IFERP Explore Your Research Journey...

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 11, Issue 7, July 2024

Smart Conservancy Model for Endangered Species

[1] Peter Nyongesah Obimo, [2] Özge Cihanbeğendi,

[1] Research Scholar, Department of Electrical and Electronics Engineering, Dokuz Eylul University Izmir, Turkey
[2] Lecturer, Department of Electrical and Electronics Engineering, Dokuz Eylul University, Izmir, Turkey
Corresponding Author Email: [1] peternyongesah.obimo@ogr.deu.edu.tr, [2] ozge.sahin@deu.edu.tr

***Abstract*— Majority of world indigenous species are endangered, facing extinction. Governments and organizations are putting measures of ensuring conservation of the endangered flora and fauna that once flourished naturally and mutually within a complete self-sustaining ecosystem. The extinction of most animal species in developing countries has been occasioned by uncontrolled poaching, human encroachment into animal habitat for purposes of enhancing rainfed agriculture and acquiring land for settlements and industrialization, environmental degradation, pollution, natural calamities like wildfires, prolonged famine and above all global warming. This paper presents a smart sustainable animal conservation model. Motivated by Internet of Things (IoT) technology, a conservation and management system is presented that encompasses interconnection of different smart subsystems that interacts with the conservation stakeholders, a sanctuary and the specified endangered species flock. The system uses remote sensing to protect the species through geofencing and geolocation capabilities. This ensures the endangered species are remotely monitored within a virtual locality thereby, protecting them from both human and nonhuman predators. To solve the issue of unpredictable weather patterns and natural calamities, a smart irrigation, watering and disaster monitoring systems are incorporated respectively. These subsystems are interlinked to an intelligent management system as well as a web-based interface for monitoring, marketing and advertisements to ensure self-sustainability. This paper therefore realizes a low cost self-sustaining smart conservation model suitable for developing countries that are keen with conservation.**

***Index Terms*— conservation, endangered species, geofencing, Internet of Things (IoT), smart irrigation system.**

I. INTRODUCTION

Most world indigenous species are endangered and at the verge of extinction [1–4]. Governments and organizations are putting measures of ensuring conservation of the endangered flora and fauna that once flourished naturally and mutually within a complete self-sustaining ecosystem. The extinction of most animal species has been occasioned by uncontrolled poaching, human encroachment into animal habitat for purposes of enhancing rain-fed agriculture and acquisition of land for settlements and industrialization, environmental degradation, pollution, natural calamities like wildfires, prolonged famine and above all global warming [5–7]. Global warming, for instance, has led to unpredictable weather conditions making it harder for conservationists to ensure sustainable ecosystem for animals. Most developing countries that were once habitats of most unique species, faced with a choice on whether to prioritize wildlife conservation, rather; opt for saving the equally insecure human population that still faces challenges of poverty, hunger, disease and illiteracy [8]. Therefore, animal conservation is given the least priority if any [9]. This paper presents a smart sustainable animal conservation model. Motivated by internet of things (IoT) technology, it is possible to integrate many subsystems and control them centrally with a lot of ease [10, 11], a concept on which this research is anchored on. It envisages development of a wholesome endangered species conservation and management system that encompasses interconnection of different smart subsystems. This allows interaction between conservation stakeholders, the geographical conservation area (sanctuary) and the endangered species flock. The system incorporates smart remote sensing capability that monitors the species movement through geofencing and geolocation technology [12]. This ensures the endangered species are remotely monitored within a virtually fenced locality thereby, protecting them from both human and nonhuman predators. To solve the issue of unpredictable weather patterns and natural calamities, a smart irrigation and drinking water subsystem as well as disaster/calamity monitoring subsystems are incorporated respectively. These are further linked to an intelligent management system which connects to a web-based interface system for monitoring, marketing and advertisement respectively. The scope of the paper is limited to system design and modeling, realization and operational analysis. The design focuses on a model suitable for a small animal sanctuary mostly suitable for a developing country. The rest of this paper is organized as follows: firstly, description of key concepts is given. Secondly, conceptualization, design, modeling and analysis of the system is highlighted followed by the benefits and importance of the system. Further, the specific components required for realization of the model are underscored with the core items specified and designed. Lastly, discussions, inferences and conclusion for the study is presented.

II. CONCEPTUALIZATION

A. Internet of Things (IoT)

This paper is anchored on Internet of Things (IoT) technology. IoT is an integration of networks, computing systems, smart things, animals, people, through use of unique

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 11, Issue 7, July 2024

identifiers and the exchange of data among these entities without human intervention. It is a combination of information technology, computer science, electronics and telecommunication, smart mechanical systems and many more [13, 14]. The architecture of IoT is shown in Fig. 1. IoT can be harnessed for systematic and scientific analysis of animal diversity. For animals to be integrated to the system, they require to be implanted with chips or tagged with sensors that can collect their physiological and locational information and allow exchange of the acquired data.

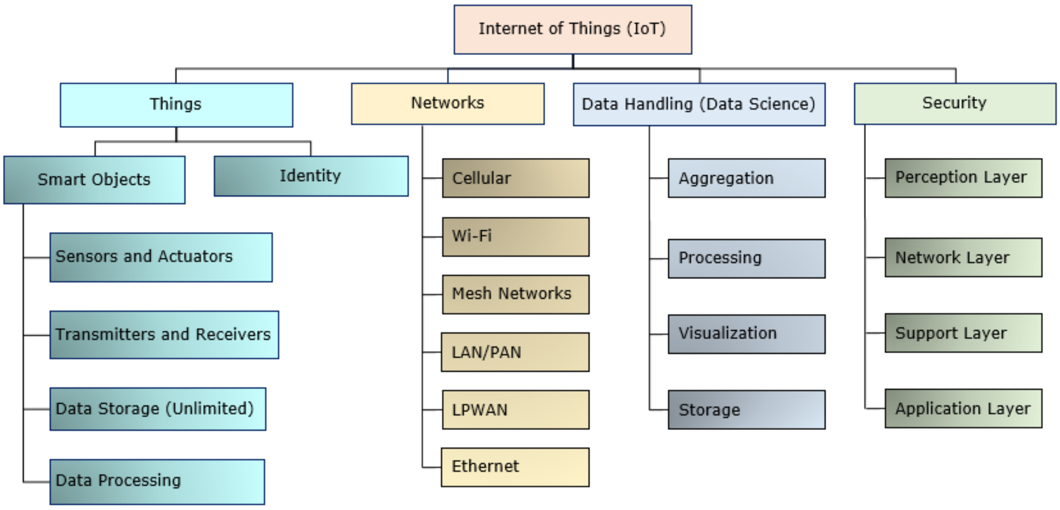

Fig. 1. IoT architecture [15], Author 2023

B. Concept Description

The design of the smart conservancy model involves interconnection of five subsystems where each sub-system may further be considered as an autonomous system capable of operating independently. An intelligent interconnection of these various subsystems is what enables the realization of a complete smart multi-conservancy system. Fig. 2 illustrates the block diagram of the platform.

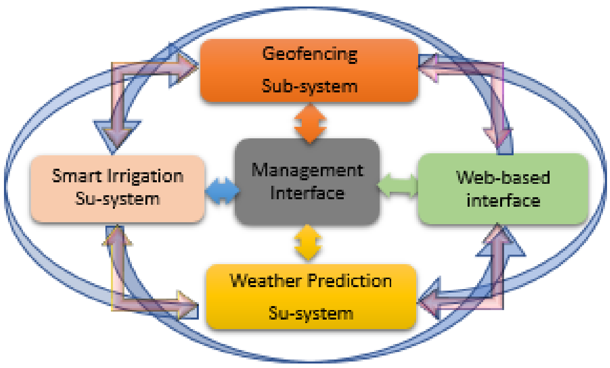

Fig. 2. Block diagram of the smart conservancy system, Source: Author,2023.

In the subsequent sub-section, an elaborate description and design of each subsystem is given. The design has been highlighted in parts to represent each autonomous unit.

III. DESIGN AND IMPLEMENTATION

A. Part One: Geofencing and Geolocation Subsystem

1) Description

Geofencing is a technology anchored on telemetries and global positioning system (GPS) through satellite network that enables remote monitoring of a defined geographical areas surrounded by a virtual fence for specific registered devices through automatic detection when they enter or exit area [16]. This technology has been used in various fields related to the monitoring of people and mobile assets specifically in transport and logistics sector, fleet management, defense and security and product advertisements. The conservancy area is virtually marked and controlled in such a way that the species of interest are fitted with trackers which monitors their movement so at any given point they are within the virtually fenced region. If an animal that has been fitted with a tracker (in form of a sensor or implant chip) gets out of the area, an alert is sent to the monitoring center for the animal to be relocated back [12, 16–19]. The physical control of the animals is achieved through drones that are flown lowly in the conservancy to scare away the animal [20, 21]. Geofencing and geolocation are one of the location based services (LBS) with devices communicating within the set range. The virtual fencing can assume any geometric shape thereby covering any distance as desired like a polygonal shape for this case. It can operate in an area of range of over 50,000 meters to several kilometers. Amboseli National Park in Kenya was targeted which covers hundreds of square kilometers and the species of interest were

IFERP
ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 11, Issue 7, July 2024

the Rhinoceros. After a virtual boundary is defined, it creates a zone that the entrance and exits of targeted species are monitored.

2) Components of Geofencing System

Geofencing system comprises of three interlinked segments as described below:

--Tracker: Rhinoceros are fitted with satellite communication tracker devices which are in constant communication with the satellite. Although a mere location information signals are deemed adequate, other sophisticated sensors may be added if more information about the animal is required.

--Wireless Satellite Network: Since the selected sanctuary covers vast land mass; it is economically viable to use satellite network as opposed to mobile cellular networks.

--Management Interface: This acts as the control center for the system. The received position signals are processed and appropriate action triggered.

3) Operation

Geofencing and geolocation is realized by implementing a satellite communication system, the tracker device and the control center. Two tracker methods were investigated: In the first model, only location information is of concern and therefore, a satellite tracker device is fitted around the necks of the animals and it transmits the locational coordinate signals directly to the satellite. It is a low-cost system and easy to implement and maintain. The second model is where animals are fitted with low-power chips that collects the geolocation data as well as other physiological information and converts the data into signals that are then transmitted to the nearby base transceiver stations (BTS) for re-transmission to the management center. The block diagram of the geofenced area is shown in Fig. 3 where there are two specified zones: critically fenced and buffer zones.

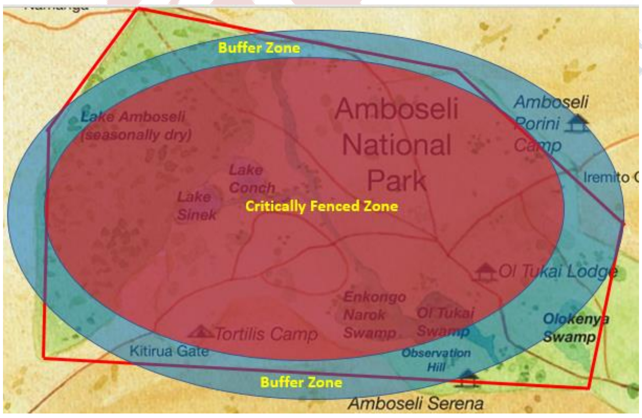

Fig. 3. A polygon geofence, Source: Author, 2023.

If the rhinoceros is in critically fenced zone, the position signals delivered are neglected, if in the buffer zone, the signals are made to trigger the drone system which are directed to hover over the animal to return them to the former zone. Further, to control poachers, the system is made in a way that it detects and tracks all wireless communication devices where only whitelisted devices are allowed in the conservancy region. Any other device is blacklisted, and their encroachment is considered trespass. The base transceiver stations (BTS) which are erected nearly around the sanctuary will pick the information of the intruder mobile device and send to the monitoring center for appreciate action in which case the game warders are alerted to arrest the intruder.

4) GPS Tracker Design

The geofencing design described here is a robust system that is interlinked as shown in Fig. 4. The location signals are picked by the tracker device and from the poacher mobile device and sent to the satellite which later sends the signals to the server and the database for processing. The rangers are alerted if the animal gets out of the geofenced area to either send drones or use appropriate means to return them to the sanctuary. For the case of poachers, the rangers are alerted, and the arrest is done promptly. To implement geofencing and a coordinated drone system, the implementation conceptual framework shown in Fig. 5 is adopted. The critical parameters of the system are location coordinates which are converted to distances for defining the range for critically fenced, buffer zone and restricted areas.

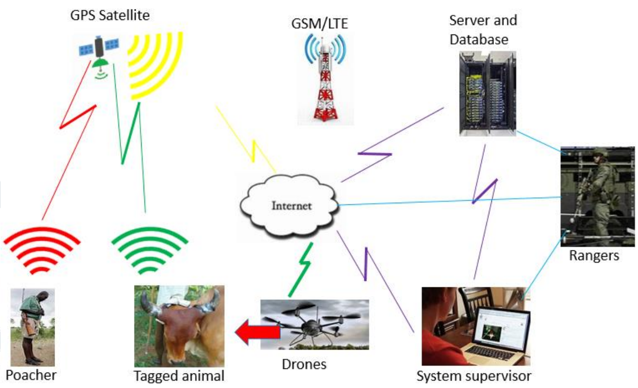

Fig. 4. Design block diagram for the geofencing subsystem, Source: Author, 2023.

Assumed that D is animal distance from critically fenced area and that there exists, T, a threshold distance, then action taken to control the animal is defined by (1).

$$\begin{cases} D < T \quad send\ drones\ and\ alert\ warders \\ D = T \quad re - evalaute\ the\ position \\ D > T \quad reset\ tracker\ for\ new\ evaluation \end{cases} \tag{1}$$

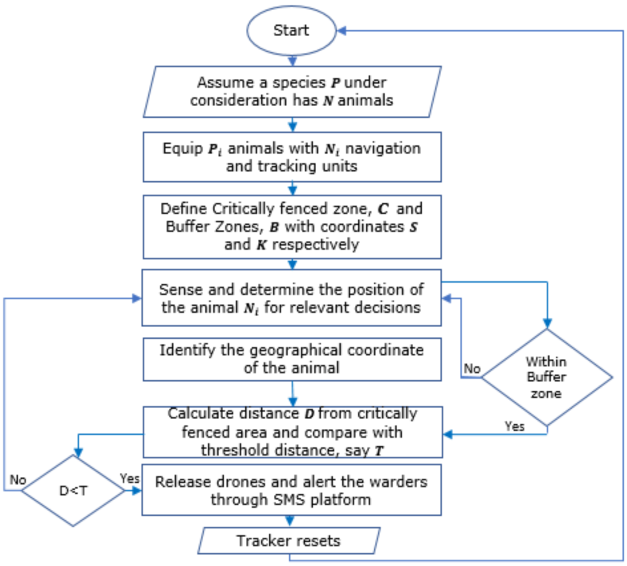

Fig. 5. Geofencing system implementation conceptual framework, Source: Author, 2023.

B. Part Two: Smart Irrigation Subsystem

1) Description

One of the major challenges faced by most conservancies is famine/drought and unpredictable weather patterns. Most vulnerable animal species die due to lack of water to drink and pasture to feed on. The paper therefore focuses on ensuring a sustainable flora ecosystem by supplementing rainfall with a smart irrigation and animal watering system whose design has been motivated by the ideas in [22–26]. The irrigation subsystem incorporates the following;

-- A solar power harnessing system
-- Solar power operated water pump that pumps the water from the underground drilled water wells as well as rainfed underground storage wells
-- Smart irrigation module with moisture sensors
-- Smart animal watering system for providing drinking water to the animals
-- Wireless communication unit for interlinking with the management interface and
-- Intelligent control system for processing the data

2) Design and Analysis

This is a smart irrigation model that is intended to optimize the use of water as a resource through utilization of renewable energy sources and wireless communication technology. The subsystem is made up of four functional units which are solar energy, pumps and irrigation systems, wireless communication system and sensors. The system is powered by solar energy harnessed onsite. The harnessed electricity is stored in battery banks and used to power the pump which moves the water from underground storage well or drilled boreholes. The water fills the animal drinking troughs through a valve fitted with sensors and actuator to avoid wastages. For irrigation, there are moisture sensors safely fitted across the sanctuary. When the soil moisture level drops below a certain threshold, the irrigation system is triggered to irrigate the pasture. Further all this circuit is interlinked to the central control through wireless GSM system all which is powered by the solar power. A block diagram of the smart irrigation system is shown in Fig. 6.

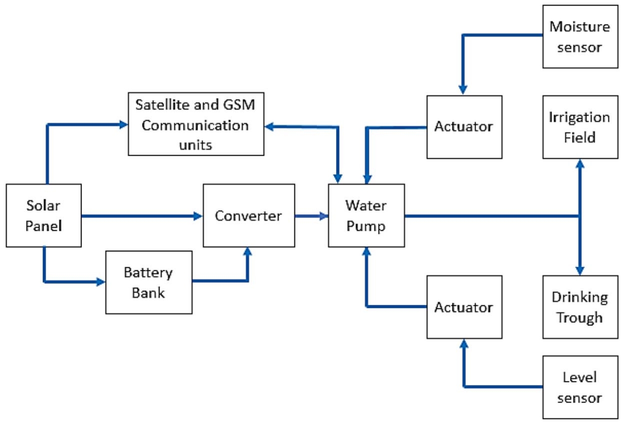

Fig. 6. Block diagram for smart irrigation and animal watering system.

3) Description of Selected Sensors

In this subsection, different practical sensors associated with the weather and calamity detection subsystem are described in detail. The description scope however does not include the design procedure.

--Soil Moisture Sensor

The soil moisture sensor measures soil moisture through detecting the electrical conductivity of the soil. When the moisture is high, the resistance of the soil reduces. This increases with decrease in moisture content. The soil moisture sensor has two probes as shown in Fig. 7 below.

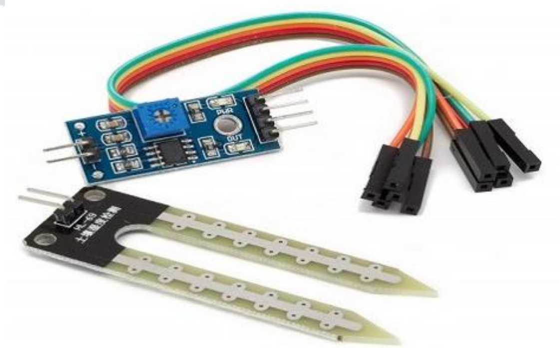

Fig. 7. Soil moisture sensor.

--Rainfall Sensor

Rainfall sensor detects rainfall droplets. This sensor is essential in ensuring that the water from rain is stored in the underground storage and that during rain, the irrigation systems are not turned on. Further, it helps in approximating the rain levels for possibility of floods. A rainfall sensor is shown in Fig. 8.

Fig. 8. Rainfall sensor.

C. Part Three: Weather and Calamity Management Subsystem

1) Description

For a sustainable animal ecosystem, weather plays a big role in determination of animal breeding patterns, migration patterns and even their wellbeing. To ensure a sustainable conservancy for the animals, there are a lot of weather elements that need to be monitored in a daily basis. Most of these elements can easily be accessed from the web-based interface, however, very specific aspects like floods, localized humidity, smoke etc. needs to be recorded onsite. For this reason, a weather prediction system [27–29] is designed and incorporated in the system. This subsystem incorporates the following.

-- Weather forecasting systems among which include temperature sensors, humidity sensors

-- Calamity monitoring systems like lightning sensors, smoke detection systems for detecting wildfire outbreaks and flood detection systems.

2) Design and Analysis

Weather prediction subsystem is realized through installation of several sensors in different points of the conservancy area for collection of different weather elements. The collected signals are converted into digital signals and then transmitted for analysis in the management system through the GSM/LTE/5G wireless network. The specific sensors include lightning prediction sensor, smoke detection sensors, flood detection sensors as well as other weather elements sensors. The block diagram of weather prediction signal flow is shown in Fig. 9.

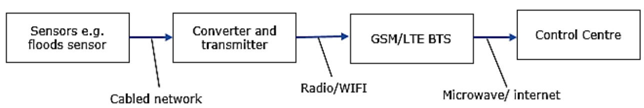

Fig. 9. Signal path

3) Lightning Prediction

Lightning strikes is a common phenomenon along the tropics with recorded diverse effects on wildlife. A lightning prediction system is incorporated with the potential of detecting atmospheric conditions likely to result in lighting and send the warning signals to the control center where appreciate measures are taken to refuge the animals. The systems consist of sensors capable of detecting changes in electrical charges within the atmosphere. To avoid false positives associated with such detectors, electric field data is used in conjunction with detection information. Lightning detector is critical to ensuring the conservationists averts mass death of animals especially for species that like swarming together during storms.

D. Part Four: Web-Based User Interface

Most sub-Saharan countries endowed with virgin indigenous vegetation until recently have been a habitat to most indigenous animal species. They had the greatest world population of the big 5 cats as well as other big mammals. Since the time they attained independence and self-governance, these countries have majorly depended on foreign exchange from tourism.

There is a fast-growing decline in the population of these animals and these countries cannot manage to wait any longer for proper plans to conserve tourism attraction sites, which is their biggest economic drivers. This work tries to ensure sustainable foreign income generation through controlled and smart conservation system. Therefore, the model incorporates a subsystem that is web-based where the countries can market their resources. Through the same system, interested conservationist, zoophilists, expatriates, educationists and different national and international stakeholders can make their contributions towards conservation and global biodiversity. Further, the platform acts as an advertisement platform for the tourists who would wish to visit the sites and part of the revenue generated ploughed back to self-sustain the model.

E. Part Five: Management Interface

1) Description

This acts as the backbone of the model where it incorporates intelligent data analytics tools enabling prompt decision making and resource mobilization and allocation. For instance, all the collected signals from the geofencing subsystem, smart irrigation system, weather and calamity management subsystem and web-based user interface subsystems are collated and processed for relevant action plan. Further, the resources are allocated depending on the reports from the analyzed data.

2) Design and Analysis

The management subsystem is realized through collation of different data sets that is harnessed from the field. The data subsets can be arranged as per the subsystem from which they have been collected as indicated in the chart of Fig. 10. After the analysis, the relevant information that requires quick response is executed and the rest of the data being stored in the data bank for future analysis.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 11, Issue 7, July 2024

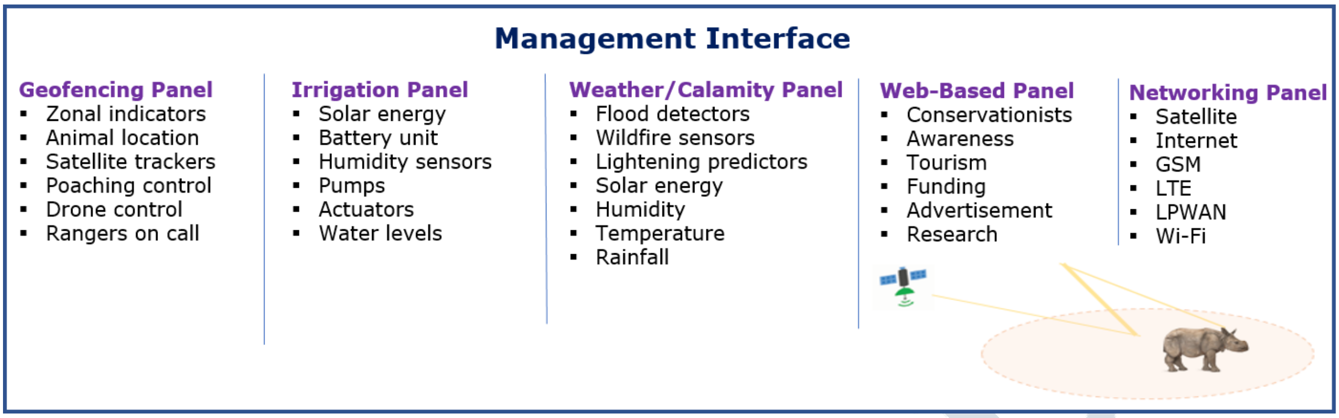

Fig. 10. Monitoring and management interface

IV. CONCLUSION

This paper focused on design and modeling of a smart conservancy system. It provides a smart way of ensuring global biodiversity through conservation of endangered world species by use of AI and IoT concepts which is basically a way of interconnecting autonomous subsystems and ensuring a centralized control of the whole interlinked system. The approach taken was to subdivide the model into five subsystems and then realize each subsystem independently. This low cost smart conservancy system is a game changer in this 21st century.

REFERENCES

[1] J. Delord. The nature of extinction. Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 38(3):656–667, 2007.

[2] R. C. Bishop. Endangered species and uncertainty: the economics of a safe minimum standard. American journal of agricultural economics 60(1):10–18, 1978.

[3] H. B. Wilson, L. N. Joseph, A. L. Moore, H. P. Possingham. When should we save the most endangered species? Ecology letters 14(9):886–890, 2011.

[4] R. Serrouya, D. R. Seip, D. Hervieux, et al. Saving endangered species using adaptive management. Proceedings of the National Academy of Sciences 116(13):6181–6186, 2019.

[5] H. Dale. The relationship between land-use change and climate change. Ecological applications 7(3):753–769, 1997.

[6] W. H. Organization, et al. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization, 2014.

[7] D. Berteaux, M. Humphries, C. J. Krebs, et al. Constraints to projecting the effects of climate change on mammals. Climate Research 32(2):151–158, 2006.

[8] J. Chike. Poverty and climate change, which is a greater evil? IIARD International Journal of Geography and Environmental Management 3(3), 2017.

[9] L. R. Gerber, M. C. Runge, R. F. Maloney, et al. Endangered species recovery: A resource allocation problem. Science 362(6412):284–286, 2018.

[10] J. Tang, T. Dong, L. Li, L. Shao. Intelligent monitoring system based on internet of things. Wireless Personal Communications 102:1521–1537, 2018.

[11] G. Karthick, M. Sridhar, P. Pankajavalli. Internet of things in animal healthcare (iotah): review of recent advancements in architecture, sensing technologies and real-time monitoring. SN Computer Science 1:1–16, 2020.

[12] S. Rodriguez Garzon, B. Deva. Geofencing 2.0: taking location-based notifications to the next level. In Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 921–932. 2014.

[13] P. P. Ray. A survey on internet of things architectures. Journal of King Saud University-Computer and Information Sciences 30(3):291–319, 2018.

[14] P. Dulari, A. Bhushan, B. Bhushan. On observing the animal ecology through internet of things (iot). J of Comp & IT 10(6):42–46, 2019.

[15] Ghosh, D. Chakraborty, A. Law. Artificial intelligence in internet of things. CAAI Transactions on Intelligence Technology 3(4):208–218, 2018.

[16] F. Reclus, K. Drouard. Geofencing for fleet & freight management. In 2009 9th International Conference on Intelligent Transport Systems Telecommunications, (ITST), pp. 353–356. IEEE, 2009.

[17] Suyama, U. Inoue. Using geofencing for a disaster information system. In 2016 IEEE/ACIS 15th International Conference on Computer and Information Science (ICIS), pp. 1–5. IEEE, 2016.

[18] R. Passarella, S. P. Raflesia, D. Lestarini, et al. Disaster mitigation management using geofencing in indonesia. In 2017 11th International Conference on Telecommunication Systems Services and Applications (TSSA), pp. 1–4. IEEE, 2017.

[19] M. N. Stevens, E. M. Atkins. Multi-mode guidance for an independent multicopter geofencing system. In 16th AIAA Aviation Technology, Integration, and Operations Conference, p. 3150. 2016.

[20] J. Kamminga, E. Ayele, N. Meratnia, P. Havinga. Poaching detection technologies—a survey. Sensors 18(5):1474, 2018.

[21] [21] P. O'Donoghue, C. Rutz. Real-time anti-poaching tags could help prevent imminent species extinctions. The Journal of Applied Ecology 53(1):5, 2016.

[22] [22] C. K. Sahu, P. Behera. A low cost smart irrigation control system. In 2015 2nd International conference on electronics and communication systems (ICECS), pp. 1146–1152. IEEE, 2015.

[23] S. Vaishali, S. Suraj, G. Vignesh, et al. Mobile integrated

smart irrigation management and monitoring system using iot. In 2017 international conference on communication and signal processing (ICCSP), pp. 2164–2167. IEEE, 2017.
[24] K. Pernapati. Iot based low cost smart irrigation system. In 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), pp. 1312–1315. IEEE, 2018.
[25] K. Namala, K. K. P. AV, A. Math, et al. Smart irrigation with embedded system. In 2016 IEEE Bombay section symposium (IBSS), pp. 1–5. IEEE, 2016.
[26] S. Rawal. Iot based smart irrigation system. International Journal of Computer Applications 159(8):7–11, 2017.
[27] Mwangi. Low cost weather stations for developing countries (kenya). In Proceedings of the 7th United Nations International Conference Space-Based Technol. Disaster Risk Reduct, Beijing, China, pp. 23–25. 2017.
[28] E. Nkiaka, A. Taylor, A. J. Dougill, et al. Identifying user needs for weather and climate services to enhance resilience to climate shocks in sub-saharan africa. Environmental Research Letters 14(12):123003, 2019.
[29] M. Xue, D. Wang, J. Gao, et al. The advanced regional prediction system (arps), storm-scale numerical weather prediction and data assimilation. Meteorology & Atmospheric Physics 82, 2003.