***An approach to identifying social protest potential based on a city-to-city similarity metric***

***Introduction.*** Nowadays, the evaluation of city-to-city similarity is a relevant approach that can be applied to various tasks, including infrastructural, architectural, and other areas [1, 2, 3, 4]. Interest in this research direction is mainly driven by the possibility of using similarity assessment to address urban planning problems [4]. At the same time, social conflicts that arise during the implementation of construction projects are of great importance in the field of urban planning [5, 6]. Therefore, forecasting social risks (such as protests and conflicts) is a relevant task for urban planning. Undoubtedly, this problem is even more relevant for socio-economic policymaking [7–11].

Motives and factors of modern social protests are under careful investigation due to their significant impact on the socio-political situation, which, in turn, is closely connected with socio-economic processes [7–11]. The relevance of this research area is beyond doubt, since certain mechanisms of protests remain debatable or even unknown [7, 8]. The growing number of recent studies on this topic also serves as evidence of strong interest.

The main goal of this research is to develop a method for assessing the potential for social conflict in a given municipality (city, town, or village). The core of the approach is estimating the similarity not only of the socio-economic environment, but also the demographic structure (human capital) to characteristics that could show the predisposition to certain types of social conflict. In other words, similarity between two municipalities, where one of which has experienced a particular social conflict, can serve as an indicator of a likely comparable social response to the same type of stimulus.

***Related works.*** There are various approaches to investigating social conflicts. So far, the most common approach has been to examine the problem within the context of sociological and psychological research [7, 8]. However, it should be noted that forecasts based only on sociological data do not demonstrate high accuracy [7].

Also one of the common approaches is based on mathematical modeling of collective behavior [8]. It mainly involves the development of various agent-based systems that allow the analysis of protest dynamics through imitation processes. For example, an epidemiological model is often used as a representation of protest movements [8].

In recent years, machine learning approaches have also gained popularity in this field of research [9, 10, 11]. These studies are generally based on analyzing public sentiment through the monitoring of social networks and mass media [9, 10, 11].

In study [9], protests are investigated through the analysis of the stylistic features of mass media articles covering labor protests that took place in Romania (2018–2025). Within the context of the present research, particular interest lies in the evidence supporting the spatio-temporal hypothesis of protest diffusion, meaning that a protest in one location increases the occurrences of protests in neighboring areas [9]. This conclusion resonates with the effectiveness of the epidemiological approach to analyzing protest dynamics. However, the present research proposes a method that considers at least the “spatial” component in terms of the socio-economic and demographic space, which is often influenced by geographical closeness but is not determined by location alone.

The study [10] used social network data to forecast civil unrest events. A modified neural network was proposed, trained on Twitter data (now X.com) using the example of the 2019 protests in Hong Kong. The effectiveness of this approach was demonstrated by comparing it with various other machine learning algorithms [10].

In [11], protests in Latin America (2012–2014) were examined using a logistic regression model that was trained on data not only from the social network Twitter (now X.com), but also from other sources, including news feeds, political event databases, the TOR network, and economic indicators. It is important to note that only currency exchange rates were used as the economic indicator [11]. While this is a valuable factor, it is not sufficient to capture the full socio-economic condition of a territory within a country.

***Data.*** The analyzed dataset includes socio-economic and demographic data for over 1800 municipal entities in Russia (districts, cities, and villages) for the period 2014 to 2022, collected from the Federal State Statistics Service (ROSSTAT). Most records (around 80%) correspond to municipal districts, as separate data for small cities and villages are generally unavailable in open access. In total, the dataset includes more than 9000 examples, since each municipality–year combination is treated as an independent observation.

Table 1 presents the selected socio-economic indicators. These factors were chosen based on their demonstrated effectiveness in migration forecasting study []. Therefore, they provide a reliable basis for assessing the socio-economic conditions of a municipality.

1. Average number of employers in organizations - avgemployers (ppl.)

2. Average salary - avgsalary (rub.)

3. Shopping area - shoparea (sq.m.)

4. Number of seats in café, bars and restaurants - foodseats (num.)

5. Retail turnover - retailturnover (thnd. rub.)

6. Live area per capita - livarea (sq.m.)

7. Number of sporting venues - sportsvenue (num.)

8. Number of services (barbershops, repairs) - servicesnum (num.)

9. Length of roads - roadslen (km.)

10. Number of livestock - livestock (num.)

11. Productivity of land (vegetables) - harvest (centners)

12. Agricultural production - agrprod (thnd. rub.)

13. Number of healthcare organizations - hospitals (num.)

14. Number of places in preschool organizations - preschool (num.)

15. Volume of self-produced goods - factoriescap (thnd. rub.)

All socio-economic indicators (except average salary) were normalized on a per capita basis to enable fairer similarity evaluation across municipalities and to provide a better assessment in terms of population well-being (see Table 1).

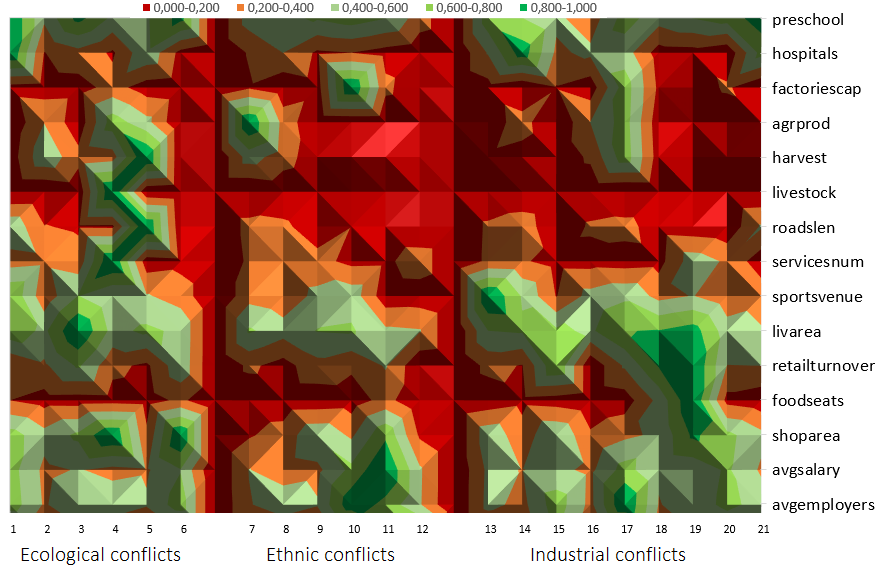
To represent the population structure of the municipalities, demographic data were collected for 14 cohorts (from ‘0–4’ to ‘65–69’), disaggregated by gender for each year. Unfortunately, data for cohorts older than ‘65–69’ were missing for many municipalities. It is important to note that the demographic data were also normalized as the proportion of each cohort (age group) in the total population of a given municipality, which makes it possible to evaluate human capital in terms of structure rather than quantity.

***Set of Social Conflicts.*** The socio-economic and demographic characteristics of a municipality at the time it experiences a protest could be used to identify a predisposition to certain social conflicts or general social tension. Thus, the set of municipalities (or conflict cases) against which similarity is assessed forms one of the crucial components of the proposed approach.

A set of the most notable social conflicts in Russia from 2013 to 2023 has been collected. It includes 21 cases of social protests in different municipalities, each involving mass gatherings of people (over 100 participants) and receiving wide media coverage. These cases can be grouped into three categories: six ecological conflicts (Shies 2018, Poltavskaya village 2022, etc.); six ethnic conflicts (Chemodanovka 2019, Makhachkala 2023, etc.); and nine industrial conflicts (Kushtau 2020, Anapa 2021, etc.).

The focus on high-profile conflicts is motivated by their potential to highlight the socio-economic and demographic indicators that predispose municipalities to social tension. In other words, these cases can be viewed as “local extrema” of an abstract function representing social conflict.

During the comparison of the socio-economic conditions of these local extrema (conflict cases), certain trends can be observed. Figure 2 shows that in the entertainment (“servicesnum”, “sportsvenue”, “retailturnover”, “foodseats”) and in the production sectors (“factoriescap”, “agrprod”, “harvest”, “livestock”) municipalities that experienced ethnic conflicts exhibit the lowest values (many red zones), while municipalities with other types of conflicts display more favorable conditions. Notably, municipalities with ecological conflicts appear to be the most balanced (see Fig. 2).



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