ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 10, pp.74547-74553, October, 2018

DOI: https://doi.org/10.24941/ijcr.32752.10.2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

DETERMINATION AND MAPPING OF CLIMATIC PARAMETERS OF A COUNTRY WITH A DRY TROPICAL CLIMATE FOR THE ENERGY STUDY OF THE SYSTEMS

[1]Oumar Bailou, [2, 3]*Emmanuel Ouédraogo, [1]Ousmane Coulibaly and [1]Alfa Oumar Dissa

[1]Laboratoire de Physique et Chimie de l'Environnement, Université Ouaga I Pr Joseph, KI-ZERBO, 03 B.P. 7021, Ouagadougou, Burkina Faso

[2]Laboratoire d'Energies Thermiques Renouvelables, Université Ouaga I Pr Joseph, KI-ZERBO, 03 B.P. 7021, Ouagadougou, Burkina Faso

[3]Département de Physique-Chimie, Unité de Formation et de Recherche en Sciences et, Technologies, Université de Ouahigouya, Burkina Faso

ARTICLE INFO

Article History:
Received 16th July, 2018
Received in revised form
27th August, 2018
Accepted 24th September, 2018
Published online 31st October, 2018

Key words:

Cooling Degree Days, Insolation, Relative Humidity, Maximal Temperature, correlation, Map, Global Radiation, Climate zoning.

ABSTRACT

This article presents the study on the determination of climatic parameters used in sizing of solar and thermal systems. Our work aimed at determining the air temperature, the relative humidity of the air, the insolation period and the global solar radiation of several localities of Burkina Faso. These weather data have been obtained over 30 years from ten (10) synoptic stations. The averages of these parameters have been calculated. From these averages, we have proposed the correlations between climatic parameters and geographical coordinates. We have also determined the geographical coordinates of 162 sites throughout the national territory. From the correlations, we determined four (04) climatic parameters of 162 sites. A zoning has been proposed for each climatic parameter and for all four (04) weather parameters.

Citation: Oumar Bailou, Emmanuel Ouédraogo, Ousmane Coulibaly and Alfa Oumar Dissa. 2018. "Determination and mapping of climatic parameters of a country with a dry tropical climate for the energy study of the systems", *International Journal of Current Research*, 10, (10), 74547-74553.

INTRODUCTION

The rising costs of conventional energy on the one hand, and the limitation of their resources on the other hand, have made renewable energy, a solution among promising energy options with benefits like abundance, the absence of any pollution and permanent availability. Currently, there is an interest in solar equipment installations, especially for isolate localities. However, sizing solar equipment and thermal requires the knowledge of basic climate data such as temperature, relative humidity, insolation and global irradiation. It is in this sense that we have determined the climatic parameters of several localities in Burkina Faso and we have proposed the map of each parameter. Several approaches have been used for climatic parameters zoning. In particular the map of climatic parameters of the Island have consisted firstly a zoning by climatic variable such as: pluviometry, thermometry and insolation.

Corresponding author: **Emmanuel Ouédraogo,**
Laboratoire de Physique et Chimie de l'Environnement, Université Ouaga I Pr Joseph, KI-ZERBO, 03 B.P. 7021, Ouagadougou, Burkina Faso.

Then, observing that the climatic characteristics of Island vary greatly according to the altitude, and they have proposed a zoning by altitude as a result: 0 - 400 m, 400 - 800 m, and 800 m and beyond (Perene, 2004). For Morocco, the method has consisted to subdividing into homogeneous climatic zones while being based on an analysis of climate data recorded by 37 stations over 10 years. This method has allowed to gather stations that have averages and variabilities similar to the maximum for a given class. Thus, the classes obtained must correspond to homogeneous zones. For that, two zonings are made: a zoning for winter and a zoning for the summer and then combined for a single zoning (ADEREE, 2011).For Tunisia, the climatic zoning has carried out on the basis of the extreme values of certain climatic parameters. During the coldest months (December, January, February) and the hottest months (June, July, August). The identification of the contours of the zones has based on the normal of certain climatic parameters calculated over the period from 1970 to 1985 for each of the two seasons (the cold season and the hot season). Tunisia's approach has been to determine the climate data of the available weather stations. From these data, a correlation between these climatic parameters and the geographical coordinates of several localities has been proposed (ANER, 2003). In Burkina Faso, the collection of 30 years climate data has made it possible to determine a correlation between climate parameters and their geographical coordinates (Coulibaly, 2011). For our work, we have considered the approach of Tunisia. The study have based on the correlations established by (Coulibaly, 2011) to determine the climatic parameters of several localities in Burkina Faso. Knowing their geographical coordinates, zonings are proposed for each climatic parameter, from which a single climatic zoning has been realize.

MATERIALS AND METHODS

The collection of climate data: The climatic data such as temperature, insolation, relative humidity and global radiation has been collected during 30 year at metrology center of Burkina Faso. Figure 1 shows the geographical position of the ten (10) synoptic stations in Burkina Faso.

Where T_{hr} is the hourly temperature recorded during each day of the month in question and for each year taken into account; T_{bre} the basic cooling temperature. The + sign indicates that only positive values are taken in account. That is if $T_{hr}<T_{bre}$, then CDD=0

$$CDD = \frac{1}{24}\sum\left[T_{hd} - T_{bc}\right]^{+} \tag{1}$$

Where T_{hr} is the hourly temperature recorded during each day of the month in question and for each year taken into account; T_{bre} the basic cooling temperature. The + sign indicates that only positive values are taken in account. That is if $T_{hr}<T_{bre}$, then CDD=0. The collected temperature data has used to calculate the day cooling days at 26 ^{o} C. Where 26 ^{o} C is the reference base temperature for thermal comfort in the building in tropical zone (Coulibaly, 2011).Table 1 presents the average values of the climatic parameters and the values of the cooling day degree.

Determination of correlations: Correlations have determined using the multiple linear regression method (Skeiker, 2006). This method is a statistical tool for studying multidimensional data. A quantitative variable y (result) is related to p quantitative independents variables $x_1,\dots,x_p$. The correlation is given by equation 2.

$$y = ax_1 + bx_2 + cx_3 + dx_4 + ex_5 \tag{2}$$

Where a, b, c, d, e are regressions coefficients and x_1, x_2, x_3, x_4 and $x_5$are correlation parameters. Using the multiple linear regression method, the correlations between each climatic parameter and the geographic coordinates of the place have been proposed (Coulibaly, 2011):

$$DJR = -1437{,}99 + 193{,}26la - 21{,}62long - 0{,}088h \tag{3}$$

With $R = 0{,}9786$

$$Hr = 46{,}95 + 2{,}20la + 2{,}81long - 0{,}17h - 100{,}90\log(la) - 3{,}75\log(long) + 47{,}89\log(h) \tag{4}$$

With $R = 0{,}8926$

$$N = 78{,}52 + 2{,}94la - 0{,}35long + 0{,}016h - 32{,}28\log(la) + 0{,}36\log(long) - 5{,}231\log(h) \tag{5}$$

With $R = 0{,}8926$

$$T_{\max} = 212{,}98 - 1{,}60la + 0{,}05long + 0{,}15h + 32{,}96\log(la) + 0{,}28\log(long) - 49{,}47\log(h) \tag{6}$$

With $R = 0{,}8336$

$$RG = -7893{,}86 - 6674{,}53la - 190{,}58long + 17{,}45h + 91205{,}23\log(la) + 436{,}54\log(long) - 9308{,}411\log(h) \tag{7}$$

With $R = 0{,}8519$

Where R is regression coefficient; la is latitude; $long$ is longitude and h is altitude.

RESULTS AND DISCUSSION

With the correlations defined above, we have determined the meteorological parameters of 162 localities using their distributed geographic coordinates as shown in Figure 2: For the maximum temperature, we proposed three (03) zones:

Zone I: It occupies the south of the country, it is characterized by a temperature varying between 34.98 and 37.32 ° C, with an average temperature of 36.15 ° C. This is the part that records the low temperatures of the country.

Zone II: It extends from west to east while crossing the central part of the country and it is characterized by a temperature between 37.32 ° C and 39.66 ° C and average temperature is 38.49 ° C.

Zone III: It extends over the North frontal zone. It is characterized by a temperature between 39.66 and 42 ° C. In this part we record the high temperature. We remark some pockets with high temperatures range from 42 to 44.34 ° C. This is because these pockets are locating desert or mountainous. Figure 4 shows the degree day of cooling (CDD) at 26 ° C, where 26 ° C is the basic temperature indicated for the search for thermal comfort in a building in Sahelian zone. The degree day of cooling at 26 ° C has also been grouped into four zones:

Zone I: It extends over the southern part of the country. It is characterized by a CDD between 360.14 and 611.43 °C with an average of 485.78 °C. This is the area of the country that requires less energy for cooling a building.

Zone II: It is characterized by CDD between 611.43 °C and 862.71 °C with an average of 737.5 °C.

Zone III: It is characterized by a CDD between 862.71 °C and 1114 °C, with an average of 988.35 °C.

Zone IV: It is characterized by a CDD higher than 1114 °C, with an average of 1239.64 °C

Figure 5 shows the zoning of the average insolation

For the duration of insolation, we have grouped it into four zones:

Zone I: Insolation is between the 7.01h and 7.58h with average insolation 7.3 h. This is the part of the territory where there is an insolation low.

Zone II: It is characterized by an insolation between 7.58 h and 8.15 h with an average 7.87 h.

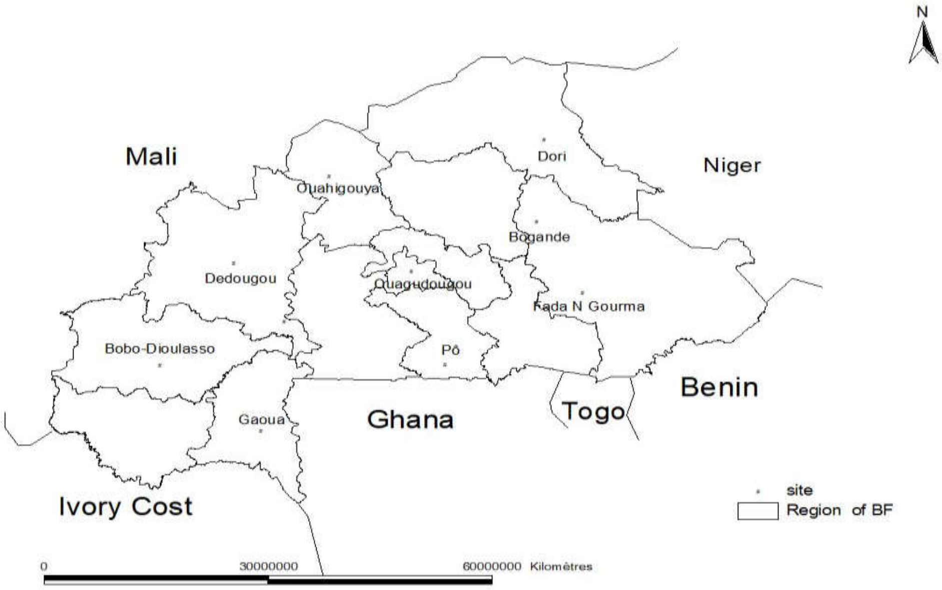

Figure 1. Meteorological stations of Burkina Faso

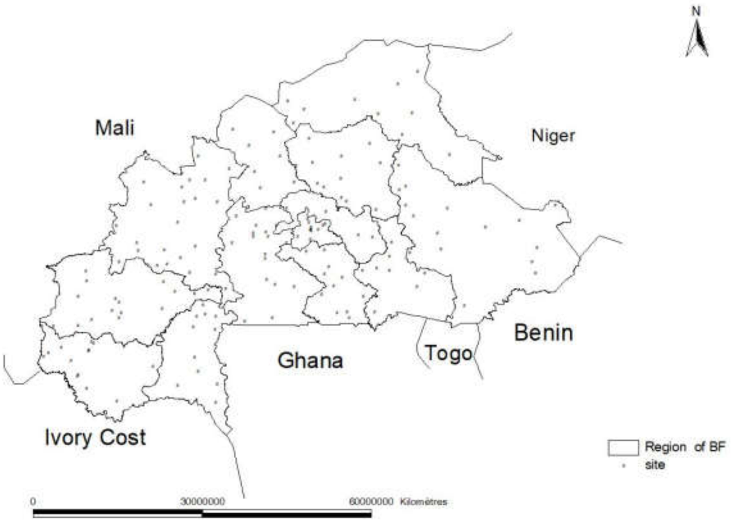

Figure 2. Localities considered for simulation

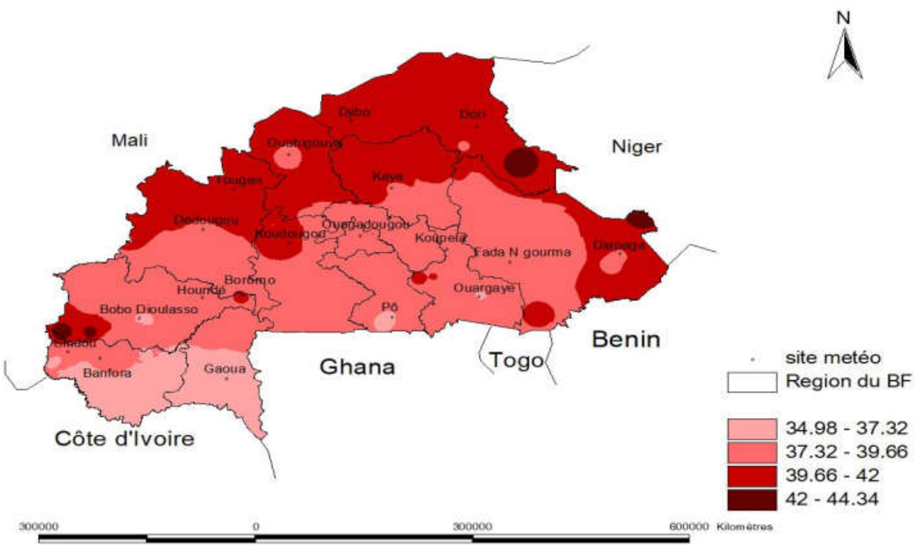

Figure 3. Map of the maximum temperature

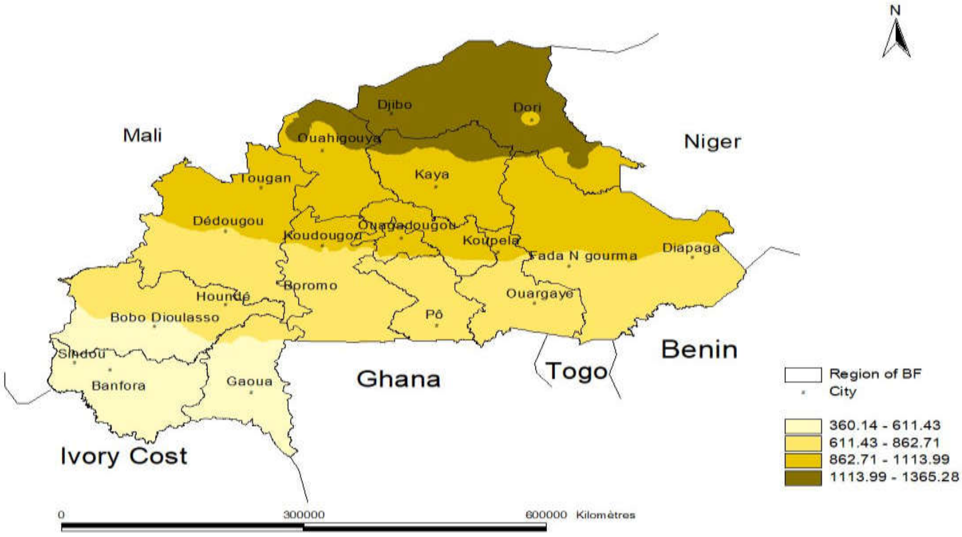

Figure 4. Map of the degree of cooling at 26 °C

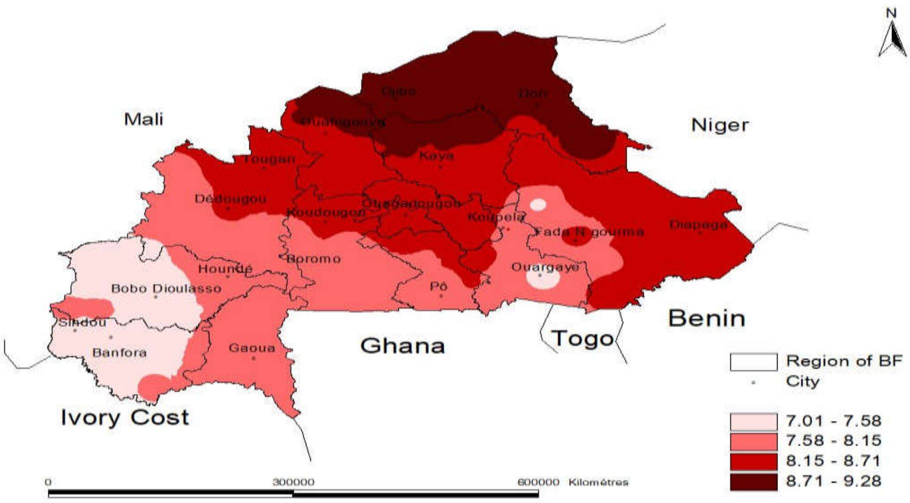

Figure 5. Map of the Insolation

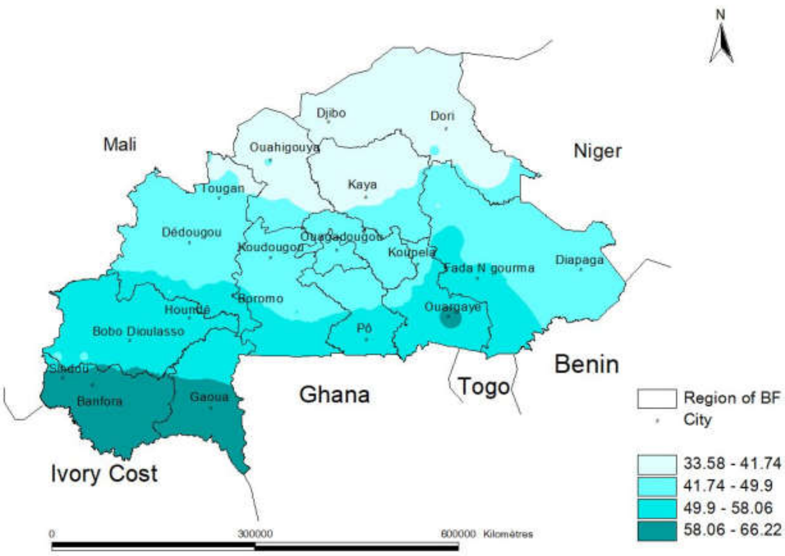

Figure 6. Map of the relative humidity

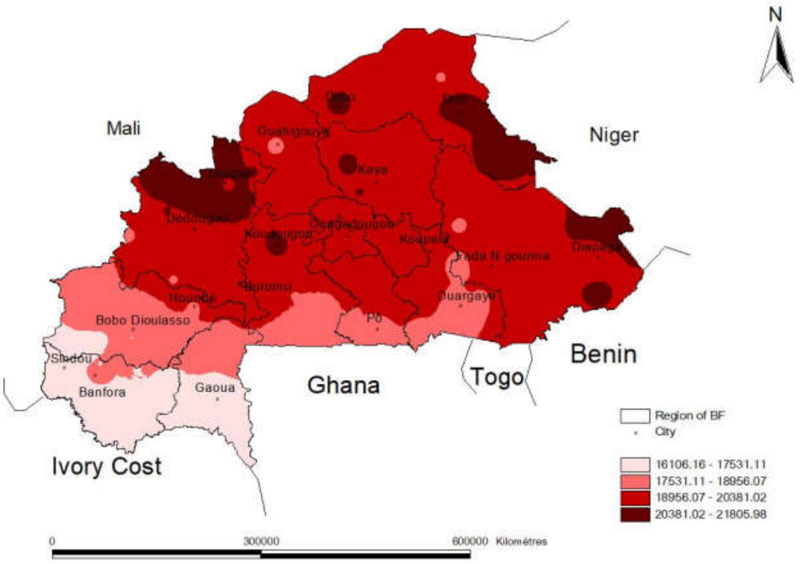

Figure 7. Map of the global radiation

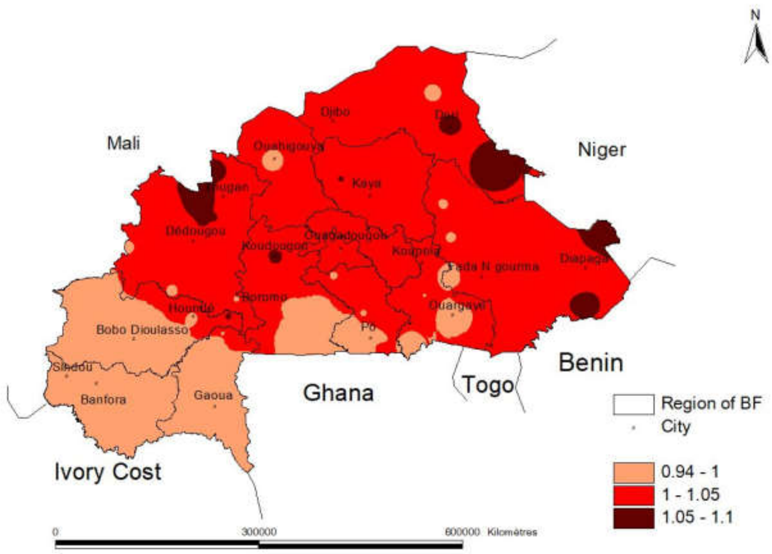

Figure 8. Map of the climate zoning

Table 1. Determination of average climate parameters

Stations	Cooling degree days	Insolation (h)	relative Humidity (%)	Maximaltemperature (°C)	global radiation (kJ/(m^2.day))
Ouagadougou	840,37	8,37	48,08	37,60	18528
Dori	1087,87	8,92	37,91	40,44	21806
Ouahigouya	948,93	8,60	42,00	38,66	18326
Dedougou	835,99	8,55	47,39	37,97	19136
Bogande	898,51	8,54	41,57	37,78	19338
Fada	776,42	8,38	51,25	37,41	19454
Bobo-Dioulasso	521,95	7,58	57,96	34,98	18608
Boromo	780,61	7,63	52,14	37,51	19158
Po	654,23	8,01	55,01	36,17	18474
Gaoua	553,97	8,09	62,48	35,37	16842

Table 2. Weight of the climatic parameters

Climatic Parameters	Global radiation	Maximal Temperature	Relative humidity	Insolation
Statistical weight	1/2	1/4	1/8	1/8

Zone III: It is characterized by duration of sunstroke between 8.15 h and 8.7 h with an average insolation of 8.42 h.

Zone IV: It is characterized by an insolation greater than 8.7 h with an average 8.99 h.

Figure 6 shows the relative humidity zoning

The relative humidity zoning map is subdivided into four (04) zones:

Zone I: It is characterized by a relative humidity between 58.06 % and 66.22 % with average 62.11%.

Zone II: It is characterized by a relative humidity between 49.9 and 58.06% with average 54%.

Zone III: It is characterized by a relative humidity between 41.74 % and 58.06 % with average 46%.

Zone IV: It is characterized by a relative humidity between 33.58% and 41.74% with average 37.79%.

Figure 7 shows the mapping of the mean global radiation.

The global radiation map is grouped into four (04) zones:

Zone I: It is characterized by an overall radiation is between 16106.17 and 17531 kJ/(m^2.day), with global average radiation 16818.57 kJ/(m^2.day).

Zone II: It is characterized by an overall radiation between 17531 and 18957 kJ/(m^2.day)with average 18244 kJ/(m^2.day).

Zone III: It is characterized by an overall radiation between 18957 and 20382 kJ/(m^2.day), with average 1966 9.5 kJ/(m^2.day).

Zone IV: the global radiation here is between 20381.01 and 21805.96 kJ/(m^2.day) with average 21094 kJ/(m^2.day).

Climate Zoning: The construction of climatic zones was carried out on the basis of the maximum temperature, the relative humidity, the global radiation and the insolation. for practical needs for sizing of solar system ,a single climatic zoning was carried out on the basis of the results of simulations of these four climatic parameters. The climatic parameters do not have the same dimensions (units). to connect them, we have normalize them . To do this, we used the average values of each of these climatic parameters (Insolation: 8.267 h, Radiation: 18967,00 kJ/(m^2.day), Temperature: 37.389 °C, Relative Humidity: 49.579%). The normalize values of the parameters were linked by equation 8 using statistical weights.

$$x = \alpha \cdot HG + \beta \cdot T_{\max} + \gamma \cdot Hr + \lambda \cdot N \tag{8}$$

With $HG = \frac{HG_i}{HG_{moy}}$, $T_{\max} = \frac{T_{\max i}}{T_{\max moy}}$, $N = \frac{N_i}{N_{moy}}$, $Hr = \frac{Hr_i}{Hr_{moy}}$

Where HG: Global Radiation, T_{max}: Maximum Temperature, N: Insolation Duration, Hr: Relative Humidity. And α, β, γ and λ are the respective statistical weights of Global Radiation, Maximum Temperature, Relative Humidity and Insolation Duration. Thusequation 8 becomes:

$$x = \alpha \frac{HG_i}{HG_{moy}} + \beta \frac{T_{\max i}}{T_{\max moy}} + \gamma \frac{Hr_i}{Hr_{moy}} + \lambda \frac{N_i}{N_{moy}} \tag{9}$$

To determine the statistical weights, we consider zero weights for the wind speed. Inspired by literature (Cebecauer and Suri, 2014; Ouedraogo, 2012). We determined the weight of the four (4) other climatic parameters (table 2).In general, we note that Burkina Faso have significant solar radiation. However, the south of the country is less radiated because the humidity in this area is high compared to the north of the country. This increasing of moisture content causes the suspension of the water molecules. These molecules contribute to the reflection of direct radiation. We can see that all the center and the north have important energy potential in addition to some pockets where there is a high solar potential. For the sizing of thermal equipment (kiln, solar concentrator, photovoltaic system ...), the center and the north are appropriate zone because of the high rate of global solar radiation.For the south-west an additional contribution of heat is necessary especially in the case of drying.

Conclusion

This study made possible to propose a climatic zoning in Burkina Faso for sizing the solar systems. The determination of the climatic parameters of ten (10) weather stations over a period of 30 years allowed us to determine the climatic parameters of 162 localities across the country usingthe correlations. These correlations were obtained by the multiple linear regression method. The profile of these parameters allowed us to propose a zoning for each climatic variable. Using statistical weights for each parameter, we proposed a correlation linking the maximum temperature, insolation, the global radiation and the relative humidity. This last correlation allowed us to propose a climatic zoning of Burkina Faso.

REFERENCES

Aderee, 2011. Agence Nationale pour le Développement des Energies et de l'Efficacité Energétique, Règlement thermique de Construction au Maroc (RTCM).

Aner, 2003. Agence Nationale des Energies renouvelables (Tunisie), réglementation thermique et énergétique des Bâtiments neufs en Tunisie : Données climatiques de base pour le dimensionnement de chauffage et de refroidissement.

Cebecauer et T. M. Suri, 2014.Typical Meteorological Year data: Solaris approach, International Conference on Concentrating Solar Power and Chemical Energy Systems, Solar PACES.

Coulibaly, O. 2011. Contribution à l'élaboration d'une réglementation thermique et énergétique des bâtiments au Burkina Faso : Données de base multiparamétriques et modélisation thermo-aéraulique sous CoDyBa et TRNSYS.

Kuznik, F., Virgone J. et K. Johannes, 2010. Development and Validation of a New TRNSYS Type for the Simulation of External Building Walls Containing PCM, Energy and Buildings 42(7) 1004-1009.

Ouedraogo, E., Coulibaly O., et A. Ouedraogo, 2012.Elaboration d'une année météorologique type de la ville de Ouagadougou pour l'étude des performances énergétiques des bâtiments,Revue des Energies Renouvelables 15(1) 77 – 90.

Perene, R. 2004. Performances Energétiques des Bâtiments à La Réunion Rapport final, Règles de conception thermique et énergétique des bâtiments tertiaires et résidentiels adaptées aux zones climatiques de l'Ile de La Réunion, 48 pages.

Skeiker, K. 2006. Correlation of global solar radiation with common geographical and meteorological parameters for Damascus province, Syria, Energy Conversion and Management 47, 331–345.

****