SMART OASIS: USING ICT ADVANCED SOLUTIONS FOR SOCIETAL AND ECONOMIC RECONNECTION

A. El Idrissi, A. Haidine, A. Dahbi and A. Aqqal

Laboratory of Information Technology (LTI)
National School of Applied Sciences
University Chouaib Doukkali, El Jadida, Morocco
ayoub.elidrissi.ae@gmail.com, {haidine.a, dahbi.a, aqqal.a}@ucd.ac.ma

KEY WORDS: Smart oasis, smart application, IoT, advanced ICT, mobile networks, machine learning, environment management, sensors.

ABSTRACT:

The climate change is hitting the whole world, and with different level of severity from one geographical zone to another. There are different sensible environments, where its impact is having dramatic consequences on the life, for human being as well for fauna and flora. One of this sensible environment is the oasis. For example, in Moroccan oases, the conditions are getting more dramatic, with harsh desertification, scarcity of the precipitations, and more dangerously is the diminished groundwater, caused by less rain, less snow on the mountains, and evaporation of few available water due to thigh temperature. Other factors come to worsen the situation, such diseases in palm trees, olive tree, more frequent fire even outside of the hot season, etc.
In this paper, we list and discuss some of the major challenges and problems facing the oasis environment, and we propose some smart applications to hep this environment to overcome such problems/challenges from societal, economic as well as environmental aspects. These solutions are pointed as smart to, because they are based on some advanced Information and Communication Technologies (ICT), through data collection from sensors, data transmission, and then data analysis in order to make some intelligent decisions through algorithms to meet some optical decisions for resources utilisation. The term of "resources" covers energy, water, space, etc. In other works, we discuss "Internet-of-Things" (IoT) paradigm for modelling, synthesis and deployment of smart oasis.

1. INTRODUCTION

The oasis is a specific and fragile ecosystem adapted to extremely arid areas. It is an agro-ecosystem whose structure depends mainly on the desert-oasis-river components, which elements (climate, water, soil, plant, animal and human) are highly interdependent and interact with each other. This makes the oasis system both complex and fragile, (El Koumsi, 2017). The date palm constitutes, for the Saharan and pre-Saharan regions, the essential element of the oasis ecosystem. It is the core and the symbol of this system and its presence symbolizes water in the desert. Generally, oases develop along watercourses and groundwater. Indeed, the existence and functioning of palm groves has always been linked to the presence of water and the practice of irrigation. Unfortunately, the climate change hits strongly this fragile environments, which results in warmer short winter and longer hot summer. This had dramatic consequences for groundwater and or plants/trees/palm trees. An example of an oasis from Morocco is illustrated in Fig. 1 alongside the river of Daraa, where the geographic isolation and harsh climate and geology are making the daily life a real challenge of survival for all living elements (human, agricultural plants, fauna and flora).

In this paper we discuss the main challenges facing the oasis (people, animals and environment), how far can intelligent systems, based on information and communications (ICT), can help to overcome these challenges. Such ICT systems cover sensors/actuators layer (sensors for data collection and actuators for instruction execution on systems), data transmission layer, data processing and visualisation, and on the top a smart applications for some intelligent decisions/optimizations. These elements build the components of an Internet-of-Things (IoT) model, which builds a framework for an intelligent environment, which we call in this work: Smart Oasis.

Figure 1. Example of geography, climate and geology condition of an oasis alongside Oued Darâa in south-east Morocco (Source: GoogleMaps).

The objectives for the realization of such smart oasis can be summarized as follows:

- Water efficiency
- Energy efficiency
- Environment monitoring/protection (fire protection, desertification, air pollution –through diesel engines of pumps- illness of trees and harvest products, illness through parasites contaminations of trees/ harvest/ crop, deforestation, etc.)
- Economic efficiency (agriculture efficiency, small enterprises for artisanal products, tec.)
- Social connection of people of such isolated areas

The remaining of the paper is organized as follows: The second section discusses the main challenges facing the oasis environment. The third section addresses the proposed notion of smart oasis, which is an ensemble of smart applications. The fourth section discusses the deployment of the main applications, based on the wires sensors networks as basis. Finally, the fifth section discusses the general hierarchical architecture of the communications networking layer as pivot of the IoT system in the smart oasis.

2. MAJOR CHALLENGES AND PROBLEMS IN OASIS REGIONS

2.1 Water Scarcity

The climate changes has led to temperature increase with different levels in world regions. North Africa and Middle East are on the warmest regions in the world, and the temperatures there are increasing continuously. This phenomena together with less rains, less snows on the mountains, high evaporation effect of (surface water) lead also to the decrease of groundwater. For example, in the Moroccan region Draa, its valleys and its oases are threatened by the depletion of their groundwater, due to drought and the overexploitation of water for irrigation purposes with non-rational and less economical methods to serve massive, as reported in (Younsi, 2022). So that the groundwater in this region is close to exhaustion. After more than seven consecutive years of drought (2014-2022) and without an aid program dedicated to this region, even the unique dam in the region, which irrigated no less than 26,000 hectares of palm fields in the Daraâ oases, now has a filling rate of 10%. This caused the closure of the dam valves. Furthermore, massive cultivation of watermelon (new and inappropriate product for this region), combined with climate change and drought, have transformed the palm fields of the Draâ oases into deserts. Pushing small farmers to abandon their land and in most of the cases to leave their homes and migrate to city.

Different dramatic results can be observed as consequences: always less harvest from historic agricultural activities principally the date palm trees. Desert is harshly attacking the green zones in the oasis, and finally people immigrating to the city to live in hard condition. Knowing that cities, in the developing countries are hart hit first through the Covid pandemic and then more recently with increasing prices and scarcity of food supplies through the Ukraine war.

2.2 Geographic Isolation

The geographic isolation create different challenge, which to be faced by the habitants, such as:

- affects the supply of essential goods (food, oil, medicaments, gas for cooking,
- Usual medication of the population and supply of medicaments, and medical lab tests.
- Difficult or impossible interventions in case of health emergency situation, when people bitten by snakes or scorpions, complicated or premature childbirth,
- Abandoning school prematurely: after finishing primary school, children just remain at home, because they are not able to leave their family to go to visit the secondary school in the city. Girls are largely affected by this problem than the boys, because of different factors,
- People are isolated and cannot acquire new knowledge from diversified domains, like theatre, painting, theatre, new languages, etc.

2.3 Demographic Fragility

The absence of real economic opportunities, adult male person (building male active population) leave to work in the cities. Because they work in hard and badly paid jobs, they cannot rent apartments. So they are forced, to leave their families in the oasis and go alone to the cities. They work hard, live in hard conditions to save money and send a part of it to their families in the oasis. The general picture of the population in the remote and poor villages/oases is dominated by old people (males and females), children and adult women (as main active elements). This picture is getting more dominated by old people and children, which build are the most sensible and fragile segments of the any population. Such picture can also be observed in Eastern European countries, like Romania, Moldavia, etc.

2.4 Economic Fragility

The economic productivity in the oasis is composed of some agricultural products (dates, olives, cereals) with low productivity and products from small artisanal manufacture. Generally, women can produce some traditional clothes, carpets, handmade decorations; however, they cannot meet people who may be interested it their products and most important ready to pay a fair price. To commercialize their products they must “Meet clients, show/expose the products, negotiate, pay and deliver”. This can also be application to the food and goods from the agriculture (dates, olives, aromatic/medicinal plants, etc.

An electronic platform over Internet could be a suitable place and solution to overcome this problem, which is a consequence of the geographic isolation. Anther challenge remains the targeted women/producer, who are most of them illiterate.

2.5 Fragile Environment

In the recent years, the hot temperature in the summer causes large fires in different regions in the world, and mostly in the Mediterranean areas, which is the focus of our discussion. Here are always more frequently fires in the oases, like the case reported in (AgriMaroc, 2019) where one fire ravaged 8997 date palms and 3326 olive trees. This is meanly caused by the extreme dry climate and the dense planted trees in an old manner, as shown on Fig. 2.

Another aspect of the fragile environment sis the wild treatment of solid wastes and wastewater. This are just thrown in open areas, without any treatment. This can be worst, when solid wastes are just burned in the open areas without any precautions or initial treatment of the resulting smoke. As everywhere in the world, plastic is the dominating component of solid waste.

As dry regions, farmers are forced to pump the ground water to irrigate their agricultures, all the pumps uses diesel motors, which burns diesel and emits lot of dioxide and other toxic gas in the air.
To protect their poor and small agriculture and trees, farmers use pesticides, without taking care about the permitted amount of pesticides. Furthermore, some pesticides are used without knowing their origins.

Figure 2. Short hard winters and long hot summers lead frequent to fires [top, (Panafricaines, 2020)] and deadly illnesses of the palm trees [bottom, (Geo, 2020)].

2.6 High energy costs

For the developing countries and especially in the poor regions like isolated villages and oases, the energy was always expensive regarding the very low incomes. By considering the international energy crisis caused by the war in Ukraine, the situation is getting worse for poor populations and countries. Diels as liquid product is getting always expensive. This is also true for cooking gas and the electricity bills, which are produced mostly through the traditional methods of burning row material (gas, coal).
The major companies of the energy consumption in the oasis environment are mainly (some function are foreseen for smart oasis):

- Irrigation pumps
- Telecom infrastructures
- Residential homes (lighting, cooking, water heating, small white appliances, etc.)
- Groundwater treatment/cleaning (if any)
- Solid waste treatment
- Waste water treatment/cleaning
- Hostels/ hotels: need heating and hot water in the baths for tourist because of harsh but short winters, and cooling systems for long and hot summers

3. DEVELOPING THE PARADIGM OF –SMART OASIS-

3.1 Our Proposed Model and Smart Applications

The smart oasis is an oasis environment where different ICT systems are deployed in order to achieve the objectives previously cited namely: Water efficiency, Energy efficiency, Environment monitoring/protection, Economic efficiency and Social re-connection. These ICT infrastructure allows the implementation of a set of smart applications around the smart oasis as summarized in Fig. 3:

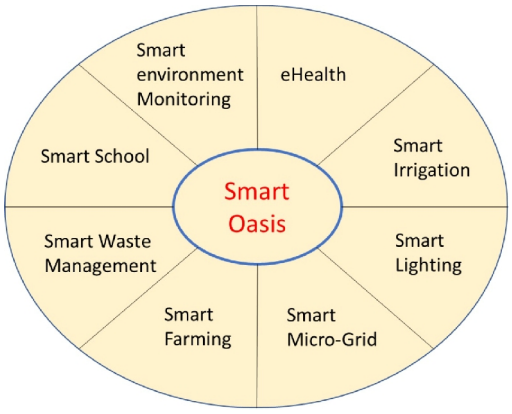

Figure 3. Ensemble of Smart Applications to build the Smart oasis.

Smart environment monitoring covers different functions, as will be discussed in details later. As examples, the main functions should be:

- Control of ground waters (sur-)exploitation by using smart water meters in wells (or water pumps)
- Control of agriculture types, to avoid products that consuming large volumes of waters, like watermelons, and encourage environment friendly cultures
- Trees felling to gain wood used for cooking or water heating for baths or heating in winter (because gas is expensive and its supply is not guaranteed at anytime
- Detection of illness and parasites attacking: animals, trees, tree fruits, harvest, etc.

Smart micro-grid should built the core component of the energy efficiency and energy liability in any smart environment, and especially in oasis environment. The decision about the type of renewable energy should be the result of a deep analysis, because this will change from one use case to another. For example, oasis laying deeper in a valley will have weak winds blowing. Thus, wind energy or turbines will not be efficient. Solar energy is guaranteed along the year in the oasis, but an economic efficient energy storage solution must be selected, because the energy production occur during the day light, while in the night electricity will be also needed. An optimization of the battery solution requires that activities consuming high energy should be operated by day when the electricity production is at its high. For example, water heating, water pumps for irrigation, etc.

4. DEPLOYMENT OF IOT SYSTEM FOR SMART OASIS

Type text single-spaced, with one blank line between paragraphs and following headings. Start paragraphs flush with left margin.

4.1 Characterisation of Oasis Environment for ICT Deployment

Usually, before the design and the deployment of communications networks, engineers must analyse the deployment environment, including the general characteristics of the deployment environment, the types and volume of information traffic to be transmitted, characteristics of end-users (residential, professional or industrial and their payment ability for services, which depends on the monthly/yearly income as well as their level of education). So, the oasis environment can be characterised by:

- Very low density of population
- Very low income and social fragility
- High percentage of illiteracy
- Used services is dominated by the usual voice services, to contact their relatives either in the same oasis area or in cities. The communications session in most of the cases are started though entering calls (relatives in cities start the calls)
- Very low use of modern smartphones, because they are too expensive for such poor population. Of course, there will be some exceptions, like for the one doctor in the areas, school instructors, some tourists, etc.
- One of the important facts for the deployment of mobile networks is the extremely high flexibility of spectrum use. Generally, mobile network operators make some reuse schemes of the owned frequencies/spectrum according to a given scheme, in order ensure a high exploitation of the frequencies but also to avoid interferences. The worst case for such schemes is the city centres of big cities, with high density of users and large number of small cells. But, for the oasis, we have low users as well as traffic density, and oases are geographically isolated (which easily avoid interferences)
- Small habitations of the oases build an optimal environments for the radio signal propagation of mobile/wireless communications. The attenuation are much lower than in urban environments, and therefore, the signal coverage will be larger than in cities. This makes the deployment of the network very easy to design, deploy and optimize.
- One obstacle for the radio wave propagation could be the dense vegetation, but this is only for the old plantations. For new plantation the ministry of agriculture recommend at least 10 meters distance between the trees for a better productivity and less damage in case of fires.
- Normally, the newest generation of networking technologies could solve almost the problems related to quality of service (QoS) performances. However, this cannot be applied in such environment, because this requires that end-users have also the newest version and brand of end-devices. Thus, technologies like the fifth generation 5G cannot be applied in this case.

4.2 Sensors for Environment Monitoring

The environment monitoring is based on sensors and can have different possible configurations, from a simple one to a more complex and advanced one. A general layer monitoring of the environment monitoring is presented in Fig. 4.

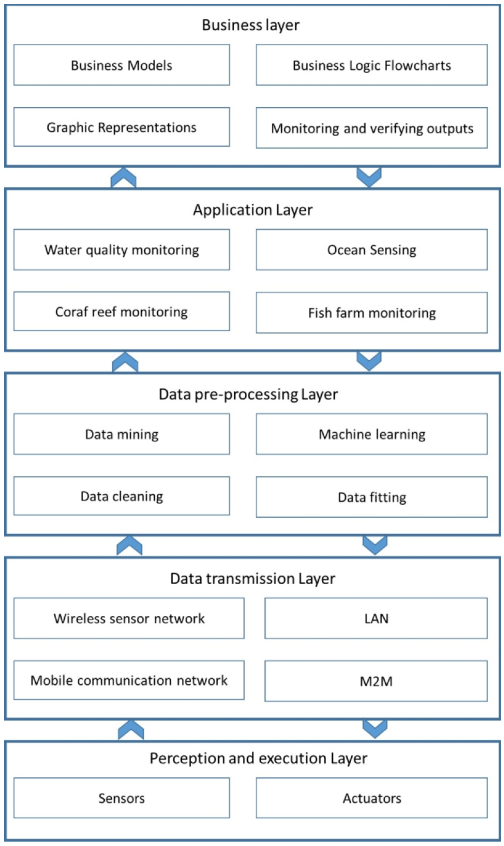

Figure 4. Advanced IoT model for environment monitoring that can be reduced and adapted to the special case of oasis environment.

The deployment of the previously cited environment monitoring applications requires the placement of a given number of sensors and actuators in the oasis environment and possibly in its neighbouring regions. The sensors must be connected to each other from one side, and to central points on the other side. Such central point can be a local servers/computer or to the system of ministry/agency for agriculture or energy or natural resources, etc. A communications network(s) is necessary to transmit the collected/measured data to the (intelligent) server system(s), as illustrated in Fig. 5. In this generic architecture, the different sensors are connected with each other or directly to central sink node over short range wireless communications (generally ZigBee or Bluetooth). The collector nodes needs another wireless link to transmit data to the system server. We call this part “WSN Backhauling”. Usually WSN is composed by a set of fixed sensors, but in the recent years drones are gaining an increasing interest in all monitoring application fields. Therefore, this should also be considered in smart oasis. To build the WSN backhauling different wireless techniques can be taken into consideration, as listed in Table 1 with main advantages and drawbacks for each solution.

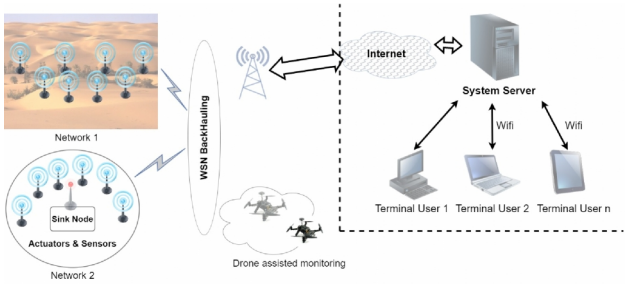

Figure 5. Deploying WSN as bottom level in IoT architecture for Environment Monitoring (extended version based on (Xu et al. 2019)).

4.3 More Advanced Technologies

Drones has realized a high degree of flexibility in different monitoring activities, especially in harsh environments where risk of incidents is higher than usual. For example, drones have been introduced in maritime port operations as described in (Bexiga, 2019). Drones utilisation in maritime ports has been extended to environment monitoring in (Haidine et al. 2021). Similarly, drones can also be used for some environment monitoring tasks in oasis environment, such as:

- Use of heat camera to detect any smoke or fire as early as possible, to save lives, goods and natures (animals, plants and trees). Also drones can be used to get more detailed and clear view on the circumstances of any detected (or probable) fire. This monitoring can be applied to the nature landscape, rivers and the neighbourhood of the oasis. Drones can fly intensively in very hot days with high risk of bush fire.
- Drones assisted with cameras and ML/AI can also be used to supervise tress implantations to detect if any illnesses/parasites touched trees, crop, etc. Such applications for olive trees has been developed in (Raouhi et al. 2022).
- Use of drones for agriculture in general is gaining an increasing interest. Different products are currently on the market for different types of utilisation in agriculture referred to as "Agricultural Drone Technology" for Mapping/ Surveying, Cropdusting/ Spraying, etc. (Raouhi et al. 2022). More details about benefits of drones in agricultures can be found, e.g. in (Minhaj, 2022).

5. NETWORKING AND COMMUNICATIONS LAYXER AS PIVOTAL SYSTEMS IN THE IOT MODEL

5.1 Selection of Technologies

The above cited smart applications contain different services, besides the usual communications applications (like voice communications, Internet access, etc.). Table 1 summarizes the different types of data flows and services that could be met in the environment of smart oasis, and the adequate communications technologies that can be used for the transmission for such traffic. It is clear that we have “vertical market” or “vertical applications”, which work independently of each other. However, they must use the same communications infrastructure, as far as possible, in order to optimize the deployment costs.

TABLE 1: Types of data flows in oasis areas and adequate transmission technologies

Service/Data types	Technical Solution	Remarks
Usual voice services	2G/ 3G	People are still using old phone handsets
IoT short data packets	-Wireless sensor networks (WSN) base on ZigBee/ Bluetooth -Narrowband PLC as special solution for smart lighting -LPWAN (LoRa)	-For smart oasis apps -Needs backhauling
WSN backhauling	LPWAN (LoRa) 4G/LTE	
IoT large data packets	4G/LTE	-For heats and surveillance cameras
Usual Internet access (indoor use)	Wi-Fi (IEEE 802.11)	-only indoor use -needs backhauling
Usual Internet access (outdoor)	4G/LTE	Mostly avoided, because the costs of mobile Internet/data are too high for such population with very low income
WiFi backhauling	4G/LTE	
Broadband access to regional/national wide area networks (WAN)	Satellite and/or microwave links	Important to have one primary link as normal use and a secondary link as backup

5.2 Integrated Hierarchical Architecture

The general picture on the networking layer is illustrated in Fig. 6, and it is constituted by the following:

- A bottom level constituted by a narrowband network connecting sensors/actuators with each other and finally with the sink-node (in form of gateways or head-end). The radio links can be built by different short range technologies, such as ZigBee or Bluetooth as example. Such wireless sensors network is distributed in the assets in the irrigation systems, renewable energy parks, etc. A special case is the smart lighting, where the control elements in each lamp is connected with the sink node over narrowband power line communication (PLC) system that uses the electric lines as transmission medium. This solution has been developed in the framework of smart grid evolution in European as well as in North American utilities. Detailed description of such systems can be found in (InteliLIGHT, 2022).
- A second level of this architecture constituted by the indoor broadband access. This is needed either in simple homes or in the buildings, such local administration, local small hospital, buildings for cooperative for small local industries, etc. Here WiFi (or technically referred to as IEEE 802.11) is the adequate solutions.
- This level has different tasks: a) backhauling the gateway/sink of different WSN, b) backhauling the indoor broadband Internet (WiFi), c) covering the outdoor Mobile Internet (outdoor) (even if smartphones and tablets are not widely used by these people with very low income). Besides 4G/LTE,

WIMAX can be used as alternative or even we can use the most recent and powerful 5G. However, it is hard to find end-devices containing models for these technologies in such deployment environments.

- On the top of this architecture, we need to have gateways to the national/regional wide area network (WAN). Seeing the characteristics of these isolated regions, point-to-point broadband microwaves are unique solutions that seems to be adequate for this scenario. However, we need to have a second links as redundancy for the case of incidents that could damage/disturb the primary one. For telecom infrastructure this is often the case in such harsh environment. These incidents can occur in form of rain storms or dust storms, floods, fires, etc. Satellite is the best solution build this secondary redundant link. Satellite could also be used as primary links; however, the financial aspects make this solution appropriate as secondary solution.

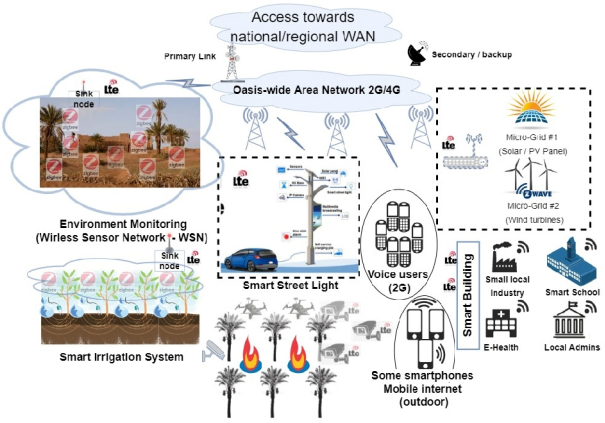

Figure 6. Hierarchical architecture for communications networking layer in smart oasis.

6. CONCLUSIONS AND PERSPECTIVES

In this work, we discussed the main challenges facing the oasis, which represents a fragile and isolated environment. These challenges are facing all components; the human, climate, natural resources, animals, trees (especially the most important source of nutrition an income, namely pal tree), etc. We proposed the notion of smart oasis build around an ensemble of smart applications, which are based on ICT solutions. This ICT infrastructure is built through wireless sensors networks as a basis for network and communications layer.

As next steps, we aim to take some uses cases from the country, in order to make a concrete technical design of the networking layer and to assess its technical performances as well as its techno-economical aspects.

REFERENCES

AgriMaroc, 2019: Après 8997 palmiers et 3326 oliviers brûlés, l'Oasis Ksar Blaghma peine à renaître de ses cendres," News article from AgriMaroc.ma. Online https://www.agrimaroc.ma/incendie-oasis-ksar-vallee-ziz/ (last retrieved on 30.06.2022)

V. Bexiga, 2019: Blue Innovation – Drones in Port Operations," Escola Europa Intermodal Transport, online available https://escolaeuropea.eu/odiseo/issue-30-spring-2019/blue-innovation-drones-in-port-operations, (last retrieved on 30.06.2022).

W. El Khoumsi, 2017: La durabilité du système oasien face à la détérioration des ressources en eaux souterraines: cas de la palmeraie de Tafilalet. *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, March 2017 (in French).

GEO Magazine, 2020: "Dans le sud du Maroc, des oasis ancestrales menacées d'extinction," News Article from 14/02/2020. Online https://www.geo.fr/environnement/dans-le-sud-du-maroc-des-oasis-ancestrales-menacees-dextinction-199908. (Last retrieved on 30.06.2022).

A. Haidine, A. Aqqal and A. Dahbi, 2021. Communications Backbone for Environment Monitoring Applications in Smart Maritime Ports— Case Study of a Moroccan Port. 2021 IEEE Asia-Pacific Conference on Geoscience, Electronics and Remote Sensing Technology (AGERS), 2021, pp. 136-140, doi: 10.1109/AGERS53903.2021.9617440.

InteliLIGHT® Streetlight Management System, 2022: inteliLIGHT® StreetLight Control Solution-- communication technologies. https://intelilight.eu (last retrieved on 30.06.2022).

Meola, A. 2021: "Precision agriculture in 2021: The future of farming is using drones and sensors for efficient mapping and spraying," Business Insider Reports, Feb 8, 2021, © 2022 Insider Inc. Online https://www.businessinsider.com/agricultural-drones-precision-mapping-spraying. (Last retrieved on 30.06.2022).

Minhaj, 2022: 5 Benefits of Drones in Agriculture. Review of Drones on yourdronereviews.com, June 9, 2022. Online https://yourdronereviews.com/benefits-of-drones-in-agriculture

Raouhi, E. M., Lachgar, M., Hrimech, H. and Kartit, A., 2022: Impact of regularization on the effectiveness of transfer learning for olive disease classification. 2022 11th International Symposium on Signal, Image, Video and Communications (ISIVC), 2022, pp. 1-6, doi: 10.1109/ISIVC54825.2022.9800749.

Les Panafricaines, 2020. Maroc. L'oasis de Tighmert meurtrie par une série d'incendies mystérieux. News from 31/08/2020; online https://lespanafricaines.com/lng/fr/2020/08/31/maroc-loasis-de-tighmert-meurtrie-par-une-serie-dincendies-mysterieux/ (Last retrieved on 30.06.2022).

Xu, G., Sun, X. and Shen, W., 2019: Internet of Things in Marine Environment Monitoring: A Review. *Sensors 2019, 19, 1711; April 2019*, doi: 10.3390/s19071711.

Younsi, M., 2022. Zagora: Surexploité, la nappe phréatique proche de l'épuisement. News article, from 24/02/2022. Online https://fr.le360.ma/societe/zagora-surexploitee-la-nappe-phreatique-proche-de-lepuisement-255475. (Last retrieved on 30.06.2022).