National Adaptation Plan for Serbia: Vectors and Vector-borne Diseases

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CONTENTS

1. Introduction

Changes in the epidemiology of infectious diseases transmitted by arthropods (vector-borne diseases) are associated with changes in climatic parameters [1]–[4]. Trends in average temperatures and rainfall in the temperate climate zone led to the spread of habitats suitable for the establishment of exotic vectors (disease-transmitting arthropods, such as ticks, mosquitoes, and sand flies) beyond the subtropical and tropical areas that they had lived in so far. Climate change, intensification of transport of goods and people and urbanization, contribute to the spread of tropical species and the diseases they transmit to countries with temperate climates and contribute to the increasing number of autochthonous vector and pest species (insects that disturb humans and animals). Mosquitoes stand out among the vectors, being one of the most dangerous animals in the world because they use to take more than 725,000 human lives every year (Figure 1) due to their ability to transmit deadly pathogens that cause malaria, West Nile fever (WNF), dengue and chikungunya fever, among others [5]. According to the World Health Organization (WHO), vector-borne diseases make more than 17% of all infectious diseases in the world, with more than half of the world's population living in areas exposed to this type of diseases. Over a billion people are infected every year, with about 600,000 deaths.

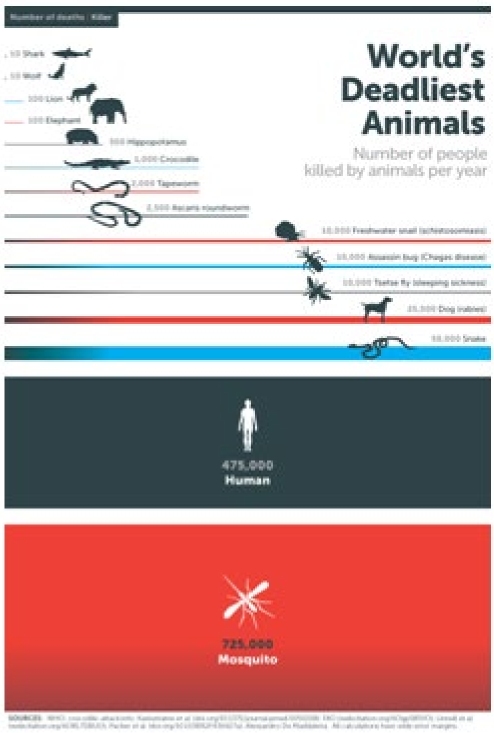

Figure 1: Fifteen most dangerous groups of animals

The number of cases of vector-borne diseases in the human population is proportional to the number of vector populations in the period in which the disease can be transmitted. The influence of climate is reflected in its influence on the vectors that transmit the disease and on the speed of development/multiplication of pathogens within the vector, with the greatest influence (on the activity and distribution of vectors) being in relation to air temperature parameters and precipitation. In temperate climates, vector-borne diseases have a seasonal character with a peak that follows the period of the largest number of vectors. The dynamics are determined by the characteristics of the climate both during the season of vector activity and in the wintering season, but also by the abundance of the previous generation.

The two most dangerous vectors for human health in Serbia are the autochthonous (domestic) species:

1. *Culex pipiens* - house mosquito, which transmits the West Nile virus (WNV) and
2. *Aedes albopictus* - an invasive species, the Asian tiger mosquito, which transmits more than 20 viruses, such as dengue, chikungunya and zika viruses.

The house mosquito is widespread in Serbia, and the Asian tiger mosquito was first registered in 2009 in the Srem district (on the border with Croatia) [6]. According to publicly available data by the end of 2020, *Ae. albopictus* settled in Batrovci, Adaševci, Ruma, Novi Sad, Loznica, Lešnica, Banja Koviljača, Apatin, Belgrade, Valjevo and Niš.

For the West Nile virus (WNV), transmitted by house mosquitoes, climate and the degree of urbanization were the main factors for the occurrence of infection [3]. Petrić et al. [7] found that the retention and circulation of West Nile virus in house mosquitoes in a given area are most related to the microclimate of the observed area, size 25 km2, the highest correlation was observed with the average air temperature during the period corresponding to the overwintering of females (October-March). The same authors linked the spread and increase in the number of another autochthonous species, *Anopheles hyrcanus*, a vector of malaria, with the increase in the average annual temperature in the territory of Vojvodina in the period 1985-2015. The spread of the most dangerous vector of arbovirus in Europe, the invasive tropical Asian tiger mosquito, in the temperate climate zone is mostly determined by the human factor and climate change [8], [9].

Vector-borne diseases, in addition to fatal outcomes in human and animal populations, also significantly affect the economies of the countries in which they occur. This impact on the economy further justifies the need for prevention. Data on the economic damage caused by vector-borne diseases are rare. In Texas, the costs caused by the WNV epidemic in 2012 were over US$ 47 million, with an average cost of hospitalization and absenteeism of US$25,000 per patient with inpatient treatment and US$1,200 per patient who was not provided with hospital care. The economic losses caused by the chikungunya epidemic on the island of Réunion (2005–2006) amounted to EUR 43.9 million, of which 60% was due to direct medical costs and 40% was lost due to reduced productivity caused by the disease. Even when they do not transmit diseases, mosquitoes can significantly endanger the country's economy (primarily agriculture and tourism). In the valley of the upper Rhine in Germany, the profit in food production and tourism revenues generated by investing EUR 1.5 per capita for mosquito control (EUR 3 million for 2 million inhabitants), is estimated at EUR 6.2 million.

The costs of the 2012-2017 WNV epidemics in Serbia have not yet been estimated. The only assessment was made within the project III 43007 and it analyzed the economic aspect of the epidemic in 2018, which are presented below in order to get an impression of the need for prevention, as a measure of adaptation to climate change. Based on the data of the Institute of Public Health of Serbia "Dr Milan Jovanović Batut" for 2018, 415 cases of West Nile fever have been registered on the territory of the Republic of Serbia. Cases of neuroinvasive West Nile fever have been reported from Južnobački (56 persons), Južnobanatski (54), Braničevski (24), Podunavski (19), Sremski (10), Kolubara (8), Zapadnobački (7), Severnobanatski (6), Srednjebanatski (6), Pomoravski (3), Zlatiborski (2), Mačvanski (1), Raški (1), Borski (1), Šumadijski (2) and Rasinski (1) districts and from the territory of the city of Belgrade (214). The spatial distribution is shown in Figure 2).

Most infections in humans are asymptomatic. After an incubation period of 3 to 14 days, only 20% of those infected develop mild West Nile fever symptoms, half of which seek medical attention [10]. The neuroinvasive form of the disease occurs in less than 1% of patients (415 cases of the disease in 2018). Based on the number of neuroinvasive forms of the disease (415), we predict that in 2018, 4,150 patients sought medical help related to milder forms of West Nile fever (for all, the presence of West Nile virus was detected by ELISA test or PCR). The average price of ELISA tests for one patient in laboratories for human virology is RSD 2,600 - 3,900 (ELISA IgM WNV 1,300, ELISA IgG WNV 1,300 and ELISA IgG avidity 1,300), PCR WNV analysis is RSD 4,500 and specialist examination RSD 3,000 [11]. As the WNV PCR test was routinely used in diagnostics only in Vojvodina, where 33.5% of patients with severe neuroinvasive form of the disease were recorded, we assumed that the distribution of 4,150 patients with mild form of the disease requiring only specialist examination and diagnosis was similar, i.e. 1,390 patients in Vojvodina + 2,760 patients in the rest of Serbia.

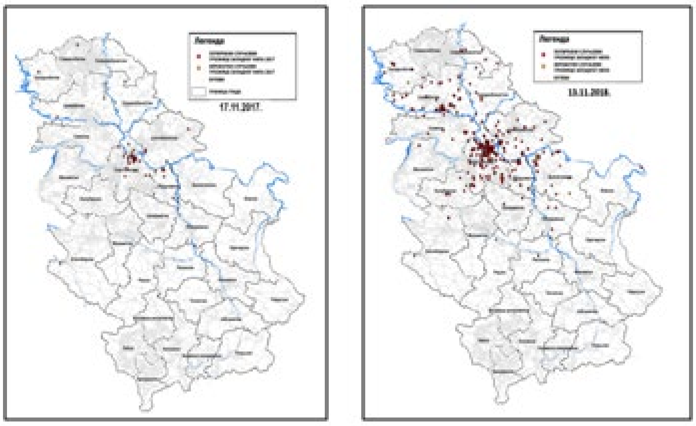

Figure 2: Spatial distribution of confirmed and probable cases of West Nile fever in Serbia in 2017 (left) and in 2018 (right) (Source: Institute of Public Health of Serbia) (http://www.batut.org.rs)

Pursuant to this forecast, the prices of specialist examination and diagnostics services amounted to RSD 10,425,000 (EUR 88,347) + RSD 19,044,000 (EUR 161,390). The total costs of examinations and diagnostics for patients with a milder form of the disease are estimated for 2018 at **RSD 29,469,000 (EUR 249,737)**. If we accept the price from the Price List of Health Services in the Clinical Center of Vojvodina for two specialist examinations (RSD 6,000), a hospital day of intensive care in the departments of infectious disease clinics in the amount of RSD 7,500 and an average hospitalization lasting 14 days, for 415 cases in 2018, we get the cost of treatment of patients of: **RSD 46,065,000**, or **EUR 390,380**. In addition, the price should include the cost of absence from work, which we projected for 2 days for patients with mild and 14 days (10 working days) for patients with severe form of the disease. In both cases, the daily cost was calculated based on the average gross personal income for Serbia for 70% of registered/estimated patients (2905 + 291) due to the fact that about 30% of patients belong to the age category of retired persons [12]. Based on the Announcement ZR10 of the Statistical Office of the Republic of Serbia (No. 344 of December 25, 2018), the average gross salary per employee in the Republic of Serbia in October 2018 amounted to RSD 69,467 (RSD 3,308 per day). The loss due to absence from work was estimated at RSD 19,219,480 (EUR 162,877) for patients with a mild form of illness who were absent from work for two days and RSD 9,626,280 (EUR 8,1579) for patients with a more severe form of illness who were absent from work for 10 working days. (14 days of hospitalization), a total of **RSD 28,845,760 (EUR 244,456)**.

The costs of mosquito control were estimated at half of the total amount spent on mosquito control in 2018, of RSD 472,000.00 (EUR 4,000), so that the total burden on the Serbian budget due to the West Nile virus epidemic in 2018 amounted to **RSD 57,6379,760**, or **EUR 4,884,574**. The average price of hospitalization and absence from work was RSD 134,196 (EUR 1,137) per patient with hospital treatment and RSD 11,732.00 (EUR 99) per patient who was not provided with hospital care.

The influences of meteorological parameters, climate and other factors that trigger changes in the complex system vector - pathogen - environment, can result in changes in epidemiology, i.e. occurrence and spread of vector-borne diseases. The results given in the subchapter "Impact assessment" (Chapter 2) show that the projected climate change will contribute to the spread of areas suitable for vector settlement to areas outside their primary habitat in the case of both indigenous and invasive species. Also, the rise in temperature will contribute to prolonging the duration of the seasonal activity of the vector, shortening the incubation period of the virus in the vector, increasing the abundance of vectors and thus the probability of pathogen transmission. Among other drivers of change, we single out the globalization of the exchange of goods and services, more intensive international travel and population migration. These factors can contribute to the spread of vectors and the introduction of invasive species and lead to changes in the number of patients with new as well as previously eradicated infectious vector-borne diseases. The current lack of comprehensive (including all groups of vectors), scientifically based, legally supported and systematically organized (obligation to implement guided by identical principles from the national to the local level) surveillance and control of vectors and diseases they transmit contributes to additional vulnerability.

1.1 Overview of sector components

1.1.1 The main factors influencing the occurrence and transmission of vector-borne diseases

Factors (triggers) that cause changes in the system of new infectious zoonoses (diseases transmitted between humans and animals, e.g. West Nile fever, Covid 19) are usually classified into several groups [13] of changes related to: (i) the environment and land use (urbanization); (ii) susceptibility of the human population to infections; (iii) agricultural and industrial production; (iv) international travel and trade; (v) wars, famines and human migrations; (vi) medical industry policy; (vii) climate and weather; (viii) demographics and human behavior; (ix) collapse of the health system (e.g. COVID-19); (x) use of wild animals for food; and (xi) the food industry.

Of all the modes of transmission of infectious zoonoses (airborne, direct contact with an infected subject, direct contact with the environment, direct contact with infected objects or food, oral transmission and vector transmission), vector transmission has the potential to cause the majority of epidemics in the future [13].

The main drivers influencing the distribution, seasonality and the abundance of vectors and diseases they transmit are (in order of importance): (i) temperature, (ii) precipitation in specific cases, (iii) demography and human behavior, and (iv) habitat characteristics [3], [4], [14]–[17].

The methodology for detecting, verifying and mitigating changes in the system "vector and diseases they transmit" is based on monitoring (only registration of changes without planned mitigating actions), surveillance (registration is strongly related to mitigating actions), forecasting changes in the short and long term (modeling), a database with quality entomological and epidemiological data, data on vector control, assessment of economic effects and availability of data and their communication.

1.1.2 Monitoring and Surveillance

Vector monitoring and surveillance is conducted in an active and passive way. The active method involves collecting eggs, larvae and adult stages of the vector in nature, applying various techniques [18]. The passive way implies the participation of citizens (citizen science) in the collection of data on vectors. In Serbia, the first system of passive monitoring of invasive mosquito species via a mobile phone application was launched by the Provincial Secretariat for Urbanism and Environmental Protection in 2018. In 2020, Serbia joined the European tracking system on the "Mosquito Alert" mobile phone application, in which 26 European countries are participating, and which was organized within the AIM COST action (https://www.aedescost.eu/).

According to the goal, monitoring and surveillance methods are divided into transversal and longitudinal monitoring methods. The transversal method involves registering the presence or absence of vectors and is usually based on a single collection of vectors during the season at several different locations. It is irrelevant in this method what developmental stage of the vector is registered (egg, larva, adult) or how they are collected, but it provides valuable data on the import of invasive and distribution of invasive and indigenous species of vectors in a particular territory. Citizen participation in this surveillance method allows obtaining important data on the presence and distribution of vectors while reducing costs and increasing the area covered by monitoring. Passive monitoring can be organized by a mobile phone application or by citizens collecting mosquitoes and sending them to a scientific institution responsible for identification of species (Serbia before 2018, Germany in the last 9 years).

The longitudinal method involves multiple collection of vectors (eggs and/or larvae and/or adults) at the same site over one or more years. It provides data on seasonality (time in the year when the vector is active) and the abundance of vectors. For seasonality, similar to the transversal method, the technique and developmental stage of the vector being monitored are less important, and citizens can contribute with passive monitoring. In contrast, strict standardization of techniques is crucial for monitoring vector abundance. The abundance of invasive mosquitoes in Europe is most often monitored by registering the number of eggs laid in oviposition traps. For indigenous species of mosquitoes, the collection of adult mosquitoes is most often used, which, in addition to strict rules of transport, determination and storage of collected individuals, is also used for the detection of pathogens in vector pools/individuals. Qualitative abundance data can only be obtained if the same trap type is constantly used for collection in a given area, if the trap location is chosen by trained persons and by strictly observing small details such as: (i) use of the same amounts of attractant (e,g,, dry ice) which attracts mosquitoes to the proximity of the trap into which they are sucked; (ii) use of batteries of constant voltage and high capacity (for each collection new or charged in the standard way); (iii) regular inspection and maintenance of traps; and d) tuning the electric motor to adjust the RPM number of the trap propeller [19].

The basic precondition that influences the output results of the model is the existence of multi-year, frequent and precise measurements of the vector population in a certain area, which is carried out within the framework of the entomological surveillance. Quality field measurements of the distribution, seasonality and abundance of vectors are extremely important for the development of a reliable model. Quality implies long time series of monitoring/surveillance (longer than 4 years) which increases the accuracy of the model and the high frequency of measurement (e.g., daily, weekly) which increases the accuracy of the model [14], [20].

1.1.3 Predicting Changes in the Short and Long Term

Meteorological conditions and climate change significantly affect the time of occurrence, the abundance of vectors and their activity. The only way to understand the causes and consequences of these phenomena is based on the simulation of the risk of increasing the abundance and distribution of vectors with the possibility of analyzing the influence of each individual factor. In addition to quality data on the distribution, seasonality and abundance of vectors and data from scientific and grey literature reviewed by curators (information selected, organized and prepared for use using professional expertise), the choice of a good model is crucial. The advantage of mechanistic models over statistical ones is that they can be used to evaluate the influence of an isolated factor on a dynamic system and corresponding changes in the abundance of vectors. Mechanistic dynamical systems are used to describe the mechanism of a biophysical process or part of this process depending on the forcing unit.

In this segment, education of users at all levels is needed, from decision makers to contractors and citizens, on the need to include models for predicting changes and risk assessment, as well as model simulating the potential effects of vector control in order to create a platform for implementing effective mitigation measures. It is also necessary to legally formalize the link between the sectors of meteorology, medical entomology, veterinary medicine, public health, and ecology according to the principles of "One Health". Only in this way will it be possible to efficiently solve complex and burning problems related to vectors and diseases they transmit.

Based on the existing literature, the following parameters were considered in the risk and vulnerability analysis for the most important vector species in Serbia: (i) mean annual air temperature; (ii) total annual precipitation; (iii) number of days with precipitation> 0.1 mm; (iv) distance from floodplains and larger areas of natural waters; (v) mean air temperature in the period from October to April; (vi) mean air temperature in the period from June to August; (vii) population density determined by remote observations of night illumination; (viii) mean monthly air temperature for January; (x) mean air temperature from April to May; (x) mean air temperature in the period from December to February; (xi) average precipitation in the period from March to June.

1.1.4 Vector Control

In cases where a vaccine is not available, the best way to prevent the spread of vector-borne diseases, and thus to mitigate the effects of weather and climate change, is to control the vectors.

To explain the shortcomings of vector control, we will list a few facts. We will first look at the differences in the organization, that is, the sectors that perform vector control in the USA and Europe. In the USA, vector control is the responsibility of state institutions (Mosquito Abatement Districts). The state formed District Organizations as a public enterprise in the early 20th century as a national response to epidemics of vector-borne diseases (malaria, yellow fever, western and eastern equine encephalitis, St. Lois encephalitis) with the main reason for protecting public health. The problem with vector control in Europe is that all species of vectors present, until recently did not poseda major threat to public health. As a consequence, in most European countries, control is carried out by private companies that often do not follow good control practices and whose actions are not coordinated in a wider area. The effects of control are often unsatisfactory for the reason that profit, and not the protection of human health as in the USA, determines decision-making. Also, most private companies do not use the results of predictive models. Low efficiency is also caused by decision-making without knowledge of ecology and the current abundance of vectors and without linking to vector monitoring/surveillance databases (if they exist and are publicly available). In support of this statement are the findings of a scientific paper in which weekly field measurements of the abundance of *Cx pipiens*, house mosquito, a WNV vector, collected during 34 years of observation in Greece, Italy, Serbia and France within treated and untreated areas were analyzed. To the authors' surprise, the differences in the abundance and dynamics of house mosquito populations between the places where the control was carried out and those where it was not done were not significant [14].

The *Aedes* Invasive Mosquitoes (AIM) COST Working Group on Conventional and Innovative Mosquito Control Methods (WG2) formulated an expert opinion based on the knowledge and experience of leading European scientists in this field at the annual conference held in Lisbon in February 2020. Experts estimate that more than 100 million. € is spent annually on mosquito control in Europe, but without real knowledge of the results achieved. They also assumed that private companies do not use the available methods of vector control in an appropriate way, which jeopardizes their efficiency - incorrect use of an excellent tool cannot bring satisfactory results. In the case of vector-borne diseases transmitted by mosquitoes, this makes the chances of mitigation quite vulnerable. Further, after the implementation of ECDC "After Action Reviews with a Health Perspective" in Slovenia, Italy, Serbia and Greece after the worst season of WNV epidemics in Europe in 2018, it was discovered that increasing knowledge about vector control is a chronic priority area to be improved [21].

One of the ways to improve the efficiency of control would be the introduction of mandatory quality control measures (efficiency) of the derived control measures. In USA and several European countries, which still have public vector control companies, it is a mandatory measure implemented by each organization over the measures it implements. In this case, there are no problems with falsifying quality control results because the main goal of these public, non-profit companies is to successfully fight mosquitoes and prevent disease transmission.

In order to scan the opinion on the need to introduce mandatory control of mosquito control efficiency within the AIM COST action, 155 persons dealing with medical entomology, public health, veterinary medicine and mosquito control from 41 countries in Europe, Asia and North Africa were interviewed. The following answers were given to the question: "Should an external (independent) assessment of the quality of mosquito control be systematically included in the mosquito control program and linked to a contractual obligation?" (Figure 3). Since scientists dominated among the respondents, only the responses of employees in private mosquito control companies were analyzed in the second iteration (Figure 3). The result was almost identical, showing that representatives of the private mosquito control companies would also support the introduction of quality control. We did not expect such an answer, but we may explain it by unfair competition when participating in tenders for the job of mosquito control. It is possible that there is an awareness of the different quality of mosquito control work, and that most of the interviewed contractor representatives saw external control as an opportunity to mitigate the effects of unfair competition.

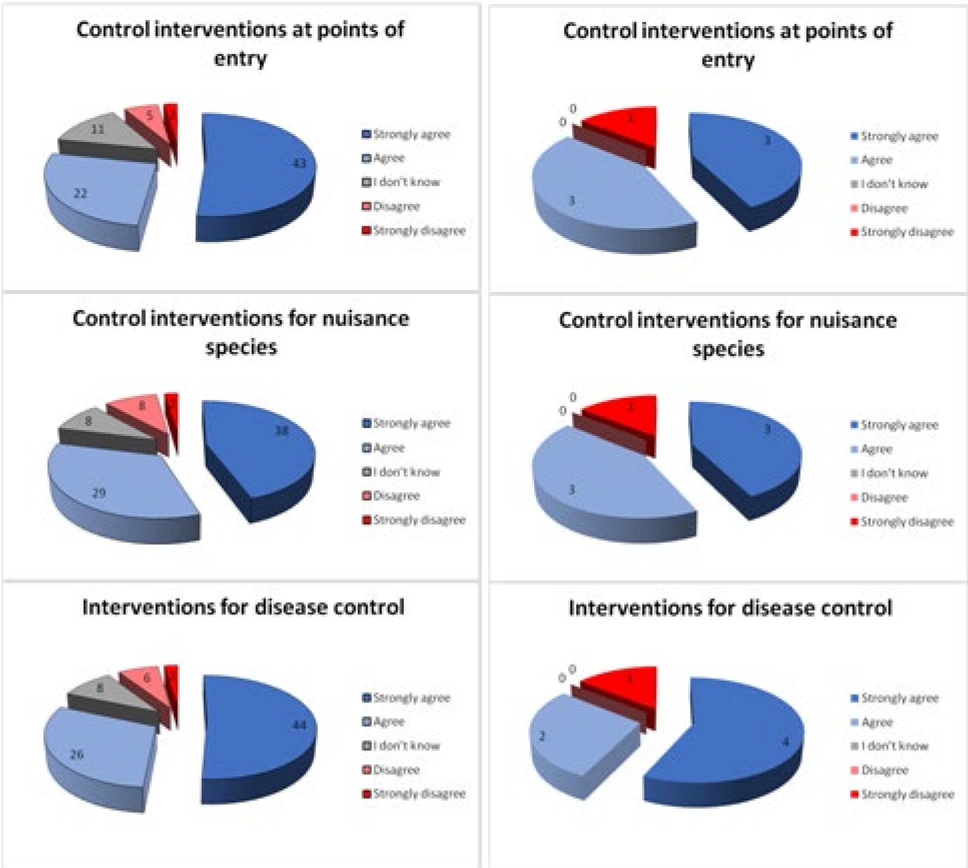

Figure 3: Answer to the question about the introduction of quality control of mosquito control: left) respondents of different profiles (86 answers) and right) representatives of private mosquito control companies (7 answers). Dark blue - totally agree; light blue - agree; grey - don't know; bright red - disagree; dark red - completely disagree.

1.1.5 Economic Effects

The damage caused by vectors by disturbing and disrupting normal human activities, and even more so those resulting from epidemics of vector-borne diseases, is not easy to estimate. While the impact of harmful organisms is easily quantified in the agricultural production sector by the yield lost and the quality of the final product, the damage is not easy to measure in the sector of vectors and vector-borne diseases. If the spread of vector-borne diseases was combatted by vector control, it is difficult to estimate how many fewer people were infected or lives saved (how to quantify the cost of human life?). For this reason, it is very difficult to explain to the authorities the importance of monitoring changes in the vector/vector-borne disease system and convincing them to support ongoing surveillance programs and changes in legislation related to vector control.

In the subchapter Introduction (Chapter 1) of the report we present an analysis of the costs of the West Nile virus epidemic in Serbia in 2018, which was carried out as part of the project of the Ministry of Science and Technological Development III43007.

1.1.6 Communication and Data Availability

Surveillance of vectors and the diseases they transmit generates a wide range of data that needs to be communicated to different stakeholders. The method of dissemination depends on: (a) the communicator, (b) the message, and thus the type of data and level of detail, (c) the medium chosen for presentation (charts, maps, plain text), (g) recipients (both end users and uninformed citizenship) and (e) desired social, political or scientific influence and anticipated feedback (Figure 4, Lasswell's model). The timing (e.g. phase of outbreak) and the cost of the dissemination method must also be taken into account.

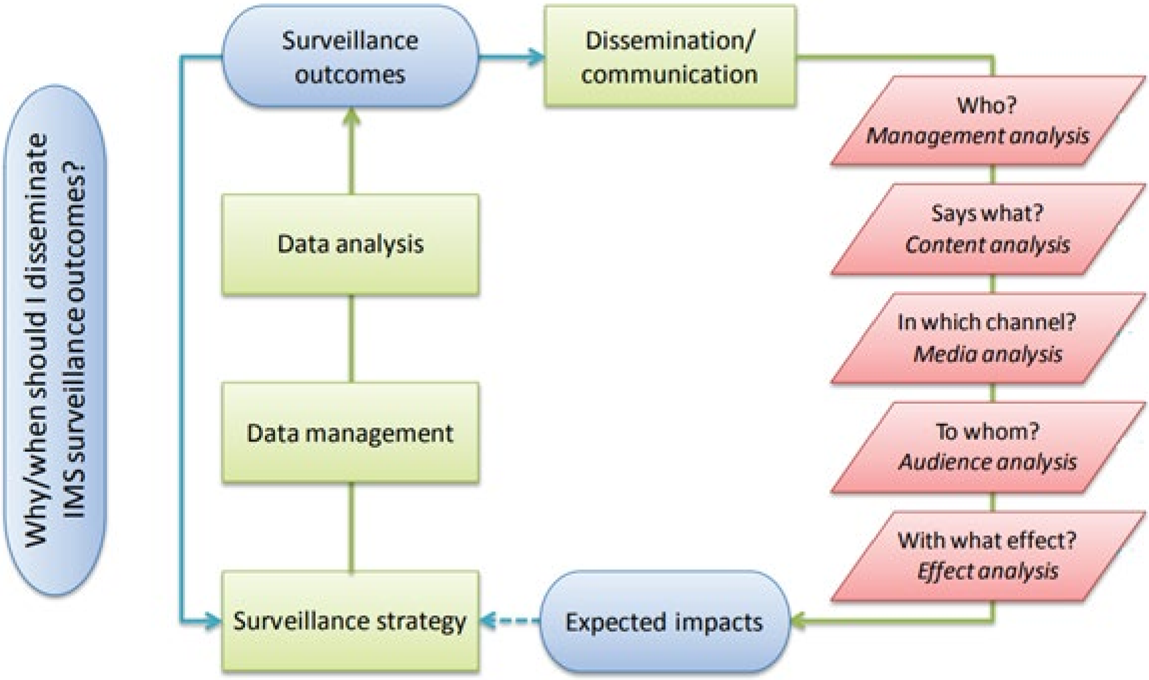

Figure 4: Communication/communication of vector surveillance outcomes and effects (according to ECDC 2012, [18])

Dissemination pathways for stakeholders, end-users and other target groups (citizens, NGOs, etc.) should be carefully developed, taking into account the sensitivity of the information. The choice of data type, level of detail and presentation style (charts, maps, plain text, etc.) should be tailored to the target group and designed to achieve the desired impact. The language used may depend on the scale of the communication campaign. The timing of the campaign should be determined in accordance with the desired reaction of the target group: launching a campaign before the mosquito development season is significantly different from launching a campaign during the season, when the general public is already well aware of the trouble caused by mosquitoes.

2 Impact assessment: observed phenomena, vulnerability, and gaps

2.1. Observed impact on vectors and vector-borne diseases

In the Republic of Serbia, during the ten-year period, from 2009 to 2018, the most significant vector-borne diseases from the aspect of epidemiology and public health were analyzed [22]. The number of registered human cases based on the data from the Report on infectious diseases of the Institute of Public Health of Serbia "Dr Milan Jovanović Batut" are:

- **West Nile virus (mosquitoes)**: A total of 988 cases, annual range with a total of 30 to 415 patients per year, median 71 (the first cases in the human population were registered in 2012, so there is no data for the period from 2009 to 2012 https: //www.ecdc.europa.eu/en/publications-data/table-transmission-west-nile-fever-may-november-2012-table-cases-2012)
- **Malaria (mosquitoes)**: A total of 158 imported cases, annual range from 8 to 28 patients per year, median 13.
- **Lyme disease (ticks)**: Total 7,007, annual range from 487 to 997 patients per year, median 925 (no data from 2018 when the obligation to register this disease ceased)
- **Tick-borne encephalitis (ticks)**: A total of 23 cases, range 1 to 13 patients per year, median 4.5 (first case recorded in 2015 [23], so no data for 2009–2014)
- **Leishmaniasis**: A total of 6 cases, range 0 to 2, median 1 (no data for 2014-2018)

Analyses of the impact of climate change on the presence of West Nile virus in mosquito vectors (species *Cx. pipiens*, house mosquito) for which we used the observed values of meteorological indicators (temperature and relative humidity) in combination with the regional climate model for scenario A1B and period 2001–2030 indicate a significant influence of microclimatic (5x5 km) variations on virus circulation in the vector population. By correlating the pools of mosquito vectors in which West Nile virus was detected for the period 2010-2015 (collected at 21 locations throughout Vojvodina) with the corresponding average values of meteorological factors, the highest agreement was found for the average air temperature for the period October-March (TOA) ($r = 0.755$; $p < 0.05$), i.e. the period in which female mosquitoes overwinter.

The results of the Poisson regression model indicated that **for each increase in the average air temperature of 0.5 ° C, the number of mosquitoes of the species *Cx. pipiens* infected with West Nile virus and thus the risk of transmitting the virus to the human population doubled** (Figure 5) [4].

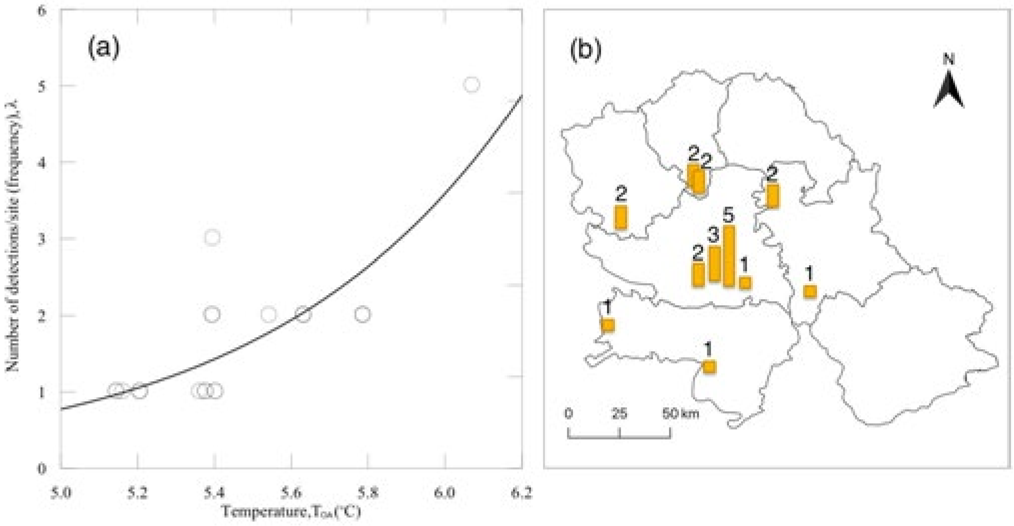

Figure 5: (a) Relationship between the frequency (λ) of detection of WNV positive Culex pipiens at the same site and the overwintering temperature from October to April (TOA); (b) Frequency of sampling of mosquitoes infected with WNV (1–5 times) during six years (columns and numbers) in Vojvodina, Serbia [4]

Figure 5 shows an evident linear trend of the mean annual temperature Ta for the period 1985–2030 ($r = 0.467$; $p = 0.001$; $\tau = 0.328$) calculated based on the output of the EBU-POM regional model for 29 representative locations in Vojvodina. All parameters chosen to estimate the spread and population growth of the malaria vector *Anopheles hyrcanus* were positive but correlated to a different extent with the time argument (periods in which sampling was performed since the beginning of monitoring in 1985), which indicates a monotonous trend. The increase in parameters follows the trend of Ta (Figure 6a). The strongest positive correlation was found with the relative number of positive samples per year ($r = 0.986$; $p = 0.000307$; $\tau = 0.828$), followed by the number of mosquitoes collected per trap per night ($r = 0.919$; $p = 0.009639$; $\tau = 0.733$) and the number of newly inhabited locations ($r = 0.889$; $p = 0.01766$; $\tau = 0.6$). By 2030, a further increase in the number of newly inhabited locations and the number of mosquitoes is predicted, by 1.71 and 1.27 times, respectively (Figure 6b and c).

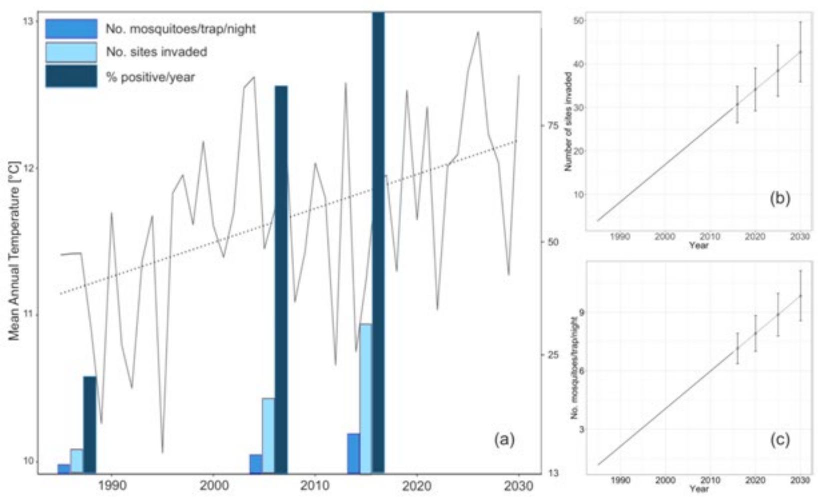

Figure 6: (a) Regional climate model EBU-POM projection of mean annual air temperature (Ta) for the period 1985–2030. and: i) number of Anopheles hyrcanus specimens trapped in one trap during one sampling (blue bars); ii) number of newly inhabited locations (light blue columns); and iii) the relative number of positive samples per year (dark blue columns), (b) the projected increase in the number of sites that An. hyrcanus inhabit (period 2001–2030 ± S.E.), and (c) the projected increase in the number of individuals sampled in one trap during one sampling (2001–2030 ± S.E.).). [4]

In Serbia, in 2018, the surveillance of the Asian tiger mosquito was planned for the first time according to the outputs of Petrić et al. [5], and the presence of this invasive species was determined at 15 of the 16 sites selected based on the model outputs [24]. In August 2018, at the Ljuba border crossing, the presence of a new invasive mosquito species, *Aedes japonicus*, was registered in Serbia for the first time [24], [25]. This finding confirmed the capacity of the model for early detection of invasion (based on model outputs). Also, based on the model, the expectation that the area of Novi Sad is extremely favorable for the settlement of *Ae. albopictus* [5] was confirmed in 2018. We single out Novi Sad because according to the Mahalanobis distance, its area is ecologically favorable for the spread of a dangerous tropical virus that causes dengue fever, and in September 2015, in nearby Kać, the first imported case of dengue was registered in Serbia, [26]. In the period until 2040, the area of Novi Sad is predicted to become favorable for the transmission of another tropical disease, chikungunya fever, whose first epidemic on European soil was recorded in 2007 in Italy, and the vector in question was the tropical, invasive Asian tiger mosquito - *Ae. albopictus*.

Based on the same model, it can be expected that by the end of the century, most of the area of Serbia will become a much more climatically suitable area for the establishment and development of the *Aedes albopictus* mosquito.

The spatial resolution provided by the regional analysis enables a more precise risk assessment and planning of habitat-oriented surveillance within which the main routes of invasive vector introduction and places of appropriate climatic convenience are connected [5].

2.2 Current situation of the sector in Serbia and Europe

2.2.1 Mosquito Monitoring in Serbia

The idea of the possible risk of the West Nile virus (WNV) coming to Serbia began to develop in 2003 with the cooperation between the Department of Meteorology and the Laboratory for Medical and Veterinary Entomology of the Faculty of Agriculture, University of Novi Sad. Then, the climatic conditions around Bucharest and the Central Valley in California (as the areas of the largest epidemics of WNV at the end of the 20th and the beginning of the 21st century) and Vojvodina were compared and similarities were revealed, which indicated a high risk for the virus outbreak. During the cooperation within the pp2 of the project "Modeling, monitoring and environmental quality" (III43007), as well as with fellow veterinarians (project TR31084), a monitoring system was developed that showed the capacity for high spatial specificity (capacity to predict the spatial distribution of risk for neuroinvasive West Nile fever) and sufficient sensitivity to detect early circulation of the virus in nature [7], [27].

During the work on the issue of WNV surveillance, the existing product "Trap for collecting hematophagous insects and monitoring of arboviruses and other pathogens they transmit - type NS2" was significantly improved within the project TR31084 [8] and a new technical solution "West Nile virus surveillance program" was developed based on the results of research in projects III43007 and TR31084. The programe was accepted by the Veterinary Directorate, the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, which incorporated it into the

"Guidelines for monitoring the West Nile fever" (Number: 323-02-2199/2014-05) on which the national program is based. The guidelines were updated three times (2015, 2017 and 2018), in line with project and monitoring results. The National Veterinary Surveillance Program was assessed by experts from the European Center for the Prevention of Infectious Diseases (ECDC) and the World Health Organization (WHO) as one of the best in Europe, and colleagues from the Faculty of Veterinary Medicine in Vienna recommended it as a model for initiating a similar program in Austria.

Since 2014, there have been two parallel WNV surveillance programs at the national level, by the Ministry of Health (MoH; 2012-2019) and the Ministry of Agriculture, Forestry and Water Management, Veterinary Directorate (VD; 2014, 2015, 2017, 2018). Apart from them, some local governments (LG; e.g. Novi Sad and Loznica cities) have independent programs in their territories. All programs follow only the house mosquito (*Culex pipiens*) a WNV vector, they are not based on the same methods, there is no data exchange between the programs, nor a common database. In addition to these shortcomings, the following are also present: i) entomological part of surveillance is often performed by sectors/institutions with insufficiently trained staff (MoH program, part of VD and LG programs) so that vector identification is unreliable, which makes the results unusable; ii) detection of WNV virus in mosquitoes in MoH and LG programs is not confirmed by the national virology laboratory (this is an obligation in the VD surveillance program); and iii) in case of entomological surveillance of WNV organized by MoH institutions dealing with entomological surveillance and virus detection in mosquitoes also provides vector control services to the same local governments, leading to conflicts of interest and possible data manipulation. Data on spatial distribution and sources of funding are shown in Table 1 (sources: VD, Institute for Biocides, own data).

Monitoring of the most dangerous vector of arboviruses (viruses whose vectors are arthropods) in Europe, the invasive tropical mosquito, Asian tiger mosquito (*Aedes albopictus*) started through the projects of the Administration for Ecology of the City of Novi Sad, then the Provincial Secretariat for Science, and continued within the projects III 43007 and VectorNet (ECDC/EFSA). Due to the importance of the results for the international scientific community, Serbia was chosen as a participant in the regional project of the International Atomic Energy Agency (IAEA) in Vienna (RER5022 Establishing Genetic Control Programs for *Aedes* Invasive Mosquitoes). For the same reason, the Provincial Secretariat for Urbanism and Environmental Protection in 2018 started financing the first regional program for the surveillance of invasive vector species in Serbia. The program continued in 2019, but was suspended in 2020 due to the redirection of funds to combating COVID-19. This program has enabled us to expand the number of monitoring sites and increase the capacity for early detection of invasive species. The new monitoring sites were selected based on the results of research [5], in which using three mechanistic models with climate data from the regional climate EBU-POM model, was predicted that most of Serbia will become a much more suitable area for *Ae. albopictus* by the end of the century. The spatial resolution and accuracy of the maps obtained by regional analysis is higher than those available in the global models, which enables more accurate risk assessment and planning the surveillance oriented to habitats within which the main input routes and climate suitability are connected [5].

2.2.2 Tick Monitoring in Serbia

As far as we know, the only tick monitoring program (2018-2020) is limited to the Fruška gora National Park (Monitoring and control of ixodid ticks in the Fruška gora National Park. Autonomous Province of Vojvodina, Provincial Secretariat for Urbanism and Environmental Protection). All other activities are related to domestic or foreign research projects (TR31084, VectorNet and others) and are shown in Table 1 and Figure 7 (Snežana Tomanović and Aleksandar Jurišić oral communication).

2.2.3 Sandfly Monitoring in Serbia

Monitoring was carried out in the Vojvodina Province in the period 2013-2015 (after 60 years long negligence) within the research related to the preparation of the doctoral dissertation [28] and in other parts of Serbia within the VectoNnet project (ECDC/EFSA) in 2016 after 26 years of inactivity [29], [30] - Table 1and Figure 7.

The table below (Table 1) provides an overview of the surveillance of vectors in Serbia for the period 2015-2020, with indications related to the territorial level and method of financing

Table 1: Duration, scope and source of funding for vector surveillance in Serbia 2015 – 2019.

	2015		2016		2017		2018		2019	
District	Vector group*	Source**	Vector group*	Source**	Vector group*	Source**	Vector group*	Source**	Vector group*	Source**
Bor										
Braničevo	HM	MOH	HM	MOH	HM	MOH	HM	MOH	HM	MOH
City of Belgrade	T, HM	LG, MOH	T, HM	LG, MOH	T, HM	LG, MOH	T, HM	LG, MOH	T, HM	LG, MOH
Jablanica				P						
South Bačka	T,HM, IM, SF	PS, MA, MOH, P	T,HM, IM	PS, P, MOH	T,HM, IM	PS, MA, MOH	T,HM, IM	PS, P, MOH	T,HM, IM	PS, P, MOH
South Banat	HM,SF	PS, MA, MOH, P	HM, IM	PS, P, MOH	T,HM, IM	PS, MA, MOH	T,HM, IM	PS, P, MOH	HM, IM	PS, P, MOH
Kolubara			SF	P						
Mačva	T,HM, IM	LA, MOH	T, HM, IM, SF	LA, MOH, P	T,HM, IM	LA, MOH	T,HM, IM	LA, MOH	T,HM, IM	LA, MOH
Moravica			SF	P						
Nišava	HM	MOH	T, HM SF	P, MOH, P	HM	MOH	HM	MOH	HM	MOH
Pčinj	T	P	SF	P						
Pirot			T	P	T	P				
Danube	HM	MOH	T,HM	P,MOH	HM	MOH	HM	MOH	HM	MOH
Morava										
Rasina	HM	MOH	T,HM	MOH,P						
Raška			SF	P	T	P				
North Bačka	T,HM	P,MA, MOH	T,HM, IM	PS, P, MOH	T,HM, IM	PS, P, MOH	T,HM, IM	PS, P, MOH	T,HM, IM	PS, P, MOH
North Banat	T, HM, SF	PS, MA, P	T,HM, IM	PS, P	T,HM, IM	PS, MA	T,HM, IM	PS, P		PS, P, MOH
Middle Banat	HM, SF	PS, MA, MOH, P	HM, IM	PS, P, MOH	HM, IM	PS, MA, MOH	T,HM, IM	PS, P, MOH	T,HM, IM	PS, P, MOH
Srem	T, HM, IM, SF	PS, MA, P	T,HM, IM	PS, P	T,HM, IM	PS, MA	T,HM, IM	PS, P	T,HM, IM	PS, P
Šumadija			SF	P						
Toplica			SF	P						
Zaječar										
West Bačka	HM, IM, SF	PS, MA, MOH, P	HM, IM	PS, P, MOH	HM, IM	PS, MA, MOH	HM, IM	PS, P, MOH	HM, IM	PS, P, MOH
Zlatibor			SF	P						

** T - ticks; HM - home mosquito WV vector; IM - invasive mosquito; SF - sandfly*
*** MA - Ministry of Agriculture; MOH - Ministry of Health; P - national and international projects; LA - local authority*

2.2.4 Vector surveillance in Europe

These data were also shown in the maps published by ECDC and EFSA [31]–[33] in February this year (Figure 7). The maps show that Serbia is actively involved in reporting to ECDC and EFSA. In addition to the information provided in Table 1 and Figure 7 indicating whether or not surveillance is carried out, for Serbia and other countries that cooperated in the development of the map, data on the length of surveillance during the vector activity season are shown in a number of different calendar months s (Figure 8). For example, if the surveillance took place during August 2017 and 2018, it is shown as one calendar month, and if the surveillance took place during July and August 2017, it is shown as two calendar months.

From the table, it is clear that the intensity of surveillance is unevenly distributed across districts and groups of vectors, and that in some districts surveillance was rarely performed or was not performed at all. The ticks monitoring is of lower intensity than mosquito monitoring, and the sandflies monitoring was performed only in 2015 and 2016, as part of the projects. This situation can be explained by defining (VD veterinary surveillance of the WNV vector) or not-defining (MOH public health surveillance of the WNV vector) spatial categories with different levels of risk as well as sources of funding, i.e. different goals of research projects and programs of local governments. The same can be seen in other European countries (Figure 7 and Figure 8), where the intensity and seasonality of surveillance were determined by the dominance of certain groups of vectors, but also largely related to the orientation of the strongest and most active research groups (conclusion based on the author's knowledge).

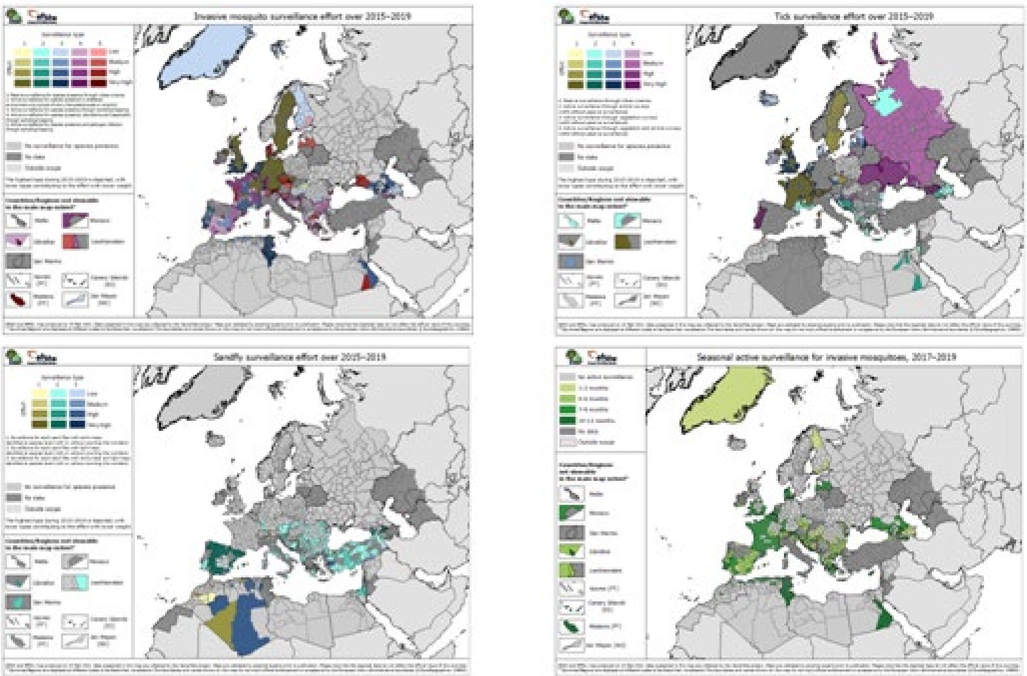

Figure 7: Prevalence of entomological surveillance vectors in Europe 2015 - 2019:
a) invasive mosquitoes, b) ticks, c) sandflies; d) seasonal coverage of invasive mosquito control [31]–[33]

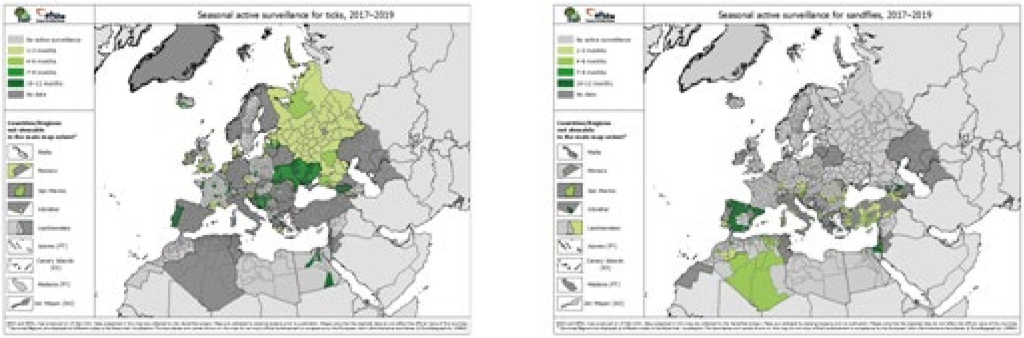

Figure 8: Seasonal coverage of entomological vector surveillance in Europe 2017 - 2019: a) ticks, b) sandflies [32], [33]

2.3 Gaps identified

In Serbia, there is no unified national program for the surveillance of vectors and transmissible diseases (infectious diseases transmitted by vectors, vector-borne diseases), nor the principles on which national, and then regional and local programs must be based. The existence of long-term surveillance programme, which includes scientifically conceived and guided data collection, modelling of risk and vulnerability, secure databases, quality assessment of vector control, assessment of economic impact and communication strategy, is necessary in order to be able to assess the impact of climate change on vectors and diseases they transmit, i.e. on human and animal health. Without understanding the influence of meteorological factors on long-term fluctuations in vector populations and the occurrence of vector-borne diseases, it is not possible to plan effective mitigation measures. Long term data are also the basis for developing risk assessment models that then feedback improving and rationalising entomological surveillance programs.

2.3.1 Monitoring and Surveillance

In the area of monitoring and surveillance, there is a clear lack of a unified science-based program at the national level that would serve as a guideline for the development of regional and local programs. There is also a gap in the intensity and uneven distribution of surveillance by districts and groups of vectors (Table 1). The surveillance on ticks is of lower intensity than on mosquitoes, and the surveillance of sandflies was performed only in 2015 and 2016, as part of research projects. This situation can be explained by defining (surveillance of the WNV vector by the Veterinary Directorate) or non-defining (surveillance of the WNV vector by the Ministry of Health) spatial categories with different levels of risk as well as by sources of funding, i.e. different goals of scientific research projects and programs of local governments (Table 1).

Also, one of the basic shortcomings of the system of monitoring vectors and diseases they transmit in Serbia is the non-existence or insufficiently strong (legally regulated) connection between monitoring and the action that should follow, i.e. vector control. This particularly jeopardizes the implementation of mitigation measures.

2.3.2 Predicting Changes in the Short and Long Term

In this segment, education of users at all levels is needed, from decision makers to contractors and citizens on the need to include models for predicting changes and risks they bring, as well as vector suppression models in order to create a platform for implementing effective mitigation measures. It is also necessary to legally formalize the link between the sectors of meteorology, medical entomology, veterinary medicine, public health, and ecology according to the principles of "One Health". Only in this way will it be possible to efficiently solve complex and pressing problems related to vectors and diseases they transmit.

2.3.3 Database

There is no national database of quality and curated entomological and epidemiological data related to vectors and diseases they transmit in Serbia. The development of this database began in 2019 in Vojvodina within the Special Program in the field of public health for the territory of AP Vojvodina, whose fourth task is "Integrated monitoring and surveillance of transmissible anthropozoonoses on the territory of AP Vojvodina." The key partners in the development of the program task are the Institute of Public Health of Vojvodina, Clinical Center of Vojvodina - Clinic for Infectious Diseases, Scientific Institute of Veterinary Medicine “Novi Sad”, University of Novi Sad - Faculty of Agriculture, Laboratory for Medical and Veterinary Entomology and Laboratory for Infectious Diseases and Zoonoses. Other participants are 6 Institutes of Public Health, 4 Veterinary Specialist Institutes and 9 General Hospitals in the territory of AP Vojvodina. In addition to entomological and epidemiological data, the database should enable the storage of relevant economic indicators that would serve to improve and rationalize the system.

It is necessary to form an open (with different levels of data access) database of quality and curated (verified) data at the national level.

2.3.4 Vector Control

There are no mandatory measures for quality assurance (expert evaluation of vector control programmes) nor quality control (expert evaluation treatment efficiency) in Serbia.

2.3.5 Economic Effects

The diligent recording and analysis of all costs related to impact of the vectors and diseases they transmit on national economy does not exist in Serbia. Recording the costs of monitoring/surveillance, modeling and control, through the costs of disrupting normal work activities, losses in the tourism and food production sectors and the costs of hospitalisation (lost lives?) and absences from work due to epidemics is necessary for better understanding of impact and acceptance by the relevant government institutions.

2.3.6 Communication and Data Availability

The scope and methodologies of vector surveillance vary widely between areas, local situations, and scenarios. Consequently, approaches to data communication and communication content will also differ. In general, precautions should be taken to avoid misinterpretations of surveillance results and identified risk levels.

Such a system has not yet been developed in Serbia.

3 Methodology

The analysis of the impact of climate change is based on the assessment of: (i) current suitability of climatological factors for the development and distribution of vectors (together with the current level of vulnerability); (ii) projected suitability of climatological factors for vector development and distribution.

The risk index defined by the multi-criteria decision analysis model (MCDA index) in the interval from 0 to 100 [dimensionless unit] was chosen as the unit of measurement for vector development and distribution. A description of the model and methodology is presented in more detail in Annex 1 of this report.

Input parameters were selected based on literature and expert opinion [5], [16], [34]–[45] and represent the empirical functions of the main factors influencing the activity, development and distribution of vectors: (i) mean annual air temperature; (ii) total annual rainfall; (iii) number of days with precipitation > 0.1 mm; (iv) distance from floodplains and larger areas of natural waters; (v) mean air temperature in the period from October to April; (vi) average air temperature in the period from June to August; (vii) population density determined by remote observations of night illumination; (viii) mean monthly air temperature for January; (x) mean air temperature from April to May; (x) mean air temperature in the period from December to February; (xi) average rainfall in the period from March to June. The model for climate impact analysis for vector development and distribution for Serbia has been confirmed in two international papers [5], [37], and is based on the methodology of the European Centre for Disease Prevention and Control, ECDC [38].

The analyzed vector types were selected as having one or both of the following characteristics: (i) that they are vectors of the most significant vector-borne diseases for Serbia; and (ii) that changes in their numbers and distribution have been observed in recent years (Table 2).

Table 2: Vectors of the most significant vector-borne diseases for Serbia for which changes in the number and distribution have been observed in recent year

Vector species	Group	Common name	The most significant vector-borne diseases transmitted to humans
Ixodes ricinus	Ticks	-	Lyme disease and tick-borne encephalitis
Culex pipiens	Mosquitoes	House mosquito	West Nile fever
Aedes albopictus	Mosquitoes	Asian tiger mosquito	Dengue, chikungunya, zika
Anopheles hyrcanus	Mosquitoes	Malaria mosquito	Malaria
Phlebotomus papatasi	Sandflies	Sandfly	Leishmaniasis and sandfly fever

Adaptations for the vector sector and the diseases they transmit do not exist at the national, regional or local level in Serbia, and there are no differences in vulnerability between and within these levels. In this situation, vulnerability is practically equated with risk. Thus, in the analysis of the impact of climate change on the sector, we will use the terms "MCDA risk index" and "vulnerability" accordingly in the following text.

The term vulnerability refers to the analysis of several factors that together contribute to the risk of people contracting vector-borne diseases, namely: (i) climate suitability leading to the increase or decrease of the territory in which the vector can live, including altitude at which it can transmit a disease to humans; (ii) the length of the season when the vector is active during the year, bearing in mind that the longer the season, the greater the possibility of disease transmission (the longer the period when the vector feeds on blood and can transmit the disease to humans); (iii) vector abundance that directly depends on the length of the season (the more vectors, the higher the probability of transmitting the disease to humans).

The degree of vulnerability is mathematically defined through the MCDA risk index as: (i) 0 - 25: very low vulnerability; (ii) 25 - 50: low vulnerability; (iii) 50 - 75: moderate vulnerability; (iv) 75 - 100: high vulnerability. Areas for which the MCDA risk index is zero (MCDA = 0) can be interpreted as absolutely unsuitable for vector overwintering and survival, i.e. the vector does not have the capacity to inhabit there. Areas of very low and low vulnerability (MCDA < 50) are areas where the expected probability of the vector becoming established is small. Even if settlement were to occur, the expected number of active weeks, the number of generations, and the total population of the vector would be significantly lower compared to areas characterized by moderate and high vulnerability. This directly affects the reduced probability of disease transmission from the vector to humans, i.e. risk of transmitting the infection.

The analysis was done for the reference period 1971-2000 and three future periods 2011-2040, 2041-2070, 2071-2100 for RCP45 (intermediate emission scenario) and RCP85 (high emission scenario), which are defined in the 5th IPCC report [46].

According to the EEA classification, indicators related to the vector sector and the diseases they transmit belong to the first group: Descriptive indicators (type A) that answer the question:

What is happening? The indicator codes are CLIM 037, and the indicators are: (i) presence or absence of various vectors and infections (without unit of measure) and (ii) climatic suitability for vector spread and disease transmission, in our text vulnerability (0-100).

European Union documents related to the vector sector and the diseases they transmit: (i) 7th Environment Action Programme; (ii) Climate-ADAPT: Adaptation in EU policy sectors; (iii) DG CLIMA: Adaptation to climate change и (iv) EU Adaptation Strategy Package.

4 Expected impacts

This chapter presents the results of the risk and vulnerability analysis of the health sector of the Republic of Serbia for the period from 1971 to 2000 (reference period) and three future periods (2011-2040, 2041-2070, 2071-2100), for the following vector species and vector-borne diseases: i) *Culex pipiens* biotype *pipiens*: a biotype of the common house mosquito that feeds on the blood of birds and transmits WNV from bird to bird in the wild; (ii) *Culex pipiens* biotype *molestus*: another biotype of the common house mosquito that feeds on human blood, and in urban areas is important for the transmission of WNV from birds to humans; (iii) *Aedes albopictus*: Asian tiger mosquito, transmits dengue, chikungunya and zika viruses and canine heartworm; (iv) *Anopheles hyrcanus*: malaria mosquito; (v) *Ixodes ricinus*: a species of tick that transmits Lyme disease and tick-borne encephalitis; (vi) *Phlebotomus papatasi*: sandflies, carrier of leishmaniasis and papatachi fever. Vulnerability is shown through the MCDA risk index on a scale of 1-100 with the following vulnerability categories: (i) 0 - 25: very low vulnerability; (ii) 25 - 50: low vulnerability; (iii) 50 - 75: moderate vulnerability; (iv) 75 - 100: high vulnerability.

4.1 Culex pipiens: house mosquito, transmits the West Nile virus and the dog heartworm

Within this species, there are three ecological forms/biotypes that share a role in the transmission of WNV. Individuals of the *pipiens* biotype are anautogenic (females cannot lay eggs without feeding on blood), ornithophilic (females feed on the blood of birds), eurygamous (males make swarms to mate with females) and have winter diapause (do not feed) in conditions of temperate climate. They live in nature, outside the settlements and are important for the amplification of the virus by transmission from bird to bird. Individuals of the second biotype of *molestus* are autogenic (can lay the first egg without feeding on blood), mammophilic (females feed on mammalian blood), stenogamous (males mate without swarming, in small spaces, even in a space of 1cm3 - Petrić D. unpublished data) and have a mandatory diapause (they can feed during the winter if temperatures are above 10 °C). Individuals of this biotype develop in settlements and their immediate vicinity, not further than 200-500 m). There is also a third, hybrid form that serves as a bridge to transmit the WNV from birds to horses and humans. It also inhabits urban areas where it feeds on the blood of birds, humans and animals.

Culex pipiens is a native vector species throughout Europe, and one of the most common mosquito species in Serbia, present in rural and urban areas. It is characterized by a high level of ecological adaptation and can transmit a large number of vector-borne diseases (e.g. WNV, *Dirofilaria* spp.). For the transmission of West Nile virus, amplification of the virus in nature (number of individuals of the biotype *pipiens*) and overflowing into urban areas (number of hybrid forms directly related to the number of *molestus* biotypes) are important, details are given in Annex 1. Due to this complex situation related to the WNV vector, we did a vulnerability prediction for both biotypes, including the differences that characterize them in the models. We decided to do this because of results that were obtained in previous research by Petrić et al. [7]: using Ripley's K-function and Average Nearest Neighbor analysis, the existence of 346 statistically significant groupings of infected mosquitoes, wild birds, horses and humans was proven for observations collected in 2014 (ANN = 0.463375, z-score : -11.705051, p-value: 0.000000) and 2015 (ANN = 0.671317, z-score: -348 4.356416, p-value: 0.000013). Directional Distribution analysis showed that the largest number of a total of 349 cases of infected animals and humans in both years was distributed along the Danube and Tisa basins, where the two *Cx. pipiens* species biotypes are found closest (Figure 9).

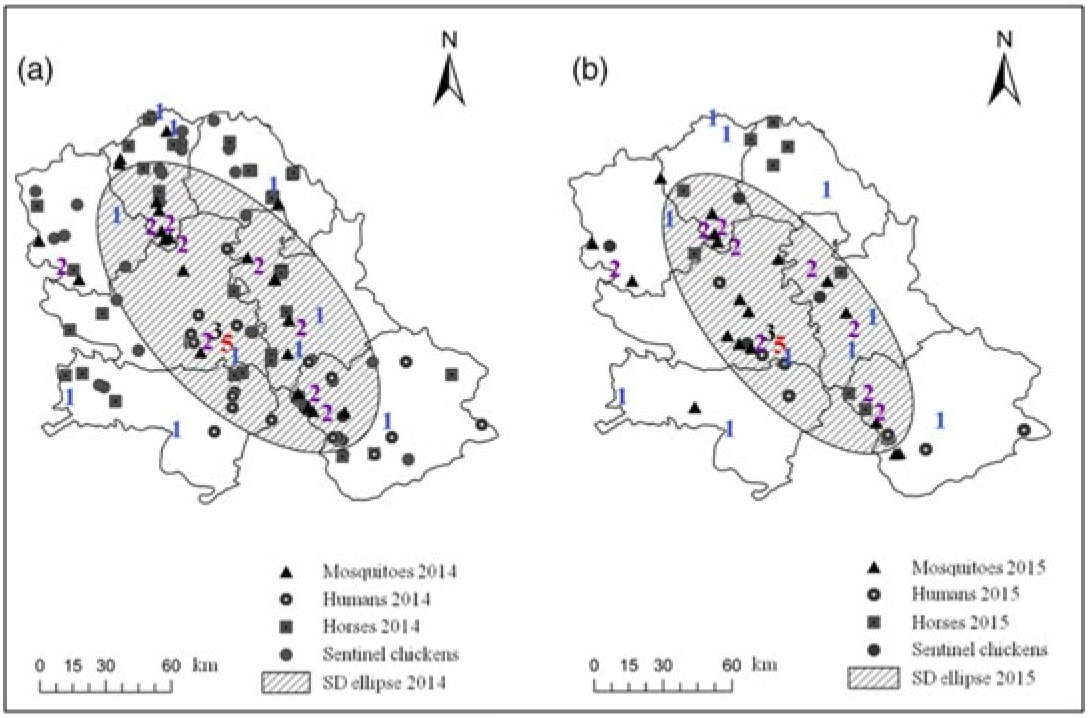

Figure 9: Frequency of sampling of mosquitoes infected with WNF (1–5 times, colored numbers) during the period 2010–2016, covered with a layer of recorded cases of mosquitoes, birds, horses and people infected with WNF in (a) 2014 and (b) 2015. The standard deviation ellipse (1-σ) is centered around the mean coordinates of the total number of mosquitoes, birds, horses, and humans infected with WNF (modified according to [7]). https://doi.org/10.1371/journal.pone.0227679.g005

Females of the complex *Cx. pipiens* contribute to the virus amplification cycle in vertebrates such as birds in the case of West Nile virus and contribute to the infection of humans and other mammals. The West Nile virus is transmitted by the bite of an infected mosquito that previously fed on the blood of birds. Birds are considered "amplifiers" of the virus due to a long period of high viremia, while humans and horses are the so-called "blind hosts". Due to the short period of low viremia, mosquitoes cannot transmit the virus from infected people and horses.

Culex pipiens is a major vector of WNF and Usutu virus. Among other things, it has the capacity to transmit multiple arboviruses such as Rift Valley Fever [47], Japanese encephalitis [47], Syndbis virus [48], Tahina virus [49], as well as avian malaria [50]–[52] and nematodes of the genus *Dirofilaria*. Of these diseases, based on the current intensity of vulnerability, WNF is the most important for Serbia. There is no vaccine against West Nile virus, the most effective measure to prevent the outbreak and spread of the epidemic is the control of house mosquitoes.

West Nile virus has been present in Europe for the last 30 years [53]. In Serbia, West Nile virus was first detected in the horse population in 2009, the first detection of the virus in mosquitoes was in 2010, while the first human case and the first case in wild birds were registered in 2012. In 2018, Serbia was the second country in Europe, after Italy, in terms of the number of cases of the West Nile virus, with 415 reported cases and 35 deaths.

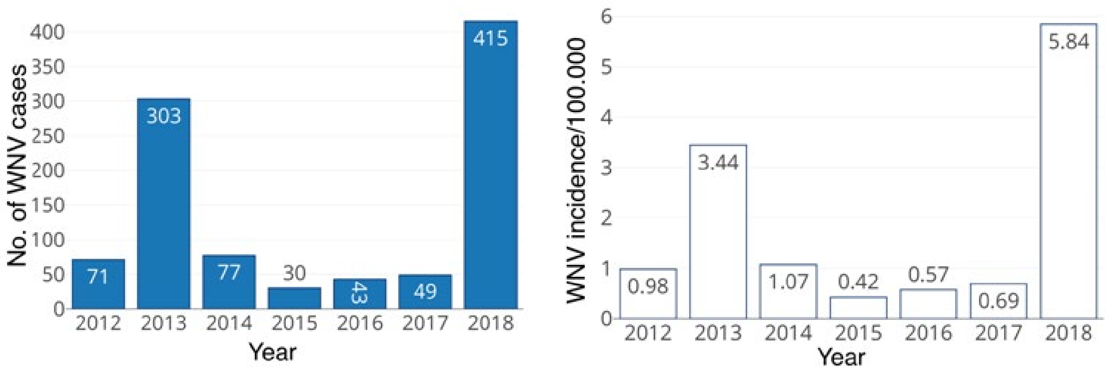

Figure 10: Data on the number of patients and incidence/100,000 West Nile fever from the Batut Report on Infectious diseases in the Republic of Serbia for 2018

Culex pipiens biotype pipiens: a biotype of the house mosquito that feeds on the blood of birds and transmits WNV from bird to bird in the wild

This chapter presents the main results of the risk and vulnerability analysis for the vector *Culex pipiens pipiens* for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 11) and the high emission scenario, RCP85, (Figure 12). The lower panel of both figures shows the relative deviation of the projected MCDA risk index in relation to the reference period (1971-2000), i.e. the expected percentage increase in risk for three future periods.

Current Vulnerability Assessment (1971-2000)

The current vulnerability for the *Culex pipiens* vector biotype *pipiens* in the period 1971-2000 was characterized by a risk index ranging from 59.83 (moderate vulnerability) to 86.46 (high vulnerability) with a mean of 75.56 (σ = 5.85) for the RCP45 scenario (Figure 11); and ranging from 60.01 (moderate vulnerability) to 86.62 (high vulnerability) with a mean of 75.74 (σ = 6.27) for the RCP85 scenario (Figure 12). The climatic parameters that had the greatest impact on the output variability of the MCDA climate suitability model for *Culex pipiens* biotype *pipiens* are from the most significant to the least significant: (i) Distance from floodplains of larger rivers; (ii) Mean air temperature for the period October to April; (iii) Mean annual air temperature; (iv) Distance from surfaces of stagnant natural waters (ponds/lakes); (v) Total annual rainfall; (vi) Mean air temperature for the period from June to August; (vi) Number of days with rainfall > 0.1 mm.

Risk and vulnerability assessment for the period 2011 - 2040

Vulnerability for the vector *Culex pipiens* biotype *pipiens* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 62.03 (moderate vulnerability) to 90.16 (high vulnerability) with a mean value of 80.13 (σ = 6.35) for the RCP45 scenario (Figure 11); and ranging from 61.27 (moderate vulnerability) to 90.41 (high vulnerability) with a mean of 80.50 (σ = 6.87) for the RCP85 scenario (Figure 12). The projected change in the risk index across all districts ranges from 4.57 to 17.83% (the change in risk per district is given in Annex 1, Figure A 4)

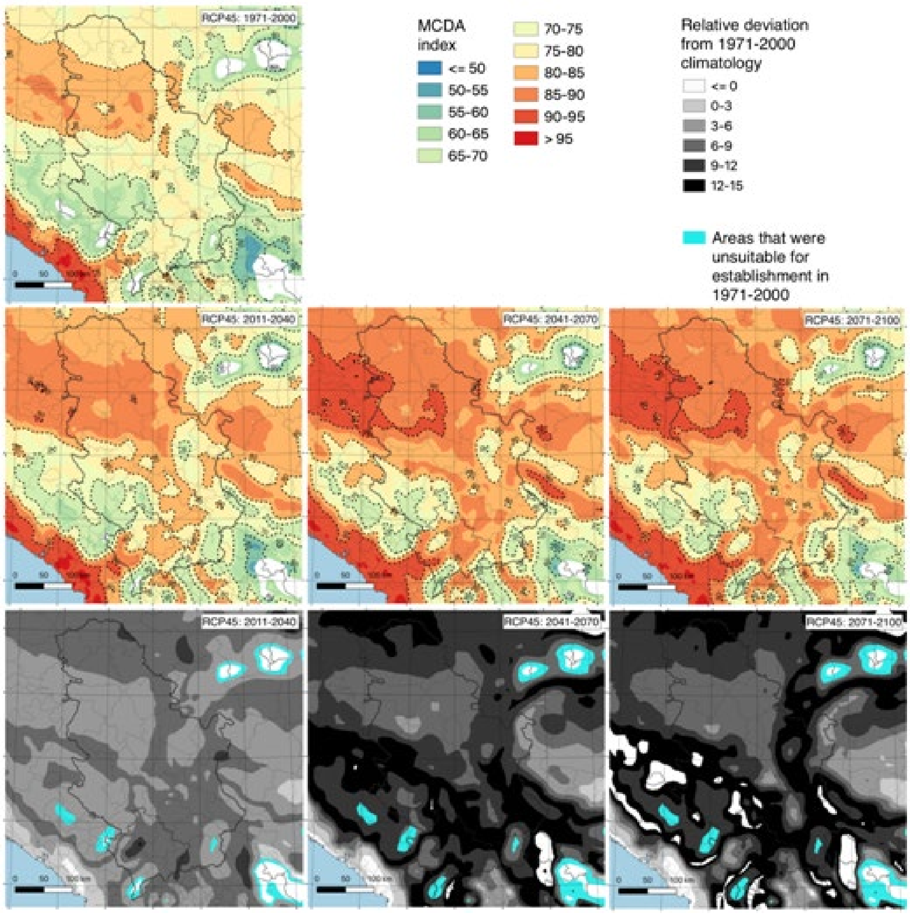

Figure 11: MCDA risk index for the RCP45 scenario for Culex pipiens biotype pipiens for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index from the reference climatology (1971-2000) [%]

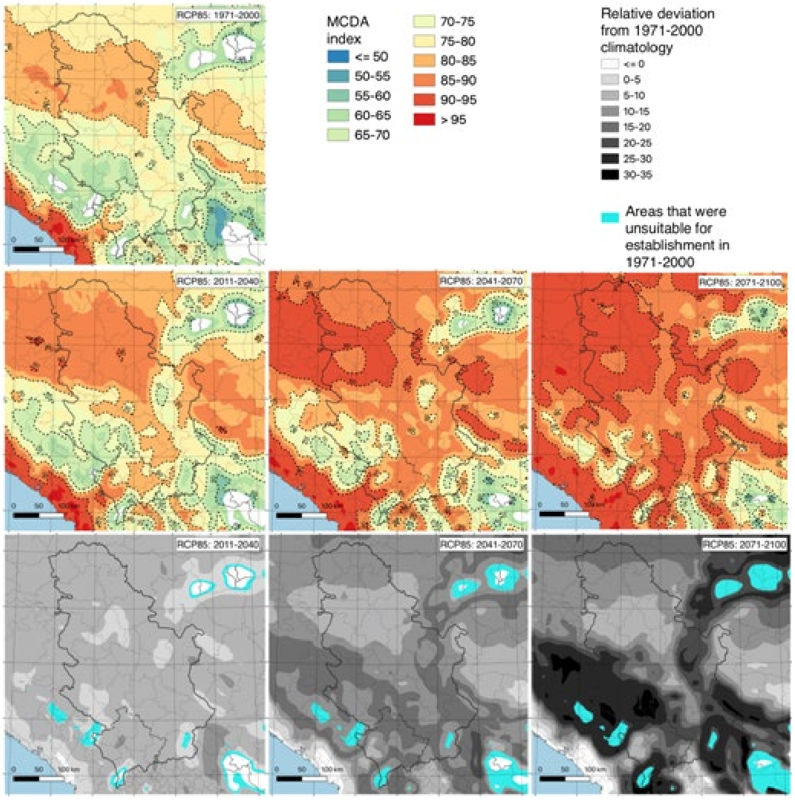

Figure 12: MCDA risk index for the RCP85 scenario for Culex pipiens biotype pipiens for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

Risk and vulnerability assessment for the period 2041 - 2070

Vulnerability for the vector *Culex pipiens* biotype *pipiens* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 62.54 (moderate vulnerability) to 92.56 (high vulnerability) with a mean of 83.17 ($\sigma = 5.89$) for the RCP45 scenario (Figure 11); and ranging from 63.17 (moderate vulnerability) to 93.57 (high vulnerability) with a mean of 85.17 ($\sigma = 5.91$) for the RCP85 scenario (Figure 12). The projected change in the risk index across all districts ranges from 6.77 to 26.37% (the change in risk per district is given in Annex 1, Figure A 7)

Risk and vulnerability assessment for the period 2070 - 2100

Vulnerability for the vector *Culex pipiens* biotype *pipiens* in the period 2071-2100 for Serbia was characterized by a risk index ranging from 63.29 (moderate vulnerability) to 92.74 (high vulnerability) with a mean of 83.44 ($\sigma = 5.73$) for the RCP45 scenario (Figure 11); and ranging from 67.87 (moderate vulnerability) to 95.06 (high vulnerability) with a mean of 88.56 ($\sigma = 4.02$) for the RCP85 scenario (Figure 12). The projected change in the risk index across all districts ranges from 7.03 to 35.41% (the change in risk per district is given in Annex 1, Figure A 9).

Culex pipiens biotype molestus: the biotype of the house mosquito that feeds on human blood, and in urban areas is important for the transmission of WNV from birds to humans

This chapter presents the main results of the risk and vulnerability analysis for the *Culex pipiens molestus* vector for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 13) and the high emission scenario, RCP85, (Figure 14). The lower panel of both figures shows the relative deviation of the projected MCDA risk index in relation to the reference period (1971-2000), i.e. the expected percentage increase in risk for three future periods.

Current Vulnerability Assessment (1971-2000)

The current vulnerability for the *Culex pipiens* biotype *molestus* vector in the period 1971-2000 was characterized by a risk index ranging from 59.81 (moderate vulnerability) to 87.85 (high vulnerability) with a mean of 77.09 (σ = 6.31) for the RCP45 scenario (Figure 13); and ranging from 52.29 (moderate vulnerability) to 87.96 (high vulnerability) with a mean of 77.29 (σ = 6.73) for the RCP85 scenario (Figure 14).

The climatic parameters that had the greatest impact on the output variability of the MCDA climate suitability model for *Culex pipiens* biotype *molestus* are from most significant to least significant: (i) Mean air temperature for the period October to April; (ii) Mean annual air temperature; (iii) Total annual rainfall; (iv) Population density; (v) Number of days with rainfall > 0.1 mm; (vi) Mean air temperature for the period from June to August.

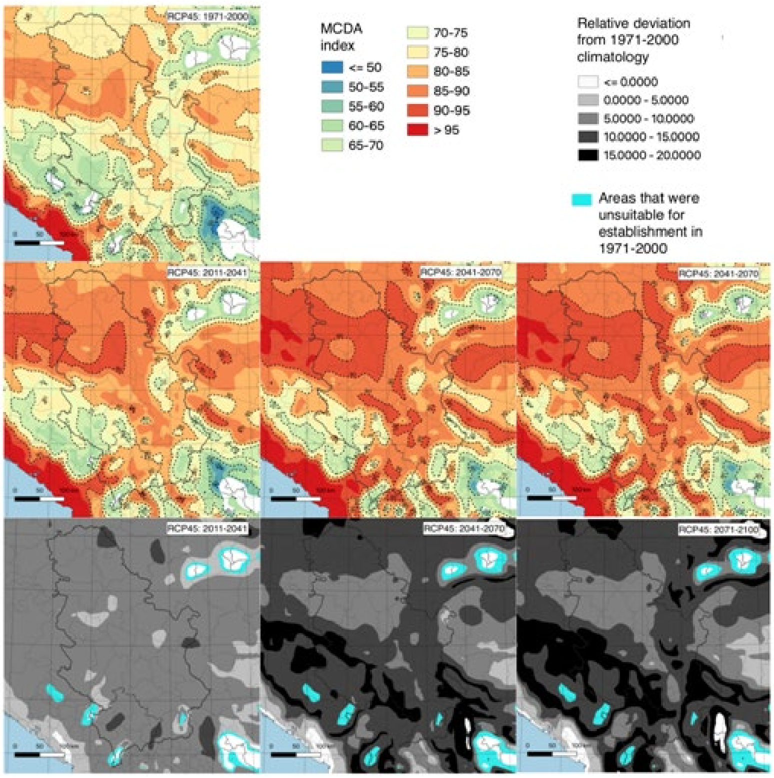

Figure 13: MCDA risk index for the RCP45 scenario for Culex pipiens biotype molestus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

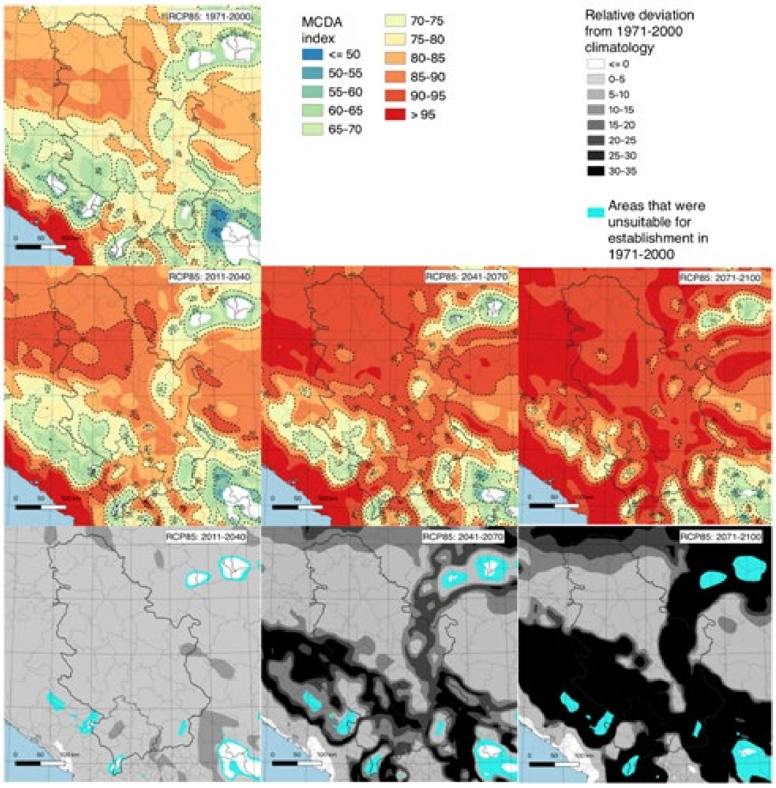

Figure 14: MCDA risk index for the RCP85 scenario for Culex pipiens biotype molestus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

Risk and vulnerability assessment for the period 2011 - 2040

Vulnerability for the vector *Culex pipiens* biotype *molestus* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 60.43 (moderate vulnerability) to 92.35 (high vulnerability) with a mean value of 82.40 (σ = 6.94) for the RCP45 scenario (Figure 13); and ranging from 59.82 (moderate vulnerability) to 92.57 (high vulnerability) with a mean of 82.84 (σ = 7.52) for the RCP85 scenario (Figure 14). The projected change in the risk index across all districts ranges from 5.21 to 18.37% (the change in risk per district is given in Annex 1, Figure A 12).

Risk and vulnerability assessment for the period 2041 - 2070

Vulnerability for the vector *Culex pipiens* biotype *molestus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 61.65 (moderate vulnerability) to 95.09 (high vulnerability) with a mean of 85.94 (σ = 6.53) for the RCP45 scenario (Figure 13); and ranging from 62.22 (moderate vulnerability) to 96.15 (high vulnerability) with a mean of 88.28 (σ = 6.54) for the RCP85 scenario (Figure 14). The projected change in the risk index across all districts ranges from 7.72 to 28.25% (the change in risk per district is given in Annex 1, Figure A 14).

Vulnerability for the vector *Culex pipiens* biotype *molestus* in the period 2071-2100 for Serbia was characterized by a risk index ranging from 62.44 (moderate vulnerability) to 95.28 (high vulnerability) with a mean of 86.25 (σ = 6.31) for the RCP45 scenario (Figure 13); and ranging from 68.87 (moderate vulnerability) to 97.71 (high vulnerability) with a mean of 92.25 (σ = 4.41) for the RCP85 scenario (Figure 14). The projected change in the risk index across all districts ranges from 8.05 to 38.69% (the change in risk per district is given in Annex 1, Figure A 16).

4.2 *Aedes albopictus*: Asian tiger mosquito, transmits dengue, chikungunya and zika viruses and canine heartworm

Aedes albopictus is an invasive tropical mosquito species known as the Asian tiger mosquito; its spread in the temperate zone is largely determined by climate change and human activity [6]. *Aedes albopictus* originates from the subtropical zone in Southeast Asia. In recent decades, the vector has spread to many countries around the world [15]. The larvae of this vector develop in water reservoirs of natural and human origin. This type of behavior coupled with resistance to drought conditions during embryo development in the egg has contributed to the spread of this vector through international transport and trade to countries with continental climates. The most probable model of transport is through the trade of used tires and the "lucky bamboo" plant (*Dracaena* sp.) [54].

Globally, *Ae. albopictus* is considered a potential vector for a large number of pathogens that can affect human and animal health (eg, chikungunya, dengue, Japanese encephalitis, zika, Rift Valley, and the nematode *Dirofilaria* spp.) [55], [56]. In Europe, this vector species is considered the main vector of dengue and chikungunya viruses. Documented cases of transmission of dengue and chikungunya viruses, but also zika virus [57], were recorded in the period from 2007 to 2020 in Croatia, France, Italy and Spain [58]–[61]. There is no vaccine against the dengue, chikungunya and zika viruses, and the most effective measure to prevent an outbreak and the spread of the epidemic is to control their vector, the Asian tiger mosquito.

In Serbia, this vector has been detected every year since its presence was first registered (2009-2020). The Asian tiger mosquito was first registered in 2009 in the Srem district (on the border with Croatia) [6]. According to the data we obtained through active and passive ("citizen science“, [62], [63]) surveillance, *Ae. albopictus* settled in Batrovci, Adaševci, Ruma, Novi Sad, Loznica, Lešnica, Banja Koviljača, Apatin, Belgrade, Valjevo and Niš. In September 2015, the first case of dengue in Serbia was registered in Kać [26]. This chapter presents the main results of the risk and vulnerability analysis for the vector *Aedes albopictus* for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 15) and the high emission scenario, RCP85, (Figure 16). The lower panel of both figures shows the relative deviation of the projected MCDA risk index in relation to the reference period (1971-2000), i.e. the expected percentage increase in risk for three future periods.

Current Vulnerability Assessment (1971-2000)

Current vulnerability for the *Ae. albopictus* vector in the period 1971-2000 ranged from 50.66 (moderate vulnerability) to 75.54 (high vulnerability) with a mean of 65.48 ($\sigma = 3.19$) for the RCP45 scenario (Figure 15); and from 50.93 (low vulnerability) to 75.63 (high vulnerability) with a mean of 66.13 ($\sigma = 3.65$) for the RCP85 scenario (Figure 16).

The climatic parameters that had the greatest impact on the output variability of the MCDA climate suitability model for *Aedes albopictus* are from the most significant to the least significant: (i) Mean annual air temperature; (ii) Mean January air temperatures; (iii) Number of days with precipitation > 0.1 mm; (iv) Population density; (v) Total annual rainfall; (vi) Mean air temperatures for the period from June to August.

Risk and vulnerability assessment for the period 2011- 2040

Vulnerability in the presence of the vector *Ae. albopictus* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 55.97 (moderate vulnerability) to 81.99 (high vulnerability) with a mean value of 70.79 ($\sigma = 3.71$) for the RCP45 scenario (Figure 15); and ranging from 55.37 (moderate vulnerability) to 81.59 (high vulnerability) with a mean of 70.42 ($\sigma = 3.72$) for the RCP85 scenario (Figure 16). The projected change in the risk index across all districts ranges from 4.77 to 72.95% (change in risk per district is given in Annex 1, Figure A19).

Risk and vulnerability assessment for the period 2041 - 2070

Vulnerability for the vector *Aedes albopictus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 60.00 (moderate vulnerability) to 87.09 (high vulnerability) with a mean value of 75.99 ($\sigma = 4.19$) for the RCP45 scenario (Figure 15); and ranging from 60.80 (moderate vulnerability) to 88.49 (high vulnerability) with a mean value of 76.72 ($\sigma= 4.69$) for the RCP85 scenario (Figure 16). The projected change in the risk index across all districts ranges from 13.43 to 149.03% (change in risk per district is given in Annex 1, Figure A 21).

Risk and vulnerability assessment for the period 2071 - 2100

Vulnerability for the vector *Aedes albopictus* in the period 2071-2100 for Serbia was characterized by a risk index ranging from 64.19 (moderate vulnerability) to 91.40 (high vulnerability) with a mean of 79.49 ($\sigma = 4.76$) for the RCP45 scenario (Figure 15); and ranging from 65.69 (moderate vulnerability) to 93.50 (high vulnerability) with a mean of 82.13 ($\sigma = 4.52$) for the RCP85 scenario (Figure 16). The projected change in the risk index across all districts ranges from 19.63 to 176.67% (change in risk per district is given in Annex 1, Figure A 23).

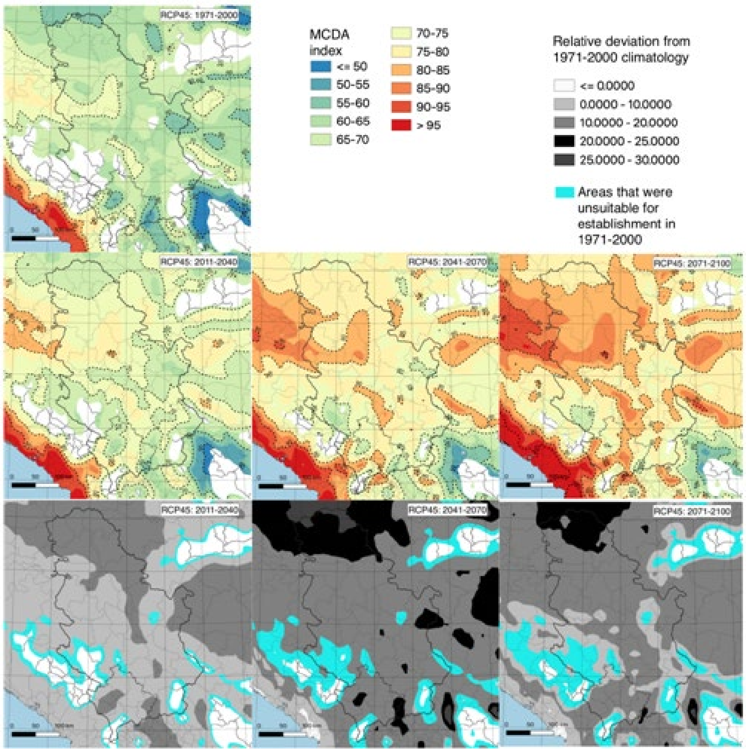

Figure 15: MCDA risk index for the RCP45 scenario for Aedes albopictus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

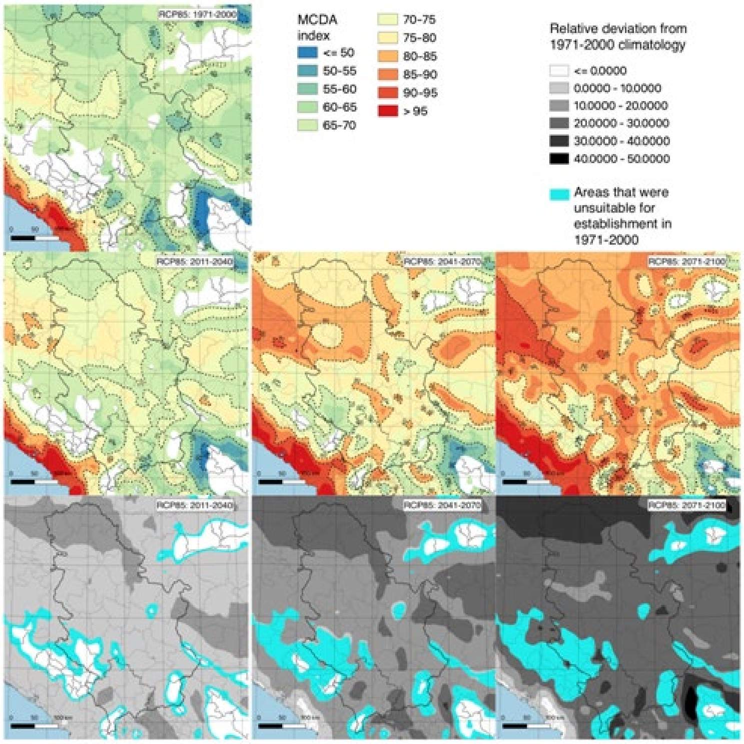

Figure 16: MCDA risk index for the RCP85 scenario for Aedes albopictus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

4.3 Anopheles hyrcanus: transmits malaria

Anopheles hyrcanus is predominantly distributed along the southern belt of the Palearctic zone and Oceania. It has the capacity to transmit the *Plasmodium vivax* parasite that can cause malaria in infected people.

Only mosquitoes of the genus Anopheles can transmit malaria, which together with tuberculosis and HIV is one of the three most dangerous infectious diseases that annualy take more than 2,500,000 human lives in the world. In Serbia, until the moment when it was eradicated (1974), malaria was transmitted exclusively by species from the *Anopheles maculipennis* complex. Since 1974, only imported cases of this disease have been registered in Serbia. Due to the tendency to feed exclusively outdoors, outside residential buildings, *An. hyrcanus* was not considered the primary vector of malaria in Europe. However, the settlement of vectors in areas with greater latitude combined with changes in human activity, potential longer periods of stay in nature, and population migrations, *An. hyrcanus* could become a significant vector of malaria in Serbia and other areas with temperate climates. There is no vaccine against Plasmodium malaria, the most effective measure to prevent the outbreak and spread of the epidemic is the control of mosquitoes of the genus *Anopheles*.

Until the end of the 20th century, Serbia was considered the northern border of the distribution of *An. hyrcanus* vectors in Europe. The mosquito was first detected in Serbia in 1979 [64], in the northern part of the autonomous province of Vojvodina. The mosquito was registered in the central part of the province in 1985 [45], after which a continuous increase in the vector population was recorded. *Anopheles hyrcanus* has been detected north of Vojvodina on several occasions: in Slovakia in, 2004 [65], in the Czech Republic in 2005 [66], and in Austria in 2012 [35].

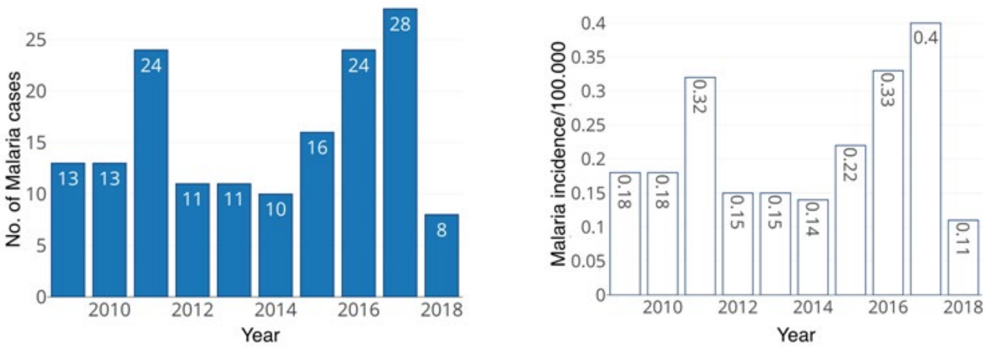

Figure 17: Data on the number of malaria cases and incidence/100,000 from Batut's Report on Infectious diseases in the Republic of Serbia for 2018.

This chapter presents the main results of the risk and vulnerability analysis for the vector *Anopheles hyrcanus* for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 18) and the high emission scenario, RCP85, (Figure 19). The lower panel of both figures shows the relative deviation of the projected MCDA risk index in relation to the reference period (1971-2000), i.e. the expected percentage increase in risk for three future periods.

Current Vulnerability Assessment (1971 -2000)

Current vulnerability for the vector *An. hyrcanus* in the period 1971–2000 was characterized by a risk index ranging from 45.69 (low vulnerability) to 74.19 (moderate vulnerability) with a mean of 64.40 (σ = 4.59) for the RCP45 scenario (Figure 18); and ranging from 46.34 (low vulnerability) to 74.11 (moderate vulnerability) with a mean of 64.90 (σ = 4.54) for the RCP85 scenario (Figure 19). Climatic parameters that had the greatest influence on the output variability of the MCDA model of climate suitability for *An. hyrcanus* are from the most significant to the least significant: (i) Distance from the floodplains of major rivers; (ii) Mean annual air temperature; (iii) Mean January air temperatures; (iv) Distance from surfaces of stagnant natural waters (ponds/lakes); (v) Total annual rainfall; (vi) Mean air temperatures for the period from June to August; (vii) Number of days with precipitation > 0.1 mm; (viii) Population density.

Risk and vulnerability assessment for the period 2011 - 2040

Vulnerability for the vector *An. hyrcanus* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 47.63 (moderate vulnerability) to 75.77 (high vulnerability) with a mean value of 66,415 (σ = 4.58) for the RCP45 scenario (Figure 18); and ranging from 47.79 (low vulnerability) to 75.62 (high vulnerability) with a mean of 66.93 (σ = 4.64) for the RCP85 scenario (Figure 19). The projected change in the risk index across all districts ranges from 2.11 to 129.37% (the change in risk per district is given in Annex 1, Figure A 26).

Risk and vulnerability assessment for the period 2041 - 2070

Vulnerability for the vector *An. hyrcanus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 47.84 (low vulnerability) to 78.49 (high vulnerability) with a mean value of 68.53 (σ = 4.69) for the RCP45 scenario (Figure 18); and ranging from 48.75 (moderate vulnerability) to 78.86 (high vulnerability) with a mean of 69.30 (σ = 4.87) for the RCP85 scenario (Figure 19). The projected change in the risk index across all districts ranges from 4.15 to 248.01% (the change in risk per district is given in Annex 1, Figure A 28).

Risk and vulnerability assessment for the period 2070 - 2100

Vulnerability for the vector *An. hyrcanus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 47.57 (moderate vulnerability) to 77.86 (high vulnerability) with a mean value of 67.08 (σ = 4.18) for the RCP45 scenario (Figure 18); and ranging from 52.22 (moderate vulnerability) to 83.21 (high vulnerability) with a mean of 73.36 (σ = 4.9) for the RCP85 scenario (Figure 19). The projected change in the risk index across all districts ranges from 2.66 to 274.54% (the change in risk per district is given in Annex 1, Figure A 30).

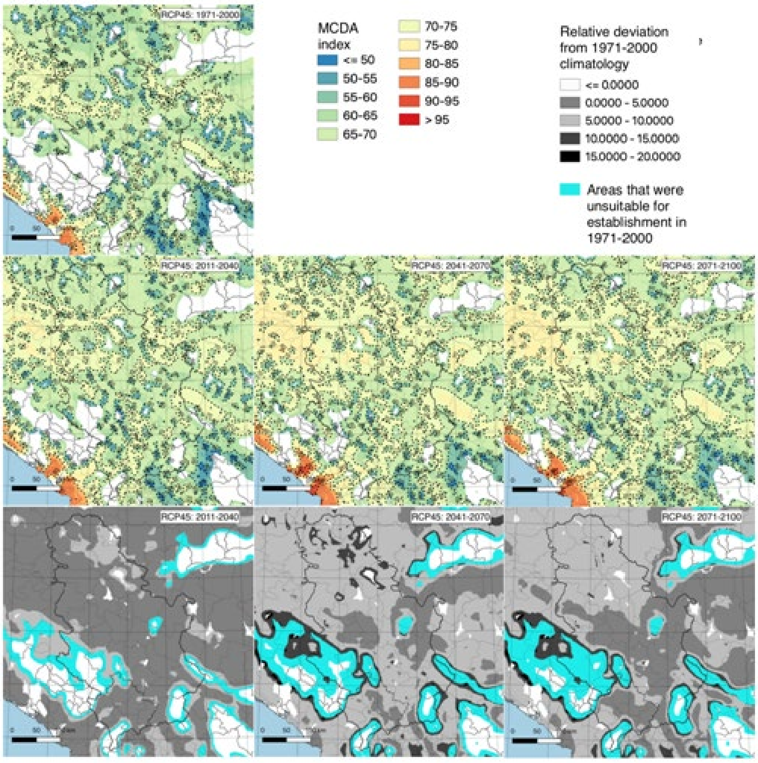

Figure 18: MCDA risk index for the RCP45 scenario for Anopheles hyrcanus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

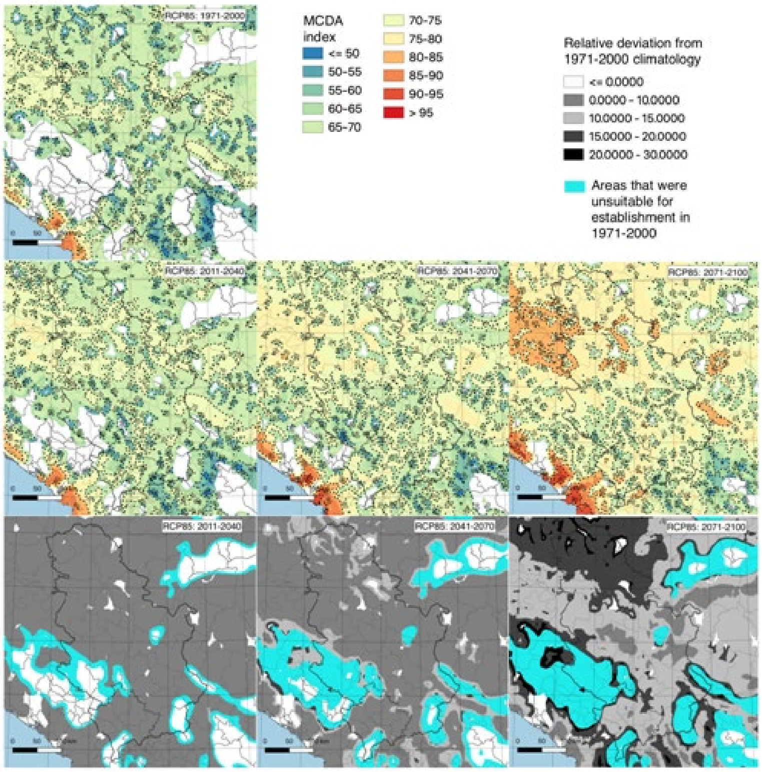

Figure 19: MCDA risk index for the RCP85 scenario for Anopheles hyrcanus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

4.4 Ixodes ricinus: a tick species; transmits Lyme disease and tick-borne encephalitis

After mosquitoes, ticks of the genus *Ixodes* (Acari: Ixodida) are one of the most important vectors that transmit a large number of pathogens that cause infectious diseases in humans and animals. In Europe and Serbia, the most widespread species is *Ixodes ricinus* [67]. Other species from the genera *Hyalomma, Ixodes, Dermacentor* and *Rhipicephalus* generally do not endanger humans, but have been observed in other domestic animals. The exceptions are the species *Hyalomma marginatum* and *Rhipicephalus sanguineus*, which transmit the Crimean-Congo hemorrhagic fever virus. Many species parasitize wild warm-blooded animals such as moles, mice, hedgehogs, foxes and wolves. Lyme disease, or Lyme borreliosis, is a bacterial disease that is transmitted to humans by the bite of infected ticks and is a very common disease in Europe.

The number of cases in Europe is steadily increasing, with more than 360,000 cases reported over the last two decades. Central Europe is the region with the highest incidence of Lyme borreliosis. [68]. Ticks of the species *Ixodes ricinus* transmit the bacterium that causes Lyme borreliosis in dogs, cats and humans. In addition to Lyme and other borreliosis, ticks also transmit the tick-borne encephalitis virus, which is present in Europe, and recently (2015), after more than 40 years, was registered again in Serbia [23].

Based on a report on an increase in the incidence of tick-borne encephalitis (TBE) in southern Germany in 2020, ECDC hired VectorNet experts to analyze the current situation in Europe compared to previous years [69]. An increase in the adult population of *Ixodes ricinus* was cited as a possible reason. The responses from the questionnaire, prepared for this purpose, showed that the relative changes in tick density over two years (2019-2020) do not allow a reliable assessment of the change in the risk of TBE observed in Germany. Only Finland reported an increase in the number of nymphs. The United Kingdom adults. France, Belgium and Serbia recorded small changes (-25% to 25%) in nymphs, and Finland, Denmark, Bosnia and Herzegovina and Serbia recorded small changes (-25% to 25%) in adults. Great Britain, Sweden and Denmark recorded a small decrease (-50-25%) in the number of nymphs. In general, there is no evidence of an increase in tick density across Europe. However, it is possible that tick density has increased in some areas [69]. The research conducted by Milutinović et al. [70] describes *Borelia burdgoferi* s.l. as the most present pathogen in *Ixodes* castor ticks sampled from 18 sites across the country. Lyme disease in the Republic of Serbia was reported until 2017, when it was the leading disease in the group of vector-borne diseases. By 2017, a total of 7007 cases had been registered, ranging from 487 to 997 per year. In addition to borreliosis, tick-borne encephalitis was recently (2015) registered again in Serbia after more than 40 years [23]. By 2018, a total of 23 cases were recorded, the annual range considering the number of patients in this period was from 1 to 13 cases per year, with a median of 4.5.

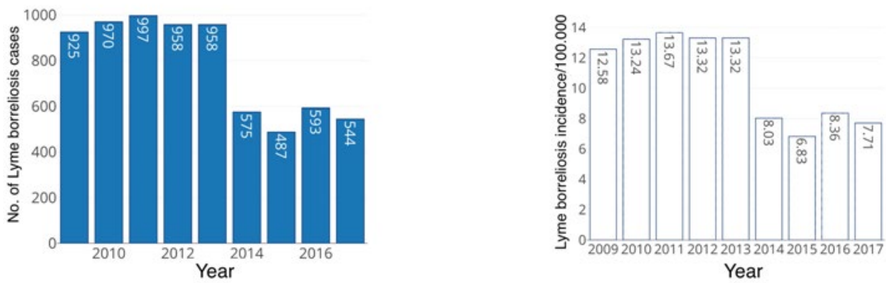

Figure 20: Data on the number of patients and incidence/100,000 of Lyme borreliosis from Batut Report on Infectious diseases in the Republic of Serbia for 2018

This chapter presents the main results of the risk and vulnerability analysis for the vector *Ixodes ricinus* for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 21) and the high emission scenario, RCP85, (Figure 22). The lower panel of both figures shows the relative deviation of the projected MCDA risk index in relation to the reference period (1971-2000), i.e. the expected percentage increase in risk for three future periods.

Current Vulnerability Assessment (1971-2000)

The current vulnerability for the vector *Ixodes ricinus* in the period 1971-2000 was characterized by a risk index ranging from 55.60 (moderate vulnerability) to 82.83 (high vulnerability) with a mean of 71.18 (σ = 4.15) for the RCP45 scenario (Figure 21); and ranging from 57.72 (moderate vulnerability) to 83.11 (high vulnerability) with a mean of 72.22 (σ = 4.0) for the RCP85 scenario (Figure 22).

The climatic parameters that had the greatest impact on the output variability of the MCDA climate suitability model for *I. ricinus* are from the most significant to the least significant: (i) Total annual rainfall; (ii) Mean annual air temperature; (iii) Mean air temperatures for the period from April to May; (iv) Mean January air temperatures; (c) Total precipitation in the period from March to June; (vi) Mean air temperature for the period from December to February; (vii) Mean air temperatures in the period from June to August.

Risk and vulnerability assessment for the period 2011- 2040

Vulnerability for vector *I. ricinus* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 59.79 (moderate vulnerability) to 86.84 (high vulnerability) with a mean value of 75.28 (σ = 4.33) for the RCP45 scenario (Figure 21); and ranging from 58.85 (low vulnerability) to 85.92 (high vulnerability) with a mean of 76.36 (σ = 4.48) for the RCP85 scenario (Figure 22). The projected change in the risk index across all districts ranges from 3.43 to 9.89% (the change in risk per district is given in Annex 1, Figure A 33).

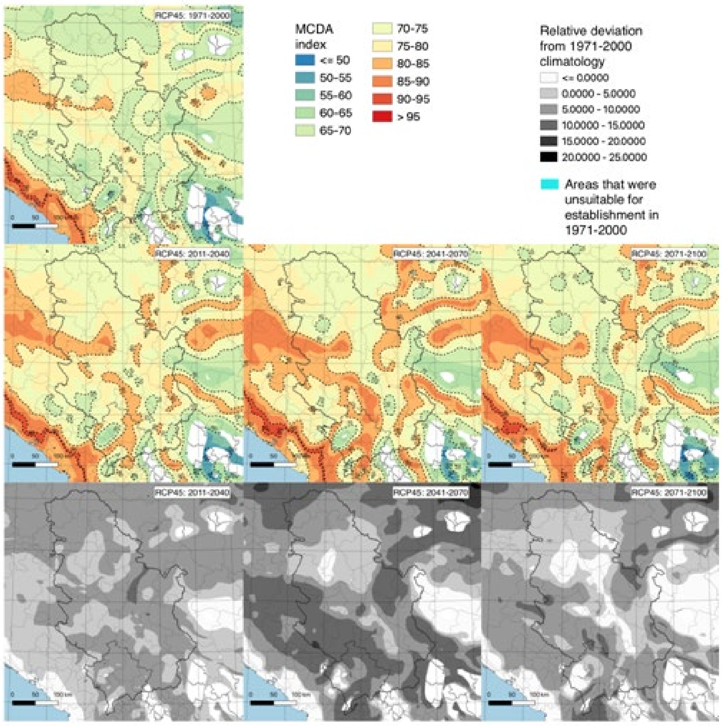

Figure 21: MCDA risk index for the RCP45 scenario for Ixodes ricinus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

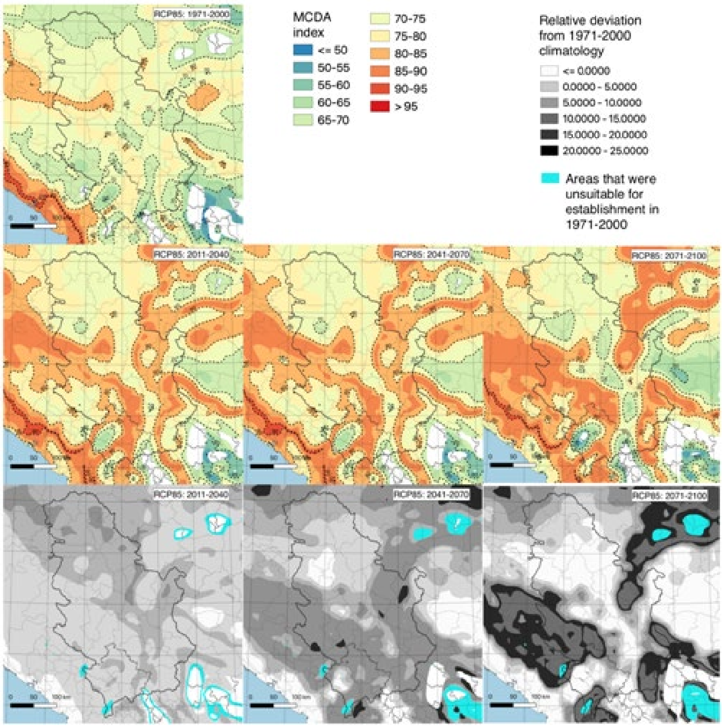

Figure 22: MCDA risk index for the RCP85 scenario for Ixodes ricinus for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

Risk and vulnerability assessment for the period 2041- 2070

Vulnerability for vector *I. ricinus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 61.6 (moderate vulnerability) to 89.30 (high vulnerability) with a mean of 76.62 (σ = 5.19) for the RCP45 scenario (Figure 21); and ranging from 60.89 (moderate vulnerability) to 88.57 (high vulnerability) with a mean of 78.03 (σ = 5.06) for the RCP85 scenario (Figure 22). The projected change in the risk index across all districts ranges from 1 to 12.14% (the change in risk per district is given in Annex 1, Figure A 35).

Risk and vulnerability assessment for the period 2070- 2100

Vulnerability for vector *I. ricinus* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 59.35 (moderate vulnerability) to 87.59 (high vulnerability) with a mean of 74.19 (σ = 5.42) for the RCP45 scenario (Figure 21); and ranging from 53.63 (moderate vulnerability) to 89.30 (high vulnerability) with a mean of 76.83 (σ = 7.10) for the RCP85 scenario (Figure 22). The projected change in the risk index across all districts ranges from -4.3 to 18.8% (change in risk per district is given in Annex 1, Figure A 37).

4.5 Phlebotomus papatasi: a sandfly species; transmits leishmaniasis and sandfly fever

Sand flies (sand-colored flies) are small, delicate insects known as the main vectors of the parasite *Leishmania spp*., which causes leishmaniasis. In addition to *Leishmania spp*., these insects transmit other pathogens, including bartonella and phleboviruses [28]. The risk of recurrence of leishmaniasis in Serbia increases due to the increased flow of people, animals and goods, which dramatically facilitates the intake of vectors and pathogens [29]. In central Serbia, the most numerous species is *P. neglectus*, followed by *P. tobbi*, *P. balcanicus*, *P. simici*, *P. perfiliewi*, *P. sergenti*, *P. papatasi*, *P. mascittii* and *P. alexandri*. In Vojvodina, *P. papatasi* are the most numerous by far, and we chose to model this species because of the presence of Leishmania parasites in Serbia and the availability of ecological parameters required for modelling the climatic suitability[28]. The data indicate that there is a diverse fauna of low density in Serbia, and that the diversity and abundance of species varies significantly depending on the study area [29].

Leishmaniasis is a tropical/subtropical disease caused by a protozoan of the genus Leishmania, which is spread by the bite of the infected sandfly. The reservoir are dogs and some species of wild carnivores. There are several different forms of leishmaniasis in humans. Cutaneous leishmaniasis causes wounds on the skin that often heal within a few months, but can leave ugly scars; it occurs worldwide, including the Mediterranean coast. Visceral leishmaniasis causes a systemic disease, which is accompanied by fever, malaise, and weight loss, anemia, swelling of the spleen, liver and lymph nodes. Most of the reported cases worldwide have been registered in Bangladesh, Brazil, India, Nepal and Sudan. In Europe, the most endangered countries are Albania, Greece, Spain and Turkey. Vaccines or effective drugs to prevent infection are not available. The annual number of reported cases is estimated at about 0.7 to 1.3 million cutaneous leishmaniasis and about 200,000 - 400,000 viseral forms with over 20,000 deaths per year [28].

In Serbia, cases of leishmaniasis were first recorded at the end of World War II. Due to the relatively high number of sandflies in that period. The disease soon took on an epidemic character, so that the first major epidemic was recorded in 1945 [29]. Leishmaniasis first appeared in the southern part of the country, the northern border of the recorded cases in that period was central Serbia. The last major epidemic was recorded in 1953, after which the number of cases decreased and appeared only sporadically. [29]. Although the disease has been considered eradicated since 1968, new cases of endemic transmission have been reported in dogs in Vojvodina in the last decade, which was previously considered a non-endemic area [71]. This indicates a possible recurrence of this disease in Serbia [28].

This chapter presents the main results of the risk and vulnerability analysis for the *Phelobotus papatasi* vector for the reference period (1971-2000) and three future periods (2011-2040, 2041-2070, 2071-2100), for the intermediate emission scenario, RCP45, (Figure 23) and the high emission scenario, RCP85, (Figure 24). and the high emission scenario, RCP85.

Current Vulnerability Assessment (1971-2000)

The current vulnerability for the vector *P. papatasi* in the period 1971-2000 was characterized by a risk index ranging from 10.36 (very low vulnerability) to 83.27 (high vulnerability) with a mean of 55.19 (σ = 24.42) for the RCP45 scenario (Figure 23); and ranging from 10.61 (very low vulnerability) to 81.61 (high vulnerability) with a mean of 52.56 (σ = 24.10) for the RCP85 scenario (Figure 24). The climatic parameters that had the greatest impact on the output variability of the MCDA climate suitability model for *Phelobotomus papatasi* are from the most significant to the least significant: (i) Mean annual air temperature; (ii) Mean air temperatures for the period from June to August. Details of vulnerabilities by district are presented in Annex 1 of this report.

Risk and vulnerability assessment for the period 2011- 2040

Vulnerability for the vector *P. papatasi* in the period 2011-2040 for Serbia was characterized by a risk index ranging from 10.44 (very low vulnerabilityt) to 87.97 (high vulnerability) with a mean of 64.60 (σ = 23.98) for the RCP45 scenario (Figure 23); and ranging from 9.82 (low vulnerability) to 86.17 (high vulnerability) with a mean of 61.75 (σ = 24.12) for the RCP85 scenario (Figure 24). The projected change in the risk index across all districts ranges from 6.3 to 193.55% (the change in risk per district is given in Annex 1, Figure A 40).

Risk and vulnerability assessment for the period 2041- 2070

Vulnerability for the vector *P. papatasi* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 10.33 (very low vulnerability) to 91.86 (high vulnerability) with a mean of 72.94 (σ = 22.08) for the RCP45 scenario (Figure 23); and ranging from 10.07 (very low vulnerability) to 91.83 (high vulnerability) with a mean of 74.14 (σ = 21.8) for the RCP85 scenario

(Figure 24). The projected change in the risk index across all districts ranges from 10.76 to 628.19% (the change in risk per district is given in Annex 1, Figure A 42).

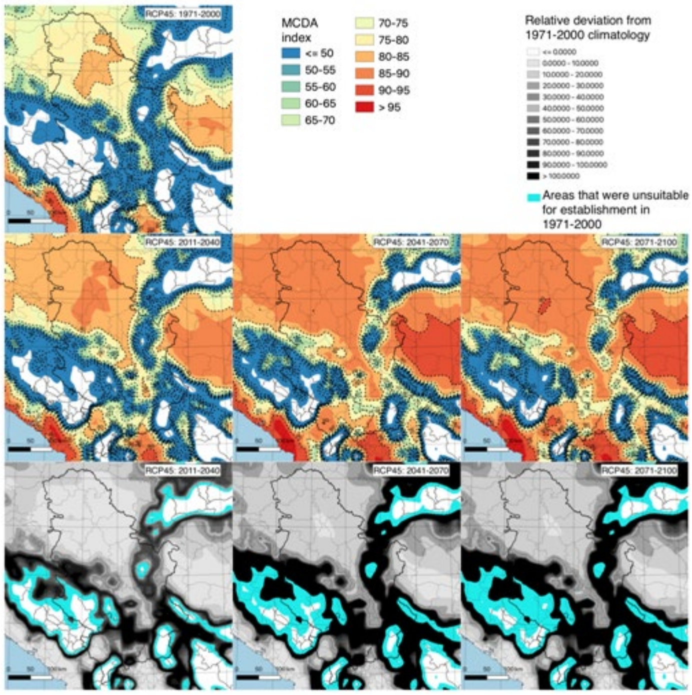

Figure 23: MCDA risk index for the RCP45 scenario for Phlebotomus papatasi for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

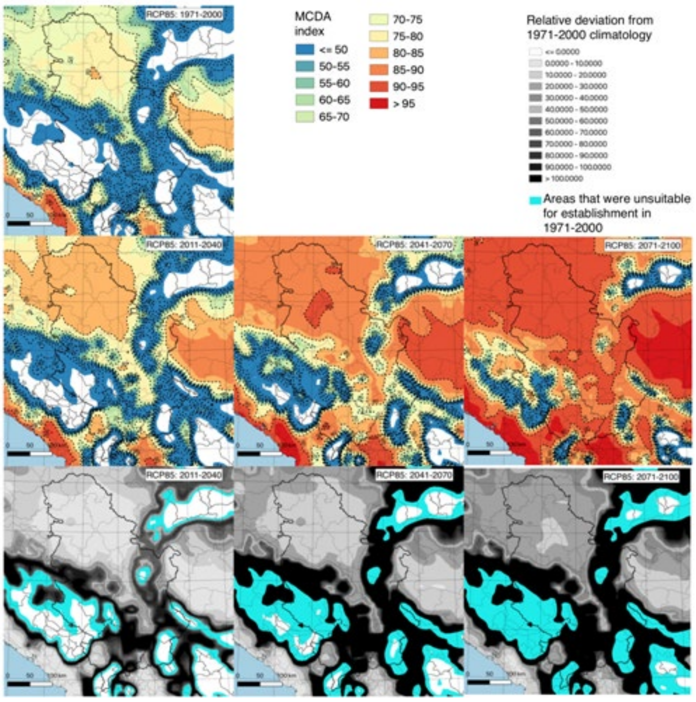

Figure 24: MCDA risk index for the RCP85 scenario for Phlebotomus papatasi for the reference climatology (1971-2000) and three projections (2011-2040, 2041-2070, 2071-2100). Maps in the last row represent the relative deviation of the MCDA risk index compared to the reference climatology (1971-2000) [%]

Risk and vulnerability assessment for the period 2070- 2100

Vulnerability for the vector *P. papatasi* in the period 2041-2070 for Serbia was characterized by a risk index ranging from 10.76 (very low vulnerability) to 92.44 (high vulnerability) with a mean of 74.06 (σ = 21.66) for the RCP45 scenario (Figure 23); and ranging from 11.97 (very low vulnerability) to 96.53 (high vulnerability) with a mean of 86.44 (σ = 13.13) for the RCP85 scenario (Figure 24). The projected change in the risk index across all districts ranges from 10.97 to 1189.57% (the change in risk per district is given in Annex 1, Figure A 44).

4.6 Overview of vulnerability

Figure 25 provides an overview of the vulnerability index by district for the 4 analyzed periods from 1971 to 2100. where columns represent MCDA index for different vectors and emission scenarios, by the dominance of red, you can clearly see that the vulnerability index increases for (almost) all vectors in all districts!

The results showed that most of Serbia would become significantly more suitable for all the investigated vector species. The number of high-risk districts increased from 1 to 23 (median of 9) by the end of the century.

The risk index for the period 2011-2040 was taken as the starting point for surveillance planning (defining high and low risk districts, and the proposed intensity (number of sampling) of monitoring/surveillance during the year for each group of vectors separately; details are given in Chapter 5, “Proposed Adaptation Measures”). Changes to the projected risk index for each district are given in Annex 1.3 of this report.

1971-2000	*Cx. pipiens pipiens* RCP 45	*Cx. pipiens pipiens* RCP 85	*Cx. pipiens molestus* RCP 45	*Cx. pipiens molestus* RCP 85	*Aedes albopictus* RCP 45	*Aedes albopictus* RCP 85	*Anopheles hyrcanus* RCP 45	*Anopheles hyrcanus* RCP 85	*Ixodes ricinus* RCP 45	*Ixodes ricinus* RCP 85	*Phlebotomus papatasi* RCP 45	*Phlebotomus papatasi* RCP 85
Borski	76.0	76.7	76.6	77.4	61.9	63.1	63.8	63.7	68.1	70.5	55.3	51.9
Braničevski	75.5	75.8	76.2	76.5	58.6	58.0	55.5	54.6	70.8	72.4	43.8	39.9
City of Belgrade	83.9	84.0	85.9	86.0	70.9	71.5	55.3	55.9	76.3	78.1	77.5	74.8
Jablanički	73.1	72.2	74.2	73.2	53.1	52.5	51.1	50.1	70.3	71.5	29.7	25.7
South Bačka	80.3	81.6	81.4	82.9	64.4	65.4	64.3	65.5	70.0	71.5	77.8	75.3
South Banat	81.8	82.7	83.5	84.6	66.6	67.5	56.7	57.7	72.3	74.3	79.0	76.4
Kolubarski	78.9	78.4	81.0	80.5	70.2	70.6	67.8	67.8	77.5	78.5	48.7	45.0
Mačvanski	82.0	82.0	83.4	83.4	69.8	70.2	66.9	67.3	74.8	75.8	65.8	62.8
Moravički	71.4	70.9	73.3	72.7	45.1	44.1	40.5	39.5	72.2	72.9	26.1	23.0
Nišavski	74.9	74.5	78.9	78.4	65.3	65.8	64.2	64.3	70.6	72.2	47.5	42.1
Pčinjski	64.0	61.1	64.5	61.7	33.3	31.7	30.1	28.6	63.7	65.9	20.7	18.0
Pirotski	70.2	69.5	71.3	70.6	52.0	49.6	46.7	42.9	70.6	71.2	14.3	11.7
Podunavski	81.3	82.4	82.8	84.0	66.5	67.4	58.8	59.9	70.7	72.9	77.1	73.9
Pomoravski	75.2	75.2	77.8	77.8	60.1	59.6	55.1	54.5	69.8	71.2	49.4	44.8
Rasinski	73.2	72.9	77.2	76.8	58.9	58.3	50.6	49.9	72.9	73.4	40.6	36.8
Raški	67.7	66.8	70.5	69.5	41.4	35.9	29.0	24.4	72.0	71.9	13.0	10.7
North Bačka	76.7	78.4	77.8	79.8	60.7	61.8	55.3	56.5	67.1	68.5	74.7	71.9
North Banat	76.3	78.3	77.0	79.4	60.3	61.4	56.8	58.1	67.1	68.3	77.3	74.7
Mid Banat	79.7	81.4	80.6	82.5	63.5	64.5	62.4	63.8	69.8	71.1	80.1	77.8
Sremski	82.9	83.5	84.1	84.8	67.4	67.9	66.0	66.8	71.3	72.6	79.1	76.9
Šumadijski	77.3	77.3	79.9	79.9	66.3	67.2	66.3	66.9	72.0	73.8	54.7	49.2
Toplički	75.5	74.9	77.3	76.6	65.7	65.2	59.7	58.7	74.7	75.1	34.8	30.4
Zaječarski	72.7	72.5	74.8	74.6	61.6	61.5	61.4	60.4	71.2	72.5	34.5	30.6
West Bačka	78.5	79.9	79.6	81.2	62.0	63.2	61.4	62.7	68.5	70.4	76.1	73.6
Zlatiborski	68.7	68.1	68.5	67.8	34.2	28.3	22.8	19.0	70.6	70.6	7.1	5.5

2011-2040	*Cx. pipiens pipiens* RCP 45	*Cx. pipiens pipiens* RCP 85	*Cx. pipiens molestus* RCP 45	*Cx. pipiens molestus* RCP 85	*Aedes albopictus* RCP 45	*Aedes albopictus* RCP 85	*Anopheles hyrcanus* RCP 45	*Anopheles hyrcanus* RCP 85	*Ixodes ricinus* RCP 45	*Ixodes ricinus* RCP 85	*Phlebotomus papatasi* RCP 45	*Phlebotomus papatasi* RCP 85
Borski	80.8	81.6	82.2	83.1	68.2	68.0	66.1	66.7	72.2	75.4	69.7	65.6
Braničevski	80.0	80.1	81.5	81.5	69.1	67.8	63.8	62.8	76.1	76.8	57.2	52.1
City of Belgrade	87.8	88.2	90.4	90.9	77.0	76.8	57.1	57.6	79.6	82.5	83.9	81.8
Jablanički	78.1	77.9	79.9	79.7	62.5	61.1	57.8	56.7	74.2	74.8	47.9	43.3
South Bačka	85.7	86.9	87.7	89.1	71.8	71.8	67.1	68.4	74.8	77.7	83.8	81.7
South Banat	86.5	87.5	89.0	90.2	74.0	74.0	59.3	60.5	76.0	80.6	84.2	81.9
Kolubarski	83.1	83.1	85.9	86.0	74.5	74.0	69.7	69.8	81.1	81.5	65.2	61.6
Mačvanski	86.1	86.8	88.2	88.9	75.2	74.8	68.7	69.3	78.2	79.8	77.3	74.7
Moravički	75.3	75.3	77.9	77.9	56.4	54.7	48.3	47.3	75.4	75.5	41.4	38.5
Nišavski	79.8	79.8	84.6	84.6	70.4	70.0	66.0	66.5	74.8	76.4	67.5	62.7
Pčinjski	72.3	72.0	73.3	73.0	47.3	44.5	40.8	37.7	68.4	69.2	32.9	29.4
Pirotski	74.6	74.0	76.5	75.8	63.1	60.6	58.5	56.4	74.6	74.5	30.8	24.9
Podunavski	86.0	87.0	88.2	89.4	73.1	73.1	61.0	62.0	74.7	78.4	83.3	81.0
Pomoravski	79.9	79.8	83.2	83.1	70.1	68.7	62.3	61.6	75.6	75.8	63.5	59.8
Rasinski	77.7	77.8	82.4	82.6	71.5	70.1	57.9	56.0	76.5	76.6	57.0	53.5
Raški	71.5	71.3	74.8	74.6	59.9	57.6	50.6	48.6	76.0	74.5	25.6	23.3
North Bačka	82.6	84.5	84.8	86.9	68.0	68.4	57.7	59.3	72.1	74.4	82.9	80.5
North Banat	82.8	84.9	84.5	87.0	68.2	68.3	59.4	61.1	72.3	74.5	84.1	81.9
Mid Banat	85.5	87.0	87.4	89.1	71.6	71.5	65.6	67.0	73.5	78.0	85.2	83.1
Sremski	87.0	88.1	88.9	90.2	74.0	73.8	68.2	69.1	74.4	77.1	84.6	82.7
Šumadijski	81.8	82.0	85.2	85.4	71.0	70.7	67.7	68.3	76.6	78.3	72.2	68.5
Toplički	80.3	80.2	82.9	82.8	72.3	71.0	64.2	63.6	78.5	78.2	56.6	51.7
Zaječarski	77.4	77.6	80.3	80.5	68.1	67.2	65.7	65.4	76.1	76.5	54.1	49.2
West Bačka	84.2	85.7	86.2	88.0	69.4	70.1	64.1	65.9	74.1	77.3	83.1	80.9
Zlatiborski	72.3	72.0	72.7	72.4	50.9	49.0	45.7	43.7	74.5	73.0	18.3	16.1

2041-2070	*Cx. pipiens pipiens* RCP 45	*Cx. pipiens pipiens* RCP 85	*Cx. pipiens molestus* RCP 45	*Cx. pipiens molestus* RCP 85	*Aedes albopictus* RCP 45	*Aedes albopictus* RCP 85	*Anopheles hyrcanus* RCP 45	*Anopheles hyrcanus* RCP 85	*Ixodes ricinus* RCP 45	*Ixodes ricinus* RCP 85	*Phlebotomus papatasi* RCP 45	*Phlebotomus papatasi* RCP 85
Borski	82.6	86.2	84.2	88.5	72.8	75.0	66.7	68.5	72.6	77.4	81.0	82.3
Braničevski	82.9	85.3	84.8	87.6	74.7	75.8	67.9	69.0	77.3	79.9	69.9	72.1
City of Belgrade	89.6	90.8	92.5	93.9	81.9	83.8	59.4	60.1	77.7	79.5	88.0	88.7
Jablanički	82.0	83.8	84.4	86.5	71.6	73.2	64.0	65.6	76.9	79.0	62.7	64.5
South Bačka	88.1	89.9	90.5	92.6	78.2	79.6	70.1	71.5	74.6	74.9	87.6	88.5
South Banat	87.9	89.9	90.7	93.0	78.8	80.6	61.8	63.2	74.1	76.6	88.2	88.7
Kolubarski	86.7	88.2	90.2	91.9	80.1	80.1	71.9	72.2	83.0	82.9	77.2	79.9
Mačvanski	88.8	90.1	91.3	92.8	81.0	81.4	71.4	71.8	78.6	78.2	83.8	85.1
Moravički	79.3	80.9	82.5	84.5	70.0	73.1	58.2	60.8	78.4	78.5	53.9	57.0
Nišavski	83.2	85.3	88.6	91.1	75.9	77.3	67.7	68.7	75.0	79.6	79.9	80.7
Pčinjski	75.1	77.2	76.7	79.1	60.0	64.7	51.4	54.9	68.5	72.3	43.9	46.1
Pirotski	79.0	81.1	81.6	84.1	73.0	73.3	67.9	68.5	77.6	79.8	52.4	56.2
Podunavski	86.9	89.5	89.3	92.3	77.6	79.6	62.9	64.5	72.3	75.1	87.7	88.0
Pomoravski	82.8	84.9	86.6	89.1	75.6	76.6	65.6	66.5	76.0	79.1	74.2	75.8
Rasinski	81.4	83.2	86.7	88.9	77.8	77.9	61.4	61.8	78.7	80.3	69.9	71.8
Raški	75.9	77.7	80.0	82.2	72.8	72.8	62.1	63.7	80.1	80.5	42.7	47.8
North Bačka	85.8	88.5	88.5	91.6	75.7	77.8	60.3	62.0	73.7	74.4	87.0	88.0
North Banat	85.6	88.4	87.8	91.1	75.3	77.3	62.1	63.8	72.6	73.5	87.8	88.9
Mid Banat	87.6	89.7	89.9	92.2	77.6	79.2	68.5	70.1	73.2	73.6	88.7	89.7
Sremski	88.7	90.3	90.9	92.7	79.4	80.5	71.0	72.2	72.9	73.3	88.3	89.2
Šumadijski	85.0	87.0	88.9	91.2	76.4	77.2	69.0	69.7	77.5	79.5	81.8	82.8
Toplički	84.7	86.5	88.0	90.1	79.1	79.3	67.3	67.7	81.9	83.3	72.6	74.5
Zaječarski	81.2	83.8	84.8	87.7	74.0	74.9	68.0	68.9	77.9	81.1	72.1	74.3
West Bačka	87.3	89.4	89.8	92.2	76.9	78.8	67.2	68.8	75.5	76.0	87.0	88.1
Zlatiborski	76.7	78.5	77.8	80.0	71.5	70.5	57.8	66.3	78.6	79.1	33.6	40.0

2071-2100	*Cx. pipiens pipiens* RCP 45	*Cx. pipiens pipiens* RCP 85	*Cx. pipiens molestus* RCP 45	*Cx. pipiens molestus* RCP 85	*Aedes albopictus* RCP 45	*Aedes albopictus* RCP 85	*Anopheles hyrcanus* RCP 45	*Anopheles hyrcanus* RCP 85	*Ixodes ricinus* RCP 45	*Ixodes ricinus* RCP 85	*Phlebotomus papatasi* RCP 45	*Phlebotomus papatasi* RCP 85
Borski	83.1	88.1	84.8	90.7	76.3	79.3	66.3	71.1	70.5	74.4	82.0	91.1
Braničevski	83.5	88.9	85.5	91.8	78.6	81.6	67.6	72.3	75.5	79.3	71.9	87.1
City of Belgrade	89.9	91.6	92.9	94.8	86.8	85.8	59.0	63.7	76.4	74.7	88.3	93.7
Jablanički	82.0	88.2	84.4	91.7	75.1	80.5	63.9	72.0	73.8	76.1	65.4	82.1
South Bačka	88.1	91.5	90.4	94.4	82.2	84.3	69.3	76.5	71.6	73.5	87.8	93.2
South Banat	88.0	90.6	90.8	93.8	83.6	83.6	61.3	67.2	72.4	73.2	88.4	93.8
Kolubarski	87.1	91.1	90.6	95.2	84.0	85.9	71.4	76.0	81.6	81.6	78.8	88.5
Mačvanski	89.3	91.7	91.8	94.7	85.4	85.8	70.9	76.0	77.1	75.7	84.4	91.4
Moravički	79.8	86.3	83.1	90.8	76.6	79.8	59.8	69.4	76.1	79.9	56.4	76.7
Nišavski	83.0	87.6	88.3	93.7	78.9	82.6	66.3	72.0	71.4	73.7	83.7	90.4
Pčinjski	75.6	82.7	77.2	85.5	66.7	76.6	53.6	69.8	66.1	70.8	46.7	71.6
Pirotski	79.7	87.9	82.4	92.1	75.5	81.0	67.4	72.3	74.8	81.8	57.3	81.3
Podunavski	87.0	89.7	89.4	92.6	82.3	82.2	62.3	68.2	70.3	70.0	88.0	93.4
Pomoravski	82.6	87.7	86.4	92.3	78.7	81.6	64.5	69.6	72.2	75.4	76.3	89.0
Rasinski	81.3	86.8	86.7	93.1	80.8	84.0	60.6	65.4	75.5	78.7	72.3	87.1
Raški	76.6	85.3	80.9	90.9	75.8	80.7	63.0	68.7	77.1	84.2	47.4	77.5
North Bačka	85.8	90.8	88.4	94.3	79.1	83.6	59.5	67.0	70.9	74.2	87.0	92.7
North Banat	85.7	90.4	88.0	93.4	79.2	82.5	61.5	68.7	70.5	71.0	87.9	93.5
Mid Banat	87.6	91.0	89.8	93.8	81.8	83.3	67.8	74.9	70.8	71.3	88.9	94.2
Sremski	89.2	91.3	91.4	93.9	84.1	84.0	70.6	76.7	71.4	70.8	88.5	93.7
Šumadijski	84.9	89.2	88.8	93.8	79.8	82.9	68.0	73.3	74.7	75.7	82.8	90.2
Toplički	85.1	90.8	88.4	95.1	82.2	86.7	66.7	71.7	79.8	82.5	75.3	87.5
Zaječarski	81.8	87.7	85.4	92.3	76.9	81.2	67.3	71.9	74.4	78.1	75.1	88.1
West Bačka	86.9	91.4	89.4	94.6	80.2	84.4	66.1	74.0	71.9	76.6	87.2	92.7
Zlatiborski	77.5	86.5	78.8	89.5	74.3	78.4	65.9	71.3	75.8	83.9	39.2	70.8

Figure 25: Vulnerability indices by districts for 4 analyzed periods: (top-left) 1971-2000; (top-right) 2011-2040; (bottom-left) 2041-2100; (bottom-right) 2071-2100. Indices for the period 2011-2040 are taken as the starting point for defining high and low risk districts

5 Proposed adaptation measures

We took the current situation in the monitoring/surveillance of vectors and the degree of connection with the monitoring and modeling of climate change as a focus for proposed adaptation measures. Taking into account the results of previous analyses, starting from the expected vulnerability for the period 2011-2040, there is a clear need for urgent planning and implementation of adaptation measures. In the initial phase, it is necessary to establish a system of monitoring and surveillance, forecasting changes, forming a database, and reporting data and vector control (see details below). Once this system becomes operational, Serbia will be able to anticipate, implement and improve mitigation measures in a timely manner.

It should be borne in mind here that entomological surveillance of vectors must be based on scientific principles, organized and led by scientific institutions with experience in the field. Only in this way can quality (precise and accurate) data be provided for modeling the effects of climate change and mitigating negative effects. Proof of this claim is the fact that based on data collected during scientifically guided surveillance of the West Nile virus organized by the Veterinary Administration, 5 papers [4], [7], [27], [72], [73] have been published so far in leading journals from the SCI list that have served to improve the surveillance program. Also, based on the monitoring of the presence/absence, seasonality and abundance of the invasive, Asian tiger mosquito, two papers were published on the climate impact assessment for this species [5], [37] which served to rationalize and focus surveillance on the most endangered parts of Serbia. We do not know that other surveillance programs have been improved based on the collected entomological observations, and only one paper has been published based on the LS program [74]. In 2012, the Ministry of Health organized surveillance of the West Nile virus, the design of which did not include any of the 4 scientific research institutions from Serbia (Faculty of Agriculture in Novi Sad, Institute of Public Health of Vojvodina, Scientific Veterinary Institute "Novi Sad" and Veterinary Specialist Institute Kraljevo), which were the only institutions in the country dealing with this issue. For this reason, entomological surveillance data under this program have never been associated with human cases, have not been used to improve surveillance programs, nor have they been recognized by ECDC and EFSA.

First, it is necessary to establish a national framework in which the principles will be defined according to which the surveillance and control of vectors will be planned and supervised through cooperation of scientific institutions and competent government institutions (Ministry of Health, Ministry of Agriculture, Forestry and Water Management, Ministry of Environmental Protection and Ministry of Public Administration and Local Self-Government) based on the principles of "One Health".

The concept of "One Health", recognizable in Serbia as "Jedno zdravlje“ (Figure 26), implies the joint work and expertise of experts in the field of veterinary medicine, human medicine, public health, ecology, meteorology, toxicology, medical entomology and other related disciplines who act locally, nationally, regionally and globally in order to optimize human and animal health as well as to preserve the environment. The "One Health" approach supports the idea that a successful struggle against factors that negatively affect human and animal health as well as the environment is possible only if good interdisciplinary and inter-institutional communication and cooperation is established.

Figure 26: Graphic representations of the concept "One Health"

"One Health" aims to reduce, through a holistic approach, the risks to human and animal health, as well as the factors that negatively affect society and the environment.

An example of successful, and until 2018, informal cooperation of three scientific research institutions supports our proposal to apply the principles of "One Health" in solving the burning problems that threaten us through vectors and the diseases that they transmit.

The collaboration was started by experts in the field of medical entomology and meteorology, from the Faculty of Agriculture in Novi Sad in 2003, comparing the climate of the West Nile virus (WNV) circulation hotspot in the USA (Central Valley of California) and Europe (Bucharest area) with the climate of Vojvodina. As the climates of the compared areas showed quite similar patterns, meteorologists and medical entomologists were joined by their colleagues from public health (Faculty of Medicine in Novi Sad, Institute of Public Health of Vojvodina) and from veterinary medicine (Scientific Institute of Veterinary Medicine "Novi Sad"). With the idea of a better use of resources and combining knowledge from different sectors, research and programs have been designed and implemented that have contributed to achieving good results in zoonosis control (diseases common to animals and humans, such as West Nile fever). The cooperation contributed to the achievement of the following results: (i) the first detection of WNV in horses in Serbia in 2009 [75]; (ii) the first detection of WNV in mosquitoes in Serbia in 2010 [8]; (iii) the first detection of WNV in wild birds in Serbia in 2012. [76]; (iv) design, development and implementation of a national WNV surveillance program in mosquito, bird and horse populations adopted by the Veterinary Directorate, Ministry of Agriculture, Forestry and Water Management [76], in combination with human surveillance in Vojvodina since 2014 [7]; (v) increasing visibility in the European Center for Disease Control and Prevention (ECDC), the European Food Safety Authority (EFSA) and the World Health Organization (WHO) (projects, expertise, invited lectures, letters of support); (vi) the first detection of an imported case of dengue virus in Serbia, in 2016 [26]; (vii) first detection of zoonotic pathogens in ticks and/or reservoirs (*Rickettsia raoultii, Rickettsia massiliae, Babesia venatorum, Babesia microti, Candidatus Neoehrlichia mikurensis and Borrelia miyamotoi*); [26], [77] (viii) established natural foci of tick-borne encephalitis virus after several decades of initial research [23]; and (ix) development and implementation of the electronic One Health platform in Vojvodina from 2018 (Assembly of the Autonomous Province of Vojvodina adopted a Special Program in Public Health for AP Vojvodina, Integrated Surveillance and Control of Transmissible Anthropozoonoses in territory of AP Vojvodina within the adoption of the Provincial Budget for 2019, the decision was published in the Official Gazette of AP

Vojvodina No. 60/18). Once the principles have been defined at the national level, it is relatively easy to set frameworks that must be respected at the regional and local levels. In Chapter 6 "Proposed amendments, revision and drafting of national regulations and policies" we provide a proposal based on the "Law on Protection of the Population from Infectious Diseases" of the Republic of Croatia.

Proposals for mitigation measures for specific system components are given in the same order as described in the chapter " Overview of sector components" in Chapter 1.1 of the report. A tabular overview of the proposed adaptation measures is given after the corresponding subchapter.

5.1 Monitoring and Surveillance

In the area of monitoring and surveillance of vectors and the pathogens they transmit, the need for a unified science-based program at the national level that would serve as a guideline for the development of regional and local programs is clearly visible. It is also necessary to reduce the gap in the intensity and uneven distribution of surveillance by districts and groups of vectors based on the recommendations of science and risk assessment given in the results of this report. In particular, it is necessary to set the framework by the end of 2023, including the necessary legislation, rules and methods, places, frequency and sampling rules, as well as responsible institutions, ways of exchanging data and information, etc. and provide funding for the national mosquito, tick and sandfly monitoring program on the territory of the whole of Serbia. It is necessary to include a link between monitoring and control of vectors in the legislation related to monitoring and control.

Based on the risk assessment, it is proposed that the program include a sampling period of: 7 months during the active season for mosquitoes and ticks, 3 months for sandflies. Sampling density: 1 sample per square 10x10km2 to 20x20km2. Sampling frequency: 2 times per month in higher risk districts and 1 time per month in lower risk districts. The initial level of risk was determined according to the MCDA risk indices obtained by analysis for the period 2011-2040 (Figure 25). The categorization of districts as higher or lower risk should be revised every year based on the data collected during the 7/3 months of monitoring/surveillance, and the obtained results are used to improve and rationalize monitoring and surveillance models and programs.

Sampling method according to VectorNet and ECDC protocols [18], [78], [79]. Institution responsible for implementation: Ministry of Health (MoH). Institution in charge of conceptualization, planning and quality control: Laboratory for Medical Entomology, Faculty of Agriculture in Novi Sad (LME - laboratory with the strongest references in medical and veterinary entomology in Serbia) in cooperation with the Faculty of Biology, University of Belgrade (BF), Institute for Medical research, University of Belgrade (IMI) and the Faculty of Natural Sciences and Mathematics, University of Kragujevac (PMF).

The action includes: (i) agreement on joint work in the control of vectors and diseases they transmit and division of responsibilities at the level of local communities (vector sampling and quality control of vector determination), Ministry of Agriculture, Forestry and Water Management (MAFWE - detection of pathogens in vectors, quality control of pathogens detection), the Ministry of Public Administration and Local Self-Government (MPALGS) and the Provincial Secretariat for Urbanism and Environmental Protection (PSUEP - quality control of vector control); (ii) procurement of equipment, in particular of traps and other equipment for the collection and determination of vectors and the recording of microclimate data; (iii) amendments to laws/bylaws (details are presented in Chapter 6).

Progress indicators: (i) a body for defining a national framework for planning and carrying out surveillance and control of vectors formed (middle of 2022); (ii) national framework defined (end of 2022); (iii) changes incorporated in the law on health protection, provided funds for financing (end of 2023); (iv) the vector monitoring and surveillance system has started to function (2024), and if the proposal is accepted by policymakers, (v) the presence or absence, seasonality, abundance, of various vectors and infections (without a unit of measure).

An overview of the estimated costs of scientific research institutions required for the implementation of the national program of surveillance and monitoring of vectors and pathogens they transmit are given in Table 3.

Program implementation year	**Type of cost**							**Total**
	Sampling, determination	Equipment (traps, flags, batteries)	Material (dry ice, lab material, software)	Salaries for the 8 new employees in LME, BF, IMI, PMF	Pathogen detection in samples	Validation and calibration of the MCDA model	Data base LoRa, IoT	
First	6696500	4522604	964220	1406590	7913500	391548	2344132	36880423
Every following	6696500		964220	1406590	7913500	391548	2344132	32357819

Table 3: Overview of costs of scientific research institutions required for the implementation of the national program of surveillance and monitoring of vectors and pathogens they transmit

The costs of examination and diagnosis, hospital treatment and absences from work caused by the WNV epidemic in 2018, according to the analysis presented in the observed case, amounted to 104,379,760. Significant costs that we did not include due to unavailability of data are the costs of blood serum analysis for transfusion. In the same year, at the national, provincial, and local self-government level, RSD 47.2 million were spent for the control of the vector mosquitoes of WNV, out of about RSD 944 million in total spent for the control of mosquitoes in Serbia. We are sure that the establishment of the proposed system would raise the level of efficiency and enable the rationalization of all cost categories.

The current weak or nonexistent link between vector surveillance and control particularly jeopardizes the implementation of mitigation measures. Actions to be implemented: establishment of communication channels between institutions in charge of conceptualizing, planning and quality control of monitoring and surveillance and the Ministry of Health and the Ministry of Public Administration and Local Self-Government /Provincial Secretariat for Urbanism and Environmental Protection, which lead and co-finance mosquito control with the other side.

REPORTING FORMAT		
Activity/measure title: Vector monitoring and surveillance		
Description of the activity/measure	The availability and quality of data are crucial for assessing the impact of climate change on human health. Location: all of Serbia. Monitoring the impact of climate-sensitive vector-borne diseases on health is currently fragmentary and heterogeneous. This makes it difficult to identify significant trends in the vector-vector-borne diseases system and compare them by region. The reasons for the intervention are the transmission of vector-borne diseases in Serbia and the possibility of the introduction and spread of new vectors and diseases. It is necessary to develop and establish a national system of vector surveillance and link it to the surveillance of vector-borne diseases in the human population and vector control. The measure includes sampling of vectors and detection of pathogens in them and it should be carried out every year. Actions that must be previously met for the implementation of the measure are: (i) agreement on joint work in the control of vectors and of diseases they transmit and division of responsibilities at the level of the Ministry of Health (vector sampling and quality control of vector determination), Ministry of Agriculture, Forestry and Water Management (detection of pathogens in vectors, quality control of pathogen detection), Ministry of Public Administration and Local Self-Government and the Provincial Secretariat for Urbanism and Environmental Protection (quality control of vector control treatments); (ii) procurement of equipment, in particular traps and other equipment for the collection and determination of vectors and the recording of microclimate data; (iii) employment of 2 persons in each of the following scientific research institutions who will be engaged in the collection and identification of vectors; (iv) drafting laws/bylaws (policy recommendation).	
Type of measure	Policies	yes
	Financial	yes
	Technology/infrastructure	partly
	Capacity strengthening/training	partly
	Preventive measure	yes
	Mitigation of consequences	no
Measure status	Planned	
Content and link to other measures	Establishment of national surveillance of vectors according to the methodology of the VectorNet project (recommended by the EEA). It should be directly related to the prediction of changes in the short and long term (modeling) and vector control, and indirectly, through a database, to the control of vector-borne diseases in the human population and the assessment of economic effects.	
Basis for activity/measure	The basis for the measure should be defined by amendments to the "Law on Protection of the Population from Infectious Diseases"	
Period of implementation of activities/measures	If accepted by policymakers, this measure needs to be repeated annually	
Potential problems and obstacles	Not being accepted by policymakers.	

Institution(s) responsible for the measure	Drafting	The Ministry of Health, the Ministry of Agriculture, Forestry and Water Management and the multi-sectoral "Surveillance Group for Vectors and Diseases they Transmit" described in the report
	Implementation	Faculty of Agriculture, Novi Sad; Faculty of Biology, Belgrade; Institute for Medical Research, Belgrade, Faculty of Science, Kragujevac.
	Monitoring	Faculty of Agriculture, Novi Sad;
Total expected investments in the drafting and development of the measure	RSD 750,000/USD 7,710 at the middle exchange rate of the NBS on the date 14.5.2021	
Total funds required for the implementation of the measure	In the first year, RSD 34,144,744 /USD 351,002 In each following year, RSD 29,622,140/304,510 at the middle exchange rate of the NBS on the date 14.5.2021	
Source of funding in the reporting year (if there are several sources, indicate the percentages)	Budget of the local self-government and for which sector	
	National budget	Health sector and Veterinary sector
	Private investment	
	Grant	
	Loan	
Duration of the results of the activity/measure (indicate the time period in which it will be necessary to repeat the activity/measure)	Up to 5 years	Every year
	5-15 years	Every year
	Over 15 years	Every year
Additional benefits	The possibility to assess the risk of vector-borne disease, the possibility of preventive action, the ability to reduce the number of ill and dead people, increase in efficiency of vector control and in the analysis and rationalization of protection costs.	
Links to GHG emission reductions	none	

Indicators	Initial value (indicate the unit)	There is no initial value
	Target value (in the last year, if it is multi-year) (indicate the unit)	(i) The body for planning and conducting national surveillance and vector control is established (mid/2022); (ii) national program is defined (end of 2022); (iii) changes are incorporated in the Law on Health Protection, funds for financing provided (end of 2023); (iv) the vector monitoring and surveillance system becomes operational (2024), assuming that national surveillance is established: (v) presence or absence, seasonality, abundance, of different vectors and infections (without unit of measure)
	Achieved value (indicate the unit)	As the indicators are descriptive (type A), the achieved values will refer to the detection of the health effects of vector-borne diseases, the ways in which they change, risk forecasting (modeling) and increasing the preventive protection of the population.
	Describe the methodology used to monitor and check the quality of the data, or attach links in the following field	"Field sampling methods for mosquitoes, sandflies, biting midges and ticks", VectorNet project 2014–2018. European Centre for Disease Prevention and Control and European Food Safety Authority (www.ecdc.europa.eu)
Links to relevant documents, technical documentation and the like	• https://www.eea.europa.eu/data-and-maps/indicators/vector-borne-diseases-2 • ECDC VBORNET vector distribution maps • Climate change effects on Chikungunya transmission in Europe • West Nile fever maps • The climatic suitability for dengue transmission in continental Europe	
COMMENTS	All of this implies that the policymakers have accepted the recommendation "**Develop and implement a specific regulatory framework for the national system for the surveillance of vectors and vector-borne diseases as well as for vector control.**"	

5.2 Forecasting changes in the short and long term (modeling)

The use of the MCDA model for early warning and prevention has shown high reliability of prediction and has confirmed that it can be used for accurate surveillance planning (described in Chapter 2). Validation and calibration of the MCDA model based on measured data for each year should become a mandatory part of the monitoring and control system, and the costs are minimal (RSD 391,548 per year - Table 3). Institution responsible for implementation: Ministry of Health (MoH). Institution in charge of conception, planning and implementation: LME - Laboratory for Medical Entomology in cooperation with the Institute of Meteorology, Faculty of Physics, University of Belgrade.

In this segment, the following actions need to be taken: (i) amending laws and bylaws (details in Chapter 6) (ii) educating users at all levels from decision makers to contractors and citizens on the need to use the model; (iii) inclusion of the model in the data analysis and planning system (changes and improvement of monitoring and control programs) on an annual basis; (iv) development and use of vector control models in the national program for implementation of effective vector control measures (changes and improvement of vector control programs - mitigation). Progress indicators: (i) implemented education campaigns (end of 2022); (ii) laws and regulations in line with the changes (end of 2023); (iii) the model included in the data analysis and planning system (2024); (iv) the vector control is functional and is used in the national vector control program (2025), and if the proposal is accepted by policymakers, (v) climate risk and vulnerability to vector spread and disease transmission and the "MCDA risk index" (0-100) and (vi) increased vector control efficiency (0-100% compared to the previous period).

Indicators based on the MCDA risk index reflect the success of general climate change adaptation measures implemented at the national level and beyond in order to reduce the total emitted concentration of greenhouse gases. Performance defined against the reference period (2011-2040, Figure 25): (i) high performance: the district risk index below the projected risk index for the intermediate emission scenario (RCP45); (ii) medium performance: the district risk index between the projected risk index for the intermediate emission screnario (RCP45) and the high emission scenario (RCP85); (iii) low performance: the district risk index is above the high emission scenario risk index (RCP85).

REPORTING FORMAT	
Activity/measure title: Forecasting changes in the short and long term (modeling)	
Description of the activity/measure	Location: all of Serbia. Determining the impact of climate change on health is difficult due to the complexity of interactions and the potential modifying effects of a number of other factors (such as changes in land use, the public health sector capacity, and socioeconomic conditions). Criteria for defining the expected impact of climatic conditions on vector-borne diseases and human health have not been clearly identified and their description must rely on complex observational or prospective studies, with mandatory use of modeling methodologies. The measure implies the development, validation and improvement of models that will connect the seasonal dynamics of vectors, the appearance of pathogens in the population of vectors and humans, and the effects of vector control with economic effects. Actions that must be previously satisfied for the implementation of the measure are: (i) amendment of laws and bylaws; (ii) educating users at all levels from decision makers to contractors and citizens on the need to use the proposed model; (iii) inclusion of the model in the data analysis and planning system (changes and improvement of monitoring and control programs) on an annual basis; (iv) development and use of vector control models in the national program for implementation of effective vector control measures (changes and improvement of vector suppression programs- mitigation).

Type of measure	Policies	yes
	Financial	yes
	Technology/infrastructure	partly
	Capacity strengthening/training	partly
	Preventive measure	yes
	Mitigation of consequences	no
Measure status	Planned	
Content and link to other measures	The incorporation of modeling as a permanent measure in the program of national surveillance of vectors will enable the prediction of changes caused by climate, other environmental changes, urbanization, socio-economic changes on the occurrence of vector-borne diseases in the short and long term. Modeling should be directly related to vector monitoring and surveillance, vector control, vector-borne disease control in the human population and assessment of economic effects.	
Basis for activity/measure	The basis for the measure should be defined by amendments to the "Law on Protection of the Population from Infectious Diseases"	
Period of implementation of activities/measures	If accepted by policymakers, this measure needs to be repeated annually	
Potential problems and obstacles	Not being accepted by policymakers.	
Institution(s) responsible for the measure	Drafting	The Ministry of Health and the multisectoral "Surveillance Group for Vectors and Diseases they Transmit" described in the report
	Implementation	Faculty of Agriculture, Novi Sad; Faculty of Physics, Belgrade.
	Monitoring	-
Total expected investments in the drafting and development of the measure	RSD 750,000/ USD 7,710 at the middle exchange rate of the NBS on the date 14.5.2021	
Total funds required for the implementation of the measure	Each year, RSD 391,548/ USD 4,025 at the middle exchange rate of the NBS on the date 14.5.2021	

Source of funding in the reporting year (if there are several sources, indicate the percentages)	Budget of the local self-government and for which sector	
	National budget	Health sector
	Private investment	
	Grant	
	Loan	
	Budget of the local self-government and for which sector National budget	
Duration of the results of the activity/measure (indicate the time period in which it will be necessary to repeat the activity/measure)	Up to 5 years	Every year
	5-15 years	Every year
	Over 15 years	Every year
Additional benefits	The possibility to assess the risk of vector-borne disease, the possibility of preventive action, the ability to reduce the number of ill and dead people, increase in efficiency of vector control and in the analysis and rationalization of protection costs.	
Links to GHG emission reductions	none	
Indicators	Initial value (indicate the unit)	There is no initial value
	Target value (in the last year, if it is multi-year) (indicate the unit)	(i) Conducted education campaigns (end of 2022); (ii) laws and regulations in line with changes (end of 2023); (iii) the model is included in the data analysis and planning system (2024); (v) the vector control model is functional and is used in the national vector suppression program (2025). Assuming that national regulations are in place: (i) climate risk and vulnerability to the spreading of vectors and disease transmission and the "MCDA risk index" (0-100) and (ii) increased vector control efficiency (0-100% compared to the previous period).
	Achieved value (indicate the unit)	As the indicators are descriptive (type A), the achieved values will refer to the detection of the health effects of vector-borne diseases, the ways in which they change, risk forecast (modeling) and increasing the preventive protection of the population.
	Describe the methodology used to monitor and check the quality of the data, or attach links in the following field	

Links to relevant documents, technical documentation and the like	• Climate change effects on Chikungunya transmission in Europe • The climatic suitability for dengue transmission in continental Europe • Semenza et al. (2016): Climate Change Projections of West Nile Virus Infections in Europe.
COMMENTS	All of this implies that the policymakers have accepted the recommendation "**Develop and implement a specific regulatory framework for the national system for the surveillance of vectors and vector-borne diseases as well as for vector control**."

5.3 Establishment and operationalization of the database

There is no national database of quality and curated data related to the vector sector and the diseases they transmit in Serbia. It is necessary to form an open (with different levels of data access) database at the national level in which data from the regional and local levels will be stored. The database should contain basic meteorological indicators, data on types of collected vectors and their number by monitoring dates, georeferences of monitoring sites, habitat data, data on detected pathogens related to the appropriate type of vector, costs of monitoring, modeling and control, costs of disrupting normal work activities, losses in the tourism and food production sectors, hospital treatment costs, lost lives and absences from work due to epidemics. Institution responsible for implementation: Ministry of Health (MoH). Institutions in charge of conception, planning and implementation: LME (coordinator), BF, IMI, PMF.

The following actions need to be taken: (i) amendments to laws and bylaws (details in Chapter 6); (ii) employment of one person for data curation and database management in a scientific research institution in charge of design, planning and quality control (LME), the same person would establish and manage the wireless sensor network for microclimate measurements (LoRa, IoT - costs 2,344,132 per year - Tab 1); (iii) development of a wireless sensor network for microclimatic measurements and modeling (LoRa, IoT-price of equipment included in Table 3); (iv) purchase of software for the acquisition and secure storage of data (VecMap EUR 1,100 per year - costs shown in the barrier to consumables Tab. 1). Progress indicators: (i) laws and regulations in line with changes (end 2023) (ii) the VecMap (database) software for the acquisition and secure storage of data functional (mid 2024); (iii) wireless sensor network functional and connected to the database and model (end 2024); (iv) microclimate data are stored in a database and used for modeling, and if the proposal is accepted by policymakers, (v) evaluation of climate risk and vulnerability to vector spread and disease transmission; (vi) evaluation of vector control; (vii) evaluation of economic indicators.

REPORTING FORMAT		
Activity/measure title: Data base		
Description of the activity/measure	Location: all of Serbia. There is no national database of quality and curated data related to the sector of vectors and diseases they transmit in Serbia. The measure includes the creation of a database that will contain microclimatic meteorological indicators, data on the types of collected vectors and their number by monitoring dates, georeferencing of monitoring sites, habitat data, data on detected pathogens related to the appropriate vector species, monitoring, modeling and control costs, costs of disrupting normal work activities, losses in the tourism and food production sectors, hospital treatment costs, lost lives and absences from work due to epidemics. Actions that must be previously satisfied for the implementation of the measure are: (i) amendment of laws and bylaws; (ii) hiring one data curator and database manager in a scientific research institution responsible for designing, planning, implementing and quality control, the same person would establish and take care of the microclimate measurement (IoT) sensor network; (iii) development of a network of sensors for microclimate measurements and modeling (LoRa, IoT-price of equipment included in the costs of the first year); (iv) purchase of software for the acquisition and storage of data with protection (VecMap- license renewal reported every year).	
Type of measure	Policies	yes
	Financial	yes
	Technology/infrastructure	partly
	Capacity strengthening/training	no
	Preventive measure	yes
	Mitigation of consequences	no
Measure status	Planned	
Content and link to other measures	The data from the database will enable quality modeling and forecasting of changes caused by climate, other environmental changes, urbanization, socio-economic changes in the occurrence of vector-borne diseases in the short and long term, assessment of economic impact on the state and mitigation costs. The database will store data obtained by monitoring the microclimate of the vector habitats, monitoring and surveillance of the vectors, vector control, control of vector-borne diseases in the human population and assessment of economic effects.	
Basis for activity/measure	The basis for the measure should be defined by amendments to the "Law on Protection of the Population from Infectious Diseases"	
Period of implementation of activities/measures	If accepted by policymakers, this measure needs to be repeated annually	
Potential problems and obstacles	Not being accepted by policymakers.	

Institution(s) responsible for the measure	Drafting	Ministry of Health, Ministry of Agriculture, Forestry and Water Management and the multisectoral "Surveillance Group for Vectors and Diseases they Transmit" described in the report
	Implementation	Faculty of Agriculture, Novi Sad; Faculty of Biology, Belgrade; Institute for Medical Research, Belgrade, Faculty of Science. Kragujevac.
	Monitoring	Faculty of Agriculture, Novi Sad
Total expected investments in the drafting and development of the measure	RSD 750,000/ USD 7,710 at the middle exchange rate of the NBS on the date 14.5.2021	
Total funds required for the implementation of the measure	In the first year, RSD 3,446,016/ USD 35,424 In each following year, RSD 2,521,132/ USD 25,917 at the middle exchange rate of the NBS on the date 14.5.2021	
Source of funding in the reporting year (if there are several sources, indicate the percentages)	Budget of the local self-government and for which sector	
	National budget	Health sector and Veterinary sector
	Private investment	
	Grant	
	Loan	
Duration of the results of the activity/measure (indicate the time period in which it will be necessary to repeat the activity/measure)	Up to 5 years	Every year
	5-15 years	Every year
	Over 15 years	Every year
Additional benefits	The possibility to assess the risk of vector-borne disease, the possibility of preventive action, the ability to reduce the number of ill and dead people, increase in efficiency of vector control and in the analysis and rationalization of protection costs.	
Links to GHG emission reductions	none	

Indicators	Initial value (indicate the unit)	There is no initial value
	Target value (in the last year, if it is multi-year) (indicate the unit)	(i) Laws and bylaws are harmonized with changes (end of 2023) (ii) software for acquisition and storage of data with protection VecMap (database) is functional (middle 2024); (iii) sensor network is functional and connected to database and model (end 2024); (iv) microclimate data are stored in a database and used for modeling (from 2025). Assuming that national regulations are in place: (i) evaluation of climate risk and vulnerability to vector spread and disease transmission; (ii) evaluation of vector control; (iii) evaluation of economic indicators.
	Achieved value (indicate the unit)	As the indicators are descriptive (type A), the data from the database will be used to detect the health effects of vector-borne diseases, the ways in which they change, risk prediction (modeling), evaluation of control success, assessment of economic effects and increase in preventive protection of the population
	Describe the methodology used to monitor and check the quality of the data, or attach links in the following field	The ECDC and EFSA methodology for database creation developed within the VectorNet project will be used.
Links to relevant documents, technical documentation and the like		
COMMENTS	All of this implies that the policymakers have accepted the recommendation "**Develop and implement a specific regulatory framework for the national system for the surveillance of vectors and vector-borne diseases as well as for vector control.**"	

5.4 Defining a system for effective vector control and quality control

Basic rules (methodology, time and place, frequency, selection of biocides for application in different habitats, required level of efficiency, quality control, etc.) should be defined at the national level, and the plans of regions and local governments should be reviewed and approved. France, Italy, and Croatia have national plans that regions and local governments adapt to their ecoclimatic conditions and vulnerabilities. All those whose plans are in line with national norms must undertake to introduce external quality control measures (which will not be carried out by the same private company that conducts mosquito control on the territory of that same local self-government) (efficiency) of the implemented control measures. Serbia, has a "Team for the unified implementation of mosquito control activities." Unfortunately, the Team's program is based on insufficient knowledge of the issue and misinterpretation of WHO experts' recommendations.

Also, it only deals with mosquitoes, and it is not defined whether it's only the house mosquitoes if it also includes mosquito vectors of dengue, chikungunya, zika and malaria.

The following actions need to be taken: (i) amending the vector control legislation in terms of defining national standards that must be respected at regional and local level (details in Chapter 6); (ii) defining the procedure for approving regional and local vector control plans and (iii) the obligation to introduce external quality control in all control programs - detailed recommendations for policy changes are given in the next chapter. Progress indicators: (i) regulatory amendment completed (by the end of 2023); (ii) quality control started (2024). Institutions responsible for implementation: Ministry of Health, Ministry of Public Administration and Local Self-Government (MPALS) and the Provincial Secretariat for Urbanism and Environmental Protection (PSUEP). Institution in charge of conceptualization, planning and quality control: Laboratory for Medical Entomology, Faculty of Agriculture in Novi Sad (LME) in cooperation with the Institute for Pesticides and Environmental Protection (IP) and the Faculty of Agriculture in Zemun (PFZ). The costs of quality control of the mosquito control co-financing program organized by MPALS and PSUEP would amount to 29.5 million annually. The success of adaptation measures should be monitored in parallel by reporting on quantitative indicators defined by the MCDA risk index. Reporting should be done on an annual basis from the time of the establishment of the national vector surveillance and control system. At present, it is not possible to define quantitative indicators for monitoring the adaptation measures related to vector control and vulnerabilities related to vector-borne diseases because protocols and a surveillance and control system have not yet been defined.

REPORTING FORMAT	
Activity/measure title: Vector Control	
Description of the activity/measure	Location: all of Serbia. Basic rules (methodology, time and place, frequency, selection of biocides for application in different ecosystems, required level of efficiency, quality control methods, etc.) should be defined at the national level, plans of regions and local governments reviewed and approved. Regions and local governments are adapting plans to their environmental conditions and vulnerabilities. All those whose plans align with national standards must undertake to introduce external quality control measures (efficiency) of the implemented control measures. The measure includes the development of national rules for the control of vectors, forming a body for the approval of local plans, and introducing mandatory external quality control of the implemented control measures. The actions that must be previously met for the implementation of the measure are: (i) amendment of the legislation related to the suppression of vectors in terms of defining national norms that must be respected at the regional and local level; (ii) the establishment of an institution for the approval of regional and local control plans; and (iii) the obligation to introduce external quality control in all regional and local control programs.

Type of measure	Policies	yes
	Financial	yes
	Technology/infrastructure	no
	Capacity strengthening/training	yes
	Preventive measure	yes
	Mitigation of consequences	yes
Measure status	Planned	
Content and link to other measures	It is crucial to base vector control on monitoring and surveillance results, , and model outputs. Introduction of quality control of planning and execution of vector control. Control should be directly related to vector monitoring and surveillance, vector modeling, surveillance of vector-borne diseases in the human population and assessment of economic effects.	
Basis for activity/measure	The basis for the measure should be defined by amendments to the "Law on Protection of the Population from Infectious Diseases"	
Period of implementation of activities/measures	If accepted by policymakers, this measure needs to be repeated annually	
Potential problems and obstacles	Not being accepted by policymakers.	
Institution(s) responsible for the measure	Drafting	The Ministry of Health, the Ministry of Public Administration and Local Self-Government, the Provincial Secretariat for Urbanism and Environmental Protection and the multi-sectoral "Surveillance Group for Vectors and Diseases they Transmit" described in the report
	Implementation	Faculty of Agriculture, Novi Sad; Institute for Pesticides and Environmental Protection, Belgrade and the Faculty of Agriculture in Zemun
	Monitoring	Faculty of Agriculture, Novi Sad
Total expected investments in the drafting and development of the measure	RSD 750,000/ USD 7,710 at the middle exchange rate of the NBS on the date 14.5.2021	
Total funds required for the implementation of the measure	Each year, RSD 29,500,000/ USD 303,255 at the middle exchange rate of the NBS on the date 14.5.2021	

Source of funding in the reporting year (if there are several sources, indicate the percentages)	Budget of the local self-government and for which sector	
	National budget	Ministry of Public Administration and Local Self-Government, Provincial Secretariat for Urbanism and Environmental Protection
	Private investment	
	Grant	
	Loan	
	Budget of the local self-government and for which sector National budget	
Duration of the results of the activity/measure (indicate the time period in which it will be necessary to repeat the activity/measure)	Up to 5 years	Every year
	5-15 years	Every year
	Over 15 years	Every year
Additional benefits	Environmental protection, increasing the efficiency of vector control, the possibility of preventive action, reducing the risk of vector-borne diseases, reducing the number of sick and dead people, analysis and rationalization of control costs.	
Links to GHG emission reductions	none	
Indicators	Initial value (indicate the unit)	There is no initial value
	Target value (in the last year, if it is multi-year) (indicate the unit)	(i) Amendments to legislation completed (by the end of 2023); (ii) quality control of control plans and measures started (2024). Assuming that national regulations are in place: (i) increased vector control efficiency (0-100% compared to the previous period).
	Achieved value (indicate the unit)	As the indicators are descriptive (type A), the achieved values will refer to the increase of environmental protection from biocides for vector control and the decrease in vector population, which will be implemented through quality control of vector control plans and implementation; risk mitigation and increasing the preventive protection of the population by increasing the success of vector control.
	Describe the methodology used to monitor and check the quality of the data, or attach links in the following field	

Links to relevant documents, technical documentation and the like	• https://www.who.int/vector-control/en/ • Michaelakis A, Balestrino F, Becker N, Bellini R, Caputo B, Della Torre A, Figuerola J, L'Ambert G, Petric D, Robert V, Roiz D, Saratsis A, Sousa CA, Wint W, Papadopoulos N. A Case for Systematic Quality Management in Mosquito Control Programmes in Europe. International journal of environmental research and public health 2021 18 (7) https://www.mdpi.com/1660-4601/18/7/3478
COMMENTS	All of this implies that the policymakers have accepted the recommendation "**Develop and implement a specific regulatory framework for the national system for the surveillance of vectors and vector-borne diseases as well as for vector control**."

5.5 Assessment of economic effects

The central database should record all costs, starting from the costs of surveillance, modeling and control, through the costs of disrupting normal work activities, losses in the tourism and food production sectors and the costs of hospital treatment, lost lives and absences due to epidemics. The analysis of these data will contribute to a better understanding of the system and raise the interests of the competent government institutions. Institutions responsible for implementation: MoH, MPALS and PSUEP. Institution in charge of designing, planning and maintaining the database: Laboratory for Medical Entomology, Faculty of Agriculture in Novi Sad (LME). It is necessary to take the same actions that are needed to form a database. The indicators are also the same.

5.6 Communication and data availability

In case scientific research institutions are in charge of the monitoring/surveillance of vectors and pathogens they transmit and controlling the quality of treatment, they will, in cooperation with the competent ministries and secretariats, develop a protocol for communicating the results. The protocol needs to be developed as described in this chapter, as well as according to additional guidelines proposed by the ECDC [18]. MCDA risk index reporting should be conducted on an annual basis with clearly defined (i) reference levels; (ii) relative deviation of the indicator from the reference level; (iii) relative deviation of the indicators from the previous year; (iv) necessary modifications to comply with the new regulations relating to climate change adaptation measures relevant to this sector [80].

6 Proposed Amendments, Revisions and Drafting of National Regulations and Policies

Based on the results of the analyzes presented in the report, in order to effectively include aspects of climate change in sectoral policies, measures and activities, the basic recommendation for amendments to laws, bylaws, technical instructions, planning and strategic documents is:

To develop and implement a specific regulatory framework for the national surveillance system for vectors and vector-borne diseases as well as for vector control.

The national system for the surveillance of vectors and vector-borne diseases as well as vector control should contain all the components explained in Chapter 5 of the Report (“Proposed Adaptation Measures”): (i) Monitoring and surveillance; (ii) Forecasting changes in the short and long term (modeling); (iii) Database; (iv) Vector control; (v) Assessment of economic effects; (vi) Communication and availability of data.

According to WHO [81], a network of regional reference laboratories for pathogen identification in the human population exists, however a network of reference entomological laboratories has not yet been established. The report emphasizes the importance of establishing national reference laboratories and establishing a regional network for adequate notification of vector-borne diseases (Core activity: Regional framework for surveillance and control of invasive mosquito vectors and re-emerging vector-borne diseases 2014-2020).

First, it is necessary to expand the scope of work of the existing "Team for the unified implementation of mosquito control activities" (Team) when formed by the Ministry of Health (MoH) to cover all groups of vectors, and to work based on the principles of "One Health". This would allow for timely adaptation and mitigation of the changes that climate change brings to the sector. We propose that instead of the Team, the MoH, at the proposal of the Institute of Public Health established for the territory of the Republic of Serbia (the Institute) and with the consent of the Republic Expert Commission for Infectious Diseases, establish an expert body "Group for surveillance of vectors and diseases”. The group should consist of: (i) representatives of the MoH (adopts the principles of surveillance, control and quality control and finances surveillance; through amendments to the "Law on Protection of Population from Infectious Diseases"), Ministry of Agriculture, Forestry and Water Management (MAFWE - finances pathogen detection in vectors and quality control of pathogen detection in accordance with the Law); (ii) representatives of the Ministry of State Administration and Local Self-Government (MSALSG) and the Provincial Secretariat for Urbanism and Environmental Protection (PSUEP) (funding vector control and quality control); and (iii) experts from different sectors whose joint action is necessary for the application of the principle of "One Health" in solving the problem of vector-borne diseases and mitigation of climate change - representatives of the Faculty of Agriculture, University of Novi Sad, Faculty of Biology (BF), Faculty of Physics (FF), The Faculty of Agriculture (PFZ), the Institute for Medical Research (IMI) and the Institute for Pesticides and Environmental Protection (IP), University of Belgrade, and the Faculty of Natural Sciences and Mathematics, University of Kragujevac (PMF). The first task of the group would be to propose the adoption of: (i) a Rulebook on the control of vectors and diseases they transmit (in accordance with Commission delegated regulation (EU) 2016/429, 2020/689); (ii) a Rulebook on the conditions to be met by legal and natural persons who carry out disinfection and pest control activities as measures for prevention and control of infectious diseases of the population, and (iii) Rulebook on the manner of disinfection and pest control.

It would then be necessary for the Minister to determine by decision, pursuant to the law, a reference laboratory for vectors that would work on: (i) development of a joint, national, science-based monitoring program according to ECDC and EFSA principles that would serve as a guideline for regional and local programs (design, planning and quality control of the program); (ii) defining national vector control standards (methodology, time and place, frequency, selection of biocides for use in different habitats, required level of efficacy, quality control, etc.) that must be respected at regional and local level, establishing an institution approving regional and local control plans and the obligation to introduce external quality control in all control programs; (iii) designing and planning systems for monitoring and forecasting changes in the short and long term (modeling the effects of climate and other changes affecting vectors and the diseases they transfer); (iv) designing, establishing and maintaining a database containing basic meteorological indicators, place and date of collection, data on types of collected vectors and their number by monitoring dates, georeferencing of monitoring sites, habitat data, data on detected pathogens by vector types, costs of monitoring, modeling and control, costs of disrupting the normal work activity of the population, losses in the tourism and food production sectors, costs of hospital treatment and absence from work, lives lost due to outbreaks of vector-borne diseases; (v) analysis of the economic effects of the established supervision and control system (costs and benefits); (vi) developing protocols for communicating and communicating results in cooperation with relevant ministries and secretariats; and (vii) addressing *ad hoc* problems at the request of ministries (e.g. outbreak of vector-borne disease, vector control intervention).

We propose that the Minister, in accordance with the law, determine the Laboratory for Medical and Veterinary Entomology (LME), the Faculty of Agriculture, the University of Novi Sad as the reference laboratory for vectors. This is because LME is: (i) the only laboratory for medical and veterinary entomology in Serbia that studies all groups of vectors (ticks, mosquitoes, simulids, sand flies) and deals with their ecology, determination, monitoring and surveillance and control, and has the strongest scientific results in this field in the country; (ii) was a reference laboratory and regional coordinator of the VectorNet project for Eastern and South-Eastern Europe (Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Northern Macedonia, Albania, Romania, Bulgaria, Greece, Moldova, Belarus, Ukraine and Russia); VectorNet (first phase 2014-2018) was the largest European project to study arthropods that transmit vector-borne diseases and was co-funded by the European Center for Disease Prevention and Control (ECDC) and the European Food Safety Authority (EFSA); (iii) is currently the reference laboratory of the MediLabSecure project for Serbia. The project “One Health network for the prevention of vector-borne diseases around the Mediterranean and Sahel regions (MediLabSecure)” is funded by the European Union (DEVCO/EuropeAid) within the CBRN Centres of Excellence Initiative. The project coordinator is the Institute Pasteur in Paris. The Faculty of Agriculture was chosen as the reference laboratory for Serbia in a competition in which seven national institutions of a similar profile participated.

All entrusted tasks of LME would be realized in close cooperation with partner institutions, BF, FF, PFZ, IMI, IP and PMF.

We are of the opinion that the recommended adaptation and mitigation measures (Chapter 5 of the Report) can be addressed by amendments to the Law on Protection of the Population from Infectious Diseases, Official Gazette of the RS, nos. 15 of 25 February 2016, 68 of 10 May 2020, 136 of 13 November 2020", hereinafter: the Law) and the adoption of bylaws (ministries that are accountable in accordance with the proposed in Chapters 5), programs, plans and expert-methodological instructions. An example is the "Guidelines for monitoring West Nile virus" of the Veterinary Administration (MAFWM). The first guidelines were adopted in 2014 and then they were updated every year based on the results of scientifically based supervision (Guidelines from 2018 are given in Annex 2).

Many articles (2, 3, 5, 7 - 21, 24, 25, 30, 41, 44, 52, 53, 66, 71, 73, 75, 75a, 76, 87) of the Law support the basic settings of the methodology of identifying, verifying and mitigating the effects of climate on changes in the vector-vector-borne disease system described in Chapters 4 and 5 of the Report. They are based on monitoring (registration of changes only, without planned mitigation actions), surveillance (registration is strongly related to mitigation actions), forecasting of changes in the short and long term (modeling), existence of a database of quality entomological and epidemiological data, vector control, assessment of economic effects and availability of data and their communication. Therefore, we believe that the Law offers the basis and has the regulatory capacity necessary for the adoption of amendments in order to urgently implement measures to adapt to the impact of climate change on the vector sector and the diseases they transmit.

Also, in Article 3, the Law defines the protection of the population from infectious diseases that can be transmitted from animals to humans and supports cross-sectoral cooperation in the field of mutual reporting on the occurrence and movement of these diseases, organization and implementation of anti-epidemic, hygiene and other measures to prevent and control certain infectious diseases. This indicates that the formation of the Group as an expert body that will define the principles and establish a national framework according to which the planning and control of vectors will be planned and performed is relatively simple.

Article 3 also states that "Implementation of measures to protect the population from infectious diseases prescribed by this Law and provision of funds for their implementation have priority over the implementation of other measures in the field of health care", which may contribute to urgent adoption of measures proposed in Chapter 5 of this report.

All proposed changes are also in line with the principles and recommendations of the International Health Regulations (IHR) https://www.who.int/health-topics/international-health-regulations#tab=tab_1 [82].

Proposed guidelines for amendments to the Law are given below.

6.1 Proposed general guidelines for amending the Law on Protection of the Population from Infectious Diseases

A number of articles of the Law on Protection of the Population from Infectious Diseases (hereinafter the Law) (articles: 2, 3, 5, 7 - 21, 24, 25, 30, 41, 44, 52, 53, 66, 71, 73, 75, 75a, 76, 87) support the basic principles of the methodology of identifying, verifying and mitigating the impact of climate change on the changes in the vector-vector-borne diseases system described in Chapters 4 and 5.

The proposal of guidelines for amendment of the Law is given in accordance with; (i) the results of previous research related to the vector and vector-borne diseases sector in Serbia; (ii) the experience and opinion of experts; and (iii) the legislation of the Republic of Croatia given in the "Law on the Protection of the Population from Infectious Diseases", which is the most precise in Europe when it comes to regulating the sector of combating vectors and the diseases they transmit.

The Law should provide a basis for the preparation and implementation of a national vector surveillance program (ticks, mosquitoes, sand flies) and a functional link between the surveillance program and vector control (surveillance results should be the drivers and they should provide a basis for action and annual amendments to the surveillance program). Vector surveillance (or entomological surveillance) should be carried out on the basis of the programs of the Republic of Serbia, and on the basis of the programs of the autonomous province and local self-government units after they are adopted.

The Republic of Serbia, autonomous provinces and local self-government units are obliged to ensure the implementation of measures for protection of the population from vector-borne diseases prescribed by Law and the means for their implementation, as well as expert and scientific supervision over the implementation of these measures.

Also, the Law should provide a basis for the preparation and implementation of a national vector control program (ticks, mosquitoes, and sand flies), functional links with the surveillance program and the obligation of external quality (efficiency) control of the implemented control measures. Vector control should be carried out on the basis of the programs of the Republic of Serbia, and on the basis of the programs of the autonomous province and local self-government units when they are adopted. All programs must be harmonized with the program of the Republic of Serbia, reviewed, and approved by the expert body of the "Group for the Control of Vectors and Diseases they Transmit". All approved programs must provide external quality control of the implemented control program through the instrument of scientific supervision. Scientific supervision over the implementation of preventive and mandatory intervention vector control is carried out by the reference laboratory for vectors and by the public services it cooperates with. Scientific supervision should be financed from funds of the Republic, the provinces and the local governments. Reports are prepared on the conducted scientific supervision, and their content, form and manner of preparation and communication are prescribed by the Minister. Mandatory, interventional, anti-epidemic vector control is carried out in order to quickly and effectively stop the spread of vector-borne diseases, as a safety and mandatory measure that is also subject to quality control.

6.2 Proposed specific guidelines for amending the Law on Protection of the Population from Infectious Diseases

These guidelines are proposed for specific amending of the articles of the Law (editorially refined text "Službeni Glasnik RS" no. 15, 25 February 2016; no. 68, 10 May 2020; and no. 136, 13 November 2020; www.pravno-informacioni-sistem.rs).

in **Article 2**, introduce and define the term vector - "a vector is an arthropod (tick, mosquito, sand fly, etc.) that can transmit a pathogen from an infected to a healthy host (animal or human)"

in **Article 2**, introduce and define the term vector-borne disease - "vector-borne, or transmissible/ communicable/infectious, disease is a disease transmitted by vectors"

in **Article 2**, introduce and define the term reference laboratory for vectors - reference laboratory for vectors is a laboratory that organizes scientific supervision over vectors and carries it out in cooperation with the Institute and the network of state health care scientific research institutions of general interest, as follows: diagnosis, confirmation and identifying vector types of infectious diseases, in accordance with its planned activities, and is part of the national network, established for laboratory support of the epidemiological surveillance, warning and response system at the national level (in accordance with Commission delegated regulation (EU) 2016 / 429, 2020/689);

in **Article 2**, introduce and define the term scientific surveillance of vectors and diseases they transmit - "scientific surveillance of vectors means vector surveillance based on the principles of science and the One Health concept, quality control of vector determination, and effectiveness of vector control measures. Surveillance is carried out by the responsible public services that conduct activities in the field of education and science, organized by the reference laboratory for vectors in accordance with the Law.

in **Article 5**, correct the categorization of infectious diseases in order to: (i) group diseases transmitted by vectors into one category; (ii) include the diseases which outbreaks can, on the basis of a sector analysis, be expected in the future. In the list under ordinal number 5) Other diseases, (5) Diseases transmitted by vectors (supplement the category with - anthroponoses and zoonoses), in addition to tick-borne encephalitis, add: (i) Lyme disease; (ii) Malaria - move from (4) Serious imported disease because it was present (indigenous) in Serbia until the 1960s and may reemerge; (iii) Plague (Pestis) - move from (4) Serious imported disease; (iv) West Nile virus infection - move from (3) Zoonoses - other than those listed in (4); (v) Dengue virus infection; (v) Chikungunya virus infection; (vii) Zika virus infection; (viii) Leishmaniasis; (ix) Phlebovirus infection.

in **Article 5**, delete the list of diseases and state that the list is attached to the Law or similar, so that it can be amended more quickly in accordance with the epidemiological situation and risk assessments.

in **Article 7**, add Entomological surveillance is carried out on arthropod vectors of infectious diseases, factors that contribute to changes in their number and disease transmission, as well as the effects of measures to control them. Entomological surveillance referred to in paragraph 2 of this Article on the territory of the Republic of Serbia shall be conducted and coordinated by the responsible public services that carry out activities in the field of education and science in accordance with the Law. The Reference Laboratory for Vectors established for the territory of the Republic of Serbia (hereinafter: Refvek), coordinates the implementation of entomological surveillance on the territory of the Republic of Serbia and issues expert instructions for entomological surveillance for vector-borne diseases and vector control. Entomological surveillance is carried out on vector-borne diseases, and vector control in accordance with the recommendations of the European Center for Disease Prevention and Control (ECDC) and the WHO. Refvek consolidates, analyzes and interprets data collected by entomological surveillance on the territory of the Republic of Serbia and exchanges them with other countries, ECDC, WHO and other international organizations.

in **Article 8**, in addition to epidemiological, introduce entomological surveillance as an obligation

in **Article 9**, supplement that the Republic programs related to the vector surveillance and control in accordance with the Law and obligations established by international agreements shall be prepared by Refvek, in cooperation with partner scientific research institutions

in **Article 10**, supplement with: ...based on the opinion of the Institute, and in the case of vector-borne disease, Refvek in accordance with the Law

in **Article 11**, supplement with: In order to establish expert views on the preservation and promotion of health, prevention and control of vector-borne diseases based on evidence and international recommendations, a Group for Control of Vectors and Diseases they Transmit (hereinafter the Group) shall be established and it shall have a representative member in the Republic Expert Commission for Protection of the Population from Infectious Diseases. The Commission and the Group referred to in paragraphs 1 and 2 of this Article shall be formed by the Minister, upon the proposal of the Institute and reference health and scientific research institutions.

in **Article 15**, supplement with: in and around residential buildings, on public areas and public buildings in cities and settlements and other buildings of public health and communal importance.

in **Article 16**, supplement with: Disinsection as a general measure means mechanical, physical, biological or chemical measures carried out in order to prevent retention, reproduction, reduction in the number of harmful arthropods and keeping their number below the harmful threshold, in order to ensure quality hygienic and sanitary conditions on the surfaces, in the premises and facilities referred to in Article 15, paragraph of this Law. Supervision over the implementation of general disinsection measures is the responsibility of Refvek and public services associates.

in **Article 17**, supplement with: Supervision over the implementation of special disinsection measures is the responsibility of Refvek and public services associates.

in **Article 18**, supplement the first sentence with: Early detection of sources, reservoirs and vectors of infection and pathways ...

in **Article 19**, supplement with: The data collected by entomological surveillance of vectors are kept in a single database for vectors and vector-borne diseases. Paragraph 4 In case of occurrence of a vector-borne disease, scientists in the field of medical entomology, meteorology, and in zoonoses and veterinary medicine sciences, i.e. from leading scientific research institutions in Serbia, are also included in the research. The epidemiological research referred to in paragraph 1 of this Article shall be conducted by public health institutes, and *for vector-borne diseases and institutions referred to in paragraph 4*, in the case of: .... then item 4 - Institutions referred to in paragraph 4 ensure funds for material expenditures and compensation for conducting alertness from the funds of the national program for the control of vectors and diseases they transmit.

in **Article 20**, supplement the second paragraph with: ... are organized and conducted by institutes of public health and *institutions referred to in Article 19 (paragraph 4)*, ...

in **Article 21**, paragraph 3 supplement with ... microbiology, in accordance with the Law governing health care. *Detection of the presence of pathogens in vectors shall be carried out by authorized veterinary institutes in accordance with the law governing animal health.*

in **Article 24**, replace yellow fever with vector-borne diseases; the yellow fever vector has never been present in Serbia and the chances of it occurring in the long run are, according to climate change forecasts, minimal. In the penultimate paragraph, add at the end: *In the case of vector-borne infectious disease, the Institute shall immediately notify the reference laboratory for vectors.*

in **Article 25**, supplement the first, second and fourth paragraphs with: ... inform the competent veterinary organization, *and in the case of vector-borne zoonosis, the reference laboratory for vectors* and inspection bodies as well...; ... Institute of Public Health, *and in the case of vector-borne zoonosis, a reference laboratory for vectors*, and the administrative body competent ...; ... organization *and, in the case of vector-borne zoonosis, the reference laboratory for vectors*, makes a unique annual ...

in **Article 30**, remove yellow fever.

in **Article 41**, replace the second paragraph with: In case of autochthonous vector-borne disease, it is obligatory to disinsect residential and other buildings, means of transport, settlements, and their surroundings, in the endangered or infected area according to the recommendations of the reference laboratory for vectors.

in **Article 52**, supplement with: The Minister, based on the proposal of the Commission and the Institute *(and in the case of vector-borne disease the reference laboratory for vectors as well)* may order:

e) special measures for vector control according to the recommendations of the reference laboratory for vectors

in **Article 53**, supplement with: ... the proposal of the Commission, and the Office a) *in case of vector-borne disease and reference laboratory for vectors*, may order ... and ... b) *special measures to engage the population in the vector control*

in **Article 66**, supplement with: ... 1) monitor the movement of infectious diseases based on the report of the Institute *and the reference laboratory for vectors*; ... 4) *at the proposal of the Institute, and in the case of vector-borne disease and the reference laboratory for vectors*, orders the implementation of ...

in **Article 75a**, supplement ... joint inspection supervision, and in case of vector-borne diseases, *reference laboratories for vectors with public services with which it cooperates* also participate in surveillance.

in **Article 76**, supplement with: ... i.e. institutes for public health *and reference laboratory for vectors with public services with which it cooperates* to perform surveillance, i.e. ...

in **Article 77**, supplement with: 2) ... health workers and *employees of public services for the surveillance of vectors* to perform surveillance and prescribed tests ...

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Annex 1 Detailed Methodology of Modelling and Risk Assessment at District Level

A1.1 Introduction

Vector-borne disease or transmissible disease is a disease caused by arthropods that can transmit pathogens from an infected person to a healthy person. According to the World Health Organization (WHO), vector-borne diseases make more than 17% of all infectious diseases in the world, with more than half of the world's population living in areas exposed to this type of diseases. Over a billion people are infected every year, with about 600,000 deaths. The probability of an epidemic of transmissible diseases is directly proportional to the abundance of vectors and the length of the interval of increased activity during the year.

Meteorological conditions significantly affect the time of occurrence, the abundance of vectors and their activity. In the conditions of evident climate changes, it is of great importance to consider the impact of expected climate changes on the suitability of conditions for the occurrence of selected vectors. Also, significant changes in the fluctuations of meteorological elements in relation to the multi-year average and the increasingly frequent occurrence of extreme weather conditions lead to unexpected behavior of the vector population, which significantly affects the quality of life and human health. The only way to identify the causes and consequences of these phenomena is based on the simulation of the activity and abundance of vectors, with the possibility of testing the influence of each individual factor. This possibility is provided by mechanistic models based on climatic parameters from regional climate models and biological characteristics of the population. These influences of meteorological parameters, climate and other factors that trigger changes in the complex system vector - pathogen - environment, can result in changes in epidemiology, i.e. occurrence and spread of vector-borne diseases. The results given in the sub-chapter "Impact assessment" (Chapter 2) show that the projected climate change will contribute to the spread of areas suitable for vector settlement to areas outside their primary habitat in the case of both indigenous and invasive species. Also, the rise in temperature will contribute to prolonging the duration of the seasonal activity of the vector, shortening the incubation period of the virus in the vector, increasing the abundance of vectors and thus the probability of pathogen transmission. Among other drivers of change, we single out the globalization of the exchange of goods and services, more intensive international travel and population migration. These factors can contribute to the spread of vectors and the introduction of invasive species and lead to changes in the number of patients with new as well as previously eradicated infectious vector-borne diseases. The current lack of comprehensive (including all groups of vectors), scientifically based, legally supported and systematically organized (obligation to implement guided by identical principles from the national to the local level) surveillance and control of vectors and diseases they transmit contributes to additional vulnerability.

A1.2 Modeling of climate suitability and spatial distribution of vectors – detailed methodology and data source

Analysis of changes in climatic suitability for vector establishment and activity in a given area, based on climatic parameters specific to that region, is important for assessing potential risk and identifying possible foci for vector development as well as consequent circulation of vector-borne diseases. This type of analysis can especially contribute to the assessment of the vulnerability of a certain region for the introduction of a new invasive vector species as well as the change in the distribution and abundance of the autochthonous, already present, species. Two types of models can be distinguished within this research topic: (i) correlative species distribution models (SDM); (ii) mechanistic models of climatic suitability based on the specific climatic conditions required for vector establishment and activity in a given area.

Correlative SDM models use a stochastic top to bottom approach based on data on the presence/absence of vectors and the correlation of these data with different abiotic and biotic factors. The most important factors are most often climatic parameters derived from climatic normals of temperature and precipitation [1].

Mechanistic models, on the other hand, use a bottom to top approach, do not require data on the presence/absence of vectors and are based on empirical knowledge (laboratory and field experiments) regarding known vector ecology [2], [3].

SDM models can be divided into the following numerical infrastructures: (i) Generalized linear models (GLMs) [4]–[6]; (ii) Generalized additive models (GAMs) [6], [7]; (iii) Climate envelope models (CEMs) [8]; (iv) Random forest (RF) [4], [7], [9]; (v) Neural networks (NNs). New generations of statistical models like NN use sophisticated models with learning algorithms that can reproduce analogous new situations based on the analysis of the historical datasets on which they are first trained. Statistical models are currently expanding due to the possibility of applying this type of modeling to systems for which there is no quantitative mathematical description or adequate parameterization of the simulated process. In their 2019 paper, Jeschke and Strayer [8] compared the accuracy and applicability of different SDM models and concluded that newer techniques, such as Random forest models and Bayesian weighted models, give consistently better results than more commonly used older models [10]–[12]. They also stressed the need for the model to be adapted to the type of the analyzed vector.

Mechanistic models use a set of climatic threshold values to construct a suitability algorithm based on existing literature and field observations of the most important factors affecting different vector populations in different eco-climatic zones. These threshold values are usually determined by laboratory experiments conducted in climate chambers or based on the existing distribution of vectors in a certain area. The most common numerical structures in use in this field are: (i) Mechanistic GIS models; (ii) MCDA models [13]–[16]; (iii) Seasonal limit models [3].

Models from the second group (Mechanistic models) are deterministic models based on a direct relationship between the observed meteorological variables and the expected impact on the vector population. Mechanistic models allow direct analysis of the model's sensitivity to input parameters and analysis of the mechanism influencing the increase or decrease of risk and thus offer a more transparent structure for the analysis and magnitudes of the influence of climatic quantities on the current distribution of vectors in a given area. The advantage of mechanistic deterministic models over stochastic ones is that they can be applied to areas where there is no regulated vector monitoring, required for the calibration and training of statistical models.

Description of the MCDA Model

Spatial analysis of the impact of climate change on the risk and vulnerability of the sector to vectors and the diseases they transmit at the state level was carried out within the project using the mechanistic Multi Criteria Decision Analysis (MCDA) model. The MCDA model is a sophisticated method of analyzing the contribution of multiple input factors to an outcome, as well as its sensitivity to different scenarios and input value configurations. It is often used as a tool to critically analyze administrative decisions, illustrate alternative scenarios and compromises, formulate actions, and test their robustness. A typical MCDA process consists of (i) problem contextualization, (ii) numerical analysis and output simulation, (iii) susceptibility analysis, and identification of major factors influencing the risk of vector-borne disease.

Numerical analysis of climatic suitability for vector activity consists of the construction of a family of sigma functions determined by empirical thresholds that describe the limit values of meteorological variables for vector development/activity/overwintering. These functions translate the value of the input climatological quantity into the corresponding value of the MCDA risk index corresponding to a certain vulnerability threshold of the area. Functions are continuous, smooth functions defined in the domain of values by a certain empirically defined minimum and maximum (Tc, Sc). The model analyzes the input group of sigma functions defined for each vector type. Characteristic sigma functions have the following general form:

$$\sigma_s = \frac{a_1}{1 + \exp\left(a_2 \cdot (x - a_3)\right)} + a_4$$

a2 is a constant defined by:

$$a_2 = \frac{4}{(T_c - S_c)}$$

and a3 as

$$a_3 = \frac{T_c + S_c}{2}$$

x is the value of the climatic quantity with the eigenvalues for Tc and Sc, the parameters a1 and a4 determine the interval of the MCDA index, in this case [0-100]. The characteristic sigma functions for each species are graphically shown in Figure A 2. The final output value, the MCDA risk index, is defined by:

$$\sigma = \left(\prod_{s=1}^{n} \sigma_s^{\omega_s} \right)^{1/\sum_{s=1}^{n} \omega_s}$$

Where n is the number of climatic parameters for a given vector species, σs is the characteristic sigma function for that parameter and ωs is the statistical averaging weight. The index takes values from 0-100 (a_1=100,a_4=0). The MCDA risk index is divided into four categories of vulnerability for ease of interpretation: (i) very low vulnerability (0-25); (ii) low vulnerability (25-50); (iii) moderate vulnerability (50-75); (iv) high vulnerability (75-100).

Values for Tc and Sc parameters were determined from the literature and expert opinion for the most important vector species in Serbia: (i) *Culex pipiens pipiens*; (ii) *Culex pipiens molestus*; (iii) *Aedes albopictus*; (iv) *Anopheles hyrcanus*; (v) *Ixodes ricinus*; (vi) *Phlebotomus papatasi*.

An overview of the input parameters for these six MCDA models is schematically shown in Figure A 1.

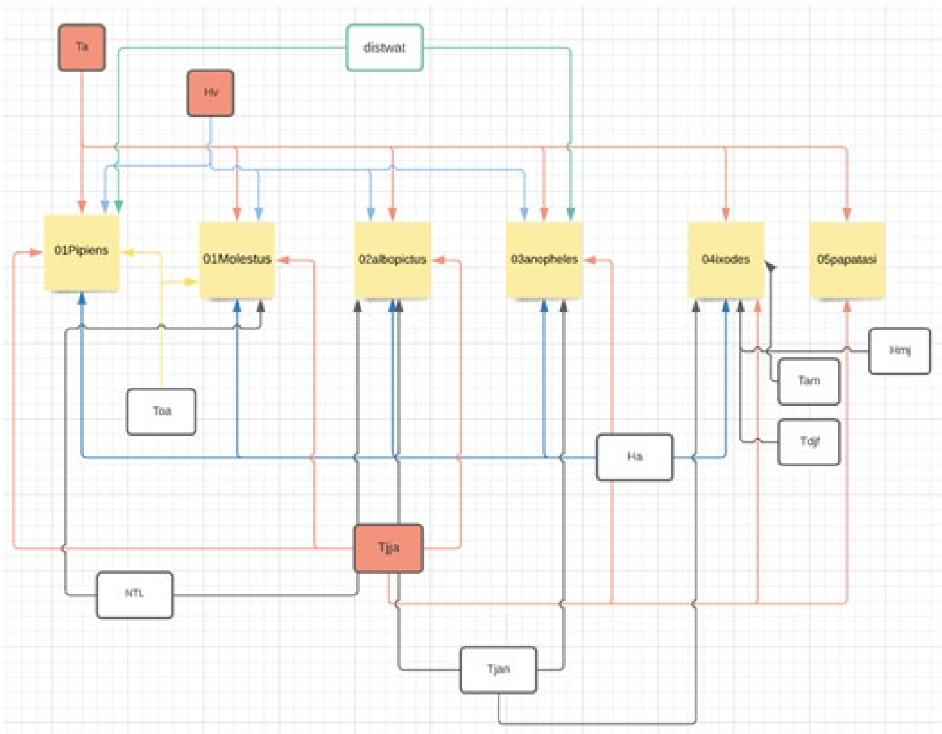


Figure A 1: Overview of input values for MCDA models: Ta - mean annual air temperature; Ha - total annual rainfall; Hv - number of days with precipitation >0.1 mm; Distwat - distance from floodplains and larger areas of natural waters; Toa - average air temperature in the period from October to April; Tjja - average air temperature in the period from June to August; NTL - population density based on remote observations of night lighting; Tjan - average monthly temperature for January; Ha - total annual rainfall; Tam - the average temperature in the period from April to May; Tdjf - average air temperature in the period from December to February; Hmj - the average amount of precipitation in the period from March to June.

Culex pipiens biotype pipiens: The climatic criteria that must be met in order for a vector to be established and active in a particular area, based on the literature, are: (i) Mean annual air temperatures above 7 °C and optimally 12 °C; (ii) Mean air temperature in the period from October to April above 5 °C and optimally 11 °C; (iii) Total annual rainfall over 400 mm and optimally over 600 mm; (iv) Mean air temperature for the period June to August above 11 °C and below 35 °C, optimally between 16 and 27 °C; (v) Number of days with rainfall >0.1 mm over 36 and optimally over 96; (vi) Distance from floodplains of larger rivers less than 10 km optimally below 5 km; (vii) Distance from larger natural bodies of water (ponds/lakes) less than 10 km and optimally less than 5 km.

Culex pipiens biotype molestus: The climatic criteria that must be met in order for a vector to inhabit and be active in a given area are, based on the literature: (i) Mean annual air temperatures above 7 °C and optimally 12 °C; (ii) Mean air temperature in the period from October to April above 5 °C and optimally 11 °C; (iii) Total annual rainfall over 400 mm and optimally over 600 mm; (iv) Mean air temperature between June and August above 11 °C and below 35 °C, optimally between 16 °C and 27 °C; (v) Population density expressed by remote measurements of night illumination over 10 and optimally 30; (vi) Number of days with rainfall >0.1 mm over 36 and optimally over 96.

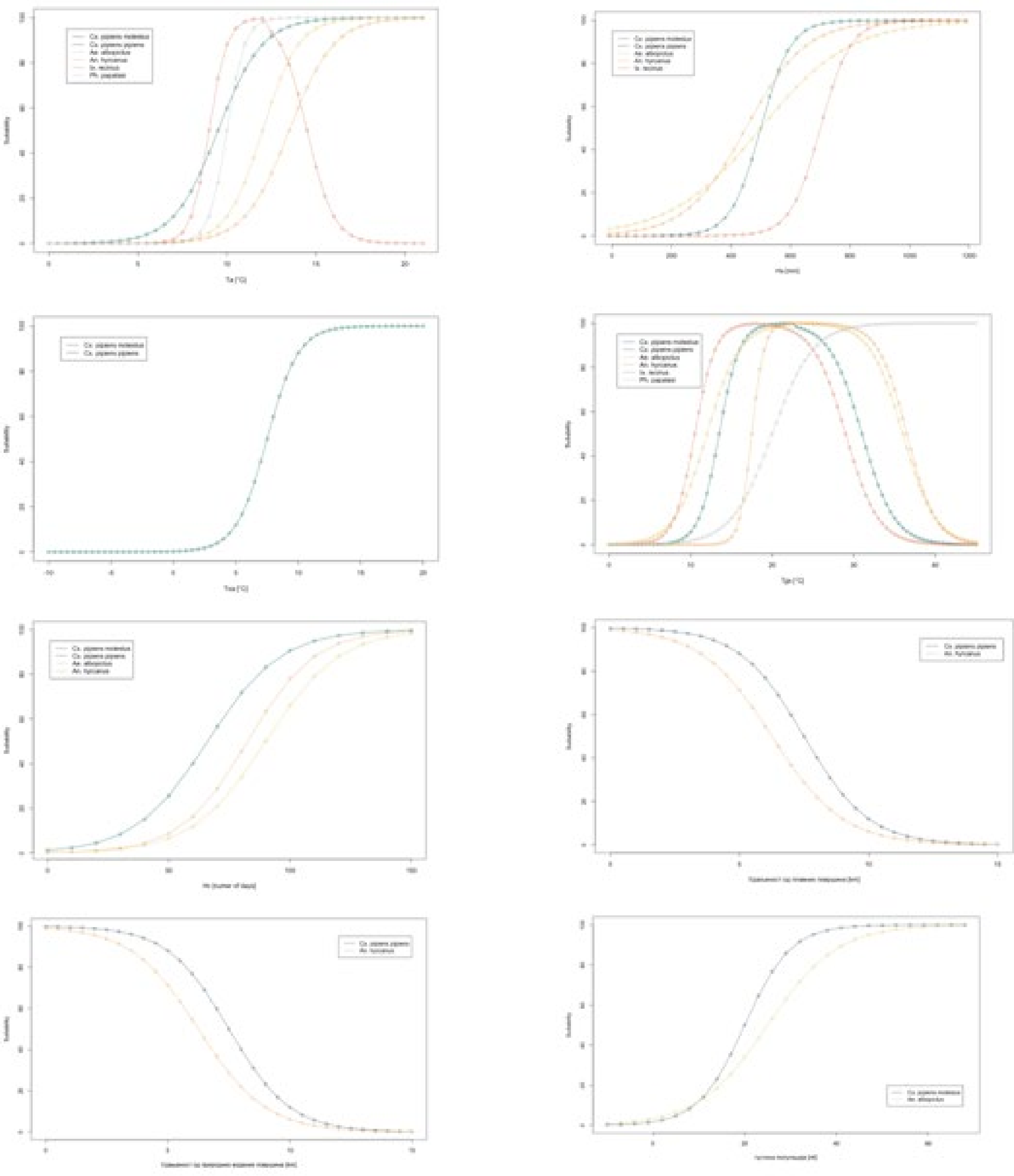
Aedes albopictus: The climatic criteria that must be met in order for a vector to inhabit and be active in a given area are, based on the literature: (i) Mean annual air temperatures above 10 °C and optimally 12 °C; (ii) Total annual rainfall over 200 mm and optimally over 800 mm; (iii) Mean January air temperature above -4 °C and optimally 3 °C; (iv) Mean air temperature for the period June to August above 8 °C and below 40 °C, optimally between 16 °C and 32 °C; (v) Number of days with rainfall >0.1 mm over 60 and optimally over 120; (vi) Population density expressed by remote measurements of night illumination over 10 and optimally 40.

Anopheles hyrcanus: The climatic criteria that must be met in order for a vector to inhabit and be active in a given area are, based on the literature: (i) Mean annual air temperature above 10 °C and optimally 16 °C; (ii) Total annual rainfall over 300 mm and optimally 650 mm; (iii) Mean January air temperature above 2 °C, and optimally 12 °C; (iv) Mean air temperature between June and August above 16 °C and below 40 °C, optimally between 19 °C and 33 °C; (v) Number of days with rainfall >0.1 mm over 55 and optimally 110; (vi) Distance from floodplains of larger rivers less than 7 km optimally below 3.5 km; (vii) Distance from larger natural bodies of water (ponds/lakes) less than 7 km and optimally below 3.5 km.

Ixodes ricinus: Climatic criteria that must be met in order for a vector to inhabit and be active in a given area are, based on the literature: (i) Mean annual air temperature above 7 °C and below 15 °C, optimally between 11 °C and 12 °C; (ii) Mean air temperature for the period April to May above 6 °C and below 28 °C, optimally between 12 °C and 18 °C; (iii) Total annual rainfall over 400 mm and optimally 700 mm; (iv) Mean January air temperatures above -10 °C and optimally 3 °C; (v) Mean temperature in the period from December to February above 0 °C and optimally above 3 °C; (vi) Mean temperature between June and August above 8 °C and below 33 °C, optimally between 13 °C and 25 °C; (vii) Average rainfall between May and June over 20 mm and optimally 60 mm.

Phlebotomus papatasi: The climatic criteria that must be met in order for a vector to inhabit and be active in a given area are, based on the literature: (i) Mean annual air temperature above 9 °C and optimally 12 °C; (ii) Mean air temperature from June to August above 15 °C and optimally 25 °C.

Graphs of characteristic functions for each species and climate parameter are shown in Figure A 2.



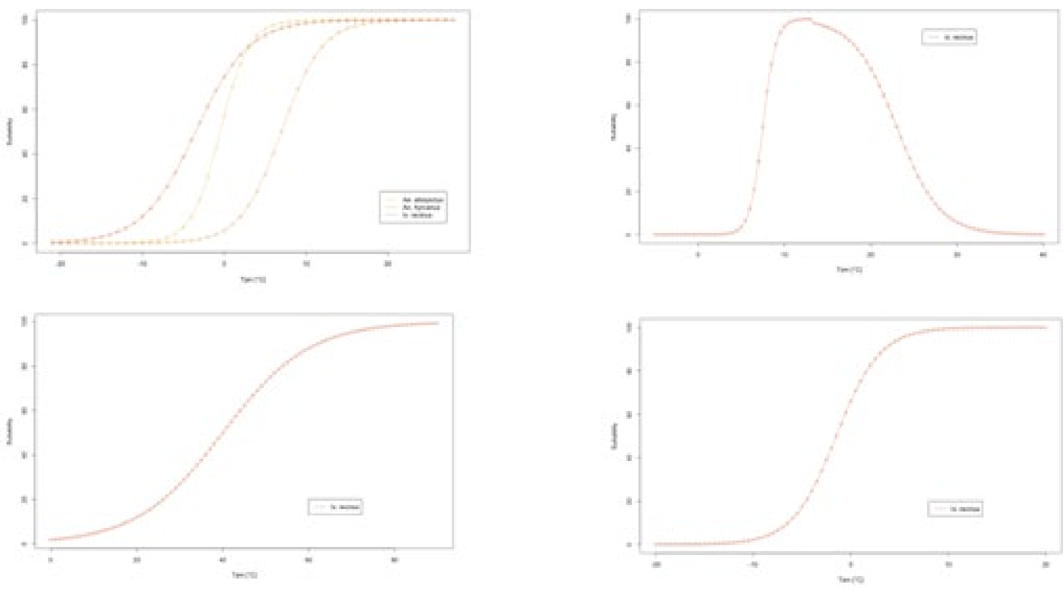


Figure A 2: Characteristic sigma functions for: (i) Culex pipiens pipiens; (ii) Culex pipiens molestus; (iii) Aedes albopictus; (iv) Anopheles hyrcanus; (v) Ixodes ricinus; (vi) Phlebotomus papatasi. The MCDA risk index is shown on the y axis, the value of the climate input quantity is shown on the x axis: Ta - average annual temperature; Ha - total annual rainfall; Hv - number of days with precipitation >0.1mm; Distwat - distance from floodplains and larger areas of natural waters; Toa - average air temperature in the period from October to April; Tjja - average air temperature in the period from June to August; NTL - population density based on remote observations of night lighting; Tjan - average monthly temperature for January; Ha - total annual rainfall; Tam - the average temperature in the period from April to May; Tdjf - average air temperature in the period from December to February; Hmj - the average amount of precipitation in the period from March to June

Input Data

Vulnerability analysis was conducted for all sites for the periods: (i) 1971-2000; (ii) 2011-2040; (iii) 2041-2070; (iv) 2071-2100.

The input values for the MCDA model are climatic parameters derived from the EURO-CORDEX (EUR-11) ensemble of Regional Climate Models [17]. The ensemble used consists of 8 models: (i) gcm-ICHEC-EC-EARTH-rcm-DMI-HIRHAM5 [18]; (ii) gcm-MOHC-HadGEM2-ES-rcm-CLMcom-CCLM4-8-17; (iii) gcm-MOHC-HadGEM2-ES-rcm-KNMI-RACMO22E; (iv) gcm-MPI-M-MPI-ESM-LR-rcm-MPI-CSC-REMO20091; (v) gcm-MPI-M-MPI-ESM-LR-rcm-MPI-CSC-REMO20092; (vi) gcm-ICHEC-EC-EARTH-rcm-CLMcom-CCLM4-8-17; (vii) gcm-ICHEC-EC-EARTH-rcm-KNMI-RACMO22E; (viii) gcm-MPI-M-MPI-ESM-LR-rcm-CLMcom-CCLM4-8-17. The median MCDA risk index for each ensemble member was taken as a representative value for the RCP45 and RCP85 scenarios [19].

Sensitivity Analysis of the Model

Sensitivity analysis was conducted for the purpose of analyzing the dependence of the output values of the MCDA model on the input climate parameters. The technique is based on the analysis of parametric space based on the methodology developed by Chalom et al. [20].

In the first step, the analysis of the spatial distribution and the probability density function of the input parameters was performed. In the second step, a multidimensional parametric space was defined using a Latin hypercube sampling (LHS) sampling algorithm [20], [21]. The size of the sampled subset was determined via SMBA statistics [20], [22] which takes values from -1 to 1 and indicates complete mismatch of output (-1) or complete match of output (1). The sample size was chosen so that the LHS outputs reflect matching >0.7 [20]. In the final step, the results of the sensitivity analysis are presented through the empirical cumulative distribution function (ECDF) and partial rank correlation coefficient (PRCC). The ECDF output shows the distribution of the MCDA output and indicates areas of greater or lesser convenience in the parameter space. The PRCC illustrates the correlation of individual input factors with the MCDA output, in parallel with the elimination of the influence of other correlated factors.

A1.3 Results of risk and vulnerability analysis by district

Culex pipiens: house mosquito, transmits WNV and the dog heartworm

Within this species, there are three ecological forms/biotypes that share a role in the transmission of WNV. Individuals of the *pipiens* biotype are anautogenic (females cannot lay eggs without feeding on blood), ornithophilic (females feed on the blood of birds), eurygamous (males make swarms to mate with females) and have winter diapause (do not feed) in conditions of temperate climate. They live in nature, outside the settlements and are important for the amplification of the virus by transmission from bird to bird. Individuals of the second biotype of *molestus* are autogenic (can lay the first egg without feeding on blood), mammophilic (females feed on mammalian blood), stenogamous (males mate without swarming, in small spaces, even in a space of 1cm3 - Petrić D. unpublished data) and have a mandatory diapause (they can feed during the winter if temperatures are above 10 °C). Individuals of this biotype develop in settlements and their immediate vicinity, not further than 200-500 m). There is also a third, hybrid form that serves as a bridge to transmit the WNV from birds to horses and humans. It also inhabits urban areas where it feeds on the blood of birds, humans and animals.

Culex pipiens biotype pipiens: a biotype of house mosquito that feeds on the blood of birds and transmits WNV from bird to bird in the wild

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model for the period 1971-2000 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, Braničevo, City of Belgrade, South Bačka, South Banat, Kolubara, Mačva, Danube, Morava, North Bačka, North Banat, Central Banat, Srem, Šumadija, Toplica and West Bačka. Districts with moderate vulnerability (50-75) are: Jablanica, Moravica, Nišava, Pčinj, Pirot, Raška, Rasina, Zaječar and Zlatibor (Figure A3).

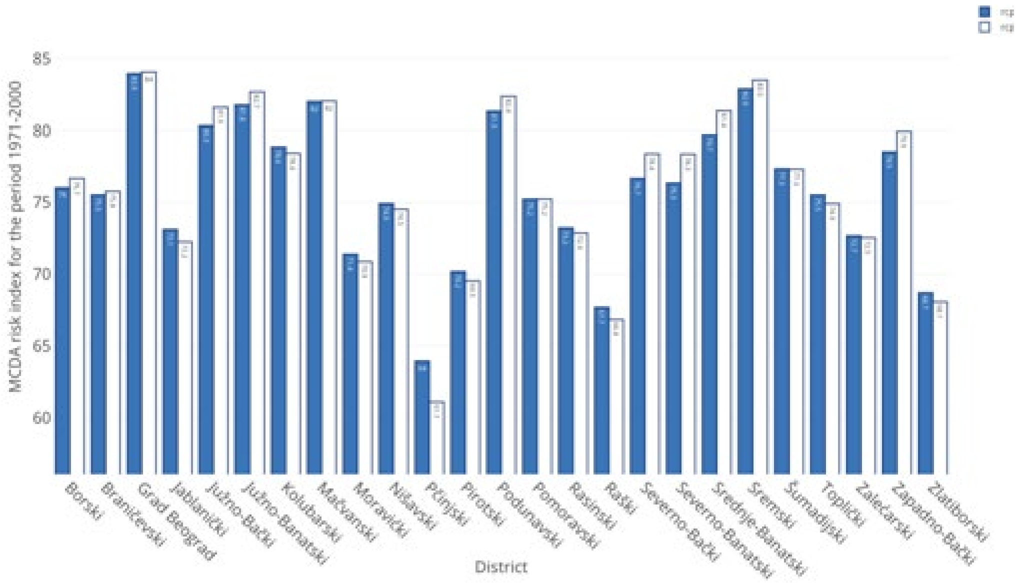


Figure A 3: MCDA risk index for Culex pipiens biotype pipiens for RCP45 and RCP85 scenarios for the period 1971-2000

Risk and vulnerability assessment by districts for the period from 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, Braničevo, City of Belgrade, Jablanica, South Bačka, South Banat, Kolubara, Mačva, Moravica, Nisava, Podunavlje, Morava, Rasina, North Bačka, North Banat, Central Banat, Srem, Šumadija, Toplica, Zaječar and West Bačka. Districts with moderate vulnerability (50-75) are: Pčinj, Pirot, Raška and Zlatibor (Figure A4).

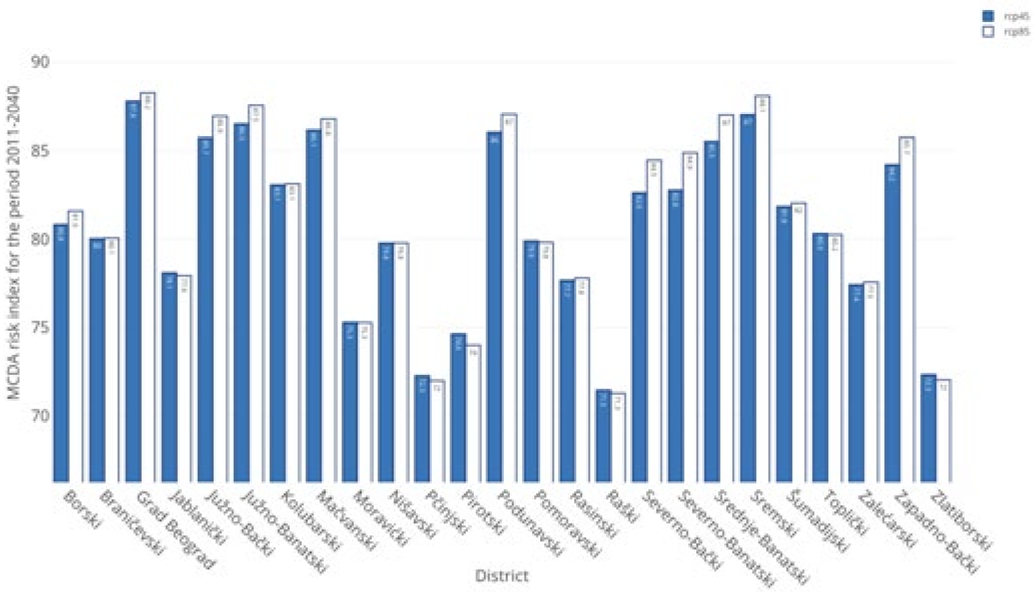


Figure A 4: MCDA risk index for Culex pipiens biotype pipiens for RCP45 (blue) and RCP85 (white) scenarios for the period 2011-2041

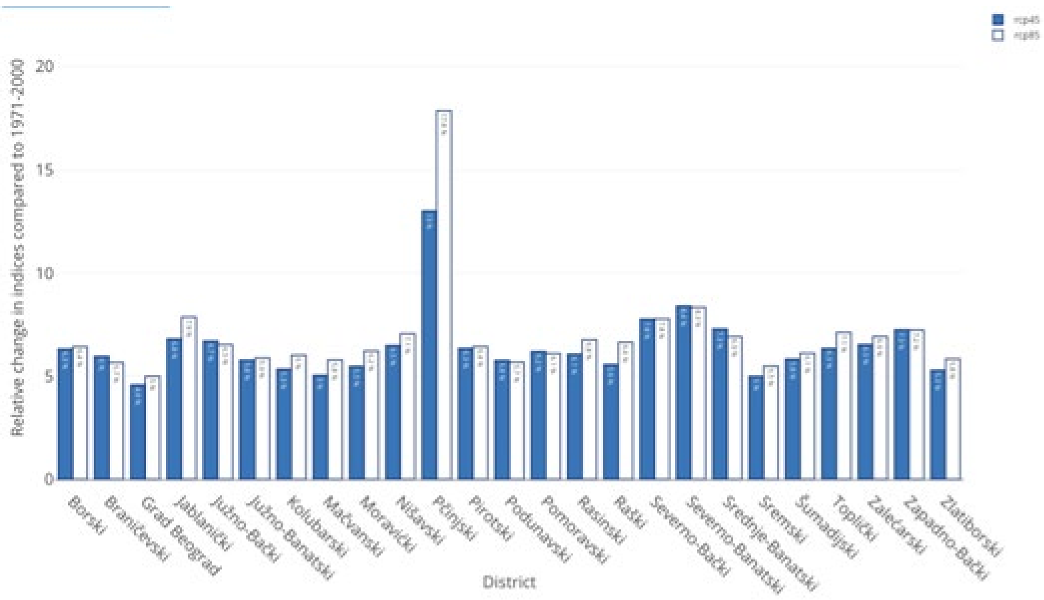


Figure A 5: Relative change [%] of projected MCDA risk index for Culex pipiens biotype pipiens for 2011-2040 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, all districts are characterized by high vulnerability (75-100) (Figure A6).

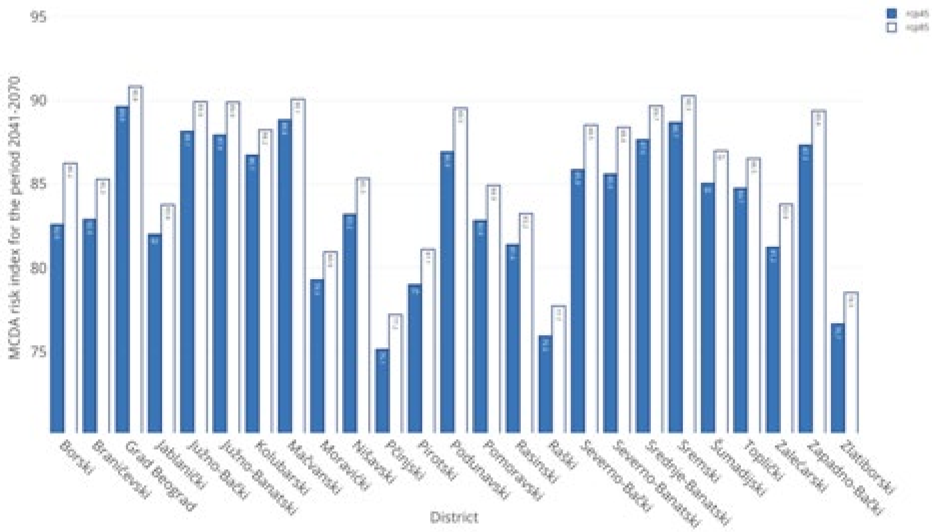


Figure A 6: MCDA risk index for Culex pipiens biotype pipiens for RCP45 (blue) and RCP85 (white) scenarios for the period 2041-2070

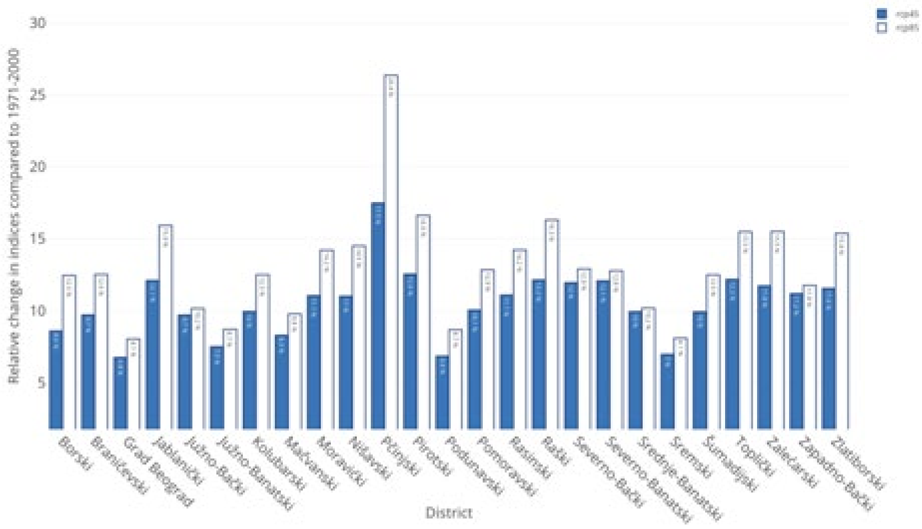


Figure A 7: Relative change [%] of projected MCDA risk index for Culex pipiens biotype pipiens for 2041-2070 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2071-2100 for the medium emission scenario, RCP45, all districts are characterized by high vulnerability (75-100) (Figure A8).

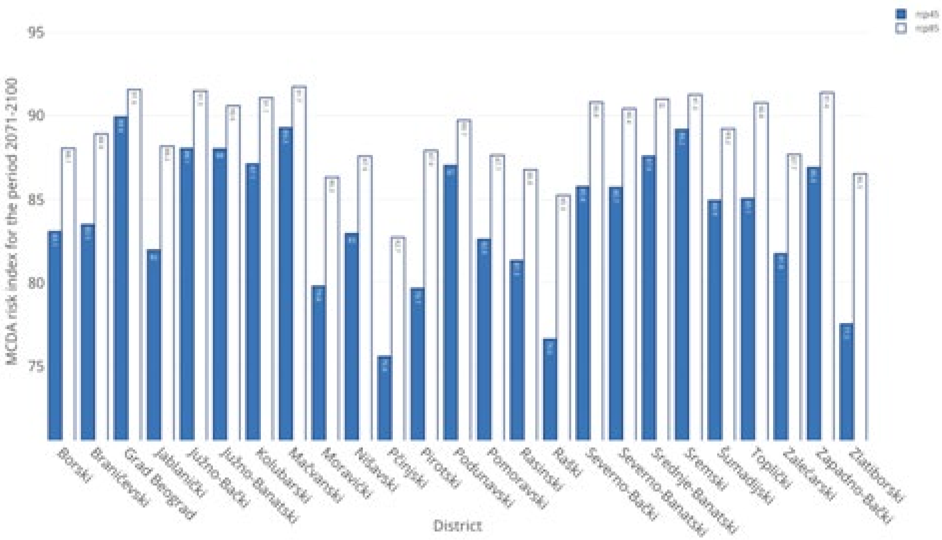


Figure A 8: MCDA risk index for Culex pipiens biotype pipiens for RCP45 (blue) and RCP85 (white) scenarios for the period 2071 to 2100

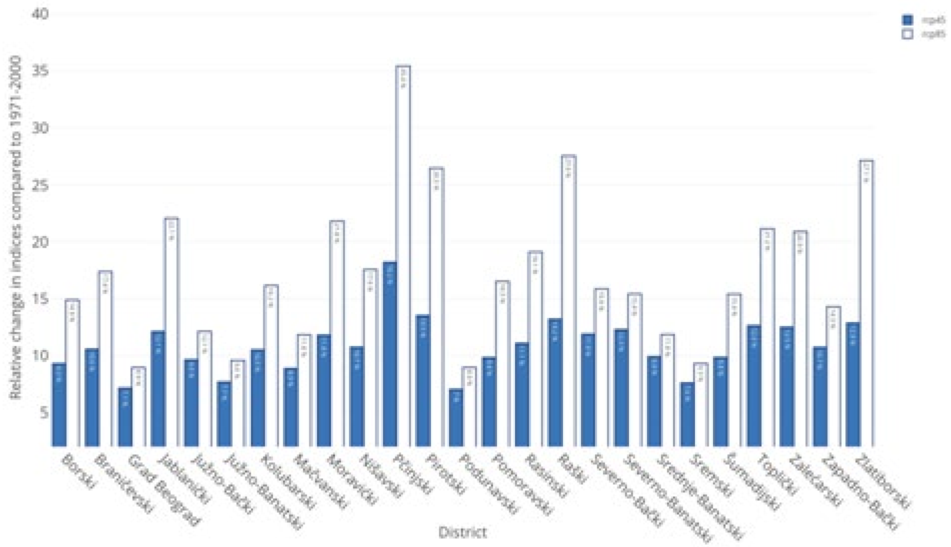


Figure A 9: Relative change [%] of projected MCDA risk index for Culex pipiens biotype pipiens for 2071-2100 compared to reference period 1971-2000

Culex pipiens biotype molestus: the biotype of the house mosquito that feeds on human blood, in urban areas is important for the transmission of WNV from birds to humans

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model for the period 1971-2000 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, Braničevo, City of Belgrade, South Bačka, South Banat, Kolubara, Mačva, Nišava, Danube, Morava, Rasina, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica and Zapadno-Bački. Districts with moderate vulnerability (50-75) are: Jablanica, Moravica, Pčinj, Pirot, Raška, Zaječar and Zlatibor (Figure A10).

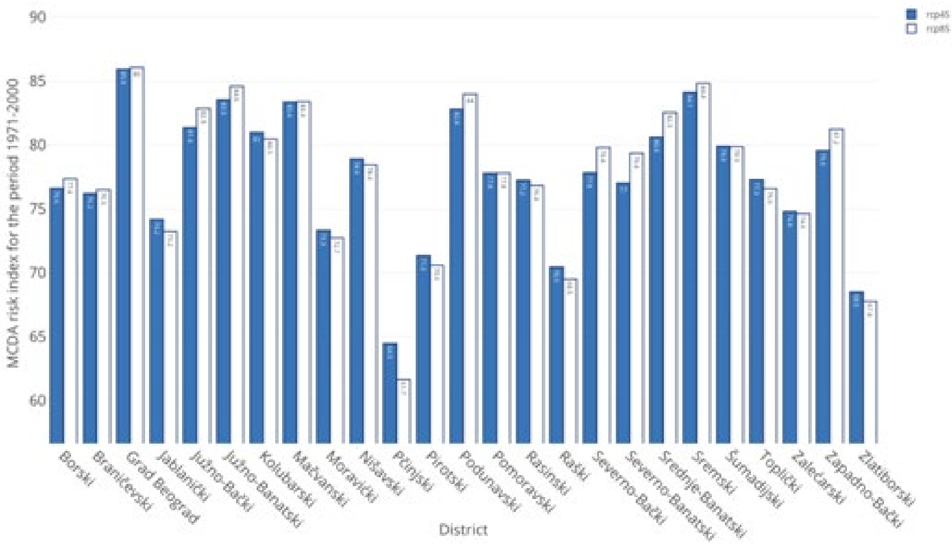


Figure A 10: MCDA risk index for Culex pipiens biotype molestus for RCP45 (blue) and RCP85 (white) scenarios for the period 1971-2000

Risk and vulnerability assessment by districts for the period from 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, Braničevo, City of Belgrade, Jablanica, South Bačka, South Banat, Kolubara, Mačva, Moravica, Nišava, Pirot, Danube, Morava, Rasina, North Bačka, Middle Banat, Srem, Šumadija, Toplica, Zaječar and West Bačka. The districts with moderate vulnerability (50-75) are: Pčinj, Raška and Zlatibor (Figure A 11).

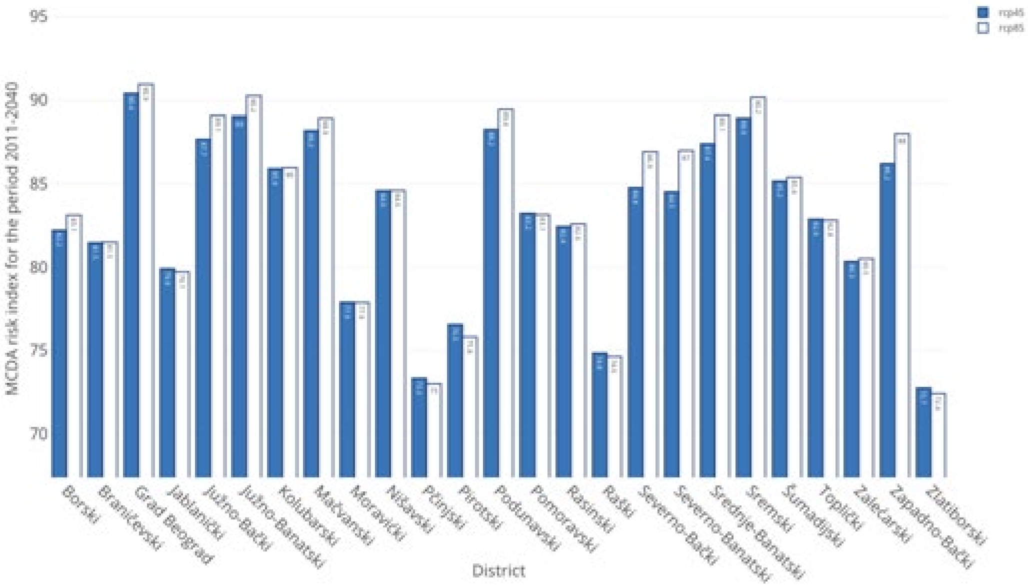


Figure A 11: MCDA risk index for Culex pipiens biotype molestus for RCP45 (blue) and RCP85 (white) scenarios for the period 2011-2041

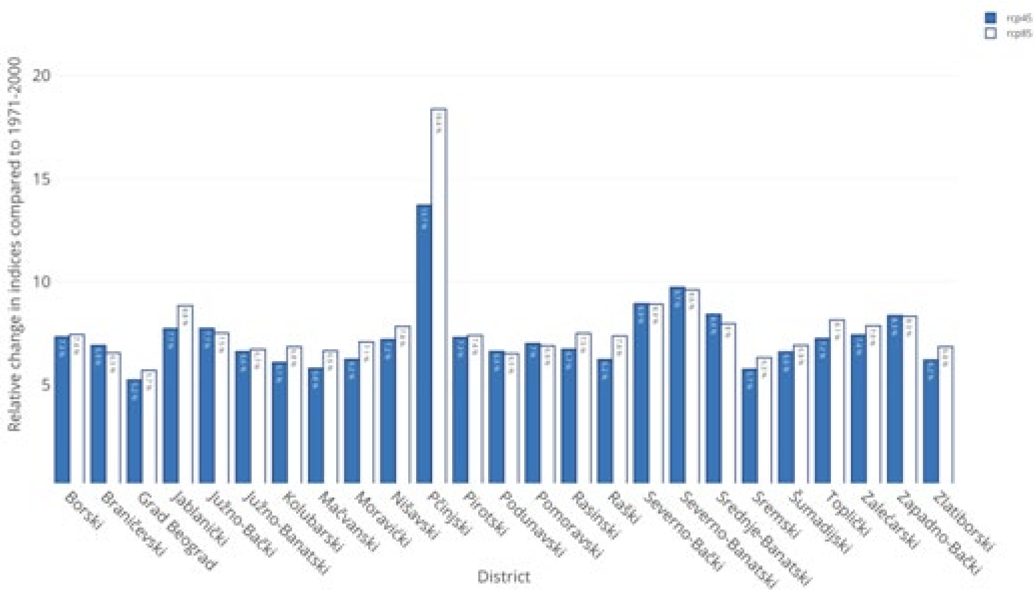


Figure A 12: Relative change [%] of projected MCDA risk index for Culex pipiens biotype molestus for 2011-2040 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, all districts are characterized by high vulnerability (75-100) (Figure A13).

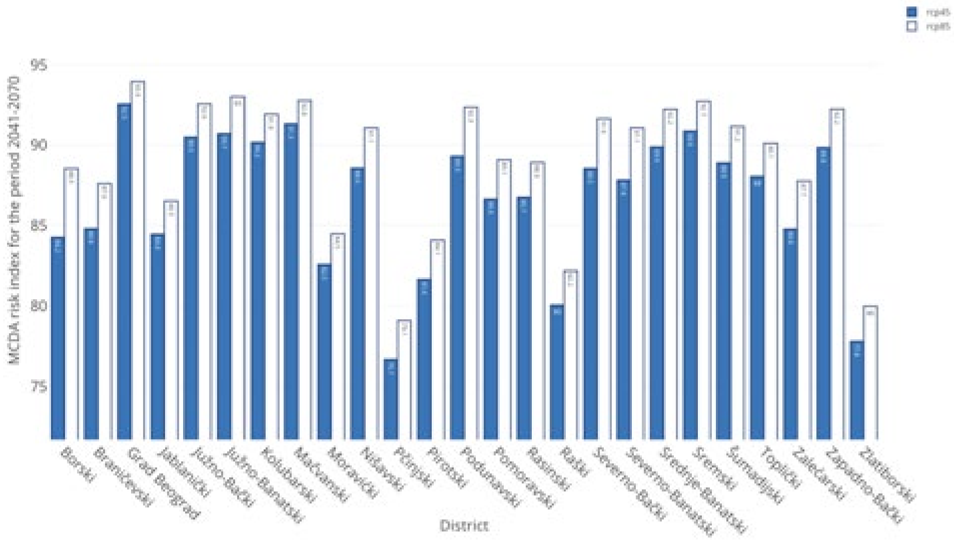


Figure A 13: MCDA risk index for Culex pipiens biotype molestus for RCP45 (blue) and RCP85 (white) scenarios for the period 2041-2070

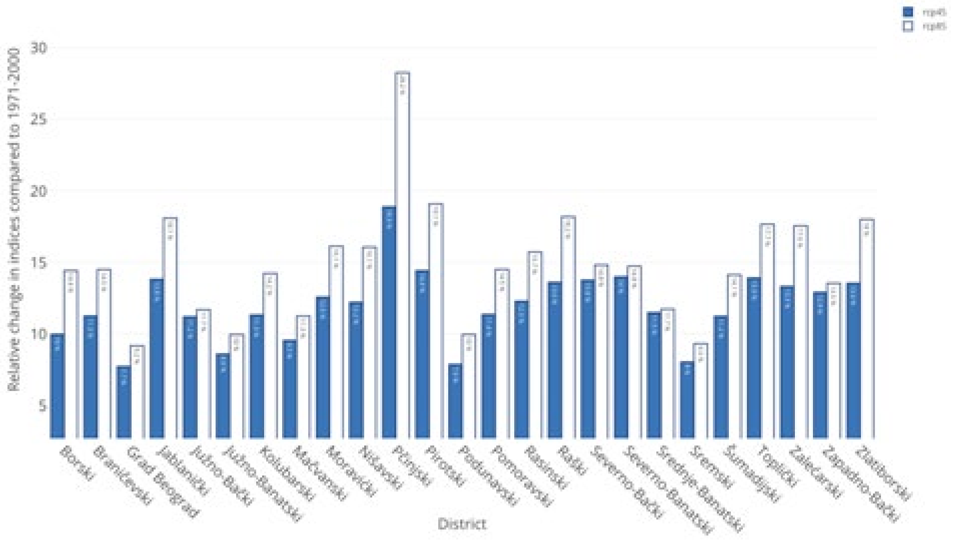


Figure A 14: Relative change [%] of projected MCDA risk index for Culex pipiens biotype molestus for 2041-2070 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2071-2100 for the medium emission scenario, RCP45, all districts are characterized by high vulnerability (75-100) (Figure A15).

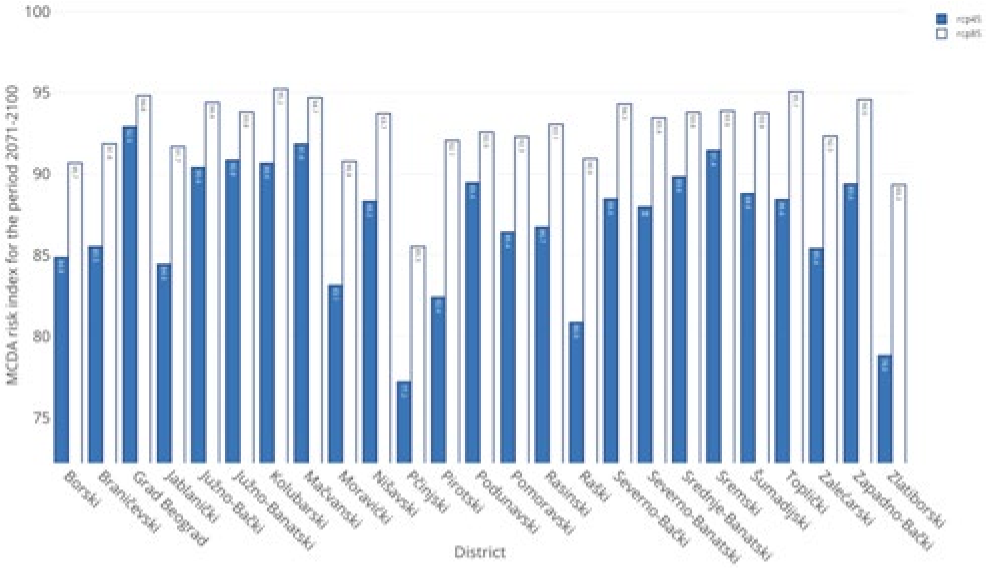


Figure A 15: MCDA risk index for Culex pipiens biotype molestus for RCP45 (blue) and RCP85 (white) scenarios for the period 2071 to 2100

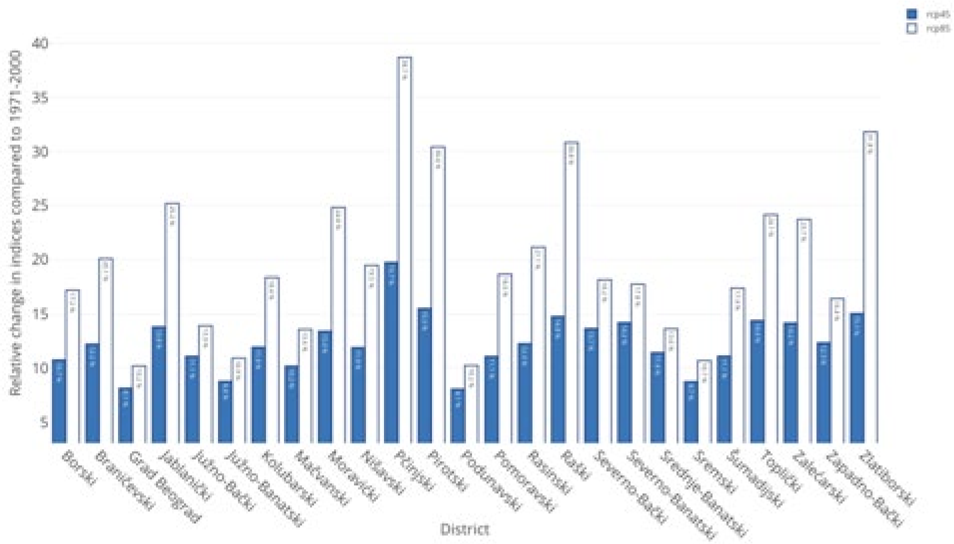


Figure A 16: Relative change [%] of projected MCDA risk index for Culex pipiens biotype molestus for 2071-2100 compared to reference period 1971-2000

Aedes albopictus: Asian tiger mosquito, transmits dengue, chikungunya and zika viruses and dog heartworm

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model for the period 1971-2000 for the medium emission scenario, RCP45, the districts with moderate vulnerability (75-100) are: Bor, Braničevo, City of Belgrade, Jablanica, South Bačka, South Banat, Kolubara, Mačva, Nišava, Pirot, Danube, Morava, Rasina, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica, Zaječar and West Bačka. Districts with low vulnerability (25-50) are: Moravian, Pcinj, Raška and Zlatibor (Figure A17).

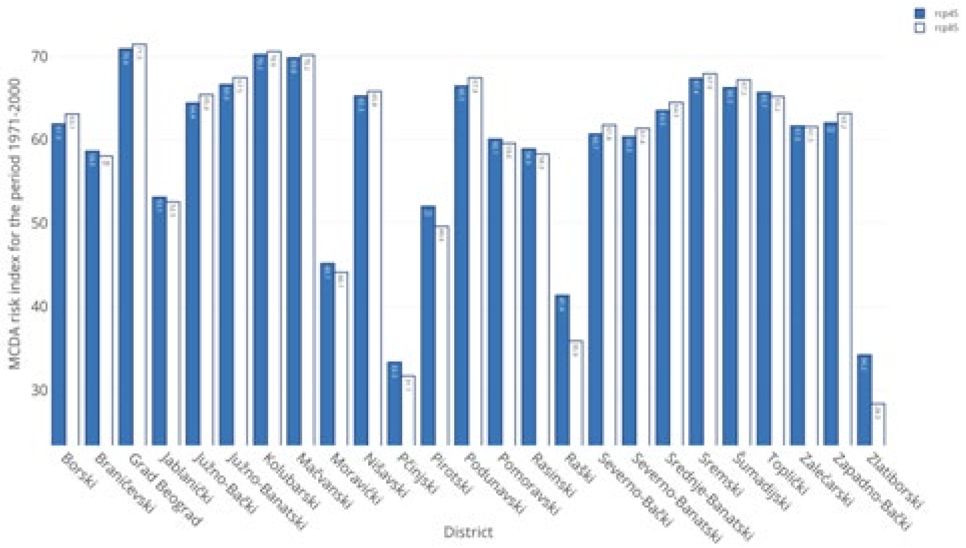


Figure A 17: MCDA risk index for Aedes albopictus for RCP45 (blue) and RCP85 (white) scenarios for the period 1971-2000

Risk and vulnerability assessment by districts for the period from 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: City of Belgrade and Mačva. Districts with moderate vulnerability (50-75) are: Bor, Braničevo, Jablanica, South Bačka, South Banat, Kolubara, Moravica, Nisava, Pirot, Danube, Morava, Rasina, Raška, North Bačka, North Banat, Central Banat, Srem, Šumadija, Toplica, Zaječar, West Bačka and Zlatibor. The district with the highest vulnerability (25-50) is Pčinj (Figure A 18).

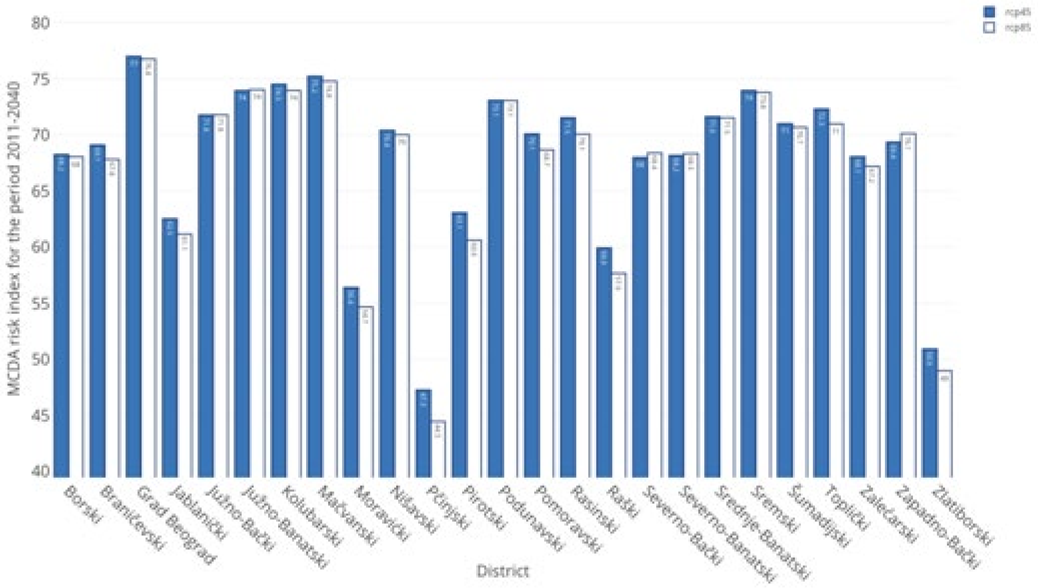


Figure A 18: MCDA risk index for Aedes albopictus for RCP45 (blue) and RCP85 (white) scenarios for 2011-2041

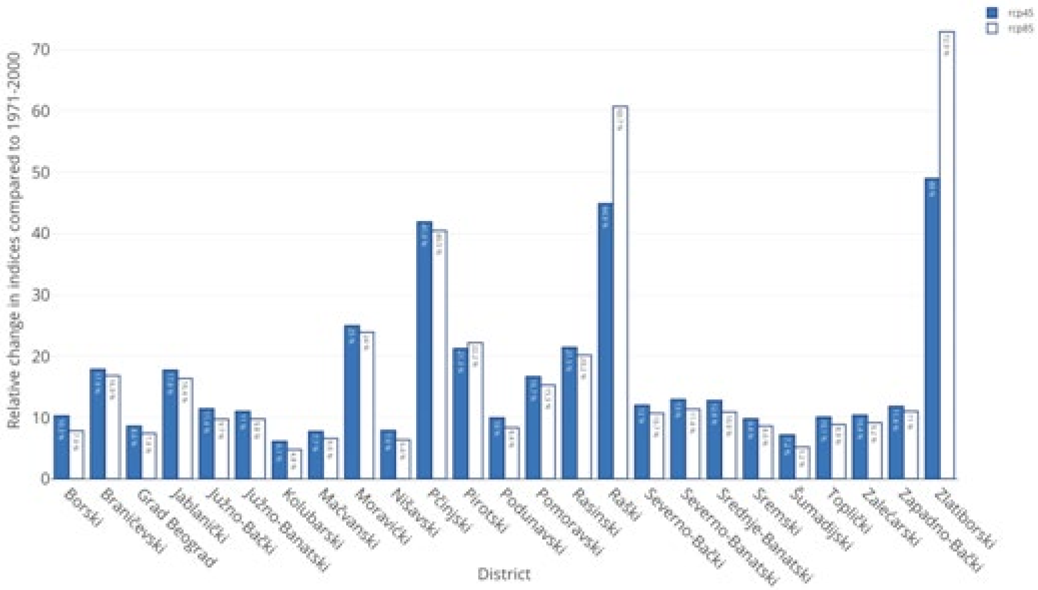


Figure A 19: Relative change in projected MCDA risk index for Aedes albopictus for 2011-2040 compared to the reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: City of Belgrade, South Bačka, South Banat, Kolubara, Mačva, Nišava, Danube, Morava, Rasina, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica and West Bačka . Districts with moderate vulnerability (50-75) are: Bor, Braničevo, Jablanica, Moravica, Pčinj, Pirot, Raška, Zaječar and Zlatibor (Figure A20).

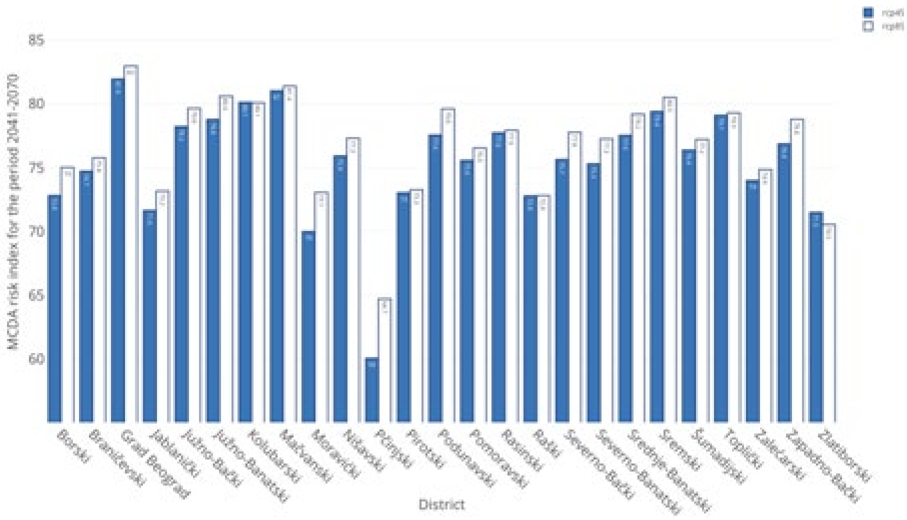


Figure A 20: MCDA risk index for Aedes albopictus for RCP45 (blue) and RCP85 (white) scenarios for 2041 - 2070

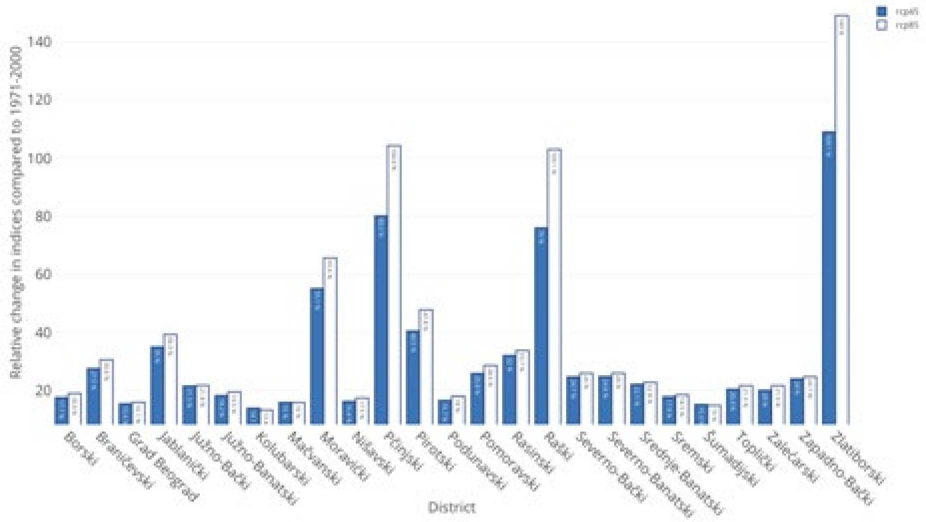


Figure A 21: Relative change in projected MCDA risk index for Aedes albopictus for 2041-2070 versus reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2071-2100 for the medium emission scenario, RCP45, all districts are characterized by high vulnerability (75-100) (Figure A22).

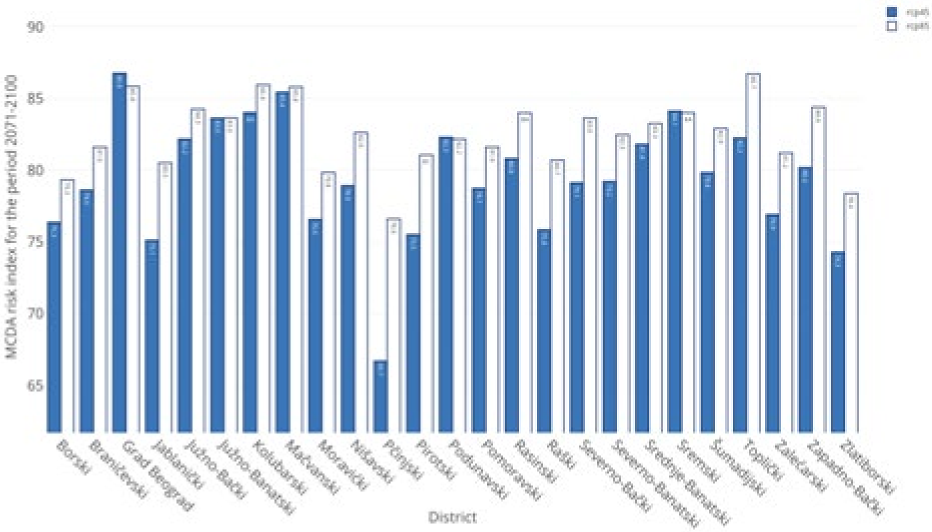


Figure A 22: MCDA risk index for Aedes albopictus for RCP45 (blue) and RCP85 (white) scenarios for the period 2071 - 2100

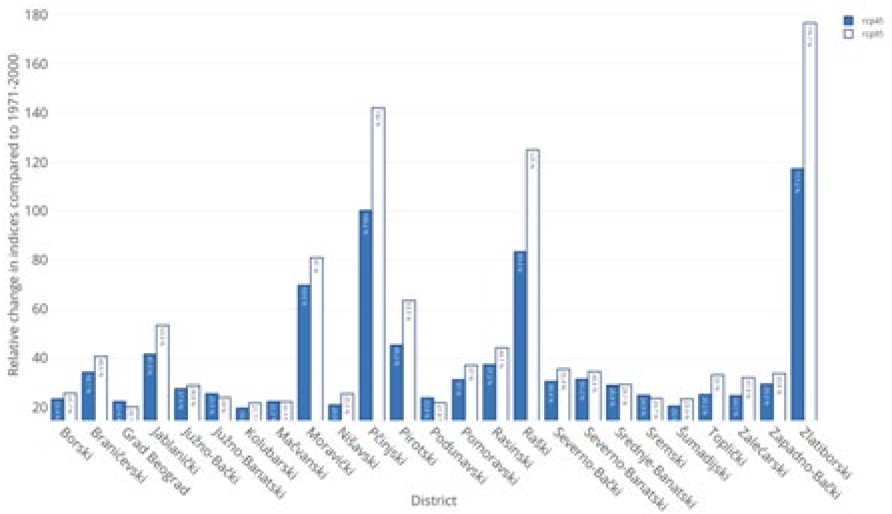


Figure A 23: Relative change in projected MCDA risk index for Aedes albopictus for 2071-2100 versus reference period 1971-2000

Anopheles hyrcanus: malaria mosquito

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model for the period 1971-2000 for the medium emission scenario, RCP45, the districts with moderate vulnerability (50-75) are: Bor, Braničevo, City of Belgrade, Jablanica, South Bačka, South Banat, Kolubara, Mačva, Nišava, Danube, Morava, Rasina, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica, Zaječar and Zapadno-Bački. Districts with low vulnerability (25-50) are: Moravica, Pčinj, Pirot and Raška. The district with very low vulnerability (0-25) is Zlatibor (Figure A24).

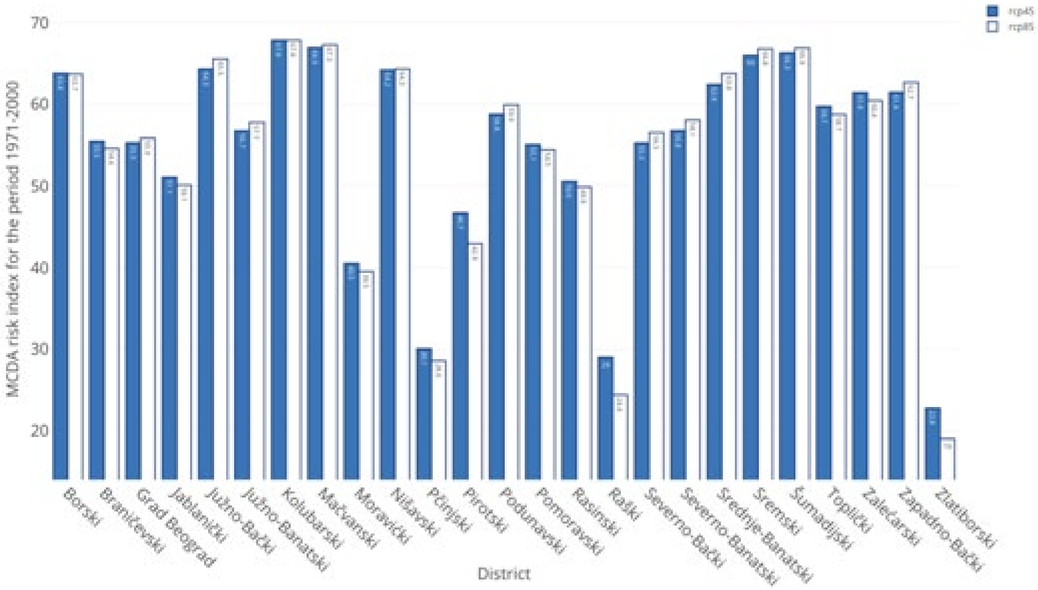


Figure A 24: MCDA risk index for RCP45 and RCP85 scenarios for Anopheles hyrcanus for the period 1971-2000

Risk and vulnerability assessment by districts for the period from 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with moderate vulnerability (50-75) are: Bor, Braničevo, City of Belgrade, Jablanica, South Bačka, South Banat, Kolubara, Mačva, Nišava, Pirot, Danube, Morava, Rasina, Raški, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica, Zaječar and Zapadno-Bački. The districts with low vulnerability (25-50) are: Moravica, Pčinj and Zlatibor (Figure A25).

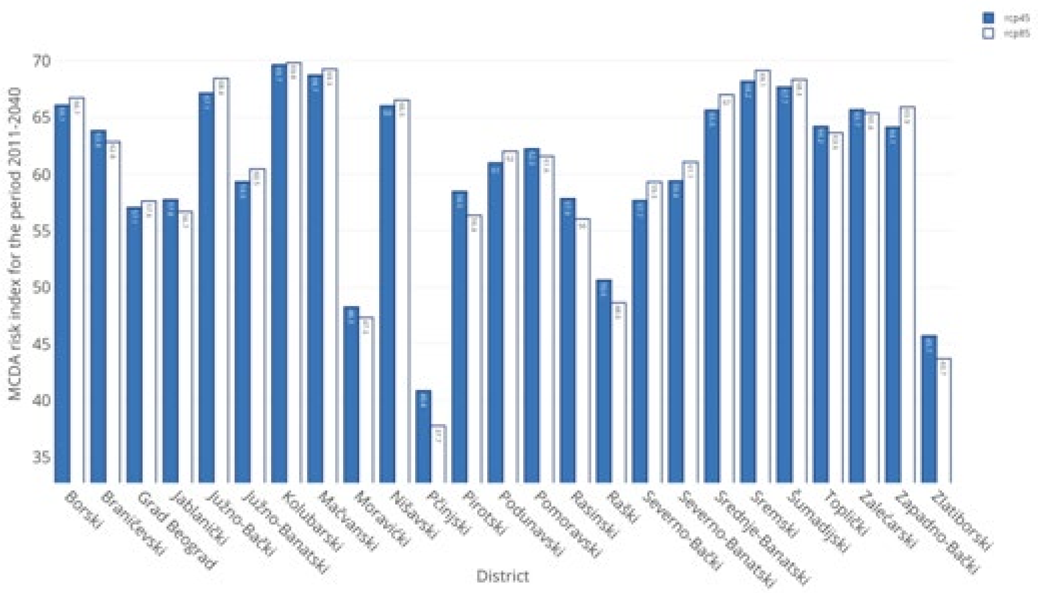


Figure A 25: MCDA risk index for Anopheles hyrcanus for RCP45 and RCP85 scenarios for the period 2011-2041

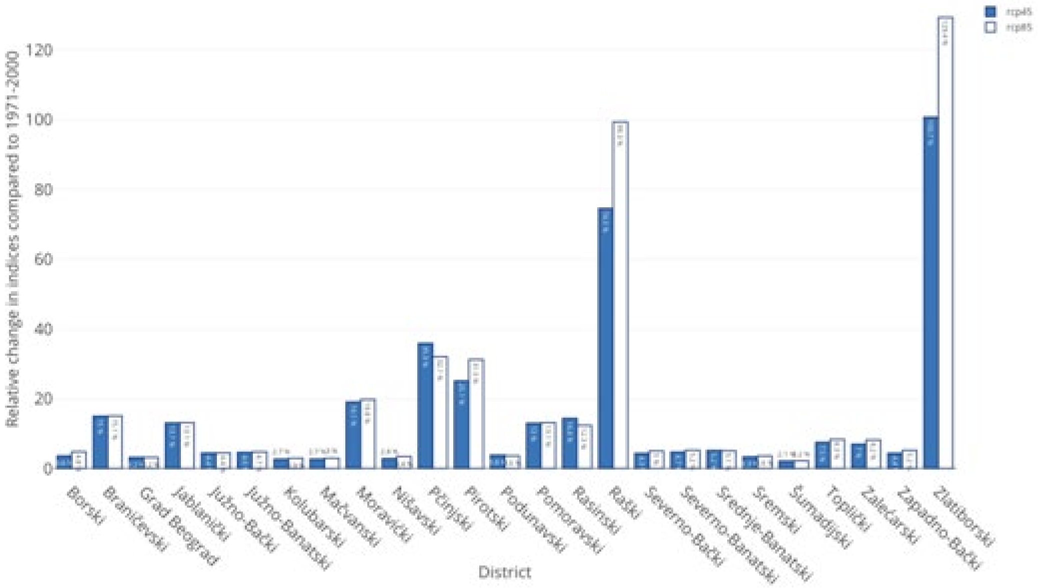


Figure A 26: Relative change in projected MCDA risk index for Anopheles hyrcanus for 2011-2040 versus reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, all districts with moderate vulnerability (50-75) (Figure A 27).

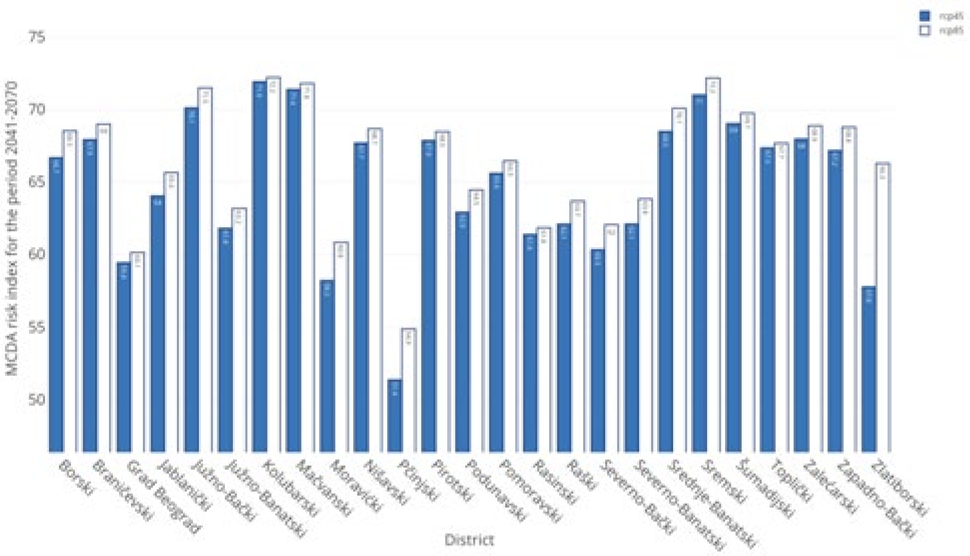


Figure A 27: MCDA risk index for Anopheles hyrcanus for RCP45 and RCP85 scenarios for the period 2041-2070

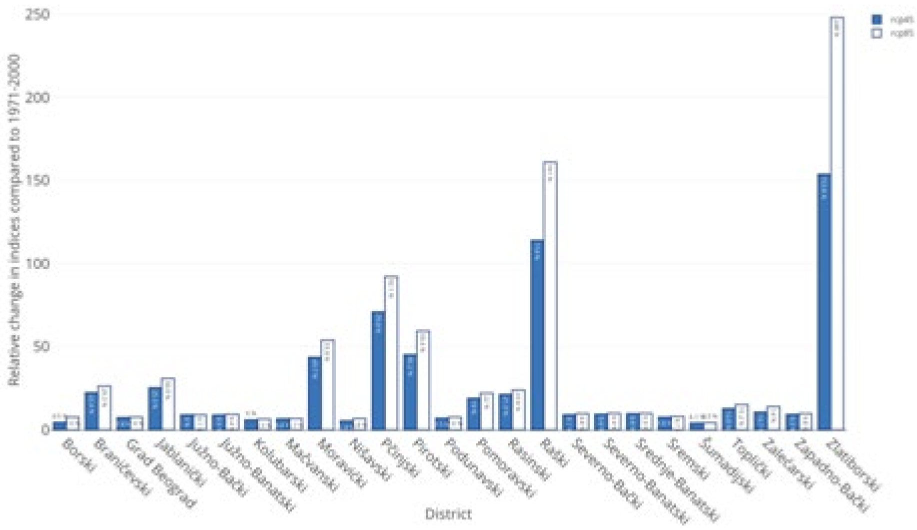


Figure A 28: Relative change in projected MCDA risk index for Anopheles hyrcanus for 2041-2070 versus reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, all districts with moderate vulnerability (50-75) (Figure A29).

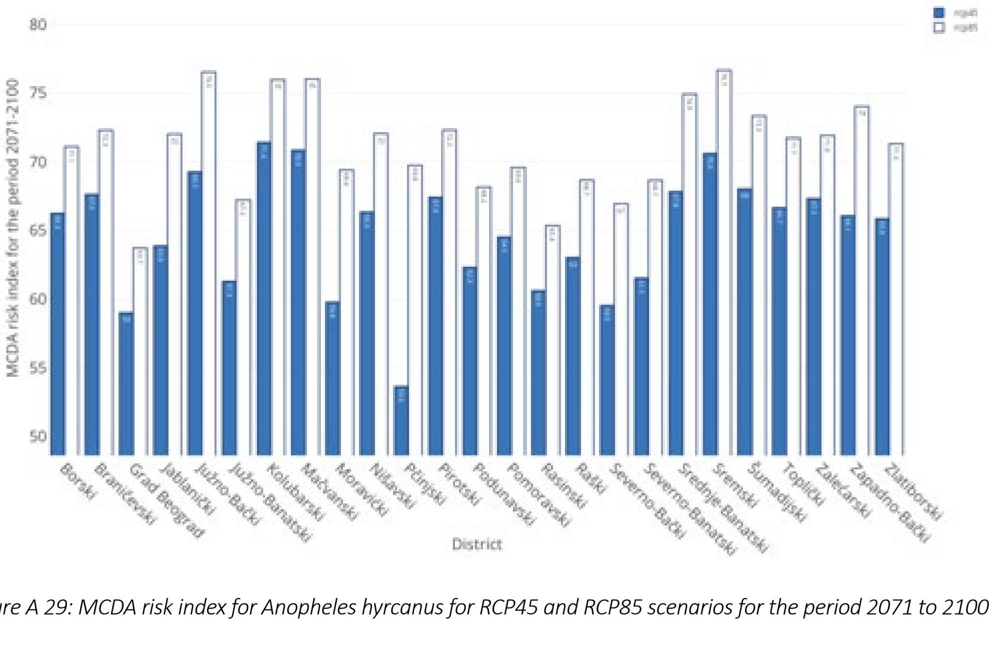


Figure A 29: MCDA risk index for Anopheles hyrcanus for RCP45 and RCP85 scenarios for the period 2071 to 2100

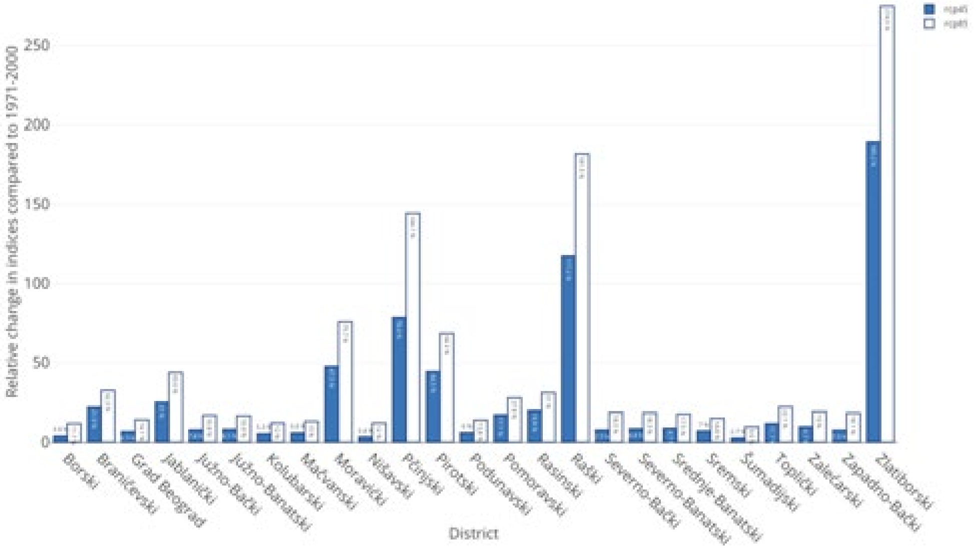


Figure A 30: Relative change in projected MCDA risk index for Anopheles hyrcanus for 2071-2100 versus reference period 1971-2000

Ixodes ricinus: a tick species that transmits Lyme disease and tick-borne encephalitis

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model for the period 1971-2000 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Kolubara and the City of Belgrade. Districts with moderate vulnerability (50-75) are: Bor, Brančevo, Jablanica, South Bačka, South Banat, Mačva, Moravica, Nisava, Pčinj, Pirot, Danube, Morava, Rasina, Raška, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica, Zaječar, West Bačka and Zlatibor (Figure A31).

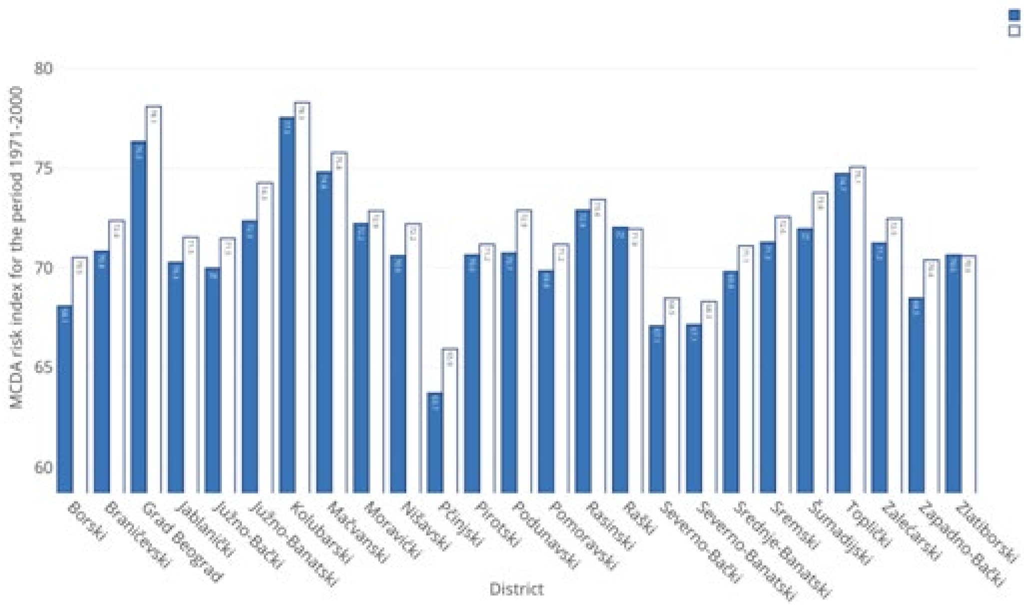


Figure A 31: MCDA risk index for RCP45 and RCP85 scenarios for Ixodes ricinus for the period 1971-2000

Risk and vulnerability assessment by districts for the period from 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Brančevo, City of Belgrade, South Banat, Kolubara, Mačva, Moravica, Morava, Rasina, Raška, Šumadija, Toplica and Zaječar. Districts with moderate vulnerability (50-75) are: Bor, Jablanica, South Bačka, Nišava, Pčinj, Pirot, Danube, North Bačka, North Banat, Middle Banat, Srem, West Bačka and Zlatibor (Figure A32).

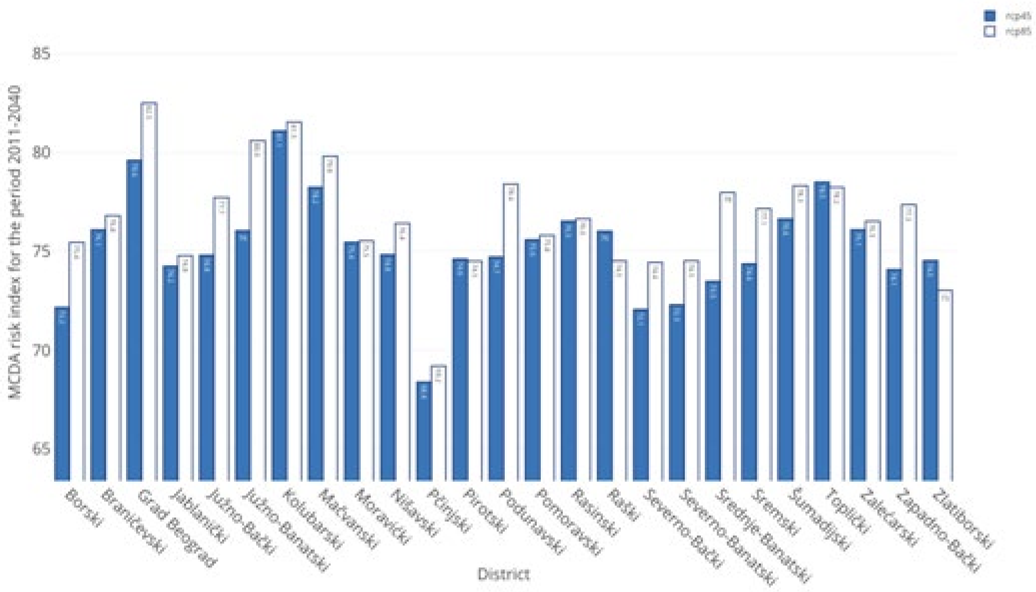


Figure A 32: MCDA risk index for Ixodes ricinus for RCP45 and RCP85 scenarios for the period 2011-2041

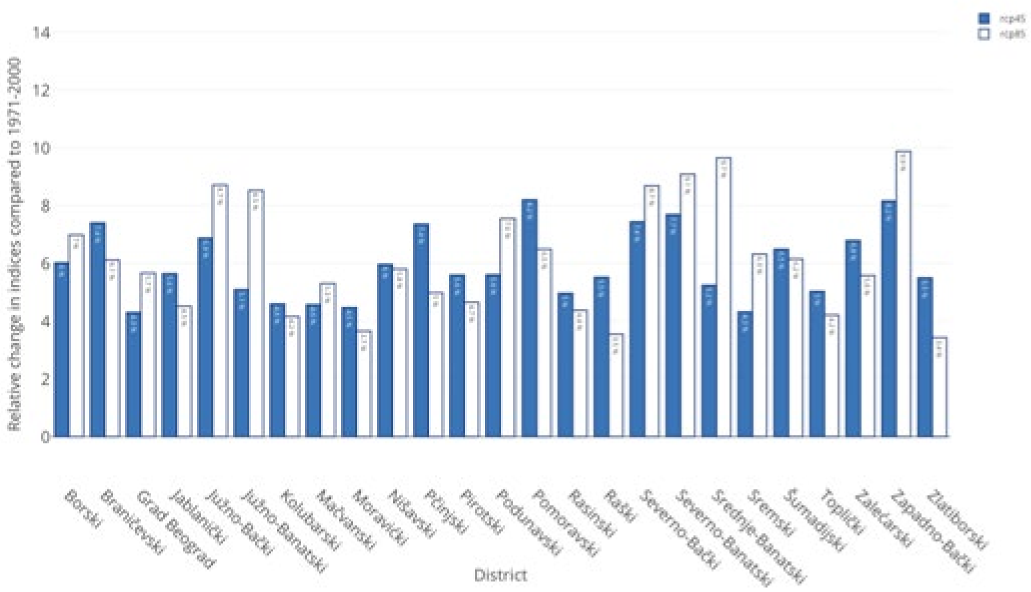


Figure A 33: Relative change [%] of projected MCDA risk index for Ixodes ricinus for 2011-2040 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Brančevo, City of Belgrade, Jablanica, Kolubara, Mačva, Moravica, Pirot, Morava, Rasina, Raška, Šumadija, Toplica, Zaječar, West Bačka and Zlatibor. Districts with moderate vulnerability (50-75) are: Bor, South Bačka, South Banat, Nišava, Pčinj, Danube, North Bačka, North Banat, Middle Banat and Srem (Figure A34).

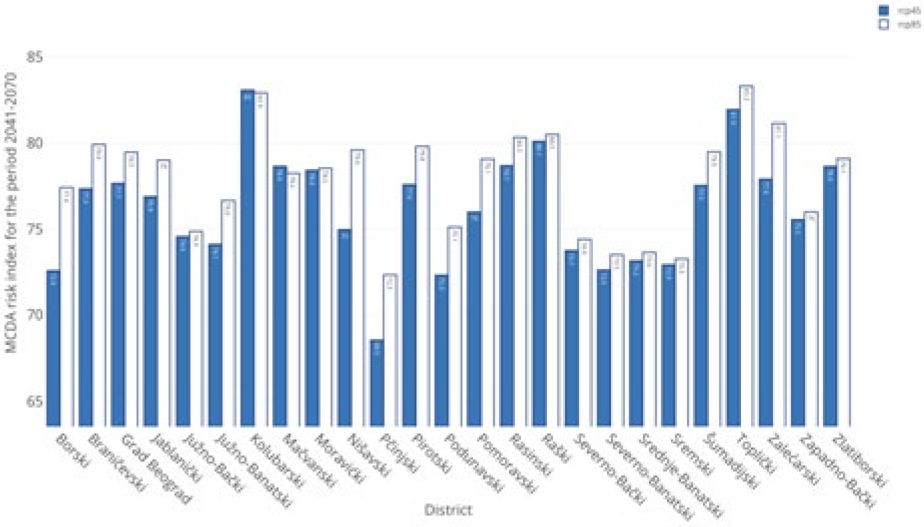


Figure A 34: MCDA risk index for Ixodes ricinus for RCP45 and RCP85 scenarios for the period 2041-2070

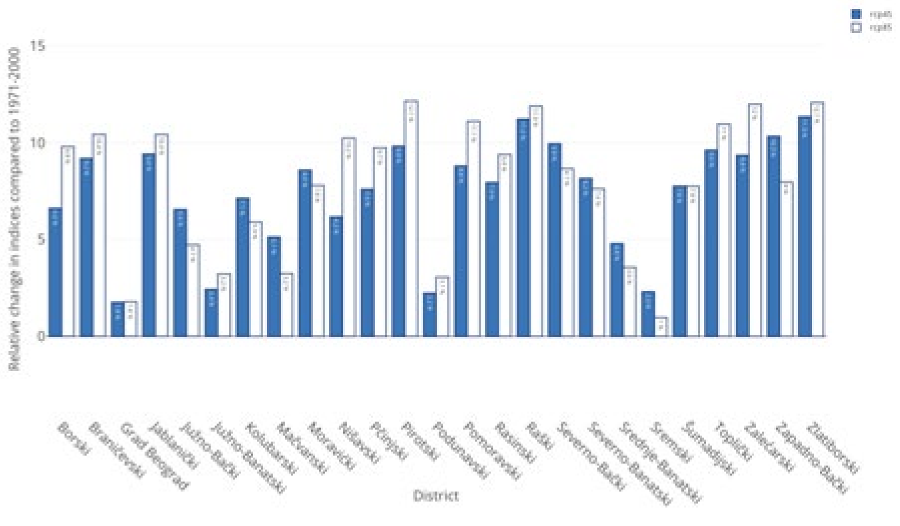


Figure A 35: Relative change [%] of projected MCDA risk index for Ixodes ricinus for 2041-2070 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2070-2100 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Brančevo, City of Belgrade, Kolubara, Mačva, Moravica, Rasina, Raška, Toplica and Zlatibor. Districts with moderate vulnerability (50-75) are: Bor, Jablanica, South Bačka, South Banat, Nišava, Pčinj, Pirot, Danube, Morava, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Zaječar and West Bačka (Figure A36).

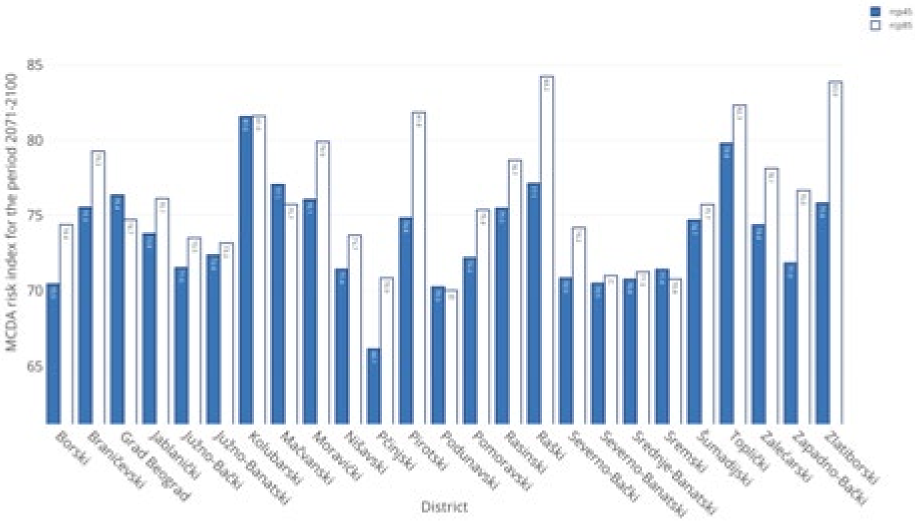


Figure A 36: MCDA risk index for Ixodes ricinus for RCP45 and RCP85 scenarios for the period 2071 to 2100

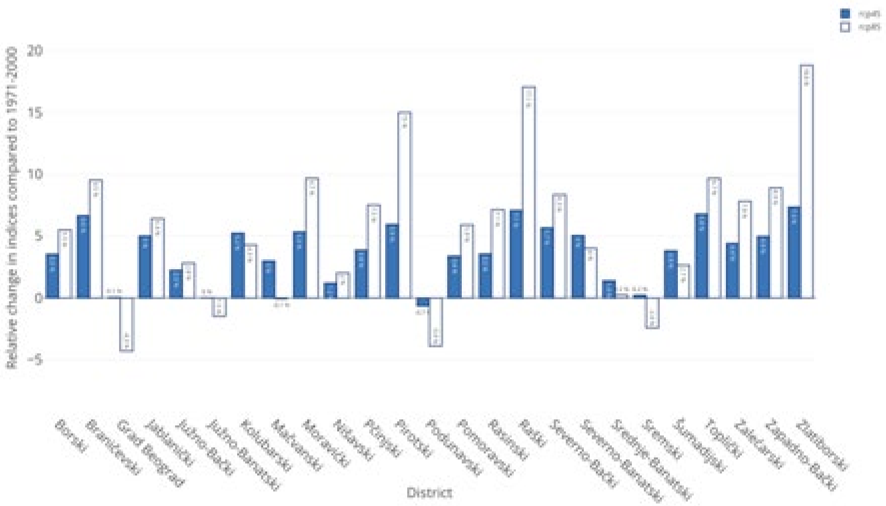


Figure A 37: Relative change [%] of projected MCDA risk index for Ixodes ricinus for 2071-2100 compared to the reference period 1971-2000

Phlebotomus papatasi: a sandfly species that transmits leishmaniasis and sandfly fever

Assessment of current vulnerability by districts (1971-2000)

Based on the output of the model from the RCP45 medium emission scenario, the districts with high vulnerability (75-100) are: Belgrade, South Bačka, South Banat, Danube, North Banat, Middle Banat, Srem and Zapadno-Bački Districts with moderate vulnerability (50-75) are: Bor, Mačva, North Bačka and Šumadija. Districts with low vulnerability (25-50) are: Braničevo, Jablanica, Kolubara, Moravica, Nišava, Morava, Rasina, Toplica and Zaječar Districts with very low vulnerability (0-25) are: Pčinj, Pirot, Raška and Zlatibor (Figure A38).

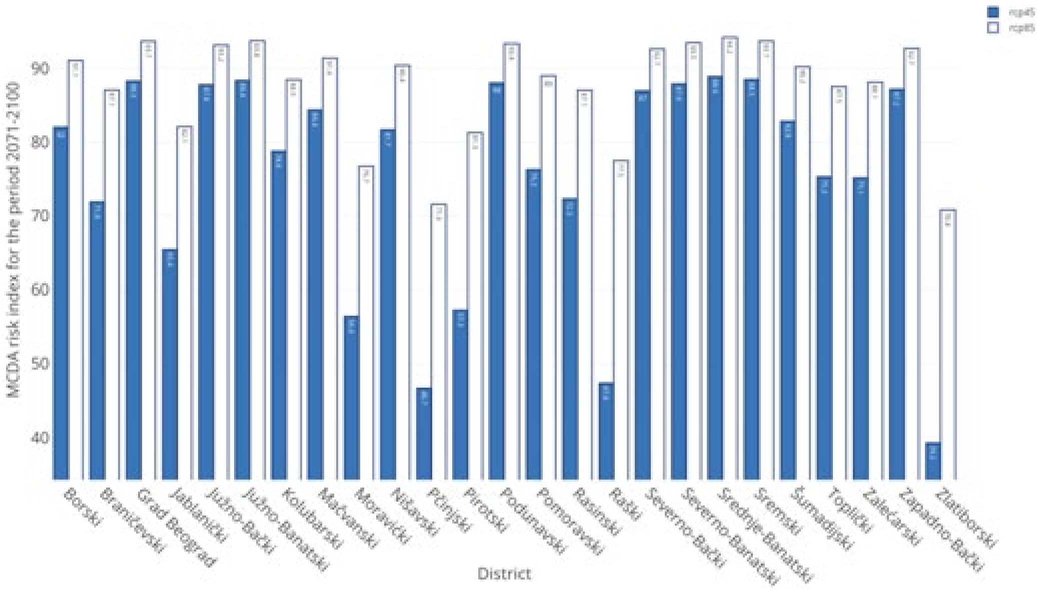


Figure A 38: MCDA risk index for RCP45 and RCP85 scenarios for Phlebotomus papatasi period 1971-2000

Risk and vulnerability assessment by districts for the period 2011 to 2040

Based on the output of the model for the period 2011-2040 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: City of Belgrade, South Bačka, South Banat, Mačva, Danube, North Bačka, North Banat, Central Banat, Srem and West Bačka. Districts with moderate vulnerability (50-75) are: Bor, Braničevo, Kolubara, Nišava, Morava, Rasina, Šumadija, Toplica and Zaječar. Districts with the highest vulnerability are: Jablanica, Moravica, Pcinj, Pirot and Raška. The district with very low vulnerability is Zlatibor (Figure A 39).

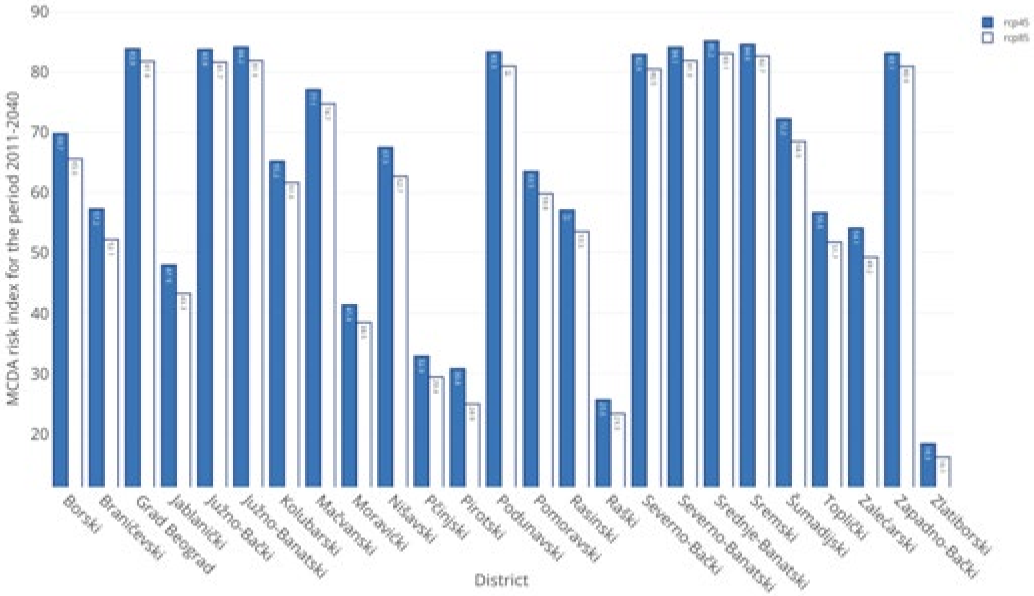


Figure A 39: MCDA risk index for Phlebotomus papatasi for RCP45 and RCP85 scenarios for the period 2011-2041

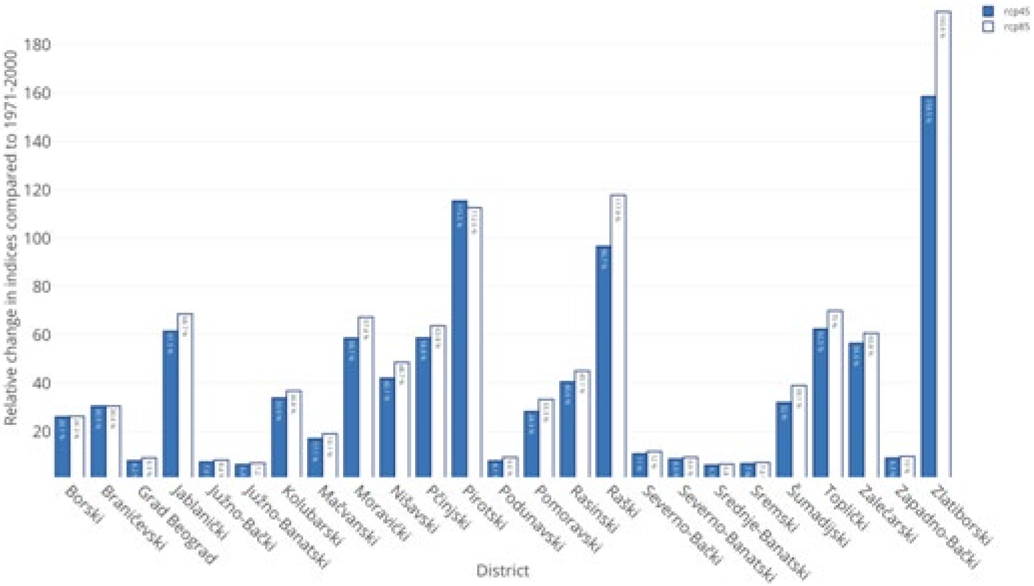


Figure A 40: Relative change in projected MCDA risk index for Phlebotomus papatasi for 2011-2040 versus reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2041 to 2070

Based on the output of the model for the period 2041-2070 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, City of Belgrade, South Bačka, South Banat, Kolubara, Mačva, Nišava, Danube, North Bačka, North Banat, Middle Banat, Srem, Šumadija and Wetst Bačka. Districts with moderate vulnerability (50-75) are: Brančevo, Jablanica, Moravica, Pirot, Morava, Rasina, Toplica and Zaječar. The districts with low vulnerability (25-50) are: Pcinj, Raška and Zlatibor (Figure A41).

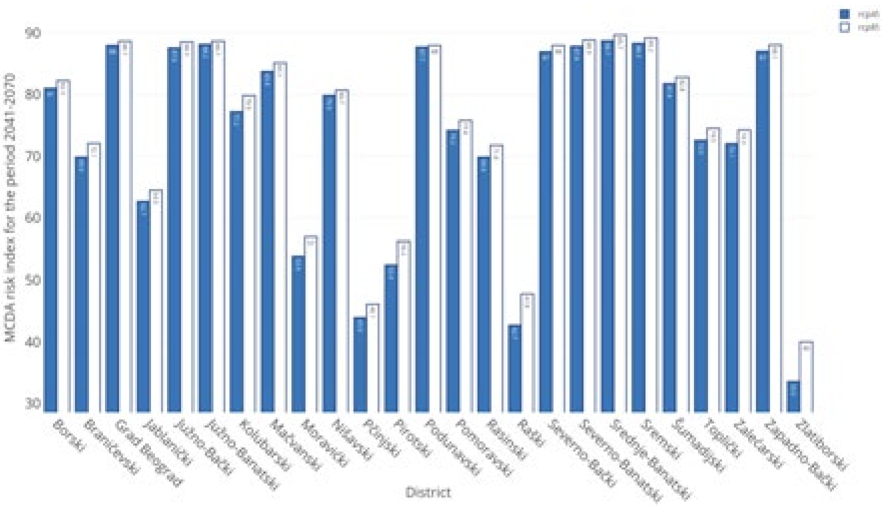


Figure A 41: MCDA risk index for Phlebotomus papatasi for RCP45 and RCP85 scenarios for the period 2041-2070

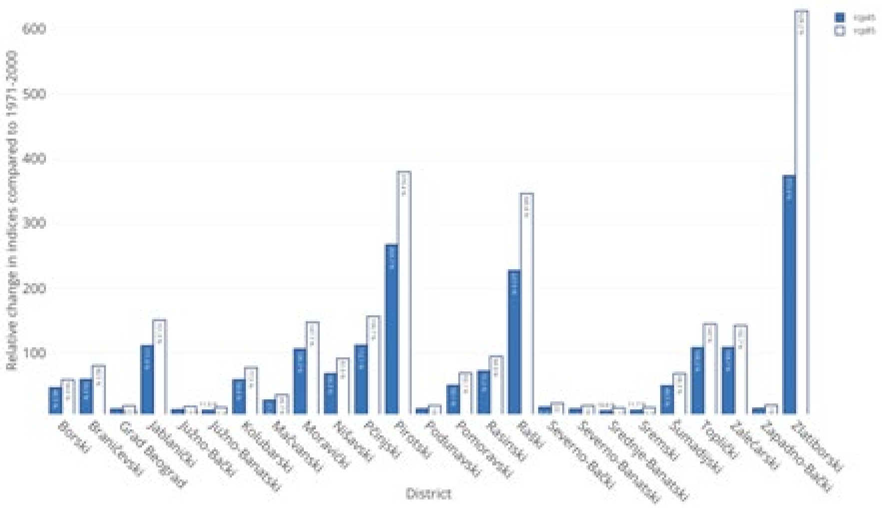


Figure A 42: Relative change [%] of projected MCDA risk index for Phlebotomus papatasi for 2041-2070 compared to reference period 1971-2000

Risk and vulnerability assessment by districts for the period from 2071 to 2100

Based on the output of the model for the period 2070-2100 for the medium emission scenario, RCP45, the districts with high vulnerability (75-100) are: Bor, City of Belgrade, South Bačka, South Banat, Kolubara, Mačva, Nišava, Danube, Morava, North Bačka, North Banat, Middle Banat, Srem, Šumadija, Toplica, Zaječar and West Bačka. Districts with moderate vulnerability

(50-75) are: Brančevo, Jablanica, Moravica, Pirot and Rasina. Districts with low vulnerability (25-50): Pčinj, Raška and Zlatibor (Figure A43).

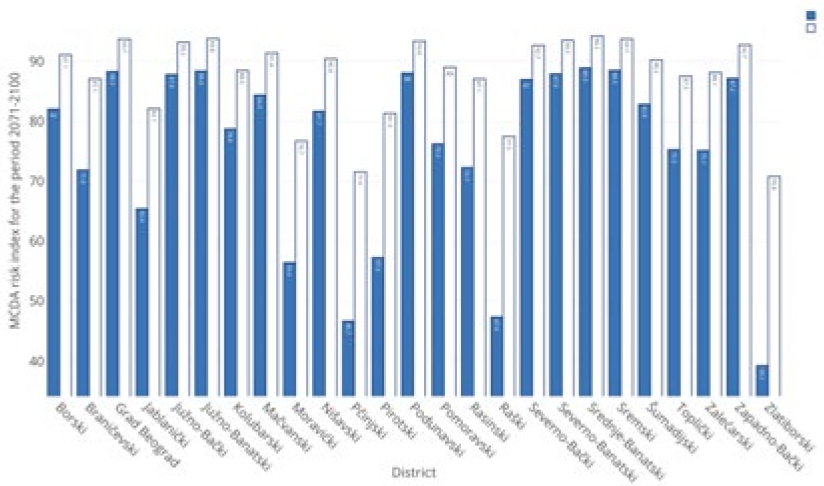


Figure A 43: MCDA risk index for Phlebotomus papatasi for RCP45 and RCP85 scenarios for the period 2071 to 2100

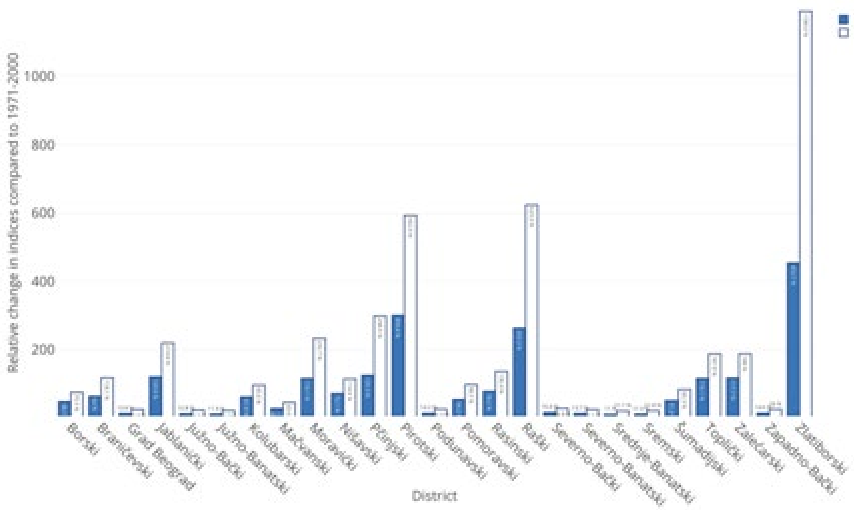
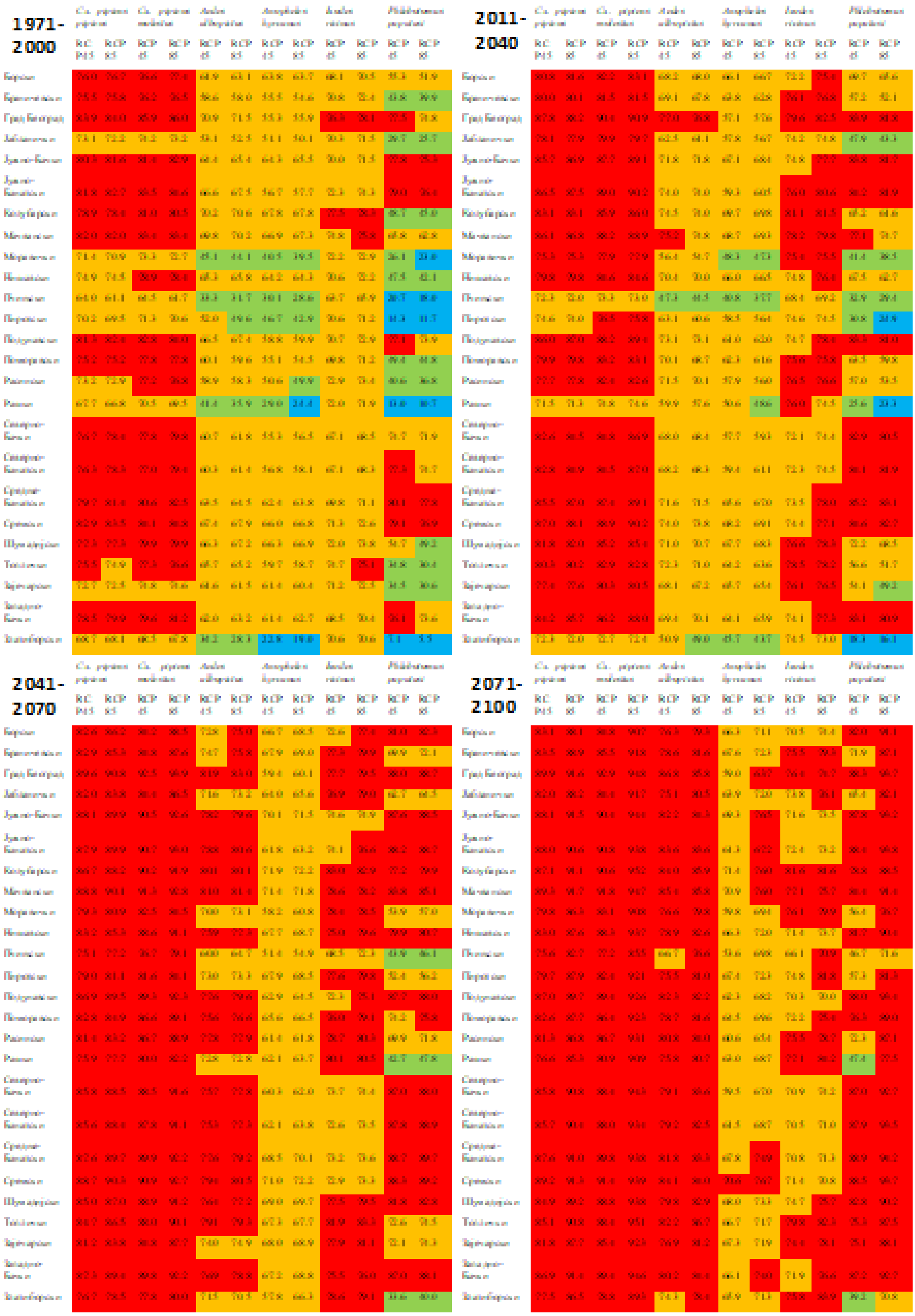


Figure A 44: Relative change [%] of projected MCDA risk index for Phlebotomus papatasi for 2071-2100 compared to reference period 1971-2000

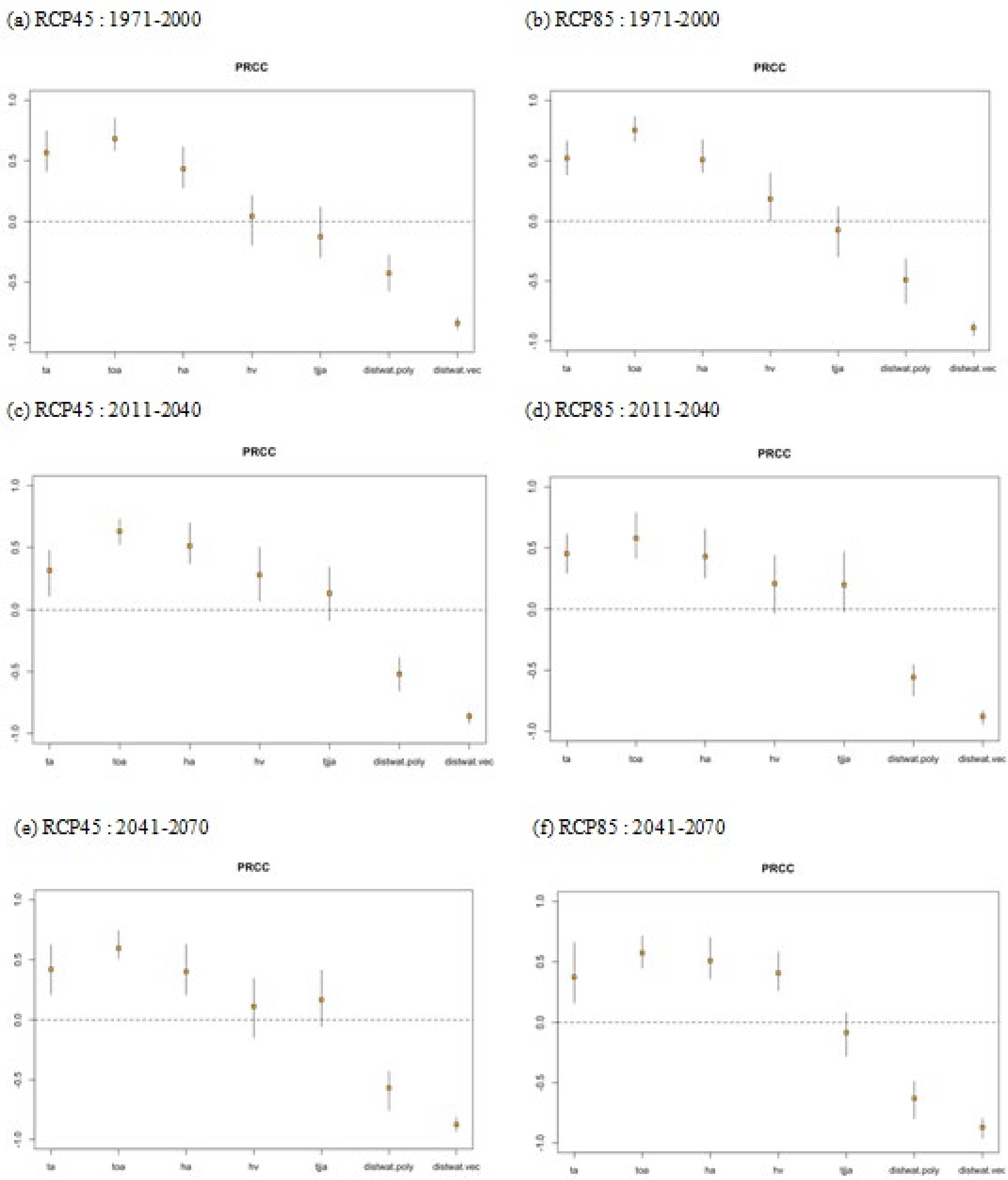
Overview of risks and vulnerabilities by districts (1971-2000; 2011-2040; 2041-2070; 2071-2100)



A1.4 Results of model sensitivity analysis

This chapter presents the results of the sensitivity analysis of the MCDA model. PRCC presents statistics of the correlation (y-axis) of the output value of the MCDA risk index and the input climate parameters (x-axis) using the “one factor at a time” (OAT) approach. The results are presented graphically for the periods 1971-2000, 2011-2040, 2041-2070, 2071-2100 and the scenarios of medium (RCP45) and high (RCP85) emissions.

Culex pipiens biotype pipiens: a biotype of the house mosquito



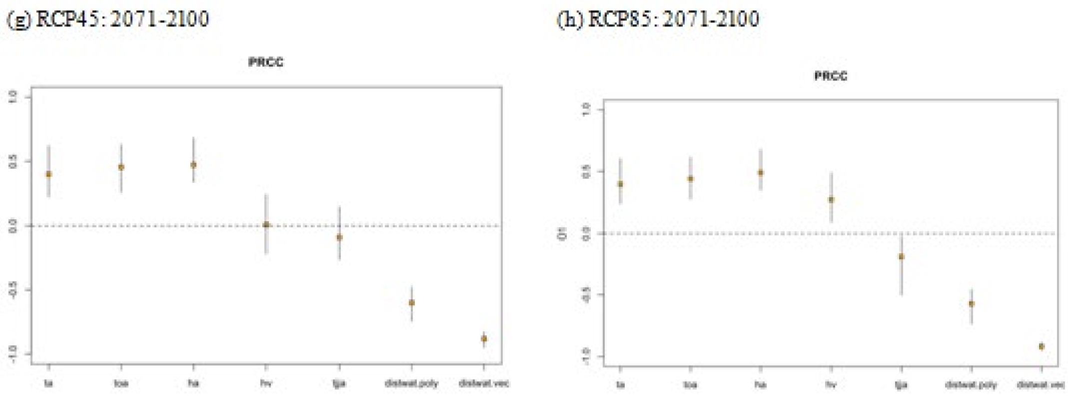
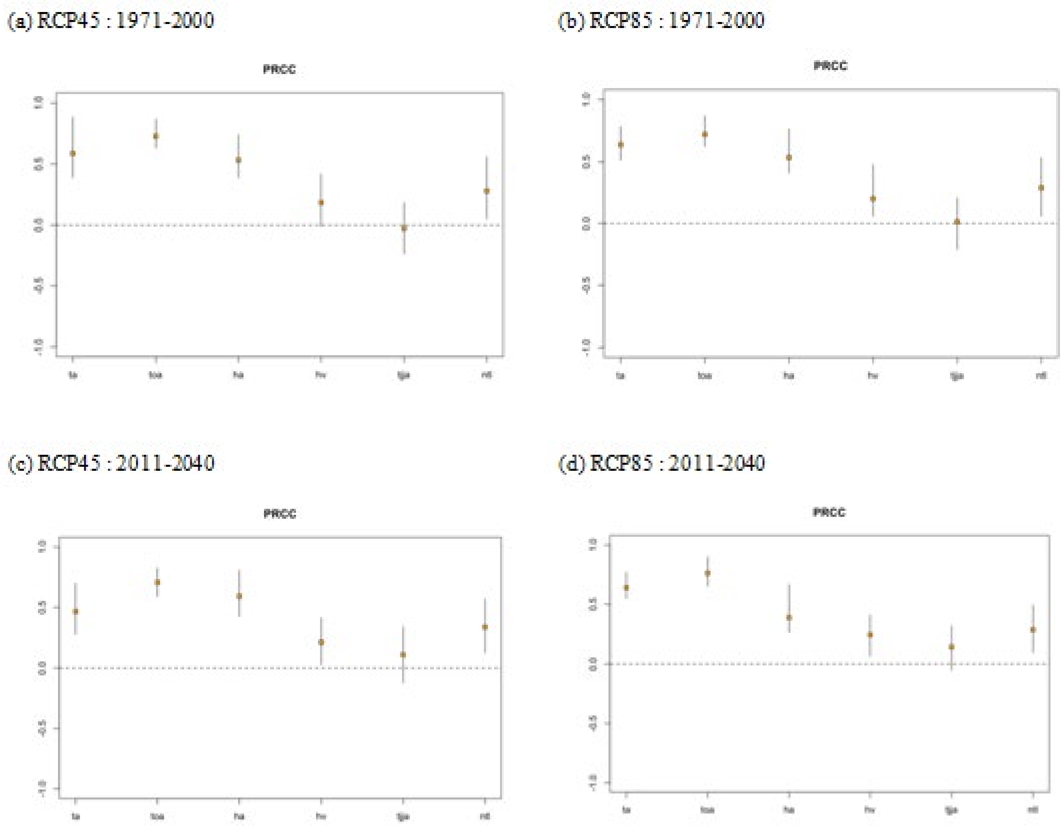


Figure A 45: Results of MCDA model sensitivity analysis for Culex pipiens biotype pipiens for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. Climatic parameters presented on the x-axis of the graph are: Ta - average annual air temperature; Toa - average air temperature in the period from October to April; Ha - total annual rainfall; Hv - number of days with precipitation >0.1mm; Tjja - average air temperature in the period from June to August; Distwat.Poly - distance from larger areas of natural waters (ponds/lakes); Distwat.Vector - distance from the floodplains of larger rivers.

Culex pipiens biotype molestus: the biotype of the house mosquito



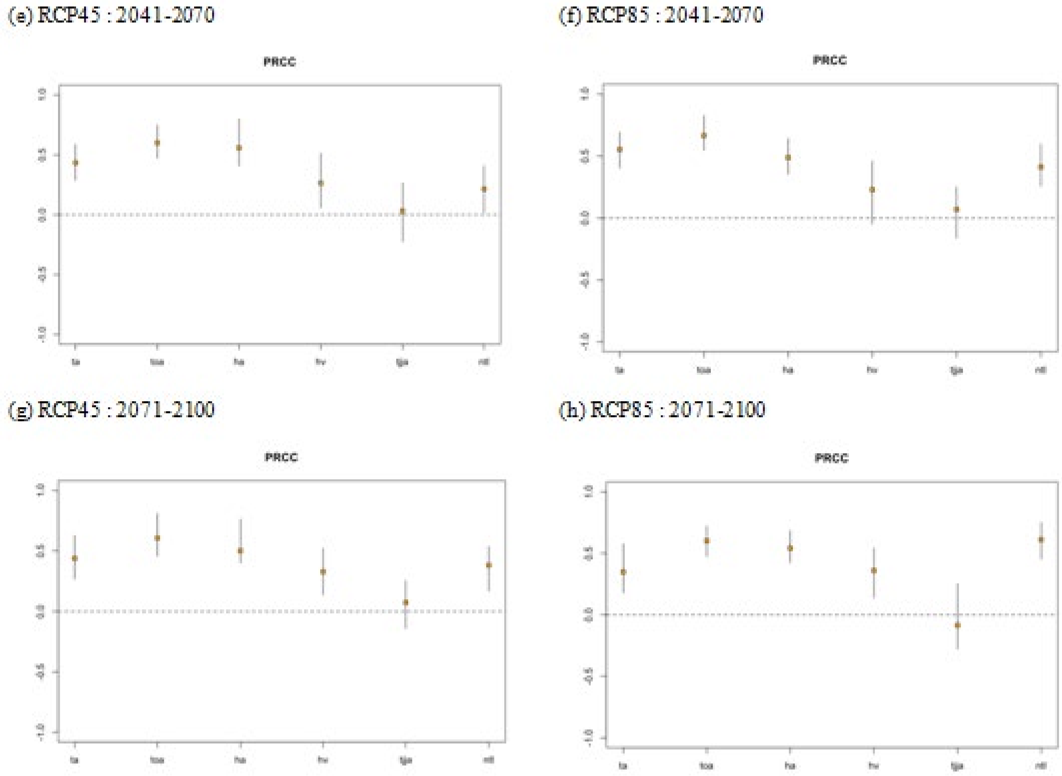
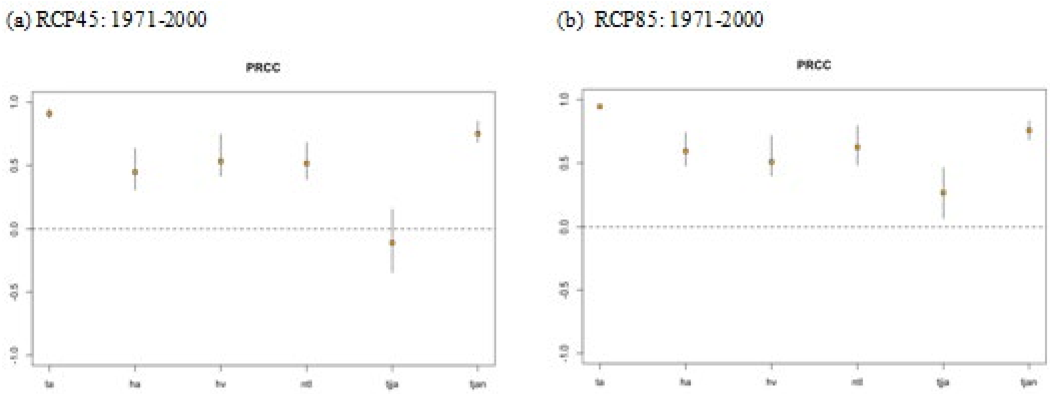


Figure A 46: Results of sensitivity analysis of MCDA model for Culex pipiens biotype molestus for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. Climatic parameters presented on the x-axis of the graph are: Ta - average annual air temperature; Toa - average air temperature in the period from October to April; Ha - total annual rainfall; Hv - number of days with precipitation >0.1mm; Tjja - average air temperature in the period from June to August; Distwat.Poly - distance from the floodplains of larger rivers; NTL - population density based on remote observations of night illumination.

Aedes albopictus: Asian tiger mosquito



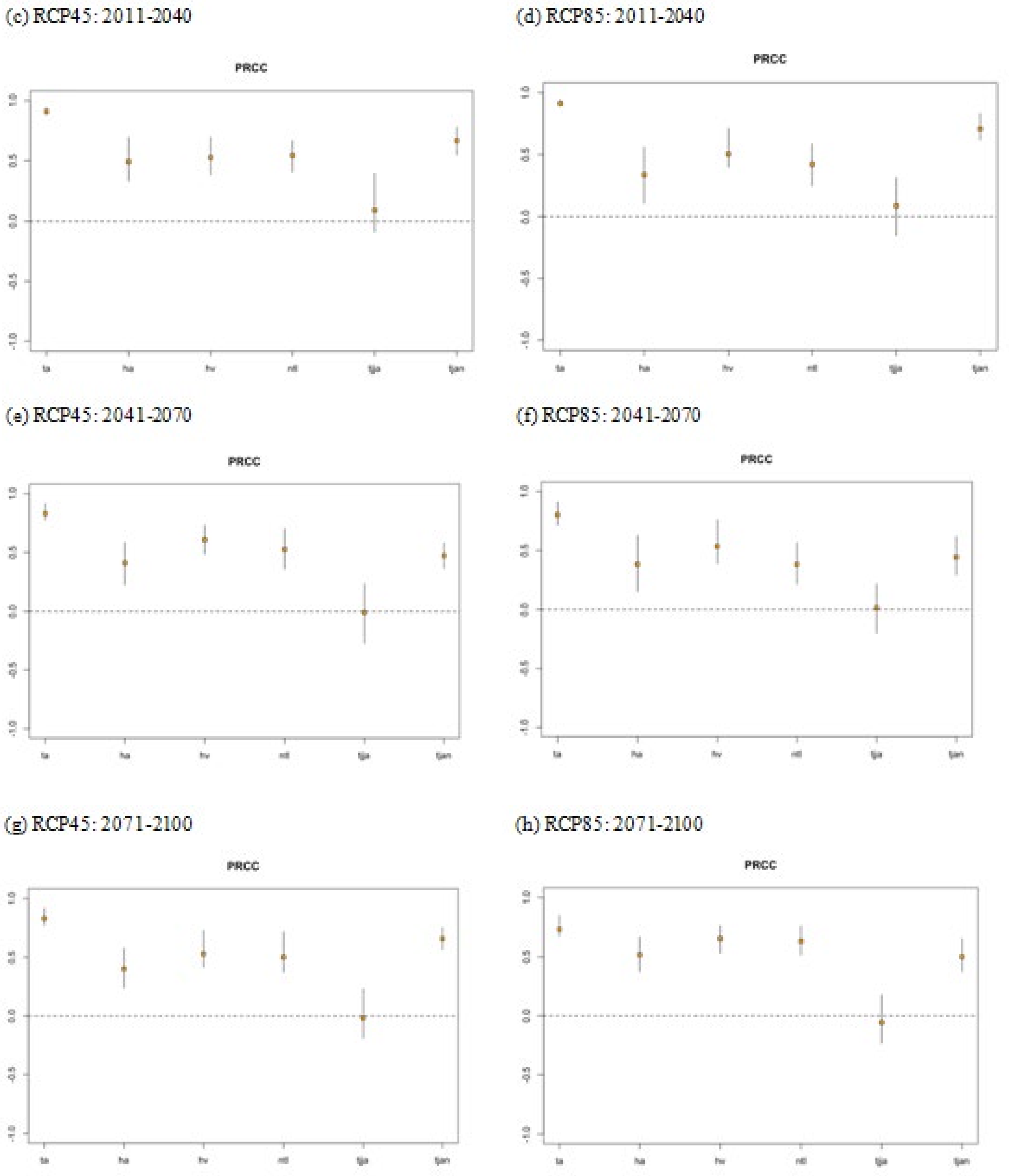


Figure A 47: Results of MCDA model sensitivity analysis for Aedes albopictus for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. Climatic parameters presented on the x-axis of the graph are: Ta - average annual air temperature; Toa - average air temperature in the period from October to April; Ha - total annual rainfall; Hv - number of days with precipitation >0.1 mm; Tjja - average air temperature in the period from June to August; Distwat.Poly - distance from the floodplains of larger rivers; NTL - population density based on remote observations of night illumination.

Anopheles hyrcanus: malaria mosquito

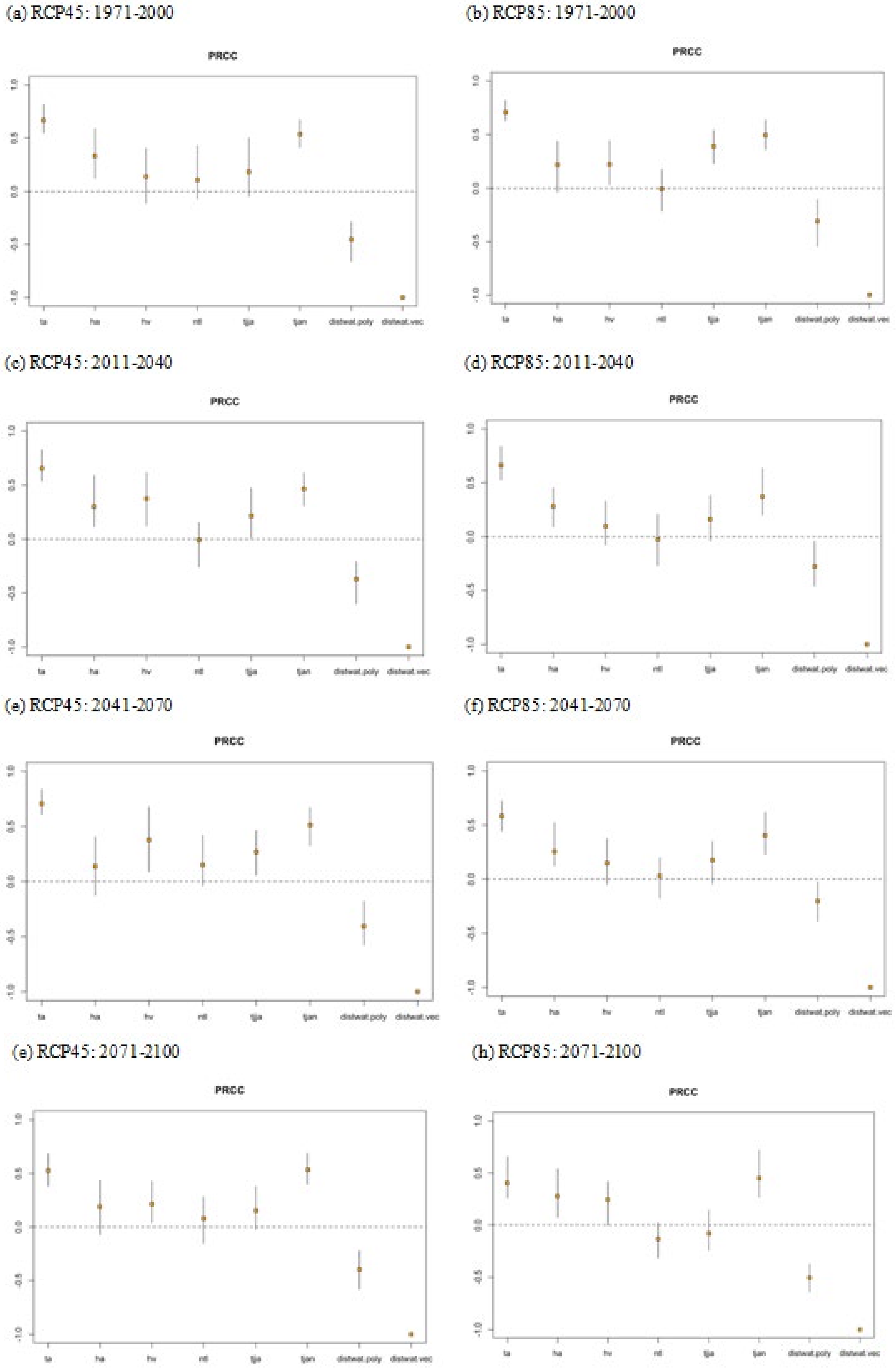


Figure A 48: Results of MCDA model sensitivity analysis for Anopheles hyrcanus for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. Climatic parameters presented on the x-axis of the graph are: Ta - average annual air temperature; Ha - total annual rainfall; Hv - number of days with precipitation >0.1mm; NTL - population density based on remote observations of night lighting; Tjja - average air temperature in the period from June to August; Tjan - average monthly temperature for January; Ha - total annual rainfall; Distwat.Poly - distance from larger areas of natural waters (ponds/lakes); Distwat.Vector - distance from the floodplains of larger rivers.

Ixodes ricinus: a tick species that transmits Lyme disease and tick-borne encephalitis

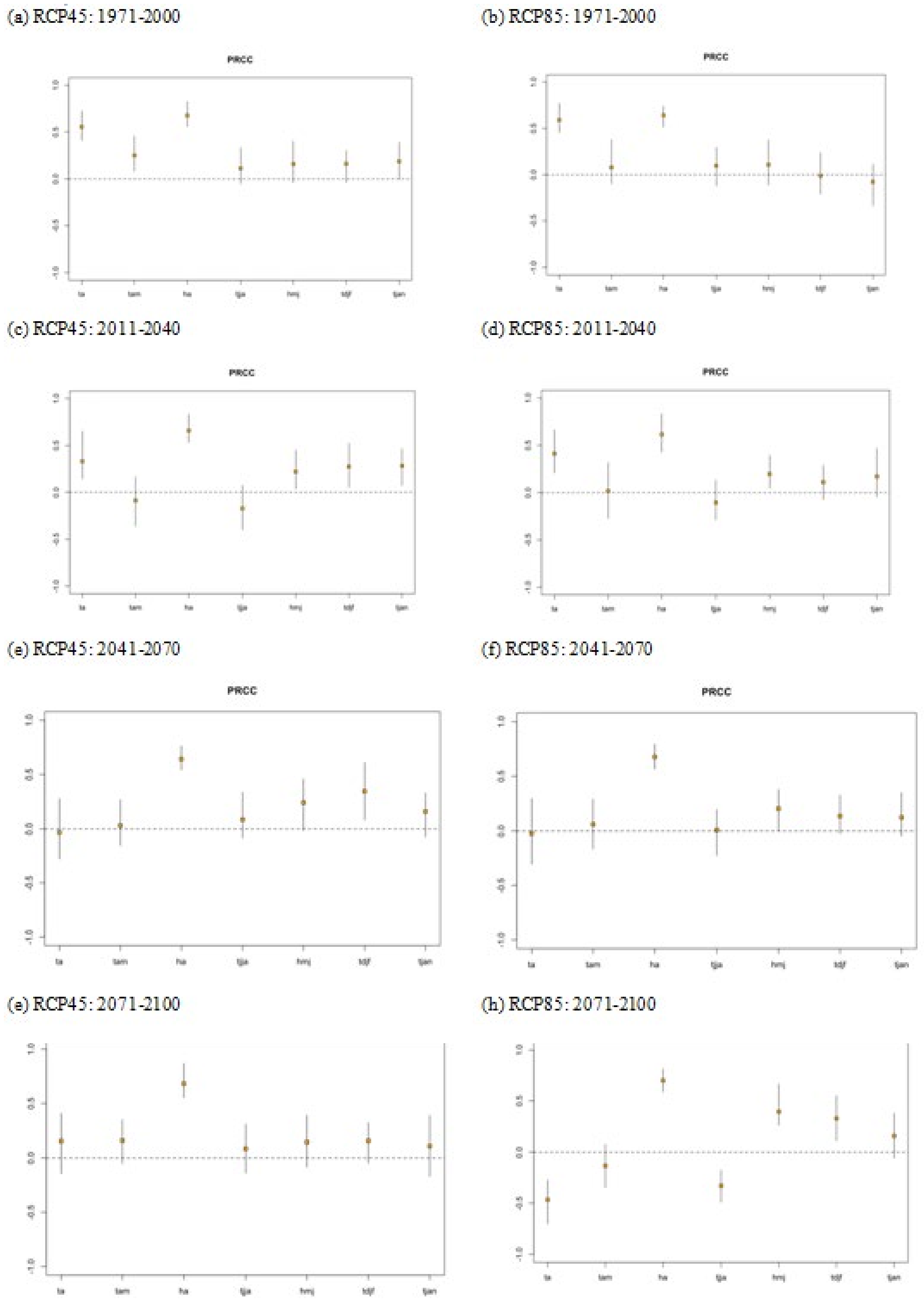


Figure A 49: Results of MCDA model sensitivity analysis for Ixodes ricinus for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. Climatic parameters presented on the x-axis of the graph are: Ta - average annual air temperature; There - the average temperature in the period from April to May; Ha - total annual rainfall; Tjja - average air temperature in the period from June to August; Hmj - average amount of precipitation in the period from March to June; Tdjf - average air temperature in the period from December to February; Tjan - average monthly temperature for January.

Phlebotomus papatasi: a sandfly species that transmits leishmaniasis and sandfly fever

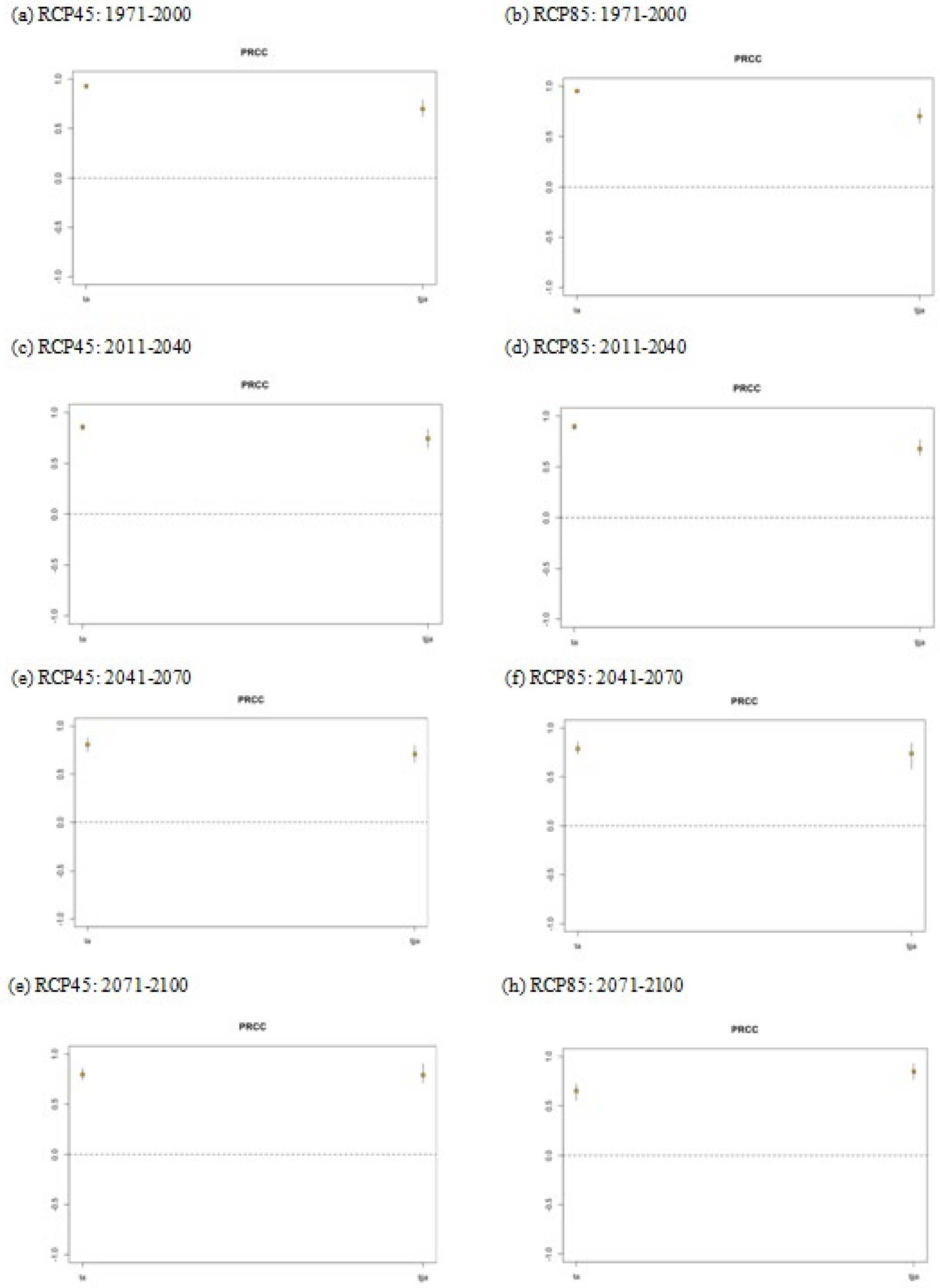


Figure A 50: Results of MCDA model sensitivity analysis for Phlebotomus papatasi for all periods for RCP45 (a, v, d, e) and RCP85 (b, g, f, f) scenarios. The climatic parameters presented on the x-axis of the graphs presented in this chapter are: Ta - average annual air temperature; Tjja - average air temperature in the period from June to August.

A1.5 Annex 1 Bibliography

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Annex 2 Instructions for Conducting the West Nile fever Surveillance; Republic of Serbia, Ministry of Agriculture Forestry and Water Management, Veterinary Directorate

Republic of Serbia
MINISTRY OF AGRICULTURE
FORESTRY AND WATER MANAGEMENT
- Veterinary Directorate -
Number: 323-02-2199/2014-05
10/04/2014
Belgrade

INSTRUCTIONS FOR CONDUCTING THE WEST NILE FEVER SURVEILLANCE

These Instruction s closer define the conducting of the West Nile fever surveillance (hereinafter: WNF) with horses, birds and virus vectors (mosquitoes, particularly the species *Culex pipiens*), as prescribed in the Ordinance on Establishing the Animal Health Protection Measures Program for 2014 (Official Gazette of RS, no: 24/14).

With the goal of early detection, surveillance and control of WNF, as well as of the presence of the virus in natural reservoirs and ensuring a timely risk assessment on possible transmission and spreading of the virus to the susceptible animals and the human population, active and passive surveillance shall be carried out in the susceptible animal species and the virus vector.

I Methodology for Conducting the Surveillance

1. Active Surveillance
    - Serologic testing of the sentinel poultry and animals and horses (animals that were not in contact with the WNF virus, or that do not have the specific WNF anti bodies in their blood);
    - Testing to the presence of the virus in the samples of the vector mosquitoes population (particularly the species Culex pipiens, which was the most frequent WNF vector in over 99% of the cases in our country)that were caught by special traps set in the period of highest activity of the vector;
    - Testing to the presence of the virus in samples of all dead susceptible species of wild birds collected throughout the year.

2. Passive Surveillance
   Serologic (testing of even serum samples) and virologic testing of samples from diseased horses with signs of CNS disorders.

3. Choosing the Sampling Location

The distribution and the choosing of the sampling location shall be carried out by epizootiological service of the competent or specialized veterinary institute for its epizootiological area, based on the risk assessment for the exposure to the WNF virus. The following should be taken into consideration:

- The existing results of serological tests;
- Presence of areas favorable to the development of mosquitoes (swamps, rivers, water flows, canals etc.)
- Settlements where cases of diseased humans were registered.

Based on the current knowledge about the presence and the circulation of the WNF virus in the Republic of Serbia, areas have been divided by administrative districts, by the risk of occurrence of the WNF infection in Table A1.

Table A 1: Distribution of areas by the risk of occurrence of the WNF

High-risk areas	Lower risk areas
North Bačka district	North Banat district
South Bačka district	West Bačka district
Middle Banat district	Šumadija district
South Banat district	Morava (Pomoravski) district
Srem district	Bor district
City of Belgrade	Zaječar district
Mačva district	Zlatibor district
Kolubara district	Moravica district
Danube (Podunavski) district	Raška district
Braničevo district	Rasina district
	Nišava district
	Toplica district
	Pirot district
	Jablanica district
	Pčinj district

II Active Surveillance

Active surveillance includes serologic and virologic surveillance.

1. Serologic Surveillance

Serologic surveillance means sampling and testing of blood serums of sentinel horses and poultry to the presence of specific anti-bodies to the WNF virus. Serologic testing will be carried out by the use of the ELISA test, in the competent scientific specialized veterinary institutes.

1.1. Serologic Surveillance with Sentinel Poultry

Serologic testing of the sentinel poultry will be conducted with the blood serum samples of poultry bred in the extensive system of production. Only chickens hatched in the year of conducting the surveillance will be tested, which were bred on farms located in the periphery of settlements (smaller towns).

In high-risk area districts (Table A1 of these Instructions), sampling needs to be carried out in 10 settlements, with up to 5 blood serum samples of poultry for each settlement, from at least 1 farm with an extensive system of production. The sampling and testing will be carried out from May to September (a total of 6 samplings), as following:

- 1st sampling - end of May;
- 2nd sampling - in June;
- 3rd and 4th sampling - in July;
- 5th sampling - mid August;
- 6th sampling - before September 15;

or once or twice a month, depending on the level of risk for the occurrence of the infection in the particular month of the year.

In lower-risk area districts (Table A1 of these Instructions), sampling needs to be carried out in 6 different settlements, with up to 5 blood serum samples of poultry for each settlement, from at least 1 farm with an extensive system of production. The sampling and testing will be carried out from June to September (a total of 4 samplings), as following:

- 1st sampling - in June;
- 2nd sampling - in July;
- 3rd sampling - mid August;
- 4th sampling - before September 15;

The locations of blood serum of poultry sampling should be identical for all samplings (from May, or June, to September) throughout the entire period of the surveillance program. In this sense, the location s considered to be areas of the chosen settlements.

The sampling pattern is shown in Table A2 of these Instructions. Blood serum samples of poultry collected for the supervision of aviary influenza virus may be partly used for this surveillance.

1.2. Serologic Surveillance with sentinel horses

In the preparatory period for conducting surveillance of WNF in horses, with the goal of identifying eligible sentinel animals it is necessary to conduct serologic surveillance in the period from March to May 2014, and identify horses that are seronegative to the WNF virus (they will be the sentinel animals).

The serologic testing of blood serum samples of sentinel horses means sampling up to 50 samples from as many as possible locations (minimum 3), in each district at risk of the infection (Table A1 and Table A2 of these Instructions), or up to 30 samples from as many as possible locations (minimum 3), in each district at lower risk of the infection (Table A1 and A2 of these Instructions). Sampling should we carried out successively and the same seronegative horses should be tested in three samplings, as following:

- 1st sampling - in June;
- 2nd sampling - in July;
- 3rd sampling - in August;

2. Virologic Surveillance

Virologic surveillance means sampling and testing organs and tissues of dead wild birds and, or of throat swabs of captured living wild birds of susceptible species, as well as of collective samples of vector mosquitoes (species *Culex pipiens*) to the presence of the WNF virus.

Presence of the virus will also be tested in brain and cerebrospinal fluid samples taken from horses who have died with clinical signs of neurological disorders.

Virologic testing shall be carried out by the use of molecular method (*real time* RT-PCR or RT-PCR) in reference laboratories of the Veterinary Specialist Institute “Kraljevo” from Kraljevo, Science Veterinary Institute of Serbia “Belgrade” and Science Veterinary Institute “Novi Sad” from Novi Sad. The veterinary institutes deliver samples for testing pursuant to the following territorial organization:

NIV SRBIJE BELGRADE	NIV NOVI SAD	VSI KRALJEVO
NIV Srbije, Belgrade	NIV “Novi Sad”, Novi Sad	VSI “Kraljevo” Kraljevo
VSI “Požarevac”, Požarevac	VSI “Subotica”, Subotica	VSI “Niš”, Niš
VSI “Šabac”, Šabac	VSI “Sombor” Sombor	VSI “Jagodina”, Jagodina
	VSI “Pančevo”, Pančevo	VSI “Zaječar”, Zaječar
	VSI “Zrenjanin”, Zrenjanin	

2.1. *Virologic Surveillance with Wild Birds*

Dead birds found outdoors, especially the non-migratory species - especially those that are the most susceptible to WNF virus infection (*Corvidae* - magpies, crows, rooks, ravens etc., raptors - goshawks, falcons, eagles and songbirds) found in the wild, or those who have died in rehabilitation centers, as well as goshawks, falcons, eagles and other raptors who have died in the zoos and in breeding nurseries are tested to the presence of the WNF virus in VSI “Kraljevo”, NIVS “Belgrade” and NIV “Novi Sad”.

In case the findings and laboratory testing of the dead birds are impossible, sampling can be conducted by catching live birds at high risk of WNF virus infection and collecting throat swabs, in the period from May to October, in one of the high risk areas, or by shooting a number of birds from the family of *Corvidae* (magpies, crows), in cooperation with hunters’ associations.

A cold chain needs to be provided for keeping and transporting the samples to the relevant laboratory that will conduct the testing (samples stored on ice, or frozen). Samples from dead birds (brain and parenchymatous organs) and throat swab are tested to the presence of WNF virus by molecular methods (*real time* RT-PCR or RT-PCR).

The collection of samples from dead birds and their testing to the presence of the WNF virus is carried out throughout the year in the high risk areas (Table A1 and A2 of these Instructions), or from May to October in lower risk areas (Table A1 and A2 of these Instructions).

2.2. *Virologic Surveillance of Virus Vector Mosquitoes*

Vector mosquitoes, species *Culex pipiens*, are tested to the presence of the WNF virus by molecular methods (*real time* RT-PCR or RT-PCR). The mosquito samples are tested as a collective sample (up to 50-100 mosquitoes in a pool) by a sampling location.

The collection of mosquitoes is carried out by the means of traps, in the period of their intensive activity (end of May - September), in areas favorable to the development of mosquitoes (swamps, rivers, water flows, canals etc.) and in proximity of susceptible animal species (horse stables and poultry farms).

In the high risk area districts, the sampling is carried out twice a month in 10 locations distributed throughout these areas, with a total of 7 samplings, starting end of May, and then at middle and the end of the following months, until the first half of September.

In the lower risk area districts, the sampling is carried out once a month in 5 locations distributed throughout these areas, with a total of 5 samplings, starting end of May, and then in the second half of the following months, until the first half of September (Table A1 and A2 of these Instructions).

For the mosquitoes caught with CO2 traps and other traps in native state (fluid free), the quickest possible cooling should be provided (freezing) and transportation of frozen samples.

III Passive Surveillance

Passive surveillance includes mandatory testing of all horses manifesting neurological difficulties, by conducting serologic testing even blood serum samples, collected in a 3-4 week interval, to the presence of specific antibodies to the WNF virus. The testing shall be carried out by a competent scientific or specialized veterinary institute. In case of death of an ill horse, a sample of brain tissue and of cerebrospinal fluid need to be sent for testing to the presence of the WNF virus.

Table A 2: Surveillance Plan (Sampling and Testing)

	High-risk areas	Lower risk areas
1. Testing of sentinel animals (poultry and horses)		
Surveillance of sentinel poultry bred in an extensive system of production- chickens hatched in the year of conducting the surveillance (extensive production)	Serologic testing in a competent institute, in the period May-September on samples from 10 settlements, with 5 blood serum samples for each settlement, from at least 1 farm according to the described plan. 6 samplings (1 end of May, 1 in June, 2 in July, 1 in mid-August and 1 before 15th September)	Serologic testing in a competent institute, in the period June-September on samples from 6 different settlements, with 5 blood serum samples for each settlement, from at least 1 farm according to the described plan. 4 samplings (1 in June, 1 in July, 1 in mid-August and 1 before 15th September)
Surveillance of sentinel horses	Serologic testing in a competent institute of 50 sentinel horses sampled from a minimum of 3 locations per district. Sampling and testing of blood from the same seronegative sentinel horses shall be carried out 3 times (June, July, August).	Serologic testing in a competent institute of 3 0 sentinel horses sampled from a minimum of 3 locations per district. Sampling and testing of blood from the same seronegative sentinel horses shall be carried out 3 times (June, July, August).

2. Testing in natural reservoirs and virus vectors		
Surveillance to the presence of the virus in wild birds	Application of the RT-PCR or *real time* RT-PCR methodology to samples from dead birds of susceptible species found throughout the year, or from 100 samples taken from planned shot, or caught living susceptible species per district, in the period May-October.	Application of the RT-PCR or *real time* RT-PCR methodology to samples from up to 50 dead birds of susceptible species found per district, in the period May-October.
Surveillance to the presence of the virus in mosquitoes (*Culex pipiens*)	Catching mosquitoes every 2 weeks in the period May-September on 10 locations distributed throughout the whole district and testing by RT-PCR or *real time* RT-PCR methodology (7 samplings from the end of May to the first half of September)	Catching mosquitoes once a month in the period May-September on 5 locations distributed throughout the whole district and testing by RT-PCR or *real time* RT-PCR methodology (5 samplings, once a month, from the second half of May to the first half of September)

IV Mode of Sampling and Distribution of Samples

Sampling of a calculated number of samples from sentinel horses and poultry from settlements, or farms, according to the presented dispositions in the surveillance plan shall be carried out by, with the collecting of basic epizootiological and anamnestic information, epizootiological service of the competent or specialized veterinary institute in cooperation with the competent veterinary station and veterinary inspection.

The competent epizootiological service will collect the samples from wild birds, carcasses of dead wild birds, swabs and mosquitoes in their areas and it will send these samples to VSI "Kraljevo", NIVS "Belgrade" and NIV "Novi Sad", in accordance with the territorial organization given for the virology surveillance.

The samples for laboratory testing shall be accompanies by the *Order for sending the material* (Annex 1 of these Instructions).

If the testing establishes a positive finding of seroconversion (a positive serologic result in a previously negative sentinel animal) or if the presence of the WNF virus is established in wild birds, vectors or horses, **suspected infective disease is to be immediately reported**, and the laboratory report shall be sent to the competent veterinary inspector and the Veterinary Directorate.

Samples that are positive, or suspected to have the presence of the WNF virus shall also be immediately sent to the national reference laboratory for the WNF virus in VSI "Kraljevo", for a verification testing. If this laboratory gets a positive result, it shall immediately notify the sender, and it will also send copies of the report to the sender of the sample, to the Veterinary Directorate and to the competent veterinary inspector.

Samples of blood serum from horses and poultry that have been verified to be positive to the presence of antibodies to the WNF virus, as well as samples from wild birds and mosquitoes that have been confirmed positive to the presence of the WNF virus need to be frozen, for the needs of further testing (including samples from infected or dead horses tested during passive surveillance that have been found positive to the WNF virus).

In order to ensure a smooth and timely execution of WNF surveillance, especially of the part requiring activities that are technically more complicated and complex (surveillance of wild birds and vector mosquitoes), all participants in the surveillance need to plan all the necessary resources (people, equipment, reagents) and inform the Veterinary Directorate that they are prepared.

The following conditions need to be ensured for the surveillance of wild birds and vector mosquitoes as technically more complicated segments of the surveillance:

1. Permit to catch and sample wild birds;
2. Participation of qualified ornithologists, or at least certified ring marker of wild birds, for the needs of field work and for the right identification of the wild bird species from which the samples are collected;
3. Cooperation with the hunter's associations and organizations;
4. Legal, or registered nets for capturing wild birds;
5. Participation of qualified entomologists to precisely identify the species of mosquitoes captured in traps, who will test the presence of the WNF virus and work in the field on their capturing;
6. A sufficient amount of adequate traps for capturing the vector mosquitoes (species *Culex pipiens*);
7. Dry ice for storing and transport of the collected samples to the laboratory.

In case a veterinary institute cannot meet the listed conditions, or if it doesn't have the necessary resources for this segment of conducting surveillance, including the preconditions for laboratory testing, it shall immediately notify the Veterinary Directorate n writing, and the Veterinary Directorate shall coordinate the surveillance activities in the epizootiological area of that institute.

V Reporting and Invoicing

Scientific and specialized veterinary institutes shall deliver collective monthly reports before the 10th in the month for the previous month (Annex 2 and 3 of these Instructions), with all the individual reports on testing conducted for that month and an invoice for the conducted activities. The documents shall be sent to the Ministry of Agriculture Forestry and Water Management, Veterinary Directorate, Omladinskih Brigada 1, 11070 New Belgrade.

VSI "Kraljevo", in coordination with NIVS "Belgrade" and NIV "Novi Sad" and other institutes shall prepare the final report on this surveillance, in the form of a study, with a detailed analysis of data.

VI Pricelist of Services

1. Sampling:

- Targeted wild birds (shot, dead) sample, whole cadaver: **RSD 700.00**;
- Targeted wild birds (caught alive) sample, throat swab: *RSD 1,500.00 (addition to the previous item, and only if there are no dead birds in the risk areas)*;
- Poultry (blood): **RSD 100.00**;
- Horse (blood): **RSD 350.00**;
- Mosquitoes, collective sample (50 pieces): **RSD 700.00** (maximum up to 1,075 samples).

2. Laboratory testing:

- ELISA with diagnostics: **RSD 1,000.00**;
- PT-PCR or real time PT-PCR: **RSD 3,500.00**;
- Entomological testing: **RSD 500.00** per sample.

DIRECTOR
Dejan Bugarski

Sub-Annex 1

(NIV/VSI) Order for sending the material
Number: ____________
Date: ____________, 2014

Subject: Sampling of materials for the West Nile Fever
SAMPLE IDENTIFICATION/TYPE OF TESTING

No.	Sample type	Quantity	Sample marking
1.			
2.			
3.			
4.			
5.			

a. Date of sampling: ___________ GPS coordinates: ___________
b. Settlement: ___________, municipality: _____________
c. Owner/holder: ___________________________
d. (farm ID): _________________
e. Species/breed/category of animal: ______________
f. Number of animals at the farm: ________________
g. Origin: __________________
h. Settling: date: _____________, age: __________________
i. Other categories and types of animals ___________________________
j. Comment (information of importance in the epizootiology of WNF: potential contact with wild birds, mosquitoes)

Responsible person

Sub-Annex 2

NIV/VSI __________
Number: __________
Date: __________

COLLECTIVE REPORT
OF THE NATIONAL REFERENCE LABORATORY
ON THE SCOPE OF SAMPLING AND TESTING RESULTS
WITHIN THE PROGRAM OF SURVEILLANCE OF WEST NILE FEVER
ON THE TERRITORY OF THE ________________* DISTRICT
FOR THE MONTH ______, 20

No.	SAMPLE TYPE	Number of samples	Types of testing and results				(comment)
			Serology		Virology		
			positive	negative	positive	negative	
1.	HORSES- blood						
2.	HORSES- organs						
3.	POULTRY- blood						
4.	MOSQUITOES						
5.	BIRDS- throat swabs						
6.	BRDS- dead						
7.	BIRDS- shot						
8.	OTHER						
	TOTAL						

* In reference to the risk, a district belongs to a 1. High risk area; 2. Lower risk area; (circle your choice)

Responsible person

Sub-Annex 3

VSI "Kraljevo", Kraljevo
Number: __________
Date: __________

COLLECTIVE REPORT
ON THE SCOPE OF SAMPLING AND TESTING RESULTS
WITHIN THE PROGRAM OF SURVEILLANCE OF WEST NILE FEVER
ON THE TERRITORY OF THE ________________* DISTRICT
FOR THE MONTH _______, 20

No.	SAMPLE TYPE	Number of samples	Types of testing and results				Samples sent to VSI "Kraljevo", NIVS "Belgrade" or NIV NS** (comment)
			Serology		Virology		
			positive	negative	positive	negative	
1.	HORSES- blood						
2.	HORSES- organs						
3.	POULTRY- blood						
4.	MOSQUITOES						
5.	BIRDS- throat swabs						
6.	BRDS- dead						
7.	BIRDS- shot						
8.	OTHER						
	TOTAL						

* In reference to the risk, a district belongs to a 1. High risk area; 2. Lower risk area; (circle your choice)
** In reference to the sampling location

Responsible person

Annex 3 Selected Papers of the Authors of the NAP

Books and book chapters

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