Historical censuses and a search for perspective farmland in the context of global climate change

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Abstract

Due to global climate change, there is a gradual change in the use of farmland: some degrades in terms of traditional exploitation, while other becomes more suitable for cultivation. The study is focused on the latter, namely, on identifying those areas of the Russian Far East where climate change will have a positive impact in terms of both economic development and demographic improvement. The peculiar feature of our methodology is the use of historical data to identify areas for the most comfortable and economically feasible residence of peasants in the region. Having identified these locations and their physical and geographical characteristics, the authors have attempted to find similar conditions in areas that currently remain undeveloped, yet ready to accommodate settlers in the coming 20 years. With the beginning of the development of these territories by the Russians, it turned out that the south of the Primorskaya Oblast, the so-called South Ussuri Krai, was the most suitable area for agriculture (and for population concentration in general). Therefore, it was the settlements in this area that were taken as a sample for the analysis. The following four most important landscape characteristics of an agriculturally successful settlement have been identified – soil, average temperature for August, average precipitation for August, and elevation above sea level (up to 200 m). The authors used down-scaled¹ monthly climate data from the CMIP6 multimodel for GCM BCC-CSM2-MR of the SSP3-7.0 scenario for the period 2021-2040 as climate change data (this is an average, most likely scenario of global warming with due regard to partial global policy measures to reduce greenhouse gas emissions). As a result, 26 still undeveloped (in terms of arable farming) and uninhabited areas were identified in the Primorye, Khabarovsk Territories and the Jewish Autonomous Region with a total area of about 1 million hectares. It is these areas that should be given a special attention when planning the region’s development; they require an additional in situ testing.

¹ Downscaled forecasts of future climate in the CMIP6 multimodel. A full model, which is being developed under the auspices of the Intergovernmental Panel on Climate Change (IPCC), has not so far been completed.
Keywords
CMIP6, GIS analysis, farming, zoning, historical maps, climate, peasantry, settlements, population census, soils, Primorye Territory, terrain, Khabarovsk Territory, South Ussuri Krai

JEL codes: Q1, Q5

Introduction

Global climate is gradually changing. Looking back, it can be noted that, for instance, winters have become warmer. The fact that summer is getting a little cooler is much more difficult to notice, nevertheless, the average annual temperature on Earth is gradually increasing. Not too rapidly, yet significantly within decades. This warming manifests in different regions of our planet in various ways: in some places it is well-pronounced, while in others is hardly noticeable.

However, our study is focused on emerging new territories that will become suitable for the common to the region management rather than degradation of agriculture in the traditional areas (although, the degradation will take place, and a solution will be changing cultivated plants).

The situation is further complicated by the fact that it will change unevenly throughout the Northeast Asia region. For example, in Hokkaido, conditions for land use are likely to improve; such conditions in Heilongjiang will partially change for the better; while agriculture in North Korea is likely to be heavily affected. This may lead to the uncontrolled «climate» migrations within the region, which are currently being restrained by political methods.

Our work used a number of state-of-the-art CMIP6 climate models (the project is operated under the auspices of the Intergovernmental Panel on Climate Change (IPCC), but has not been completed yet and is currently more than a year behind schedule). It can be assumed that climate changes, which have dramatically increased nowadays (first of all, global warming), have already necessitated evaluation of new areas both for the resettlement of people and agricultural activities in order to feed these people.

Our calculations are based on the intermediate, most likely scenario according to which some countries will pursue a policy of reducing emissions, while others will not (SSP3-7.0). However, even with such a model, it is difficult to predict specific locations that open up opportunities for land use, for example, freed from permafrost. It is possible to understand which of these territories can be used in the most rational way, using historical data on those locations where farming used to be most effective in the past. At present, we have yet to see any domestic works using this approach. Of course, they will appear in the very near future and in a fairly large number.

Methods

In general, our idea was as follows:
1. Identify the most successful agricultural peasant settlements in the studied region (in our case, south of the Russian Far East) on the basis of historical data of the XIX – early XX centuries;
2. Identify physical and geographical conditions of their location;
3. Find similar areas with due regard to climate change in the near future.
Let’s make some remarks.

First, the question may arise why we are referring specifically to historical data, and not to more up-to-date data. Despite difficulties related to specifying climate a century ago (as will be indicated below), the authors believe that the use of pre-Soviet censuses in this case is of fundamental importance. The fact is that at that time settlements had a clearer specialization: we know exactly what kind of activity was dominant out there. Of course, inhabitants of rural areas earned their living in different ways: in some places carrying was well-developed, in others forestry, etc., but we can quite clearly identify areas with a dominant agriculture. In the already Soviet, later period, specialization of settlements became broader and often hardly dependable upon both traditional types of employment and geographical conditions in general. That is, a large settlement, not related to agriculture at all, could have been formed because of the construction of an integrated plant, a combined heat and power plant or an airfield, even though the soils suggest efficient farming out there. In this regard, the further away the observation, the more accurate data on perspective agricultural areas.

The biggest challenge in working with statistical materials is a correct selection of those that will prove reliable during processing. The authors wanted to find a source of data on the history of the Far East in the pre-revolutionary period to meet the following two criteria: massive and reliable. It is not by chance that we have turned to censuses. They are conducted according to a strict methodology and cover large groups of the population. It was only a matter of validation. We have opted for statistics prepared by the Primorsky Resettlement Administration in 1915 (Populated and residential areas… 1915). The analysis of the resulting database compiled on the basis of this census proved its reliability (although due to its vastness, a lot of errors in calculations had to be corrected during summation, which is not surprising with manual data processing practiced at that time). In general, it can be said that the 1915 census of the rural population of the Primorska Oblast was conducted at a very high-quality level. Of great interest are also data collected from reports of the uyezd peasant chiefs¹ (A reference book… 1913). In addition, these materials were methodologically uniform by large, so in some cases they could complement each other and be used for verification. In the authors’ opinion, they are of better quality than data collected by military and civilian officials for the annual reports of the Governor-General of the Primorskaya Oblast. The main statistical sources the authors used in this paper are the following: (Populated and residential areas… 1915) and (A reference book… 1913).

To clarify some data (dates of settlement formation, conditions, reasons for resettlement, choice of settlement location, ethnic and social composition of settlers, etc.), the following sources were used: (Menshchikov 1910; Materials on the survey… 1911; Review of the Primorskaya… 1916; Busse 1896; Compendium of the most important… 1884).

The resulting material turned out to be so detailed and voluminous making the authors create an extensive geo-statistical database on its basis. The basis was (Populated and residential areas… 1915). It contains data on 1944 settlements in the Primorskaya Oblast, namely:

- type of settlement and its administrative relation to a particular volost (a small administrative division), uyezd (an administrative subdivision) or stanitsa (a Cossack village);

¹ Official position in Siberia since 1898; uyezd peasant chiefs were appointed by the Minister of Internal Affairs.
- ethnic affiliation of inhabitants (Russians, Koreans, Chinese, Japanese, Giliaks (the Nivkh), Golds (Nanai people), Orochis, Tazy, Tungus (the Evenkis), Yakuts);
- their citizenship (Russian and foreign nationals);
- affiliation with local population (de-jure and de-facto population);
- gender and marital status (singles);
- number of families.

The data are grouped into 52 columns for most settlements and 44 columns for non-Slavic camps.

Data from (A reference book… 1913) were added to this database as well. It contains information about 1,482 settlements and private land allotments of the Primorskaya Oblast. The most valuable for us data in this source included the following:

- year of formation of the site and settlement;
- amount of suitable land on the site (arable land, meadow, dry or damp steppe, forest) and unsuitable land (swamps, rocky places, etc.);
- standard of the allotment, number of land plots and number of land plots already claimed.

Finally, the authors have clarified some information from the above-mentioned sources, and also introduced new calculation data. The result is a table consisting of 1944 rows and 135 columns.

Critical evaluation of sources. The sources are reliable. Verification was carried out through Gaussian distributions for several characteristics. In general, there are no significant contradictions to historical facts and logical violations in the data.

Source defects

- Censuses are not simultaneous. There is an interval of 2.5 years between each (1913 and 1915).
- There were household censuses, but the cards for each family were filled out in the office of peasant chiefs. At the same time, data on the Ussuri Cossack army were simply transferred to the Resettlement Department by military authorities. And these data were collected six months earlier, namely in winter, when the number of, for example, the Chinese population could be by an order of magnitude less.
- Errors in calculations and typos which, however, have all been corrected.
- Difficulties related to identification of certain settlements, especially with non-Slavic camps on Sakhalin.
- Non-Slavic population was assigned to one or another tribal group based on the opinion of the local Russian population.
- Ethnic composition of the «Russian» population is not specified.

After data verification and subsequent statistical analysis, the authors have undertaken a spatial analysis. 831 out of the 1944 settlements turned to be eligible for this purpose. This was due to the fact that it was impossible to accurately localize small settlements (farms, isolated household with arable land, individual fanza, guard booths, barracks, etc.), as well as a number of camps (on the maps at our disposal, there were only marks «camp.», «gold.», etc. without a name). However, this had little effect on the results.

In order to link statistical data to specific localities and conduct a further spatial data processing, the authors have used the following cartographic sources: (Schematic map of the Iman Uyezd 1917; Schematic map of the Nikolsk-Ussuriysky Uyezd 1917; Schematic map of the Olginsky Uyezd 1917; Map of localities… 1913; Map of the Primorskaya… 1920; WorldClim, 1970-2000; Climate SSP 370; SRTM -30m; Digital soil map…, 1988),
OpenStreetMap, Google Satellite, Google Road, Bing Aerial, opentopomap.ru. The QGIS platform version 3.10.3 - Odense was used for GIS analysis.

Next, the authors had to make the following assumptions.

1. It was assumed that the economic well-being of a settlement can be estimated by its size (i.e. by the number of its population). This is an external yet most accurate in the authors’ opinion manifestation in terms of agricultural development of the region.

2. Modern science lacks accurate spatial historical and climatic data. Although data since 1881 are used to calculate (verify) climate models, in the authors’ opinion, for local cases such as the Primorskaya Oblast of the early twentieth century, this is unacceptable. The authors have used the earliest acceptable averaged climate data for the period 1970-2000. It was assumed that these data roughly correspond to the period under study (although during this time the global temperature increased by about 0.4-0.5 degrees Celsius). A plain extrapolation of this increase to our region is inappropriate due to climatic uniqueness of his seaside location.

3. As data on climate change the database of 2.5 minute (accuracy 1 km²) reduced monthly climate data from CMIP6 for GCM BCC-CSM2-MR scenario SSP3-7.0 for the period 2021-2040 was used (for a general understanding of the process the authors used the SSP5-8.5 extreme scenario– the worst scenario of global warming without any global policy to reduce greenhouse gas emissions). SSP3-7.0 is in the middle of the range of initial results obtained using energy system models, and is considered the most likely scenario of the future global warming (Hausfather 2019).

**Results**

Based on the SSP3-7.0 probabilistic data for the period 2021-2040 the authors have created maps with distribution of temperature and precipitation by summer month. The analysis shows that against the background of a general increase in temperature, July turns out to be the most favourable month for harvesting (the highest temperature coupled with lowest amount of precipitation). This improves farming conditions, as it enables avoiding floods due to typhoons and the Amur River overflow happening in August.

Using the SRTM topographic database (spatial accuracy – 30 meters along the equator line), soil map and forecast July climatic map for our region, the authors have identified several areas that are currently hardly developed, yet potentially suitable for agriculture with climatic, soil and terrain characteristics similar to those of areas that used to be suitable for agriculture in the South Ussuri Krai at the turn of the XIX and XX centuries. These sites are located in the Pozharsky and Krasnoarmeysky districts of the Primorye Territory; Vyazemsky, Lazo, Khabarovsky, Nanai and Amur districts of the Khabarovsky Territory, Smidovichi, Oktyabrsky and Obluchensky districts of the Jewish Autonomous Region (Fig. 1).

The authors have classified areas with elevation under 100m as the most suitable (first level) and with elevation of 100-200 m as the second most suitable. The total area of the first level land equals to 417,800 hectares and the second level land adds up to 661,500 hectares. An important point is the fact that a significant part of these areas is connected with the region’s main transport routes by railways and highways.
Discussion

The spatial analysis made it possible to find a number of interesting patterns of peasants’ settling within the Primorskaya Oblast.

First, in economic terms, this region can be divided into at least three zones under the study period (Fig. 2):

1. The South Ussuri Krai (a Russian territory south of the line: stanitsa Busse on the Ussuri River – St. Olga’s post on the coast of the Sea of Japan) with the right bank of the Ussuri River as far as Khabarovsk (including downstream of the Iman and Khor rivers) (341,111 people)\(^1\).

2. Middle reaches of the Amur River with the Tunguz volost and the Birsky area up to the mouth (mainly the right bank) (25,481 people)

3. Northern Sakhalin (7,347 people).

The first zone was most populated with a clear focus on agriculture in economic management (yet, with a wide range of fishing and hunting industries, transport services, temporary employment in towns and in construction projects).

In the second zone areas, agriculture was mainly represented by gardening and was of a limited nature, with a focus on the Khabarovsk market. As a rule, non-urban population was engaged in logging to meet demands of the army, Khabarovsk and the Amur Shipping Company, seasonal hunting and fishing.

Sakhalin was mainly dominated by local traditional crafts, hunting and fishing.

\(^1\) All calculations were carried out by the authors based on (Populated and residential areas… 1915).
Settlement of the peasantry was primarily determined by external conditions and market needs.

The authors were most interested in analyzing settlement of peasants, so the first zone enjoyed a higher attention, more specifically the South Ussuri Krai (238,303 people).

Using the averaged climatic, hypsometric and soil data, the authors have found out that the vast majority of settlements (except for «transit» ones, that is, located on communication routes and passes) correspond to the territories located (Table 1):

- at a height below 200 m above sea level;
- with an average temperature for August (the warmest month) above 20 °C;
- with less than 130 mm of precipitation for August;
- on 5 types of soils (out of 306 types available in Russia).

Some of these arguments are easily explained. For example, floods caused by typhoons have been of critical importance to the South Ussuri Krai (they are highly intensive in August-September), especially during the harvest period. That is why the amount of precipitation is so important: the lower the August value, the better (Fig. 3). An exception is the southernmost part of the South Ussuri Krai, the Posyetsk area, inhabited almost entirely by the Koreans. All attempts undertaken by the Resettlement Administration to invite the Russian peasants to settle down in this area failed.
Table 1. Physical and geographical conditions for setting-up successful agricultural settlements in the pre-Soviet period in the South Ussuri Krai

| Criteria                          | Number of settlements | % of the number of all settlements | Live on this territory (people) | % of the population | %%  |
|----------------------------------|-----------------------|------------------------------------|---------------------------------|---------------------|-----|
| **Altitude above sea level**     |                       |                                    |                                 |                     |     |
| up to 100 m                      | 288                   | 62.3                               | 168,087                         | 70.5                | 95.5|
| 100-200 m                        | 133                   | 28.8                               | 59,623                          | 25                  |     |
| over 200 m                       | 41                    | 8.9                                | 10,593                          | 4.5                 |     |
| **Av. t in August**              |                       |                                    |                                 |                     |     |
| over 20°C                        | 431                   | 93.3                               | 232,925                         | 97.7                | 97.7|
| below 20°C                       | 31                    | 6.7                                | 5,378                           | 2.3                 |     |
| **Precipitation in August (mm)** |                       |                                    |                                 |                     |     |
| 110-120                          | 202                   | 43.7                               | 148,020                         | 62.1                | 93.8|
| 120-130                          | 206                   | 44.6                               | 75,478                          | 31.7                |     |
| 130-140                          | 28                    | 6.1                                | 6,836                           | 2.9                 |     |
| over 140                         | 26                    | 5.6                                | 7,969                           | 3.3                 |     |
| **Soil type**                    |                       |                                    |                                 |                     |     |
| 98                               | 41                    | 8.9                                | 14,172                          | 5.9                 |     |
| 175                              | 56                    | 12.1                               | 45,126                          | 18.9                |     |
| 52                               | 67                    | 14.5                               | 33,327                          | 14                  | 89.6|
| 53                               | 101                   | 21.9                               | 69,483                          | 29.2                |     |
| 188                              | 108                   | 23.4                               | 51,514                          | 21.6                |     |
| other                            | 81                    | 17.5                               | 21,954                          | 10.4                |     |

*Soil types:
52 – soddy-pale-podzolic and podzolic-brown-soils
53 – soddy-pale-podzolic and podzolic-brown deep-gleyic and gleyic soils
98 – Brown forest slightly unsaturated (slightly unsaturated brown soils)
175 – Differentiated meadows (including osolodized ones)
188 – Floodplain sub-acid and neutral soils

Sources: (Populated and residential areas... 1915; A reference book... 1913; Schematic map of the Iman Uyezd 1917; Schematic map of the Nikolsk-Ussuriysky Uyezd 1917; Schematic map of the Olgin-sky Uyezd 1917; Map of Localities... 1913; Map of The Primorskaya... 1920; SRTM -30m; OpenStreet-Map; Google Satellite; Google Road; Bing Aerial; opentopomap.ru).
The settlement process was not affected by winter temperatures; however, the distribution limits of successful rural settlements strongly correlate with summer temperature values, especially in July and August: the higher the temperature, the greater the number of settlements and their population. The correlation is significant at the 20 °C isotherm (Fig. 4).

Dependence upon terrain is hard to explain; the authors have found that successful rural settlements are located at a height of under 200 m above sea level. This is a tiny value with the difference, for example, with areas at a height of 300 m in temperature, soils and precipitation being minimum. However, our analysis shows that the peasants preferred to settle as low as possible (Fig. 5).

Most settlements are located on types of the soils outlined in Fig. 6. It is significant that settlements outside the distribution zones of these soils are very few. It is worth noting that to the north, in the middle reaches of the Amur River, there are only three types of these soils found, namely 53, 98 and 175, that the farmers use the most.

It should be noted that resettlement of settlers in the area was free, that is, they were free to choose the landscapes they considered most suitable for their traditional type of activity. There are historical examples when peasants did mistake with the place, but mostly their previous experience turned out to be extremely useful here. First of all, it is worth noting the underestimated role of walkers in modern historical science, who were in charge of selecting the place for future settlement, both for themselves and for their community. How this selection was made remains almost unknown, but the walkers were hardly mistaken.
Fig. 4. Average temperature for August in the South Ussuri Krai. Sources: (Populated and residential areas... 1915; Schematic map of the Iman Uyezd 1917; Schematic map of the Nikolsk-Ussuriysky Uyezd 1917; Schematic map of the Olginsky Uyezd 1917; Map of localities... 1913; Map of The Primorskaya... 1920; WorldClim, 1970-2000; Climate SSP 370S; RTM -30m; OpenStreetMap; Google Satellite; Google Road; Bing Aerial; opentopomap.ru).

Fig. 5. Distribution of rural settlements by elevation above sea level. Sources: (Populated and residential areas... 1915; Schematic map of the Iman Uyezd 1917; Schematic map of the Nikolsk-Ussuriysky Uyezd 1917; Schematic map of the Olginsky Uyezd 1917; Map of localities... 1913; Map of the Primorskaya... 1920; SRTM -30m; OpenStreetMap; Google Satellite; Google Road; Bing Aerial; opentopomap.ru).
Based on the previous considerations, we have identified a possible location of the perspective lands for arable agriculture (Fig. 1). Such territories have always been in short supply in this region, so they are worth being taken under consideration. Our assumptions are purely analytical in nature and may be wrong. First, the CMIP6 models themselves are forecasts. Second, it is difficult to assess the future impact of typhoons on this territory (changes in their trajectory, intensity and active periods), especially on hydrology - on periods and intensity of floods. Third, one cannot assess the impact of the shift of permafrost to the north: in the authors’ opinion, this may lead to the drainage of numerous marshes in the middle reaches of the Amur River, which will increase the size of suitable lands; however, the result may be the opposite.

However, the authors believe that they have proposed an unconventional yet promising methodology for using historical data (statistical and cartographic) to handle topical issues in the future.

**Conclusion**

In this study, the authors have attempted to predict emergence of new areas suitable for agricultural use. That is, historical data have been extrapolated to obtain practically important information that can be useful for the purposes of the region's socio-economic development in the near future.
Of course, this is only a forecast for 2021-2040, a purely analytical one. The authors cannot tell for sure how the climate and hydrology of the region will change, however it is these areas to pay a special attention to when planning development of the region, and they require an additional in situ testing.

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