UNIVERSITÀ DI TORINO

ICT FOR DEVELOPMENT AND SOCIAL GOOD

Crash Course #1: Data in-practice, final assignment

Request for Proposals (RFP): Mitigating Urban Heat Islands for Vulnerable Populations in Developing Countries

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Introduction

The term "urban heat island" (UHI) refers to a phenomenon that occurs when temperatures in urban areas are higher than those in the areas that surround them (suburban area).

The urban heat island phenomenon can result in increase of energy consumption, increase of air pollution, decrease of water quality, and increase of greenhouse gas emissions, all of which have the potential to negatively impact people in a variety of ways.

When we talk about "Urban Heat Islands for Vulnerable Populations," we refer to groups of people such as the homeless, migrants, elderly individuals, young children, and people with pre-existing medical conditions. These groups often have less access to resources to protect themselves from extreme heat, such as air conditioning, adequate shelter, or access to clean water. This situation could lead in health problems as heat strokes or dehydration.

UHI have additional environmental effects, including increased air pollution and greenhouse gas emissions. UHI worsens air quality due to higher fossil fuel consumption, resulting in the production of carbon dioxide (CO2) and other pollutants like sulphur dioxide (SO2) and nitrogen oxides (NOx), which contribute to the greenhouse effect.

Project description

Project aims to identify urban areas affected by UHIs impacting vulnerable populations. The proposal will propose and develop actionable strategies based on geospatial and weather data to reduce disparities and improve conditions.

Research question

How to change conditions and reduce disparities caused by UHIs to improve vulnerable population lives?

Hypotheses

The mapping and the identification of vulnerable population per country and UHIs can provide guidance to modify those areas.

Hypothesis notes

**Find data from the weather systems (forecast and historic) by locations. Areas with high density of vulnerable population to map it. Identify possible solutions and the available resources in the area **

Actions

Steps needed to perform:

- Investigate the vulnerable populations affected in the contexts of UHIs and how to identify them
- Investigate the impacts of land cover types on ambient temperatures
- Examine the relationship between ambient temperatures and vulnerable populations
- Identify specific locations with high ambient temperatures and high percentages of vulnerable populations
- Recommend mitigation measures to reduce the adverse effect of urban heat islands.

DATA COLLECTION

Vulnerable populations in UHI context

In this study, we focused on identifying and analysing vulnerable populations in the context of Urban Heat Islands (UHI). To efficiently collect and organize data, we utilized the online tool Smallpdf to convert a PDF document containing relevant information into an Excel file. That document can be found by clicking in the following Source.

I have employed Smallpdf tool to extract and convert the data table from the PDF into a easily manageable Excel format. Once we obtained the Excel file with the data, we proceeded to convert it to CSV to store it and study it in our Github folder.

In [ ]:

```
#Install to be able to convert from XLSX to CSV
sudo apt-get install xlsx2csv
```

In [ ]:

```
#That copies the excel into the csv

xlsx2csv UHIguia.xlsx --sheet 4 --delimiter ';' >> UHIguia.csv
```

- **Heat-health studies stated that older people are more vulnerable to extreme temperatures due to their existing illness and low tolerance to handle it (Ebi et al., 2021; Flynn et al., 2007; Knowlton et al, 2007; Worfolk, 2000). The study concentrated on 2020 population datasets of people aged 60 to 80.**

Case of Study

For the RFP we will be focusing in Manila city in Philippines, so then we can ensure it can be escalated to other areas, following the same methodology for data gathering, analysis and solution proposal.

Country	Philippines
Study type	Cross-sectional
Findings	Population density was positively associated with the level of heat stress experienced by respondents. Those who felt little heat stress lived in areas with lower population density (less than 1467 people/km2), while those with higher levels of heat stress lived in areas with higher population density (up to 41,500 people/km2 in Manila City).

According to the Koppen Climate Classification Manila has a tropical rainforest climate (Af). There is no dry season in a tropical rainforest environment, and it rains at least 60 mm per month throughout the year (2.36 in). Tropical rainforest climates do not have distinct seasons; it is hot and humid year-round, with frequent and heavy rains. Manila has an annual average temperature of 27.8 degrees Celsius, or 82.0 degrees Fahrenheit. With an average temperature of 85.0 °F (29.4 °C), April is the hottest month of the year, while the lowest month is January at 79.0 °F (26.1 °C).

Meteorological raw data can be gathered from the weather bureau of the Philippines. The data can be requested in a excel format by filling the following form. The meteorological parameters include rainfall

amount, mean temperature, maximum temperature, minimum temperature, wind speed, wind direction, and relative humidity. Since just one synoptic station is in Port Area, Manila (14.5878°N latitude and 120.9690°E longitude). That allows to take the information directly from the source.

Impacts of land cover types on ambient temperatures

A comprehensive temperature dataset is needed to assess urban heat islands (UHIs) and their associations with land types and vulnerable populations.

Land Surface Temperature (LST)

Land Surface Temperature (LST) is the radiative skin temperature of the land derived from solar radiation. A simplified definition would be how hot the "surface" of the Earth would feel to the touch in a particular location. From a satellite's point of view, the "surface" is whatever it sees when it looks through the atmosphere to the ground. It could be snow and ice, the grass on a lawn, the roof of a building, or the leaves in the canopy of a forest. Land surface temperature is not the same as the air temperature that is included in the daily weather report.

Information from sources as Glovis should be retrieve in order to get the Land surface temperature from Manila City

The Moderate Resolution Imaging Spectroradiometer MODIS satellite LST data is used to measure the magnitude of UHI in the Philippines.

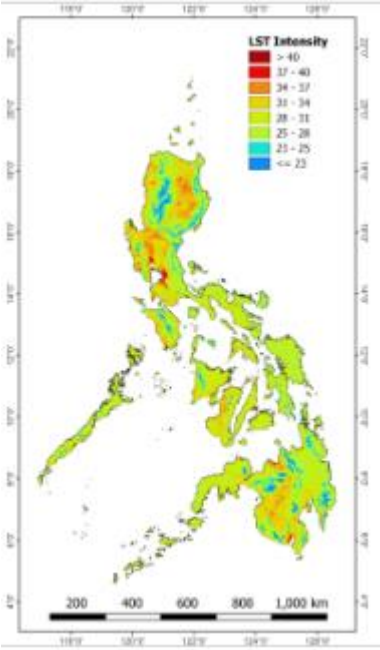
Taking that into consideration, we can retrieve all the information from this sources and following the guide documents presented:

- MODIS Land-Surface Temperature Algorithm Theoretical Basis Document LST ATBD
- MODIS Land Surface Temperature Products Users' Guide
- How to download LST information from Modis:
- Data pool from MODIS link

MOD11A1 product

All Modis MOD11A1 product images data can be found here in link as also Information for all the MODIS products in the link

The MOD11A1 product is a daily global Land Surface Temperature (LST) product generated by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Terra satellite. It provides information on the surface temperature of the Earth's land areas at a spatial resolution of 1 kilometer. The data is derived from MODIS observations and is available in an integer zed sinusoidal or sinusoidal projection. Each MOD11A1 product contains a grid of 1200 rows by 1200 columns, covering the entire globe. This product represents a snapshot of the land surface temperature for a single day, making it suitable for daily monitoring and analysis of temperature variations on the Earth's surface.



In [ ]:

```
# How to download the information from the Application with Script:

#!/bin/bash

GREP_OPTIONS=''

cookiejar=(������������·��������)�����=(mktemp
netrc.XXXXXXXXXX)
chmod 0600 "$cookiejar" "$netrc"
function finish {
  rm -rf "$cookiejar" "$netrc"
}

trap finish EXIT
WGETRC="$wgetrc"

prompt_credentials() {
    echo "Enter your Earthdata Login or other provider supplied
credentials"
    read -p "Username (sainzpaa): " username
    username=${username:-sainzpaa}
    read -s -p "Password: " password
    echo "machine urs.earthdata.nasa.gov login
������������password" >> $netrc
    echo
}

exit_with_error() {
    echo
    echo "Unable to Retrieve Data"
    echo
    echo $1
    echo
    echo "https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000056.h29v07.061.2020043121141/MOD11A
1.A2000056.h29v07.061.2020043121141.hdf"
    echo
    exit 1
}

prompt_credentials
  detect_app_approval() {
    approved=`curl -s -b "$cookiejar" -c "$cookiejar" -L --max-redirs 5
--netrc-file "$netrc" https://data.lpdaac.earthdatacloud.nasa.gov/lp-
prod-
protected/MOD11A1.061/MOD11A1.A2000056.h29v07.061.2020043121141/MOD11A
1.A2000056.h29v07.061.2020043121141.hdf -w '\n%{http_code}' | tail -1`
    if [ "$approved" -ne "200" ] && [ "$approved" -ne "301" ] && [
"$approved" -ne "302" ]; then
        # User didn't approve the app. Direct users to approve the app
in URS
        exit_with_error "Please ensure that you have authorized the
remote application by visiting the link below "
    fi
}

setup_auth_curl() {
    # Firstly, check if it require URS authentication
```

```
    status=$(curl     -s     -z     "$(date)"     -w     '\n%{http_code}'
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000056.h29v07.061.2020043121141/MOD11A
1.A2000056.h29v07.061.2020043121141.hdf | tail -1)
    if [[ "$status" -ne "200" && "$status" -ne "304" ]]; then
        # URS authentication is required. Now further check if the
application/remote service is approved.
        detect_app_approval
    fi
}

setup_auth_wget() {
    # The safest way to auth via curl is netrc. Note: there's no checking
or feedback
    # if login is unsuccessful
    touch ~/.netrc
    chmod 0600 ~/.netrc
    credentials=$(grep 'machine urs.earthdata.nasa.gov' ~/.netrc)
    if [ -z "$credentials" ]; then
        cat "$netrc" >> ~/.netrc
    fi
}

fetch_urls() {
  if command -v curl >/dev/null 2>&1; then
      setup_auth_curl
      while read -r line; do
        # Get everything after the last '/'
        filename="${line##*/}"

        # Strip everything after '?'
        stripped_query_params="${filename%%\?*}"

        curl -f -b "$cookiejar" -c "$cookiejar" -L --netrc-file "$netrc"
-g -o ��������������������--line && echo || exit_with_error
"Command failed with error. Please retrieve the data manually."
      done;
  elif command -v wget >/dev/null 2>&1; then
      # We can't use wget to poke provider server to get info whether
or not URS was integrated without download at least one of the files.
      echo
      echo "WARNING: Can't find curl, use wget instead."
      echo "WARNING: Script may not correctly identify Earthdata Login
integrations."
      echo
      setup_auth_wget
      while read -r line; do
        # Get everything after the last '/'
        filename="${line##*/}"

        # Strip everything after '?'
        stripped_query_params="${filename%%\?*}"

        wget --load-cookies "$cookiejar" --save-cookies "$cookiejar" --
output-document
��������������������--����-�������-�������--line
&& echo || exit_with_error "Command failed with error. Please retrieve
the data manually."
      done;
  else
```

```
      exit_with_error "Error: Could not find a command-line downloader.
Please install curl or wget"
  fi
}

fetch_urls <<'EDSCEOF'
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000056.h29v07.061.2020043121141/MOD11A
1.A2000056.h29v07.061.2020043121141.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000057.h29v07.061.2020043121141/MOD11A
1.A2000057.h29v07.061.2020043121141.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000058.h29v07.061.2020043121141/MOD11A
1.A2000058.h29v07.061.2020043121141.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000059.h29v07.061.2020043121140/MOD11A
1.A2000059.h29v07.061.2020043121140.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000060.h29v07.061.2020043121140/MOD11A
1.A2000060.h29v07.061.2020043121140.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000061.h29v07.061.2020043121140/MOD11A
1.A2000061.h29v07.061.2020043121140.hdf
https://data.lpdaac.earthdatacloud.nasa.gov/lp-prod-
protected/MOD11A1.061/MOD11A1.A2000062.h29v07.061.2020043121140/MOD11A
1.A2000062.h29v07.061.2020043121140.hdf

EDSCEOF
```

****All the documents downloaded can be found in the fetch_urls.md file, located in the folders**

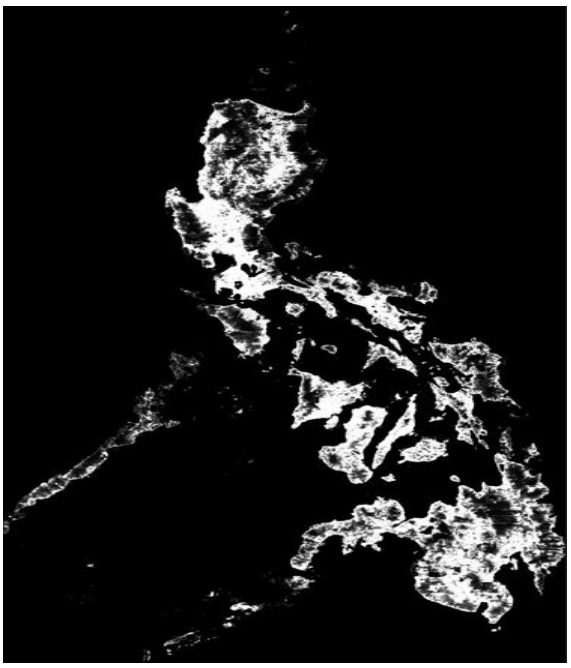
In order to visualize and analyse all the data, I would need a tool like HDFView, this is a free visualization tool that allows to open and explore all the HDF files. That mapping can provide us the final report needed using geospatial information of the land temperature and being able to identify all the UHIs in the desired area.

Examine the relationship between ambient temperatures and vulnerable populations

It is important to understand where the population is located by checking the population density. That information can help us to match it with the LST information retrieved and identify those UHIs where vulnerable population can be affected and determine possible solutions to implement.

In order to retrieve the information of population density, this can be done through the Worldpop HUB page. This tool provides different sources information that would hep us in our investigation to understand demographic behaviours.

Filtering by Philippines, we can get map information for the last 20 years and download it. For example, downloading the information from 2020. As the file is more than 25MB cannot be uploaded in the GitHUB folder, but if needed, can be downloaded in the link. The information provided is as follow:



The information is an estimated of the total number of people per grid-cell. The dataset is available to be downloaded in Geotiff format at a resolution of 3 arc (approximately 100m at the equator). The units are number of people per pixel with country totals adjusted to match the corresponding official United Nations population estimates that have been prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2019 Revision of World Population Prospects). The mapping approach is Random Forest-based dasymetric redistribution.)

The image download arrives as .TIF document. In order to be able to be visible by the standard image visualization tools, it can be transformed into PNG with one tool as:: https://www.iloveimg.com/es/convertir-a-jpg/tiff-a-jpg

The same information can be also downloaded in a CSV format to be analyzed. Getting that detailed information, we can get the estimated population density per grid-cell. The dataset is available to download in Geotiff and ASCII XYZ format at a resolution of 30 arc (approximately 1km at the equator). The projection is Geographic Coordinate System, WGS84. The units are number of people per square kilometer based on country totals adjusted to match the corresponding official United Nations population estimates that have been prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2019 Revision of World Population Prospects). The mapping approach is Random Forest-based dasymetric redistribution.

All the details related to the csv file for Philippines analysed can be found in the following phl_pd_2020_1km_UNadj_ASCII_XYZ.csv file

Identify specific locations with high temperatures and high percentages of vulnerable population

Some studies have highlighted that approximately one-third of Manila's population resides in informal settlements, where inadequate housing and deficient infrastructure are commonly identified as primary issues. This underscores the influence of poverty, alongside urbanization, in driving urban migration. Analysis of the exposure layer output reveals that densely populated regions coincide with elevated UHI values. Consequently, a significant portion of the population is exposed to the heightened temperatures associated with UHI effects.

As previously stated "Heat-health studies stated that older people are more vulnerable to extreme temperatures due to their existing illness and low tolerance to handle it" Taking the information to understand where the people aged 60 to 80 is normally located, we extract the information from Worldpop HUB focusing in the range of ages agreed. (Information can be downloaded as before and converted from TIF document to PNG.)

All images can be found in the Following folder.zip

Once we can match both information sources, we are able to estimate and evaluate which UHIs areas are the ones affecting more vulnerable people. This will help us to create a ranking of areas to focus on starting the assessment and planning creation for implementing the following proposals based on the geospatial information gathered.

SOLUTION DEVELOPMENT

As the standard mitigation strategies to fight against UHIs for different neighbourhoods and communities, the most common proposals are:

- **Plant trees and increase vegetation**: Enhance green urban areas by planting trees and promoting the growth of vegetation. This can help by reducing the UHIs effect, improving air quality, and provide shade and cooling benefits to communities.
- **Install green or cool roofs**: Implement green roofs or cool roofs on buildings to reduce heat absorption. Green roofs involve growing vegetation on rooftops, while cool roofs are made of materials that reflect sunlight and heat.
- **Replace normal pavement with cool pavement**: Explore innovative pavement solutions that can mitigate the urban heat island effect. Cool pavements, which reflect more solar energy and enhance water evaporation, help reduce surface temperatures and improve night-time visibility. More information
- **Think about adopting a smart growth**: Consider adopting smart growth principles in urban planning and development. Smart growth strategies focus on creating compact, walkable communities with mixed land uses, efficient transportation options, and preservation of open spaces. This approach promotes sustainable development and resilience to climate change impacts.

Our proposal has to be differently faced. The situation and the solutions needs to be adapted for low-income neighbourhoods or low resources areas. Knowing those limitations, I can readapt those proposals as follow:

- **Affordable Solutions**: Implementing low cost and local materials to make it more accessible. For example, local community participation initiatives for tree planting using indigenous species.
- **Consider painting surfaces white**: Painting surfaces white or using light colours materials can help reflect sunlight and reduce heat absorption. This simple strategy can enhance and be effective on roofs, pavements, and walls to low temperatures.
- **Capacity Building**: Investing in education and training program, focus on design, installation, and maintenance with the local communities to led them and provide ownership of sustainable development projects. This approach fosters skills and economic opportunities within the community.
- **Partnerships and Collaboration**: Build partnerships with local governments, NGOs, community organizations, and international development agencies to leverage resources, expertise, and funding.
- **Adaptation and Innovation**: Adapt green infrastructure solutions to suit the specific needs and environmental conditions of each community. Innovative approaches such as vertical gardens or green walls can maximize limited space while providing cooling benefits and improving air quality.
- **Policy Support**: Advocate for policy frameworks that incentivates and support green practices. Looking to establish sustainable urban development, and integrating green infrastructure into urban planning policies.
- **Community Engagement**: Foster community participation, providing ownership and empowering local community for new sustainable projects through inclusive decision-making processes, community consultations.

IMPLEMENTATION PLAN

Affordable Solutions:

Steps	• Conduct an assessment of low cost and local materials suitable for green infrastructure projects. • Identify indigenous tree species that can adapt to the climate and soil by community consultation and local expert guidance. • Organize tree planting initiatives within the community, providing training on proper planting techniques and ongoing care. • Look for Methods of irrigation and water acquisition solutions.
Resources	• Look for funding from government grants, corporate sponsorships, or crowdfunding to support tree planting initiatives and material acquisition. • Establish local partnerships to ensure the availability of indigenous tree species and affordable prices.
Partnerships	• Collaborate with local authorities and community organizations to coordinate efforts and maximize resources. • Engage with local NGOs and development agencies to access expertise, technical assistance, and funding.

Consider painting surfaces white:

Steps	• Conduct a study of feasibility and effectiveness of white painting surfaces to mitigate UHIs. • Identify target areas such as rooftops, pavements, and walls. • Collaborate with local authorities and building owners to gain permission for painting initiatives.
Resources	• Procure eco-friendly white paint or light coloured materials and equipment for surface painting. • Train community members or volunteers on proper painting techniques and safety protocols.
Partnerships	• Form partnerships with local businesses or manufacturers to secure discounts or donations for the needed supplies. • Work with urban planners and architects to incorporate the strategy into new urban design and projects.

Capacity Building:

Steps	• Develop educational materials and training programs on green infrastructure design, installation, and maintenance. • Conduct workshops, and training sessions facilitated by experts in sustainable development and green infrastructure.

Resources	• Establish training centres for the local community or hubs with needed tools and resources. • Foster mentorship programs in green infrastructure practices.
Partnerships	• Collaborate with educational institutions, training centres, and NGOs to deliver the training and spread it to a wider audience. • Engage with local businesses and industry associations to provide internships, apprenticeships, or job opportunities.

Partnerships and Collaboration:

Steps	• Identify potential partners: local governments, NGOs, community organizations, and international development agencies. • Organize meetings or workshops to discuss project goals, objectives, and areas of collaboration.
Resources	• Allocate staff for coordination and management. • Create communication channels to exchange information, share resources, and coordinate activities.
Partnerships	• Look for fundraising initiatives to secure funding's. • Engage with academic institutions and research organizations to leverage scientific expertise and data analysis for project implementation.

Adaptation and Innovation:

Steps	• Conduct community surveys or consultations to identify specific environmental challenges and priorities. • Explore innovative solutions such as vertical gardens, green walls... to address space constrains. • Look for Methods of irrigation and water acquisition solutions.
Resources	• Invest in research and development to explore new technologies, materials, and design approaches for sustainable urban development. • Procure necessary equipment, materials, and technical expertise for implementing innovative green infrastructure solutions.
Partnerships	• Collaborate with technology firms, start-ups, and research institutions to co-develop and pilot test innovative green infrastructure solutions. • Engage with urban planners, architects, and landscape designers to integrate adaptation measures into urban development plans and projects.

Policy Support:

Steps	• Advocate for the adoption of policies and regulations that incentivize green infrastructure practices and sustainable urban development. • Lobby government officials and policymakers to allocate funding and resources for green infrastructure projects and initiatives. • Participate in public consultations, hearings, and policy forums to provide input and recommendations on relevant legislation and policy frameworks.
Resources	• Develop advocacy materials such as policy briefs, fact sheets, and case studies to support evidence-based policy advocacy. • Mobilize community members, activists, and advocacy groups to amplify voices and influence decision-making processes.
Partnerships	• Form coalitions or alliances with like-minded organizations and advocacy groups to advocate for collective policy goals and objectives. • Collaborate with government agencies, think tanks, and policy research institutes to conduct policy analysis and evaluation of green infrastructure policies and programs.

Community Engagement:

Steps	• Organize community meetings, workshops, to raise awareness and trainings and inform about the benefits and opportunities. • Facilitate participatory planning processes involving the community members in the decision-making, to empower local community.
Resources	• Allocate funding's for the engagement activities. • Develop resources to share the knowledge and engage the community.
Partnerships	• Collaborate with local community leaders, grassroots organizations, and neighbourhood associations. • Partner with schools, youth groups, and community centres.