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Bioclimatic Chart Informed Urban Design for Debre Berhan Town

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Abstract

Discomfort occurs when the surrounding average temperature is below 20^{o}C and above 27^{o}C while surround relative humidity is under 20% and above 80% which is Thermal Comfort principles. Due to this, in the case of Debre Berhan, most of the time discomfort was occurred in different seasons and bioclimatic chart of the towns hadn't been developed to get it the cooling demand to employ appropriate strategies that are shown by the bioclimatic chart. Thus, the purpose of this study was to inform Bioclimatic chart of Debre Berhan Town by focusing on developing neutral temperature and measure the thermal sensation of the resident's perception by sematic scale. Both primary and secondary data was analyzed by qualitative and quantitative research approach. Temperature, humidity and air speed were the major types of microclimate data to analyze in TMY (Typical Metrological Year) and perception of the residents by sematic scale. Based on this, the findings of the study indicated that for Debre Berhan town, the neutral temperature of Debre Berhan was 27.17^{o}C which exceeded by 1.16^{o}C from the standard. The sematic scale highlighted that the temperature perception of the residents was slightly cool, with slightly dry humidity and very low wind speed. Finally, the comfort zone is between 11.68^{o}C to 29.24^{o}C. Hence, Debre Berhan town needs cooling strategies especially from June end to January of the year.

Key Words: Bioclimatic Chart, Comfort Zone, Temperature, Humidity, Air Speed

1. Introduction

The state of mind, which expresses fulfillment with the warm environment is known as thermal comfort which is affected by a personal factor (clothing level and metabolic rate) and microclimate factors (temperature, relative humidity, and wind speed and direction) (ASHRAE 55, 2010). According to Olgyay (1963), discomfort occurs when the surrounding average temperature is below 20^{o}C and above 27^{o}C while surround relative humidity is under 20% and above 80% (Olgyay, 1963).

Hypothetically, the human body produces abundance warm into the environment, so the body can proceed to function and exchange warm relative to the temperature distinction. In cold situations, the body loses warmer within the environment whereas in hot situations the body sweats to maintain a strategic distance from abundance warm. Both hot and cold extremes lead to discomfort. Avoiding discomfort of the environment, the inactive cooling frame work is fundamental since it centers on warm pick-up control and warm scattering in a building in arrange to make strides the indoor warm consolation with low or no vitality utilization (Santamouris & Asimakopoulos, 1996). It works either by avoiding warm from entering the insides (warm pick-up avoidance strategies) or by evacuating warm from the building which is called Modulation and heat dissemination procedures (Limb M.J., 1998). Urban geometry plays a primary component in outdoor thermal comfort, solar radiation and ventilation (OKE, 1988). Street orientation is one of the basic factors, which impede wind movement and reduce access of solar radiation. Consequently, it has rather a key impact on the human thermal outdoor comfort. Indeed, the presence of wide-ranging geographical settings is the core barrier that leads the researchers to be more thoughtful with designing street orientation. It is argued that the streets that are directed parallel or at a small angle to the direction of the wind creates undisturbed ventilation. When evaluating north-south orientated streets with east-west oriented streets, it is observed that the east-west orientated streets cast some shades through the hottest period of the day. Nevertheless, streets that are oriented towards east-west are subject to a higher degree of solar radiation throughout the summer, particularly during morning and afternoon hours, when comparing with streets that are oriented towards north-south (Syrios K, Hunt G, 2008). But it should be known the bioclimatic chart of particular urban area to determine the street orientation and the urban form of the settlement layout.

According to Olgyay (1963), human comfort is highly affected by the microclimate component. For these effects, the dominant components are air temperature, radiation, wind speed, and humidity. Human comfort encounters when the boundaries of temperature are between 20°C and 26°C whereas the relative humidity is between 20 and 80%. When the relative temperature is above this, the cooling strategies can control the more heat gain, minimizing the temperature of the surrounding and attempts to lower air temperature towards the comfort zone of the bioclimatic chart (Santamouris & Asimakopoulos, 1996).

Thermal comfort has been characterized by Jan Hensen as ‘‘a state in which there are no driving forces to adjust the environment by the behavior’’ (Jan 1991). The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) characterized it as ‘‘the condition of the mind in which satisfaction is expressed with the thermal environment’’ (ASHRAE 55, 2010). As such, it will be affected by individual contrasts in mood, culture, organizational, and social variables. Based on the above definitions, comfort isn't a state condition, but or maybe a state of mind. The definition of thermal comfort clears out open as to what is implied by the condition of mind or satisfaction, but it accurately emphasizes that the judgment of comfort may be a cognitive process including numerous inputs affected by physical, physiological, mental, and other variables (Lin Z, Deng S, 2008).

According to ASHRAE 55 (2010), current comfort standards are intended to optimize the thermal acceptability of indoor environments. Unfortunately, they have tended to require energy-intensive environmental control strategies and often preclude thermally variable solutions, such as many climates-responsive and energy-conserving designs, or imaginative mechanical techniques that permit for individual control. As a result, maintaining room temperature is mandatory to make a comfortable indoor living environment. A limited studies and reviews have been found on the bioclimatic information of cities and towns in Ethiopia. It is therefore, this study was conducted to generate the vital bioclimatic information of DebireBirhan Town.

2. Material and Method

2.1 Description of Study Area

Debre Berhan is a town and woreda in central Ethiopia. Located in the North Shewa Zone of the Amhara Region, about 120 kilometers north east of Addis Ababa on Ethiopian highway. The town has an elevation of 2,840 meters, which makes it the highest town. The total coverage area of the town is 14.71 km^2 and Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this town has a total population of 65,231, of whom 31,668 are men and 33,563 women. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 94.12% reporting that as their religion, while 3.32% of the population said they were Muslim and 2.15% were Protestants. Debre Berhan is one of the coolest cities found in the subtropical zone of Ethiopia. The city has a typical subtropical highland climate.

2.2 Research Approach

In this study, both quantitative and qualitative data were collected. The temperature, humidity data and wind speed were quantitative, whereas the perception of the resident toward temperature, humidity, and wind speed are qualitative data useful to study the thermal sensational of Debre Berhan Towns.

2.3 Sampling Design

The populatlion of the study was finite but it was unorganized pupulation number from homogenous group of the people who were living in the study area (Debre Berhan). Based on 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), Debre Berhan has totoal population of 65,231.

2.4 Sampling Frame

As described above the population of the the study area was finite however, which was unogranized group of people who are living in the two town. the sampling frame of the study was taken from this unorganized population group who were living in the town as permanent residents, who were working in office and who living in the town at list more than one year.

2.5 Sample size

The parameters to determine the sample size are the characterstics of the population which is homogenous, type of universe is finite because the population number of each town is known based on central statisitcs agency report.

However, it is unorganized homogenous population size which is greater 10,000. Inadditon to this the degree of variability is unkown. When the population is unorganized it may be shifted from finite to infinite due to large number of poulation. Secondly the degree of variability is viceverse with sample size situation. When those points are occurred, Cochran (1977) developed a formula to calculate a representative sample for proportions as

$$n = \frac{z^2 pq}{e^2}$$

where, n is the sample size, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population, q = 1- P and e is the desired level of precision. Assuming the maximum variability, which is equal to 50% (p =0.5) and taking 95% confidence level with ±5% precision, the calculation for required sample size will be as follows: -

p = 0.5 and hence q =1-0.5 = 0.5; e = 0.05; z =1.96

Therefore,

$$n = \frac{(1.96)^2 * 0.5 * 0.5}{0.05^2}$$

$$n = 384.16$$

$$n = 384$$

3. RESULT AND DISCUSSION

3.1 RESULT

3.1.1 Review findings

According to ASHRAE (2004), thermal comfort is defined as 'the state of mind, which expresses satisfaction with the thermal environment'. Jan Hensen (1991) also defines it as 'a state in which there are no driving impulses to correct the environment by the behavior'; which has the similarities with Givoni's opinion that thermal comfort is 'the absence of irritation and discomfort due to heat or cold and as a state involving pleasantness' (Givoni, 1998).

Thermal comfort Model

To understand climatic comfort, thermal comfort model has been developed by different scholars and in different time appropriate test was conducted. The general knowledge, concepts, principles and characteristics of thermal comfort are reviewed and findings are presented as follows.

Fangel Model

Fanger at first developed the predicted mean votes (PMV) model of an expansive number of subjects for utilization inside mild climate zones (C. Su, H. Madani and B. Palm, 2018). The model has been set up as a universal standard since 1980 and it was created based on the standards of thermal heat adjust with the physiology of thermoregulation. An experimental fit of subjects' votes, the ASHRAE seven-point scale was utilized for the alteration of the model which is appeared in table 2.1 (Charles, K.E.). Fanger's demonstrate is a forecast of a numerical record by combining four environmental factors and two individual factors to measure the discernment of the occupants of the thermal condition within the building. Those environmental factors are temperature, air velocity, Mean Radiant Temperature (MRT), and relative humidity. Whereas, clothing insulation and activity level are individual factors. Thus, a person's thermal sensation does not as it depended on the surrounding air temperature alone. Thermal comfort is accomplished when the heat produced by the metabolism is disseminated and is in thermal equilibrium with the environment (Yau and Chew, 2014).

The PMV demonstrates predicts the comfortable temperatures well under a controlled environment, particularly under a cold climate. Mishra et al. (2010) expressed that having more control over the surrounding environment might increment people's fulfillment toward their indoor thermal environment. This may be accomplished, for instance, by giving personalized thermal situations. Fanger used the heat adjust condition to foresee a value for the degree of sensation using his test information and other distributed information for any combination of activity level, clothing value, and the four thermal natural parameters. To measure the thermal sensation index, seven points of psycho-physical ASHRAE scale were employed which is called ASHRAE thermal sensation scale as shown in Table 2.1 (Fanger, 1982).

Table 1. ASHRAE Thermal Sensation Scale

-3	**-2**	**-1**	**0**	**1**	**2**	**3**
Cold	Cool	Slightly Cool	Neutral	Slightly Warm	Warm	Hot

(Source: Fanger, 1982)

Adaptive Model (Approach)

The adaptive approach states that if a variation occurs to produce discomfort, people react in different ways to restore their comfort. The adaptive approach suggests that the people's satisfaction with an indoor climate is attained by matching the actual thermal environmental conditions of the existing time and space with their thermal expectations (Djamila et al., 2012).

The adaptive process comprises of three categories, which are physiological adjustment, mental adjustment, and behavioral alteration. Physiological adaptation is imperative in keeping up the body temperature at a comfortable level. This adaptation includes perspiration, vasoconstriction, and vasodilatation. Physiological adaptation contains a genetic adaptation and acclimatization. Psychological adaptation is immeasurable, it describes a feeling of thermal perception based on past experiences (Lechner, 2015).

The human body sensitivity will be decreased in the case uncovered to a certain thermal level over some time. The inactive thermal heat adjusts models are not able to account for these mental impacts, and it is expected that the relationship between mental strain and thermal sensation is settled. Lastly, behavioral adjustment is an action a person might take to attain thermal comfort by changing the body's heat balance (Yau and Chew, 2014).

To determine if thermal conditions are comfortable, these are plotted in the psychometric chart in the comfort zone plotted on it too. For instance, in ASHRAE Standard 55-2004 the comfort zone for typical environments is plotted from the operative temperature and humidity ratio (Yau and Chew, 2014).

To examine the operative (neutral) temperature by employing a bigger database, Auliciems found a relationship between the thermal lack of bias in free-running buildings and the open-air (De Dear R., and Brager G., 1998). In 1998, ASHRAE appointed researchers to conduct a specific project (RP-884) to collect information from different field studies performed in different countries. De Dear and Bragger (1998) examined the relationship between thermal comfort and indoor and outdoor temperature in a database of 21000 raw thermal comfort data from building in 160 locations worldwide (De Dear R., and Brager G., 1998). De Dear and Brager (1998) showed that comfort temperature is related to the outdoor temperature and so on the climate. Through a regression developed within the work of outdoor ET (Effective Temperature), a record that combines the impact of temperature, relative humidity, and air movement on the thermal sensation of the human body. Finally, the proposed equation for all building is shown in Equation-1 below.

$Tn = 20.9 + 0.16 \times ET$ ……………Eq. 1

Where, ET is Effective Temperature and T_n is Neutral Temperature

The output of the RP-884 analysis became part of ASHRAE Standard 55 in 1992, and these were implemented in the ASHRAE comfort standard 95. The model is valid when the mean of the monthly outdoor temperature is on the range of 10ºC and 33.5ºC. It confirms that the dichotomy between people's thermal perceptions in spaces with and without air conditioning is influenced by previous thermal experiences, clothing habits, possibilities for thermal regulations, and variables expectations of occupants.

Agreeing to Hyde (2000), the impartial temperature (adaptive demonstrate) is the temperature at which an individual ought to be not one or the other as well hot nor as well cold. The comfort zone is 2.5°C underneath and over the impartial temperature. On the other hand, Szokolay (2004) has set the comfort zone for 80% to 90% adequacy to be 2.5°C above and below the impartial temperature after (Auliciems, 1981). Equation-2 is developed by Auliciems to calculate the mean monthly outdoor temperature and neutral temperature of particular urban area.

$T_n = 17.6 + 0.31 \times T\ av$ …………Eq. 2

Where, Tav = the mean monthly outdoor temperature (°C) and Tn = neutral temperature (°C)

On the other hand, The ASHRAE-55 2010 Standard introduced the prevailing average outdoor temperature as the contribution variable for the adaptive model. It depends on the arithmetic average of the mean outdoor temperatures (ASHRAE 55, 2010). It can moreover be calculated by weighting the temperatures with diverse coefficients allotting increasing significance to the foremost later temperatures. In order to apply the adaptive model, there ought to be no mechanical cooling framework for space, inhabitants ought to be locked in in inactive activities with metabolic rates of 1-1.3 met, and a prevailing average temperature more prominent than 10 °C and less than 33.5 °C.

Qualitative and Quantitative Bioclimatic Chart

In 2014, bioclimatic chart analysis (Figure 1) was conducted by M.C. Katafygiotou and D.K Serghides and they used them both qualitative and quantitative bioclimatic chart to determine bioclimatic chart of three climatic zones in Cyprus. The qualitative chart is composed of twelve strategies to attain the thermal comfort of the people either by increasing or decreasing temperature. Below comfort zone, shading line, preventing heat loss, and promoting passive solar heating strategies are found. At the right of it, dehumidification appears and both evaporative cooling and humidification are found at the right of the comfort zone. When the relative humidity is below 20% and the maximum average temperature between 22 ºC to 27 ºC, evaporative cooling system and humidification are appropriate strategies to attain thermal comfort. The other strategies which are conventional dehumidification, high thermal mass and night ventilation, radiate cooling and natural ventilation are found above the comfort zone as shown in figure 2.9 (Katafygiotou, M. and Serghides, D, 2015).

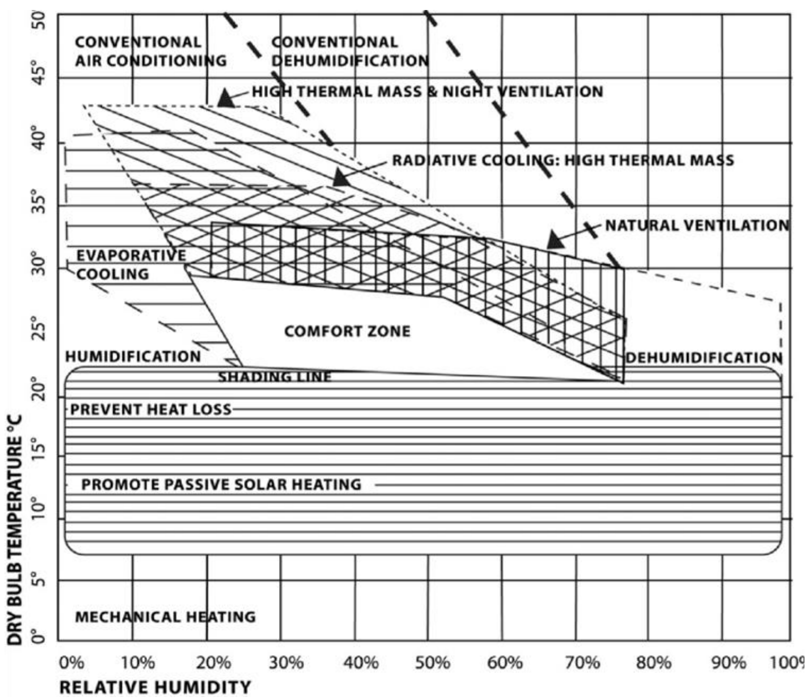

Figure 1. Qualitative bioclimatic chart; (Source: Katafygiotou, M. and Serghides, D, 2015)

The quantitative bioclimatic chart (Figure 2) is based on the minimum and maximum average temperature of a particular urban area. As described in a comfort zone, different countries use a different range of temperature to observe thermal comfort and determine comfort zone. Based on Olgyay's (1963) description the quantitative bioclimate chart is shown in figure 2.9 and the temperature of the comfort zone is bounded between 21ºC and 27ºC and the relative humidity is between 30% to 65% with an acceptable limit of 20% to 80% (Olgyay, 1963). From the qualitative bioclimate chart (Figure 1) the comfort zone creates up and down the portion of the chart. When the value of temperature above the shading line and with greater than 60% of the humidity, the discomfort needs high wind to achieve a comfortable environment whereas if it falls at the top left side of the broken line curve, moisture air is necessary for the comfortable situation. Below the shading line or if the temperature is below 21ºC, solar radiation is needed to achieve thermal comfort as and the qualitative bioclimatic figure is shown in figure 2.10 below (Katafygiotou, M. and Serghides, D, 2015).

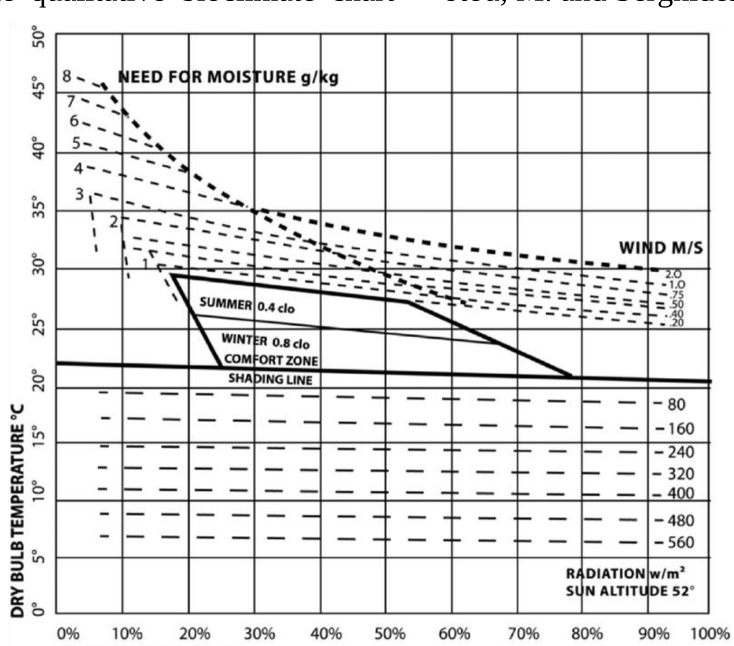

Figure 2. Quantitative Bioclimatic Chart; (Source: Katafygiotou, M. and Serghides, D, 2015)

In the case of Debre Berhan Town, the resident wear traditional cotton product like Gabi, when the microclimate condition of the town is so cold. The young people also wear jacket which provide to accommodate their body towards the surrounding environments. The farmers who are living at the countryside of the town also build G+1 traditional building and the ground floor is living for their animals. The breath air from the animal is provided and create warm condition in the first floor. In addition to this, it is requested that the urban layout of the town can provide environmental mitigation with related to street orientations, width and alignment of the street at specific orientation by bioclimatic condition or not? However, except body sensation, the problem had never been dealt with scientifically. No bioclimatic chart of the towns had been developed to get it the cooling demand to employ appropriate strategies that are shown by the bioclimatic chart. Thus, the purpose of this study was confirming of Bioclimatic informed urban design for Debre Berhan Town and specifically, focusing on developing neutral temperature and measure the thermal sensation of the resident's perception by sematic scale.

3.1.2 Adaptive Model and Thermal Sensation

The analyzed data described that the neutral temperature is one of the critical points to check at what value the human being is at normal condition and in the case of Debre Berhan the neutral temperature is 27.17 ^{o}C, which is above the standard. Based on the correlation of both neutral temperature and outdoor air temperature, the neutral temperature is exceeded by 1.16 ^{o}C from the normal neutral temperature. Hence the characteristics of the adaptive chart of Debre Berhan town is changed because of that the air speed is above 2 m/s. As a result, the adaptive chart for Debre Berhan town is shown in Figure 3.

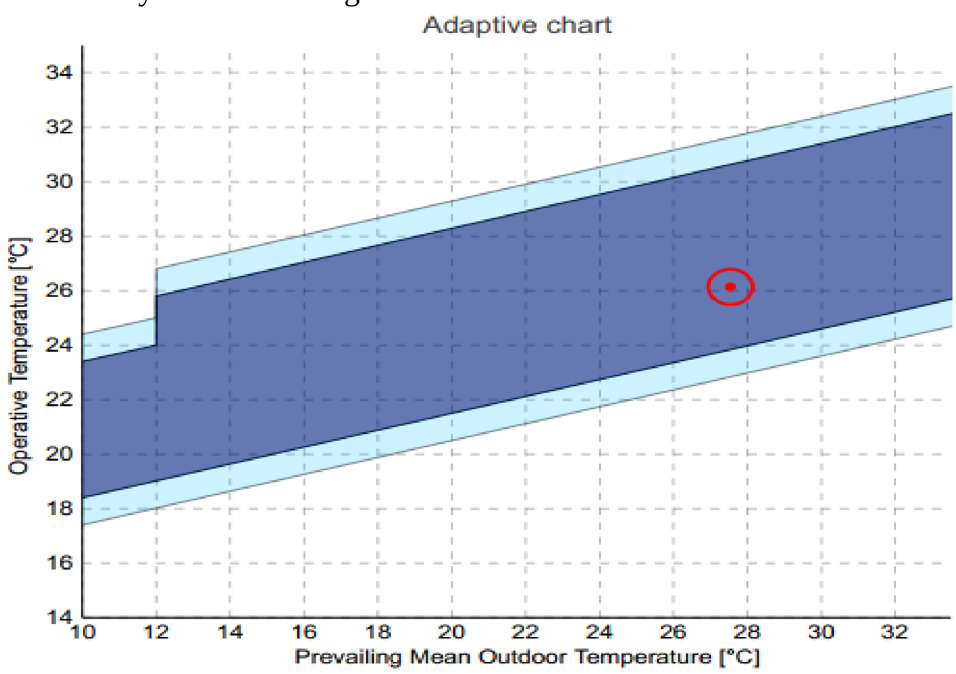

Figure 3. Adaptive Chart for Debre Berhan Town

Thermal Sensation

Thermal sensation result was focus on the perception of the respondents in the case of Debre Berhan on major variables of temperature, relative humidity and wind-speed of the town during June to January.

Temperature perception of the residents from June to January

From the 347 respondents, 61.7% of them feel cool environment, 12.4% of the respondents perceived that it was slightly cool, whereas, 10.4% and 8.4% of the respondents perceive thermal sensation as slightly warm and warm Condition. It indicates that most of the occupants adjusted for the climatic variation and dissatisfied with the outdoor thermal environment. As a result, warming mechanisms is so mandatory that has power to achieve thermal comfort.

Humidity perception of the residents from June to January

Based on the respondent's result which was analyzed by sematic scale, 8.82% of the respondents perceive that it was slightly dry and 82.89% of them believe that the humidity rate was slightly dry. Whereas, 3.21% of the respondent's response show that the tendency of humidity in the case of Debre Berhan was at neutral condition. But 5.08% of the residents from the respondent perceived that the humidity condition of Debre Berhan town was so slightly warm condition.

Air-Speed perception of the residents from June to January

Based on the collected data, 2.9% of them perceived that the wind speed was very low whereas, 1.9% of the respondents feel that the wind speed was low. It indicates that the wind speed affects their thermal comfort and need some adaptive method to reduce the wind speed in the town by means of interventions. Beside this, 29.80% of the respondents observed that the wind speed of the town was slightly low and 19.20% of the total respondent's answers indicate it was neutral condition. Whereas, 46.20% of the respondents agreed up on slightly high wind condition of Debre Berhan Town.

Generally, the aggregates of temperature, relative humidity and wind speed perception of the respondents which are shown in Table 1 and describes that the thermal sensation of the town lies at + 1 based on the scale and the town is so slightly warm and humid.

Table 1. Thermal Sensation Scale of Debre Berhan Town

Thermal Performance	Thermal Sensation Scale						
Parameter	-3	-2	-1	0	1	2	3
Air Temperature	0	**61.7%**	12.4%	7.2%	10.4%	8.4%	0
Relative Humidity	0	8.82%	**82.89%**	3.21%	5.08%	0	0
Air Velocity (Speed)	2.9%	1.9%	29.8%	19.2%	**46.2%**	0	0

Thermal Comfort Zone

Based on the analyzed microclimate data, which are done by TMY method average temperature, relative humidity and wind speed of the town are find to be 20.66°C, 53.18% and 2 m/s, respectively (Table 2). The maximum average temperature in Debre Berhan town was also calculated which was 26.46 °C from the TMY result which is long historical temperature of Debre Berahan. From the historical data the maximum temperature was occurs at May with value of 29.24 °C and minimum temperature of the town was 11.68°C which occurs at December in long run history of the town. Hence, those values are the parameters which are used to plot the bioclimatic chart and by using temperature, relative humidity and wind speed, the bioclimatic chart of the town is plotted as shown in Figure 2. Finally, the bioclimatic chart shows that (Figure 4) the town needs cooling for the months of June to January.

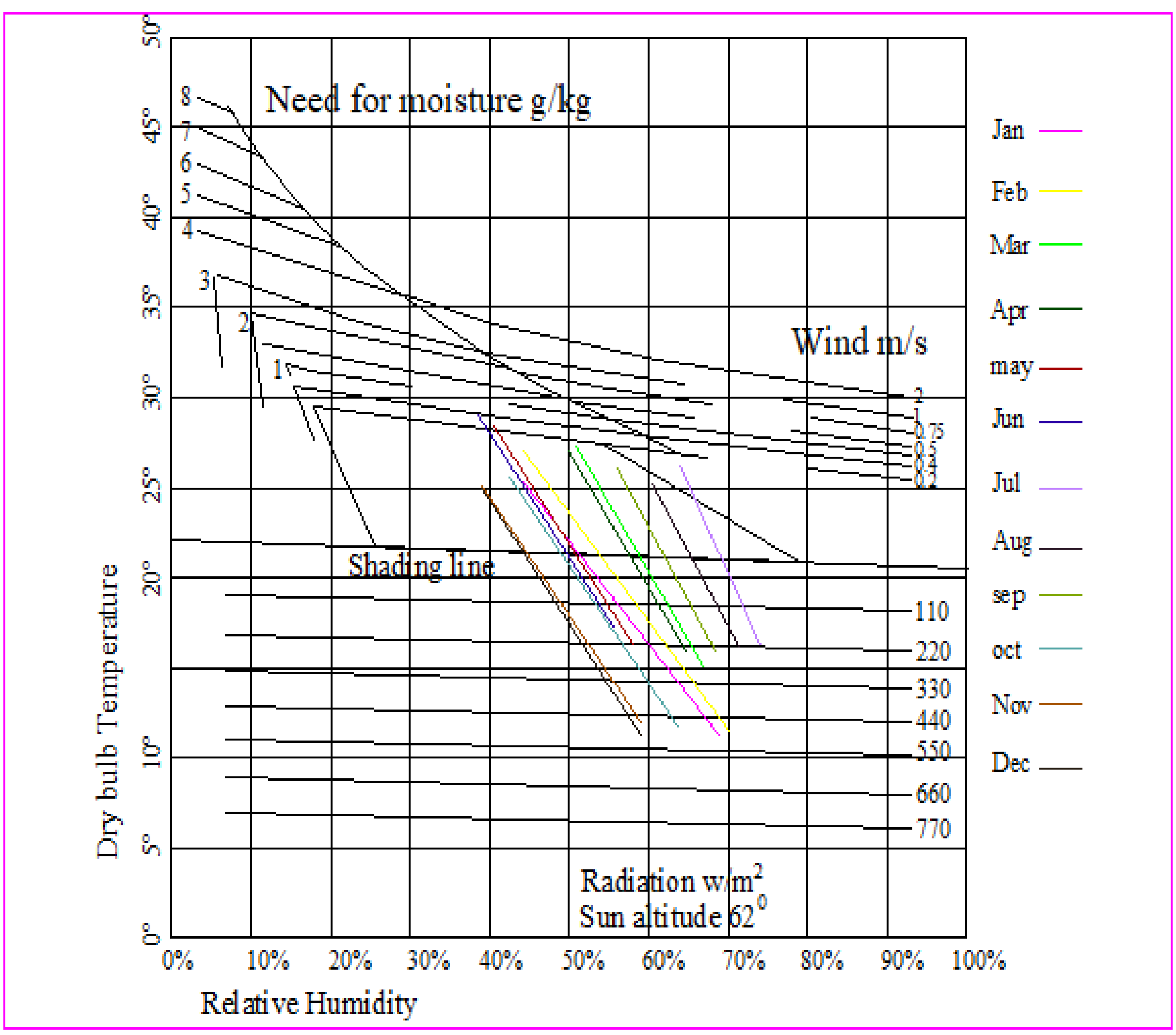

Figure 4. Quantitative Bioclimatic Chart of Debre Berhan town

Table 2. Average Temperature and Relative Humidity of Debre Berhan

Month	Ave T_{max}	Ave T_{min}	RH
Jan	25.70	12.46	48
Feb	27.08	13.52	44.2
Mar	27.63	15.15	50.1
April	27.14	15.96	57
May	29.24	16.81	51.2
Jun	28.34	17.6	47.2
July	26.33	16.68	60.9
Aug	25.34	16.34	66.2
Sep	25.6	16.11	62.3
Oct	25.26	13.54	53.1
Nov	25.26	12.11	49
Dec	24.92	11.68	48.9

The qualitative and quantitative bio climate chart (Figure 5) indicate the overall result of the Debre Berhan town comfort chart. As it indicates that preventing heat loss at high rate and promoting passive solar heating condition which is more required in summer seasons. Especially, from September to January the average temperature of the town exceeds from the minimum comfort temperature value and the qualitative bioclimatic chart indicate that passive solar heating as well as preventing heat loss are needed with solar radiation of 110 to 550 w/m^2 to get warm condition in the case of Debre Berhan town.

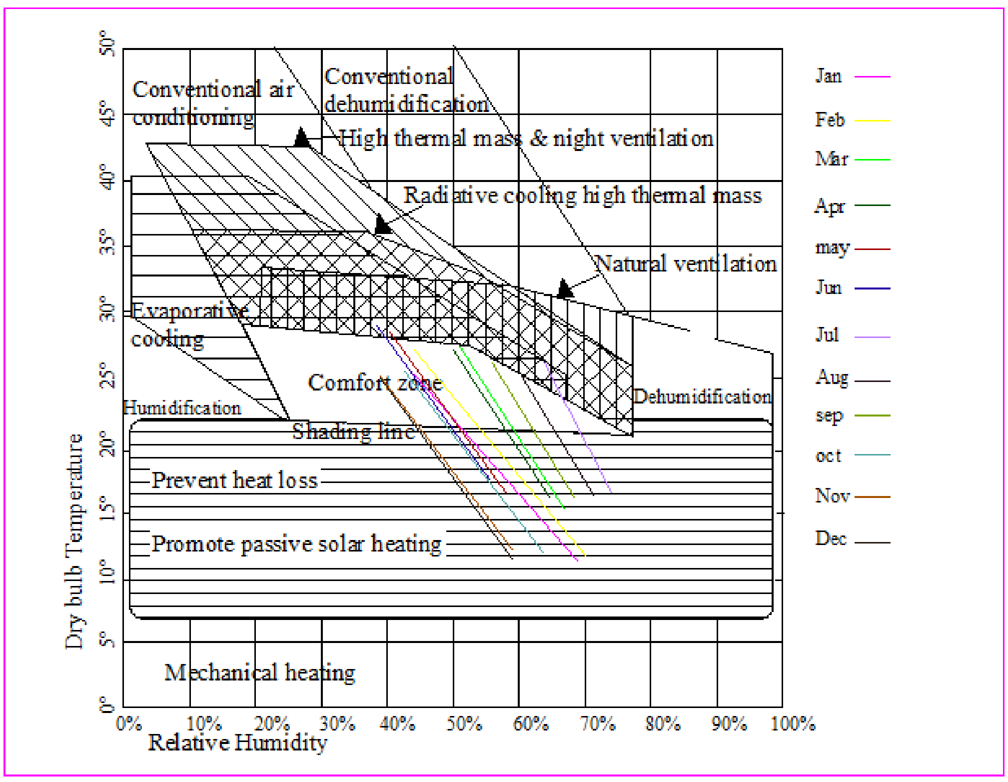

Figure 5. Qualitative Bioclimatic Chart of Debre Berhan town

3.2 DISCUSSION

3.2.1 Adaptive Model

According to Lechner (2015), the adaptive model of the relation between the outdoor temperature and indoor operative temperature and 80% of the comfort condition should be acceptable for the indoor and 90% of the comfort condition also acceptable for the outdoor temperature. In addition to this, based on the adaptive model theory operative temperature should be between 18°C and 24°C. However, the average temperature of Debre Berhan town is 20.66°C which is acceptable. On the other hand, ASHRAE-55 (2010) standard recommends that normal neutral temperature is 23°C with an average wind speed of 0.2m/s. This implies that the characteristics of the adaptive model of Debre Berhan town are changed by the result of different airspeed when it is above 0.2m/s since the neutral temperature is 27.17°C with a wind speed of 2.4m/s.

3.2.2 Thermal Sensation

The thermal sensation of Debre Berhan was analyzed by using a semantic scale analysis method that contains temperature, relative humidity, and airspeed of the town. Based on this, the perception of residents replies the level of temperature was so cool and it indicate the need for a warming system especially from

September to January end. The relative humidity is another factor that alters the level of comfort zone either by increasing its value or decreasing Givoni (1998). The perception of the residents in the case of Debre Berhan Town, they perceived that the level of relative humidity was slightly dry. Wind speed and wind direction don't affect the thermal comfort of the resident indirect ways. However, it creates discomfort in the living environment, especially in urban areas. In the case of Debre **Berhan**, the respondents perceived that the level of wind speed was slightly low in the town.

3.2.3 Thermal Comfort Zone

The comfort chart (bioclimatic chart) of the town is plotted based on the parameters of temperature, relative humidity and wind speed. Thus, appropriate strategy to achieve comfort in town from the bioclimatic chart is Prevent heat loos and promoting passive solar heating strategy and especially from September to January based on the result of comfort chart. Finally, According to ASHRAE (2010), for American people, the study indicate that the normal neutral temperature is 23^{o}C. At this temperature the human being is found at neither cool nor warm environment, it is called Normal Thermal conditions points. Based on this research, 27.17^{o}C is neutral temperature for Debre Berhan town based on the microclimate analyzed data and the average temperature of the town for the last thirty years (1991 to 2021) was 20.6^{o}C. The perception of the respondents from the town also indicates that level of the temperature in the town is cool, especially from September to January with slightly dry humid and slightly low wind condition with 2.5m/s of wind speed.

4. CONCLUSION

The main objective of the study is to investigate of thermal comfort and passive cooling system of Debre Berhan Town and specifically, examine the adaptive and thermal sensation of the town, and determine the thermal comfort zone by using thermal comfort factors are basic.

The bioclimatic chart indicates the thermal comfort situation and appropriate types of cooling systems to maintain the living environment by considering temperature, relative humidity and air-speed of the area. To obtain this, 30 years of microclimate data were analyzed and presented by the TMY method. The semantic scale was also used to analyze the temperature, relative humidity and air-speed perception of 347 residents of Debre Berhan Town. Based on this, thermal sensational condition of the town was analyzed by temperature, humidity and wind speed by using sematic scale which shows the perception of the residents. On this, Debere Berhan town is perceived by cool town, with slightly dry humid and slightly low wind speed. On the other hand, the bioclimatic chart of the town was plotted by using 30 years microclimate date which is from 1991 to 2021 and the types of microclimate data were temperature, relative humidity and wind speed.

Thus, the bioclimatic chart indicates that preventing heat loss and promoting passive solar heating are needed to keep the human thermal comfort or to achieve the thermal comfort between 20^{o}C to 26^{o}C in the case of Debre Berhan Town. To sum up and the conclusion, the skin of building is the interface between Architecture and Urban Design. For comfortable condition the indoor environment for human, the outdoor or environment climate condition is essential. Thus, the following are recommended at different levels at the human settlements.

To maintain the outdoor space of this climate zone different parameters used in urban design and planning of the city. In the cool zone, the main suggested design strategy is low shading percent in the winter season, solar heating and preventing heat loss. In this climate zone heating strategies required. Shading is used at the peak hours and normal wind speed used for natural ventilation. Urban design contribution for those passive design strategies and recommended design techniques are the Street oriented from east to the west direction to get more morning light, freestanding urban form and low compactness, full enclosures (equal level of H/W) and high level of SVF, restriction of harsh solar radiation in the southwest direction using deciduous trees by the observance of appropriate distance from building for urban space, linking open urban spaces to form the corridors between the buildings, building orientation in a direction to get more morning sunlight, urban orientation across the prevailing wind, reduction of the building's height in the orientation of prevailing wind and morning solar radiation and avoiding evaporative cooling.

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Authors' Contribution: The author has contributed in the analysis and interpretation of the data manuscript

Competing Interest: There is no conflict of interest

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