0)^3$	Khorasanizadeh et al. [51]
324	H/H_0 =-0.898+5.936(S/S_0)-7.493 $(S/S_0)^2$+3.326$(S/S_0)^3$	Khorasanizadeh et al. [51]
325	H/H_0 =0.147+0.099(S/S_0)-0.009 $(S/S_0)^2$+0.0005$(S/S_0)^3$	Sivamadhavi et al [95]
326	H/H_0 =0.160+0.093(S/S_0)-0.008 $(S/S_0)^2$+0.0004$(S/S_0)^3$	Sivamadhavi et al [95]
327	H/H_0 =-1.88+12.65(S/S_0)-21.87 $(S/S_0)^2$+12.37$(S/S_0)^3$	Yaniktepe et al. [27]
328	H/H_0 =0.420+0.529(S/S_0)-0.777 $(S/S_0)^2$+0.521$(S/S_0)^3$	Assi et al. [79]
329	H/H_0 =0.441+0.829(S/S_0)-0.977 $(S/S_0)^2$+0.421$(S/S_0)^3$	Assi et al. [79]
330	H/H_0 =0.164-683(S/S_0)+1.073 $(S/S_0)^2$-0.0009$(S/S_0)^3$	Soler [55]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
331	$H/H_0 = 10.09-38.46(S/S_0)+50.75\ (S/S_0)^2-21.83(S/S_0)^3$	Hejase et al. [33]
332	$H/H_0 = 0.346+0.422(S/S_0)+2.33\ (S/S_0)^2-1.634(S/S_0)^3$	Marwal [53]
333	$H/H_0 = 0.11-0.01(S/S_0)+5.3\ (S/S_0)^2-10.4(S/S_0)^3+5.6(S/S_0)^4$	Marwal [53]
334	$H/H_0 = 0.40-0.85(S/S_0)+4.1\ (S/S_0)^2-4.9(S/S_0)^3+2.1(S/S_0)^4$	Zabara [132]
335	$H/H_0 = 0.550 + 0.656(S/S_0) + 0.721 \log(S/S_0)$	Sarsah and Uba [115]
336	$H/H_0 = -0.337 + 0.656(S/S_0) + 0.406 \exp(S/S_0)$	Sarsah and Uba [115]
337	$H/H_0 = 0.809 + 0.386 \log(S/S_0)$	Onyango et al. [24]
338	$H/H_0 = 0.8336 + 1.0573 \log(S/S_0)$	Ampratwum et al. [73]
339	$H/H_0 = 0.6050 + 0.1917 \ln(S/S_0)$	Yao et al. [43]
340	$H/H_0 = 0.34 + 0.40\ (S/S_0)+ 0.17 \ln(S/S_0)$	Newland [92]
341	$H/H_0 = 0.753 + 0.561 \ln(S/S_0)$	Hejase et al. [33]
342	$H/H_0 = 0.7166 + 0.2705 \ln(S/S_0)$	Marwal [53]
343	$H/H_0 = 0.6290 + 0.1053 \log(S/S_0)$	Assi et al. [79]
344	$H/H_0 = 0.6858 + 0.01531 \log(S/S_0)$	Assi et al. [79]
345	$H/H_0 = 0.880 - 0.1295\ (S/S_0) + 0.666 \ln(S/S_0)$	Hejase et al. [33]
346	$H/H_0 = 0.7621 - 0.1627(S/S_0) + 0.08576 \log(S/S_0)$	Assi et al. [79]
347	$H/H_0 = 0.7081 - 0.0127(S/S_0) + 0.08576 \log(S/S_0)$	Assi et al. [79]
348	$H/H_0 = 0.3396\ e0.8985(S/So)$	Togrul et al. [126]
349	$H/H_0 = 0.3593\ e\ 0.6093(S/So)$	Khorasanizadeh et al. [51]
350	$H/H_0 = 0.3593\ e0.6093(S/So)$	Yao et al. [43]
351	$H/H_0 = 0.2674\ e1.0391(S/So)$	Elagib et al. [42]
352	$H/H_0 = 0.4248\ e0.3947(S/So)$	Hejase et al. [33]
353	$H/H_0 = 0.263\ e1.088(S/So)$	Assi et al. [79]
354	$H/H_0 = 0.5399\ e0.1630(S/So)$	Marwal [53]
355	$H/H_0 = 0.3158\ e0.9251(S/So)$	Assi et al. [79]
356	$H/H_0 = 0.6416\ e0.099(S/So)$	Almorox et al. [15]
357	$H/H_0 = -0.0271 + 0.3096 \times e(S/So)$	Khorasanizadeh et al. [51]
358	$H/H_0 = 0.3661 + 0.1133\ e(S/So)$	Togrul et al. [126]
359	$H/H_0 = 0.7316\ (S/So)0.4146$	Nwokoye et al. [71]
360	$H/H_0 = 0.6673\ (S/So)0.5343$	Yao et al. [43]
361	$H/H_0 = 0.6128\ (S/So)0.2499$	Elagib et al. [42]
362	$H/H_0 = 0.7399\ (S/So)0.5201$	Marwal [53]
363	$H/H_0 = e-0.4698\ (S/So)0.034$	Assi et al. [79]
364	$H/H_0 = e-0.4058\ (S/So)0.00014$	Assi et al. [79]
365	$H/H_0 = e-0.1361\ (S/So)1.7156$	Ampratwum et al. [73]
366	$H/H_0 = -0.864 +1.862\ (S/So)2.344$	El-Sebaii et al. [14]
367	$H/H_0 = -3.386 +0.220(T_{max})- 0.003\ (T_{max})^2$	Okonkwo and Nwokoye [78]
368	$H/H_0 = -3.388.434 +0.638(T_{mean})-0.012\ (T_{mean})^2$	Ohunakin [111]
369	$H/H_0 = -0.987 +5.256(T_R)- 4.536\ (T_R)^2$	Okonkwo and Nwokoye [78]
370	$H/H_0 = 0.24 + e^{0.064(T/So)}$	Ayodele and Ogunjuyigbe [124]
371	$H/H_0 = 0.45 +0.39 \log(\Delta T/So)$	Ayodele and Ogunjuyigbe [124]
372	$H/H_0 = 0.219 + 0.526\ (S/So) + 0.004\ w$	El-Metwally [97]
373	$H/H_0 = -0.107 + 0.70\ (S/S0) - 0.0025T + 0.004\ RH$	Maghrabi [12]
374	$H/H_0 = -0.139+0.229\ (S/So)+0.01T+0.004V+0.002RH+0.002PS$	Trabea and Shaltout [134]
375	$H/H_0 = -1.92 + 2.60\ (S/So) + 0.006T$	El-Sebaii et al. [14]
376	$H/H_0 = -1.62 + 2.24\ (S/So) + 0.332RH$	El-Sebaii et al. [14]
377	$H/H_0 = 0.388 \cos\phi + 0.367\ (S/So)$	Raja et al. [40]
378	$H/H_0 = 0.388 \cos\phi + 0.407\ (S/So)$	Raja et al. [40]
379	$H/H_0 = 0.3092 \cos\phi + 0.4931\ (S/So)$	Ulgen et al. [74]
380	$H/H_0 = 0.12 + 0.58\ (S/So) + 7.56 \times 10^{-5}h$	Lewis [83]
381	$H/H_0 = 0.28 - 0.141 \cos\phi + 0.026h + 0.542(S/So)$	Rensheng et al. [22]
382	$H/H_0 = 0.122 + 0.001 \cos\phi + 2.57 \times 10^{-2}h+ 0.543(S/So)$	Rensheng et al. [22]
383	$H/H_0 = 0.275+4.27\times10^{-5}\psi+0.141\cos\phi + 2.63\times10^{-2}h+0.542(S/So)$	Rensheng et al. [22]
384	$H/H_0 = 0.117+4.11\times10^{-5}\psi+0.001\cos\phi + 2.59\times10^{-2}h+0.543(S/So)$	Rensheng et al. [22]
385	$H/H_0 = -0.117+4.11\times10^{-5}\psi+0.001\cos\phi + 2.59\times10^{-2}h+0.543(S/So)$	Rensheng et al. [22]

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Table 1: Models of GSR used in the present research for calculation of monthly average daily of GSR on horizontal surface.

No. of Model	Modeling of GSR	Author/References
386	$H/H_0 = 0.001\phi + 2.41x10^{-2}h + 0.109 + 1.03(S/So) - 1.22(S/So)^2 + 0.79(S/So)^3$	Rensheng et al. [22]
387	$H/H_0 = 3.614 – 0.364\ (RH)^2$	Kolebaje et al. [110]
388	$H/H_0 = 0.507 – 0.863\ (C/C_o)^2$	Augustine and Nnabuchi [105]
389	$H/H_0 = 1.309 + 0.601\ (S/S_o) – 0.999(T_R) – 0.0129\ (T_{mean})$	Falayi et al. [104]
390	$H/H_0 = -0.839 + 0.247\ (S/S_o) + 0.0439\ (T_{mean})$	Olayinka [106]
391	$H/H_0 = 1.395 + 1.591\ (S/S_o) - 0.046\ (T_{mean})$	Ituen et al. [69]
392	$H/H_0 = -6.874 + 7.31\ (S/S_o)^{0.0237} + 0.117\ (\ln\Delta T)$	Okundamiya et al. [123]
393	$H/H_0 = 5.981 – 1.991[(\Delta T+RH)/N]^{0.5}$	Kolebaje et al. [110]
394	$H/H_0 = 2.931 – 0.570[(\Delta T+RH)/N]^{0.5} – 1.214\ (T_R)$	Kolebaje et al. [110]
395	$H/H_0 = 0.00689 + 0.0221\ (S/S_o) + 0.968\ (C/C_o))$	Olayinka [106]
396	$H/H_0 = -0.423 + 0.301\ (S/S_o) + 0.0256\ (T_{max}) + 0.0725\ (RH/100)$	Olayinka [106]
397	$H/H_0 = -0.183 + 0.279\ (S/S_o) + 0.170\ (T_R)) + 0.0179\ (T_{max}) – 0.0128\ (C)$	Okundamiya et al. [123]
398	$H/H_0 = -0.012+0.001(S/S_o)+0.999(C/C_o)+0.00053(T_{max}) -0.001 (RH/100)$	Olayinka [106]
399	$H/H_0 = -0.518 \cos\phi + 19.219 \cos n + 5.513(T_{max}) + 125.78(S/S_o) + 21.683 (T_{max}/RH) + 5.634(T_{max}/RH)^2 - 2.693(\cos\phi \cos n) – 33.15$	Ajayi et al. [135]
400	$H/H_0 = 4.251 - 4.188 \cos\phi + 0.0437h + [(-10.577 + 11.451 \cos\phi - 0.0832h) (S/S_o)] + [(12.725 - 13.099 \cos\phi + 0.1h) (S/S_o)^2]$	Jin et al. [21]

Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
1	-2.314	2.985	-8.365	0.225	2.356	0.214	0.4689	1.355	3.256	0.2546
2	-2.561	3.214	-7.325	0.365	1.325	0.145	0.5221	1.214	4.235	0.3165
3	-3.214	3.654	-11.325	0.335	1.965	0.125	0.4462	1.569	3.245	0.1245
4	-1.685	4.321	-9.356	0.229	2.365	0.0985	0.4391	1.689	5.325	-0.3269
5	-2.345	3.698	-8.365	0.256	3.245	0.168	0.4506	1.474	6.325	0.2148
6	-2.865	2.654	-15.365	0.654	2.654	0.265	0.4406	1.677	7.235	-0.3215
7	-1.324	1.356	-3.985	0.452	3.126	0.354	0.4425	1.654	3.256	-0.2352
8	-2.365	3.245	-11.325	0.362	2.547	0.247	0.5397	0.792	4.325	0.3256
9	-1.954	4.325	-9.365	0.289	2.658	0.298	0.5674	0.608	4.329	0.4243
10	-2.451	5.326	-14.325	0.654	3.658	0.345	0.6025	0.476	3.456	0.5263
11	1.365	3.265	-11.365	0.345	1.654	0.145	0.5698	0.589	6.354	0.4512
12	-3.214	2.965	-8.325	0.542	1.857	0.189	0.5385	0.795	4.358	0.3252
13	-2.324	3.321	15.362	0.654	1.365	0.247	0.3256	2.397	3.658	-1.2358
14	1.895	3.478	11.325	0.356	5.326	0.268	-0.5485	2.952	2.359	-2.3145
15	-1.987	2.689	-6.325	0.412	1.325	0.214	0.3251	2.399	5.326	-1.2452
16	-2.654	1.356	-11.524	0.325	4.325	0.236	-0.4529	2.482	4.365	-1.5641
17	-2.345	1.325	-14.356	0.421	3.256	0.314	0.5374	0.796	5.326	0.3248
18	-2.852	3.654	-3.568	0.229	1.325	0.198	0.5621	0.658	6.314	0.3849
19	-1.358	4.245	-13.654	0.325	4.325	0.145	0.4658	1.361	5.325	0.2508
20	-3.256	4.321	-9.365	0.361	2.698	0.168	-0.4789	2.689	4.325	-2.1465
21	-2.378	3.265	-8.325	0.358	2.754	0.325	0.4215	1.785	3.658	-0.359
22	-1.896	2.658	-7.256	0.568	2.568	0.254	0.3551	2.363	6.325	-0.6548
23	1.325	2.965	11.356	0.689	2.314	0.315	-0.5491	3.214	4.356	-2.3149
24	1.658	3.354	-13.654	0.452	1.658	0.125	0.2398	2.416	5.326	-1.3267
25	-2.356	3.658	9.324	0.365	2.359	0.168	-0.4582	2.511	4.325	-1.6549
26	-2.089	1.965	5.326	0.654	1.325	0.215	0.4428	1.595	7.321	0.0214
27	1.325	2.314	-3.865	0.235	2.365	0.314	0.4431	1.592	5.326	0.0658
28	-1.958	3.254	-9.541	0.214	1.658	0.326	0.4457	1.572	6.325	0.1241
29	-1.689	1.658	-12.654	0.425	2.365	0.289	0.4388	1.691	5.659	-0.3275
30	-1.365	2.365	-15.325	0.325	3.256	0.135	0.3631	2.325	6.458	-0.5425
31	-2.123	3.654	-9.325	0.658	2.358	0.147	0.5369	0.798	7.321	0.3246
32	2.912	2.365	-14.235	0.552	1.358	0.168	0.4504	1.478	6.325	0.2144

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
33	1.325	1.698	-8.325	0.356	4.325	0.128	0.6098	0.362	5.326	0.6523
34	-2.365	1.965	6.325	0.654	5.326	0.068	0.4469	1.556	4.325	0.1259
35	-2.345	2.356	7.325	0.658	3.245	0.087	0.4501	1.479	7.231	0.2141
36	5.632	3.654	-21.324	0.456	2.359	0.256	0.5405	0.785	6.325	0.3264
37	-1.356	4.325	-23.654	0.425	2.145	0.326	0.6061	0.382	5.326	0.6247
38	-2.356	4.658	-9.325	0.268	1.365	0.411	0.6023	0.479	4.365	0.5245
39	-2.314	3.265	-11.456	0.689	1.987	0.358	0.2356	2.418	5.326	-1.3269
40	-1.325	2.324	-13.698	0.754	2.365	0.265	-0.4585	2.524	6.541	-1.6587
41	-1.325	1.658	-23.654	0.452	2.895	0.124	0.5481	0.703	7.325	0.3548
42	-1.365	3.256	-22.35	0.556	3.245	0.325	0.5233	0.988	5.325	0.3179
43	-2.895	4.325	-4.325	0.542	1.658	0.258	0.4355	1.693	4.369	-0.3277
44	-3.256	3.658	5.365	0.562	5.325	0.168	0.4404	1.679	3.256	-0.3246
45	-2.365	1.689	9.356	0.345	4.235	0.178	0.4451	1.575	4.325	0.1237
46	-1.365	1.885	6.325	0.658	2.356	0.165	0.4478	1.551	4.658	0.1582
47	-1.985	2.658	-9.325	0.425	1.547	0.245	0.4597	1.367	3.256	0.2479
48	-1.568	2.365	-3.567	0.635	1.325	0.187	0.3634	2.322	3.256	-0.5247
49	-3.245	3.258	-5.632	0.411	2.356	0.314	0.4216	1.784	3.652	-0.3456
50	-3.325	3.326	-11.125	0.635	1.854	0.265	0.4509	1.472	4.214	0.2245
51	-1.235	4.457	-6.325	0.458	1.658	0.124	0.3691	2.242	5.635	-0.4154
52	1.325	3.334	-8.658	0.362	2.314	0.197	0.5036	1.239	6.785	0.2874
53	2.356	2.654	-15.452	0.578	2.224	0.311	0.4218	1.762	7.224	-0.3364
54	-1.635	1.865	-3.235	0.632	1.589	0.368	0.3685	2.254	3.568	-0.4159
55	-2.658	2.356	-3.589	0.478	2.125	0.254	0.5148	1.235	4.457	0.2958
56	-1.563	3.258	-9.785	0.365	2.256	0.234	0.5363	0.802	4.892	0.3242
57	-2.654	5.689	-11.325	0.574	3.324	0.214	0.6055	0.405	3.635	0.6217
58	1.758	3.754	-11.235	0.392	1.254	0.214	0.6235	0.263	5.325	0.7457
59	-3.635	2.635	12.356	0.457	1.541	0.136	0.6124	0.359	3.258	0.6548
60	-2.568	3.547	9.325	0.458	1.254	0.225	0.6065	0.379	4.325	0.6256
61	1.235	3.245	-3.256	0.398	5.124	0.475	-0.6165	4.214	2.865	-2.4647
62	2.356	2.365	-3.658	0.689	1.254	0.194	-0.4588	2.529	4.256	-1.6589
63	-2.235	1.568	-11.425	0.478	4.145	0.241	0.5984	0.493	4.321	0.4586
64	-2.698	1.856	-11.325	0.547	4.325	0.378	0.5511	0.689	5.785	0.3574
65	-2.445	3.224	-5.326	0.368	2.314	0.236	0.5408	0.782	5.325	0.3275
66	-1.658	4.785	-11.326	0.457	4.325	0.168	0.4892	1.245	4.925	0.2691
67	-3.568	4.658	-8.325	0.658	2.214	0.192	-0.6152	3.342	4.658	-2.4593
68	1.325	4.325	-6.324	0.457	2.325	0.378	0.3456	2.375	5.647	-0.6587
69	-1.632	2.478	-7.658	0.365	2.412	0.178	0.3325	2.386	6.478	-0.7456
70	1.785	1.547	11.785	0.745	1.389	0.265	-0.6189	4.465	5.324	-2.6582
71	1.542	1.352	-12.658	0.653	1.658	0.197	-0.4251	2.475	3.958	-1.4576
72	-2.457	3.325	4.259	0.447	2.658	0.127	-0.4325	2.476	5.236	-1.4579
73	-2.245	1.568	-4.658	0.556	1.785	0.247	0.4432	1.589	6.526	0.0854
74	1.587	2.658	-3.325	0.785	2.325	0.368	0.4467	1.558	5.458	0.1252
75	-1.458	3.564	-9.659	0.347	1.478	0.295	0.4408	1.675	5.325	-0.2569
76	-1.254	1.455	4.325	0.658	2.365	0.223	0.3614	2.337	5.952	-0.6245
77	-1.147	2.365	11.325	0.457	3.447	0.189	0.5416	0.772	6.258	0.3459
78	-2.658	3.235	6.354	0.857	2.365	0.245	0.5869	0.558	5.635	0.4563
79	2.365	2.125	-10.325	0.478	1.857	0.195	0.5098	1.238	6.854	0.2952
80	1.568	1.258	-11.325	0.457	4.447	0.168	0.6028	0.474	5.445	0.5268
81	-2.689	1.635	6.985	0.458	3.256	0.092	0.4495	1.524	4.658	0.2136
82	-2.785	2.689	7.658	0.687	3.365	0.124	0.5361	0.805	3.352	0.3238
83	5.258	3.411	-15.324	0.578	2.411	0.369	0.5686	0.596	5.935	0.4257
84	-1.658	4.857	-25.324	0.258	2.245	0.458	0.6034	0.465	5.589	0.5281
85	-2.689	4.325	-9.689	0.345	3.214	0.658	0.5924	0.495	4.578	0.4584
86	-2.457	3.635	-14.895	0.785	1.325	0.411	0.3275	2.394	5.658	-1.1954
87	-1.658	2.854	-16.321	0.658	2.658	0.365	0.3059	2.405	4.698	-1.2547

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
88	-1.547	1.441	-25.647	0.365	2.365	0.245	0.6325	0.235	6.325	0.7548
89	-1.896	3.458	-29.356	0.348	3.478	0.265	0.3547	2.365	4.358	-0.6552
90	-2.425	4.875	-4.684	0.447	1.326	0.194	0.4671	1.356	3.256	0.2542
91	1.325	3.658	5.895	0.457	4.325	0.192	0.4325	1.695	2.958	-0.3279
92	-2.125	1.356	9.457	0.689	3.214	0.132	0.4488	1.542	4.478	0.1895
93	-1.658	1.457	6.698	0.532	2.658	0.256	0.4588	1.374	4.856	0.2458
94	-1.632	2.254	-9.784	0.547	1.892	0.124	0.5413	0.775	3.478	0.3453
95	-2.568	1.457	6.589	0.632	3.256	0.135	0.4483	1.547	5.326	0.1863
96	-1.458	1.365	9.325	0.547	2.114	0.245	0.4492	1.528	4.784	0.2132
97	-1.567	2.235	-7.365	0.365	1.214	0.158	0.5419	0.769	3.247	0.3468
98	-3.256	2.456	-7.325	0.423	2.425	0.145	0.5348	0.807	2.356	0.3235
99	-2.125	3.658	-6.245	0.449	1.658	0.245	0.5863	0.561	3.254	0.4558
100	-3.658	2.356	-12.356	0.658	1.547	0.189	0.5326	0.809	3.457	0.3231
101	-1.247	3.254	-9.556	0.523	2.457	0.089	0.3452	2.377	4.325	-0.6589
102	-2.568	4.325	-8.658	0.452	3.356	0.168	0.5852	0.563	5.326	0.4552
103	-2.145	2.325	-12.365	0.457	2.547	0.158	0.4211	1.985	6.325	-0.3566
104	-1.658	2.365	-3.658	0.589	3.589	0.257	0.3617	2.336	3.254	-0.5892
105	-2.457	3.245	-10.658	0.658	2.235	0.289	0.6162	0.281	4.568	0.7434
106	-1.356	4.568	-9.785	0.457	2.125	0.195	0.5896	0.524	4.785	0.4581
107	-2.925	4.235	-11.325	0.526	3.456	0.248	0.5631	0.641	3.658	0.4117
108	1.558	3.457	-9.325	0.457	1.358	0.235	0.5593	0.669	6.785	0.3694
109	-3.657	2.235	-8.658	0.589	1.457	0.245	0.5894	0.541	4.698	0.4576
110	-2.457	3.658	15.125	0.358	1.658	0.312	-0.3657	2.466	3.122	-1.3654
111	1.263	3.256	11.658	0.457	5.425	0.247	-0.6124	3.335	2.852	-2.456
112	-1.145	2.325	-6.365	0.658	1.578	0.158	-0.4483	2.478	5.125	-1.4582
113	-2.789	1.547	-8.325	0.658	4.452	0.125	0.2985	2.408	4.857	-1.2563
114	-2.457	1.657	-11.367	0.567	3.358	0.245	0.5592	0.672	5.245	0.3686
115	-2.536	3.856	-5.364	0.365	1.658	0.325	0.5842	0.566	5.236	0.4547
116	-1.438	4.547	-11.258	0.457	4.458	0.245	0.6021	0.482	4.325	0.5241
117	-3.625	4.658	-9.635	0.547	2.425	0.245	-0.5236	2.788	3.256	-2.1691
118	-2.547	3.635	-8.857	0.534	2.624	0.236	0.3311	2.391	3.258	-0.8571
119	-1.587	2.245	-7.568	0.349	2.425	0.189	0.4036	2.128	5.236	-0.3655
120	1.559	2.658	10.325	0.524	2.415	0.235	-0.6163	3.458	4.258	-2.4632
121	2.354	3.547	-13.124	0.658	1.524	0.158	-0.4591	2.534	5.124	-1.6592
122	1.256	3.254	9.568	0.471	2.658	0.198	0.2547	2.411	4.325	-1.2582
123	-3.256	1.568	6.345	0.511	1.578	0.195	0.5476	0.705	6.325	0.3543
124	1.635	2.547	-3.258	0.325	2.458	0.247	0.4447	1.577	4.325	0.1235
125	-1.456	3.625	-9.785	0.452	1.258	0.254	0.5422	0.767	5.236	0.3508
126	-1.325	1.245	-11.356	0.652	2.125	0.314	0.3669	2.258	4.325	-0.4163
127	-1.758	2.145	-12.689	0.725	3.415	0.245	0.3365	2.379	5.362	-0.6592
128	-2.658	3.365	-7.689	0.457	2.458	0.325	0.5671	0.609	6.325	0.4155
129	2.456	2.452	-12.458	0.657	1.625	0.245	0.5324	0.845	4.352	0.3227
130	1.558	1.457	-8.785	0.258	4.356	0.235	0.6032	0.468	2.356	0.5274
131	-2.457	1.256	6.658	0.658	5.659	0.145	0.5548	0.674	1.356	0.3682
132	-2.698	2.556	7.895	0.457	3.415	0.125	0.5403	0.787	6.325	0.3261
133	5.245	3.457	-15.356	0.756	2.425	0.236	0.4582	1.375	4.235	0.2455
134	-1.924	4.658	-21.245	0.857	2.356	0.248	0.5892	0.544	3.256	0.4574
135	-2.657	4.452	-9.478	0.365	1.758	0.356	0.6017	0.485	4.254	0.5237
136	-2.458	3.547	-11.689	0.245	1.659	0.256	-0.3685	2.468	5.124	-1.3663
137	-1.745	2.568	-13.75	0.356	2.415	0.198	0.2937	2.409	4.356	-1.2574
138	-1.865	1.245	-22.356	0.754	2.356	0.258	0.5668	0.612	6.325	0.4151
139	-1.365	2.356	-21.356	0.758	3.451	0.235	0.6089	0.365	4.236	0.6357
140	-2.652	3.254	-4.785	0.635	1.259	0.129	0.3638	2.319	2.365	-0.4583
141	-3.568	3.256	5.689	0.758	5.652	0.154	0.3625	2.329	2.356	-0.5482
142	-2.758	1.785	9.125	0.457	4.425	0.354	0.4577	1.377	3.256	0.2451

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
143	-1.554	1.653	5.326	0.457	2.452	0.256	0.4481	1.549	4.254	0.1647
144	-1.645	2.457	-8.654	0.547	1.411	0.547	0.4896	1.242	3.547	0.2856
145	-2.235	1.245	-9.325	0.326	2.356	0.425	0.5401	0.789	2.356	0.3259
146	-1.224	1.354	4.235	0.456	3.256	0.325	0.4465	1.568	1.598	0.1248
147	-1.324	2.235	-11.325	0.625	4.325	0.094	0.4281	1.696	4.325	-0.3281
148	-2.356	2.658	-2.547	0.425	2.456	0.521	0.3648	2.312	2.365	-0.4259
149	-1.235	3.425	-4.356	0.658	2.358	0.425	0.3286	2.392	1.569	-0.8579
150	-2.347	3.578	-10.325	0.775	1.325	0.325	0.6082	0.371	5.214	0.6328
151	-1.896	4.245	-8.356	0.556	1.452	0.452	0.3645	2.314	6.321	-0.4267
152	2.356	3.658	-6.325	0.632	2.365	0.652	0.5521	0.684	5.263	0.3662
153	3.456	2.356	-11.345	0.758	2.159	0.325	0.3622	2.331	6.256	-0.5549
154	-1.235	1.457	-4.326	0.458	1.423	0.425	0.3597	2.342	3.452	-0.6327
155	-2.457	2.658	-3.452	0.758	3.256	0.456	0.5789	0.568	4.214	0.4543
156	-1.145	3.452	-8.658	0.654	2.657	0.365	0.6049	0.425	4.254	0.5646
157	-2.356	5.455	-9.658	0.758	3.754	0.452	0.4572	1.379	3.985	0.2448
158	1.654	3.524	-10.457	0.658	1.658	0.098	0.6078	0.374	5.365	0.6325
159	-3.478	2.256	6.325	0.758	1.412	0.189	0.4571	1.381	3.158	0.2445
160	-2.254	3.415	9.458	0.659	1.523	0.326	0.4512	1.471	4.785	0.2254
161	1.547	3.659	-3.789	0.458	5.632	0.214	-0.6136	3.39	2.365	-2.4584
162	2.589	2.356	-3.365	0.658	1.456	0.354	-0.3588	2.459	4.658	-1.3372
163	-2.789	1.345	-14.214	0.658	4.854	0.569	0.4879	1.254	4.854	0.2594
164	-2.325	1.425	-13.269	0.457	4.432	0.412	0.5508	0.692	5.254	0.3565
165	-2.145	3.658	-5.547	0.569	2.623	0.425	0.5536	0.676	5.658	0.3675
166	0.765	4.356	-10.547	0.325	4.568	0.356	0.8549	0.152	4.457	0.7859
167	-3.425	4.754	-8.658	0.457	2.459	0.278	-0.5245	2.789	4.365	-2.2452
168	1.587	4.547	-6.458	0.658	2.752	0.322	0.4418	1.668	5.452	-0.2455
169	-1.245	2.785	-7.258	0.658	2.623	0.269	0.4023	2.132	6.124	-0.3667
170	1.356	1.326	11.325	0.658	1.456	0.145	-0.5597	3.226	5.356	-2.3542
171	1.145	1.587	-8.325	0.554	1.256	0.356	-0.2584	2.419	4.325	-1.3275
172	-2.658	3.325	4.569	0.457	2.985	0.265	-0.4592	2.547	3.259	-1.6595
173	-2.457	1.425	-4.758	0.325	1.452	0.159	0.4865	1.256	5.244	0.2591
174	1.258	2.256	-3.658	0.658	2.785	0.456	0.5267	0.857	4.122	0.3223
175	-1.325	3.411	-9.785	0.745	1.328	0.325	0.4236	1.758	3.259	-0.3295
176	-1.578	1.658	4.455	0.325	2.159	0.452	0.3658	2.259	4.325	-0.4238
177	-1.547	3.256	8.658	0.689	3.358	0.259	0.5264	0.865	5.326	0.3221
178	-2.547	2.356	5.324	0.754	2.425	0.324	0.5263	0.895	4.325	0.3218
179	2.457	1.356	-13.255	0.658	1.541	0.425	0.5765	0.586	5.325	0.4516
180	1.248	2.356	-10.355	0.453	4.953	0.354	0.5666	0.615	4.326	0.4142
181	-2.325	1.425	6.456	0.589	3.458	0.245	0.5214	1.234	3.256	0.3142
182	-2.248	2.325	7.258	0.745	3.635	0.245	0.5657	0.622	1.235	0.4135
183	4.658	3.245	-12.356	0.259	2.895	0.159	0.5683	0.598	3.256	0.4253
184	-1.258	4.456	-21.458	0.458	2.874	0.432	0.5472	0.707	4.235	0.3541
185	-2.457	3.254	-8.326	0.754	3.562	0.425	0.5263	0.912	6.321	0.3216
186	-2.254	3.145	-11.256	0.365	1.654	0.524	-0.5694	3.263	2.356	-2.3585
187	-1.356	2.658	-13.325	0.852	2.524	0.411	-0.5697	3.266	3.256	-2.3593
188	-1.145	1.245	-22.659	0.756	2.854	0.239	0.5469	0.742	5.326	0.3539
189	-1.658	3.225	-25.325	0.458	3.745	0.324	0.4423	1.659	1.236	-0.2364
190	-2.458	4.145	-4.425	0.321	1.852	0.245	0.5695	0.591	3.256	0.4326
191	1.625	3.325	5.325	0.658	4.423	0.148	0.3558	2.357	4.225	-0.6528
192	-2.478	1.785	8.325	0.785	3.657	0.425	0.4523	1.463	3.269	0.2358
193	2.356	1.547	5.269	0.689	2.456	0.257	0.4563	1.383	1.359	0.2442
194	-3.256	3.456	-7.659	0.365	1.652	0.457	0.5628	0.644	4.235	0.4113
195	-1.547	2.356	6.245	0.457	3.587	0.325	0.4751	1.344	3.259	0.2559
196	-2.658	1.658	6.325	0.547	2.923	0.154	0.5411	0.779	4.352	0.3451
197	-3.145	1.658	-3.245	0.421	1.547	0.325	0.6045	0.435	2.596	0.5642

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
198	-2.658	2.785	5.326	0.754	1.325	0.238	0.6324	0.247	3.124	0.7547
199	-1.356	3.325	-8.658	0.652	2.356	0.214	0.6054	0.412	2.356	0.5685
200	-2.687	2.754	-11.596	0.458	2.658	0.169	0.6144	0.329	4.235	0.6588
201	-1.546	3.689	-7.365	0.658	1.985	0.157	0.3321	2.388	5.326	-0.7459
202	-2.865	4.456	-8.452	0.358	3.245	0.235	0.6158	0.295	4.325	0.6895
203	-2.324	2.785	-12.958	0.754	2.458	0.168	0.3694	2.235	5.326	-0.4115
204	-1.987	2.788	-3.254	0.658	3.325	0.278	0.3593	2.345	3.258	-0.6329
205	-2.689	3.965	-10.325	0.457	2.745	0.325	0.8625	0.145	4.458	0.8292
206	-1.758	2.356	-7.654	0.457	2.658	0.457	0.6183	0.269	4.365	0.7454
207	-2.325	3.256	-16.324	0.325	3.145	0.325	0.6145	0.325	3.145	0.6853
208	1.456	3.875	-11.562	0.158	1.584	0.168	0.5885	0.546	5.326	0.4571
209	-3.325	2.685	-8.256	0.856	2.356	0.452	0.6141	0.335	2.356	0.6586
210	-2.214	3.425	11.569	0.289	3.256	0.245	-0.4526	2.481	3.547	-1.4594
211	1.568	3.635	-7.325	0.536	4.325	0.158	-0.6183	4.457	2.658	-2.5874
212	-1.654	2.457	-6.458	0.495	2.325	0.214	-0.3947	2.471	4.325	-1.3674
213	-2.452	1.257	-8.369	0.258	4.654	0.189	-0.4595	2.568	4.356	-1.6599
214	-2.158	1.453	-10.589	0.557	3.785	0.324	0.5785	0.571	3.256	0.4539
215	0.857	3.365	-6.578	0.754	1.458	0.258	0.9154	0.129	5.365	0.8575
216	-1.258	4.235	-8.256	0.659	3.658	0.325	0.6087	0.369	4.659	0.6353
217	-3.269	4.457	-7.356	0.458	2.856	0.156	0.2456	2.415	3.547	-1.3254
218	-1.654	3.356	-8.256	0.365	2.452	0.324	0.3329	2.385	3.458	-0.6635
219	-1.248	2.869	-7.785	0.547	2.369	0.324	0.3352	2.381	5.658	-0.6595
220	2.356	2.458	12.359	0.985	2.756	0.254	-0.5479	2.874	4.445	-2.2659
221	1.895	3.452	-2.356	0.458	1.269	0.189	-0.4125	2.473	5.658	-1.4524
222	1.895	3.857	9.245	0.547	2.562	0.145	-0.5829	3.268	4.456	-2.3624
223	-3.452	1.369	6.785	0.623	1.627	0.241	0.5881	0.549	5.326	0.4568
224	1.354	2.125	-3.589	0.457	2.568	0.324	0.4665	1.358	4.962	0.2512
225	2.356	3.365	-9.356	0.658	2.142	0.159	0.6287	0.254	5.854	0.7545
226	-1.654	1.785	-8.325	0.458	2.125	0.425	0.3589	2.346	4.632	-0.6333
227	-1.364	2.578	6.324	0.554	3.658	0.268	0.3628	2.327	5.547	-0.5473
228	-2.425	3.856	-4.325	0.657	2.985	0.245	0.6135	0.345	6.458	0.6582
229	2.689	2.753	-11.569	0.365	1.452	0.165	0.6165	0.274	4.856	0.745
230	-2.356	1.685	-8.652	0.458	4.753	0.189	0.6134	0.351	2.958	0.6575
231	0.825	1.689	6.441	0.458	5.425	0.145	0.8674	0.137	1.857	0.8468
232	-2.156	2.785	7.365	0.689	3.665	0.264	0.6269	0.258	6.857	0.7542
233	4.325	3.125	-11.325	0.458	2.785	0.159	0.6129	0.356	4.547	0.6572
234	0.755	4.259	-18.329	0.653	2.411	0.325	0.8137	0.169	3.568	0.7856
235	1.659	4.785	-9.125	0.455	1.625	0.369	0.6156	0.324	4.458	0.6891
236	-2.687	3.985	-11.574	0.562	1.258	0.425	-0.4578	2.489	4.326	-1.5742
237	-1.254	2.457	-12.658	0.754	2.658	0.362	0.6051	0.415	4.856	0.5681
238	0.758	1.857	-21.587	0.658	2.459	0.457	0.6351	0.199	6.325	0.7586
239	-1.965	2.698	-24.269	0.547	3.632	0.159	0.5467	0.751	5.326	0.336
240	-2.354	3.547	-8.236	0.356	1.547	0.246	0.3341	2.382	3.254	-0.6597
241	-3.875	3.785	4.326	0.456	5.785	0.256	0.3315	2.389	2.458	-0.7543
242	-2.459	1.689	7.658	0.857	4.632	0.457	0.6125	0.358	3.358	0.6568
243	-1.456	1.356	6.547	0.658	2.356	0.365	-0.6458	4.469	5.326	-3.2561
244	-1.547	2.758	-7.236	0.745	3.245	0.457	0.5517	0.686	3.258	0.3657
245	-2.589	1.587	-6.258	0.458	2.658	0.632	0.5872	0.555	2.657	0.4566
246	-1.935	2.658	3.256	0.345	3.325	0.524	0.4522	1.465	1.258	0.2351
247	1.356	1.658	-7.326	0.562	2.569	0.254	0.3268	2.396	3.256	-1.2326
248	-1.562	1.569	-1.569	0.742	3.256	0.652	0.4856	1.259	6.321	0.2586
249	-2.365	3.245	-3.256	0.523	2.657	0.325	0.5501	0.695	5.263	0.3558
250	-1.698	2.356	-12.365	0.689	3.754	0.425	0.5531	0.677	2.365	0.3673
251	0.785	3.245	-6.325	0.456	1.658	0.456	0.7536	0.175	1.569	0.7855
252	2.458	2.365	-5.326	0.854	1.412	0.365	-0.547	2.792	5.214	-2.2459

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
253	3.365	2.852	-11.689	0.369	1.523	0.452	0.4416	1.669	6.321	-0.2459
254	-1.589	1.658	-4.758	0.689	5.632	0.098	0.3972	2.145	5.263	-0.3675
255	-2.785	2.325	-3.698	0.754	1.456	0.425	-0.5624	3.251	6.256	-2.3549
256	-1.658	3.895	-8.325	0.856	2.657	0.356	-0.2698	2.422	3.452	-1.3283
257	-2.587	5.689	-9.654	0.689	1.523	0.278	-0.3592	2.461	4.214	-1.3379
258	1.359	3.457	-13.659	0.459	5.632	0.322	0.4854	1.324	4.325	0.2582
259	-3.658	2.658	6.758	0.365	1.456	0.269	0.5495	0.697	5.326	0.3554
260	-2.457	3.245	9.635	0.458	2.657	0.145	0.5527	0.679	4.325	0.3671
261	0.752	3.425	-3.258	0.556	3.754	0.356	0.7165	0.189	5.325	0.7853
262	2.256	2.689	-3.698	0.469	1.658	0.265	-0.3652	2.463	4.326	-1.3385
263	-2.556	1.785	-7.326	0.458	1.412	0.159	0.4852	1.325	3.256	0.2579
264	-2.852	1.358	-11.325	0.842	1.523	0.456	0.5483	0.701	1.235	0.3551
265	-2.624	3.589	-5.852	0.758	3.458	0.325	0.5524	0.682	5.214	0.3668
266	-1.458	4.365	-9.326	0.536	3.635	0.265	0.6056	0.385	6.321	0.6238
267	-3.852	4.658	-7.325	0.659	2.895	0.159	-0.5456	2.795	5.263	-2.2467
268	1.654	4.265	-6.689	0.745	2.874	0.456	0.4414	1.672	2.365	-0.2462
269	-1.785	2.256	-7.985	0.458	3.562	0.325	0.3956	2.148	1.569	-0.3683
270	1.258	1.477	14.325	0.925	1.654	0.452	-0.5632	3.254	5.214	-2.3562
271	1.568	1.632	-8.325	0.638	2.524	0.259	-0.2965	2.425	6.321	-1.3288
272	-2.452	3.458	4.852	0.852	2.854	0.324	0.9345	0.124	5.263	0.8652
273	-2.852	1.689	-4.458	0.754	3.745	0.148	-0.5476	2.857	6.256	-2.2477
274	1.365	2.589	-3.256	0.539	1.852	0.265	0.4411	1.673	3.452	-0.2468
275	-1.745	3.236	-9.689	0.657	4.423	0.159	0.3698	2.225	4.214	-0.3694
276	-1.325	1.458	4.689	0.658	3.657	0.456	-0.5689	3.259	4.325	-2.3577
277	-1.452	3.658	8.256	0.785	2.456	0.325	-0.3254	2.426	5.326	-1.3294
278	-2.658	2.589	6.356	0.358	1.652	0.452	-0.4597	2.569	1.569	-1.6624
279	2.125	1.458	-12.356	0.754	3.587	0.259	0.4785	1.329	4.214	0.2576
280	1.852	2.698	-10.562	0.658	2.923	0.324	0.5258	0.915	4.325	0.3213
281	-1.325	1.857	6.895	0.785	3.458	0.148	0.4235	1.759	5.326	-0.3359
282	-2.658	2.698	7.415	0.658	3.635	0.425	0.3652	2.261	1.569	-0.4245
283	4.258	3.758	-11.325	0.754	2.895	0.257	0.5254	0.924	5.214	0.3207
284	-1.458	4.689	-8.325	0.892	4.423	0.457	0.5251	0.935	6.321	0.3205
285	-2.632	3.458	-6.325	0.589	3.657	0.325	0.5247	0.952	5.263	0.3201
286	-2.552	3.645	-10.325	0.457	2.456	0.154	-0.6014	3.269	6.256	-2.3635
287	-1.639	2.589	-14.952	0.635	1.652	0.259	0.6839	0.193	3.452	0.7851
288	-1.451	1.658	-21.457	0.452	3.587	0.324	0.5624	0.652	5.326	0.4111
289	-1.574	3.753	-15.623	0.852	2.923	0.257	0.4721	1.347	1.569	0.2554
290	-2.853	4.478	-4.589	0.625	3.458	0.457	0.4517	1.466	5.263	0.2343
291	1.426	3.689	7.326	0.587	3.635	0.325	0.4554	1.385	6.256	0.2438
292	-2.753	1.658	6.325	0.632	3.458	0.154	0.5623	0.656	3.452	0.4108
293	2.573	1.785	4.325	0.458	3.635	0.325	0.4695	1.351	5.326	0.2551
294	-3.475	3.852	-7.265	0.458	3.587	0.148	0.5692	0.593	1.569	0.4322
295	-1.689	1.658	-5.325	0.354	2.923	0.411	0.3555	2.359	5.214	-0.6537
296	-3.569	3.256	4.589	0.658	3.458	0.239	0.4515	1.469	6.321	0.2337
297	-1.569	2.356	-6.325	0.542	3.635	0.324	0.4551	1.386	5.263	0.236
298	-1.954	1.356	11.356	0.452	2.365	0.145	-0.4562	2.484	5.326	-1.5649
299	-1.356	3.245	-13.654	0.362	1.658	0.168	0.5245	0.958	4.325	0.3198
300	-2.356	4.325	9.324	0.289	2.365	0.325	0.5597	0.659	7.321	0.3842
301	-2.314	5.326	5.326	0.654	3.256	0.254	0.4633	1.363	5.326	0.2507
302	-1.325	3.265	-3.865	0.345	2.358	0.315	-0.4793	2.698	6.325	-2.1491
303	-2.345	2.965	-9.541	0.542	1.358	0.125	0.4158	1.988	5.659	-0.3569
304	5.632	2.985	-12.654	0.654	4.325	0.168	0.3546	2.367	6.458	-0.6563
305	-1.356	3.214	-15.325	0.358	5.326	0.215	-0.5495	3.216	7.321	-2.3165
306	-2.345	2.658	-9.325	0.568	3.245	0.145	-0.3256	2.428	6.325	-1.3299
307	5.632	2.965	-14.235	0.689	2.359	0.168	-0.4599	2.582	5.326	-1.6635

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
308	-2.314	2.985	-8.325	0.452	2.145	0.325	0.5453	0.754	4.325	0.3532
309	-2.561	3.214	6.325	0.365	1.365	0.254	0.5231	0.991	3.658	0.3175
310	-3.214	2.658	7.325	0.654	1.987	0.315	0.4277	1.698	6.325	-0.3283
311	-1.685	2.965	-21.324	0.235	2.365	0.145	0.4402	1.681	4.356	-0.3249
312	-2.345	3.354	-6.325	0.214	2.895	0.168	0.4445	1.579	5.326	0.1231
313	-1.954	3.658	-11.524	0.425	3.245	0.325	0.4476	1.553	4.325	0.1574
314	-2.345	1.965	-14.356	0.654	1.658	0.254	0.4595	1.369	7.321	0.2475
315	5.632	2.314	-9.541	0.345	5.325	0.315	0.4258	1.702	5.326	-0.3286
316	-2.314	1.658	-12.654	0.542	4.235	0.125	0.44	1.683	6.325	-0.3254
317	-2.561	2.365	-15.325	0.654	2.356	0.168	0.4442	1.581	5.659	0.1228
318	-3.214	3.654	-9.325	0.358	1.547	0.215	-0.4569	2.485	6.458	-1.5654
319	-1.685	2.365	-14.235	0.568	1.658	0.314	0.5243	0.961	7.321	0.3195
320	-2.345	1.698	-8.325	0.689	5.326	0.326	0.5596	0.663	6.325	0.3835
321	-2.865	1.965	6.325	0.452	3.245	0.145	0.4625	1.364	5.326	0.2505
322	-1.324	2.356	7.325	0.365	2.359	0.168	-0.4875	2.754	4.325	-2.1556
323	-2.365	3.654	-21.324	0.654	2.145	0.325	0.4148	1.991	7.231	-0.3572
324	-1.954	4.325	-6.325	0.235	1.365	0.254	0.3544	2.369	5.326	-0.6574
325	-1.356	4.658	-11.524	0.214	1.987	0.315	-0.5578	3.219	6.325	-2.3181
326	-2.356	3.265	-14.356	0.425	2.365	0.125	-0.3259	2.431	5.659	-1.3314
327	-2.314	2.365	-3.568	0.325	2.895	0.168	0.3248	2.403	6.458	-1.2459
328	-1.325	3.654	-13.654	0.358	3.245	0.215	-0.4574	2.487	7.321	-1.5665
329	-2.345	2.365	-9.365	0.568	1.658	0.314	0.5241	0.968	6.325	0.3191
330	5.632	3.654	-8.325	0.689	5.325	0.326	0.5594	0.666	5.326	0.3831
331	-1.356	4.325	-7.256	0.452	4.235	0.289	0.4612	1.366	4.325	0.2501
332	-2.345	4.658	11.356	0.365	2.356	0.135	-0.5224	2.784	3.658	-2.1683
333	5.632	3.265	-13.654	0.654	1.547	0.147	0.4125	2.125	6.325	-0.3579
334	-2.314	2.365	9.324	0.235	1.658	0.168	0.3459	2.374	4.356	-0.6581
335	-2.561	3.654	5.326	0.214	2.314	0.125	-0.5593	3.225	5.326	-2.3199
336	5.632	2.365	-3.865	0.425	1.658	0.168	-0.3264	2.435	4.325	-1.3325
337	-1.356	1.698	-3.568	0.325	2.359	0.215	-0.4628	2.632	7.321	-1.6641
338	-2.356	1.965	-13.654	0.658	1.325	0.314	0.5448	0.756	5.326	0.3529
339	-2.314	2.356	-9.365	0.552	2.365	0.326	0.5227	0.993	6.325	0.3172
340	-1.325	3.654	-8.325	0.356	1.658	0.145	0.4256	1.705	5.659	-0.3289
341	-1.325	3.654	-7.256	0.654	2.365	0.087	0.4397	1.685	6.458	-0.3258
342	-1.365	4.325	11.356	0.658	3.256	0.256	0.4438	1.583	7.321	0.1226
343	-2.895	4.658	-13.654	0.456	2.358	0.326	0.4472	1.555	6.325	0.1571
344	-3.256	3.265	9.324	0.425	5.326	0.411	0.4591	1.371	5.326	0.2471
345	-2.365	2.365	5.326	0.268	3.245	0.358	0.4254	1.754	4.325	-0.3292
346	-1.365	3.654	-3.865	0.689	2.359	0.265	0.4394	1.688	7.231	-0.3263
347	-1.985	2.365	-9.541	0.358	2.145	0.124	0.4435	1.586	6.325	0.1224
348	2.356	1.326	-3.365	0.556	2.459	0.456	0.3569	2.348	5.263	-0.6339
349	3.456	1.587	-14.214	0.632	2.752	0.365	0.5782	0.574	6.256	0.4532
350	-1.235	3.325	-13.269	0.758	2.623	0.165	0.6041	0.457	3.452	0.5637
351	-2.457	1.425	-14.214	0.458	1.456	0.245	0.4547	1.387	4.214	0.2433
352	-1.145	2.256	-13.269	0.758	1.256	0.521	0.6073	0.377	4.254	0.6321
353	-2.356	3.411	-5.547	0.654	2.985	0.425	0.4541	1.415	3.985	0.2429
354	1.654	1.658	-10.547	0.758	1.452	0.325	0.3642	2.315	5.365	-0.4273
355	-3.478	3.256	-8.658	0.658	2.785	0.452	0.5515	0.687	3.158	0.3652
356	-2.254	2.356	-6.458	0.758	5.632	0.652	0.3621	2.333	4.785	-0.5564
357	1.547	1.356	-7.258	0.659	1.456	0.325	0.3568	2.351	3.158	-0.6347
358	2.589	2.356	-3.365	0.458	4.854	0.425	0.5776	0.579	4.785	0.4528
359	-2.789	1.425	-14.214	0.658	4.432	0.456	0.6036	0.459	5.214	0.5632
360	-2.325	2.325	-13.269	0.325	2.623	0.365	0.4538	1.435	5.263	0.2426
361	-2.145	3.245	-5.547	0.658	2.623	0.452	0.6014	0.488	6.256	0.4984
362	1.258	4.456	-10.547	0.745	4.568	0.098	0.4535	1.441	3.452	0.2422

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Table 2: The variable statistical indicator results and GPI of models in the present research.

Model	MBE	RMSE	MPE	MARE	MAE	RMSRE	R^2	t-test	U95	**GPI**
363	-1.325	3.254	-14.214	0.325	2.459	0.189	-0.3269	2.452	4.214	-1.3345
364	-1.578	3.145	-13.269	0.556	2.752	0.326	-0.4781	2.658	4.254	-1.6657
365	2.589	2.658	-5.547	0.632	2.623	0.214	0.4784	1.333	3.985	0.2571
366	-2.789	1.245	-10.547	0.758	1.456	0.354	0.3565	2.353	5.365	-0.6356
367	-2.325	2.785	-8.658	0.458	1.256	0.569	0.5771	0.582	3.158	0.4525
368	-2.145	1.326	-6.458	0.325	2.985	0.325	0.6032	0.463	4.785	0.5284
369	1.258	1.587	-7.258	0.658	1.452	0.452	0.4783	1.337	3.985	0.2568
370	-1.325	3.245	-3.365	0.325	2.459	0.259	0.5642	0.632	5.365	0.4128
371	-1.578	4.456	-14.214	0.556	2.752	0.324	0.5681	0.603	3.158	0.4251
372	-2.457	3.254	-13.269	0.632	2.623	0.425	0.5439	0.758	4.785	0.3526
373	-1.145	3.145	-5.547	0.758	1.456	0.354	0.5238	0.985	3.158	0.3188
374	-2.356	2.658	-10.547	0.458	1.256	0.245	-0.6021	3.271	4.785	-2.3641
375	1.654	1.245	-14.214	0.758	2.985	0.245	-0.6023	3.274	5.214	-2.3652
376	-2.457	2.785	-13.269	0.654	1.452	0.159	0.5435	0.759	6.321	0.3524
377	-1.145	1.326	-5.547	0.758	2.785	0.365	0.4533	1.448	5.263	0.2418
378	-2.356	1.587	-6.458	0.658	1.328	0.452	0.6031	0.469	6.256	0.5272
379	1.654	3.325	-7.258	0.659	2.159	0.098	0.4531	1.457	3.452	0.2415
380	-3.478	1.425	11.325	0.458	3.358	0.189	-0.3574	2.457	4.214	-1.3367
381	-2.254	2.256	-8.325	0.658	2.623	0.326	-0.4785	2.664	5.452	-1.6674
382	1.547	3.411	4.569	0.325	4.568	0.214	0.4754	1.341	6.124	0.2563
383	2.589	3.325	-14.214	0.658	2.459	0.354	0.5634	0.635	5.356	0.4126
384	-2.789	1.425	-13.269	0.745	2.752	0.569	0.5677	0.606	4.325	0.4247
385	-2.325	2.256	-5.547	0.325	2.623	0.325	0.5431	0.761	3.259	0.3521
386	-2.145	3.411	-10.547	0.689	1.456	0.452	0.5236	0.986	5.452	0.3182
387	1.258	1.658	-8.658	0.754	1.256	0.259	-0.6025	3.275	6.124	-2.3669
388	-1.325	3.256	-6.458	0.658	2.985	0.324	-0.6032	3.277	5.356	-2.3672
389	-1.578	2.356	-7.258	0.325	1.452	0.425	0.528	0.763	4.325	0.3518
390	-1.547	1.356	11.325	0.658	2.785	0.354	0.4528	1.459	3.259	0.2412
391	-2.457	2.356	-3.365	0.325	1.328	0.245	0.6012	0.491	5.244	0.4654
392	-2.254	1.425	-14.214	0.556	2.159	0.245	0.4525	1.461	4.122	0.2407
393	-1.356	2.325	-13.269	0.632	3.358	0.159	-0.6035	3.329	3.259	-2.3685
394	-1.145	3.245	-5.547	0.758	2.425	0.432	-0.6051	3.332	4.325	-2.3697
395	-1.658	4.456	-10.547	0.458	1.541	0.452	0.5425	0.766	5.326	0.3514
396	-2.458	3.254	-8.658	0.365	4.953	0.259	0.4421	1.666	4.325	-0.2369
397	1.625	3.145	-6.458	0.457	3.458	0.324	0.5689	0.595	5.325	0.4316
398	2.356	3.325	-10.547	0.758	2.785	0.652	0.3562	2.355	5.214	-0.6367
399	3.456	1.425	-8.658	0.654	5.632	0.325	0.5768	0.585	5.263	0.4522
400	-3.245	2.314	-5.236	0.589	1.547	0.235	0.5632	0.639	4.356	0.4121

Table 3: The Rank of models in the present research

Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank
0.8652	272	1	0.7545	225	13	0.6575	230	25	0.6238	266	37
0.8575	215	2	0.7542	232	14	0.6572	233	26	0.6217	57	38
0.8468	231	3	0.7457	58	15	0.6568	242	27	0.5685	199	39
0.8292	205	4	0.7454	206	16	0.6548	59	28	0.5681	237	40
0.7859	166	5	0.7450	229	17	0.6523	33	29	0.5646	156	41
0.7856	234	6	0.7434	105	18	0.6357	139	30	0.5642	197	42
0.7855	251	7	0.6895	202	19	0.6353	216	31	0.5637	350	43
0.7853	261	8	0.6891	235	20	0.6328	150	32	0.5632	359	44
0.7851	287	9	0.6853	207	21	0.6325	158	33	0.5284	368	45
0.7586	238	10	0.6588	200	22	0.6321	352	34	0.5281	84	46
0.7548	88	11	0.6586	209	23	0.6256	60	35	0.5274	130	47
0.7547	198	12	0.6582	228	24	0.6247	37	36	0.5272	378	48

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Table 3: The Rank of models in the present research

Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank
0.5268	80	49	0.3671	260	104	0.3172	339	159	0.2136	81	214
0.5263	10	50	0.3668	265	105	0.3165	2	160	0.2132	96	215
0.5245	38	51	0.3662	152	106	0.3142	181	161	0.1895	92	216
0.5241	116	52	0.3657	244	107	0.2958	55	162	0.1863	95	217
0.5237	135	53	0.3652	355	108	0.2952	79	163	0.1647	143	218
0.4984	361	54	0.3574	64	109	0.2874	52	164	0.1582	46	219
0.4654	391	55	0.3565	164	110	0.2856	144	165	0.1574	313	220
0.4586	63	56	0.3558	249	111	0.2691	66	166	0.1571	343	221
0.4584	85	57	0.3554	259	112	0.2594	163	167	0.1259	34	222
0.4581	106	58	0.3551	264	113	0.2591	173	168	0.1252	74	223
0.4576	109	59	0.3548	41	114	0.2586	248	169	0.1248	146	224
0.4574	134	60	0.3543	123	115	0.2582	258	170	0.1245	3	225
0.4571	208	61	0.3541	184	116	0.2579	263	171	0.1241	28	226
0.4568	223	62	0.3539	188	117	0.2576	279	172	0.1237	45	227
0.4566	245	63	0.336	239	118	0.2571	365	173	0.1235	124	228
0.4563	78	64	0.3532	308	119	0.2568	369	174	0.1231	312	229
0.4558	99	65	0.3529	338	120	0.2563	382	175	0.1228	317	230
0.4552	102	66	0.3526	372	121	0.2559	195	176	0.1226	342	231
0.4547	115	67	0.3524	376	122	0.2554	289	177	0.1224	347	232
0.4543	155	68	0.3521	385	123	0.2551	293	178	0.0854	73	233
0.4539	214	69	0.3518	389	124	0.2546	1	179	0.0658	27	234
0.4532	349	70	0.3514	395	125	0.2542	90	180	0.0214	26	235
0.4528	358	71	0.3508	125	126	0.2512	224	181	-0.2352	7	236
0.4525	367	72	0.3468	97	127	0.2508	19	182	-0.2364	189	237
0.4522	399	73	0.3459	77	128	0.2507	301	183	-0.2369	396	238
0.4516	179	74	0.3453	94	129	0.2505	321	184	-0.2455	168	239
0.4512	11	75	0.3451	196	130	0.2501	331	185	-0.2459	253	240
0.4326	190	76	0.3275	65	131	0.2479	47	186	-0.2462	268	241
0.4322	294	77	0.3264	36	132	0.2475	314	187	-0.2468	274	242
0.4316	397	78	0.3261	132	133	0.2471	344	188	-0.2569	75	243
0.4257	83	79	0.3259	145	134	0.2458	93	189	-0.3215	6	244
0.4253	183	80	0.3256	8	135	0.2455	133	190	-0.3246	44	245
0.4251	371	81	0.3252	12	136	0.2451	142	191	-0.3249	311	246
0.4247	384	82	0.3248	17	137	0.2448	157	192	-0.3254	316	247
0.4243	9	83	0.3246	31	138	0.2445	159	193	-0.3258	341	248
0.4155	128	84	0.3242	56	139	0.2442	193	194	-0.3263	346	249
0.4151	138	85	0.3238	82	140	0.2438	291	195	-0.3269	4	250
0.4142	180	86	0.3235	98	141	0.236	297	196	-0.3275	29	251
0.4135	182	87	0.3231	100	142	0.2433	351	197	-0.3277	43	252
0.4128	370	88	0.3227	129	143	0.2429	353	198	-0.3279	91	253
0.4126	383	89	0.3223	174	144	0.2426	360	199	-0.3281	147	254
0.4121	400	90	0.3221	177	145	0.2422	362	200	-0.3283	310	255
0.4117	107	91	0.3218	178	146	0.2418	377	201	-0.3286	315	256
0.4113	194	92	0.3216	185	147	0.2415	379	202	-0.3289	340	257
0.4111	288	93	0.3213	280	148	0.2412	390	203	-0.3292	345	258
0.4108	292	94	0.3207	283	149	0.2407	392	204	-0.3295	175	259
0.3849	18	95	0.3205	284	150	0.2358	192	205	-0.3359	281	260
0.3842	300	96	0.3201	285	151	0.2351	246	206	-0.3364	53	261
0.3835	320	97	0.3198	299	152	0.2343	290	207	-0.3456	49	262
0.3831	330	98	0.3195	319	153	0.2337	296	208	-0.359	21	263
0.3694	108	99	0.3191	329	154	0.2254	160	209	-0.3566	103	264
0.3686	114	100	0.3188	373	155	0.2245	50	210	-0.3569	303	265
0.3682	131	101	0.3182	386	156	0.2148	5	211	-0.3572	323	266
0.3675	165	102	0.3179	42	157	0.2144	32	212	-0.3579	333	267
0.3673	250	103	0.3175	309	158	0.2141	35	213	-0.3655	119	268

Continue on the next page

Table 3: The Rank of models in the present research

Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank	Score of GPI	Model	Rank
-0.3667	169	269	-0.6563	304	302	-1.3345	363	335	-2.1691	117	368
-0.3675	254	270	-0.6574	324	303	-1.3367	380	336	-2.2452	167	369
-0.3683	269	271	-0.6581	334	304	-1.3372	162	337	-2.2459	252	370
-0.3694	275	272	-0.6587	68	305	-1.3379	257	338	-2.2467	267	371
-0.4115	203	273	-0.6589	101	306	-1.3385	262	339	-2.2477	273	372
-0.4154	51	274	-0.6592	127	307	-1.3654	110	340	-2.2659	220	373
-0.4159	54	275	-0.6595	219	308	-1.3663	136	341	-2.3145	14	374
-0.4163	126	276	-0.6597	240	309	-1.3674	212	342	-2.3149	23	375
-0.4238	176	277	-0.6635	218	310	-1.4524	221	343	-2.3165	305	376
-0.4245	282	278	-0.7456	69	311	-1.4576	71	344	-2.3181	325	377
-0.4259	148	279	-0.7459	201	312	-1.4579	72	345	-2.3199	335	378
-0.4267	151	280	-0.7543	241	313	-1.4582	112	346	-2.3542	170	379
-0.4273	354	281	-0.8571	118	314	-1.4594	210	347	-2.3549	255	380
-0.4583	140	282	-0.8579	149	315	-1.5641	16	348	-2.3562	270	381
-0.5247	48	283	-1.1954	86	316	-1.5649	298	349	-2.3577	276	382
-0.5425	30	284	-1.2326	247	317	-1.5654	318	350	-2.3585	186	383
-0.5473	227	285	-1.2358	13	318	-1.5665	328	351	-2.3593	187	384
-0.5482	141	286	-1.2452	15	319	-1.5742	236	352	-2.3624	222	385
-0.5549	153	287	-1.2459	327	320	-1.6549	25	353	-2.3635	286	386
-0.5564	356	288	-1.2547	87	321	-1.6587	40	354	-2.3641	374	387
-0.5892	104	289	-1.2563	113	322	-1.6589	62	355	-2.3652	375	388
-0.6245	76	290	-1.2574	137	323	-1.6592	121	356	-2.3669	387	389
-0.6327	154	291	-1.2582	122	324	-1.6595	172	357	-2.3672	388	390
-0.6329	204	292	-1.3254	217	325	-1.6599	213	358	-2.3685	393	391
-0.6333	226	293	-1.3267	24	326	-1.6624	278	359	-2.3697	394	392
-0.6339	348	294	-1.3269	39	327	-1.6635	307	360	-2.456	111	393
-0.6347	357	295	-1.3275	171	328	-1.6641	337	361	-2.4584	161	394
-0.6356	366	296	-1.3283	256	329	-1.6657	364	362	-2.4593	67	395
-0.6367	398	297	-1.3288	271	330	-1.6674	381	363	-2.4632	120	396
-0.6528	191	298	-1.3294	277	331	-2.1465	20	364	-2.4647	61	397
-0.6537	295	299	-1.3299	306	332	-2.1491	302	365	-2.5874	211	398
-0.6548	22	300	-1.3314	326	333	-2.1556	322	366	-2.6582	70	399
-0.6552	89	301	-1.3325	336	334	-2.1683	332	367	-3.2561	243	400

$$\text{RMSRE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[(H_{i,m} - H_{i,c})/H_{i,m}\right]}^{2} \tag{9}$$

$$R^2 = 1 - \sum_{i=1}^{n}\left[\frac{(H_{i,m} - H_{i,c})^2}{\sum_{i=1}^{n}\left(H_{i,m} - H_{m.\ avg}\right)}\right] \times 100 \tag{10}$$

$$\text{t-Test} = \frac{\sqrt{(n-1)\,(MBE)^2}}{\sqrt{(RMSE)^2} - \sqrt{(MBE)^2}} \tag{11}$$

4. Uncertainty at 95% (U_{95})

The expanded uncertainty in the 95% confidence interval is using to represent the data of the model deviation [36].

$$U_{95} = 1.96(SD^2 + RMSE^2)^{1/2} \tag{12}$$

Among them, SD is the percentage standard deviation (W/m^2) of the difference between the predicted value and the measured value. In the above formula, 1.96 is the coverage factor corresponding to the 95% confidence interval.

5. Global Performance Index (GPI)

The Global Performance Indicator (GPI) is a statistical indicator. The values of the statistical indicators have to be scaled down between zero and one, with the median value being subtracted from the scaled value of the individual statistical indicators. Finally, using the appropriate weight factor for individual statistical indicators, GPI is obtained. The mathematical expression for GPI_i of the *ith*model is defined as [36]:

$$GPI_i = \sum^{1} 0_{j=1} \alpha j \left(\tilde{Y}_j - Y_{ij}\right) \quad (13)$$

where αj equals to (-1) for the statistical indicator coefficient of determination, while for all other statistical indicators it is equal to 1, $\tilde{Y}_j$ is the median of scaled values of indicator j, Y_{ij} is the scaled value of indicator j for model i. A higher value of GPI represents better accuracy of the model.

6. Evaluation of GSR modeling

According to a review of the literature, the sunshine hour is the most widely used parameter for calculating the monthly average global photovoltaic radiation (MADGSR). The following variables (either single or in combination) are viewed whilst deciding on the world photovoltaic radiation (GSR) models; Sunshine Hour, Latitude and Sunshine Hour, Altitude and Sunshine Hour, Latitude, altitude and sunshine hour, Latitude, longitude, altitude and sunshine hour, Latitude, longitude and sunshine hour. The GSR fashions chosen from the literature are in a range of varieties (linear, quadratic, cubic, power, exponential, logarithmic, and greater order). Throughout the method of a GSR fashion resolution, care has been taken to avoid models that characterize a widespread deviation from the measured value.

Table 1 shows that the 400 models of GSR are used in the current lookup for calculation of monthly to daily world photovoltaic radiation on a horizontal surface. The symptoms of the statistical evaluation of four hundred GSR fashions have been carried out and considered for unique chosen areas over Egypt to the use of the statistical error checks as noted in desk two Without the coefficient of dedication (R 2), the best price for all statistical error exams is zero. The ratio of world photovoltaic radiation to that of extraterrestrial photovoltaic radiation is recognized as the clearness index (H/H_o). Table 2 shows that the results of the statistical indicators viewed in the current lookup were once shocking to see that character statistical check estimate in exceptional fashion. The negative sign values of (MBE) and (MPE) indicated overestimation, while positive signs indicated underestimation as compared to the measured values. From the table we notice that the values of MBE, RMSE, MPE, MARE, MAE, RMSRE, and t-Test vary between (5.632 to -3.875, 5.689 to 1.245, 15.362 to-29.356, 0.985 to 0.158, 5.785 to 1.214, 0.658 to 0.068, and 4.469 to 0.124) respectively.

Table 3 shows the rank of the GSR Model based on the Global Performance Indicator (GPI). According to table 3, the most accurate model for the selected locations in the current study is model no 272 (GPI = 0.8652), which ranked first among all GSR models considered in the current study and was proposed by the Rietveld model. The GSR model 215 (0.8575), which was proposed by Gana and Akpotu, is ranked second, and model no. 231 (0.8468), which ranks third amongst the entire GSR models considered in the present studies. Also from table 3, we see that the GPI score varies between 0.8652 and 3.2561 for the entire models considered in the present study. The GSR model 243 shows the worst ranking, having a GPI score of −3.2561.

Table 4. The information of selected sites in the present study

Location	WMO No.	Lat. (^{0}N)	Lon. (^{o}E)	Elevation (m)
Marsa-Matrouh	62.306	31.20	27.13	25
Asyut	62.392	27.12	31.30	52
Aswan	62.414	23.58	32.47	192

7. A case study

7.1. Observations and experimental Data Used

Observations of the global solar radiation have been carried out by an Eppley normal incidence pyranometer. Its title implies that it is designed for the dimension of world photovoltaic radiation. It is already mentioned that the essential goal of this research is to comprehensively accumulate and evaluate the international photovoltaic radiation fashions reachable in the literature and categorize them primarily based on the employed meteorological parameters. In order to consider the applicability and accuracy of the amassed fashions for computing the month-to-month common day-to-day international photovoltaic radiation on a horizontal surface. The Asyut site is called the urban site, and the Aswan location is called the western desert. The information of the selected locations in the present research is summarized in table 4 and figure 1.

In the present research, the values of measured data of daily global solar radiation on a horizontal surface in the different selected locations during the period 1980–2019 are obtained from the Egyptian Meteorological Authority (EMA). The measured global solar radiation data was checked and controlled for errors and inconsistencies. The purpose of data quality control was to eliminate faulty data and inaccurate measurements. After the quality control, the measured data was averaged to obtain the monthly mean daily values by taking the data for the average day of each month. The measured data was then divided into two sets. The first sub-data set from 1980 to 2019 was employed to develop empirical correlation models between the monthly average daily global solar radiation fraction (H/H_0) and the monthly average of desired meteorological parameters. The second sub-data set from 2015–2019 was then used to validate and evaluate the derived models and correlations.

8. Results and Discussion

Figure 2 shows the spatial distribution of the long-term monthly mean of the GSR time series in the present research during the climate study period 1980–2019 over Egypt. It is noticed that the GSR increases towards the south during all months. During winter months, the GSR fluctuates from 11.25 to 9.35 MJ/m^2 in December, from 10.82 to 8.95 MJ/m^2 in January, and from 16.95 to 12.41 MJ/m^2 in February in the selected locations in the present study. During spring months, the GSR values increase markedly from March (17.91-21.39 MJ/m^2) through April (21.29-24.89 MJ/m^2) up to May (24.92-28.75 MJ/m^2). During summer months, GSR is maximum (27.52-31.65 MJ/m^2) in Jun followed by July (25.1-28.46 MJ/m^2) and August (21.35-24.71 MJ/m^2). During autumn months, the monthly GSR is similar to winter months, where September has the maximum values in (17.27-21.91 MJ/m^2) followed by October (14.39–19.25 MJ/m^2) and November has the minimum values (11.81–14.86 MJ/m^2). Also from figure 1, we indicate that the values of the GSR are nearly zonal during most of the winter and autumn months, while it has a different spatial distribution (not zonal) in the spring and summer months. Moreover, the Egyptian Nile Delta location is frequently included in the lowest GSR values for the duration of all months, which might also be due to the excessive population and current of city and industrial areas that multiplied the attention of aerosol air pollution. On the other hand, the highest values of the GSR are detected over south Egypt due to low latitude. The monthly variation of the GSR values is due to changes in the atmospheric properties; the prevailing weather pattern in winter is the middle latitude, and the formed clouds reduce the direct sunlight with low atmospheric turbidity. The relation between the average monthly clearness index versus sunshine duration ratio is clear in figure 3. It is clearly observed that a positive linear association exists between the clearness index and sunshine duration ratio. The evaluation of developed correlations in estimating the global solar radiation on the horizontal surface is assessed by comparing each model's outputs and using the top ten models according to the rank order, which is found in table 5. The measured values from the second subset of data from 2015 to 2019 based on the RMSE, MBE, MABE, R, MPE, and t-Test are summarized in table 5. The statistical indicators listed in this table generally provide reasonable criteria to compare models but do not objectively indicate whether the estimates from a model are statistically significant. The t-statistic (Eq. 11) allows models to be compared and, at the same time, indicates whether a model's estimate is statistically significant at a particular confidence level or not.

The smaller the t-value, which gives the accuracy of the model performance, A summary of all the statistical parameters is present in table 5. For higher modeling accuracy, RMSE, MBE, ABE, and MPE indices should be closer to zero, but the correlation coefficient (R) should approach one as closely as possible. The performance of the most accurate models in each category for estimating the monthly average daily global solar radiation in selected locations in the present research is present and compared in table 5. From the statistical analysis, it can be seen that the estimated values of monthly mean daily global solar irradiation are in good agreement with the measured values for all models in the selected sites.

It is found that the values of RMSE are in the range of 1.145 to 2.895 (in MJ/m^2 day) in the selected sites in the present research. The MBE achieved in this study for all models is in the acceptable range. Negative values of MBE in temperature and cloud-based models indicate an underestimation of measured global solar radiation by these models. As an overestimation of an individual observation may cancel an underestimation in a separate observation, using the MABE index is more appropriate than using MBE. The mean percentage errors (MPE) of all models are in the range of acceptable values between 1.178% and - 1.129%.

Also, according to the statistical test of the correlation coefficient (R), for all models, very good results are given (above 0.92). The highest values of correlation coefficient according to models (M 272, M 261, M 238 and M 251) are 0.998, 0.996, 0.987, and 0.982 respectively for the Marsa-Matrouh site, while for the Asyut location it is (0.992, 0.987, 0.975, and 0.971), but (0.995, 0.992, 0.971, and 0.969) for the Aswan site. Also, from table 5, it is indicated that, the smallest values of t-Test occur around the models (M 272, M 261, M 251, and M 238) for all selected sites in the present research. This means that these models have good accuracy for predicting the monthly global solar radiation (GSR) in the selected sites during the period of 2015 to 2019 and compare with measured data in the

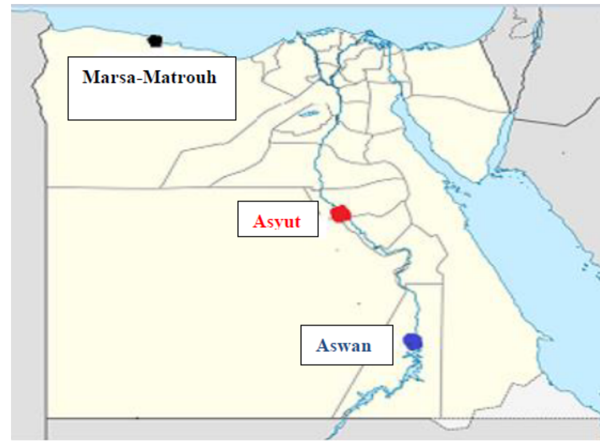

Figure 1. Map of the selected sites in the present study

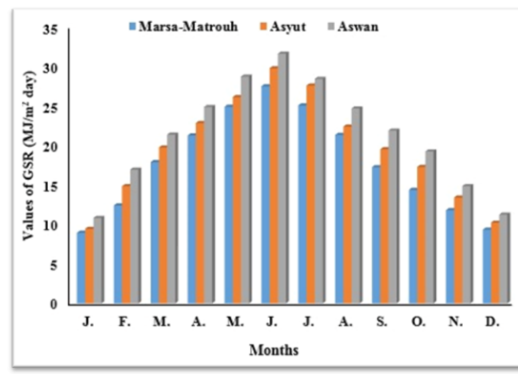

Figure 2. The measured values of monthly average daily global solar radiation for the selected sites during the period from 1980 to 2019 in the present research

Table 5. The evaluation models by using statistical indicators results during the period time from 2015 to 2019 in the present research

Marsa-Matrouh										
Model	M272 (Rank 1)	M215 (Rank 2)	M231 (Rank 3)	M205 (Rank 4)	M166 (Rank 5)	M234 (Rank 6)	M251 (Rank 7)	M261 (Rank 8)	M287 (Rank 9)	M238 (Rank 10)
MBE	-1.356	2.356	-2.854	-2.248	1.547	-2.857	-1.789	2.345	-1.658	1.985
RMSE	1.329	1.325	1.235	2.895	1.357	2.356	2.114	1.598	1.654	1.245
MPE%	-2.547	1.958	2.687	-1.785	-3.456	1.985	2.356	-2.547	-1.874	-1.548
MABE	1.658	1.235	2.589	1.325	1.257	2.315	1.325	1.487	1.347	1.198
R^2	0.998	0.948	0.947	0.938	0.924	0.918	0.982	0.996	0.968	0.987
t-Test	0.121	0.245	0.368	0.457	0.365	0.541	0.127	0.122	0.169	0.125
Asyut										
Month	M272 (Rank 1)	M215 (Rank 2)	M231 (Rank 3)	M205 (Rank 4)	M166 (Rank 5)	M234 (Rank 6)	M251 (Rank 7)	M261 (Rank 8)	M287 (Rank 9)	M238 (Rank 10)
MBE	1.568	-2.378	-1.658	1.658	-1.875	1.586	-2.356	-1.856	2.356	-1.524
RMSE	1.215	2.356	1.245	1.456	2.387	1.145	2.456	1.654	2.345	1.115
MPE%	-1.235	-2.654	1.658	1.324	-1.985	2.345	1.178	1.325	1.456	-1.325
MABE	1.325	1.198	1.654	2.312	1.658	1.325	1.235	1.115	1.245	1.102
R^2	0.992	0.932	0.958	0.928	0.947	0.958	0.971	0.987	0.954	0.975
t-Test	0.114	0.542	0.329	0.412	0.524	0.328	0.124	0.118	0.165	0.138
Aswan										
Month	M272 (Rank 1)	M215 (Rank 2)	M231 (Rank 3)	M205 (Rank 4)	M166 (Rank 5)	M234 (Rank 6)	M251 (Rank 7)	M261 (Rank 8)	M287 (Rank 9)	M238 (Rank 10)
MBE	-1.179	1.325	-1.325	-2.314	-1.354	1.247	-1.289	1.327	2.158	-1.248
RMSE	1.234	2.128	1.189	1.624	2.214	1.278	1.301	1.425	1.356	1.369
MPE%	-1.129	-2.189	1.412	1.547	-1.254	2.148	1.245	-1.658	-1.309	-1.415
MABE	1.214	1.235	1.325	2.127	1.324	1.191	1.168	1.325	1.114	1.208
R^2	0.995	0.947	0.947	0.938	0.939	0.967	0.969	0.992	0.972	0.971
t-Test	0.132	0.358	0.411	0.314	0.419	0.289	0.147	0.132	0.185	0.141

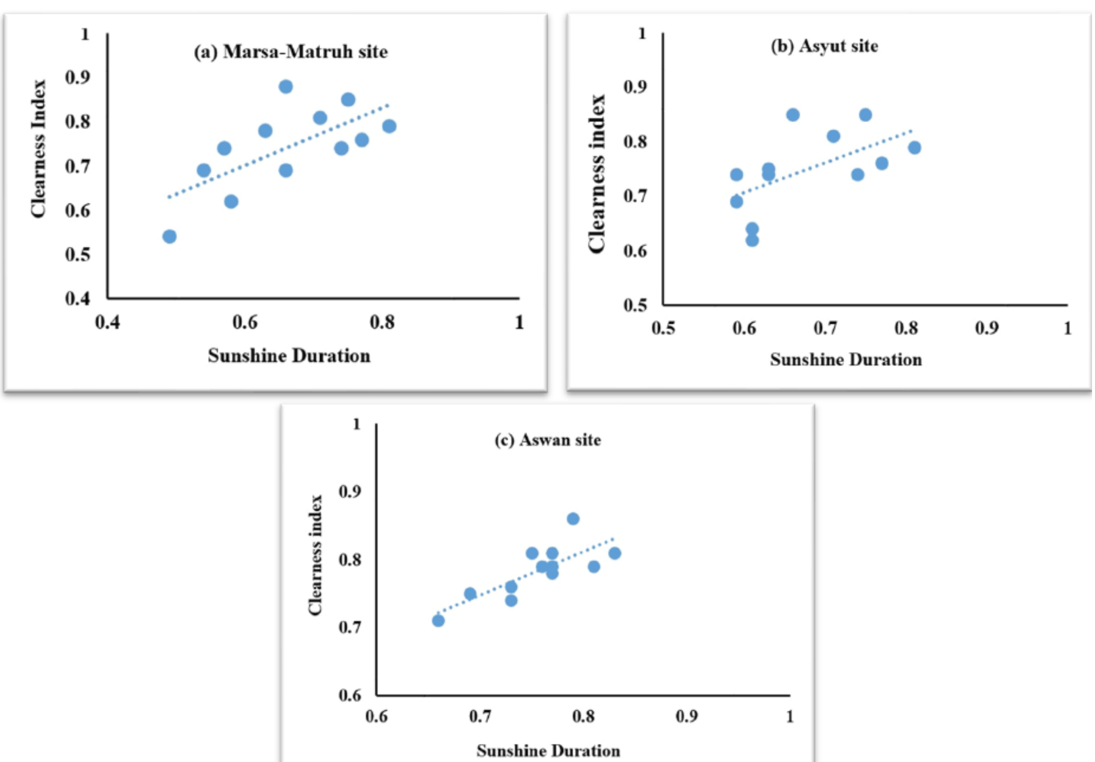

Figure 3. Average monthly of clearness index versus with sunshine duration ratio in the present study during the period time 1980 to 2019

same period of the present research. The measured values of the monthly average daily global solar radiation and corresponding calculated values by employing the Coulibaly and Ouedoraogo model (M 238) [124], Katiyar et al. model (M 251) [127], Aras et al. model (Model 261) [94] and Rietveld model (M 272) [29] for the selected locations in the present study are illustrated in figure 4. As may be seen, agreement between the values obtained from the selected models and the measured data is very good with the highest accuracy.

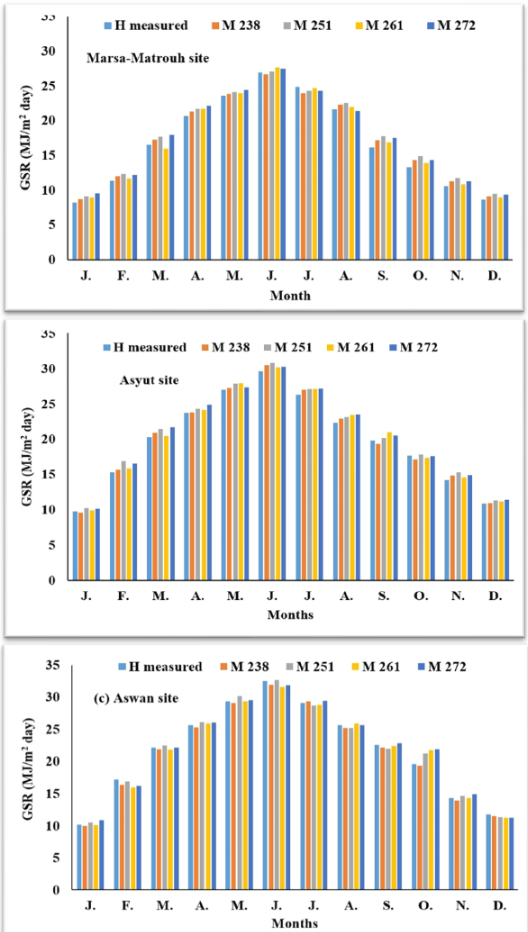

Figure 4. Comparison between measured and calculated values of monthly average GSR models for selected sites in the present study from 2015 to 2019

9. Conclusion

A global study of the global distribution of global solar radiation (GSR) requires knowledge of the radiation data in various countries. For this purpose, the designers and manufacturers of photovoltaic gear will want to recognize that in the ordinary world, photovoltaic radiation is on hand in exceptional regions. Solar energy technologies offer opportunities for use of a clean, renewable, and domestic energy resource and are essential components of a sustainable energy future.

In the present research, a quantitative review of literature on global solar radiation (GSR) models available for different stations around the world is discussed. The statistical analysis of 400 existing sunshine-based GSR models on a horizontal surface is compared using 40-year meteorological data in the selected locations in Egypt (Marsa-Matrouh, Asyut, and Aswan). Furthermore, to evaluate the accuracy and applicability of the various models for estimating the monthly average daily global radiation on a horizontal surface, the long-term measured meteorological and solar data for the selected site in the preset work is employed.

The developed models are then compared with each other and with the experimental data of the second subset based on the statistical error indicators such as RMSE, MBE, MABE, MPE, and correlation coefficient (R). In the present research, the measured data was then divided into two sets. The first sub-data set from 1980 to 2019 was used to develop empirical correlation models between the monthly average daily global solar radiation fraction (H/H_0) and the monthly average of desired meteorological parameters. The second sub-data set from 2015–2019 was then used to validate and evaluate the derived models and correlations. The monthly variation of the GSR values is due to changes in the atmospheric properties; the prevailing weather pattern in winter is the middle latitudes, and the formed clouds reduce the direct sunlight with low atmospheric turbidity.

It is established that there is a relationship between the average monthly clearness index and the sunshine duration ratio. It is clearly observed that a positive linear association exists between the clearness index and sunshine duration ratio. According to the statistical analysis, the estimated values of monthly mean daily global solar irradiation for all models at the selected sites are in good agreement with the measured values. It is found that the values of RMSE are in the range of 1.145 to 2.895 (in MJ/m^2 day) in the selected sites in the present research. The MBE achieved in this study for all models is within the acceptable range.

Negative values of MBE in temperature and cloud-based models indicate an underestimation of measured global solar radiation by these models. As an overestimation of an individual observation may cancel an underestimation in a separate observation, using the MABE index is more appropriate than using MBE. The mean percentage errors (MPE) of all models are in the range of acceptable values between 1.178% and - 1.129%. Also, according to the statistical test of the correlation, coefficient (R), for all models, very good results are given (above 0.92). The highest values of correlation coefficient according to models (M 272, M 261, M 238 and M 251) are (0.998, 0.996, 0.987, and 0.982) respectively for the Marsa-Matrouh site, while for the Asyut location are (0.992, 0.987, 0.975, and 0.971), and (0.995, 0.992, 0.971, and 0.969) for the Aswan site. The smallest values of t-Test occur around the models (M 272, M 261, M 251, and M 238) for all selected sites in the present research.

This means that these models have good accuracy for predicting the monthly global solar radiation (GSR) in the selected sites during the period of 2015 to 2019 and can be compared with measured data in the same period of the present research. The accuracy of each model is tested using ten different statistical indicator tests. Furthermore, the Global Performance Indicator (GPI) is used to rank the selected GSR models. According to the results, the Rietveld model (Model 272) has shown the best capability to predict the GSR on horizontal surfaces, followed by the Katiyar et al. model (Model 251) and the Aras et al. model (Model 261). The findings of this study are particularly valuable for developing international locations and remote areas where there are few metrological stations available due to high technology costs.

Nomenclature

I_{sc} = Solar Constant (= 1367 W/m^2).
H = Monthly average daily global solar radiation (MJ/m^2).
H_0 = Monthly average daily extraterrestrial solar radiation (MJ/m^2).
$H_{i,cl}$, $H_{i,m}$ = i^{th} estimated and measured value of monthly average daily global solar radiation (MJ/m^2).
S = Monthly average daily bright sunshine hour.
S_0 = Monthly average daily maximum sunshine hour.
h = Altitude.
n = Day of year.

Abbreviations

GSR = Global Solar Radiation.
MADGSR = Monthly Average Daily Global Solar Radiation.
MBE = Mean Bias error.
RMSE = Root mean squared error.
MPE = Mean percentage error.
MARE = Maximum absolute relative error.
MAE = Mean absolute error.
RMSRE = Root mean square error.
R^2, Correlation coefficient.
t-Test = T-statistic.
GPI = Global Performance Indicator.
U_{95} = Uncertainty at 95%.

Greek letter

Ψ = Longitude (degree).
ϕ = Latitude (degree).
ω_s = Sunshine hour angle (degree).
δ = Declination angle (degree).
a & b = Coefficient constant.

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