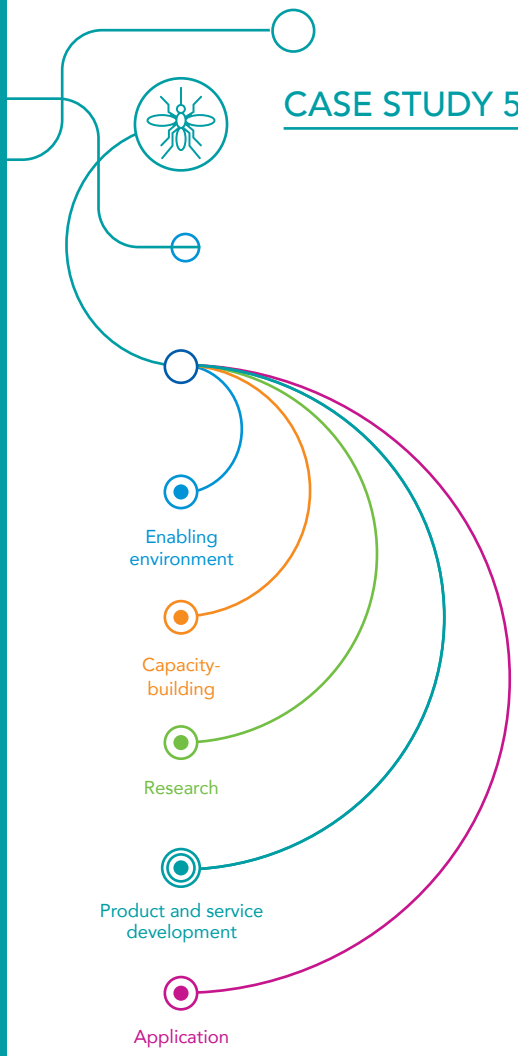

CASE STUDY 5C

MONITORING SYSTEMS AND INTEGRATED SURVEILLANCE

EPIDEMIA: INTEGRATING CLIMATE INFORMATION AND DISEASE SURVEILLANCE FOR MALARIA EPIDEMIC FORECASTING IN ETHIOPIA

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CONTEXT

Malaria epidemics can occur in highland areas of Ethiopia that support unstable transmission, such as the Amhara region. Forecasting the timing and locations of malaria epidemics can facilitate the targeting of resources for prevention, control and treatment. However, these forecasts must be accurate so that real outbreaks are not missed and resources are not wasted responding to predicted outbreaks that do not occur. Beginning in 2009, researchers from South Dakota State University (SDSU), in collaboration with the Health, Development and Anti-Malaria Association (HDAMA) the Amhara Regional Health Bureau (ARHB), and other partner organizations, have conducted research toward malaria early warning in the Ethiopian highlands. Through this work, climatic and landscape determinants of malaria have been identified *(17,18)*. A key lesson learned from this initial research was the importance of linking early warning systems based on climate data from earth-observing satellites with early detection of malaria epidemics based on epidemiological surveillance to generate integrated forecasts *(19,20)*. However, the potential for combining these approaches has been hindered by a dearth of established techniques and available tools. In response to this need, we have developed the Epidemic Prognosis Incorporating Disease and Environmental Monitoring for Integrated Assessment (EPIDEMIA) computer system (*21*).

Figure 5.6 Conceptual diagram of information flow through the EPIDEMIA system (Merkord et al. 2017).

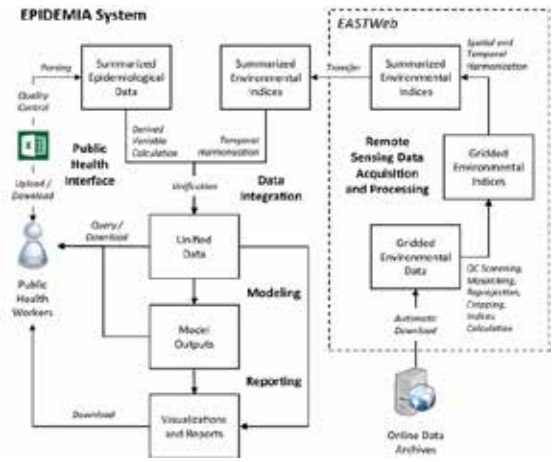
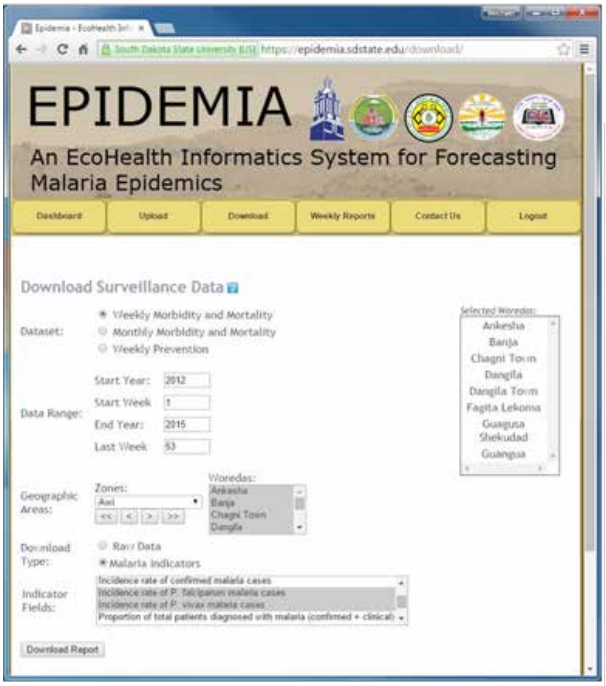
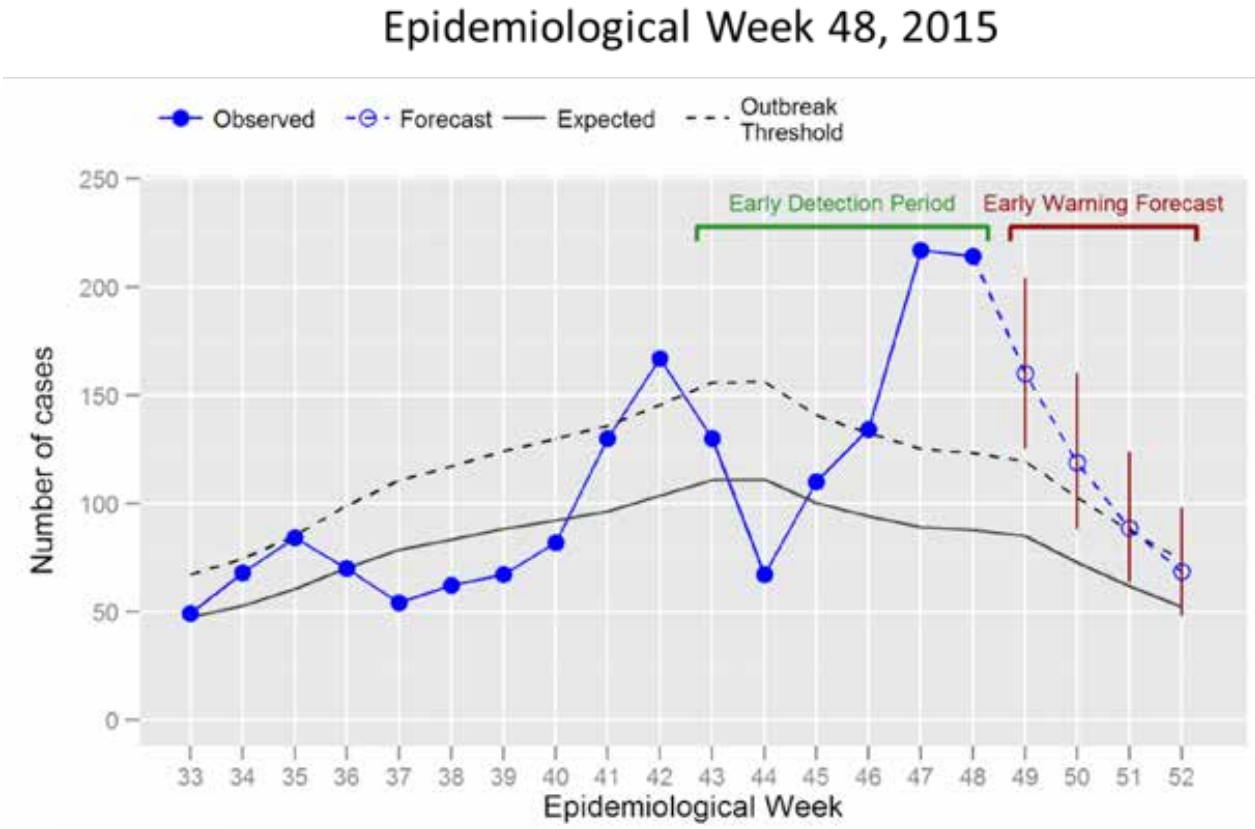
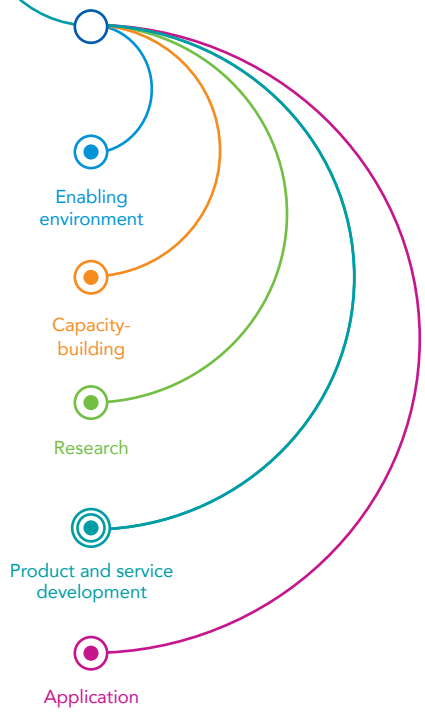


Figure 5.7 EPIDEMIA public health interface and an example malaria forecasting chart from a weekly report produced on epidemiological week 48 in 2015.





CASE STUDY 5C



NEW APPROACHES

The main goal of EPIDEMIA is to enable forecasting and rapid detection of malaria epidemics by allowing scientists and practitioners to share relevant information in real time via a web-based data processing and modelling system with a user interface targeted to the specific needs of the public health community. The core of the EPIDEMIA system consists of environmental and epidemiological databases that are linked through a data integration sub-system. Surveillance data are uploaded through a public health user interface, and climate data are continually acquired from online earth science archives. A forecasting sub-system implements data assimilation methods that account for climatic anomalies as well as recent trends in malaria indicators. The public health interface supports interactive queries and dissemination of reports, maps, forecasts and epidemic alerts (Figure 5.7). Specific alert thresholds and indicators have been developed in collaboration with public health stakeholders. Accuracy of predictions is being evaluated continuously by validating forecasts with newly-acquired surveillance data, and system usability and adequacy of outputs for decision-making is being assessed through surveys and interviews of system users.

Weekly surveillance data on malaria morbidity and public health interventions are collected from district health facilities by the ARHB, and satellite remote sensing data provide climatic observations at relatively fine temporal resolutions (hourly to weekly) and moderate spatial resolutions (1–25 kilometres). Specific products include rainfall data from the Tropical Rainfall Measuring Mission, temperature and vegetation indices from the MODIS sensor, and actual evapotranspiration modeled using a simplified surface energy balance approach. These environmental data are processed using the EASTWeb software application, which was developed to automatically acquire new data from online repositories. The data are used to fit dynamic linear models that provide outbreak detection thresholds and forecast malaria incidence for four weeks into the future.

An initial workshop was held in July 2014 to develop a design for the EPIDEMIA system, with participation by representatives of SDSU, ARHB, GAMBY, and HDAMA. The workshop included a formal requirements analysis to elucidate a list of baseline features for the public health interface, and a subsequent evaluation training and evaluation workshop was held in March 2015 after the the public health interface was implemented. The EPIDEMIA system began producing weekly forecasting reports in September 2015, and another workshop was held in February 2016 to obtain feedback on the malaria forecasts and alerts.

ACKNOWLEDGEMENTS

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Figure 5.8 Irrigation ditches provide breeding sites for malaria vectors. Photo credit: M. Wimberly/2009.

BENEFITS AND LESSONS

We are currently testing the effectiveness of the EPIDEMIA system by implementing it across a network of 30 sentinel districts in the Amhara region. Local institutions of higher education are being engaged to facilitate transfer of knowledge and technology to the public health community in Ethiopia. This innovative translational bioinformatics approach allows assessment of the practical effectiveness of the tools as they are developed and use of feedback from the public health community to upgrade and improve the technologies throughout the project. Major benefits of the project have included the improvement of malaria outbreak detection and forecasting techniques, the development of new graphical techniques for presenting data and forecasts based on feedback from end users, and increased understanding among public health partners of the linkages between climatic variations and malaria outbreaks. Key lessons include the value of automated data processing and report generation tools to ensure that forecasts can be delivered in a timely manner, and the importance of accurately documenting user requirements to ensure that the data products and forecasts can be applied for public health decision support.