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Mapping of Zoonotic Diseases in South Caucasus

Tamar Chichinadze[1,*], Zaza Gulashvili[1], Nikoloz Suknidze[1] Nana Bolashvili[1]

[1] TSU, Vakhushti Bagrationi Institute of Geography, Tbilisi, Georgia

* Corresponding author: tamar.chichinadze@tsu.ge

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Abstract

The presented article relates to geographical studies of the distribution of seven rare animal infections in the South Caucasus, digital mapping and geographic and cartographic analysis. The study focuses on mapping infections that are transmitted from animal to animal, from animal to human, and rarely from human to human. All diseases have a cause of spread (bacteria, insects, ticks, fleas) or transmission (mammals, rodents). Sometimes the provoking factor of disease and infection is a geographical variable favorable for bacteria (high temperature, humidity, flood, wind, runoff), favorable for bacteria (soil type, acidity or chemical composition of the soil, orography, perspective, landscape), etc. This article focuses on the process and methodology of digital mapping as digital mapping establishes the relationship between geographic variables and the spread of infections. Digital maps are also the main means of conducting dynamic research, analysis and further forecasting.

Keywords: Mapping, Geodata, Infection, Cartography, GIS Analysis

Introduction

The study area is the South Caucasus, located between the Black and Caspian Seas. The South Caucasus is bordered by the Russian Federation to the north, the Caspian Sea to the east, Iran and Turkey to the south, and the Black Sea to the west. Politically, it includes three independent states - Armenia, Azerbaijan and Georgia (Maruashvili, 1978).

There is a lot of different nature in the South Caucasus because of its location: it covers 190,000 km², its hypsometric height (the absolute height of the surface ranges from -28 m above the Caspian Sea to 5,208 m in Shkhara, Georgia) and its position on the border between temperate and subtropical climate zones (because it is mostly mountainous, it is also known as altitudinal climate zonality).

High mountains and plateaus occupy more than half of the South Caucasus' territory. The main orographic units are the Caucasus, the Transcaucasian Plain, the Lesser Caucasus, the Talysh Mountains, and the volcanic mountains of the South Caucasus. This geographical feature of the region shapes the natural diversity of the South Caucasus, which encompasses almost all natural landscape types. These are: desert landscapes; semi-desert landscapes; dry steppes; moderately dry steppes; wet steppes; humid subtropics; subtropical forest landscapes; mountain forest landscapes; mountain-steppe landscapes; and glacial-nival landscapes (Ukleba et al., 1970).

Due to the diversity of nature, the region often encounters various infectious and pathological diseases. Each geographical variable has a great influence on the activation of various infections (climate types) and their spread (runoffs, insects, ticks, rodents, and ungulates). The habitat of the bacteria causing the infection can be a specific type of soil, etc.

Methods and Materials

We created about fifty thematic maps to determine the relationship between infection and geographic variables.

First, data from seven zoonotic diseases was processed in Excel: infection in animals, infection in humans, ticks, and disease outbreak files, followed by a link to them in the ArcGIS program. Files of fleas, rodents, and ungulates, which contribute to the transmission and spread of diseases, were also processed (Malania, et al., 2014; Kracalik, et al., 2013). In the article, we will talk about only a few variables.

We created digital maps, conducted analysis in ArcGIS and ArcGIS Pro, and processed the atlas design in Adobe Illustrator.

Results

During the research process, it is important to prepare a general geographical basis for the study area. The general geographical basis of the South Caucasus was prepared in the ArcGIS at a scale of 1:100.000, however, since the publication of an atlas is planned, a cartographic generalization was made for A3 format. An important stage was the establishment of standards for general elements of the map, hydrographic network, and sorting of roads; The density of settlements was determined according to population census data and others (using digital maps). For maps prepared for publication, the width of lines, size of signs, colour, and others were determined for the above objects in accordance with the scale (Fig. 1, 2).

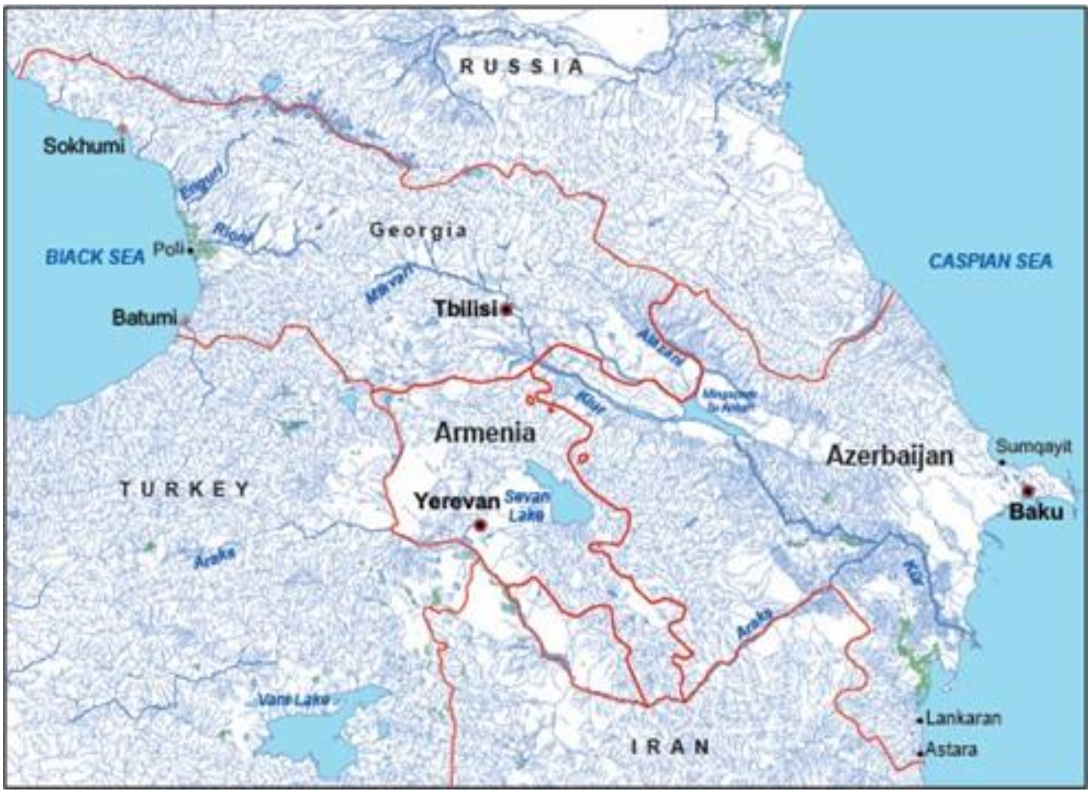

Figure 1. General hydrographic? basis of the South Caucasus

It is known that soil is a reservoir for a variety of microorganisms—including bacteria, fungi, protozoa, and viruses—that can be pathogenic to humans and animals. Human and animal pathogens in soil can be categorized into four broad groups that reflect their degree of residency in soil: permanent, periodic, transient, and incidental (Bultman & Fisher, 2013). Permanent pathogens are soil inhabitants that spend their entire life cycle in soil and sometimes become infectious for humans and animals. Examples include organisms such as Clostridium botulinum or Clostridium tetani, which produce neurotoxins when ingested in contaminated food or through contaminated wounds, respectively. Many zoonotic pathogens also either live in soil or their vectors live or spend part of their life cycle in soil (Stefan et al., 2020). Periodic pathogens are soil organisms that require the soil environment to complete part of their life cycle. For example, Bacillus anthracis, the causative agent for anthrax in humans or livestock, is often found in soils and can survive for long periods as endospores (Dragon & Rennie, 1995).

Figure 2. The general geographic basis of the South Caucasus

It is known that in order to analyze the spread of anthrax, it is important to study soil types (Fig. 3) and soil-forming rocks. To do this, we used a soil map of Georgia at a scale of 1:500,000 and determined the following parameters in the databases: soil pH, soil chemical elements, moisture index, etc. (Agrokavkaz, 2024; Matchavariani, 2012). We placed anthrax outbreaks on a digital soil pH map and calculated the frequency (Fig. 4).

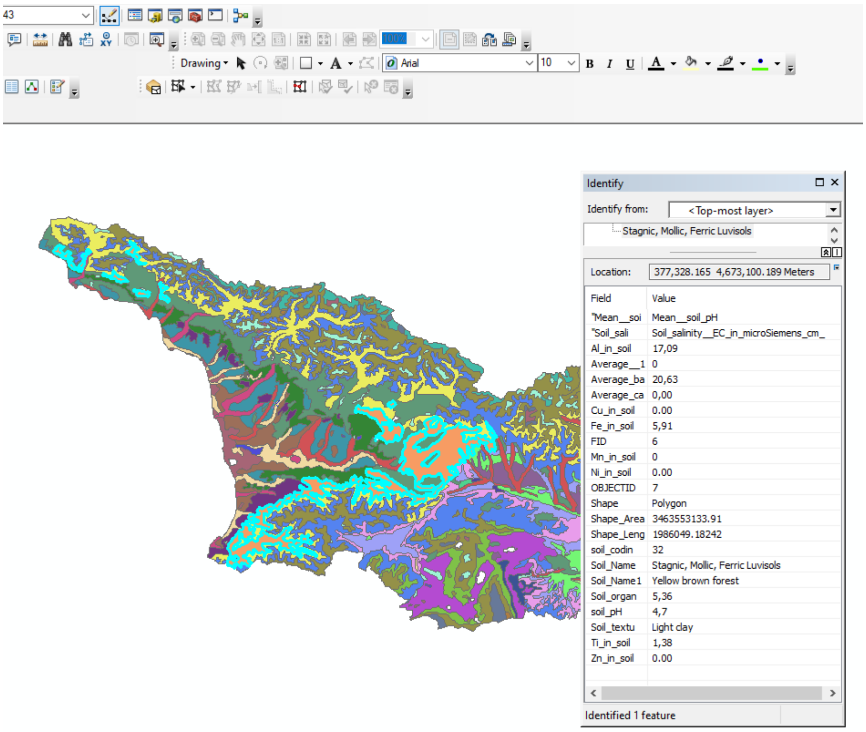

Figure 3. Soil type, important soil parameter, ArcGIS

Research has shown that the main foci of anthrax and high levels of intensity were observed mainly where the following type of soil with its own characteristics was observed: 1) *Alluvial calcareous*: Soil texture - Heavy loam, soil organic matter content 3,18 %, soil pH - 6,2, average base saturation 20,89mg, average calcium carbonate concentration 2,9%, "soil salinity (EC in microelements/cm)" 115,4, Fe in soil - 7,66%, not found here - Cu, Mn, Zn, Ni, as for Al in the soil is 15,81%, Ti – 0.55. Anthrax 155 foci have been identified in the distribution area of this type of soil; 2) *Cinnamonic*: 60 centres of anthrax have been identified in the distribution area of this type of soil. Soil characteristics are Soil texture - light loam, soil organic matter of the content of 4,9%, soil pH - 7,4, average base saturation 23,07 mg, average calcium carbonate of concentration 7,5%, "soil salinity (EC in microelements/cm)" 87,0, Fe in soil - 7,99%, not found here - Cu, Mn, Zn, Ni; in this type of soil, Al makes up 17.07% of the total, and Ti makes up 0.57; 3) Rendzic leptosols: 51 anthrax centers have been found in the area where this type of soil is found. Soil characteristics are Soil texture - light loam, soil organic matter content 4,95%, soil pH - 7,8, average base saturation 28,1 mg, average calcium carbonate concentration 20,13%, "soil salinity (EC in microelements/cm)" 68,8, Fe in the soil makes up 12.72% of it; Cu, Mn, Zn, and Ni are not found here. Al makes up 12.75% of it, and Ti makes up 0.68. There are the same number of foci in yellow soils and alluvial acid soils, and then they are spread out in this order: eutric cambisols, chernozems, yellow podzolic gley soils, andosols. Red soils, dystric cambisols, mountain forest meadows, and cleysols exhibit the lowest abundance of anthrax. Eutric cambisols and mountains have not recorded anthrax (Chichinadze et al., 2023).

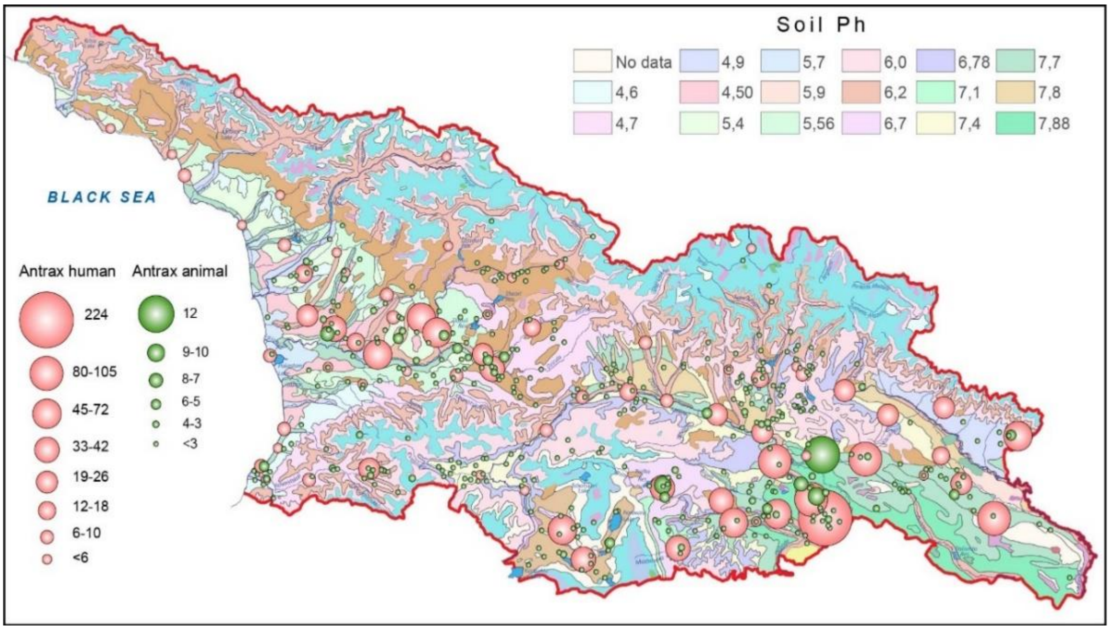

Figure 4. Anthrax density frequency

When studying zoonotic infections, we defined land use at a scale of 1:500.000. Overall, global research has shown that the prevalence and incidence of zoonotic diseases are increasing. This increase can be partly explained by changes in land use, including deforestation, urbanization and construction. Because after habitat destruction, animal carriers of infections move to different places (Bjornstad, 2021).

Our land use map databases include urban or developed land, agricultural land, grassland, forest, water, wetland, and barren land. We linked a map of land use to a map of anthrax outbreaks, distribution, and frequency. Based on the study, anthrax foci in humans are found in cities, foci in animals are found in agriculture, on pastures, farms, and in forests, and foci in soil are found in both urban and rural areas, as well as in forests (Fig. 5, 6, 7, 8).

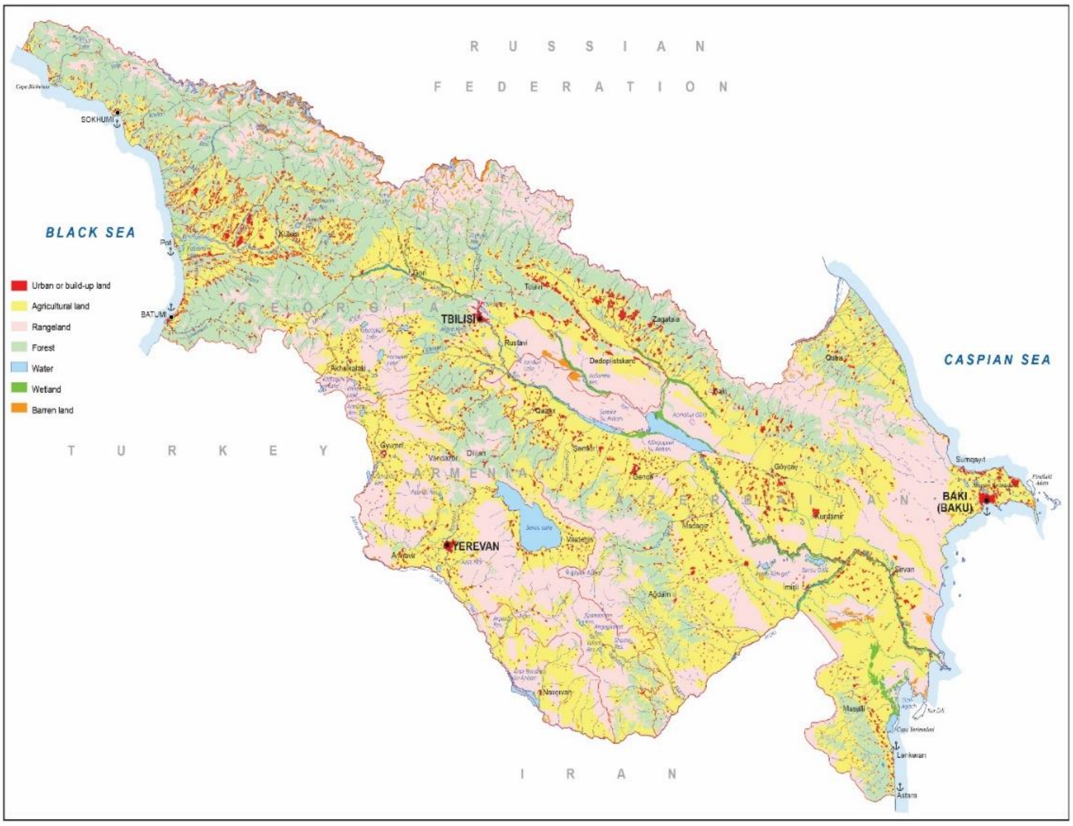

Figure 5. Land use

Figure 6. Incidence and frequency of anthrax in humans and land use

Figure 7. Incidence and frequency of anthrax in animals and land use

Figure 8. Incidence and frequency of anthrax in soil and land use

In addition to geographic variables, the movement of livestock on roads also contributes to the spread of the disease. For example, we compiled a map of cargo transportation routes and placed anthrax foci in the soil on it. These seasonal routes operate from July to October. A lot of people and places nearby are at risk of getting the disease right now because infected animals leave behind anthrax bacilli in their urine, feces, blood, and other bodily fluids (Fig. 9, 10).

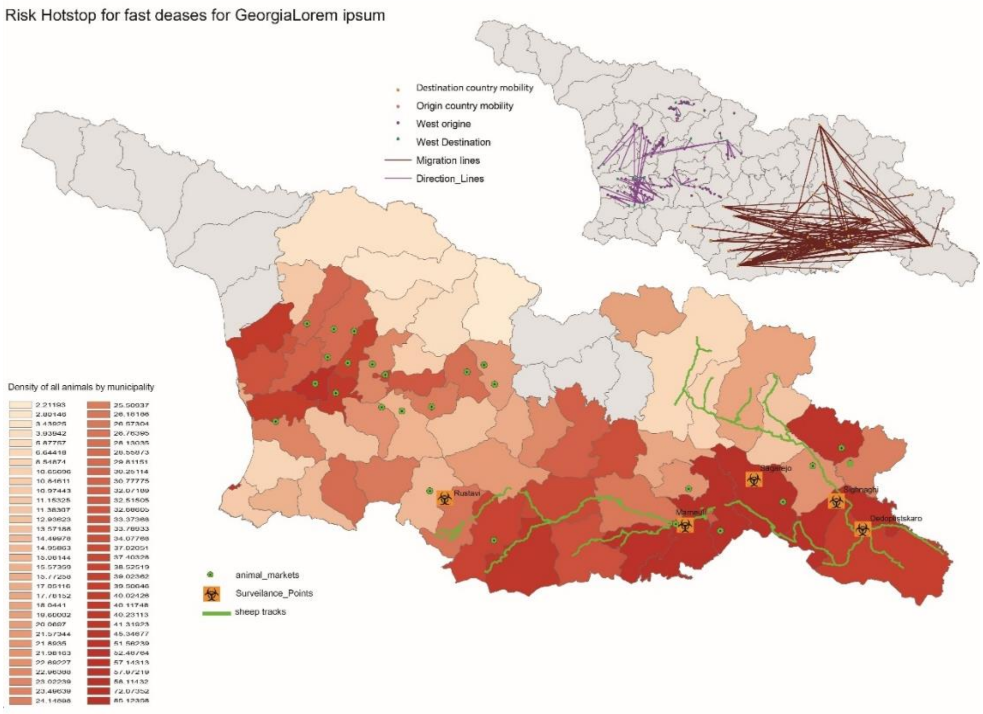

Figure 9. Livestock transport routes, density of domestic animals by municipality

Scavenger insects that feed on the carcasses of diseased animals can also act as mechanical vectors, causing and spreading the disease. Anthrax bacillus makes dormant (non-vegetative) spores when it is exposed to free oxygen. These spores are resistant to environmental conditions and stay infectious and viable in soil, animal fur, water, and plants for decades. (Chichinadze et al., 2023).

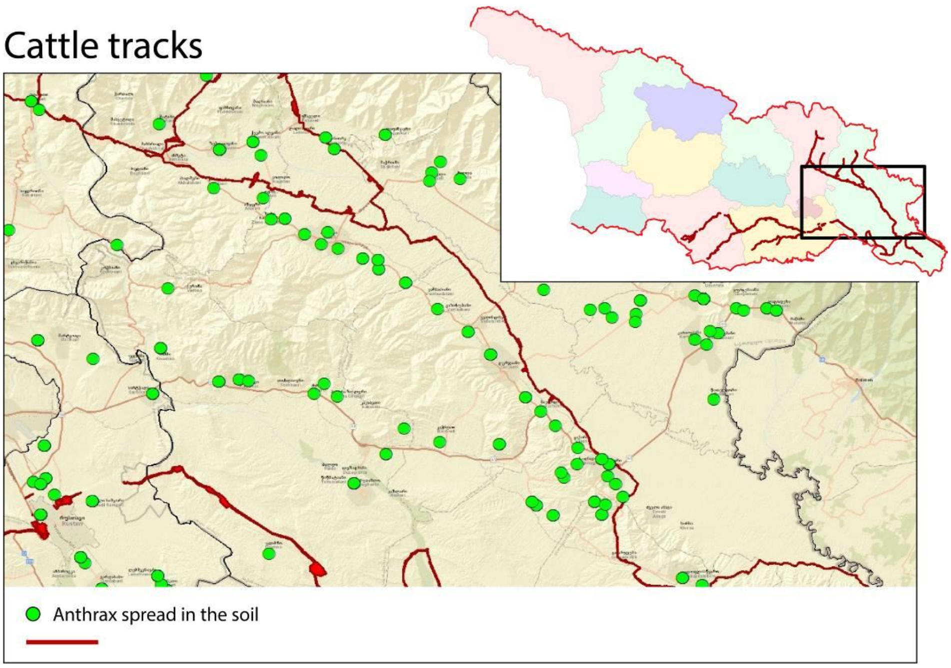

Figure 10. Cattle tracks, Small fragment, Kakheti region

One of the main factors in the spread of infections is the geographical component – climate. In this regard, climate maps of the Caucasus were compiled: elements of the average daily temperature TG, daily minimum temperature TN, daily maximum temperature TX, and the sum of daily precipitation RR. Where the database is available on a regular grid of 0.1 and 0.25 degrees, we took long-term daily data (1965-2010) and calculated the long-term average to create the map. Since the data on this site can only be viewed below 45 degrees east latitude, we have supplemented the climate maps with data from local weather stations. There was a data grid made from the Kriging method's average temperature, absolute maximum, average annual temperature (calculated from daily maximums), average annual temperature (calculated from daily minimums), and precipitation (multi-year average calculated daily amounts) (Fig. 11) **(**Chichinadze et al., 2023**).**

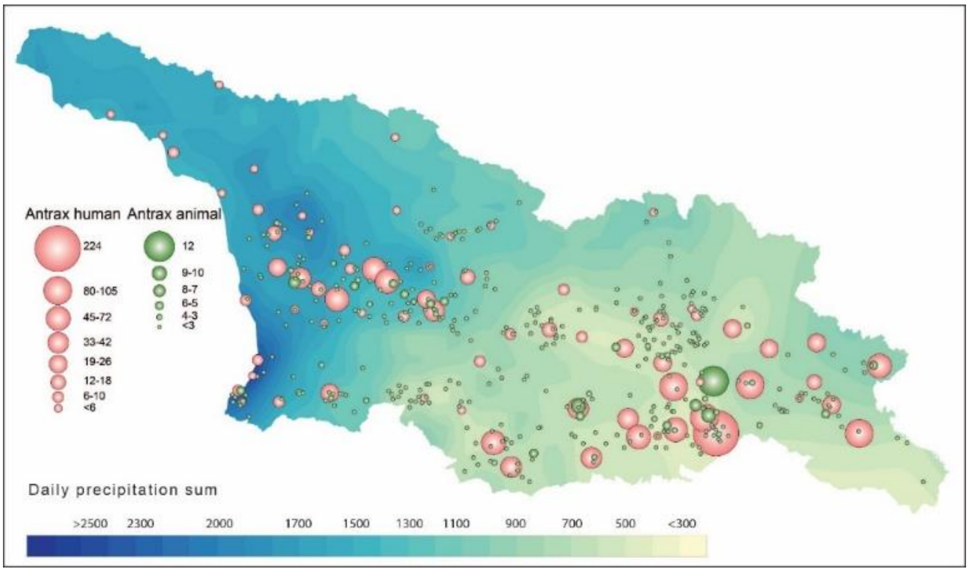

Figure 11. Intensity of Anthrax disease. Daily precipitation sum

Conclusion

When drawing up maps is it important:

The process involves determining the boundaries of the study area.

The task involves creating a large-scale map that outlines the general geographical basis of the study area for detailed analysis.

For cartographic generalization, classifying elements of a general geographic map is important.

The system should identify the specific thematic map required for a given disease and subsequently present the variables in the databases associated with that thematic map.

Two things are needed to easily find the link between a thematic map and a certain disease: correlation for a digital map and display of the case for a printed map.

It is necessary to update information since all data is constantly processed.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

T.C. and Z.G. conceived of the presented idea. N.S. performed the analytical calculations. N.B. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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ORCID iD

Tamar Chichinadze https://orcid.org/0000-0003-3741-3485
Zaza Gulashvili https://orcid.org/0000-0002-9614-314X

Nikoloz Suknidze https://orcid.org/0009-0007-1792-5260
Nana Bolashvili https://orcid.org/0000-0001-9854-2614

Reference

Agrochemical characterization of the main types of soils in Georgia. (n.d.). Retrieved from Agrokavkaz.ge: https://agrokavkaz.ge/fermerta-skola/saqarthvelos-dzirithadi-tipis-niadagebis-agroqimiuri-dakhasiatheba.html

Bjornstad, A. (2021). *The Relationship Between Land Use Change and Disease Prevalence.* Graduate Students Plan B Research Projects , Open Public Research Access Institutional Repository and Information Exchange Biology and Microbiology, Department of Biology and Microbiology.

Bultman, M. W., & Fisher, F. S. (2013). The Ecology of Soil-Borne Human Pathogens. In O. Selinus (Ed.), *Essentials of medical geology* (pp. 477-504). Dordrecht: Springer.

Chichinadze, T., Gulashvili, Z., Suknidze, N., Malania, L., & Bolashvili, N. (2023). Mapping and analysis of anthrax cases in humans and animals. *Georgian Geographical Journal, 3*(1).

Dragon, D., & Rennie, R. (1995). The ecology of anthrax spores: tough but not invincible. *The Canadian Veterinary Journal, 36*, 295-301.

E-OBS data access chunks (copernicus.eu). (n.d.). Retrieved from Climate Change Service: https://surfobs.climate.copernicus.eu/dataaccess/access_eobs_chunks.php

Kracalik, I. T., Malania, L., Tserstvadze, N., Manvelyan, J., Bakanidze, L., Imnadze, P., . . . Blackburn, J. K. (2013, September 1). Evidence of Local Persistence of Human Anthrax in the Country of Georgia Associated with Environmental and Anthropogenic Factors. *PLOS Neglected Tropical Diseases, 7*(9). Retrieved from www.plosntds.org

Malania, L., Kracalik, I., Tsertsvadze, N., Manvelyan, J., Bakanidze, L., Imnadze, P., . . . Blackburn, J. K. (2014, February). Human Cutaneous Anthrax, Georgia 2010-2012. *Emerging Infectious Deseases, 20*(2). Retrieved from www.cdc.gov/eid

Maruashvili, L. (1978). History of the study of natural conditions, chapter 1. In *Physical geography of the Caucasus.* Tbilisi.

Matchavariani, L. (2012). Soils. In *National Atlas of Georgia* (p. 71). Tbilisi: JSC Cartography.

Samaddar, S., Karp, D. S., Schmidt, R., Devarajan, N., McGarvey, J. A., Alda, A. F., & Scow, K. (2021). *Role of soil in the regulation of human and plant pathogens: soils' contributions to people.* National Library of Medicine.

Stefan, J., Derby, J., & Brevik, E. (2020). Soil pathogens that may potentially cause pandemics, including SARS coronaviruses. *Current Opinion in Environmental Science & Health, 17*, 35-40. doi:10.1016/j.coesh.2020.08.005

Ukleba, D., Jakeli, C., & Saneblidze, M. (1970). *Map of Caucasus landscapes.* Tbilisi.