ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats

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&
National Institute of Agricultural Extension Management, Hyderabad

COHEART, KVASU, Wayanand & MANAGE, Hyderabad

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Programme Coordination

Kerala Veterinary and Animal Sciences University, Centre for One Health Education, Advocacy, Research and Training, (COHEART), Pookode, Wayanad, Kerala

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This e-book is a compilation of resource text obtained from various subject experts of KVASU, COHEART & MANAGE, Hyderabad on **ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats**. This e-book is designed to educate extension workers, students, research scholars, academicians related to agri-allied sector. Neither the publisher nor the contributors, authors and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editor/authors. Publisher and editor do not give warranty for any error or omissions regarding the materials in this e-book.

Published for Dr.P.Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

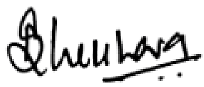
MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

New and reemerging zoonoses have evolved throughout the last three decades partly as a consequence of the increasing interdependence of humans on animals and their products and our close association with companion animals. Zoonosis is the single most critical risk factor to human health and well-being, with regard to infectious diseases. The first, and the most significant step towards the management of outbreak of zoonotic diseases is forecasting the occurrence of outbreaks. There have been unprecedented advancements in use of technology during the pandemic. ICT tools gives significant credence to the importance of examining health effects across species, in order to fully understand the public health and economic impact of such diseases and to help implement treatment and preventive programs by veterinarians.

It is a pleasure to note that, SAU-Kerala Veterinary and Animal Sciences University, Centre for One Health Education, Advocacy, Research and Training, (COHEART), Wayanad, Kerala and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats from 20-23 September, 2021 and coming up with this joint publication as e-book as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish SAU-Kerala Veterinary and Animal Sciences University, Centre for One Health Education, Advocacy, Research and Training, (COHEART), Wayanad, Kerala many more glorious years in service of Indian livestock sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Center Head-EAAS, MANAGE and Dr. M. K. Narayanan, Director of Entrepreneurship, KVASU for this valuable publication.



Dr. P. Chandra Shekara
Director General, MANAGE

MESSAGE

Livestock sector contributes nearly one-fourth to the national GDP; still the animal health and productivity remains a major concern in the country. The existing lacunae in the animal husbandry sector such as inappropriate managemental practices, infectious as well as metabolic diseases, inadequate marketing infrastructure, and unorganised marketing could only be transformed into full productive potential meeting quality livestock support services by exploiting the use of ICT or web based tools and also by improving the knowledge provided to the Veterinarians as well as para-veterinarians. Zoonoses are yet another significant public health concern that cause considerable socioeconomic problems globally. A wealth of new technologies is becoming increasingly available for more accurate monitoring of zoonotic disease activity.

In changing times, ICT tools could provide effective media for spreading awareness about the latest scientific managemental practices among Veterinarians as well as para-vets with an intention to improve the production performance and health status of animals of the country. With the recent resurgence of COVID pandemic, the significance of ICT tools in various sectors including, animal husbandry has increased manifold. Hence, it is pertinent to note that the Directorate of Entrepreneurship and Centre for One Health Education Advocacy Research and Training (COHEART) of our university in collaboration with MANAGE, Hyderabad is organising a four-day training programme in online mode (Sept. 20-23). It gives me pleasure to note that the topic of training 'ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats' is relevant. As we grapple with the gigantic task to manage the COVID-19 pandemic, ICT tools will broaden the horizon for its control.

I understand that this training has been designed in such a way to provide ample exposure to the participants in assimilating the thematic concept of ICT tools in knowledge dissemination for the control of public health threats and applying this doctrine in their respective domains of expertise. It is of utmost importance to note that this deliberation envisages the participants to learn and discuss across disciplines beyond boundaries and in close association with the stake holders in capacity building and evolve suitable models for regional, national as well as global leadership.

Let me congratulate the dynamic team behind conceptualization of this training into reality. Without their commitment and contributions, this e- book would not been possible and successfully delivered at this time.

Once again, I wish the faculty and participants all the best.

With warm regards,

Prof. (Dr.) M.R. Saseendranath
Vice Chancellor, KVASU

MESSAGE

Animal welfare is human welfare too. It is all the most revealed in the current scenario of pandemic. In most of the infectious disease, we can observe an involvement of animals in its course of spread which mark the relevance of "One Health" approach. The health and veterinary sectors in the country has undergone considerable transformation during this pandemic. The major breakthrough is the introduction of Information technology and Artificial Intelligence based approaches to control Emerging Zoonoses and Animal Health Threats. Such tools can reduce the risk of Zoonoses becoming epidemics and pandemics, by understanding disease origins, their drivers and dynamics. An early warning or forecasting system communicates information about impending risk to vulnerable population before a hazard event occurs. Thus, ICT initiatives will be the futuristic requirements of the society, immensely helping in conceptualizing and strategizing control measures of zoonotic diseases.

It is of immense pleasure to organize the training on "ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats" in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad. I would like to underline and reiterate the fact that a healthy nation could only be built by the healthy individuals and the animals and the surrounding environment. As we are in the era of global health crisis due to COVID-19 pandemic, the animal husbandry and allied sectors should take all the care and measures for controlling the emerging zoonoses and health threat in animals at large for which we will have to make best use of ICT tools. Also, technologies evolve rapidly as new tools become available, allowing for the development of more sophisticated surveillance methods and more accurate predictive models. To make it a reality One Health collaboration between institutions, scientists and public health networks involved in diseases surveillance is important in order to timely detect and respond to novel threats and pandemics.

I am pleased to note the joint publication of e-book as the outcome of the training program. I also hope, the deliberations held during the training would bring out the vital understanding on the use of ICT Tools for Control of Emerging Zoonoses and Animal Health Threats. I wish the training a grand success.

Prof. (Dr.) M. K. Narayanan
Director of Entrepreneurship, KVASU

PREFACE

This e-book is an outcome of collaborative online training program on "ICT Tools for Knowledge Management and Control of Emerging Zoonoses and Animal Health Threats". This is intended to sensitize the veterinarians and related health workers to learn about various ICT tools for Knowledge management and control of emerging zoonoses as well as other animal health threats, and also to practice and implement One Health approach, as back-up to the Global Health Security Agenda using technology driven approach. Furthermore, this e-book will update their knowledge regarding recent advances in technologies and innovations in the domain of zoonoses and animal health threats

Veterinary and Human health systems must continuously adapt and evolve to their contexts giving significance to latest technologies. ICT tools are such technologies that provide access to information through telecommunications, and includes networks, the Internet, wireless, mobile devices and other communications-related technology. The content of training programme was designed to provide updated information towards capacity building in proposed area. Attempt has been made to cover topics on Emerging Zoonoses and Animal health threats, Epidemiological Surveillance and Disease Modeling, tools such as National Animal Disease Referral Expert System and Integrated Health Information Platform. Focus was also on Artificial Intelligence driven approach for control of vector borne diseases, existing early warning system for the spread of emerging diseases and Application of Artificial Intelligence for animal health threats. The topics shall also cover GIS and Web based tools for Disaster risk mapping and innovative Participatory Disease Surveillance model that is successfully used in various countries. The applied aspects of the use of ICT tools for knowledge management of wild animal health as well as for Animal Husbandry are also covered.

Taken together, these experiences are enriched with technical insights and operational know-how. They provide practical evidence of actions that have proven imperative for improving services delivery.ICTs tools have the potential to transform the way in which the veterinary and health services are accessed and delivered. ICTs can provide information systems for reporting and research, and deliver healthcare services and advice to even the most remote locations.

The valuable suggestions for future improvements are always welcome.

September, 2021 **Editors**

CONTENTS

OVERVIEW OF EMERGING ZOONOSES AND EARLY WARNING SYSTEMS

Prejit, Officer-in-Charge,
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Introduction

Emerging and re-emerging zoonoses are a significant public health concern and cause considerable socio-economic problems globally. The COVID-19 pandemic has made us to realize that man do not have complete dominion over animals, nature or even minute organisms like virus. There are about 60 per cent of human infectious diseases that are zoonotic (Taylor *et. al*., 2001) and among the latest one (Emergng) 75% are zoonotic in nature. Emerging zoonoses are those which are newly identified and previously unknown, that cause public health problems either locally or internationally (eg: Avian Influenza, Ebola, Nipah, Zika, MERS COVID etc). Re-emerging zoonoses are those that have been known for some time, had fallen to such low levels that they were no longer considered public health problem and are now showing upward trends in incidence or prevalence worldwide (eg: Chikungunya, Japanese Encephalitis etc). The factors that make India a hotspot of zoonoses include its large area (32,87,263 sq. km, 2.4% of worlds surface area), coastal area of 7516.6km, border sharing with 7 countries , diversity of climate and physical conditions, great variety of fauna (over 92,037 species), whopping population of 135.26 crores (17.7% of world's population) and having agriculture in more than 58% of the population.

India has initiated One Health action strategies for control of emerging zoonoses such as Avian Influenza. Multi-sectoral approaches under a One Health (OH) umbrella are more expedient and effective, and lead to efficient utilization of limited resources (Heymann *et al*., 2014). Kerala has demonstrated One Health success stories for control of emerging zoonoses such as Kyasannur Forest Disease. As it is recognized that emerging infectious diseases occur at the interface of human, animal, and ecosystem health, the world now promotes a trans-sectoral approach to address infectious disease risk management. Emerging infectious diseases will continue to challenge health infrastructure, test credibility of health services, and threaten to devastate health and economic development unless a strategic vision and an effective plan of action are developed to combat these.

Emerging Zoonoses

Zoonoses are not something that is rare but it still remains one of the world's greatest threats to human and animal life, the environment, local communities and economies. A vast majority of the emerging and remerging infectious diseases have their origins in animals. Emerging zoonosescould be as a result of the globalization of trade, breakdown of public health measures, expanding human population, intensification of wildlife farming, change in land use (Japanese encephalitis, Lyme disease), agricultural industry, medical industry, food industry, International travel and commerce (SARS, MERS, COVID 19), disasters (plague, leptospirosis), climate and weather (West nile fever), human demography & behavior (KFD), bush meat consumption (Ebola). Early detection helps keep infection to its area of origin, which in our increasingly mobile world is vital in stopping life threatening diseases such as Zika, Ebola and Yellow Fever.

From age old Rabies to the recent COVID-19, the list of zoonoses keeps growing day by day. But the major hurdle in combating the zoonoses is the presence of animal reservoirs. In global scenario, there is a significant increase in the emergence of zoonotic diseases causing about 1 billion cases of illness and millions of deaths every year (Karesh *et al.*, 2012). In the last two decades, emerging diseases had direct costs of more than US$100 billion; if these outbreaks had become human pandemics, the losses would have amounted to several trillion dollars (World Bank, 2012). The greatest burden on human health and livelihoods is caused by endemic zoonoses that are persistent regional health problems around the world (ILRI, 2012). Given the high economic and societal cost of recent outbreaks (World Bank, 2012), policy decisions and investments can be oriented to create incentives for advancing a One Health approach aimed at preventing (and not just responding to) disease outbreaks.Globally, the top 13 zoonoses deemed most impactful to poor livestock keepers in developing countries are responsible for an estimated 2.7 million deaths and 2.4 billion cases of human illness each year (Grace *et al.*, 2012). The Livestock Revolution paradigm is leading to rapid increases in livestock populations in developing countries, which increases the likelihood of disease transmission (Pica-Ciamarra and Otte, 2011) with repeated outbreaks from meat, eggs, milk, and cheese, or meat by-products (Karesh*et al.*, 2012).

After the emergence of SARS in 2002 and MERS in 2012, COVID 19 was the third coronavirus resulting in a major global public health crisis. At the end of the SARS epidemic, there were more than 8,000 cases of the disease and 774 deaths, with a case-fatality rate of 7% (Anderson *et al.*, 2004). Following, MERS epidemic there were a total 2494 cases of disease and 858 deaths with 34.4% case-fatality rate (Al-Omari *et al.*, 2019). Currently

COVID 19 has become a serious global public health concern. In the current scenario, the SARS-CoV-2 has spread rapidly to various parts of the world (Yoo and Yoo, 2020). As COVID-19 spreads, there is a significant role for veterinarians under One Health framework to reduce the economic impacts on the livestock industry and food supply (Yoo and Yoo, 2020). Thus, the global impact of emerging and endemic zoonoses on both human and animal populations make their control and prevention a natural starting point for collaboration between human and animal health sectors (Rist*et al*., 2014).

Early warning systems

The use of technology has been under constant expansion following pandemic. Early detection of diseases and infections at animal source will help us to understand the etiology, epidemiology and pathogenesis of them and will pave a way to prevent transmission of them into humans. The first, and the most significant step towards the management of outbreak of zoonotic diseases is forecasting the occurrence of outbreaks. Forecasting refers to the monitoring of specific risk factors that could lead to the occurrence, and subsequent spread of the disease. The early warning or forecasts can be considered as "alert signals" intended to increase epidemic preparedness of the public. It will save the time as well as resources during an emergency. Prevention and control of zoonoses is the best strategy one could adopt in a crisis situation. Apart from emerging viral zoonoses, there are several emerging food borne zoonoses such as enterohaemorrhagic *Escherichia coli* (*E coli* O157:H7) and silent pandemics like anti microbial resistance that are becoming a major concern now. The major components of early warning system involves; routine surveillance of the targeted disease and identification of its risk indicators, examination of feasibility of their monitoring using existing data sources or modeling the risk of disease based on historical surveillance and contemporary environmental data, forecasting future risk through the use of predictive models and continued epidemiological and environmental surveillance.

Epidemiologists use ‘predictive models’ as to analyse when and where the next occurrence may occur. The use of Geographical Information System (GIS) to study associations between environmental variables like temperature, humidity, vector density etc. using satellite mapping has been gaining acceptance as a disease forecasting tool. Initiatives, such as GLEWS (Global Early Warning and response System), a joint system developed by WHO, OIE and FAO, assists in prediction, prevention and control of zoonotic disease outbreak through field work, epidemiological analysis, and sharing of the acquired information. Disease-specific collaborations such as the network for animal influenza (OFFLU), are active between the three Organizations. These collaborations range beyond surveillance to incorporate joint response mechanisms as events demand. The Joint FAO/OIE Crisis Management Centre for Animal Health supports rapid response capacities to assist countries for animal diseases events (domestic, wildlife, terrestrial or aquatic), and has collaborated in outbreak responses with WHO and the Global Outbreak Alert and Response Network (GOARN). Similarly, a cross-sectoral 'One Health' approach is increasingly being adopted within and amongst countries to address these problems.

OIE-WAHIS (OIE World Animal Health Information System) is a unique comprehensive database through which information on the animal health situation worldwide is reported and disseminated throughout the world. OIE-WAHIS data reflects the information gathered by the Veterinary Services from OIE Members and non-Members Countries and Territories on OIE-listed diseases in domestic animals and wildlife, as well as on emerging diseases and zoonoses.

Existing Surveillance systems in India include, integrated Disease Surveillance Project (IDSP, Medical Sector), National Animal Disease Reporting System(NADRS) and National Animal Disease Referral Expert System (NADRES, Veterinary Sector), ICAR - NIVEDI (Epidemic diseases), ICAR – NIHSAD (Exotic diseases), Inter-sectorial collaboration on avian influenza: Joint Task Force & Joint Monitoring Group and also on zoonoses (National Standing Committee on Zoonoses).Decreasing interactions with wild animals lowers our exposure to diseases such as Kysannur Forest Disease which is endemic in karnataka and now in Kerala, Tamil nadu and Goa. Studies of the incidence and prevalence of such diseases are necessary in the endemic areas. If a disease is preventable by vaccination, it is better to vaccinate the susceptible populations. For diseases such as rabies, apart from vaccinating the pet animals, stray dog population control is a much needed strategy.

Conclusion

Prevention is a broad and continuous effort that requires people's participation and expert knowledge. The prerequisites for controlling emerging infectious disease includes availability of diagnostic assays for mass-scale testing of samples, generating baseline data about the disease, new and better vaccines, intensify border checking at entry points at borders, enforce strict quarantine measures. Furthermore, the use of ICT based system has great advantages such as Geographic Imaging Systems, IT tools monitoring disease dynamics, dashboards for surveillance and forecasting, risk mapping tools for knowing wild life sources for diseases.

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PARTICIPATORY ONE HEALTH DISEASE DETECTION (PODD) TOOL TO DETECT EMERGING ANIMAL AND ENVIRONMENTAL HEALTH THREATS: A THAILAND EXAMPLE MODEL

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Introduction

The COVID-19 is the great example of pandemic which effect the global in several aspects, especially in economic. In tourism industry, COVID-19 causes a loss of more than $4 trillion to the global GDP during 2020 and 2021 (UNCTAD,2021). It has high potential of emerging disease occur and affect human, mostly possibly originating from animal. Animal-health surveillance provides an essential component of the evidence required to protect animal-health, facilitate trade, and ultimately protect public health, especially from zoonosis. Through early detection and informed response, surveillance reduces the impact of animal disease on animal production and welfare and on public health. Effective surveillance also ensures that confidence in the health status of animal moving between countries is maintained and ensures that trade barriers are justified. When trade is maintained, the impact of disease outbreaks on the economy is reduced, including: Severe Acute Respiratory Syndrome (SARS); Bovine Spongiform Encephalopathy (BSE); Foot-and-Mouth Disease (FMD); and Highly Pathogenic Avian Influenza (HPAI). The frequent movement of animals and their products around the world means that there is an increasing risk that infection will spread. Therefore, there is a need for exchange of comparable information about disease incidence and lead to protect population's health.

One Health approach is an effective concept that allow people monitor disease in animal and environment before spilling over to human (Stärk *et al.*, 2015). One health indicated the strong relationship of health among animal, human and environment. It plays an important role in global disease prevention with engaging multidiscipline to achieve better health. The people in community can be a part ofOne Health by participate the disease or abnormal health event reporting. The community also can responses those reports in advance before the authority takes any action.

Since the digital technology has been exploded, people increase the usage of mobile phone and internet. It has been introduced disease surveillance system and allow people to participate by reporting via their mobile or computer. The US Flu Near You system having previously demonstrated how participatory reporting using digital tools can help detect influenza outbreaks in human populations faster than traditional surveillance (*Smolinski et al.*, 2015)

PODD system

PODD system or “Participatory One-health Digital Disease Detection” system has been developed, which integrated One-health into disease surveillance activities in community level. The aim of PODD system is to early detect and response the animal health, human health and environmental problems in communities by the collaborative efforts of authorities, Local governments (LGs) and people in communities. There are 3 key elements, LG, volunteers and digital system, that are the structure of PODD system (figure 1). Volunteer reporters, who are members of the communities, report abnormal events in their communities through application on smartphone, called “PODD”, then an automated system verify the reported and notify all stakeholder (i.e., researchers, provincial and district DLD officers, provincial and district public health officers and LG staff). LGs are the front-line teams of problem response and be supported by authorities, either district or provincial level.

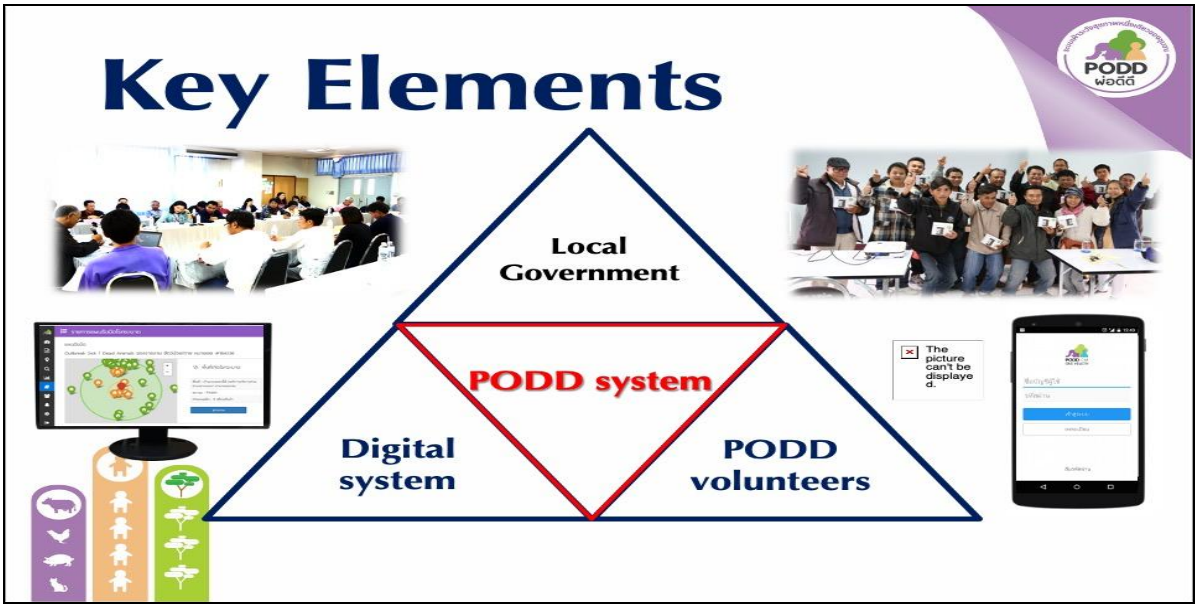

Figure 1 The key elements of PODD system, consist of Local government (LG), PODD volunteers and digital technology.

The primary objective of PODD in pilot phase was to detect abnormal deaths in backyard animal in order to elicit rapid investigation and response. Abnormal numbers or types of death can be a signal of zoonotic diseases which transmits to human and causes pandemic as a subsequence, such as abnormal death in poultry could be an early clinical sign of highly pathogenic avian influenza (HPAI), a potential precursor of an AI pandemic in humans. Use of smart phones and digital technology is one of the key factors making the PODD system workable. The daily reports of poultry health and abnormal poultry death are automatically captured, filtered with predefined case and outbreak definitions, and projected onto a GIS mapping system. The real time analysis of incoming reports allows rapid detection of outbreaks and the generation of automatic SMS warning messages to activate community contingency plans. A disease investigation team is dispatched to confirm the outbreak by clinical examination and, as necessary, laboratory confirmation. The system follows up automatically until 3 weeks after the last report of sick animals or death in the affected area. All stakeholders are notified after complete recovery to normal (figure 2)

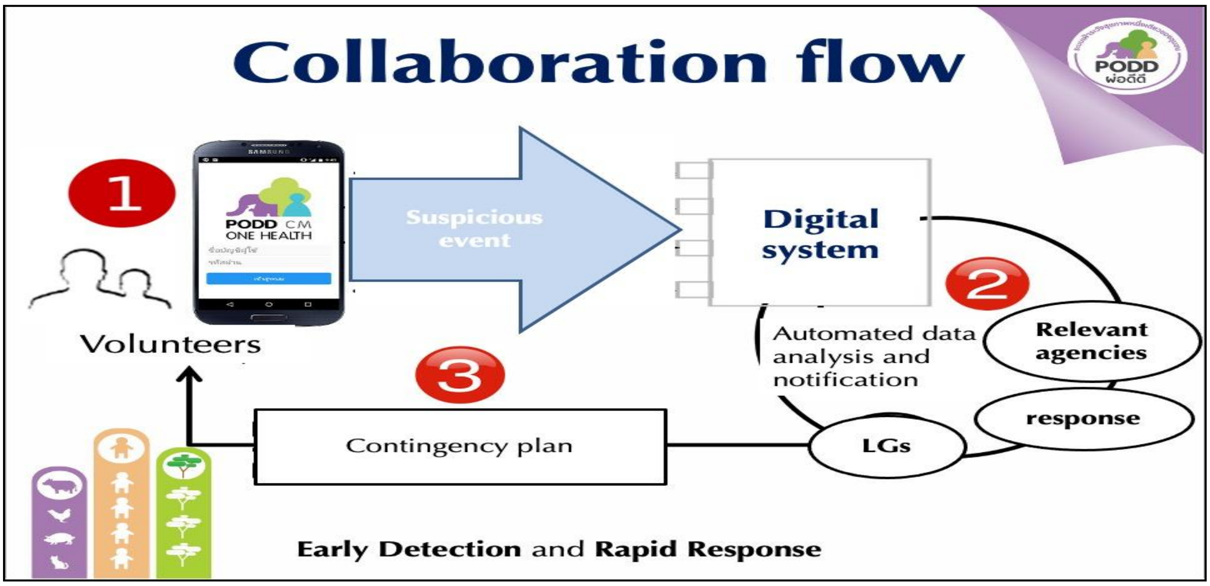

Figure 2 The workflow of PODD system for abnormal health surveillance, which aim to early detect and rapid respond.

Not only animal disease, but human health and environmental health have been added in PODD mobile application. Dengue and zoonosis in human, animal bite which has potential to be rabies, food safety issue, annoyance issues in community and disaster have been expanded the range of reporting. The PODD volunteers can report cover animal, human and environmental health through PODD mobile application (Yano et al., 2018).

The success

The PODD system has been developed and preliminary implemented in 75 LGs in Chiang Mai, Thailand, in early 2015. The community at sub-district level has been engaged to develop and own the system. After two years of implementation, the PODD system has been extended to other provinces throughout Thailand. From January 2015 to August 2021, total of 378,010 reports were sent to PODD system. Those reported included zero report and abnormal event reports. Currently, PODD system has been used in 30 provinces, within 201

LGs, together with the support of 838 active community reporters who uses PODD mobile application.

The PODD system empowered community to prevent, detect and respond disease outbreak, either human and animal, through the One-Health Operation Center and the support from PODD system. In January 2017, NongKhwai and Ban Pae LGs controlled disease outbreak in their area by the operation of the One-Health Operation Center. After PODD volunteer reported an abnormal death in chicken and owner showed flu-like symptoms, the notification was sent to LGs, district livestock and public health officers. The center activated the operation and staffs from LGs were indicated to work in the affected area and the outbreak could be controlled within a week. From August 2016 until March 2017, 38 from 68 One-Health Operation Centers have started their activity and 4 outbreaks can be controlled by the center.

Next step

The PODD research project has been transformed to be the "PODD center" in 2020. The center aims to promote and engage LGs throughout Thailand to use PODD system in their community. The PODD system added more features to reach LG's requirement, such as bedridden patients, accidental risk area or road, larva counting for Dengue prevention, COVID-19 monitoring, etc. For COVID-19 monitoring, the PODD system has been applied to monitor COVID-19 in selected communities since late 2020. The community volunteers report the strangers or people, who is not community member, come into the community, especially the people who do not notify the community headman. In the near future, the tons of data is coming to the PODD center and it will be the asset for the center. The data management and manipulation will be performed to create an impact information for the health society.

Conclusion

The community participatory combine with digital technology can be integrated with One Health approach for early disease detection and rapid response. It also empowers community to encounter the pandemic and establish the collaboration between community and authority to control disease outbreak. These practices can help the global to fight the new diseases in the future.

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INFORMATION NETWORK FOR ANIMAL PRODUCTIVITY & HEALTH

***e-resource provided by*: S. K. Rana**

National Dairy Development Board

In today's ever-changing world, the way you disseminate information assumes great significance. We must provide the right people with right information at the right time. Keeping this in view, an advanced information network has been created that can be easily accessed by all key stakeholders. This technology-driven user-friendly information network would provide reliable and timely information to enable better decision-making for improving productivity. At the heart of such a system is the unique identity assigned to each animal.

Developed and implemented by NDDB, the Information Network for Animal Productivity and Health (INAPH) would support the delivery of animal identification, breeding, nutrition, extension and health services at the doorstep of farmers. The system has multi-lingual capability and is based on best practices and Standard Operating Procedures (SOPs) recommended by domain experts.

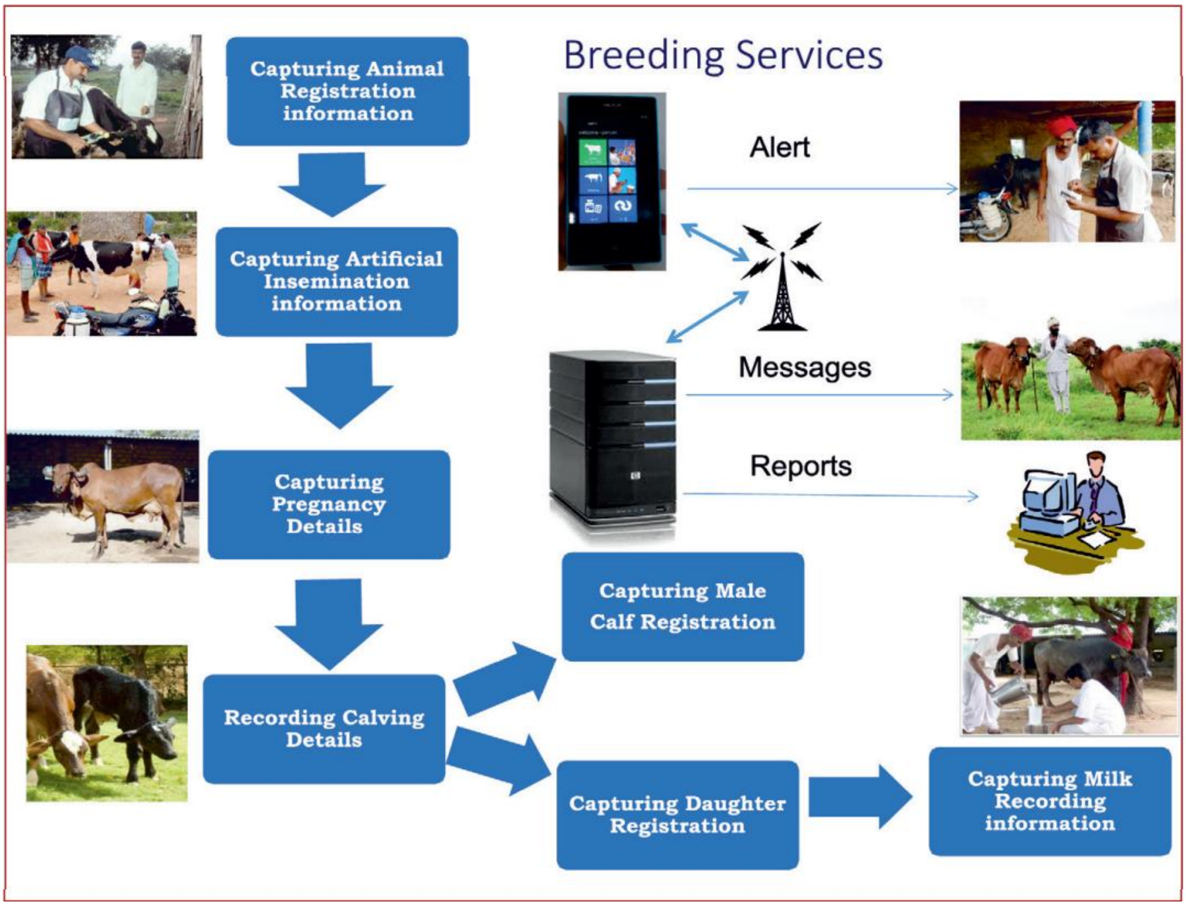
Ear-tagging with a unique 12 digit number is mandatory for each animal registered in the network which enables tracking and monitoring of these animals. NDDB administers and centrally manages the animal identification system in the country.

Animal Breeding

INAPH captures data related to animal registration, artificial insemination (AI), pregnancy diagnosis, calving, milk recording, milk sample collection for component analysis, typing, body measurement for growth rate monitoring and animal movement.

Data captured is processed for use in field activities under Progeny Testing and Pedigree Selection programmes. Operational, review and analytical reports, alerts and SMS messages are generated and forwarded to all concerned.

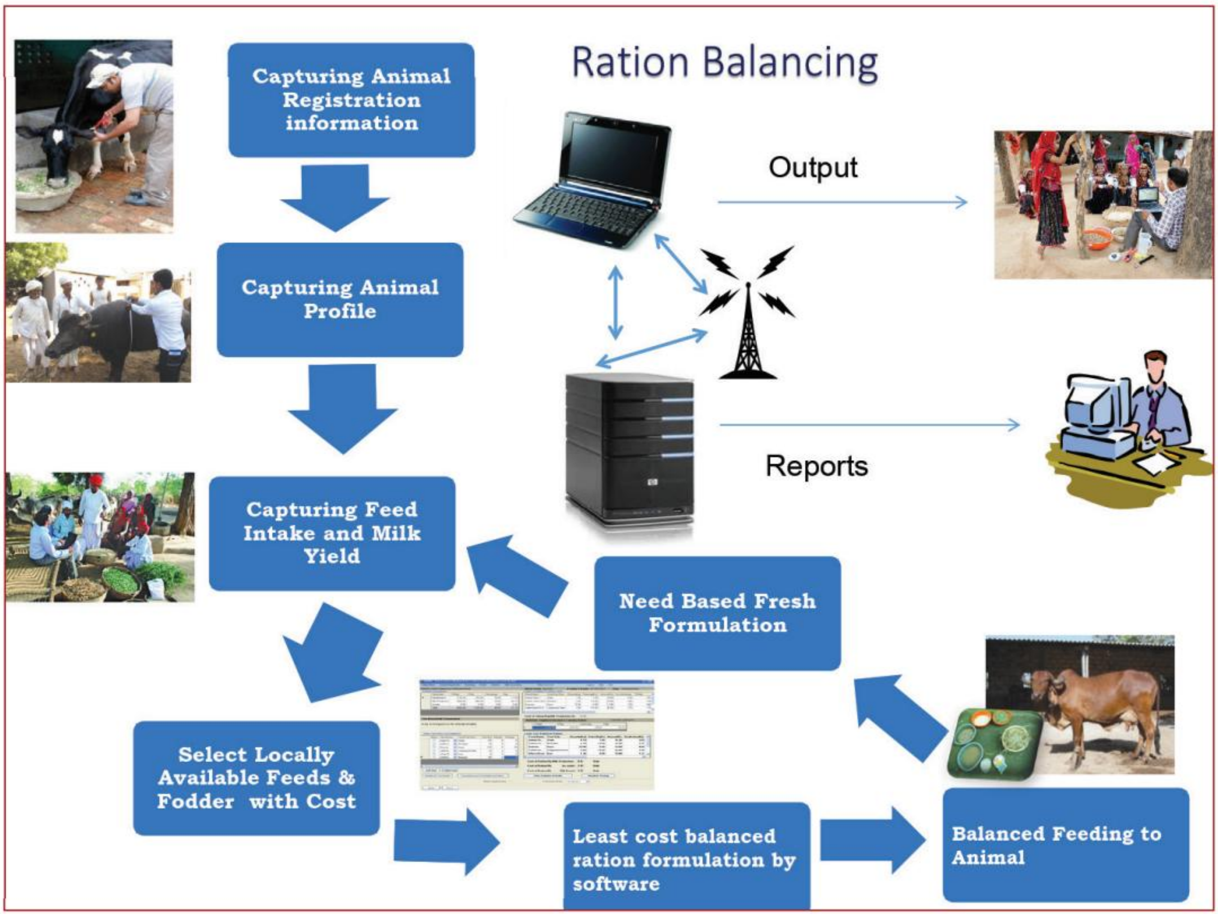
INAPH helps in monitoring AI delivery system to assess and improve conception rate, minimise inter-calving period. It also helps to evaluate breeding values of bulls as well as identification of elite animals.



Animal Nutrition

INAPH supports the Ration Balancing Programme (RBP). It has a data library on chemical composition of commonly available feed resources in India and the nutrient requirements based on body weight, milk yield/milk fat, pregnancy status etc. Based on the feeding practices, prevailing nutrient status can be seen. As per the availability of feed resources and area specific mineral mixture, a least cost ration is worked out, which is then given to the milk producers in local language, in a format easy to understand.

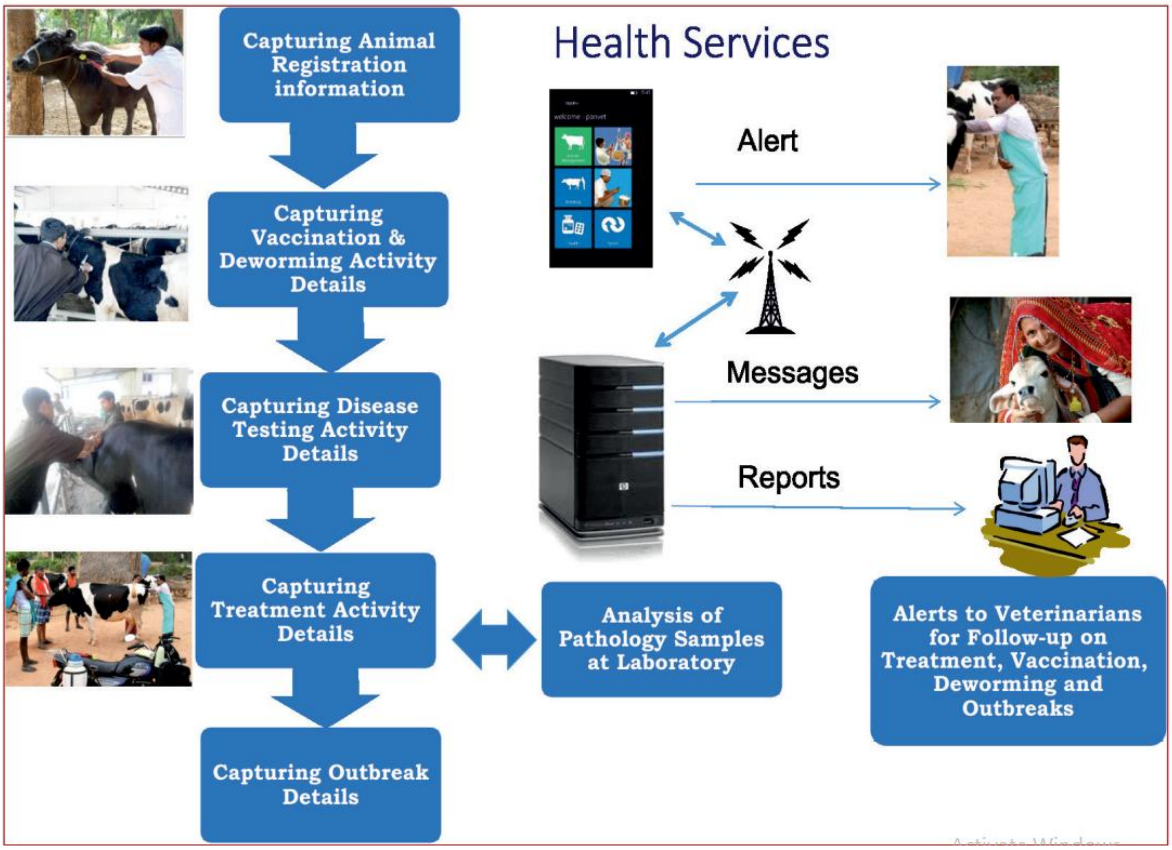
Balanced ration advisory services through INAPH based on data of one and a half lakh cows/buffaloes resulted in increase in net daily income of milk producers between ` 15-35 per animal, by enhancing daily milk yield/milk fat and/or reduction in cost of feeding per litre of milk.



Animal Health

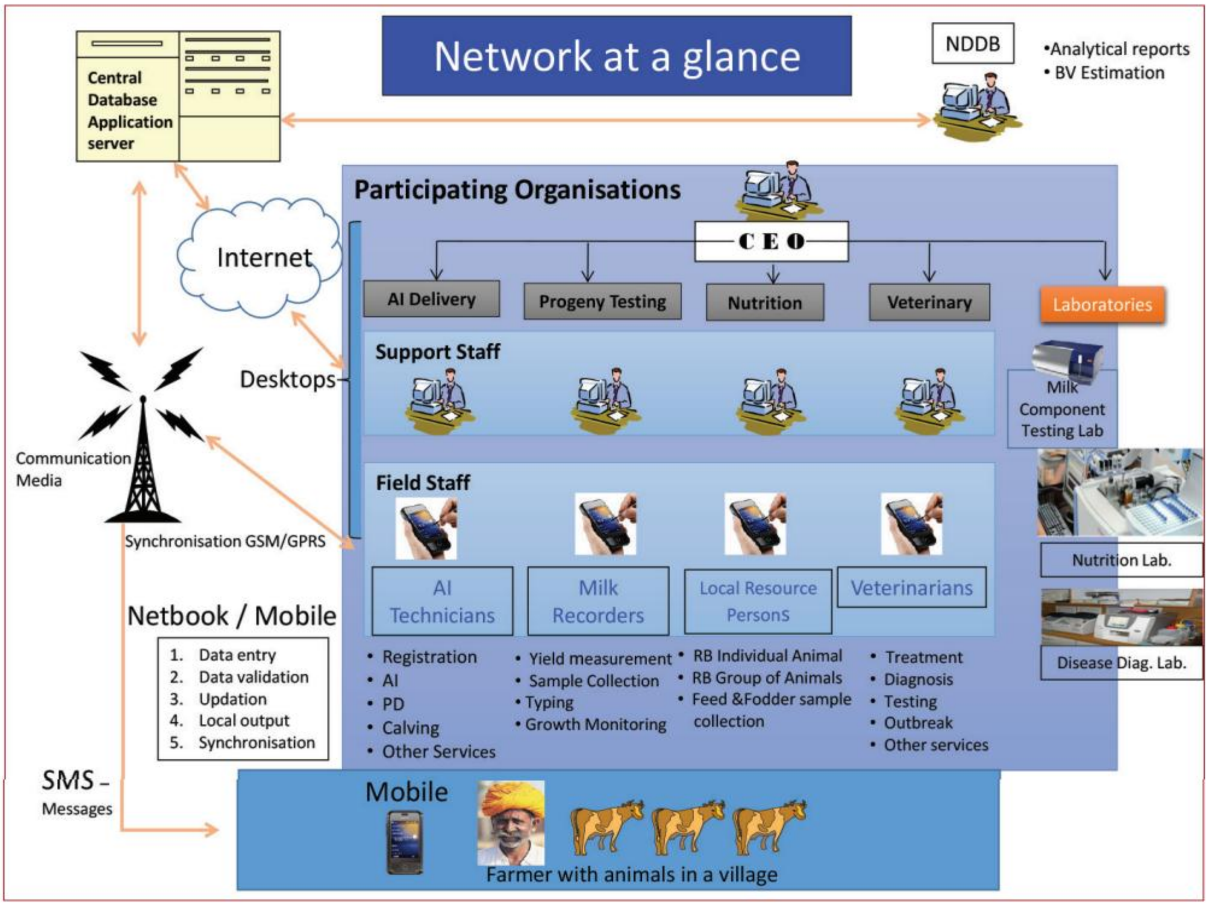
The Animal Health module of INAPH is designed to capture health related data of animals such as vaccinations, de-worming, disease testing, treatment, outbreak management and fertility camps. The complete health profile of each animal is being maintained by the system, enabling better health management and treatment. Data can also be captured at the village level on most health related interventions

INAPH is currently providing support to over 220 lakh animals belonging to around 127 lakh farmers in more than 1.70 lakh villages spread across 29 states. The system is being used by over 1.19 lakh field users in the country.



System Architecture & Deployment

The system is designed to meet the various information needs of farmers, field technicians, End Implementation Agencies (EIAs) such as Milk Unions/Federations, Producer Companies, analysts and policy makers. The application can be operated through computers/netbooks as well as hand-held devices (Android phone & tablets) with internet connectivity. Data collected in the field is stored in the central database at NDDB, Anand. In the absence of network connection (offline mode), there is a provision for data to be captured and stored for later synchronisation with the central server through the GPRS network.



INAPH is equipped to send messages to farmers, providing appropriate advice regarding their animals, when required. Web based reports are available to the managerial team and other decision makers for analysis.

Benefits

- Unique identification of animal along with the pedigree facts, lactation yields and owner details
- Record keeping of all activities related to Breeding, Nutrition & Health
- Identification of superior bull & elite female
- Tracking disease outbreak & disease pattern for different species/breed/village/district
- Healthier/productive animals increase earning of farmers
- Assess the efficiency & effectiveness of AI services & Ration Balancing Advisory Services
- Monitor and follow up genetic improvement and Ration Balancing Programmes

INAPH helps in monitoring AI delivery system to assess and improve conception rate, minimise inter-calving period. It also helps to evaluate breeding values of bulls as well as identification of elite animals.

RESISTANCEMAP: AN ICT BASED TOOL FOR GLOBAL DATA ON ANTIMICROBIAL USE AND RESISTANCE

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About ResistanceMap

Resistance Map (ResMap) is a web-based collection of data visualization tools that allows interactive exploration of antimicrobial resistance (AMR) and antibiotic use trends in countries across the globe, now including several low- and middle-income countries (LMICs). CDDEP first developed ResistanceMap in 2010 to display national and some subnational AMR data for the United States, Canada and over 30 European countries for the year 2009, as well as antibiotic use data for United States from 2000 to 2009.

In the current iteration, which is supported by a new grant from the Bill & Melinda Gates Foundation, CDDEP has expanded ResistanceMap to include more up-to-date AMR data from invasive isolates only (blood and cerebrospinal fluid) from the countries included in the previous iteration of ResistanceMap, as well as additional countries including South Africa, India, Thailand, Vietnam, Kenya, Argentina, Chile, Equador, Mexico, Venezuela, Australia, and New Zealand. Where available, data are displayed at the national, subnational or regional level. The primary sources of data are public and private laboratory networks that routinely collect AMR test results.

In addition to updated and expanded AMR data, this iteration of ResistanceMap also includes antibiotic consumption data from 75 countries from years 2000 to 2014 obtained from IQVIA's MIDAS and Xponent databases. Moreover, this iteration includes an update to the web tool itself, so that non-technical users can more easily explore trends in antibiotic use and resistance around the world.

Antimicrobial Resistance Data

Resistance data from 46 countries are represented in ResMap. AMR data are available from 1999 to 2017, depending on the country.

Twelve organisms are included - *Acinetobacter baumannii, Entero bacteraerogenes/ cloacae, Enterococcus faecalis/ faecium, Escherichia coli, Klebsiella pneumoniae , Pseudomonas aeruginosa, Salmonella Typhi/ Paratyphi, Staphylococcus aureus and Streptococcus pneumoniae*. Details of AMR data and methods for calculating resistance proportions are described in the methodology section.

Antibiotic Consumption Data

Antibiotic consumption data from 76 countries are represented. Antibiotic consumption data are available from 2000 to 2015. Sub-national antibiotic consumption data are available only for the United States through 2017. Data sources are IQVIA XPonent and IQVIA MIDAS databases.

Seventeen antibiotic classes are included: aminoglycosides, broad-spectrum penicillins, carbapenems, cephalosporins, chloramphenicols, glycopeptides, glycylcyclines, lipopeptides, macrolides, monobactams, narrow-spectrum penicillins, oxazolidinones, phosphonics, polymixins, quinolones, tetracyclines, and trimethoprim combinations.

Details of antibiotic use data and methods for calculating antibiotic consumption are described in the methodology section.

Citing Resistance Map

Please cite data or figures from ResistanceMap in the following style:

The Center for Disease Dynamics Economics & Policy. ResistanceMap: [Page Name]. 2018. [URL]. Date accessed: [Date].

Methodology

1) Antibiotic Resistance

ResistanceMap (ResMap) aggregates data on antibiotic resistance from several sources. The data have been harmonized to present similar definitions of resistance across countries and regions to enable comparisons between countries. However, comparing resistance rates between countries should be undertaken with some caution as the breadth of testing varies between countries.

The following sections describe the source of the data, the bacterial species included, and the pathogen-antibiotic combinations used to determine resistance rates.

Sources: The underlying data are obtained from multiple sources in one of two formats: (1) microbiology and test data at isolate level; (2) aggregated data listing at a minimum, the number or percentage of isolates resistant and the number of isolates tested. The following table details the source of data for each country.

Bacterial species: Depending on the country, resistance data is currently available for all or some of the following bacterial species:

- *Acinetobacter baumannii*
- *Enterobacteraerogenes/cloacae*
- *Enterococcus faecalis*

- *Enterococcus faecium*
- *Escherichia coli*
- *Klebsiellapneumoniae*
- *Pseudomonas aeruginosa*
- *Salmonella paratyphi*
- *Salmonella typhi*
- *Staphylococcus aureus*
- *Streptococcus pneumoniae*

Isolates were classified as susceptible (S), intermediate (I), or resistant (R). Clinical and Laboratory Standards Institute (CLSI) or European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints were used for antimicrobial susceptibility testing in the laboratories contributing the data. For example, laboratories in the United States use CLSI guidelines, while European countries use EUCAST guidelines.

The data presented on ResistanceMap include only invasive isolates obtained from blood, cerebrospinal fluid or both. In addition, all non-susceptible isolates (I+R) are classified as resistant and the data is presented for a pathogen only when 30 or more isolates were tested against an antibiotic. Some countries do not have data for every pathogen-antibiotic combination listed, and for certain combinations, only a few countries have data. For instance, India is currently the only country with Salmonella data available.

For each data point we calculated the 95% confidence interval using the Wilson score method for binomial data.

Pathogen-antibiotic combinations: Antibiotics are classified into several groups as needed to compensate for the lack of susceptibility data on every antibiotic and to facilitate examination of resistance based on clinical relevance. Antibiotic groups are often classes of antibiotics, but not always. Resistance to an antibiotic group was defined as non-susceptibility to at least one antimicrobial agent in that group, though not all isolates were tested against every antibiotic in a group. The pathogens and the groupings of antibiotic agents against which they are tested can be obtained from methodology on antibiotic resistance.

2) Antibiotic use

Sources: Data on antibiotic use for all countries currently included comes from the IQVIA MIDAS database. This database estimates antibiotic consumption from the volume of antibiotics sold in retail and hospital pharmacies based on national sample surveys done by pharmaceutical sales distribution channels (i.e. from manufacturer to wholesaler to retailer). In each sector, data are collected regularly to estimate direct sales from antibiotic drug manufacturers and indirect sales from wholesalers. The sales estimates from this sample are projected with use of an algorithm developed by IQVIA to approximate total volumes for sales and consumption. The algorithm uses regional, sectorial-specific, and distribution-channel-specific factors to project national estimates of antibiotic consumption. However, precise details of the algorithm are withheld for proprietary reasons.

Data on antibiotic sales in standard units (SUs) and kilograms were obtained from the IQVIA MIDAS database. SU is an IQVIA designation that represents a single dose unit such as a pill, capsule, or equal amount of liquid. Sales expressed in kilograms were converted into defined daily doses (DDDs) using the Anatomical Therapeutic Chemical Classification System (ATC/DDD, 2016) developed by the WHO Collaborating Centre for Drug Statistics Methodology. For molecules not included in the ATC/DDD index, DDD values were estimated from other sources or as the average of DDD unit values by class. DDD unit values were provided in the ATC/DDD index for 199 of the molecules in the IQVIA MIDAS database. When possible, DDD unit values not available through the ATC/DDD index were estimated from other sources. Data in SUs were available for all years, whereas kilogram data were available only for the period 2005-2015. The ratio of SUs to kilograms for 2005-2015 was used to estimate kilograms and DDDs for 2000 to 2004. Countries' annual antibiotic consumption rate in DDDs per 1,000 inhabitants was calculated using population estimates from the World Bank DataBank. In countries where hospital and retail data were both reported for some but not all years (2000-2015), consumption in the missing sector was estimated by interpolation, using the ratio of antibiotic consumption in the hospital and retail sectors for the years data had been reported. Data collection procedures imposed additional limitations for a few countries that could not be (completely) accounted for. For example, some countries had sales data reported for only hospital or retail sectors, and in some cases, certain types of antibiotic sales—such as those in supermarkets or through government channels—were not included.

To allow for a meaningful comparison across countries, standard units/DDDs per 1,000 population was calculated by dividing the reported number of standard units/DDDs by population estimates from the World Bank. Taiwan's population size data was not available in the World Bank's database, so the values from Penn World Table 7.1 were used. Antibiotic use data was available only at a grouped regional level for some countries. For the two regional groupings—Central America and French West Africa—that had such data, we pooled the population estimates for the constituent countries to generate standard units/DDDs per 1,000 population.

For the United States, additional data was available at a subnational level. This data comes from IQVIA's Xponent database. The Xponent database contains data on dispensed drug prescriptions collected from retail pharmacies (chain, mass merchandisers, independent pharmacies, and food stores) in the United States. The database covers more than 70% of all prescriptions filled in the United States, and records are then weighted to project 100% of total prescriptions dispensed. Precise details of the weighting algorithm are withheld for proprietary reasons. These data are available at the zip code level and have been aggregated into state-level values. Data were then divided by state population estimates from the US Census to give the number of prescriptions per 1,000 people.

Antibiotics: All the antibiotic products listed in MIDAS and Xponent databases constituted 90 different antibiotic molecule types. These generic antibiotics have been further combined into 18 different classes for comparisons across countries. The distribution of antibiotics into classes can be obtained from methodology on antibiotic use.

3) Drug Resistance Index

The Drug Resistance Index (DRI) is a composite measure that combines the ability of antibiotics to treat infections with the extent of their use in clinical practice. Described by Science Magazine as a Dow Jones for Drug Resistance, the DRI provides an aggregate trend measure of the effectiveness of available drugs, akin to the way composite economic indices are used to track movement in consumer prices and stock market values. DRI was developed by CDDEP researchers led by Professor RamananLaxminarayan.

The DRI can be calculated at the country, region, state, or even hospital level. Country-level DRI estimates were recently published in BMJ Global Health for a subset of countries for a single year to demonstrate the power of the DRI to communicate problems with resistance. Here we present that data, plus additional countries and years for which we have gathered enough data to calculate a composite DRI. The results underscore the urgent challenges facing the globe as DRI values are high (meaning poorer efficacy of antibiotics) in many countries, particularly many low- and middle-income countries. In the highly connected world in which we live, the disparity in efficacy is a threat to global public health as resistant pathogens can rapidly spread between countries. The DRI can also be applied to national and regional data.

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INTEGRATED HEALTH INFORMATION PLATFORM (IHIP) FOR COMMUNICABLE DISEASE SURVEILLANCE

SnehaNaik

State Data Manager, IDSP

Integrated Health Information Portal (IHIP) is designed and developed by WHO at the request of MoHFW in order to have a holistic picture of data reported under different National Health Programmes with "One-Health Approach" on a common platform. It is a web-enabled, near real time electronic health information system that is embedded with all applicable Government of India's e-governance standards, Information Technology (IT), data & meta data standards to provide state-of-the-art single operating picture with geospatial information for obtaining village wise and case-based disease surveillance data in real time mode & managing disease outbreaks in the Country.

The Integrated Disease Surveillance Programme (IDSP) is a nationwide disease surveillance system in India incorporating both the state and central governments aimed at early detection and long-term monitoring of diseases for enabling efficient policy decisions. It was started in 2004 with the assistance of the World Bank. A central surveillance unit has been set up at the National Centre for Disease Control in Delhi. All states, union territories, and district headquarters of India have established surveillance units. Weekly data is submitted from all the peripheral units.

Data from medical colleges, health centres, hospitals, labs, etc. is being utilized for the purpose of tracking and reporting of diseases.The data is being collected on ‘S’ syndromic; ‘P’ presumptive; & ‘L’ laboratory formats using standard case definitions.

Under IDSP data is collected on epidemic prone diseases on a weekly basis (Monday–Sunday) and entered on the IDSP weekly portal. Whenever there is a rising trend of illnesses in any area, it is investigated by the Rapid Response Teams (RRT) to diagnose and control the outbreak.

Currently, IHIP portal is used for online reporting under Integrated Disease Surveillance Programme (IDSP) according to real time bases through peripheral units from different logins.

DISEASE MODELLING AND FORECASTING RISK OF LIVESTOCK DISEASES IN INDIA

(With reference to NADRES $_{V2}$)

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Livestock disease Forecasting system is an important component of livestock disease risk management strategies under livestock disease surveillance program. This minimizes the morbidity and mortality of animals and subsequently helps in building efficient production system. India is endowed with vast livestock resources of 535.78 million livestock heads includes 192.49 million cattle population of which 50.42 million are exotic/Crossbreed, 109.85 million buffaloes, 74.26 million sheep, 148.88 million goats, 9.06 million pigs, 4.4 lakhs of Mithun& yaks etc., (20th Livestock Census of India, Department of Animal Husbandry & Dairying (DAHD)under the ministry of Fisheries, Animal husbandry & Dairying, Govt of India) with increased production of milk at 187.75 million tonnes by increase of 6.5% over previous year and per capita availability of milk stood at 394.gms/day(2018-19) compared to previous year 375 grams/day. The main purpose of forecasting system is to assess the risk of disease in given area and issue warnings. Forecasting systems for livestock diseases in India comprises four inter-related elements. 1. Assessment and knowledge of livestock disease risks in the area, 2. Local hazard monitoring and warning service, 3. Disease risk dissemination and communication service and 4. Community response capabilities. This type of multifunctional system improves the community preparedness & awareness for risk of livestock disease occurrence, in terms of both warnings and increased understanding of risks associated and response of policy makers, veterinarians and farmers.

Epidemiological surveillance systems that are ongoing and systematic, that use standardized routines for quality assurance, and that provide for analysis and timely dissemination of of information are critical for Expert system. Human activities are generating wave of change in the natural environment, while new technologies and globalization continue to alter economic and social patterns across the planet. It is known that global climate change and degradation of air, land and water in many areas are capable of endangering animal health. In light of this, it is to examine the potential of these changes to exacerbate the spread of infectious diseases. Systematic climatic and non-climatic observations are an important component of any forecasting system.

Ecological observations and climate forecasts can potentially be used in efforts to predict the appearance of a pathogen and thus allow opportunities to minimize its transmission. This approach is likely to have a much lower predictive value, however, given the uncertainties associated with most climate/disease relationships and the confounding influences of other factors. It is highly unlikely that precise predictions of an epidemic could be made solely on the basis of climate forecasts and environmental observations. Yet, this information can feasibly be used as the basis for issuing an alert (or a “watch”) that environmental conditions are conducive to disease outbreak, which in turn can trigger intensive surveillance efforts for the area in question. If surveillance data is available, then one can confirm the presence of the pathogen or an increase in its abundance subsequent warnings could be issued as needed,

An early warning system or forecasting system is an instrument for communicating information about impending risk to vulnerable population before a hazard event occurs, thereby enabling actions to be taken to mitigate potential harm, and sometimes, providing an opportunity to prevent the hazardous event from occurring. Early warning systems are routinely used for hazardous natural events such as hurricanes and volcano eruptions. In contrast, to date very little attention has been paid to the development of such systems for infectious disease epidemics in livestock. The goal of a disease early warning system would be to provide veterinary health officials and the farmers with as much advance notice as possible about the likelihood of a disease outbreak in a particular location, thus widening the range of feasible response options.

Machine Learning (ML) models has background concept which requires fewer assumptions and coherent statistical methods for dealing with overlaps between presence and background points. ML models are numerical tools that combine observations of species occurrence or abundance, it will be used to correlate disease outbreaks with environmental variability. The models will be evaluated using discrimination capacity in which the power of the model is the discrimination of epi units or geo-spaces of outbreaks and no-outbreaks. The reliability of ML models refers to the capability of predicted probabilities to reflect the observed proportion of locations where disease events are measured.

Finally, risk communication used to be viewed primarily as the dissemination of information to the public about health **risks** and events, such as outbreaks of **disease** and instructions on how to change behaviour to mitigate those **risks**. Risk communication has been identified as a core competence for guiding public health responses to infectious disease threats. It is a call to build capacity and a comprehensive understanding of health risks before a veterinary health emergency to allow systematic and coherent communication, response and management. Research studies indicate that while outbreak and crisis communication concepts and tools have long been on the agenda of veterinary health officials, there is still a need to clarify and integrate risk communication concepts into more standardised practices and improve risk communication and health, particularly among disadvantaged populations.

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DISASTER RISK MAPPING USING GEOSPATIAL TECHNOLOGY

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1. Introduction

Geospatial Technology is a blend of computer hardware and software designed to capture, store, display and analyses geographic (Chaudhary, N., 2014). The capturing of geographic data often relies on remote sensing and global positioning technology. Remote sensing is a common term used for data acquisition from platforms such as aircraft or satellites, that provide a bird’s eye view Remote sensing (RS) is the observation of an object, surface or phenomenon through the use of a variety of recording devices that are wireless, or not in physical or intimate contact with the object. An aircraft, spacecraft, satellite or ship may be used for this purpose and equipped with recording devices such as camera, laser, radar, sonar etc.

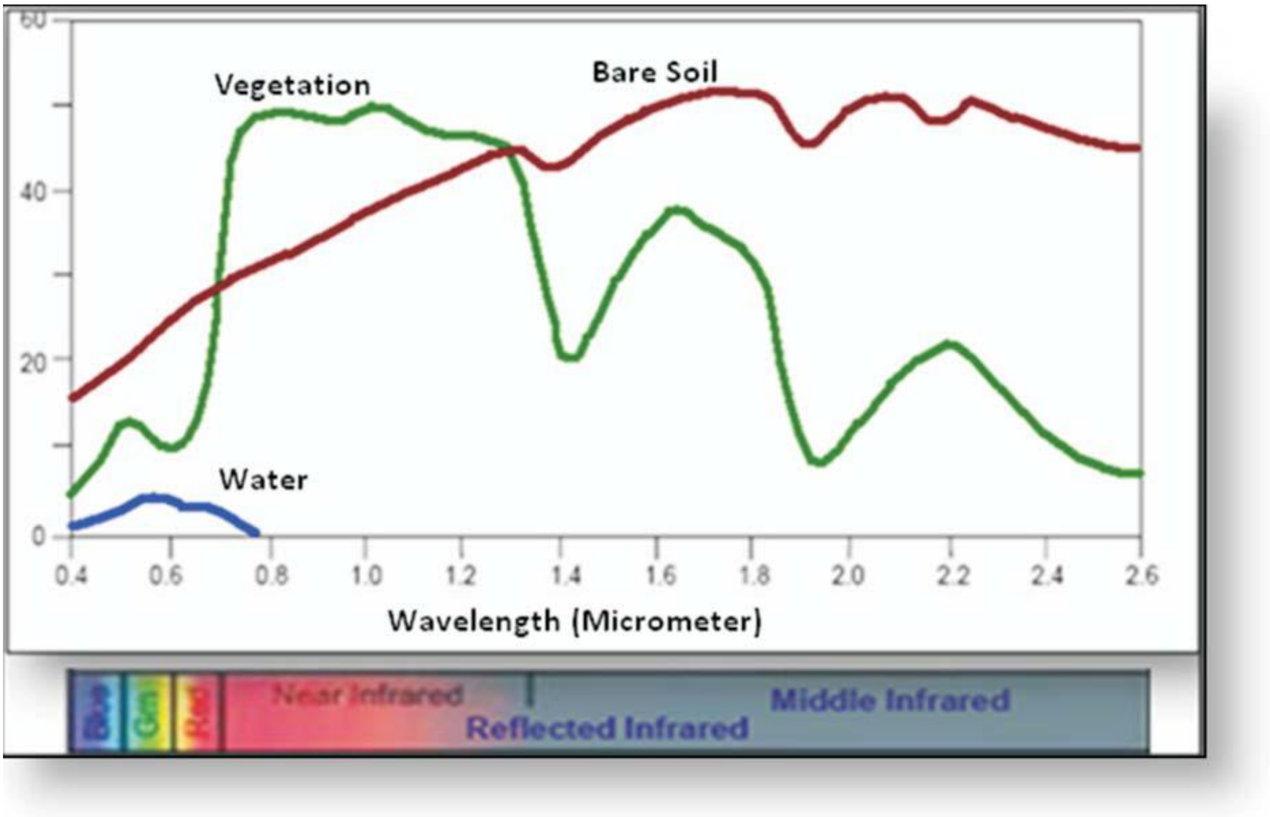
Stages in Remote Sensing

- A source of electromagnetic energy
- Transmission of Energy from the source to the surface of earth
- Interaction with the intervening atmospheres
- Interaction of EMR with the earth's surface
- Transmission of Energy from the surface to the remote sensor
- Sensor Data output
- Data transmission, Processing and Analysis

Remote sensing deals with inventory, monitoring and assessment of natural resources through analysis of data obtained from remote sensing platform. Remote Sensing measures energy such as ultra-violet, infrared, microwave, which that can- not be reached by human vision. Remote sensing data has a unique advantage of multidisciplinary application. The basic principle involved in remote sensing is that different objects reflect or emit radiations in different wavelengths and intensities depending upon properties of the objects serves as the main communication link between the sensor and the objects. All object matter that has temperature higher than absolute zero 0^0 emit EMR continuously. The intensity of the emitted radiation depends upon the composition and temperature of the body. A blackbody is an ideal body that absorbs all radiation incidents on it without any reflection. It represents a continuous spectral emission curve, in contrast to natural bodies that emit only at separate spectral bands. Temperature plays great role on the intensity of blackbody emitted radiation. This relationship is called Wien's displacement Law. Law represents as: max = A/ T where max is the wavelength (cm) where highest radiation occurs. A is constant (= 0.29 cm K) and T is the temperature (K) of the object. Using this law, it can estimate the temperature of objects by measuring the wavelength of peak radiation. The above figure shows spectral distribution of energy radiated from black bodies of various temperatures such as sun, incandescent lamp, fire and Earth. For the Sun max occurs at 0.48 µm, which measures the temperature of the Sun approx. as 6000 K similarly for the earth, the ambient temperature is 3000 K and max occurs at 9.7µm. The ambient temperature of fire is 5000 K and for incandescent lamp it is 4000 K. Most useful regions of the EMR are visible, Infra-red and thermal and microwave for carrying out RS activities. The human eye can detect energy in the visible portion of the electromagnetic spectrum. Photographic cameras are sensitive to broader range of wavelength ranges from 0.3 µm — 0.9 µm, the near ultraviolet to the near infrared. Thermal scanners operate in the thermal infrared portion of the spectrum. Multispectral scanners operate over a broad range of wavelengths from ultraviolet to thermal infrared. Passive microwave and active radar systems operate in microwave portion of the electromagnetic spectrum.

Spectral reflectance signature

The reflectance characteristics of the different features of the earth surface are measured by the incident energy that is reflected by the surface. This spectral reflectance of natural features is collected and stored by satellite sensors. Spectral reflectance of any object usually varies according to the wavelength of the EMR. A graph showing the spectral reflectance of an object for various wavelengths is known as a Spectral Reflectance Curve. It helps in selecting the wavelength bands for identifying the object. Spectral reflectance characteristics are the most important aspect for feature classification in any satellite imagery. Typical spectral reflectance curve for soil, vegetation, water is shown in below graph.



Spectral reflectance of vegetation, soil and water

Geographical Information System (GIS)

GIS is a computer-based system used to digitally represent and analyze the geographical features and events taking place. In ancient time people used maps as a tool to represent and share information about earth surface. Geographic surveyors, navigators, explorers have made many efforts to collect map data for various purposes. Science of map making has undergone many changes. Today there is a new dimension of spatial data handling with respect to various natural resources, and features. A GIS is a collection of computer hardware, software, and geographic data for digitally capturing, managing, analyzing, and displaying all forms of geographically referenced information. It allows us to capture, view, understand, acquire, interpret, and visualize data. The various themes of the same area such as Land cover/ land Use, water, soil, street can be integrated to reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

A GIS is a computer application program that stores Spatial and Non-Spatial information in a digital form. Location Information describes where a particular geographic feature is situated on Earth. Attribute Information describes the feature details like what it is, how much it is, what it contains, etc. Non-Spatial data, also called as attribute data, which refers to information like demographic distribution of a town or a village, daily discharge of a river at a particular place, Traffic contiguity of a road etc. The fundamental key of GIS is that, the association of Geographic features present on earth' surface, which can be geo-referenced with a database related to it. The figure shows the tree location and its description such as age, height, and species. GIS manages all variety of data in a single electronic file in a computer by storing different spatial features as sub-files. These sub-files are called map layers / themes (soil, water, street etc) These map layers are conveniently stored and accessed with the computer in a same scale which are very much helpful for regional planner or any administrative body to accurate study of the earth features. GIS can open all the layers showing all features. It can be displayed and overlaid depending on the requirements. For example, the land-use layer may be displayed along with elevation contours by keeping another layer off.

2. Application of Geospatial technology in drought management

Drought is the major climatic threat that affects agriculture of arid areas. Detection and evaluating the impact of drought with traditional methods has been laborious and time consuming. Recently methods for drought monitoring are improved. Space technology has made substantial contribution in all the three phases such as preparedness, prevention and relief phases of drought disaster management. The Earth Observation satellites which include both geostationary and polar orbiting satellites provide comprehensive, synoptic and multi temporal coverage of large areas in real time and at frequent intervals and 'thus' - have become valuable for continuous monitoring of atmospheric as well as surface parameters related to droughts and floods (Jeyaseelan, 2003). Geo-stationary satellites provide continuous and synoptic observations over large areas on weather including cyclone monitoring. Polar orbiting satellites have the advantage of providing much higher resolution imageries, even though at low temporal frequency, which could be used for detailed monitoring, damage assessment and long-term relief management. Advancements in the remote sensing technology and the Geographic Information Systems help in real time monitoring, early warning and quick damage assessment of both drought and flood disasters.

Monitoring and assessment of drought through remote sensing and GIS depend on the factors that cause drought and the factors of drought impact. Based on the causative factors, drought can be classified into Meteorological, Hydrological and Agricultural droughts. An extensive survey of the definition of droughts by WMO found that droughts are classified on the basis of: (i) rainfall, (ii) combinations of rainfall with temperature, humidity and or evaporation, (iii) soil moisture and crop parameter, (iv) climatic indices and estimates of evapotranspiration, and finally (v) the general definitions and statements.

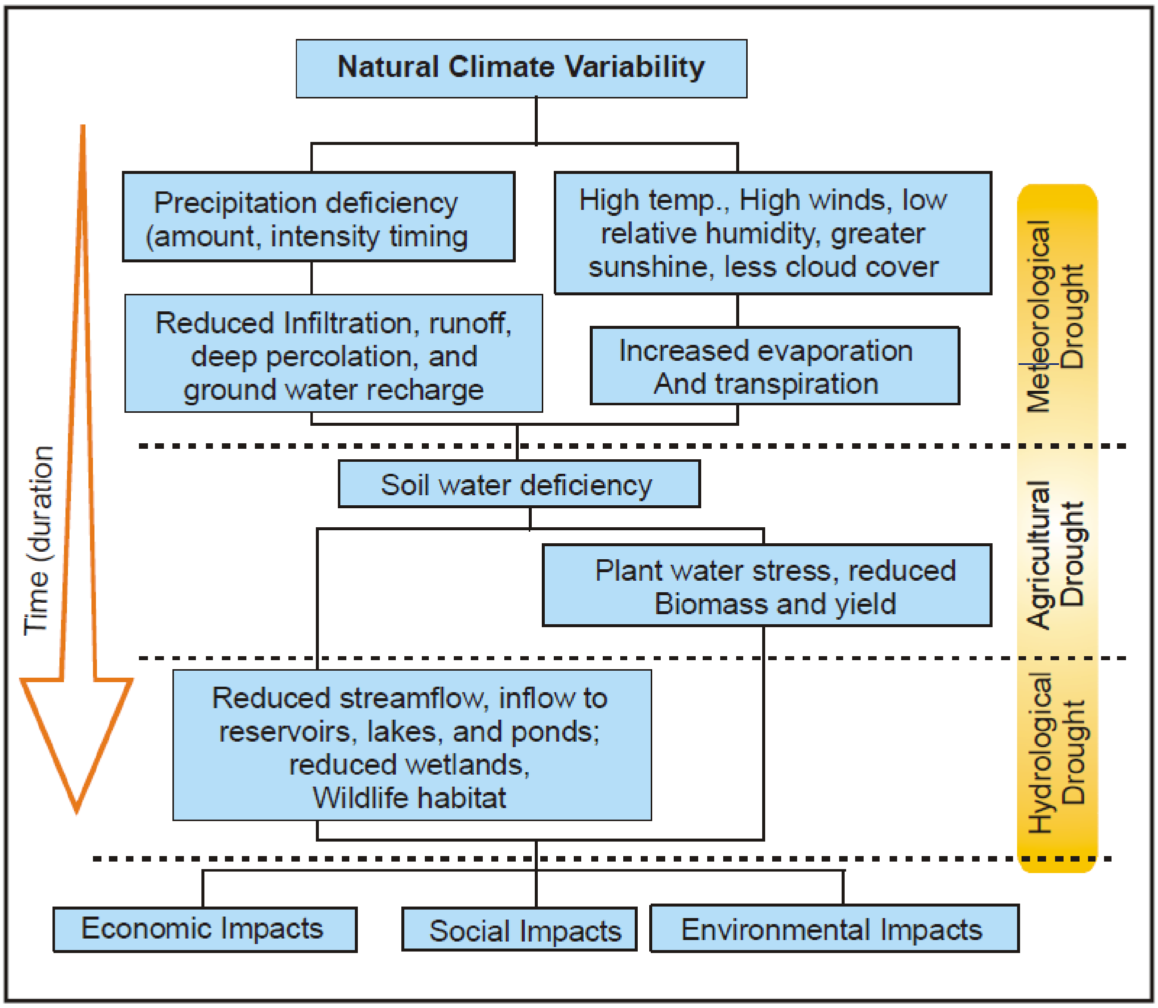


Figure 1: Sequence of Drought impacts

Drought is a normal, recurrent feature of climate and occurs in all climatic zones, although its characteristics vary significantly from one region to another. Drought produces a complex web of impacts that span many sectors of the economy and reach well beyond the area experiencing physical drought. Drought impacts are commonly referred to as direct or indirect. Reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish.

Drought Preparedness Phase

Long before the drought event occurs, the preparedness in terms of identifying the drought prone / risk zone area and the prediction of drought and its intensity is essential. Drought Prone/Risk zone identification. The drought prone area or risk zone identification is usually carried out on the basis of historic data analysis of rainfall or rainfall and evaporation and the area of irrigation support. The conventional methods lack identification of spatial variation and do not cover man's influence such as land use changes like irrigated area developed and the area affected due to water logging and salinity. The remote-sensing based method for identification of drought prone areas (Jeyaseelan and Chandrasekar, 2002) uses historical vegetation index data derived from NOAA satellite series and provides spatial information on drought prone area depending on the trend in vegetation development, frequency of low development and their standard deviations.

Drought prediction

The remote sensing use for drought prediction can benefit from climate variability predictions using coupled ocean/atmosphere models, survey of snow packs, persistent anomalous circulation patterns in the ocean and atmosphere, initial soil moisture, assimilation of remotely sensed data into numerical prediction models and amount of water available for irrigation. Nearly-global seasonal climate anomaly predictions are possible due to the successful combination of observational satellite networks for operational meteorological, oceanographic and hydrological observations. Improved coupled models and near-real time evaluation of in situ and remote sensing data - allows for the first time physically-based drought warnings several months in advance, to which a growing number of countries already relate their policies in agriculture, fisheries and distribution of goods.

The quality of seasonal predictions of temperature and precipitation (NCRC) of United States, the European Centre for Medium Range Weather Forecasts (ECMWF), the India Meteorological Department (IMD), the National Centre for Medium Range Weather Forecast of India (NCMRWF) is a function of the quality and amount of satellite data assimilated into the starting fields (e.g., SST from AVHRR and profiles from TOVS on NOAA satellites, ERS-2 scatterometer winds, SSM/I on DMSP satellites and all geostationary weather satellites: Geostationary Operational Environmental Satellites (GOES), i.e. GOES-East, GOES-West of USA, METeorologicalSATellite (METEOSAT) of Europe, Geostationary Meteorological Satellites (GMS) of Japan, Indian National Satellites (INSAT) of India etc.). The new assimilation techniques have produced a stronger impact of space data on the quality of weather and seasonal climate predictions. The potential contribution by existing satellites is by far not fully exploited, since neither the synergy gained by the combination of satellite sensors is used nor all the satellite data are distributed internationally. For example, better information flow is needed from satellite data producers to the intermediary services such as CLIPS (Climate Information and Prediction Services) project of World Meteorological Organisation (WMO), and prediction centres including the European Centre for Medium Range Weather Forecasts (ECMWF), National Centres for Environmental Predictions (NCEP), Japan Meteorological Agency (JMA), India Meteorological Department (IMD), National Centre for Medium Range Weather Forecast, India (NCMRWF) etc. to local services and ultimately to end users. Further the drought predictions need to be improved with El Niño predictions and should be brought down to larger scales. anomalies by various centres such as the National Climate Research Centre.

Drought Prevention Phase

Drought Monitoring and Early Warning

Drought monitoring mechanism exists in most of the countries based on ground-based information on drought related parameters such as rainfall, weather, crop condition and water availability, etc. Earth observations from satellite are highly complementary to those collected by in-situ systems. Satellites are often necessary for the provision of synoptic, wide-area coverage and frequent information required for spatial monitoring of drought conditions. The present state of remotely sensed data for drought monitoring and early warning is based on rainfall, surface wetness, temperature and vegetation monitoring. Currently, multi-channel and multi sensor data sources from geostationary platforms such as GOES, METEOSAT, INSAT and GMS and polar orbiting satellites such as National Oceanic Atmospheric and Administration (NOAA), EOS-Terra, Defense Meteorological Satellite Program (DMSP) and Indian Remote Sensing Satellites (IRS) have been used or planned to be used for meteorological parameter evaluation, interpretation, validation and integration. These data are used to estimate precipitation intensity, amount, and coverage, and to determine ground effects such as surface (soil) wetness. In addition, web based real time drought assessment is also proposed by Gopinath et al. (2015) and Gopinath et al (2020).

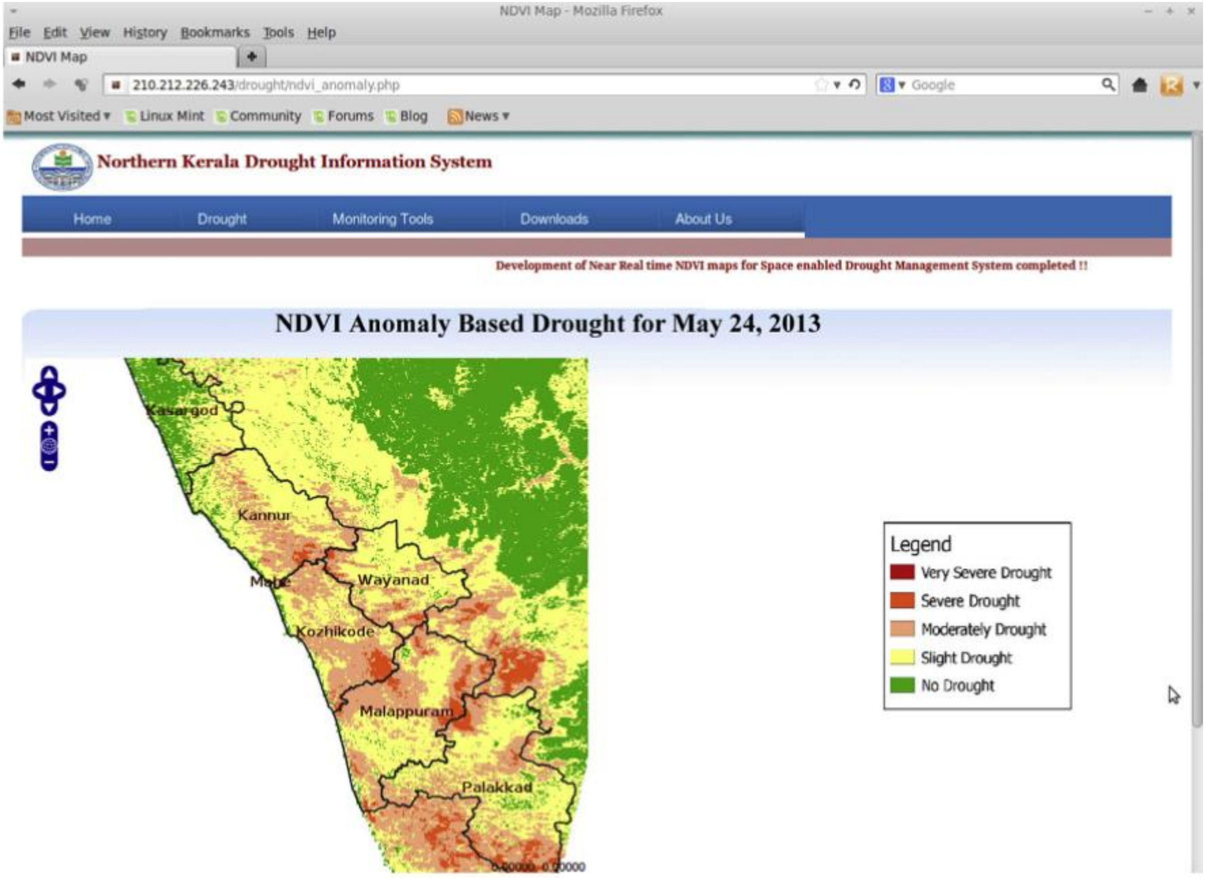
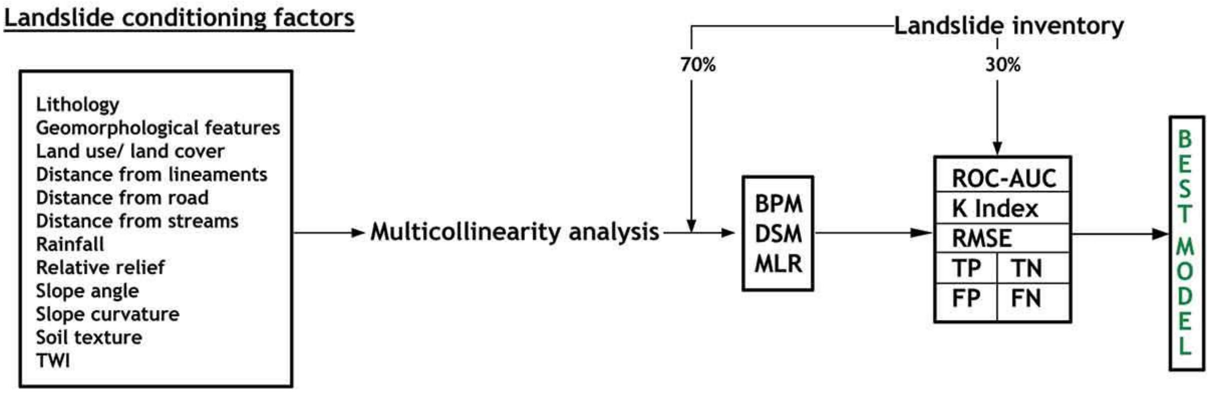


Fig. 3. Screenshot of the recent NDVI Anomaly map displayed on the Web page.

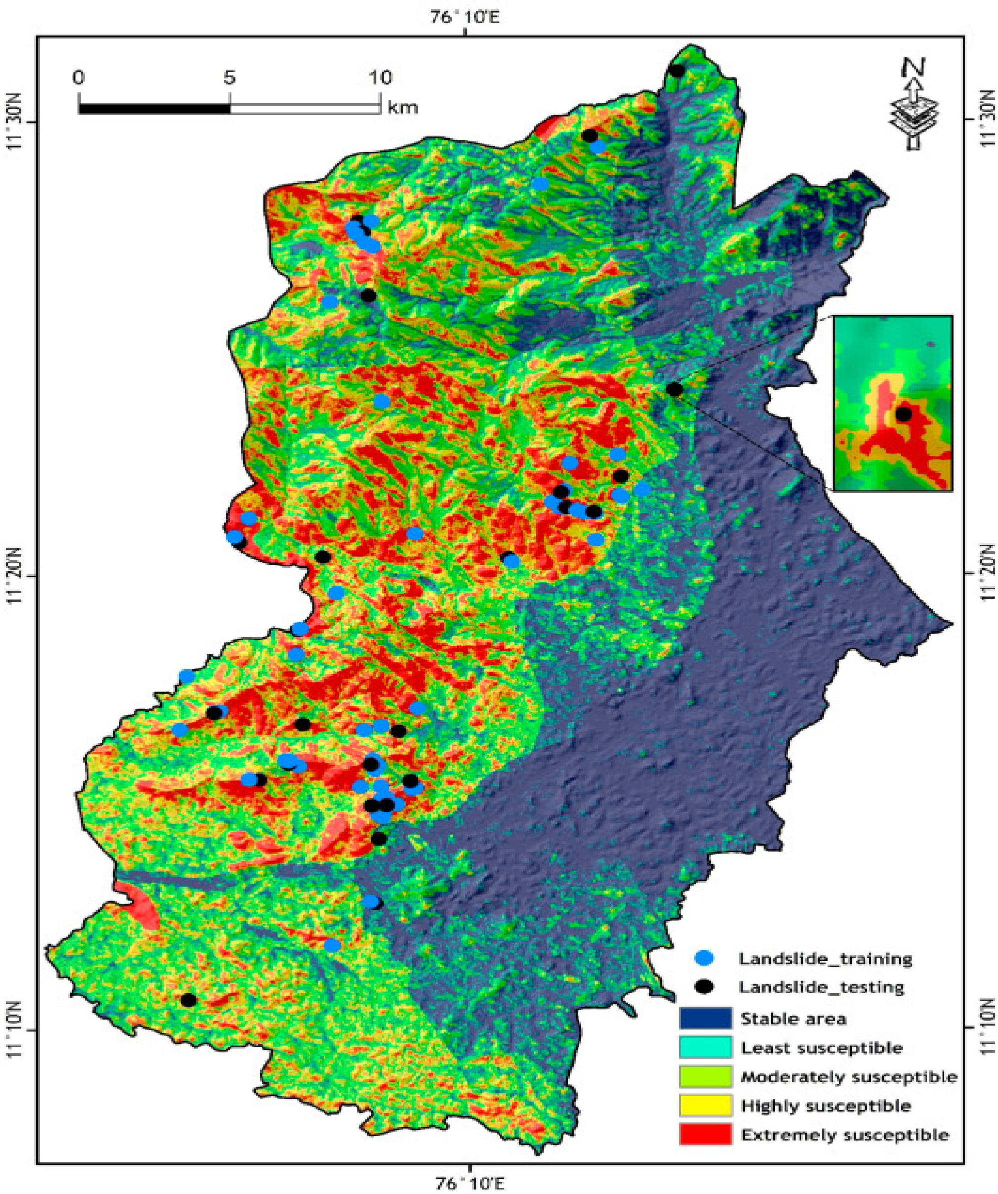
Source Gopinath et al., 2015.

3. Application of geospatial technology in Landslide susceptibility mapping

A landslide is a type of mass wasting process that acts on natural and engineered slopes. It is the movement of a mass of rock, debris, or earth down a slope, under the influence of gravity. Landslides involve flowing, sliding, toppling, falling, or spreading, and many landslides exhibit a combination of different types of movements, at the same time or during the lifetime of the landslide. Landslides are present in all continents, and play an important role in the evolution of landscapes. In many areas they also pose a serious threat to the population (Petley, 2012; Swetha& Girish Gopinath 20220; Achu et al., 2021a). Landslides are complex geomorphic processes influenced by several geo-environmental factors such as regional lithology, morphological characteristics, soil type, rainfall, slope and land use pattern, makes is difficult to predict the spatial and temporal occurrences. However, with the introduction of geospatial technology, many researchers predicted landslide susceptibility (likelihood of occurrences) by applying various heuristic, deterministic and statistical methods (Achu et al., 2020: Feby et al., 2020; Pham et al., 2021).The landslide susceptibility modelling have three major phases, starting from collecting previous landslide location, finding the suitable landslide influencing parameters like slope angle, lithology etc and modelling the probability of occurrences using weighted overlay/AHP or other statistical/ machine learning modellings as shows below.



A general methodology for landslide susceptibility analysis (Source Achu et al., 2020)



Example of landslide susceptibility map (Source Feby et al., 2020)

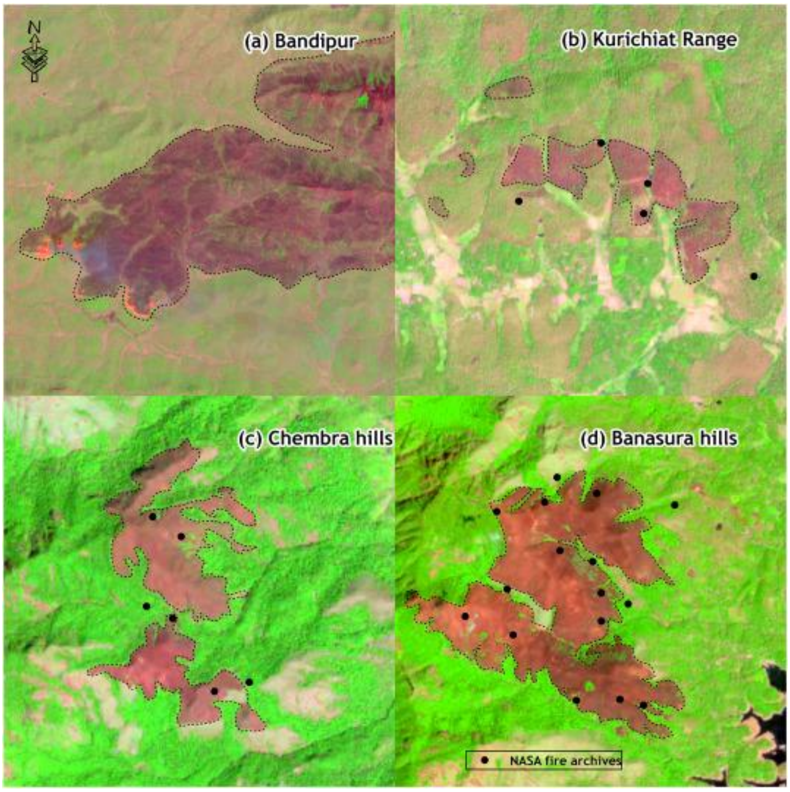
4. Application of Geospatial technology in forest fire prediction and mapping

Forest Fire is a natural phenomenon. It is part of the nitrogen cycle and it helps forests to grow healthy. However, “wildfire” is a huge and out of control fire which destroys human wealth and therefore, it is kind of disaster. The very first strategy to defend the forests against wildfire is to avoid it. So fire risk maps are produced and even prescribed burning is done. Nevertheless, wildfire happens and the only choice in this case is to control it. Knowing the fire behavior, one can use forest fire simulation to predict and control the wildfire. Nowadays application of Geospatial Information Systems (GIS) in disaster management has extended considerably and, in some cases, it is even unavoidable. Forest fire happens from time to time and this has given human a chance to observe and develop different models for forest fire behavior. GIS as a powerful tool for management of spatial information, has also proved its potential in forest fire management. There are different applications of GIS in forest fire management out of which the most important ones are hazard map production, forest fire simulation and resource management. Simulation by itself has a main role in the management of forest fire. GIS uses various information layers such as Digital Elevation Model (DEM) and index of flammability along with different models for the purpose of forest fire management. Models can be simple or complex. Simple models have few parameters and can be implemented even without GIS, however, because of their simplicity their results are not so reliable. On the other hand, very complex models which use detailed physical characteristics of fire are not reliable either as there is not either enough or up to date information on their parameters. So, finding an optimum model that takes advantage of sufficient number of parameters while has an acceptable level of simplicity is very important.

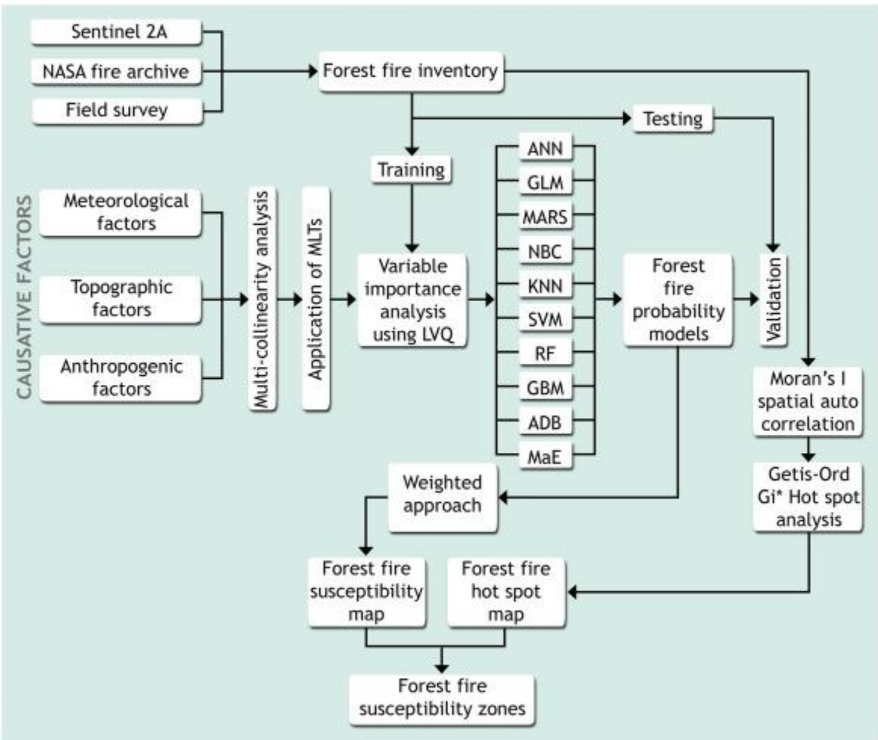
GIS is a powerful spatial processing tool which is used to solve many complex problems. In the context of forest fire some applications of GIS are as following:

1. GIS in fire risk/probability assessment
2. GIS in prescribed burn planning
3. GIS in preventing fire and its spread
4. GIS in fire simulation
5. GIS in post fire assessment and monitoring
6. GIS in disaster management

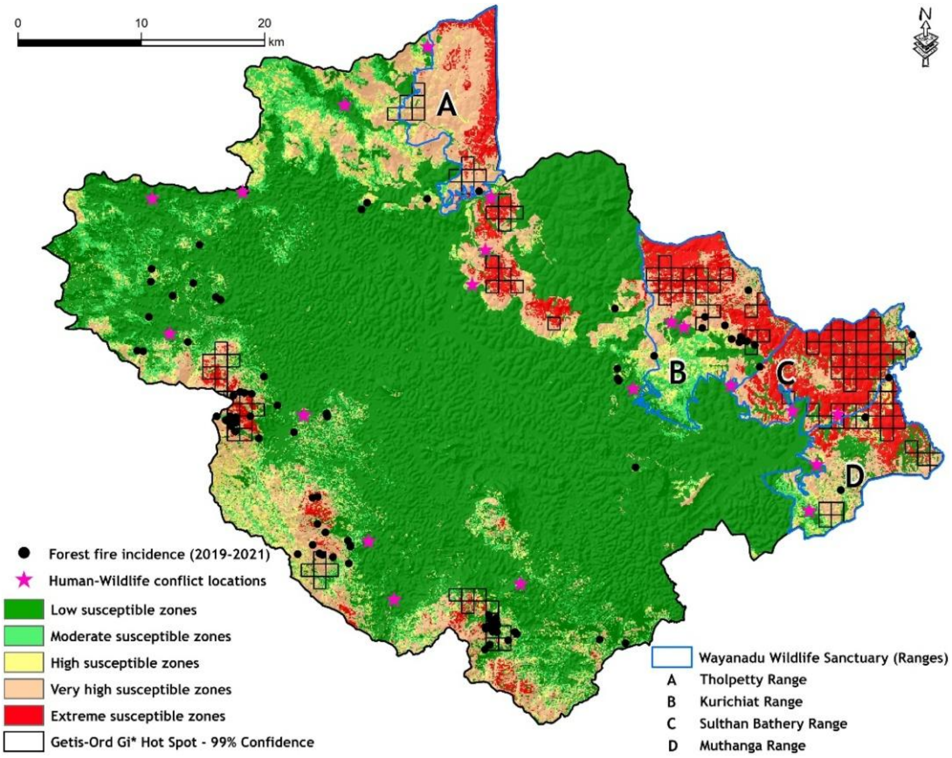
Below figure shows a live tracking of active forest fire and other burned areas in Wayanad district using Sentinel 2 Satellite images.



Forest fire inventory: Sentinel 2A 12-8-4 band combination with NASA fire archive data (a) Bandipur National Park, (b) Kurichiat forest range, (c) Chembra hills and (d) Banasura hills. (Source AchuA L 2021b)



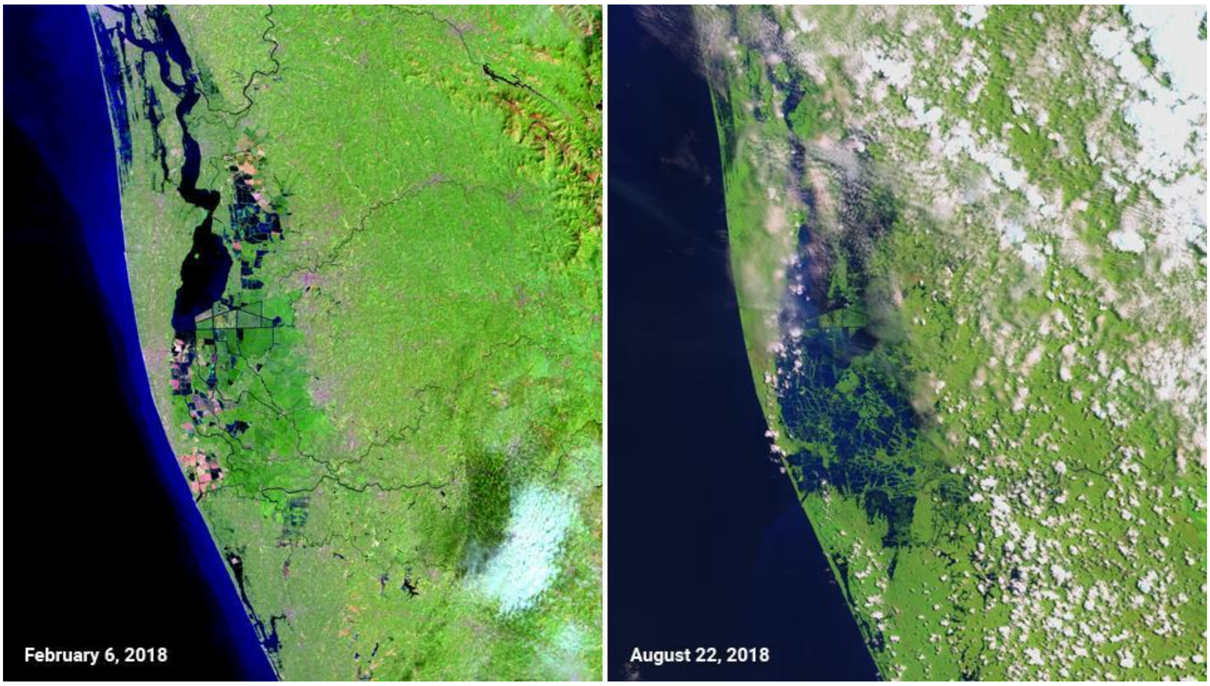
Methodology flow chart for forest fire susceptibility modelling using machine learning models (Source Achu et al., 2021b)



Forest fire susceptibility map using machine learning models in Wayanad district (Source Achu et al., 2021b).

Application of geospatial technology in flood modelling and mapping Kerala flood

Accurate and current floodplain maps can be the most valuable tools for avoiding severe social and economic losses from floods. Accurately updated floodplain maps also improve public safety. Early identification of flood-prone properties during emergencies allows public safety organizations to establish warning and evacuation priorities. Armed with definitive information, government agencies can initiate corrective and remedial efforts before disaster strikes. GIS is ideally suited for various floodplain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. For example, GIS was used to develop a River Management Plan for the Santa Clara River in Southern California. A GIS overlay process was used to further plan efforts and identify conflicting uses along the river and areas for enhancing stakeholder objectives. A 1 inch = 400 ft (1 cm = 122 m) scale base map was created to show topography, planimetric features, and parcels. Attribute data were entered into a separate database and later linked to the appropriate map location. Six layers were created for flood protection related work: 100-year floodplain, 100-year flood way, 25-year interim line, existing facilities, proposed facilities, and flood deposition. The lessons learned from this mapping project indicate that GIS is useful in capturing and communicating a vast amount of information about the study area and the river. While the use of GIS and the process to gather and record data were not without problems, the overall value of GIS was found to overweigh those challenges.

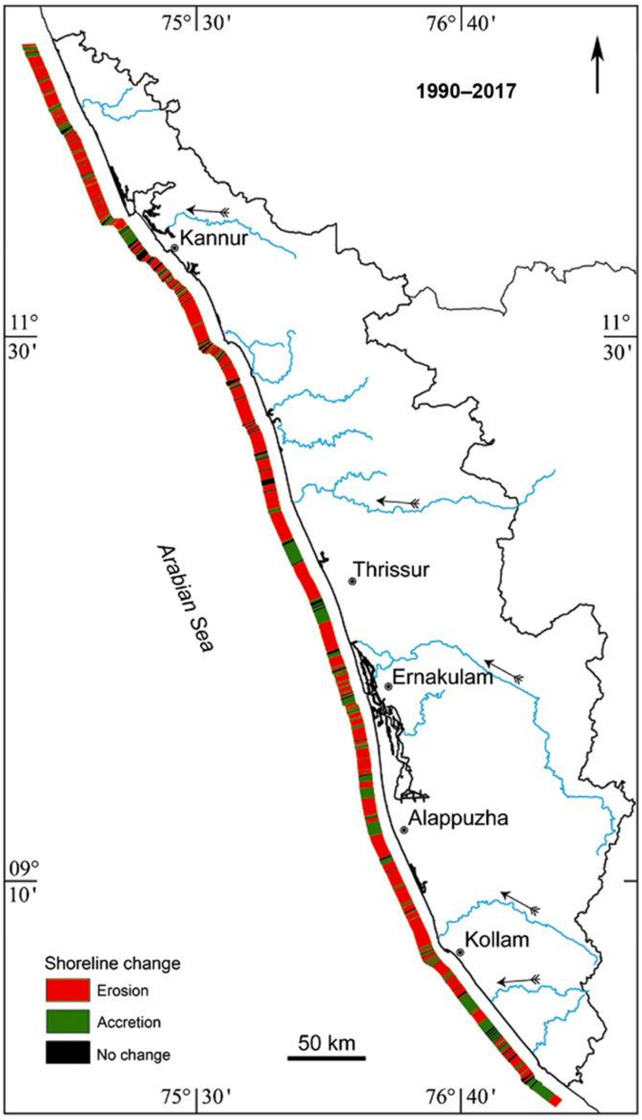


Kerala flood (Source NASA 2018)

Spatial probability of flood occurrence can be computed using GIS, often called flood susceptibility modelling.

5. Application of Geospatial technology in coastal vulnerability mapping

Coastal zone for the purpose of this paper, shall mean the area, on both side of the actual land water interface, where both territorial as well as Marine environmental influences each other. In addition, interaction between various natural processes and human activity are important factor in the coastal area. The coastal zone shows high population density with large number of urban conglomeration and in consequence, a fast population growth. Again, as a consequence, coastal zone are characterized by a high concentration of economic and, in particular, industrial activities with all the resulting problems of resource consumption, waste management and technological risk. On coastal water side, fisheries and aquaculture exploits a generally highly productive system. Very specific, and valuable as well as vulnerable, typical coastal ecosystems include estuaries, salt marshes, mangroves, coral reefs etc. Offshore activities such as oil and gas, as well as mining, are additional forms of exploitation of the coastal zone. In addition, the coastal zone is also the recipient of all water borne waste streams, primarily attributable to agriculture, its fertilizers and agrochemical, and all treated and untreated waste water the hinter land produce in their respective catchment. Determining the accurate length of the coastline is important for such coastal zone management application as shoreline classification, monitoring erosion, mapping biological resources, habitat assessment and for the planning and response to nature (e.g., storm surges) and man-made disasters (e.g. oil spills). Coastal zone management, by definition, is spatial management. Geo referenced spatial data is map data in a digital form which mean that each of the earth's features that are stored as spatial data has a unique geographic reference such as latitude and longitude. The increasing use of spatial data and GIS (Geographic Information System) by organizations and researchers is a valuable tool to help solve the planning and management issues in the coastal zone. There are many different Geographic Information Systems in use today and they tend to differ in certain aspects such as "how they link geographic location with information about those locations, the accuracy with which they specify Geographic location, the level of analysis they perform and the way they present information as graphic drawing". Following is an example of shore line changes along the coast of Kerala using time series satellite images.



Map showing the changes along the Kerala state during 1990–2017 (source Kumar et al., 2019)

Coastal region	**Time Interval**	**Erosion Length (km)**	**Accretion Length (km)**	**Stable Length (km)**	**Area lost by Erosion (km^2)**	**Area gained by deposition (km^2)**	**Net Loss (km^2)**
Kerala State	1990-2017	327	172	91	23	10	13

Source: Kumar et al., 2019

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APPLICATION OF ICTs IN LIVESTOCK PRODUCTION AND HEALTH MANAGEMENT

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Information and Communication Technologies (ICT) is a broader term as compared to Information Technology (IT), and refers to all communication technologies, including the internet, wireless networks, cell phones, computers, software, middleware, video-conferencing, social networking, and other media applications and services enabling users to access, retrieve, store, transmit, and manipulate information in a digital form (FAO, 2021).ICT encompasses both the internet-enabled sphere as well as the mobile one powered by wireless networks. It also includes antiquated technologies, such as landline telephones, radio and television broadcast -- all of which are still widely used today alongside cutting-edge ICT pieces such as artificial intelligence and robotics (Pratt, 2019).

Modern ICTs applications are made up of four layers, namely the cloud, edge, physical, andnetwork layers. The cloud layers is made up of the virtual server with the presence ofbig data analytics. There is also the presence of database clusters with potential for datavisualization and enabled machine learning (ML) and artificial intelligence (AI) potentials.The edge layer is where the users' computational activities are enabled with the existenceof ML and AI models and data processing capability.The physical layer is the layer responsible for enabling the sensors that are placed on the animalsand fittedinto farm equipment to collect data. The network layer performs thefunction of offering the gateway to allow data communication and connectivity (Akhigbe *et al.*, 2021).

ICT-enabled applications which enhance the efficiency of livestock farms and aid in precision farming can be broadly grouped into four categories – Sensors, Automation, Decision Support Systems (DSS) and Information dissemination.

A. **Sensors**: These can be of various types depending on the requirement.Bio-sensors can either be wearable (neck, ears, legs, tail, skin surface) or implanted (sub-cutaneous, intra-ruminal, intra-vaginal). They can record temperature, pH, activity (accelerometer), heart rate, respiration rate, mounting pressure, GPS location, biomarkers etc. depending on their location and utility. External sensors which can record animal data comprise video camera, microphone, thermal infrared camera and load cells. Other sensors record environmental parameters like temperature, humidity, air speed, light intensity and levels of noxious gases. In dairy farms, special sensors in the milking parlour can record milk quantity, flow rate, temperature, composition, electrical conductivity, somatic cell count, progesterone levels and antibiotic residues. In most cases, a combination of sensors is utilized to achieve desired management objective.

B. **Automation**: In view of the rising costs and unreliability of skilled labour, and the reduction in prices of automatic farm equipment, many livestock farms have adopted automation in routine operations milking, feeding, livestock handling, weighing, body condition scoring and climate control. This enables timely and precise farm operations. The data generated from automatic farm equipment is vital for handling large herds/flocks.

C. **Decision Support Systems**: Data from biosensors, environmental sensors and external sources is fused to form a Decision Support System which aids the farmer in taking appropriate management decisions. These can in the form of livestock breeding, feeding, herd management and disease control. Computerization of these process increases speed of decision making and reduces errors. Incorporation of ICTs leads to change in livestock management strategy from Reactive to Proactive to Predictive, with the system being able to predict the best management response in the future based on past data.

D. **Information Flow**: Creating awareness about scientific livestock management practices is vital for enhancing efficiency and saving of scare national resources. With the advent of wider mobile network coverage and low-cost smartphones and internet data, mobile apps have become the preferred route for information dissemination as compared to earlier technologies like information kiosks or CDs. They have advantages in the form of multi-lingual text, audio and video content, and timely updates and notifications. In addition to extension activities, critical information regarding extreme weather events, emerging diseases and vaccination drives can also be shared using ICT tools. Access to market information and online trading of livestock, livestock products and inputs like feed ingredients etc. can greatly enhance the profitability of farmers by removing middlemen.

Advanced digitalization technologies can help modern farms optimizeeconomic contribution per animal, reduce the drudgery of repetitivefarming tasks, and overcome less effective isolated solutions. Thereis now a strong cultural emphasis on reducing animal experiments andphysical contact with animals in-order-to enhance animal welfare andavoid disease outbreaks. This trend has the potential to fuel moreresearch on the use of novel biometric sensors, big data, and blockchaintechnology for the mutual benefit of livestock producers, consumers,and the farm animals themselves (Neethirajan and Kemp, 2021).Some of the ICT-enabled applications which enhance the efficiency of livestock farms and aid in precision farming are given below:

1. **Identification**: Development and commercialization of animal identification systems has reached a very advanced state. A variety of systems based on Radio Frequency Identification (RFID) are available, some of which work reasonably well and have been adopted at the country level. These systems greatly facilitate the traceability and certification of products, particularly of meat, and therefore are crucial tools to minimize the losses and market disruptions caused by localized diseases. RFID systems communication with other ICT enabled systems to aid data logging in milking, feeding, and weighing equipment.

2. **Instrumentation***:* This involves acontrol system that consists of sensors that measure variables related to the system's state and actuators that provide input of mass, momentum or information to the system towards directional modification of the state. Animal state is estimated by the history up to a recent time, position, activity, temperature, live weight and other physiological variables of all individuals in the herd. This is especially observed in commercial poultry farms where controlled environmental conditions are essential for the profitability in high producing lines.

3. **GPS**: The use of GPS collars for livestock and wildlife has opened the possibility of recording detailed position information for long periods of time, thus allowing a more complete understanding of the habits and causes of spatial distribution of ruminants. Current commercial GPS technology can determine position of individual animals with a precision of 10 m or better. The position information can be stored on small flash cards together with large amounts of behaviour and physiological data and it can be transmitted to a management centre in real time or in periodical sessions.

4. **Animal behaviour sensors**: The data recorded by these sensors is somewhat ambiguous, but models can be developed to infer activity. Various types of sensors are necessary for a detailed record of behaviour. Accelerometers have been useful to document not only head movements but also walking and lying behaviour. Sensors have been tested for measuring head angle, head acceleration, leg acceleration, steps (pedometers),

swallowing, jaw movements, biting and chewing sounds, weight, heart rate, core temperature etc.

5. **Health monitoring**: Sensors and techniques for heath monitoring are well developed for dairy production under confined conditions. Behaviour and changes in behaviour can be used to detect health problems before disease affects animal productivity. Sensors were able to detect 80% of health problems related to ketosis, locomotion and lameness at least one day sooner than the farm staff by analysis of short-term feeding. Use of the estrus mount detectors, pedometer and advanced time series analysis to detect oestrus in dairy cows has been quite successful. Mastitis detection using in-line sensors which evaluate electrical conductivity and somatic cell count have proven to be very effective in detecting sub-clinical mastitis. Rumen pH sensors enable early detection of acidosis and aid in proper feeding. Thermal infrared imaging, especially of the eye region can monitor stress and detect disease 4-6 days earlier than traditional methods (Neethirajan and Kemp, 2021). Other devices like thermometers, accelerometers, and microphones, and camerasallow farmers to monitor temperature, activity levels, sound levels in the barn (e.g., vocalizations, sneezing, and coughing) and specific behaviors (e.g. aggression in pigs, pain estimation using ‘grimace scale’).

6. **Weighing**: Body weight measurement, either using statically or walk over load cells, or through captured digital images have very good accuracy and minimise the stress associated with restraint and body weight measurement.

7. **Body Condition Scoring**: This can be done either with image processing from video cameras or using thermal imaging. The captured images and associated expert score are used to train the computer neural network model, which can predict BCS of animals with very high accuracy.

8. **Lameness score**: This can be measured using data from load cells during milking or while the animal is walking over a grid of load cells. Newer techniques use video tracking and gait analysis; these, however, need an unobscured view of the flank of a single cow. Accuracy of these methods is still not adequate for commercial use.

9. **Herd management software:** The ability to digitally store herd information is a valuable tool for all farms. Data can be entered into this software application manually or automatically through the use of other digital devices (such as milk meters, cow weighing scales) linked to this database. This enables the farmer to easily view, analyze, manipulate and sort data. Such information storage and manipulation capabilities provide farmers with an extremely valuable resource to aid them in their farm management activities and decisions.

10. **Big data analytics and Machine learning:**The use of biometric sensors and biosensors for monitoring the health and welfare of livestock results in huge amounts of data that need to be processed and analysed to provide meaningful insights for animal management.Precision livestock farming relies upon proper use of big data analytics and modelling to inform management about nutritional needs, reproductive status, and declining trends in productivity, that may indicate animal health and welfare issues. Big data models extract information from sensors, process it, and then use it to detect abnormalities in the data that may be affecting the animals. Machine learning technology allows computer algorithms to progressively learn from sensor big data sets and improve themselves accordingly, eliminating the need for a human data analyst(Neethirajan and Kemp, 2021).

11. **Blockchain**: This technology provides several important benefits to livestock agriculture, including decentralized, automated transactions that could contribute to more efficient auditing systems for certification and regulatory organizations, system integration, organized records of chain transactions throughout the life of an animal from farm to table and greater traceability and transparency within livestock agriculture.

Conclusions

Livestock production is in a period of rapid adjustment and development, both regionally and globally. ICT has the potential to change the economy of livestock, agriculture, and rural artisans in India. There are intense pressures and concurrent opportunities associated with the need to produce safe and environmentally friendly livestock products. This has created the need and opportunity to use ICTsin the form of computer software, sensors and other electronic material in regards to livestock disease control, dairy herd management, livestock production, and marketing of livestock and livestock produce.

Simultaneously, advances in electronic communications and GPS technologies have driven major declines in prices and improvements in performance, opening a window of opportunity to create cost-effective systems for large scale precision livestock production.

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EPIDEMIOLOGICAL SURVEILLANCE AND DISEASE MODELLING

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Public Health surveillance can be described as *"the ongoing, systematic collection, analysis and interpretation of health-related events or data with the a priori purpose of preventing or controlling health hazards (disease outbreaks) and identifying unusual events of health importance, followed by the dissemination and use of such information for public health action"* (Bordier*et al.*, 2020). Effective health surveillance systems require reliable, high-quality, and timely data for decision making.

Why animal health surveillance is important?

The important objectives of animal health surveillanceare (Hoinville*et al.*, 2013):

- It helps in protection of animal health and welfare. The effective surveillance also provides the real scenario on the health status of the livestock population which helps in the upliftment of national and international trade in animal and animal food products
- To protect the public health by informing our understanding of incidences of zoonoses and its prevention and assuring food safety to the consumers.
- To fulfil the requirements of international organizations, *viz.* World Organization for Animal Health (OIE)– such as reporting of outbreaks, preparing emergency reports, weekly updates etc.

The data collection, analysis and dissemination are important components of surveillance system. The various types of widely used surveillance systems are depicted in Table 1.

Table 1. Types of Surveillance systems with their description

Surveillance Category	**Brief description**
Active surveillance ('Proactive surveillance')	It includes 'investigator-initiated' collection of targeted disease data using a defined protocol to perform scheduled actions. *Disadvantage:* Not economical, especially for rare diseases where large sample sizes are necessary because of the low expected prevalence.
Passive surveillance	It includes 'observer-initiated' provision of health data (e.g., voluntary notification) or the use of pre-existing data for surveillance.

('Reactive surveillance')	*Disadvantage:* In practice, apart from underreporting, the sensitivity and timeliness of passive surveillance are often not optimal.
Sentinel surveillance	Depending on the objective, sentinel surveillance can either be passive or active. It comprises the group of unexposed non-vaccinated population/regions that are managed at fixed locations and sampled regularly for investigation of the disease.
Vector surveillance	Systematic identification of potential vector(s) can be correlated with particular relevance to targeted vector-borne diseases in a given ecology. *Disadvantage:* Not recommended as routine procedure due to its labour-intensive protocols.
Serological surveillance	Detection of antibodies against specific diseases is highly effective method to detect infection in a population. However, the positive results must be interpreted carefully within one of the 04 categories, *viz.*, natural infection, maternal antibodies, vaccination, false positive
Syndromic surveillance	It is based on the use of pre-diagnostic indicators which can be used for early detection of health events in a population (e.g., clinical cases, high mortalities, post-mortem findings) which can be defined as syndromes. *Disadvantage:* The indicators used in syndromic surveillance are not very specific and can lead to many false positives.
Targeted surveillance and **Risk-based surveillance**	It is recommended when the frequency of given health event is higher in target group. In risk-based surveillance, exposure and risk assessment methods can been applied together with traditional design approaches. *Disadvantage:* It can be expensive as it uses structured epidemiological surveys and needs a clear definition of the objectives.
Scanning surveillance	In scanning surveillance, the health services records can be used to obtain relevant information. *Disadvantage:* Underreporting and low-quality data are the limitations.
Event-based surveillance	It is organised collection of unstructured *ad hoc* information regarding health events or risks and is a functional component of early warning and response systems. *Disadvantage:* The information collected is diverse and originate from multiple sources
Indicator-based	It is routine collection of structured data of 'indicators' in health-based

surveillance	formal sources and usually measure the impact of health programmes *Disadvantage:* The data cannot be employed for early warning and response systems

As per Dufour and Audige (1997), the important set of criteria for the classification of surveillance networks are:

1. The type of disease to be monitored (exotic disease *versus* endemic diseases)
2. The number of diseases to be covered: focused networks *versus* broad networks (including multiple health events)
3. The area to be covered(regional, national or international)
4. The population to be monitored (suspected, susceptible, infected etc.)
5. Sampling strategy: sample-based networks *versus* exhaustive networks covering large population
6. Method of data collection (active or passive)
7. Network management (autonomous management *versus* integrated networks)

Key considerations for surveys and use of diagnostic tools in surveillance system: The choice of sample size, required design prevalence and confidence interval for surveys should be justified based on prevailing epidemiological situations. The sample size should be large enough to detect the infections even at a predetermined minimum rate (Bedi*et al.*, 2021).

The proper validation of the sensitivity and specificity of the diagnostic tests for targeted species should be exercised. In addition, it is important to differentiate 'vaccinated *versus* infected' animals by the diagnostic test for interpretation of the surveillance data. The surveillance framework can be supported by development of inexpensive, rapid and reliable screening tests along with the expansion of powerful information management systems to disseminate the information to the stakeholders.

Disease modelling

"A model is a representation of a system, which allows the behaviour of that system to be simulated, and manipulated, under controlled conditions". Models are used to test (verify) and improve the understanding of a system, and to analyse the behaviour of different components of the complex system (Power and Sharda, 2007).

To build a model of an infectious disease outbreak, the knowledge of epidemiological aspects of disease is very crucial so that the components of the model can be put together correctly. In animal health settings, the infectious disease models can be used for retrospective analysis of the past epidemics, contingency and resource planning, can be used as 'virtual epidemic simulators' for training purposes, and real time decision support (Potter, 2019).

Modelling disease transmission

The epidemiological models make better use of existing and potential data sources for early warning surveillance.The epidemiological models can be classified as:

1. *Deterministic and stochastic models:* The deterministic models use single point value for inputs and hence outputs; whereas the stochastic models include the 'uncertainty and variability' by using range of values for inputs and hence can produce varying outputs. The stochastic models are considered as more appropriate for modelling the real-life biological systems (Garner and Hamilton, 2011).
2. *Compartmental (or state-based) and individual-based (agent-based) models:* The compartmental (or state-based) models group individuals into different states as per the characteristics of the infectious disease processes. E.g., SIR (susceptible–infected–recovered) model and its variant. Whereas, the individual-based (agent-based) models explicitly represent the differentiation in biology or behaviour of individuals. Being stochastic, they offer more value when individual heterogeneity in transmission and structure of intervention is important.

Example of Compartmental (or state-based) model:

The infectious disease can be modelled as a state-transition model using an iterative approach. The common three states of transitions in basic **S-I-R models** are: susceptible, infected and recovered (immune) or removed.

$$S \xrightarrow{\beta \times I \times S/N} I \xrightarrow{\gamma \times I} R$$

ß = Infection rate (transmission rate)

I = Number of infections

S/N = Proportion of susceptible

$1/\gamma$ = Infectious period

In the outbreak of a contagious disease, the new cases of disease in a population occur as a result of infected units having 'effective contact' with susceptible units. These effective contacts are depending on many underlying factors like:

- the number of infected units
- the population density and intensity of mixing of the population – determined by the management system and environment
- the intensity of contact needed to be 'effective' – a property of the disease itself

It is important to understand the spread of disease in terms of basic reproduction number (R_0), that is, '*the number of new cases produced by each infected person*' (assuming that no one is immune in the population). Most of the disease control programs aim to reduce R_0 to < 1, such that each infected human/animal, on average, transmits to less than one other human/animal.

In simple equation, $\mathbf{R_0 = C \times P \times I}$

C = Contact rate (i.e., how many people get contact with infected person in unit time)

P = Probability of transmission for a given contact

I = How long an infected person can transmit the infection (infectiousness of disease)

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ROLE OF MASS MEDIA AND ICT TOOLS ON DISASTER MANAGEMENT IN ANIMALS

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Introduction

The term disaster was originated from the Greek word '*krinon*' which implies a turning point, specifically in terms of diseases and dangeroussituations in political, social, and economical problems (Soltani, 2015). Usually, disaster is regarded as a turning point that could lead to an inevitablechange (Said and Rezapour, 2010). Disasters are often followed by an unexpected series of covert and overt consequences so that thedisaster managers must always be well prepared to deal withthese consequences in a suitable manner (Ali, 2002). Hence, the mass media along with various ICT tools is regarded as the first organization by frequent reporting and reviewing all incidents and rescue actions during disasters afterward and thus became the most significant strategic tools in disaster management.

Although the complexity of health- related communication through mass media exposes professionals to the significant challenges in diverse disciplines, mass media are often considered as important tools for the transfer of various ideas and information to the public, and even contributes for achievement of public health goals. It is believed that the catastrophic impacts of disasters on animal and human sufferings can considerably be reduced through an international devoted system of co-operation, incorporating public health education, improved early warning systems, proper disaster preparedness and mitigation (Sonet, 2018).

Mass media could indulge in any stage of disaster risk reduction (DRR) cycle, starting from the pre-disaster phase to the preparedness phase, response, and immediate relief phase, finally ending in a post- disaster phase. Within a fraction of second, people around theworld are informed about the horrific news reports at their fingertips, communicated by various sources of the media at the speed of light. Immediately after a few moments of any disaster, public might have perceived the news and would anxiously be awaiting the updates and facts, from all the corners of theworld (An and Gower, 2009).

It is therefore clearly convincing that the mass media could effectively perform the bridging and channelling between people and other coordinating bodies along with NGOs and any other community level organizations in successfully dealing with disaster risk reduction cycle (Hardjosoekarto*et al*., 2013). Hence, by creating new insights regarding disasters and promoting the belief that mutual help and co-operation can bring down the adverse effects of disasters among the public, mass media has now become an inseparable part of disasters (Williams and Oliniranb, 2002). Moreover, a complete coordination and effective working relationship between media and disaster management organizations has to be established and well maintained for the fulfillment of disaster risk reduction roles of the media. Despite the sensitivity makes media into a subsidiary power of bases, it clearly focusses on the necessity of careful, and calculated planning toturn itself into a tool that enables the effective remedy to the problem insteadof making things worse (Taherian, 2009).

Technology in media

The two types of media that exists nowadays are electronic media and print media. Among the electronic media, radio and television are the most prominent players, whereas newspaper, magazines and journals form the integral components of the print media.

Technology plays a crucial role in the acquisition of information, analysis, forecasting as well as its dissemination. Newer advancement in information communication technologies (ICT) offer considerable improvement both in the prediction of sudden onset of disaster as well as dealing with its consequences. However, communication itself virtually underlines all elements of hazard mitigation. Nowadays, the capabilities of communications, data gathering and data management technology have leaped forward in parallel with our increasing knowledge in tracing out the origins and behavior of natural hazards as well as mitigation of these effects. In addition, recent advancements in the telecommunications and computer sciences are the major contributors for the recognition of the most appropriate technology which can significantly reduce the impacts of natural hazards.

The use of super computers along with the deployment of geosynchronous satellites for telecommunications and earth observation for the analysis of data gathered from space has led to the development of highly sophisticated models of tropical storm formation and providing earlier information for planning evacuations and hazard mitigation strategies. Moreover, the changes in the color of earth's surface can be effectively monitored by remote sensing, thereby enabling insect infestation. Similarly, seismological devices linked with super computers also provide updated knowledge about earthquake propagation. This updated information related to the anticipation of disasters will enable us in time to give early warnings to get prepared and plan mitigation strategies for various meteorological events (Dave, 2004).

Role of mass media:

1. **Providing early warning to people**: Electronic media like radio and television can provide early information about the likely disasters and could thereby save lives of human beings and livestock. Besides, the loss brought about to the property can also be minimized to a considerable extent. Indeed, it can also play a significant role in preparing the community by means of training and making them aware about do's and don'ts during disasters.
2. **As a watchdog on disaster machinery**: During the rehabilitation works of post-disaster, media plays the crucial role of a watch dog. In the present democratic set up, the pressure of media is tremendous, and it should be utilized in a constructive and responsible manner for the benefit of the society. The responsibility of supplying resources necessary for rehabilitation such as relief materials, search and rescue equipment and money lie with the government. Nevertheless, sometimes the system becomes lethargic, and all these responses takes some time to effect. Specifically, during these circumstances, media plays a vital role by continuous monitoring of rehabilitation works by being a watch dog and keeps the disaster machinery active.
3. **In creating an appeal to the people**: The responsive image of media in front of public can be effectively utilized for the generation of resources to help disaster management efforts. Additionally, the real pictorial depiction of miseries through the media acts as an eye opener to the people to come forward to render help in various ways.
4. **In the prevention of panic and rumors**: During the post-disaster period, with the complete breakdown of communications, rumors can have a negative impact on the relief work. By conveying the right information regarding the immediate measures to be taken, media can considerably reduce the spread of rumors.
5. **Facilitating the creation of early warning systems**: By providing information on the risks and existing technologies, media can help the disaster mitigation experts for the creation of early warning systems. Emergency Alert System (EAS) consisting of radio, television and cable network across USA for providing early warning prior to disasters is one such example.

6. **Aid prioritization of disaster risk issues**: By influencing the government in prioritization of disaster risk issues, it strictly ensures that the political interests are not emphasized at the expense of the wide population.
7. **Increase of international donations**: Media pushes the government to increase the budgetary allocations of disaster response programs. Additionally, the media invites international attention for donations subsequent to the disaster occurrence.
8. **Co-ordination of risk assessment activities**: Media can make a considerable improvement in co-ordination of risk assessment activities between policy makers and donor communities. The increased resource availability and improved work programs created as a result of integrated efforts pave the way for saving lives of vulnerable communities of affected population.
9. **Control of law-and-order situation**: The antisocial elements trying to take advantage of situations can be highlighted by the media. In addition, they can assist the law-and-order machinery in peace restoration and harmony of the affected community (Soltani, 2018)

Impacts of media

It is the media who informs the and highlights its awareness among the public. This awareness created by the media play a pivotal role in determining the plan of disaster management actions which is to be executed and level of attention that the relief agencies have to pay for it (Dave, 2004).

Positive effects of media

1. Trusted source of updated information
2. Continuous and factual coverage of events during and after disaster aids in evoking immediate response and decision making, thereby saving lives
3. Rapid dissemination of information regarding public safety at times of disaster
4. Gives a glimpse of affected communities to the outside world

Negative effects of media

1. Exaggeration of events and creation of unnecessary panic
2. Chances of bias due to manipulation of certain matters for personal or political gains
3. Biased coverage by irresponsible news reporters for purposeful sensationalism
4. Create chances of looting and lawlessness

Role of ICT tools for disaster risk reduction in Indian scenario

Disaster management and supporting IT infrastructure is firmly rooted at the state/local level in the Indian scenario. Being the responsible authority during the disaster events, it is the responsibility of the state government to provide most of the resources, infrastructure and personnel; majority of these ICT infrastructure would be used by the state government. In addition, the crucial role for facilitation of ICT infrastructure necessary for linking state-central and state-state government organizations along with standards and guideline protocols to be followed by each state is instituted by the national government. In fact, the ICT design, adoption and acquisition on pan- India basis for the purpose of disaster management is quite challenging due to the distributed responsibility of disaster management and geo-political diversities across the country within the Indian system (Dave, 2012).

The EOC network

The Government of India has integrated administrative strategy for disaster management at the national, state and sub-district levels.

At the event of disaster, the state government affords the basic responsibility of undertaking rescue, relief and rehabilitation measures. The efforts of state government are supplemented with the financial and logistic support. The departments of relief and rehabilitation handles the relief at the state level. These coordinated efforts have been restructured to form the State Disaster Management Authority (SDMA), which indulges in the relief and rehabilitation activities besides preparedness and mitigation. Moreover, the lead role in managing response during disasters goes to the administrative hierarchy of government revenue departments.

At the district level, the same system is followed by the district co-ordination and relief committee and the district magistrate would the major coordinating officer to coordinate these activities. The incident response system (IRS) guidelines issued by the NDMA recommends the network of emergency operation center (EOC) up to the district level in each state for ensuring seamless coordination, communication and collaboration activities during the disaster management cycle.

EOC is an offsite facility functioning from the National/State/District headquarters encompassing an augmented control room with data acquisition, analysis, compilation, risk assessment, video projections, and communication, alert and warning facilities to accommodate various ESFs. The EOC analyzes emerging situation and facilitate assessment, identification, mobilization and deployment of required resources. It is on the basis of EOC service requirements and geographical coverage considerations, the ICT infrastructure for emergency response and disaster management need to be planned and established.

GIS and decision support system

GIS and spatial data have characteristic role in preparing, detecting, responding and recovering from the natural as well as technological disasters (Amdahel, 2002). As the spatial data are major inputs for GIS and Emergency Response Modelling and Simulation Systems (ERMSS)s, in their absence the process of disaster management will be ineffective. Furthermore, with recent advancements in geomatic engineering and spatial data management incorporating information communication technology (ICT), with integration of Remote sensing, Geographical information services (GIS) and Global positioning system (GPS), the different phases of disaster management have undergone significant improvement (Dave, 2012).

Conclusions

The media plays a quintessential role in all stages of disaster management from before disaster to after disaster and during rebuilding efforts. For effective achievement of disaster management roles, a well-built institutional framework and close working relationship has to be established between the disaster management agencies and the media. It is necessary that the media as well as ICT tools should emphasize on the close linkages with disaster mitigation community and shares their information gathering and transmission resources with these organizations. In addition, media can educate people and increase the awareness among the public, leading to increased involvement of different parts of society and can also help use these new involvements in disaster risk reduction and minimizing its adverse effects. Taking the fact into consideration that the disasters can happen at any moment and anywhere, it is advised to make use of the mass media for improving the society's involvement in disaster management and its prevention or else help to lessen its adverse effects. Moreover, a new group of disaster correspondents, as a part of disaster journalism, can improve the supply of information about nature and high-tech hazards.

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WILDLIFE MONITORING AND MANAGEMENT USING REMOTE SENSING AND GIS

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Introduction

Mapping the wildlife and monitoring their habitats has long been one of the aims of Geospatial technology. Traditional methods of inventorying wildlife have always left some lacuna and hindered in providing a good database. The advent of remote sensing satellites has eased this labour intensive task by making use of satellite data which is measured remotely with sensors and cameras in different spatial, spectral and temporal resolution. Thus, this serves as the quickest possible method for inventorying and observing the natural resources. The advantage of remotely sensed data is that it provides synoptic, regular, near real time and quite accurate data which can be utilized by the wildlife managers for assessing the species-habitat relationship and how they are impacted by the environment (Keller et al., 2014). The latest satellite images provide with higher spatial, spectral and temporal resolutions which are now made available for free via USGS, NOAA and Copernicus portal (https://earthexplorer.usgs.gov/; https://www.copernicus.eu/en).Besides, availability of big data in cloud has made computations easier. One such platform is Global Forest Watch which is based on Google Earth Engine platform and makes use of Landsat data from the past 40years. It helps in analyses by indirect methods such as species occurrence indicators for example forest fragmentation (Riiters et al., 2014). The progress made in other technologies like in in situ sensors for example bioacoustics, tags and camera traps help in providing non – destructive and partially automated ground surveying opportunities (Lausch et al., 2016; Hansen et al., 2013). Animals are associated with their environments at different spatial and temporal scales, and they differ in having specific ranges. Animal locations on ground coupled with remote sensing data and its analysis in Geographic Information System (GIS) domain provides us with better results regarding their habitat and ranges and also their interaction with the environment. Thus, conservation policies can be benefitted from such technological solutions.

Learning Outcomes

- Wildlife Habitat Suitability analysis using remote sensing and GIS

- Some online interactive web applications like Map of Life, FIRECAST, Global Forest Watch and Half-life.

Before going further, I would like to introduce what is satellite remote sensing and GIS?

Remote sensing satellites

A satellite with remote sensors to observe the Earth and its features is called a remote-sensing satellite, or Earth observation satellite. They are characterized by their altitude, orbit and sensor. The data is available in various types of resolution; they are spectral, radiometric, spatial and temporal resolution. Resolution is defined as the ability of an entire remote-sensing system, including lens antennae, display, exposure, processing, and other factors, to render a sharply defined image.

1. **Spectral Resolution**: of a remote sensing instrument (sensor) is determined by the band-widths of the Electro-magnetic radiation of the channels used. High spectral resolution, thus, is achieved by narrow bandwidths width, collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth.
2. **Radiometric Resolution**: is determined by the number of discrete levels into which signals may be divided. Thus, it is a measure of how many grey levels are there between pure black and pure white. It is measured in bits, 7bit (0-127); 8bit (0-255); 9bit (0-511) and 10bit (0-1023). Examples: IRS -1A/1B (1988, 1991) measure images in 7 bits. Cartosat -2 (2007) produces images in 10-bit radiometric resolution.16-bit images are obtained from IRS -P3 (1996) MOS –A, MOS –B and MOS – C.
3. **Spatial Resolution**: in terms of the geometric properties of the imaging system, is usually described as the instantaneous field of view (IFOV) that is defined as the maximum angle of view in which a sensor can effectively detect electro-magnetic energy.

   4. **Temporal Resolution**: is related to the repetitive coverage of the ground by the remote sensing system. For example, the temporal resolution of Landsat 4/5 is sixteen days.

Remote Sensing science and application can be summarized in the following segments: 1) Source of electromagnetic energy (sun, transmitter carried by the sensor) 2) Transmission of energy from the source to the surface of the earth and its interaction with the intervening atmosphere 3) Interaction of energy with the earth surface 4) Transmission of the reflected/emitted energy to the remote sensor placed on suitable platform 5) Detection of the energy by the sensor converting into photographic image or electrical output 6) Transmission/recording of the sensor output 7) Preprocessing of the data for generation of data products 8) Collection of ground truth and other collateral information and 9) Data processing and interpretation.

Geographic Information System

The main components involved are computer software and hardware systems for creating, managing, manipulating, evaluating, condensing, and displaying spatial data. Many GIS packages represent geographic features in the form of points, lines and polygons. This format is known as vector as illustrated by points, lines and polygons which are connected to each other by vectors (directional line segments). Each feature in GIS database has its own identity and is associated with its coordinates and attributes. It is capable of querying and answering searches based on one's interests. The biggest advantage of GIS is that it integrates various thematic layers and finally displays as a single map for better comprehension and visualization.

Google Earth Engine

The problem of big data management was overcome by the Google Earth Engine which goes a long way in providing solutions within a smaller time frame. Large datasets can be used from local to regional levels, reduced the computation time. A repository of coves written in Javascript helps the researchers to utilize them with proficiency even though not being a professional. Active online support of developers is also commendable. The limitations of desktop computing are overcome, the major role is played by Application Programming Interface (API) and a web based Interactive Development Environment (IDE) (Tamiminia, 2020). The time series analysis (Time-lapse of GEE) and Climate Engine App helps in monitoring temporal changes.

Wildlife Habitat Suitability

Traditional methods and ground based studies have been employed in studying wildlife habitat and corridor use (Bhat and Rawat 1995, Johnsingh and Joshua 1994, Mishra and Johnsingh 1996). They are time consuming and inefficient in hilly and inaccessible areas. Studies in wildlife using geospatial technology have been gaining importance since the past few decades in India and have emphasized its role in habitat evaluation, identification and management of wildlife corridors (Khanna et al. 2001, Kushwaha and Hazarika 2004, Nandy et al. 2007).

From the conservation point of view, if wildlife habitats are known those areas can be protected and conserved from degradation and destruction. GIS platform helps in modelling wherein various parameters are included like water, land use and land cover, forests, roads, railways, streams, drainage and slope. Various criteria are decided by the researcher/analyst based on literature and ground knowledge. All the thematic layers are combined using weighted overlay technique in GIS is used to derive a suitability map. Species distribution models are prepared using various data, which identify other regions with similar environment conditions which can be potential habitat for a specific species. Such models use raster based layers such as land use/land cover and other above mentioned layers. This data is then combined with ground based information and statistical computations which predict the suitability and potentiality of the habitat (Goparaju et al., 2017; Ahmad et al., 2018).

Map of Life: Putting Biodiversity on the Map.

Utilizing various sources of data which describe species distribution worldwide, The Map of Life plays a major role in integrating them. Various organizations like International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF), Global Biodiversity Information Facility (GBIF) have provided data like expert species range maps, species occurrence points, ecoregions, and protected areas which have been put together into a cloud platform where the data is stored, managed, backed up and also can be accessed. Thus, one of the target areas where Map of Life is focusing is “the best – possible” species range information and species list for any geographic area. Besides, by accumulating a wide range of knowledge about species distributions and their dynamic state over a period of time, it also aims to support effective global biodiversity education, research and monitoring and guiding decision support system for policy makers.

MoL (https://mol.org/) provides

- Information on Species range and species list for any geographic area on Earth.
- There are multiple tools to assist in exploring species habitat and trends in biodiversity.
- There is also a Mobile App which can be used for discovering, identifying and recording biodiversity.

- https://www.gbif.org/ GBIF provides free and open access to data regarding all type of lifeform throughout the world.

Forest health assessment: Web based systems like Fire Information for Resource Management System (FIRMS) and FIRECAST

This is a web-based platform which disseminates Near Real Time active fire data within 3 hours of satellite overpass. It also generates web-based fire maps, email alerts and also has provision for active fire data download (SHP, TXT, and KML). FIRECAST utilizes satellite data observations to track ecosystem disturbances such as fires, fire risk conditions, deforestation and protected area encroachment, and ensure the details are delivered to decision makers via E-mail alerts, maps and reports. It also detects active fires (MODIS AND VIIRS), satellite-based weather conditions are also studied (https://firecast.conservation.org).

GLOBAL FOREST WATCH (https://www.globalforestwatch.org/)

The best available data about forests is available for free on Global Forest Watch Platform. Global Forest Watch (GFW) is an online platform that provides satellite data and other tools for monitoring forests. Alerts informed via E-mails and community participation has help governments and companies accountable for illegal activities. It was launched in 2014, its aim for to provide transparent data and scientific information about the forests to preserve them and decimate deforestation. GFW is free and user friendly, enabling anyone to create customized maps, analyze the changes in forest and study the trends from local to regional scale, subscribe to alerts, or download data for their local area or the entire world. Users can also contribute to GFW by sharing data and stories from the ground via GFW's crowdsourcing tools, blogs, and discussion groups.

Half – Earth Project: (https://www.half-earthproject.org/)

This is a combined initiative of ESRI and Sir E. O. Wilson's Biodiversity Foundation which aims to conserve half the earth's lands and seas in order to protect 85 percent or more of the planet's biodiversity to reverse the current species extinction crisis. According to Wilson, out of the 10million species present on the earth, only 2 million have been successfully documented. They have introduced the concept of National Report cards which will evaluate countries based on conservation efforts taken by them. It is expected that this innovative way will help theEarth restore back its green cover and could save many more species.

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INNOVATIVE SOLUTION OF VECTOR, DISEASE SURVEILLANCE, MONITORING & ENHANCING CURRENT STRATEGIES OF INTERVENTIONS

Satish Cherukumalli

Co-Founder; CEO

Technology Background

Mosquito sensor system is based on multiple classification rules to separate mosquitoes from other flying insects. It is widely known that mosquitoes can be identified by measuring their wing beat frequency (Batista, G *et al*., 2011; Chen, Y *et al*., 2014). The use of sound to detect and classify flying insects was first reported in the literature from work done at Cornell University in 1945. Since then, many other researchers (see references below) have shown that the wing beat frequency can be used as one of the parameters to classify the flying insect. In fact, wing beat frequency alone can yield 75% to 85% accuracy from other insect populations. If wing beat frequency is converted from the time domain to the frequency domain, then increased accuracy can be obtained. Work at Iowa State University (Raman, D *et al.,* 2007) and at the University of California, Riverside has been instrumental in developing algorithms that a can be used in the accurate classification of flying insects using relatively inexpensive sensors and be light weight enough so the computations can be done by the sensors' microcontroller. Previously mosquito classification devices, such as the device developed by NASA (NASA Tech. Briefs., 2007) made use of an on-sight computer and expensive hardware and software from NI Labview or MatLab. Our sensor makes use of a lightweight transform and probability algorithms to carry out most of the classification at the sensor level before sending the data to our cloud-based server.

Wing beat frequency will be measured by the disturbance of light on a phototransistor array as a mosquito enters the target zone of the sensor. Large flying insects will be prohibited from entering the zone by a 7 mm screen. Light is emitted from a constant light source. This light is reflected back onto phototransistors. Any disturbance of the light on the phototransistors is detected as a change in the current from the transistors (Unwin, D.M and Ellington, C.P., 1979).

Our sensor system uses several other measures for classification of mosquitoes. It makes use of the time of intercept and classifies on the basis of the known differences in circadian rhythm. It is known for instance that the circadian rhythm for the Aedes mosquito is different from the anopheles mosquito. The frequency spectrum for the Aedes and the Culex mosquito genus has significant overlap. As a result, frequency alone is not as accurate as needed. If the time of intercept is in the morning the *AedesAegypti*may be distinguished from the Culex. In the evening however, the *CulexPipien* and the *Aedes Detritus* are both active. By combining both the frequency spectrum and the time of intercept, the probability accuracies are increased (Kim, D *et al*., 2021).

The system also makes use of location of intercept. Different genus and species are found in different locations. By adding just these three factors in classification, accuracy can be improved beyond 95%. Location of intercept initially is based on what is known about the types of mosquitoes in the area. As data is collected for area or even a sensor location, the accuracy can be increased based on the continually expanding history. Although the frequency of the Aedes and Culex genus has significant overlap, the central tendency for the one is higher than for the other. This can shift the weighting of the frequency based on the specific sensors' location and history. Another obvious location factor is the terrain. Some mosquitoes are more prevalent in urban areas and others are more prevalent near water.

Coloration, light, sound and location will be used to help attract mosquitoes to the sensors. It is important to realize for any given sensor in a specific location, the data collected prior to and after vector control measures can be compared. The comparison can be made as a repeated measure on a particular sensor as well as across numerous sensors in a specified area of concern.

Solution:

Moskeet solution is a Smart Mosquito Diseases Control System that uses state-of-the-art sensors (IoT) and Artificial Intelligence (AI) technology to operate autonomously and provides real-time mosquito population data both by location and species. We believe that you must understand the problem before you solve it, and our network does just that. There are four key components to the solution - Sensor network, Social network, Real-time analytics, and Predictive analytics. The network of sensors (traps) across the communities identifies where problems exist, the efficacy of control methods, and when to reapply. Moskeet sensors use novel artificial intelligence (AI) algorithms to classify mosquitoes. The application provides density heat maps, conditions affecting breeding, health information, and vector control history. The platform is designed to capture data across several areas like epidemiology, entomology, human population, socioeconomic conditions, location, and the weather to help in the effective management of diseases. Using advanced assays and RT-

LAMP to identify disease-related RNA in mosquito saliva, we can pinpoint the most urgent areas and the type of vector control needed to reduce disease.

Moskeet platform integrates several stakeholders like citizens, governments, pest control and pesticide companies, hospitals, research agencies, foundations etc., to share and consume real-time data to promote efficient & transparent vector & disease control operations. TrakitNow's approach is to disrupt the Health Security sector by shifting the focus to "prevention" from "treatment" using deep technologies – AI (Artificial Intelligence) and Sensors (IoT – Internet of Things).

Moskeet platform provides situational awareness through its "always on", surveillance of mosquito population count, species make-up, and disease pressure showing the effectiveness of control measures against the vectors of infectious mosquito-borne disease. By providing historical, current, and predictive data, it allows agencies to make data-driven decisions as to what efforts are working, what efforts need to be improved, and where/when more effort is required. Getting mosquito-borne diseases under control and monitoring for potentially new diseases by exclusion requires a unified view shared across multiple activities with multiple agencies. Our system allows such a view, scalable to add new relevant data from emerging sources and to be analyzed with the latest AI and analytical tools including result graphing and geospatial mapping.

Impact:

The activity of collecting species-specific population data provides an output showing the increase or decrease the potential of the vector which is used to determine if the vector control methods are working and how efficiently. Another outcome of this activity is determining when reapplication is required, whether the application is being appropriately applied or the population is becoming resistant to pesticides.

The activity of determining the viral or parasitic load present at a given location provides an output showing where vector control needs are critical to curtailing outbreaks. The outcome of further control can lead to alerting the health community to take steps to reduce the disease potential by working with the potentially affected population of mitigating steps they can take. The activity of combining all known relevant data into a unified, holistic view provides the output of actionable data which can lead to an outcome of better understanding the impact of the vector control activities, leading to revising their strategies and focusing their resources more effectively. These outcomes can all lead to a long-term goal in the reduction of mosquito-borne disease and reduce the physical, emotional, and economic impact thereof.

Surveillance is borne on the premise that control requires being able to observe and then measure the targeted event. Our system provides the ability of stakeholders to observe and measure the effectiveness of their control activities on several levels of disease prevention.

Patents:

World Intellectual Property Organization International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

- Pub. No .: **US 2020/0245604 A1**
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Discussion:

Moskeet's major benefit is to reduce the disease burden. A single disease occurrence in a family can push it into poverty and force the kids to stop school and go to work. Other key benefits include lowering the cost of control operations, reduce pesticide usage thereby reducing the impact of pesticides on the environment, facilitate awareness campaigns and reduce the health care costs at public and family levels. Data generated across the public and private is also shared with leading pest control & pest repellent companies. This approach helps to sustain and expand the platform thereby reaching out to a large percentage of the population. This in turn helps us to be cost-effective and provide better strategic value to customers. Our data from our initial deployments indicated the following trends,

1) Improve pesticide effectiveness
2) Reduce pesticide usage
3) Reduce operational costs
4) Lower disease burden
5) Reduction in mosquito populations

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INDIAN NETWORK OF FISHERIES AND ANIMAL ANTIMICROBIAL RESISTANCE (INFAAR)- UNDERTAKING SURVEILLANCE OF AMR IN ANIMAL HEALTH SECTOR

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"Antimicrobial resistance (AMR) is a global threat to health, livelihoods and the achievement of the Sustainable Development Goals (SDG)," the statement by UN Secretary Generalduring May 2019 in relation to SDG Goal 3 "Good Health and Wellbeing" (https://undocs.org/en/A/73/869) was enough to raise alarm bells of shift in human pathogen interactions. World Health Organization has called AMRas one of the most important public health threats of the 21st century. Currently, death of 700,000 people per annum is linked to AMR and is estimated to rise to10 million annual deaths by 2050[1]. The AMR is projected to cause $100 trillion loss to global economy by 2050 which is equivalent to 3.5% reduction in global GDP[1]. In May 2015, the sixty-eighth World Health Assembly endorsed the Global Action Plan on AMR (https://apps.who.int/gb/ebwha/pdf_files/WHA68-REC1/A68_R1_REC1-en.pdf#page=27). India responded with a National Action Plan (NAP) on AMR which was launched by Ministry of Health and Family Welfare in 2017 (https://www.ncdc.gov.in/WriteReadData/linkimages/AMR/File645.pdf).

Antimicrobial resistance (AMR) is the ability of micro-organisms to resist the effects of antimicrobials. AMR can occur naturally as all microbes can adapt to their surrounding environment. However, AMR is increasing by inappropriate and excessive use of antimicrobials in both human healthcare and the animal sector. In 2014, India was the highest consumer of antibiotics in human sector, followed by China and the United States (Reference and please recheck if it is highest quantity used or number of doses). India was the fifth largest consumer of antibiotics in food animals in 2010. Antibiotic consumption is projected to grow by 312%, making India the fourth-largest consumer of antibiotics in food animals by 2030[2].

Antimicrobials are used in animal production practices to manage animal and fish health, and also as growth promoters at a sub-therapeutic level. In recent decades, the intensification of animal production due to the increasing demand for animal protein has led to an increasing overall use of antimicrobials. AMR makes disease treatments ineffective, increase severity of disease, reduces productivity and leads to economic losses. In addition, more than half the quantity of antimicrobials used in animals/fish are excreted in waste contaminating soil, water and the environment. This also contributes to the emergence and spread of AMR through selection pressure on pathogens in environment. Besides, antimicrobials residues can be present in animal/fish products which also increases public health risks.

Currently, there is limited data available on AMR in livestock and aquaculture sector in India, which is based on individual studies with limited geographical coverage, samples and questionable quality. Thus, it is important to quantify the burden of AMR in food producing animals and aquaculture through structured surveillance with pan India coverage. Implementation of a systematic approach to generate AMR data has been initiated through forging and operationalization of the Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR) is aimed to document antibiotic resistance levels in different production systems, describe the spread of resistant bacterial strains and resistance genes, identify trends in resistance and generate hypotheses about sources and reservoirs of resistant bacteria. The crucial data emerging on spatial level will be input to formulate strategies and policies to prevent and reduce the spread of AMR in farmed animals and fish and subsequently to human population.

INFAAR is a technical collaboration program between Indian Council of Agricultural Research (ICAR) and Food and Agricultural Organization (FAO) since August, 2018 with financial support from the ICAR, State agriculture Universities and the USAID. In INFAAR network, ICAR-NBFGR, Lucknow, is the leading institute for Fisheries and ICAR-IVRI, Bareilly for Animal Science. To assure maximum national coverage, INFAAR is being operationalized through 21 centers (18 ICAR and 3 State agriculture Universities) with 8 partners from fisheries and 13 from livestock sector. The INFAAR envisions to (i) undertake surveillance of antimicrobial resistance (AMR) in target microorganisms isolated from healthy farmed animals and fish/shellfish with an aim to quantify its burden and monitor the spatial and temporal trends of AMR in India. (ii) improve awareness and understanding of AMR among the farming community, veterinary and fish health professionals and policy makers, through effective communication, education and training so as to promote judicious use of antimicrobials in farmed food animals and fish.

The priority microorganisms identified under fisheries component of INFAAR are *E. coli*, *Staphylococcus aureus*, other Coagulase negative *Staphylococcus* species (CONS) and *Aeromonas* species in farmed freshwater fish; and *E. coli*, *S. aureus*, CONS and *Vibrio* species including *Vibrio parahemolyticus* in farmed shrimps and cage cultured marine fish.

Standard operating procedures (SOP) for isolation, identification and antibiotic sensitivity testing (AST) of microorganisms for fisheries sector has been developed for use by partners[3]. A field-based questionnaire is used to survey of farms to establish link between AMR data and actual use of antibiotic in culture practices. The results are analysed using internationally accepted WHONET software.

The issue of AMR also needs to be addressed by raising awareness amongst all stakeholders and especially farmers and industries on AMR and by implementing good practices to reduce the need for antimicrobials. Every year INFAAR creates awareness on "judicious use of antibiotics" among public focusing on farmers, students, school children, especially during "World Antibiotics Awareness Week" celebrated between 18-24th November in different parts of the country and world. INFAAR has launched a dedicated website (www.infaar.icar.gov.in), which provides the latest information on AMR in the country specifically on policy meetings, trainings, and other activities related to INFAAR its SOP, as well as recent and forthcoming activities of INFAAR.

The functioning and the activities of INFAAR are being regularly guided and reviewed, twice a year, by the INFAAR Advisory Board established by the Government of India.

The INFAAR is working towards safe food production for human consumption without the risk of transmitting AMR to humans through food production cycle. Safe food production without AMR risk will promote healthier human and animal health; and clean environment. The data generated by INFAAR will lead to identification of strategies to prevent and reduce the development and spread of AMR in aquaculture and food animals. Successful implementation of the program will be a key component of National Action Plan on AMR for protection of human health, animal health and food safety in India.

ONE HEALTH APPROACH AND REGIONAL DISEASE SURVEILLANCE NETWORKS

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The One Health (OH) approach is about collaboration between the different sectors such as human medicine, veterinary medicine, and environmental sciences. The world is experiencing increasing interaction of people and domestic animals in the last few years that led to events of emerging and re-emerging infectious diseases. Zoonotic diseases have always been, and are still today, a major burden for human and animal populations (Morens *et al*., 2004). This burden is particularly high in low middle income countries (Molyneux *et al*., 2011), and India is considered as the hot spot for many infectious diseases (Kessler and Peterson, 2008). Understanding the ecology of zoonotic diseases at the human–animal interface is a complex challenge. Furthermore, increasing incidence of antimicrobial resistance (AMR) has been recognized as a serious public health and animal health threat. The challenges of EIDs and AMR require a One Health approach that supports a holistic, multisectoral, coordinated and collaborative network. The international organizations such as WHO, FAO, OIE (under Tripartite agreement), and other international non-governmental organizations (NGOs) such as Rockefeller Foundation, the SGTF and the Bill and Melinda Gates Foundation, amongst others have been supporting One Health approach and establishment of regional networks for early detection and sharing of information, and responding to outbreaks in a coordinated and collective manner by multiple countries.

Animals can be used as surveillance tools for monitoring naturally occurring environmental & human health hazards. They are ideal surveillance tools because they share the same environment as humans & spend more time outdoors than humans increasing their exposure risk. Identifying the biological and environmental factors that cause interspecies pathogen leaps to predict the future zoonotic outbreaks has so far been cumbersome. But even with growing understanding of pathogen behaviour along with data pointing to regions where spillover might occur, precise outbreak predictions cannot be guaranteed. Connecting Organizations for Regional Disease Surveillance (CORDS) is an international non-governmental organization focused on information exchange between disease surveillance networks in different areas of the world. By linking regional disease surveillance networks, CORDS, an umbrella network organization based in France, builds a trust-based social fabric of experts who share best practices, surveillance tools and strategies, training courses, and innovations. CORDS exemplifies the shifting patterns of international collaboration needed to prevent, detect, and counter all types of biological dangers – not just naturally occurring infectious diseases, but also terrorist threats. Representing a network-of-networks approach, the mission of CORDS is to link regional disease surveillance networks to improve global capacity to respond to infectious diseases. The regional networks (Southeast Asia, East Africa, South East Europe, Southern Africa, and Middle East) were created in many regions of the worlds

The One Health approach

COVID-19 is one of the baleful pandemic the world had ever witnessed. The continued emergence and re-emergence of zoonoses point to the need for changes in the disease monitoring and management systems and the best solution is adopting one health approach. In 2010, recognizing the need for multidisciplinary collaboration to address health threats at the human–animal–ecosystem interface, the FAO-WHO-OIE formalized their collaboration and identified zoonotic diseases as a priority area to collaborate (OIE, 2017). The success of One Health approaches was reported in many instances such as, controlling Cysticercosis in Portugal (Fonseca *et al.,* 2018), Rabies in the Serengeti ecosystem (Cleavelandet *al.,* 2003), Brucellosis in Mongolia (McDermott *et al.,* 2013) and Malta (Buttigieg*et al.,* 2018), West Nile in Northern Italy (Paternoster *et al*., 2017). In consonance with IHR (2005), One Health approach has been advocated by the WHO, FAO and OIE for combating health threats to humans and animals and a tripartite agreement between these three organizations has been in vogue since 2010 to apply One Health approach (WHO, 2017; OIE, 2017) . The essence of One Health approach is that the actions are more strategically and collaboratively planned rather than having a reactive approach. A close networking between veterinary and medical laboratories and professionals at different levels has to be developed, along with sociologist, epidemiologists, environmentalists and climatologists. All the concerned professionals must become part of Rapid Response force to investigate epidemics of zoonoses and to formulate and enforce control strategies. The inter-faces that exist between man, livestock, wildlife, and environment are recognized as the hotspot for emerging infectious diseases. Such hotspot is considered as multifaceted problem zone that calls for multifaceted solutions where no one particular discipline can act wisely to control such threats (Prejit, 2017). We need to break the silos and plan a joint strategy by integrating ideas of the connections among humans, animals and ecosystems within the political, economic and social systems in which they operate. A clear advantage of One Health is that interventions in animal populations can result in public health and societal benefits more cost-effectively than just interventions in humans (Prejit, 2017).

Regional Disease Surveillance networks

The Asia-Pacific Strategy for Emerging Diseases (APSED) develops Member State and regional surveillance and response capacity through a policy of intersectoral collaboration and coordination, with FAO and OIE, for detection and control of zoonotic disease emerging at the human/animal/ecosystem interface. Some of the active regional disease surveillance networks includes, ***The Mekong Basin Disease Surveillance network (MBDS)***(established in 2003)comprised of Cambodia, Southern China, Lao PDR, Myanmar, Thailand, and Vietnam, coordinates efforts to mitigate H5N1, cholera, and Dengue Hemorrhagic Fever, and to develop joint strategies for containing disease in the region. *M**iddle East Consortium on Infectious Disease Surveillance (MECIDS)*** (established in 1999) is a disease surveillance network made up of public health experts and ministry of health officials from Israel, the Palestinian Authority, and Jordan. This group has had success in finding common ground across borders in conflict and has acted together to meet disease threats, including 2009 H1N1 influenza. ***The Southern African Centre for Disease Surveillance (SACIDS)*** (established in 2009)includes diseaseexperts from Tanzania, Mozambique, Zambia, Democratic Republic of Congo, and South Africa, works to improve the capacity of African institutions to detect, identify, and monitor infectious diseases affecting humans and animals, including new infectious diseases of animal origin. The network has partnered with a number of institutions, includingSokoine University of Agriculture (SUA), the Royal Veterinary College, and the London School of Hygiene and Tropical Medicine, to create an interdisciplinary network that embodies the One Health approach for collaboration between human and animal health sectors. ***The East African Integrated Disease Surveillance Network (EAIDSNet)*** (established in 2000)is a regional, inter-governmental collaborative initiative of the national ministries responsible for humanand animal health as well as the national health research and academic institutions of the five East African Community Partner States, namely the Republic of Burundi, the Republic of Kenya, the Republic of Rwanda, the Republic of Uganda, and the United Republic of Tanzania. The main objectives of EAIDSNet are to: (1) enhance and strengthen cross-country and cross-institutional collaboration through regional coordination of activities for the prevention and control of both human and animal diseases under the One Health Initiative; (2) promote exchange and dissemination of appropriate information; (3) harmonize integrated disease surveillance systems in the region; (4) strengthen capacity for implementing integrated disease surveillance and control activities; and (5) ensure continuous exchange of expertise and best practices for integrated disease surveillance and response (CORDS.2011)

Conclusion

Although we face many outbreaks of emerging zoonoses, it is also true that the world has made significant strides in tackling major public health challenges over the last several decades. One of the reasons are the collaboration among stakeholders between different disciplines, efficient and timely conveyance of information to various strata associated with disease control, and imparting proper training to public health workers and susceptible population. Effective surveillance and timely multidisciplinary action should be coupled with education and research for shackling emerging and re-emerging zoonoses. This is possible by certain strong networks that work in an One Health mode like CORDS, which unites regional disease surveillance networks from critical hotspots around the world to promote exchanges of best practices in surveillance and catalyze innovation in early disease detection. Such collaborative surveillance unit cultivates networks of professionals who have the collective strength to translate information into near-real-time action during emergency situations. The need for innovations and more effective scale-up of existing ICT tools is required so that we can control many of the emerging diseases.

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PROSPECTS OF TELEMEDICINE IN VETERINARY PRACTICE

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World Health Organisation defines telemedicine as the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities. While telehealth is defined as the delivery and facilitation of health and health-relatedservices including medical care, health information services and self care via telecommunications and digital communication technologies.

Tele veterinary medicine can be defined as extension of veterinary medical service to a remote location, using information and communication technologies. In general, the term tele veterinary medicine can be used to denote veterinary clinical services delivered by a registered veterinary practitioner while the term tele veterinary health can be used to denote use of technology for delivery of veterinary health and health related services including tele veterinary medicine. The registered veterinary practitioner or specialist may use any telemedicine tool suitable for carrying out technology-based consultation eg. telephone,video, devices connected over LAN, WAN, Internet, mobile or landline phones, chat platforms like WhatsApp, Facebook Messenger, etc., or Internet based digital platforms for telemedicine or data transmission systems like Skype/email/fax etc. irrespective of the tool of communication used, the core principles of tele veterinary medicine practice remain the same.

Let us divide Telemedicine in Veterinary practice into

Real-time telemedicine - Here, the consulting veterinary expert or specialist will see and discuss the case real-time with the referring veterinarian.

Store-and-forward telemedicine - Here, electronically stored information related to a case is forwarded to a consultant who reviews the case later.

A variant of the above two where the electronically stored information related to a case is sent to a specialist and the referring vet discuss the same with the specialist over telephone for getting the interpretation of the case and for decision making.

Few disciplines where Telemedicine can be practised in Veterinary are

1. Tele radiology
2. Tele ultrasonography
3. Tele ECG
4. Tele pathology
5. Tele ophthalmology
6. Tele cytology
7. Tele dermatology
8. Tele endoscopy
9. Tele-guided surgery

The prospects of this emerging field in veterinary practice are plenty. The paper describes a basic knowhow, possibilities and challenges of telemedicine in veterinary practice, along with experience of tele-guiding few surgeries abroad for correction of challenging surgical conditions in puppies.

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