

Using Remote Sensing of the Environment For Urban Sustainability

Modern cities are dynamic and complex settlements that manage the many different needs of the people that inhabit them ([Webb et al., 2018](#)). Accordingly, the methods we use to evaluate the sustainability of cities should reflect this dynamism and complexity. Thankfully, remote sensing of the environment offers an new way of assessing and monitoring cities that supports this kind of detailed analysis.

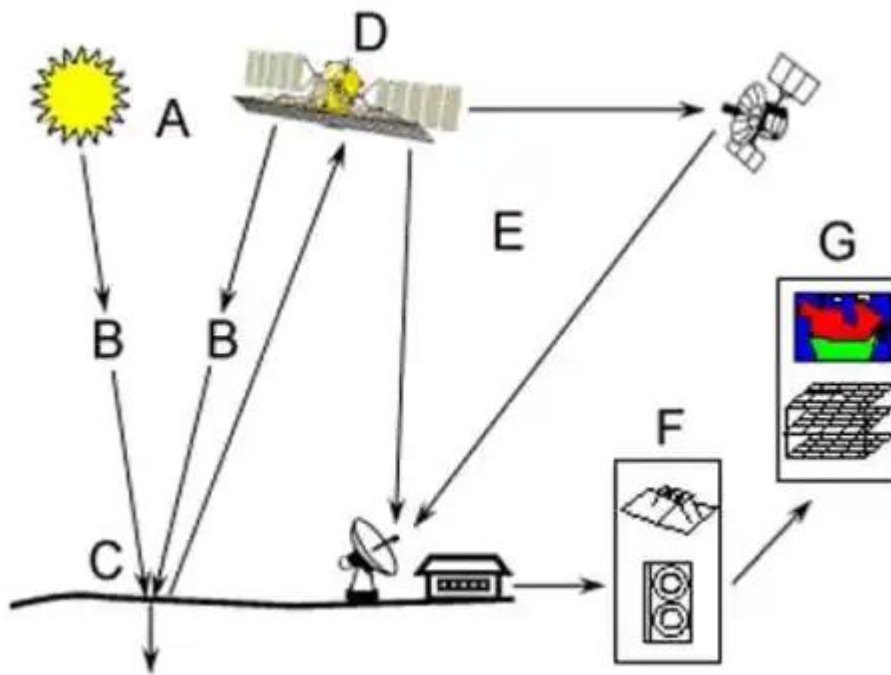
What is Remote Sensing of the Environment?

Remote sensing is a process that allows us to [detect and monitor](#) the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Remote sensing of the environment involves gathering, processing and manipulating [environmental data](#) for the purpose of solving practical environmental problems.

Interestingly, the [origins of remote sensing](#) are in photography and the development of radar, sonar, and thermal infrared detection systems during World War II. Sensors are a more recent technology, developed around 1960.

How Does Remote Sensing Work?

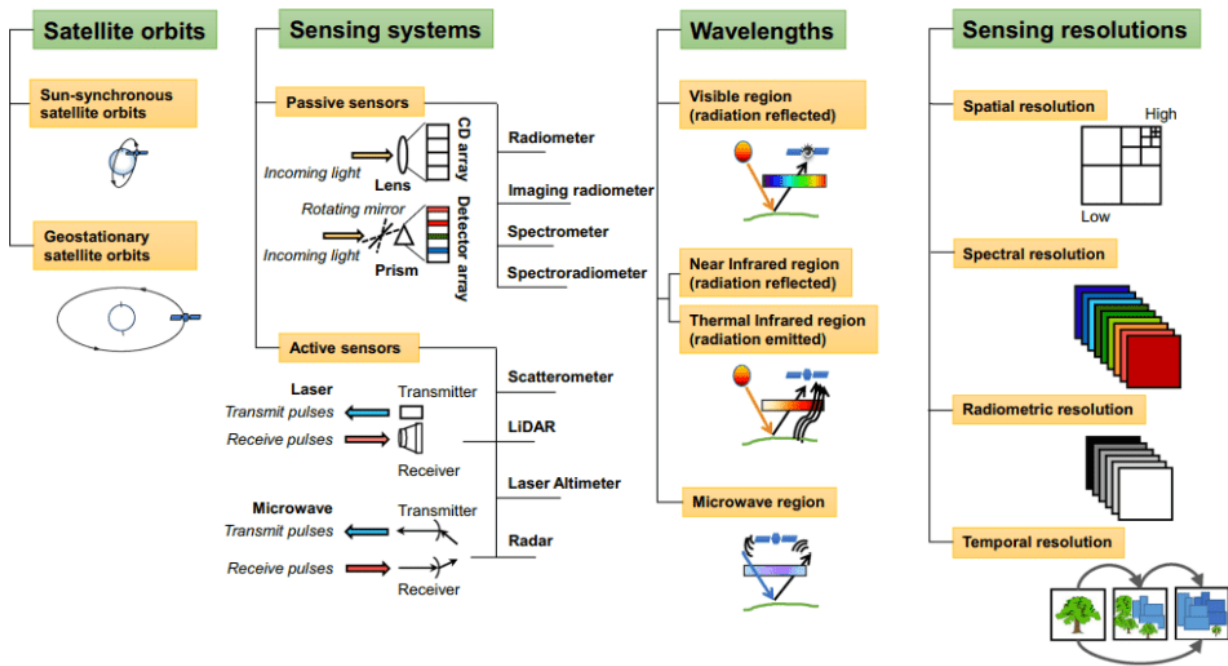
Remote sensing uses two different components: platforms and sensors. [Platforms](#) are the anchors for sensors and can be ground-level (towers and cranes), aerial (helicopters and aircraft), or spaceborne (space shuttles and satellites). The [sensors](#) on these anchors receive electromagnetic radiations and convert them into readable signals like numbers and images. Depending on the source of the radiation, a sensor could be active or passive. An [active sensor](#) has a built-in source of illumination, whereas a [passive sensor](#) relies on radiation from an external source, such as sunlight.



Some of the elements involved in remote sensing. Source: Theconstructor.com
 Satellites are used in much remote sensing of the environment because of their robustness and reliability ([Kadhim et al., 2016](#)). Also, satellite technology for remote sensing of the environment offers many [benefits](#), including:

- Coverage of large areas
- Greater spatial representation of the area monitored
- Data acquisition on a temporal basis
- Greater frequency for obtaining data
- Non-intrusive data collection
- The possibility to acquire information in difficult to access areas
- The possibility to reduce costs of monitoring programs
- Greater speed in providing information to decision makers

The process of using satellites for remote sensing of the environment involves transmitting energy from satellites, and then [sensing](#) that energy at various wavelengths and resolutions. There are various options for remote sensing including radiometry and spectrometry, which are within the visible and near infrared region of the EMS. There is also LiDAR and Radar, which are within the microwave region ([Kadhim et al., 2016](#)).



Classification of Remote Sensing. Source: [Kadhim et. al., 2016](#)

Where is This Technology Used?

Remote sensing has applications in numerous fields. Some of the most common areas in which it has been [applied](#) include:

- Land use mapping
- Weather forecasting
- Resource exploration
- Confirming the occurrence of natural hazards and determining their magnitude
- Photography of the Earth from space
- The creation of base maps for visual reference

In addition, potential uses for remote sensing may exist in urban areas. This application is beginning to gather great interest. ([Avtar et al., 2020](#))



A satellite image of Yellowstone National Park. Source: [Mariana Bobina](#) on Pexels.com

Using Remote Sensing for urban Sustainability

Remote sensing is an emerging tool for achieving urban sustainability. The technology can be used to plan settlements, monitor life quality, and assess environmental changes in urban areas.

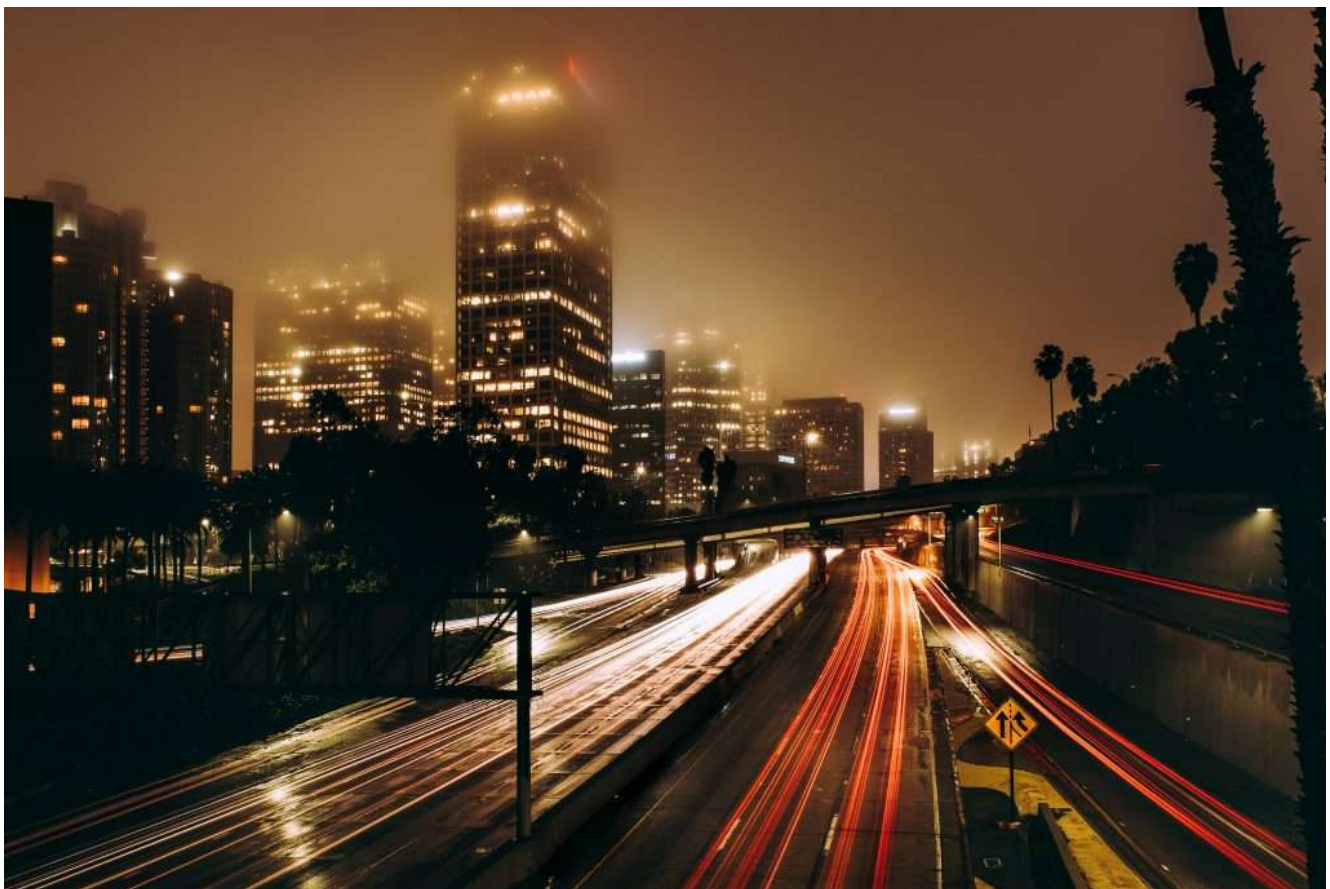
Using Remote Sensing For Urban Planning

Urban planning focuses on both the [immediate and future](#) infrastructural needs of populations. Therefore, effective urban planning requires a [holistic consideration](#) of a city's current infrastructure. It also requires consideration of what is possible and most needed according to various factors. Population growth, for example. Monitoring spatial and temporal changes in an urban area using remote sensing technology provides critical insights ([Hu et al., 2020](#)). Thus, it provides a useful urban planning tool in these areas:

- **Monitoring spatial changes and development in urban settlements.** Through remote sensing, land use changes in an urban environment can be assessed on an ongoing basis ([Yang et al., 2003](#)). Dominant urban land cover and land use types can be determined, and the urban land structure established. This knowledge might assist in enhancing [land use planning](#) and preventing possible [ecological and environmental problems](#). In addition, timely land use information could assist in preventing urban fragmentation and the development of urban sprawls ([Angel et al., 2012](#)).
- **Monitoring demographic and population changes.** The traditional ways of determining a city's population through a CENSUS are cumbersome and often involve many accessibility challenges ([Karume et al., 2017](#)). However, demographic and population changes can be monitored on a more regular basis through the deployment of remote sensing technology ([Karume et al., 2017](#)). Also, the data produced using remote sensing technology is expected to be more accurate than that sourced from a traditional CENSUS. Insights gained in this way would be invaluable for the allocation of resources in cities.
- **The implementation of new technologies.** Remote sensing is a major feature in the Internet of Things (IoT) and the creation of 'smart cities' ([Khadim et al., 2016](#)). A component of the IoT involves sensors (whether on land, in water or space) and autonomous devices like drones and unmanned aerial vehicles (UAV) ([Lagkas et al., 2018](#)). Remote sensing in this context is an input to the IoT, contributing data to the infrastructure of the IoT. Eventually, city management could meet the needs of its inhabitants using data sourced remotely. For example, some areas where [smart city technologies](#) can be implemented include: intelligent lighting, waste management, city parking, smart intersections, intelligent services (security, education and health), and real-time monitoring of energy consumption, water use and air quality.
- **Intelligent transportation systems in urban areas.** Remote sensing is becoming increasingly useful in the development of smart and efficient urban transportation systems. Computer vision, LiDAR, and other sensing technologies are increasingly being used to control traffic and improve travel efficiency in urban areas ([Bai et al., 2022](#)). In this way, traffic congestion in cities can be reduced. In addition, remote sensing technologies enable real time monitoring of vehicle movements, including

breakdowns and security risks on city roads ([Bai et al., 2022](#)).

- **Planning, operation and maintenance of energy infrastructure .** Energy infrastructure requires [ongoing monitoring and maintenance](#) to ensure its efficiency. Human resources may not be enough to cope with the many requirements of planning, operating and maintaining power grids and plants. Thus, remote sensing is a cost-effective way to provide [asset and grid planning](#) (including site selection and geophysical site investigation), [asset management](#) (including the monitoring of asset structural integrity) and [operational risk management](#) (including natural hazard detection).



Remote sensing promises new ways of managing traffic in cities. Source: [Vitaly Kushnir](#) on Pexels.com

Using Remote Sensing For The Environment

The ongoing global climate crisis and environmental challenges require a prompt and ongoing response. Remote sensing of the environment offers great potential for monitoring and responding to environmental threats in the following ways:

- **Monitoring climate change.** Cities contribute significantly to global

warming and climate change simply because they are areas of high population density and are very industrialised ([Yazdi et al., 2019](#)). The common [consequences](#) of urbanisation include deforestation, pollution, and greenhouse gas (GHG) emissions. In order to [mitigate the transboundary effects](#) of climate change, emphasis must be on cities as major contributors to this problem. Also, remote sensing technologies can serve as useful tools to monitor climate change-induced environmental changes in cities ([Ennouri et al., 2021](#)). Through remote sensing of the environment we can, for example, monitor deforestation rate, changes in urban green space, the occurrence of drought events, the loss of coastlines, and bushfire impacts. Additionally, [climate change mitigation and adaptation strategies](#) in urban areas can be enhanced using remote sensing technology. Some [mitigation and adaptation strategies](#) that become possible include analysing urban built environments, understanding typological patterns, and mapping building stock. It could also be useful in finding roofs for solar panels.

- **Monitoring urban ecological infrastructure (UEI).** Urban ecological infrastructure comprises all the parts of a city that support ecological functions and provide ecosystem services ([Childers et al., 2019](#)). [Examples of UEI](#) include parks, streams, trees, residential yards, lakes, urban agriculture and vertical forests. Remote sensing can serve as a useful tool for [monitoring the changes in UEI](#), thereby providing guidance on its current state. This will assist governments in their planning to maintain or restore UEI.
- **Urban disaster management.** Natural disasters such as volcanic eruptions, earthquakes, catastrophic fires and floods could affect cities very suddenly. In this instance, remote sensing can be used to help [identify hazard zones](#). Additionally, it could provide real time images for urban disaster monitoring, and [measurements](#) of the location and magnitude of actual events. This might create more effective responses in the future, leading to impact mitigation.
- **Soil sealing.** [Soil sealing](#) is the covering of the soil by an impermeable material. Soil sealing may have devastating [consequences](#) in an urban environment. These include higher risks of urban flooding and a contribution to city warming. Not to mention the negative effects of soil sealing on urban agricultural production and biodiversity. Remote sensing of the environment can be used to create maps showing the scale of urban

sealing ([Netzband and Meinel,1996](#)). This would provide an opportunity to reverse the trend and reduce the impacts of urban sealing on the environment.



Building footprint for Montpellier city and region in France. Source: [Theia=land.fr](#)

Remote Sensing Can Helps Us Monitor Quality Of Life In Urban Areas

Urban quality of life is determined by a mixture of economic, environmental, social, ecological, cultural factors, among others ([Yagoub et al.,2022](#)). It can be assessed subjectively through an understanding of the perceptions of a city's inhabitants. For example, their attitudes and happiness levels ([Pacione, 2003](#)). However, urban quality of life can also be measured objectively, and remote sensing offers a promising way to achieve this ([Byong-Woon, 2006](#); [Li and Weng 2007](#)); ([Yagoub et al.,2022](#)). In the future, we could use remote sensing to assess environmental, biophysical and infrastructural indicators, and then integrate these insights with CENSUS data to derive a high resolution picture of a city's quality of life ([Li and Weng 2007](#)); ([Yagoub et al.,2022](#)).

The socioeconomic variables that are commonly monitored in a CENSUS include population density, income, poverty, employment rate, educational level and household characteristics ([Li and Weng 2007](#)); ([Yagoub et al.,2022](#)). These can

then be cross-referenced with remotely sensed variables like greenness, pollution, slope, temperature, land use and landcover. The outcome of this type of cross-investigation could include better service distribution and urban planning, which greatly affect quality of life ([Yagoub et al.,2022](#)). The most important needs of urban populations can thereby be prioritised according to insights derived from remote sensing.

Remote sensing may also be used to [monitor](#) small scale subsistence farming in urban areas. This would provide important insights on how productive urban farming is currently, and how it could be improved to [enhance food security](#). Over time, food production in big cities could even become sustainable. Location should not prevent anyone from growing produce.

This Technology Will Get Better and Better

As remote sensing continues to improve in the future, the number and variety of potential applications will multiply. So, remote sensing technology will play an important role in the development and sustainability of urban landscapes as our cities become smart cities. Beyond the Internet of Things, the 'Internet of Everything' promises a future we can eagerly look forward to. Here, the availability of real-time information will drive every aspect of city life and every activity, from waste disposal to finding a parking space.

Remote sensing of the environment will collect real-time data to make this possible. Meanwhile, much needs to be done to improve remote sensing capabilities. It is emerging as a critical tool for urban sustainability in cities all over the world. As always, the application of our collective imagination is necessary to realise this vision of the future.

To learn more about how The THRIVE Project is researching, educating and advocating for a future beyond sustainability, visit our [website](#). You can follow our informative blog and podcast series, as well as find out about our regular live webinars featuring expert guests in the field. [Sign up to our newsletter](#) for regular updates.