Effects of Different Floor Covering Materials on Thermal Comfort in Landscape Design Studies

ASSOC. PROF. DR. M. AKİF IRMAK

ATATURK UNIVERSITY
ARCHITECTURE AND DESIGN FACULTY
ERZURUM/TURKEY

Urban population increases all over the world. According to 2012 United Nations Report, 52% of world population lives in urban areas (3.6 bl.), which is expected to reach 6.3 bl. by 2050.

Increase in urban population brings many problems together. While urban areas enlarge, impervious and reflecting surfaces also increase, rangelands, grasslands, wetlands and other natural rural areas decrease. Such changes on the earth surface bring together some climatic unfavorable changes among which urban heat island (UHI) takes place as the hot topics for the last years.

Some problems faced as the result of the enlargement in urban areas;

- **Increase in the release of green house gases, (**36-70 % water vapor, 9-26 % carbon dioxide, 4-9 % methane 3-7 %Ozone)

- **Increase in the use of fossil fuel consumption**

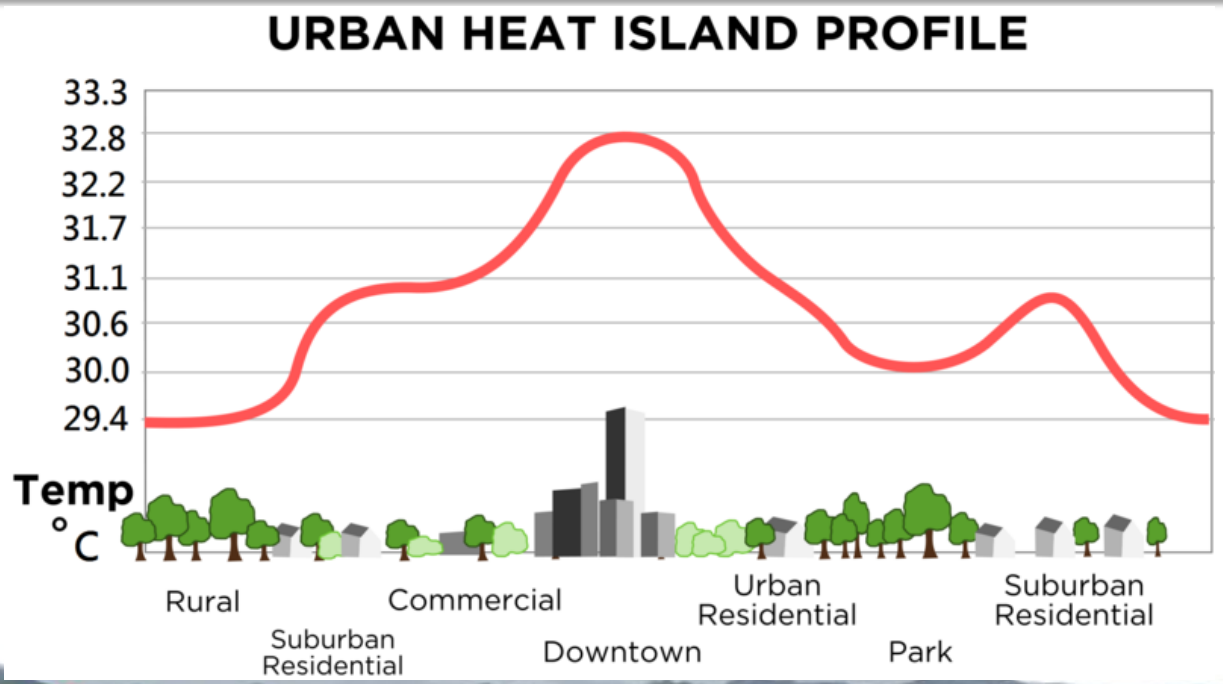
- **Decrease in the surfaces of forest and green areas,**
- **Decrease in the surfaces of wetlands**
- **Pollution in seas** (decrease in especially the rate of phytoplankton producing 70 % of oxygen all over the world)

- Increase in urban and impervious surfaces and the number of buildings and motor vehicles

Carbon emission is produced by urban areas in the rate of more than 75 % all over the world.

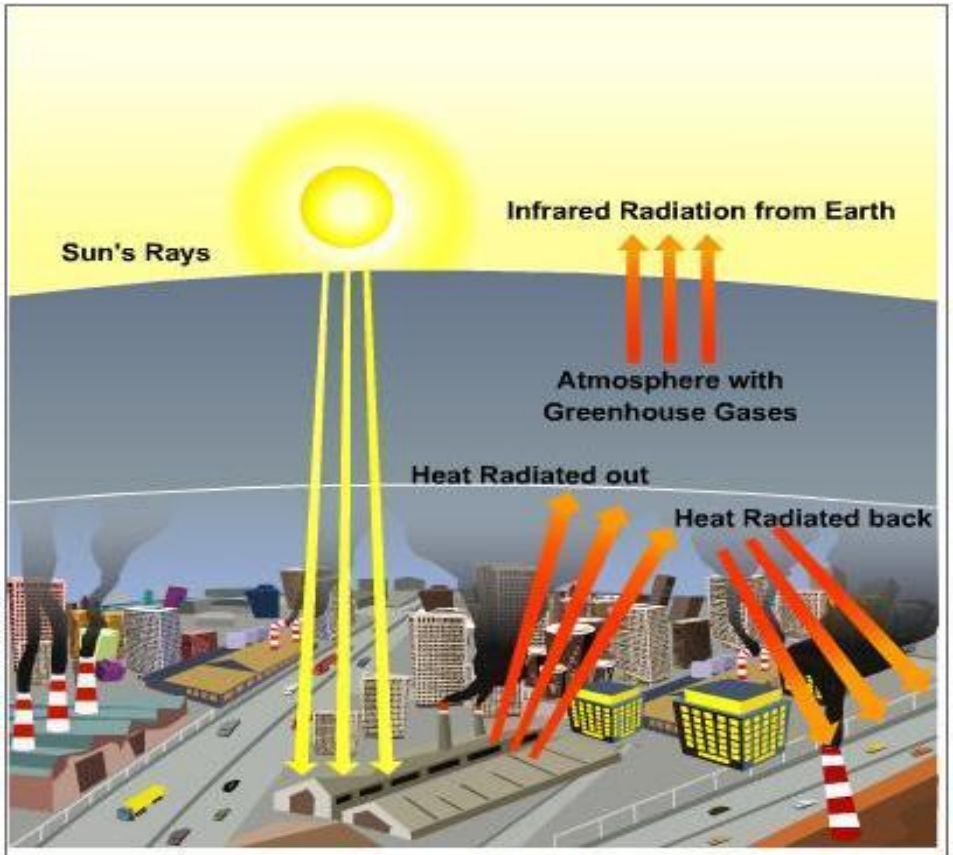
Depending on their size, urban environment is 1 to 3 °C warmer than rural.

Due to the facts mentioned above, works on urban planning and design are vitally important for human health and comfort conditions in the future.



In urban planning, climate has been accepted to be an important factor for long. Urban green areas can prevent and mitigate the effects of global warming by holding particles and carbon in the atmosphere and indirectly the formation of urban heat islands.

In urban areas planned conveniently with the sustainability principles, people feel themselves comfortable and such a comfortable condition affects positively the energy consumption.
Therefore, thermal comfort is an important factor to be considered in planning and design works.



Landscape architecture is among the disciplines contributing to shaping urban and rural landscapes, by planning, designing, restoring, protecting and managing them.

In landscape planning, decision making on land uses and in landscape design works decisions on plantation and surface covering materials are vitally important factors.

Materials and plants preferred in especially urban landscape works are also effective on urban climate. Each design work can cause a microclimate in it and its close environment.

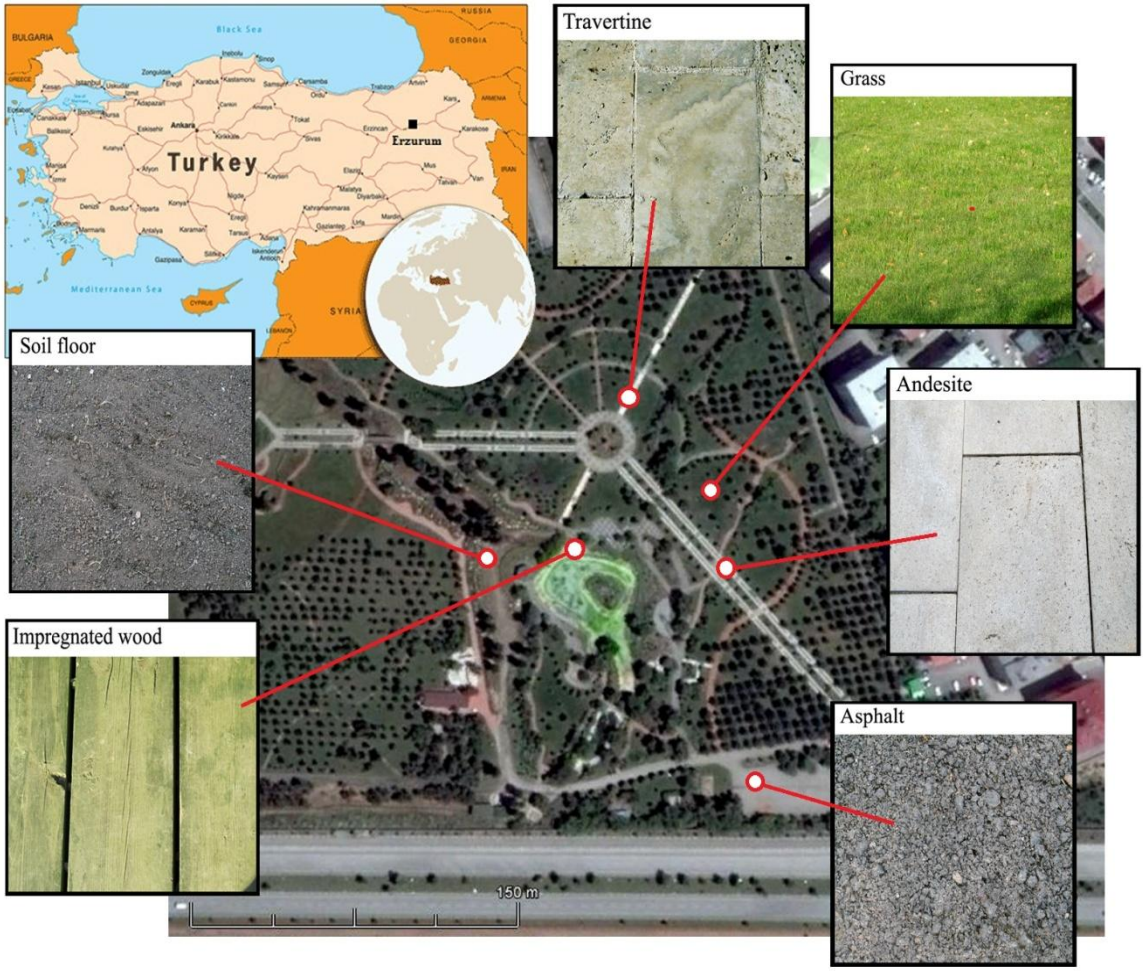
Landscape architecture occupational discipline is in the first rows among the disciplines which can actively participate in the prevention of global warming by working on planning and design of natural, rural and urban areas for ensuring human comfort and future.

Materials used in especially landscape works in urban areas can affect comfort conditions in the designed areas. Landscape works where thermal comfort is forefront are important for the construction of more livable cities.

The aim of the present study is to show that covering materials used in landscape architecture works may be effective on Urban Heat Island formation and mitigation.

Grass, travertine, impregnated wood, andesite, soil and asphalt preferred mostly in landscape works were evaluated in 3 different landscape design projects for the calculation of thermal comfort using these covering materials at different rates.

The project prepared in the scope of the study is among the first studies where thermal comfort can be calculated before the application of the project.

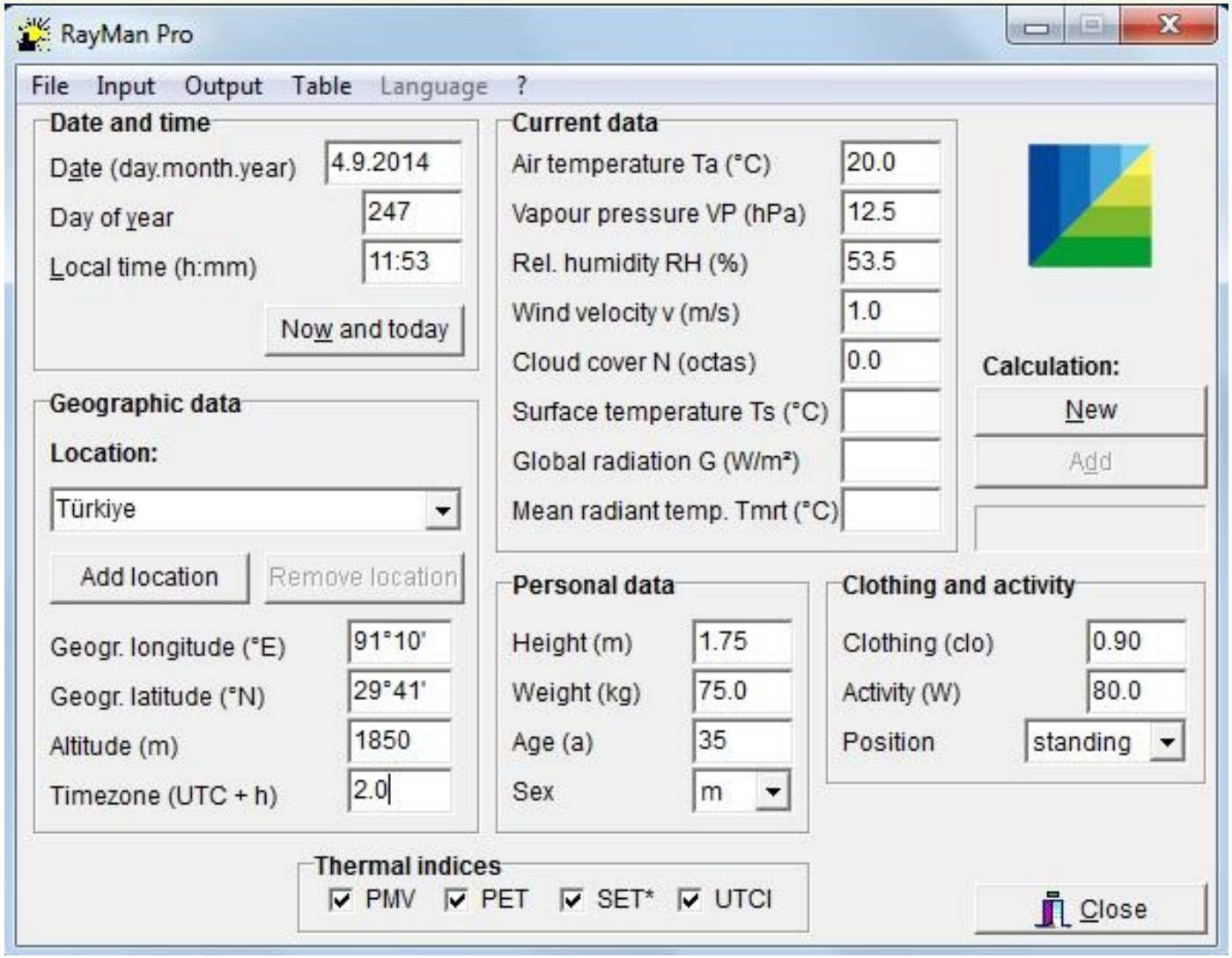


The study was carried out in the city of Erzurum, east of Turkey. Ata Botanical Garden located in the city center shelters grass, travertine, impregnated wood, andesite, soil and asphalt surfaces and surface temperatures were measured using Infrared Thermometer (CEM-DT-8812) at the Garden, on arid days at 12.00 in July one of the warmest months of the year in the city.

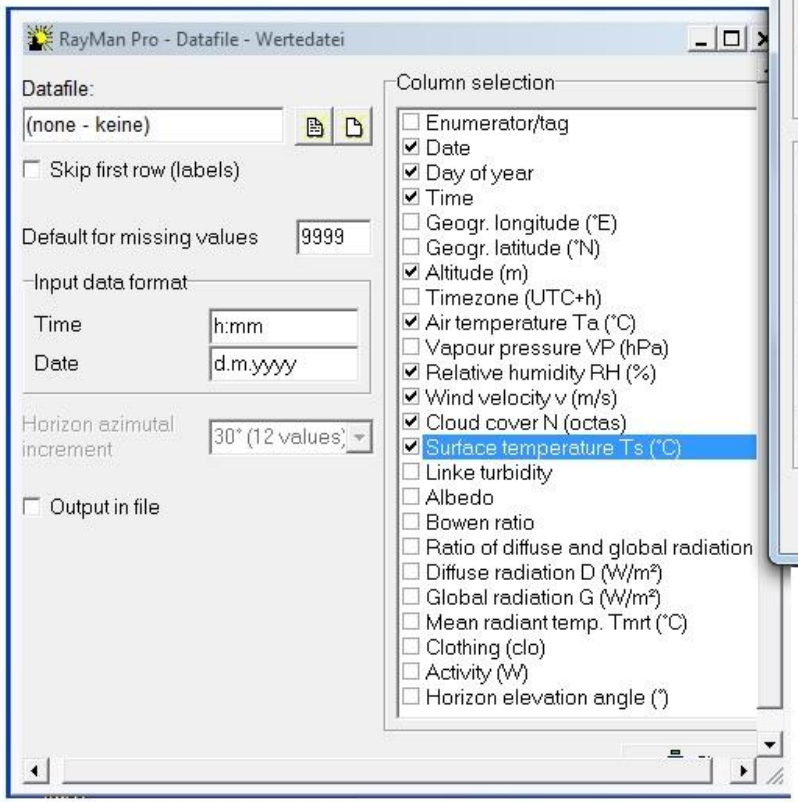

C.E.M
DT-8812
INFRARED
THERMO-
METER
Rapid Light
Laser

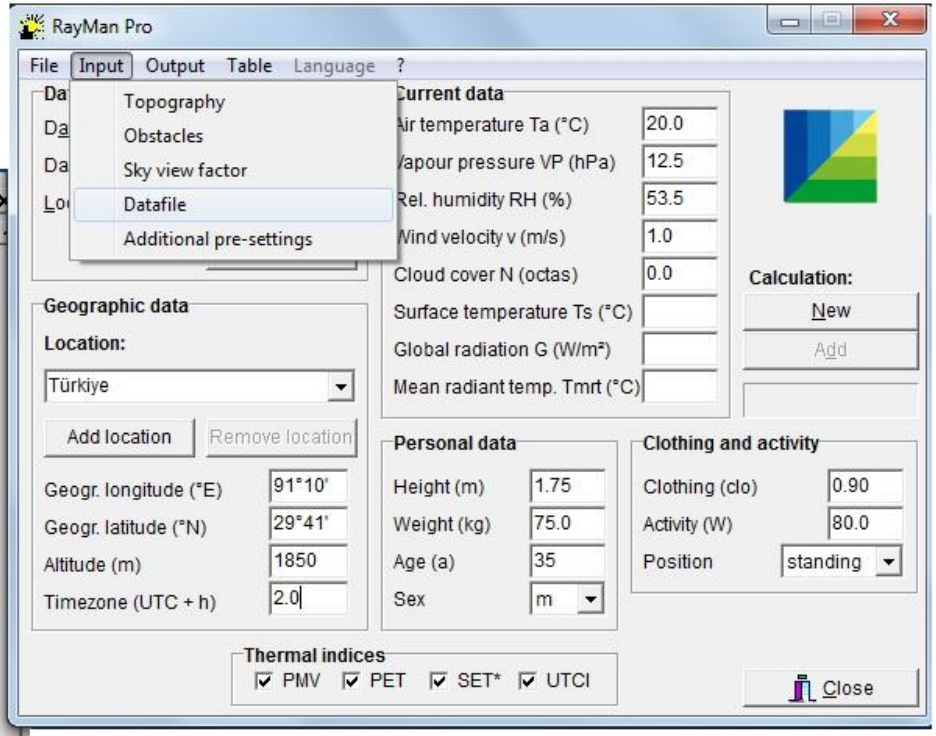

CAUTION

To quantify the thermal comfort provided by pavement, meteorological data (air temperature,air humidity, wind speed and clouds) collected from Ata Botanik field measurements were used to calculate PET (Physiologicall Equivalent Temperature) with the assistance of RayMan Pro Model.



Interface of RayMan Pro Model





tarih	Saat	Sıcaklık (°C)	Ort. Nispi Nem (%)	Saatlik Rüzgar Hızı (m_sec)	Bulut Kapalılığı (/8)
26,07,2012	18	28,4	29	5,1	3
26,07,2012	21	25,1	26	4,1	3
27,07,2012	0	23,8	44	1,5	0
27,07,2012	3	22,7	57	0,5	0
27,07,2012	6	22,2	31	5,6	2
27,07,2012	9	26,1	17	5,1	2
27,07,2012	12	29,3	12	4,1	3
27,07,2012	15	27,1	13	2,5	4
27,07,2012	18	28,4	31	1,5	4

Data input page of RayMan Pro Model

Table. Air temperature and PET at 12.00 over different covers

Hour	Sunny day	Andesite (PET ºC)	Travertine (PET ºC)	Impreg. Wood (PET ºC)	Soil floor (PET ºC)	Asphalt (PET ºC)	Grass (PET ºC)	Air (ºC)
12:00	10	31	29.4	34.5	30.3	32.7	28.9	30.5
12:00	11	29	28.7	30.8	28.8	30.6	28.5	27.8
12:00	12	34.3	33.1	35.9	35.2	35.9	31.9	32.6
12:00	13	35	34	36.8	36.6	36.6	34.1	34.5
12:00	14	32.7	31.3	33.5	31.9	32.8	31.3	30.9
12:00	15	26.2	25.3	27.9	26	27.3	25.3	24.8
12:00	16	26.7	25.2	29.6	27.5	27.9	25.5	26.4
12:00	17	25.1	23.6	26.3	25.5	26.3	23.8	23.7
12:00	18	33.2	32.1	32.4	33.4	34.1	31	32.9
12:00	19	28.7	27	27.6	27.8	30.3	26.4	26.2
12:00	20	21.1	20.3	23.4	21	22.1	20.5	19.6
12:00	21	30	28.5	32.8	31.5	31.7	28	28.0
12:00	22	20.8	20.5	22	21.5	22.2	20.5	19.9
12:00	23	23.6	22.4	24.9	24.4	25.1	23.3	22.4
12:00	26	30.1	29.3	32.5	31.5	32.5	30	29.4
12:00	27	29.1	29.1	32.4	30.1	31.1	28.5	28.5
12:00	28	13	12.3	12.1	12.2	13.3	12.2	12.7
12:00	29	20.8	20	23.8	21.4	22.5	20.3	19.3
12:00	30	22.5	21.6	25.2	23.2	24.2	21.5	20.6
12:00	31	29	27.7	33.2	30.9	31.6	27.6	27.1
Mean PET (ºC)		**27.1**	**26.1**	**28.9**	**27.5**	**28.5**	**25.9**	**25.9**

Impregnated Wood
(Mean PET 28.9 °C)

Asphalt
(Mean PET 28.5 °C)

Soil
(Mean PET 27.5 °C)

Andesite
(Mean PET 27.1 °C)

Travertine
(Mean PET 26.1 °C)

Grass
(Mean PET 25.9 °C)

PET values are categorised according to comfort intervals

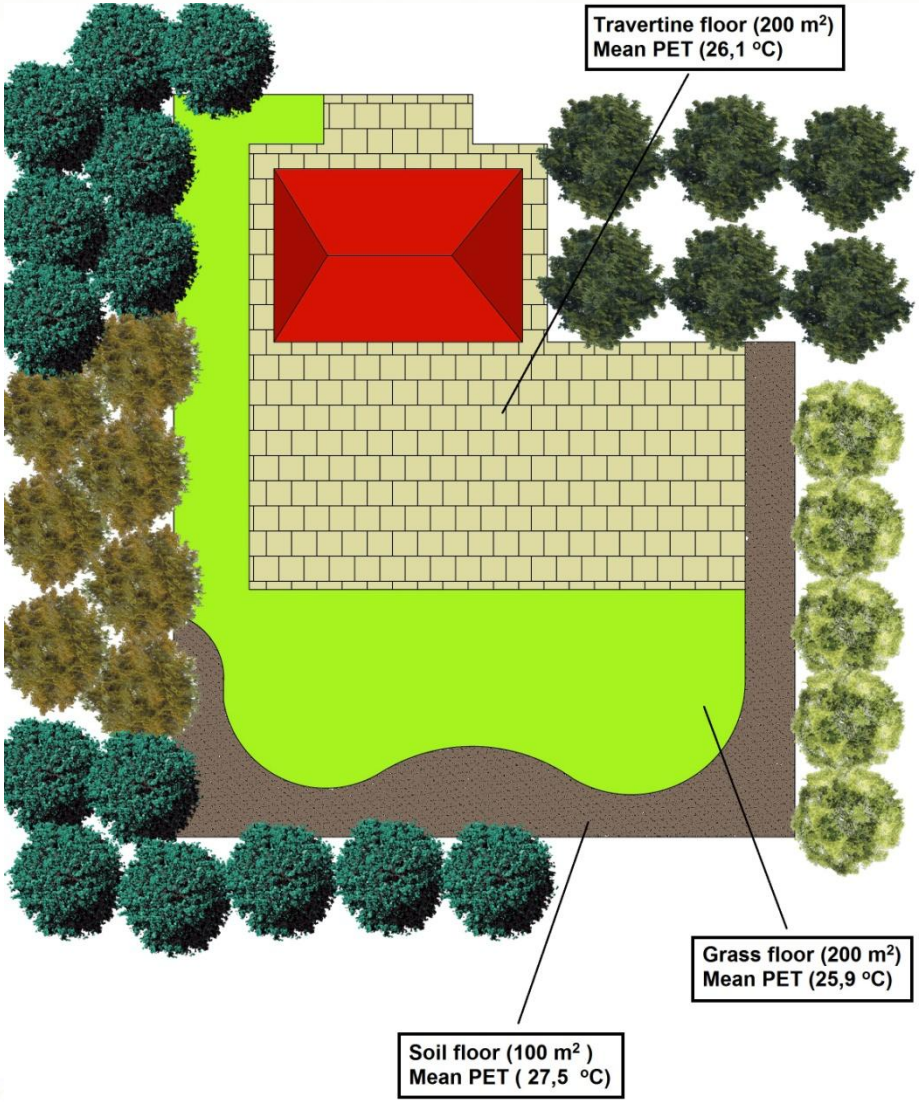
Table. PET Index Comfort Intervals

PET (°C)	Thermal perception	Grade of physiological stress
< 4	Very cold	Extreme cold stress
4,1 - 8,0	Cold	Strong cold stress
8,1 - 13,0	Cool	Moderate cold stress
13,1 - 18,0	Slightly cool	Slight cold stress
18,1 - 23,0	Comfortable	No thermal stress
23,1 - 29,0	Slightly warm	Slight heat stress
29,1 - 35,0	Warm	Moderate heat stress
35,1 - 41,0	Hot	Strong heat stress
>41,0	Very hot	Extreme heat stress

All the PET values calculated were found to be in the range of Slight heat stress (23.1 – 29.0 °C). Grass and travertine covers represented the lower PET values while impregnated wood and asphalt gave the higher comfort values. Grass and travertine surfaces offer the closest range to comfortable conditions.

By considering these values, a 500-m^2 area of house garden was designed and 3 different landscape design projects were prepared for the same area by using the different rates of these surface covering materials. By rating surface area and PET values each project was attained to a mean PET value.

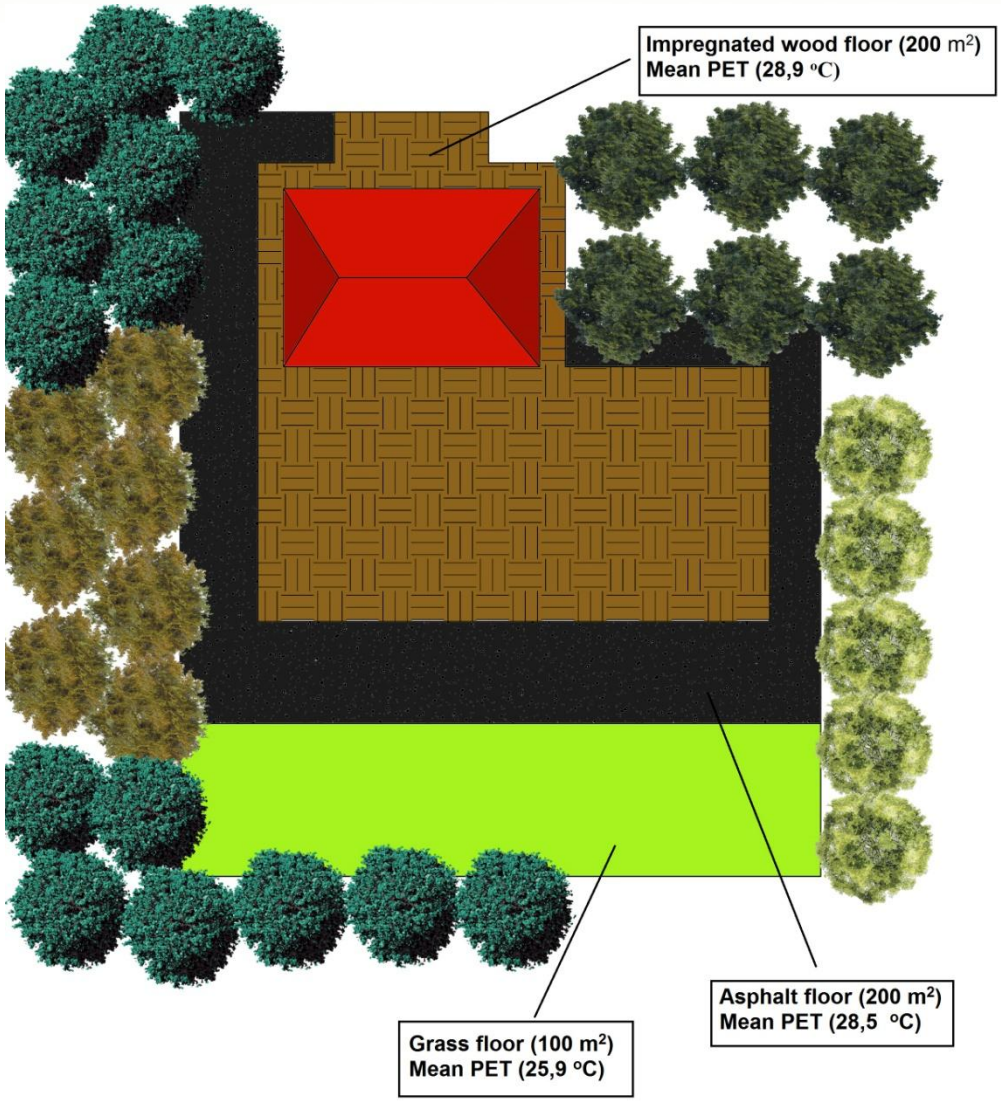
Landscape Design 1



In the Landscape Design Project 1, designed for a house garden under the conditions of Erzurum grass, travertine and soil surfaces were used and in the rates of 200 m^2, 200 m^2 and 100 m^2 , respectively

Means of PET values for the surfaces in LDP1 were 26.1 °C, 27.5 °C and 25.9 °C, for travertine, soil and grass used in the rates of 200 m^2, 100 m^2 and 200 m^2 respectively and overall PET mean was calculated to be 26.3 °C.

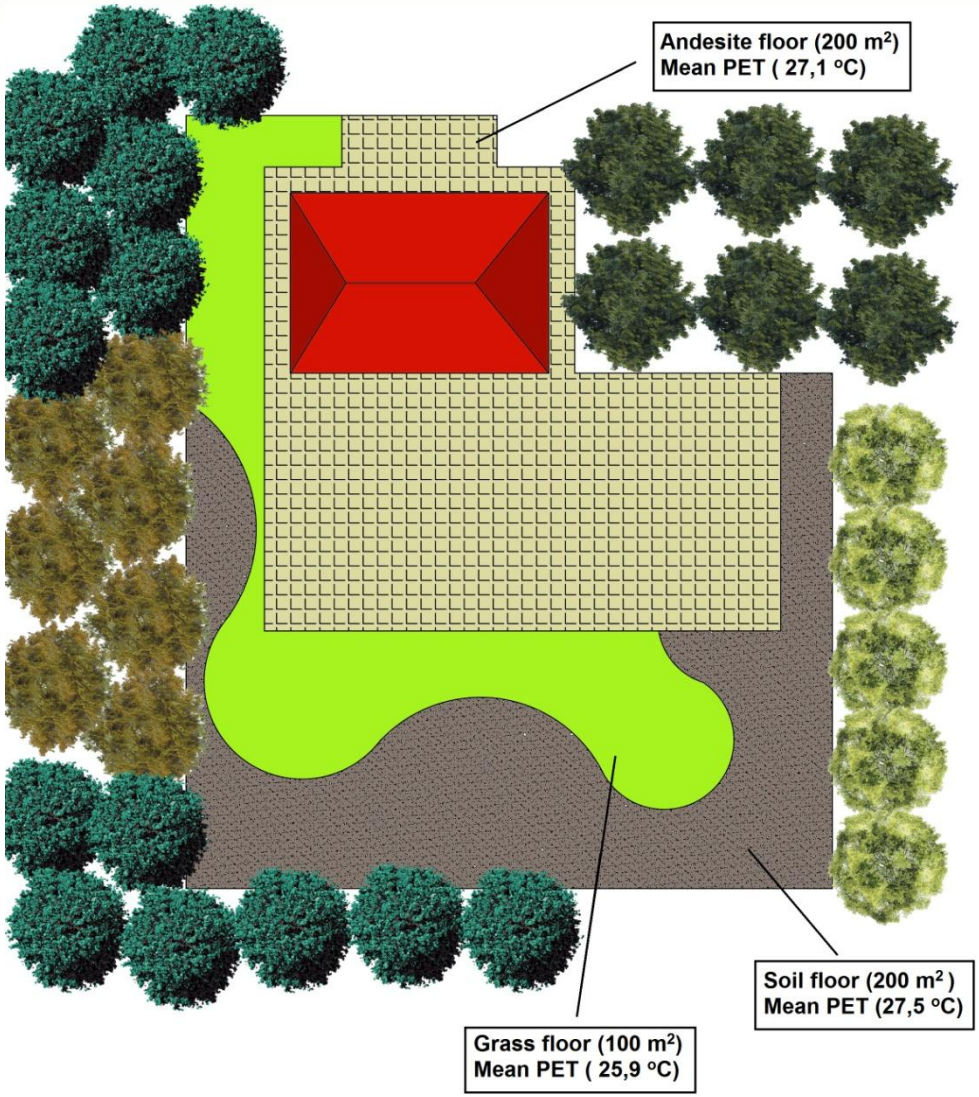
Landscape Design 2



In Landscape Design Project 2, grass, wood and asphalt surfaces were used in the rates of 100 m^2, 200 m^2 and 200 m^2, respectively

Mean PET value was found to be 28.9 °C, 25.9 °C and 28.5 °C for impregnated wood, grass and asphalt used in the rates of 200 m^2, 100 m^2 and 200 m^2 and overall mean of PET was 28.1 °C.

Landscape Design 3



In Landscape Design Project 3, grass, andesite and soil surface were used in the rates of 100 m^2, 200 m^2 and 200 m^2

Mean PET value was found to be 27.1 °C, 25.9 °C and 27.5 °C for andesite, grass and soil used in the rates of 200 m^2, 100 m^2 and 200 m^2 and overall mean of PET was 27.0 °C.

Different comfort values were obtained by applying different LDP in the same area. There is a difference of 1.8 °C PET between designs dominated by grass and travertine and asphalt and wood even in a small surface area of 500 m^2.

It is shown in the present study through measurements and evaluations that a landscape architect can offer climatically comfortable areas even in a 500 m^2 area through his/her suitable materials for surface covers.

In order to mitigate UHI and provide comfortable areas in urban landscape architecture overtake serious responsibilities. There is a need to know surface temperatures of materials used in the projects and design projects by considering thermal comfort. In even small areas, comfort conditions should be calculated and the values should be considered in the designs and thus partially mitigating Urban Heat Islands.

Thank You Very Much