# 1. Institutional setting

- No-profit research project run under the supervision of the Deanship of Scientific Research at the University of Bahrain.
- The project ideas is based on a call by the municipality of Manama Governorate (251,660 inhabitants in the north of Bahrain) and the environmental authority in Bahrain for contributions of scientists, researches and consultants to present ideas to control urban heat islands (UHIs) and their negative impacts in Bahrain.

- Project partners are:
- Bahrain, College of Eng., dep. of Architecture and Interior Design
- Germany, Dep. of Spatial Environmental Planning, Technische Universitat Kaiserslautern
- Saudi Arabia, Dep. of Landscape Architecture, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University.

# 2. Starting point/Project goal

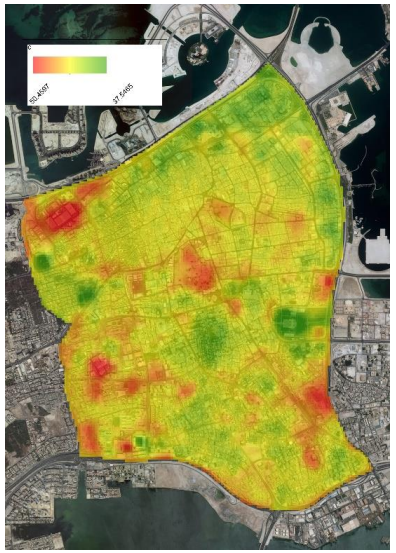
- The growing consumption of energy to serve humanity's needs, particularly in urban areas, has caused many environmental problems.  This is a pressing problem in modern cities in the Arab Gulf region, including Manama.
- The issues of urban heat islands (UHI) was investigated and documented within the project using remote sensing technology.
- The **main project target** is to face global warming in the Gulf region and to investigate the urban heat island from different aspects to achieve sustainability. The research also reviews urban activities and studies the external finishing materials of the housing' envelop to point out the main deficiencies producing these urban heat islands, and proposes adequate guidelines for controlling UHIs.

# 3. Approach

For the purpose of this research:

- a multispectral remote sensing image collected by the Sentinel 2B MSI satellite was downloaded from USGS Earth Explorer portal on 19 February 2018.
- In addition, land surface temperature (LST) maps for the kingdom of Bahrain were produced and used to investigate the spatial relationship between urban heat islands and other urban factors.
- Detects the ground sources that cause UHIs from the urban field surveys and the observation (site inventory and analysis) of the collected data.
- Sentinel 2B MSI and LST maps were cropped to match the Manama Metropolitan Area in the north of Bahrain.

LST over Manama City in the Fall of 2017.



LST over Manama City in summer 2018.

# 4. Outputs

- UHIs were defined and an accurate city vegetation map (solid/void and land use) was produced
- Moreover, the conflicts that resulted from the clashes between Bahrain development policy, the strategic plans and the action plans (the Strategic Bahrain Master Plan) were detected
- The frequent change of social structure affects the social activities as well. Accordingly, a change of roof towards places for storage and waste causes UHIs.
- There is a need for updating the Bahraini building code to contain guidelines for using the proper building materials that help in controlling UHIs.
- Moreover, controlling UHIs will be through overcoming the shortage of greenery in the city, by having greenery top of buildings (roofs) and building envelops (buildings' facades) in different forms.

# 5. Lessons

- The dominance of solid versus spaces and fragmentation of existing spaces led to a rise in urban heat and contributed to the formation of urban heat islands in Manama City.
- Using impervious surface in existence spaces (e.g. asphalt for pavement, concrete for roofs…etc.) contributed to the formation of urban heat islands in Manama City.
- Changes in urban pattern to become “Concrete Forest” played a dramatic role in changing urban climatic conditions to uncomfortable conditions.
- Urban heat islands enhanced the negative impacts of global climate changes on Manama City.
- In reference to the applying cases of having green roofs in nearest countries in Gulf Area, there are many indicators of reducing the UHIs in general.

solid versus spaces

asphalt for pavement, concrete for roofs

Social using

# 6. Follow up

- The role of vegetation land cover and impervious surface in enhancing urban heat islands in Manama city is still questioned. Remote sensing study for these environmental factors is required to give answers to this question.
- Comprehensive though should be in consideration while dealing with global warming issues and the reasons for accruing UHIs as well.
- Updating the Bahraini building code to contain guidelines for using the proper building materials (buildings' envelops and roofs)
- Using GIS, a comprehensive Landscape Architecture plan should be prepared to implement the best use of the open spaces