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CONTENT

GEOGRAPHY OF THE EUROPEAN UNION DEVELOPMENT AID ALLOCATION

Peter JANČOVIČ[A*], Natália ZAGORŠEKOVÁ[B], Andrianna BALEHA[C]

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Abstract
The European Union (EU), its institutions and Member States, represents the largest donor of development aid in the world. The present paper deals with the territorial distribution of EU's official development assistance (ODA). The aim of this paper is to identify the major determinants affecting the territorial allocation of ODA provided by the EU institutions and to examine whether the geographical distribution of official development assistance of the European Union institutions is influenced more by donor interests or recipient needs. The paper is devoted to the theoretical basis determining the territorial distribution of the amount of ODA and to actual distribution of aid from the EU institutions among developing countries that are eligible to receive ODA. Based on OECD data on the EU institutions aid allocation between 2010 and 2019, we conclude that the distribution is influenced by both donor self-interest (EU interests) and recipient needs (developmental needs of recipient countries). However, the most significant determinant associated with higher amounts of total net ODA disbursements seems to be the European Neighbourhood Policy status as well as the European Union (potential) candidate status of the recipient countries. Therefore, EU's geopolitical and geostrategic interests in its neighbourhood significantly influence the decision-making process on aid allocation.

Key words
Aid allocation, European Union, official development assistance, ODA.

INTRODUCTION

The European Union and its Member States provide more than half of the global official development aid (European Commission, 2018). Some of its Member States are among the largest donors in the world as they are, at the same time, among the largest world economies. Certain European Union countries also have a history of

A* University of Economics in Bratislava, Dolnozemská cesta 1, 852 35 Bratislava, Slovakia
https://orcid.org/0000-0002-1470-9163
peter.jancovic@euba.sk (corresponding author)

B University of Economics in Bratislava, Dolnozemská cesta 1, 852 35 Bratislava, Slovakia
https://orcid.org/0000-0002-2424-729X
natalia.zagorsekova@euba.sk

C University of Economics in Bratislava, Dolnozemská cesta 1, 852 35 Bratislava, Slovakia
https://orcid.org/0000-0002-5460-768X
andrianna.baleha@euba.sk

colonising different parts of the world, resulting in a closer relationship with some developing countries.

The main aim of this paper is to examine the determinants of official development aid (ODA) distribution from the institutions of the European Union. This paper is devoted to the theoretical basis determining the territorial distribution of the volume of official development aid and to actual distribution from the European Union institutions among developing countries that are eligible to receive ODA.

In the case of the European Union, the geographical focus of ODA is declared in the European Consensus on Development from 2017. The consensus says that *"development cooperation will continue to be country- or region-specific, based on partners' own needs, strategies, priorities and resources"* (European Commission, 2017). This document states that the EU and its Member States will target development cooperation particularly at the poorest countries and countries where the need is greatest and where it can have most positive impact. More specifically, the European Consensus on Development underlines a strong preference of African countries, least developed countries, failing and fragile states, and countries plagued by conflict. The consensus reaffirms poverty eradication as the EU's primary development objective, but it also integrates the economic, social, and environmental dimensions of sustainable development (European Commission, 2017). It is important to notice that the document also states that it fully respects the priorities and interests of individual Member States in the territorial distribution of their development assistance.

This paper is organized as follows. In the first part of this paper, we deal with literature review on the determinants of the territorial distribution of official development aid as identified in the literature on aid donors in general and specifically on the European Union. Another important base for our model is a comparison of development policies of individual EU member states. In the second part of this paper, we describe the geographical distribution of ODA provided by the EU institutions based on data obtained from OECD. The subsequent section describes methods and data applied in this paper. In the last part of this paper, we present the results of regression analysis using the generalized least squares method of estimation to examine the determinants that influence geographical distribution of ODA provided by the EU institutions. Our main purpose is to determine whether allocation of development aid is more oriented towards donor interest or recipient need. Conclusion summarizes the main takeaways from our analysis.

GENERAL DETERMINANTS OF DEVELOPMENT AID TERRITORIAL DISTRIBUTION

The territorial distribution of development aid among developing countries tends to be influenced by several factors. Scientific studies of this matter focus mainly on the factors determining the development assistance of individual states. For example, Zengin and Korkmaz (2019) state that Turkey's development aid is higher for countries where Islam is the predominant religion, where Turkey exports more or where the per capita income is lower. The former Ottoman territories and the Turkic states also receive comparatively higher amounts of official development aid from Turkey. Tuman and Ayoub (2004), as well as Cooray and Shahiduzzaman (2004), have dealt with the distribution of Japanese development aid and both state that territorial distribution is the result of a combination of recipient countries' needs and Japan's interests, such as mutual international trade and Japanese security interests.

The studies of ODA distribution by several donor countries identify common factors influencing donor community in general. One such study by Alesina and Dollar (2000) looks at data from 21 donor countries in the period between 1970 and 1994 and finds that poverty, democracy and policy determinants are less important in influencing the amount of aid by major donors. More important factors influencing ODA distribution varied among donors, but included colonial history (France), geopolitical interests (USA) and common interests demonstrated by voting patterns within the United Nations (Japan).

The level of ODA disbursement in individual countries is determined not only by country's geopolitical interest, but also by the preferences of its own citizens. Paxton and Knack (2008) studied the individual- and country-level factors influencing ODA levels in donor countries and identified several factors influencing the support for ODA, such as religiosity, attention to international affairs, wealth, or colonial history. In addition, the authors identified preferences of citizens that may influence geographical distribution of ODA. Especially in the case of the US, people were opposed to providing ODA to countries with high levels of corruption. Citizens' preferences can therefore influence not only the amount of ODA provided, but also its geographical distribution.

This approach is similar to the paper by Dudley and Montmarquette (2012) who describe aid as a good which is consumed indirectly by the residents of the donor country. Both decisions about whether to give aid and about the amount of aid given were influenced by per capita income in recipient country and economic, political and bandwagon considerations.

Neumayer (2003) focused on multilateral donors, specifically development banks and UN agencies. Based on his results, he included small populations of the recipient countries, the geographical distance from the Western powers and the needs of the recipient countries among the determinants positively correlated with the amount of development aid. On the contrary, he did not find the impact of respect for human rights or levels of corruption in the recipient countries on the amount of development aid provided by these multilateral donors.

Kim and Jensen (2017) and Neumayer (2005) focused on the determinants of the distribution of European Union development aid and humanitarian aid. Both papers state that aid flows from the European Union are mainly driven by the needs of the recipient countries and that EU's economic interests do not play a significant role. In case of Neumayer's paper, where he focused on the allocation of food aid by donor countries and multilateral donors, he found some preference of donor countries towards geographically closer recipient countries. However, he did not find an impact of former colonial relationship or trade and military ties to have significant impact. European Union food aid was particularly correlated to the needs of recipient countries. When studying EU's development assistance allocation, Kim and Jensen (2017) found that among other factors, the recipient countries' level of human rights was important for development assistance disbursements by the EU.

The principle that development assistance and humanitarian aid are mainly allocated according to recipient needs and not in accordance with geopolitical interests applies not only to ODA flows from the EU institutions, but also to development aid provided by non-governmental organizations from Europe, as pointed out by Nancy and Yontcheva (2006). However, they studied only flows by non-governmental organizations co-financed by the European Union, as the data about other non-governmental flows are less accessi-ble. This means that the flows studied by the authors reflect more the distribution preferences of the European Union institutions than the preferences of the NGOs.

The member states of the European Union display different preferences in deciding on the allocation of their bilateral development assistance. Three biggest economies in the European Union (during the period studied in our paper) France, Germany, and the United Kingdom, were studied by Lebovic (2005). He claims that, in addition to considerations about the allocation of development assistance, donors consider their involvement in relation to other donors (whether to become the primary donor). Based on his data, France follows its trade interests, the United Kingdom its political and security interests and both donors focus on their former colonies. On the other hand, Germany rarely assumes the position of primary donor resulting from their weaker global presence during the Cold War era.

The smaller western European donors also approach ODA differently, most notable differences were identified between the Netherlands and Belgium (Breuning, 1995). While the Netherlands has distinctive development policy, Belgian development policy is part of their foreign economic policy. This also influences the structure of recipient countries, together with tighter relations of these countries with their former colonies, especially in case of Belgium.

Italian official development assistance (Neumayer, 2003) shows no preference towards recipient countries respecting political and civil rights or having more democratic regimes, as the most important factor influencing its ODA distribution is former colonial ties. The amounts of Italian development aid are higher for poorer countries and countries with lower military expenditure.

Former colonies and countries with historical and cultural links have preference among recipients of Spanish official development assistance. Spanish Development Cooperation Law states that the priority areas of Spanish ODA from geographical point of view are Latin American countries and Arab countries of North Africa and the Middle East. Other factor that should be considered when distributing ODA are the degree of human development of the recipient country and the impact of Spanish ODA there (Herrera and Escuela, 2015).

Another group of generous donors within the EU, Nordic countries, shows strong preference towards recipients from Africa, despite not having strong historical ties with the continent. The share of bilateral ODA from Sweden, Denmark and Finland to Africa is higher than the EU average (Selbervik and Nygaard, 2006).

Four EU member states from Visegrad Group follow different patterns of ODA allocation, where the key factor seems to be the geographic proximity. Significant share of ODA from Slovakia, Poland, Hungary and the Czech Republic flows to the Western Balkans and post-Soviet region. ODA distribution from these countries is consistent with their economic and political interests and continuation of historic ties. More importantly, these factors are more influential than recipient countries' needs (Szent-Iványi, 2012).

The group of the three emerging donor countries within the European Union, the Baltic states, is not yet fully included in international donor community of OECD Development Assistance Committee (DAC). However, Estonia, Latvia and Lithuania have begun to develop their development policy. The three Baltic states identified former USSR countries as the most important recipients of their ODA, arguing that in these countries ODA can make the most significant differences. Therefore, they are most similar to Visegrad Group countries regarding the patterns of ODA distribution (Andrespok and Kasekamp, 2012).

DEVELOPMENT ASSISTANCE PROVIDED BY THE EUROPEAN UNION INSTITUTIONS

The institutions of the European Union together with EU Member States continue to account for the largest share of the total worldwide ODA, and they have the development cooperation presence in all regions and across all sectors (OECD, 2020). In 2019, the Member States of the European Union and the European Union institutions provided development aid that amounted 75.2 billion US$, which together accounted for about 55.2% of the total ODA provided to developing countries by members of the OECD Development Assistance Committee (Council of the EU, 2020). According to the share of the volume of collective ODA from the EU and its member countries in gross national income of the EU, which reached the share of 0.46% in 2019, the European Union is in the first place and significantly exceeds the average ratio of non-EU members of the OECD Development Assistance Committee (Council of the EU, 2020).

The development assistance provided by the institutions of the European Union has the variable trend during the period under review (2009-2019). The largest volume of official development assistance from the EU institutions was provided in 2016 – 17.75 billion US$ at constant prices. Compared to the beginning of the period under review (2009 – 11.87 billion US$), we can observe an increase of almost six billion US$ between 2009 and 2016. However, the total amount of development aid provided by the EU institutions has declined since 2016. According to the latest data, development aid provided by the institutions of the EU in 2019 reached the level of 14.91 billion US$ (OECD, 2021). In addition, the EU institutions play a significant role in mobilising private funding for development.

A typical feature of the development assistance from the European Union institutions is their bilateral basis. In 2019, gross bilateral development assistance accounted for about 98% of total ODA. Of this volume, approximately 22% of development aid was provided through multilateral organizations – earmarked contributions. According to the European Commission (2021), the main sectors of development aid provided by the institutions of the EU in 2019 were government and civil society (3.12 billion EUR), emergency response (1.85 billion EUR), banking and financial services (1.49 billion EUR), transport and storage (1.23 billion EUR), education (0.89 billion EUR), and agriculture, forestry and fishing (0.87 billion EUR). The top ten recipient countries of ODA provided by the EU institutions in 2019 were Turkey, Egypt, Morocco, Syrian Arab Republic, Ukraine, Afghanistan, Serbia, Tunisia, West Bank and Gaza Strip, and Iraq (European Commission, 2021). Thereby, the largest recipients of ODA from the European Union institutions are, except for Afghanistan and Iraq, the EU's partners within the European Neighbourhood Policy (ENP) and candidate countries such as Turkey and Serbia.

As illustrated by Figure 1, development assistance of the EU institutions is primarily focused on Africa, especially Sub-Saharan Africa, Asia and Europe. The region that has received the largest share of ODA provided by the EU institutions throughout the entire period under review is Sub-Saharan Africa (Figure 1). In 2019, approximately 33% of total EU institutions' ODA was allocated to Sub-Saharan Africa. The share of ODA allocated to Sub-Saharan Africa ranges between 25% (2016) and 38% (2010) in the period considered. The second region that receives the most ODA from the EU institutions is Asia. According to the current OECD data, the share of the EU institutions' development aid to that region represented 22% in 2019. More specifically, the main recipient countries of Asian region are predominately concentrated in South & Central Asia, followed by Middle East and then Far East Asia (Figure 1). Considering Asia as a whole, developing countries from Europe represented the third largest region to which the EU institutions allocated development aid in 2019. Figure 1 reports that aid allocated to developing countries of Europe has sharply decreased in the period 2011-2019. Latin America and the Caribbean received approximately 5% of the EU institutions' official development assistance in 2019. The share of ODA allocated to Latin America and the Caribbean shows a declining trend. The lowest share of ODA from the European Union institutions is allocated to the region of Oceania.

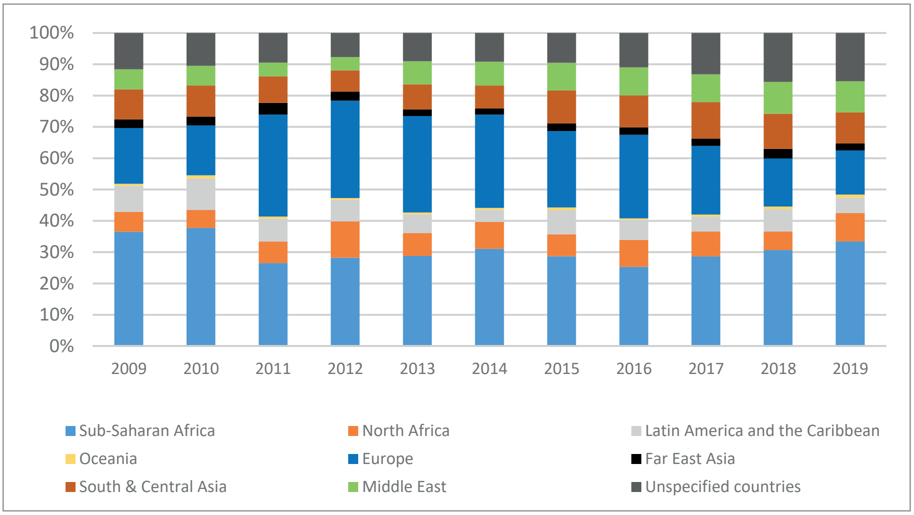

Fig. 1
Development assistance provided by the European Union institutions according to the recipient regions (in %)
Source: Own processing according to OECD (2021): Aid (ODA) disbursements to countries and regions [DAC2a]

The dynamics of the evolution of official development assistance from the European Union institutions varies considerably by region. As shown in Figure 2, the development aid directed towards Africa is volatile with a moderate increase during the period under review. In 2019, African countries received almost 7 billion US$ in official development assistance from the EU institutions. The largest amounts were allocated to Egypt (545 million US$), Morocco (440 million US$), Mali (206 million US$), Democratic Republic of the Congo (205 million US$), Ethiopia (201 million US$), Nigeria (187 million US$), Tunisia (182 million US$), Niger (173 million US$) and Somalia (165 million US$). Among them, Democratic Republic of the Congo, Ethiopia, Mali, Niger and Somalia are classified as the least developed countries (LDCs). Cooperation and support for the African region takes place through many programs, facilities and funds, such as the Pan-African program, the African Peace Facility (APF), the European Union Emergency Trust Fund (EUTF), the African Investment Platform (AIP), the EU-Africa Infrastructure Trust Fund (EU-AITF) and others (European Commission, 2020).

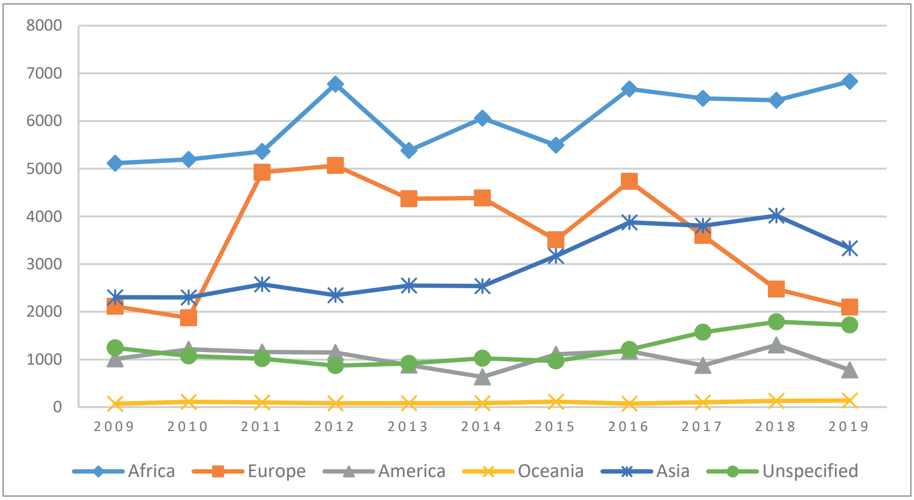

Fig. 2
Development assistance from the European Union institutions
to developing regions (million USD, constant prices)
Source: Own processing according to OECD (2021): Aid (ODA) disbursements to countries and regions [DAC2a]

After steady growth in the last 10 years, Asia surpassed Europe in 2017 as the second largest recipient of ODA provided by the EU institutions (Figure 2). In 2019, Asian countries received approximately 3.3 billion US$ in development assistance from the European Union institutions. Among the most important recipient countries within Asian region in 2019, we can find conflict-ridden countries such as Syrian Arab Republic (443 million US$) Afghanistan (416 million US$), West Bank and Gaza Strip (234 million US$), Iraq (232 million US$) and Yemen (208 million US$). Considerable amount of ODA was also allocated to the world's second most populous country – India (186 million US$).

From a regional point of view, developing countries of Europe represent the third largest recipient of ODA provided by the EU institutions (Figure 2). In 2012, the EU institutions' development assistance to European countries reached its peak for the period considered – more than 5 billion US$. A similar level of development aid to European countries was in 2016, after which we can observe a significant decline to the present day. In 2019, development assistance from the European Union institutions towards European developing countries was more than 2 billion US$. According to OECD data, the largest European recipient countries in 2019 were Ukraine (413 million US$), Serbia (193 million US$), Moldova (167 million US$), Kosovo (156 million US$) and Bosnia and Herzegovina (148 million US$).

The trend in the evolution of development aid provided to developing countries of the Americas is steady from 2009 to 2019, but at a very low level. At present, the EU institutions' development assistance to Latin America and the Caribbean amounts for 783 million US$ (Figure 2). The beneficiary countries that receive the most aid from the EU institutions are Ecuador (78 million US$), Colombia (68 million US$), Honduras (67 million US$), Bolivia (66 million US$), Haiti (57 million US$) and Venezuela (55 million US$). The lowest share of development aid provided by the European Union institutions is directed to the Oceania region. In 2019, the level of development assistance directed towards that region amounted 142 million US$. Papua New Guinea (48 million US$), Solomon Islands (12 million US$), Fiji (12 million US$), Samoa (7 million US$) and Marshall Islands (4 million US$) accounted for the largest share of development aid from the EU institutions.

DATA AND METHODS

The aim of this paper is to empirically identify the major determinants that influence the territorial allocation of official development assistance (ODA) provided by the institutions of the European Union and to examine whether the geographical distribution of the European Union institutions' official development assistance is influenced more by donor interest or recipient need. These two approaches are combined in geographical distribution of EU member states, with donor interest prevailing in Visegrad Group countries and Baltic states and recipient need being more important in western part of the European Union.

There are two main empirical approaches to analysing the determinants of development aid allocation. First, recipient need–donor interest (RN–DI) modelling approach, on the one hand, examines economic, political and strategic interests of the donor countries and, on the other, economic, humanitarian and other development needs of the recipient countries. The recipient need (RN) and donor interest (DI) are usually estimated in two separate regression equations, using different variables specific to each aspect of aid allocation (McGillivray, 2003). The most commonly used method for estimating the RN–DI models is ordinary least squares (OLS) method. However, there is a strong evidence that the RN–DI approach consisting in two separate equations provides biased results (see for instance Bowles, 1987). Second, more recent hybrid models of aid allocation group the determinants of both recipient need (RN) and donor interest (DI) into a single regression equation. The present paper belongs to this empirical approach. According to Berthélemy and Tichit (2002), more recent literature on aid allocation uses different econometric approaches that are also suitable for modelling with limited (censored) dependent variable, such as a two-part model, the most commonly applied Tobit model, or rarely used Heckman's two-step model.

Since the European Union belongs to the largest donors of development aid in the world, there are almost no countries eligible to receive ODA with zero aid allocations during the period 2010–2019. We do not have a limited dependent variable, and therefore we do not employ a model that considers a zero value in the dependent variable not just as a number but as a code, such as the Tobit model. In this research, we use panel data regression applying the generalized least squares (GLS) method of estimation in cross section weights. A panel data set consists of a time series for each cross-sectional member in the dataset and offers a variety of estimation methods (Asteriou and Hall, 2016). Researchers such as Cooray and Shahiduzzaman (2004) applied GLS method of estimation in cross section weights to identify empirically the major determinants of Japanese aid allocation in the period of 1981–2001. The generalized least squares method is applied to avoid heteroskedasticity that may occur in the data (Asteriou and Hall, 2016).

Our sample includes all developing countries which are eligible to receive official development assistance (i.e., countries on the DAC list of ODA recipients over the period examined) and for which the majority of relevant data are available. More specifically, we base our study on a comprehensive panel dataset covering 139 recipient countries of the European Union institutions' development assistance in the period from 2010 to 2019. This means that the present research potentially comprises 1,390 observations (139 countries x 10 years). The period, over which the data spans, allows us to examine the patterns of the EU institutions' development aid allocation after the 2008-09 global financial crisis.

Based on the review of theoretical and empirical literature on development aid allocation, we employ the following variables. As the dependent variable, we use total net aid (ODA) disbursements *(lnODA_EU)* to developing countries from the EU institutions at constant prices. The data on ODA are obtained from OECD statistics. According to OECD (2015), aid disbursement records the actual international transfer of financial resources, or of goods or services valued at the cost to the provider. Therefore, aid disbursements reflect the actual expenditures incurred by a donor on development assistance as compared with aid commitments that reflect a donor's commitment to provide resources under specified terms and conditions, for specific purposes and for the benefit of the aid beneficiary.

The independent variables of this research may be divided into four main categories: donor self-interest, recipient need, recipient merit and control variables (see for instance Hoeffler and Outram, 2008). The economic self-interests of the European Union are proxied by its total export of goods *(lnEX_EU)* to a particular country in a given year. The data on total EU exports are obtained from ITC Trade Map. According to researchers, such as Harmáček et al. (2017), a higher volume of exports from a donor country to a recipient country may positively influence the donor's decision to allocate more aid in favour of that recipient country. We employ the European neighbourhood dummy variable *(EN_D)* to cover geopolitical and geostrategic self-interests of the EU in the beneficiary countries. The dummy takes value of one for EU candidate and potential candidate countries as well as for those countries that belong to the European Neighbourhood Policy, and otherwise zero.

The most commonly used explanatory variable that reflects the recipient need is income or output per capita. As a proxy for the recipient need, we use GDP per capita *(lnGDP_PC)* at constant (2015) prices obtained from UNCTAD database. Developing countries with a higher level of economic development are expected to receive less aid, and therefore there should be a negative relationship between total aid disbursements and GDP per capita. Furthermore, if development aid is allocated according to recipient needs, then the least developed countries (LDCs) should receive more than the relatively wealthier countries (Cooray and Shahiduzzaman, 2004). In this context, we test whether the EU provides more assistance to the least developed countries applying the LDC dummy variable *(LDC_D)*. This dummy takes value of one for those countries which are on the United Nations list of least developed countries, otherwise zero. To cover the developmental needs of the recipient countries more comprehensively, we also employ a social performance indicator. The social development variable is proxied by under-five mortality rate *(lnMORT)* that is the probability per 1,000 live births that a newborn baby will die before reaching age five (World Bank, 2021). The data on under-five mortality rate come from the World Bank's World Development Indicators. However, according to Berthélemy and Tichit (2002), infant mortality rate can be viewed by donors as a measure of need, but also as an indicator of quality or performance of the recipient country's social policy. The relationship between the amount of aid disbursements and the under-five mortality rate is therefore ambiguous.

According to Hoeffler and Outram (2008), the recipient merit variables analyse whether donors allocate more aid to developing countries with good policies and more democratic regimes. Stubbs et al. (2016) and many other researchers argue that donors may prefer recipient countries that perform well in terms of good governance and appropriate institutions. We use government effectiveness indicator *(lnGOVEF)* that belongs to the six dimensions of governance constituting the Worldwide Governance Indicators (WGI) published yearly by the World Bank. Government effectiveness reflects perceptions of the quality of public services, the quality of policy formulation and implementation, as well as the credibility of the government's commitment to such policies (Kaufmann et al., 2010). If it is measured in percentile rank terms, the indicator ranges from 0 (lowest) to 100 (highest) rank, with higher values corresponding to better outcomes. Therefore, a positive relationship between aid disbursements and government effectiveness is expected. Another recipient merit variable used in this study is a political regime dummy variable *(REG_D)*. The dummy is equal to one for those countries that are classified as democracies, and otherwise (autocracies, anocracies, failed and transitional states) zero. This allows us to examine whether the EU prefers democratic recipient countries over non-democratic ones in terms of the volume of aid granted. The data on the type of political regime come from the Polity IV and Freedom House datasets.

As a control variable, we employ the total population *(lnPOP)* of the recipient countries. The data on total population, which is based on the de facto definition of population, come from the World Bank's World Development Indicators. A positive relationship between total aid disbursements and total population of the beneficiary is expected, as more populous developing countries tend to need a higher volume of aid. However, some researchers such as Neumayer (2003) argue that less populous countries receive more aid than more populous ones for several reasons, such as decreasing marginal benefits of aid allocation as population increases or the limited capacity of large countries to absorb additional amounts of aid.

With regard to the fact that the decision-making process on aid allocation precedes aid disbursements, all explanatory variables are in one year lag except for the dummy variables. The dependent variable and explanatory variables, such as GDP per capita, total EU exports, total population and under-five mortality rate, are employed in natural logarithmic form as they are measured at different scales. The general form of the regression equation is:

$$lnODA\_EU_{i,t} = \beta_0 + \beta_1 lnEX\_EU_{i,t-1} + \beta_2 EN\_D_{i,t} + \beta_3 lnGDP\_PC_{i,t-1} + \beta_4 LDC\_D_{i,t} + \beta_5 lnMORT_{i,t-1} + \beta_6 lnGOVEF_{i,t-1} + \beta_7 REG\_D_{i,t} + \beta_8 lnPOP_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

where the subscripts i and t refer to a recipient country and time (year), respectively, and ε is normally distributed error term.

RESULTS AND DISCUSSION

The results of regression using the generalized least squares method of estimation in cross-section weights are reported in Table 1. The adjusted R-squared is sufficiently high for the cross-sectional and time series nature of the study. Overall, selected explanatory variables account for about 75% of the variability in total net aid (ODA) disbursements from the EU institutions (Table 1). To detect potential problems of multicollinearity between the explanatory variables, we employ the variance inflation factor (VIF). Since the VIF values for independent variables do not exceed 5, there is no evidence of the existence of problematically high multicollinearity (Asteriou and Hall, 2016). In our study of the geographical distribution of ODA from the European Union institutions, all explanatory variables are statistically significant at 1% and 5% levels (see Table 1). The overall results show that explanatory variables influence the allocation of the EU institutions' development assistance in accordance with the literature review.

There exists a positive relationship between ODA disbursements from the EU institutions and explanatory variables reflecting the needs of recipient countries such as under-five mortality rate or dummy variable for least developed countries. The infant mortality rate is therefore seen as a measure of developmental needs, rather than an indicator of a recipient country's social policy performance. Whereas the results indicate that the EU institutions allocate more aid to the recipient countries with worse social performance, the EU institutions seem to favour the beneficiary countries with better governance indicators as a 10% increase in government effectiveness of the recipient countries may raise ODA allocation from the EU institutions by approximately 0.3%. A strong focus on the recipient needs from the EU institutions side is clearly demonstrated by a negative relationship between total net ODA disbursements and GDP per capita. A 10% decrease in GDP per capita tends to increase net aid disbursements from the EU institutions by 5.3%.

Tab. 1 Estimated equation using panel EGLS (cross-section weights) method

Variable	Coefficient Estimates	t-statistics
EU exports *(lnEX_EU)*	0.0495*	2.5797
European neighbourhood *(EN_D)*	2.0895**	30.6475
GDP per capita *(lnGDP_PC)*	-0.5329**	-16.2931
Least developed countries *(LDC_D)*	0.1795**	3.7704
Under-five mortality rate *(lnMORT)*	0.1743**	5.1714
Government effectiveness *(lnGOVEF)*	0.0291*	2.3207
Political regime *(REG_D)*	0.2838**	8.3016
Total population *(lnPOP)*	0.3949**	21.0774
Constant	-0.3992	-1.0492
F-statistics (prob.)	510.0386 (0.0000)	
Durbin-Watson stat	0.8881	
Number of observations	1,348	
Adjusted R^2	0.7514	

Source: authors' own using EViews.
*Notes: Dependent variable is total net aid (ODA) disbursements. ** denotes significance at 1% level and * denotes significance at 5% level.*

The results also support the hypothesis that donor self-interests influence the decision-making on aid allocation, as EU exports and European neighbourhood dummy variable are positively and significantly associated with total ODA disbursements. The relationship between ODA disbursements and EU exports is positive and a 10% increase in EU exports may increase aid flows by approximately 0.5%. The countries that are part of the European Neighbourhood Policy and EU candidate, as well as potential candidate, countries also receive higher amount of development assistance from the European Union institutions. This is supported by our findings from the second part of this paper where we point out that the largest aid recipients from the EU institutions are, except for Afghanistan and Iraq, the EU's partners within the European Neighbourhood Policy and candidate countries such as Turkey and Serbia. Furthermore, the preference of geographically closer recipient countries is also evident in Neumayer's (2005) study, where he points out that geographically closer countries tend to receive more total and emergency food aid from the EU.

The total population control variable has a positive relationship with total aid disbursements as expected. Therefore, the EU institutions tend to allocate more aid to more populous developing countries.

To determine whether the EU institutions' ODA is focused more on donor interest or recipient need, we compare the effects of the two pairs of variables: EU exports and European neighbourhood dummy variable representing donor interests, and GDP per capita and LDC dummy variable representing recipient needs. If we compare the impact of EU exports to GDP per capita, the latter has stronger impact on the amount of ODA, supporting stronger orientation on the recipient needs. However, the comparison of the two dummy variables, such as the European neighbourhood and the least developed countries dummy variables, brings the opposite result. Developing countries associated with the EU through European Neighbourhood Policy and EU candidate status receive significantly more ODA than least developed countries, although the latter are stated in the European Consensus on Development as the European Union's development policy priorities. The difference between the two coefficients is sharper than the difference in coefficients between EU exports and GDP per capita.

The system of development cooperation on the European Union level faces the challenge of incorporating differing interests of its Member States and its own commitment to provide ODA most effectively. This challenge is reflected within official documents of the EU. The most important document determining the framework of development cooperation of the European Union is the aforementioned European Consensus on Development from 2017, which reflects the global commitment towards achieving UN Sustainable Development Goals. Regarding geographical priorities of the EU development cooperation, the document describes development cooperation of the EU as ranging from providing funding for the neediest developing countries to cooperation with middle-income countries based on partnership and policy dialogue, thus the EU development aid budget should be directed towards poorest developing countries. This commitment is further spelled out by naming geographical priorities of the EU development cooperation as least developed countries, African countries, and fragile states. However, the proclamation is lessened by the statement that the consensus fully respects member states' ODA allocation priorities.

The description statistics in our paper shows that in accordance with the stated priorities, developing countries in Africa receive the highest share of ODA. The commitment is further visible in marked decline of ODA allocated to European countries since 2016 (see Figure 2).

Based on our results, all statistically significant explanatory variables influence the amount of ODA in accordance with previous studies. Developing countries with lower levels of per capita GDP, higher child mortality and LDCs receive higher amounts of ODA, which is in accordance with the priorities stated in the European Consensus on Development. Although the document does not mention other factors influencing distribution of ODA, we find that donor-interest variables, such as EU exports and European neighbourhood dummy variable covering geopolitical self-interests of the EU, also significantly influence the amount of ODA. The European Consensus on Development states that ODA should be allocated to countries where it can be most effective, which may explain the positive impact of government effectiveness indicator, which reflects the quality of policy formulation and implementation, on the amount of development assistance from the EU institutions. However, if we compare the impact of variables of recipient need and donor interest, the latter seems to have a bigger impact on the amount of allocated ODA. This result seems to contradict the proclamations of geographical priorities of the European Consensus on Development from 2017.

The results of our model suggest that the geographical allocation of development assistance from the European Union institutions combines the principles of both donor interests and recipient needs, gravitating more towards donor-interest variables. This is supported by Hout (2013) who finds that the recipient needs played a seemingly subordinate role to economic and political donor self-interests in decisions on EU aid allocation in the period from 2007 to 2013. This allocation of ODA, primarily based on donor interests, is more typical for eastern European Union Member States, while traditional donors' aid distribution gravitates more towards recipient needs. We therefore state that actual distribution of ODA from the EU institutions does not fully mirror the statements in the European Consensus on Development from 2017, which does not necessarily constitute criticism. The paper only studies ODA allocation and not the efficiency and other aspects of provided ODA.

CONCLUSIONS

The present study empirically analyses the geographical distribution of official development assistance provided by the EU institutions. It deals with the disbursements of ODA from European Union institutions between 2010 and 2019. The aim of this paper was to evaluate the possible determinants of development aid distribution from European Union institutions based on the different approaches characterized by either donor interest or recipient need.

The empirical results suggest that the geographical distribution of aid provided by the EU institutions is influenced by all the factors, which we have analysed in the present study. In general terms, the relationship between explanatory variables and total net ODA disbursements follows the predictions stemming from literature review on the determinants of aid allocation. If we compare the impact of selected explanatory variables associated with the donor interest and those representing developmental needs of the recipient countries, we can draw several conclusions from our results.

The status of the European Neighbourhood Policy partners and the status of an EU candidate country appear to be the most robust determinant in terms of the decision-making on the amount of official development aid that the EU institutions allocate to developing countries. Furthermore, the impact of being a part of the European Neighbourhood Policy seems to be a stronger factor of aid allocation than the impact of being a least developed country. These results show that ODA distributed by the EU institutions is closer to the strategy of newer member states and emerging donors, such as Visegrad Group countries or Baltic states. The development policy of founding members of the EU is reflected in a positive relationship between EU exports and the amount of ODA. Although least developed country status has a positive impact on the amount of aid, the effect is significantly weaker than the effect of European neighbourhood. This finding is in contrast mainly with the development policies of the most generous donors of northern Europe. These results also show slight deviation from stated territorial priorities of the European development policy, however, they are very broad.

To sum up, EU's geopolitical and geostrategic self-interests in its neighbourhood seem to be the predominant determinant regarding the patterns of development aid allocation from the EU institutions. This is supported by both results of regression and analysis of the largest aid recipients from the EU institutions. In terms of policy implications, the EU institutions should allocate more development aid in accordance with the developmental needs of the recipient countries to assist in eradicating poverty, reducing vulnerabilities, and achieving the UN's Sustainable Development Goals. As mentioned in the European Consensus on Development, *"by contributing to the achievement of the 2030 Agenda, the EU and its Member States will also foster a stronger and more sustainable, inclusive, secure and prosperous Europe"* (European Commission, 2017).

The conducted study is based on panel data regression analysis and does not capture the potential changes, and therefore does not answer the question whether the development policy of the EU is shifting more towards donor interest or recipient need associated with the determinants of aid allocation. The future research might also focus on the comparison of development policies of individual Member States of the European Union and the factors influencing their decisions.

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ANALYSIS OF THE 19 JUNE 2016 SUPERCELL STORM OVER TÂRGU MUREȘ CITY, ROMÂNIA

Ion BUGLEA [A*], **Marius CIGHER** [B]

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Abstract
One of the most complex mesoscale atmospheric phenomena is the supercell. In most cases it is associated with violent convective processes such as: wind intensifications that can exceed 100 km/h, high electrical activity, large hail and torrential rains in short periods of time. Such an extremely severe convective phenomenon occurred on June 19, 2016, over the city of Târgu Mureș, being the subject of this analysis. For the analysis of synoptic and mesoscale phenomena were consulted: ground and altitude maps of Global Forecast System (GFS) models, European Center for Mid-Range Weather Forecasts (ECMWF), Zentraanstalt fur Meterologie und Geodynamik (ZAMG), COSMO, ESTOFEX , Târgu Mureș Skew - T diagram, observation data from the local meteorological station, satellite images (Meteosat 08) and meteorological data from the archive of the National Meteorological Administration (ANM) and images captured by the WSR 98D Bobohalma meteorological radar. The aim of this study is to identify aspects of the structure, evolution and movement of the supercell in order to understand the synoptic and mesoscale conditions to identify the characteristic features of severe phenomena that could contribute to the effectiveness of nowcasting warnings.

Key words
Supercell, mesoscale convective system, Skew-T, low level jet, hail.

INTRODUCTION

At the base of an extreme weather situation that lasted five days was a rapidly developing cyclone. The low pressure center was formed in the Czech Republic on June 17, 2016. This center moved north and merged with the present air masses and by June 18, they formed a deep cyclone with an air pressure of 990 hPa. Further, the temperature difference between the Balkans and Central Europe increased, leading to a high horizontal temperature gradient. While in Bulgaria and Greece the pressure level was close to 25° C at an altitude of 850 hPa (about 1,500 m), above Romania it was only 10° C at the same altitude. The advection of the warm African air, which was heading north, gradually cooled, thus becoming saturated,

A* University of Oradea, 1 Universitatii Street, 410087 Oradea, Romania
https://orcid.org/0000-0002-5407-3008
bugle9@hotmail.com (corresponding author)

B Dimitrie Cantemir University, 3-5 Bodoni Sandor Street, 540545 Târgu Mureș, Romania
https://orcid.org/0000-0002-2702-7874
cighermarius@yahoo.com

providing a sufficient amount of atmospheric convection for the formation of storms. In addition to thermal parameters, an important role was played by the high altitude wind (Jetstream), and even on June 20, the altitude flow over our area was strong at the pressure level of 300 hPa (approx. 9600 m). All this created optimal conditions for thunderstorms and since the front zone has survived for a long time, along it for several days thunderstorms followed one another. The knowledge of their local climatology is not only important for weather forecasting purposes, but also for risk assessment. (Trapp et al. 2007; Kapsch et al. 2012; Allen et al. 2014; Seeley and Romps 2015; Gensini and Mote 2015; Allen 2018). Research on future climate change predicts the intensification of extreme weather events in the coming decades (Thom and Seidl, 2015). In Europe, tornadoes are rare (Dessens & Snow, 1993) and there are few studies that would associate European tornadoes with supercellular storms (Alberoni et al., 1996).

From this it can be concluded that European supercellular storms are not usually tornadoes and are much rarer than on the American continent. In central Europe thunderstorm activity peaks during summertime with a rapid increase in April and a decrease in October (Taszarek et al. 2015). Several modeling studies have been used to examine the process of supercell formation. These long-lived organized storms, first termed „supercells" by Browning (1962), have been studied extensively using radar observations and, while many characteristics are associated with supercells, the main feature that differentiates them from other thunderstorm modes is their deep, persistent, rotating updraft (Thompson 1998; Doswell and Burgess 1993). A series of studies have looked at the predictability of large-scale weather features, examining the error growth of the geopotential height forecasts at a specified pressure level (Lorenz 1982; Dalcher and Kalnay 1987; Molteni and Palmer 1993; Bengtsson and Hodges 2006).

On the other hand (Warner et al. 1984; Anthes et al. 1985; Zhang et al. 2003, 2006, 2007), have focused on the predictability on the mesoscale and a significant part dealt with the predictability of the climate and its characteristics (Kirtman 2003; Chen and Cane 2008). Only a few studies have been conducted on the predictability of the weather on the storm scale, where complex movements and turbulence occur. Studies have shown that two mechanisms are needed to form supercells in a dry environment: first, a strong flow prevents the movement of a cold exit before a storm (Klemp 1987) and second, lifting pressure gradients induce an increase in ascending current almost directly above a surface burst front (Schlesinger 1980; Rotunno and Klemp 1982).

Following studies on the environment around supercells, (Weisman and Klemp 1982) concluded that supercell formation is more favorable in environments with high instability and strong vertical wind. In Romania, the appearance of supercells is very rare, but the case of the severe meteorological phenomenon from 19.06.2016 in the Târgu Mureș area, studied in this paper suggests that such events will be more frequent in the next period. This case study analyzes the synoptic and mesoscale conditions that determined the formation of the supercell. This article is structured as follows: Section 2 describes the data sets and methodology, section 3 presents in subsections (synoptic situation, mesoscale situation, analysis of satellite images, analysis of electric discharges and precipitation, analysis of the aerological diagram and instability indices, radar data analysis), The conclusions are presented in section 4.

DATA AND METHODS

To perform this analysis were used the database of the National Meteorological Administration (ANM) archive on air temperature, pressure, humidity, amount of precipitation, meteorological phenomena with hourly and daily meteorological measurements. At the synoptic level, maps of the ground level and the baric and thermal field at different altitudes 500 and 850 hPa were analyzed from http://www1.wetter3.de/archiv_gfs_en.html.

To examine the vertical structure of the supercell, the infrared images captured by the meteorological satellite Meteosat 08 were analyzed, (ANM Archive). The horizontal evolution was analyzed using the data from the S band of the Doppler radar WSR-98D Bobohalma (RDBB) from June 19, (ANM Archive), with a coverage area of 166106 square km radius of 230 km, reflexivity field at 2.4 degree elevation, with a periodic scan of 6 minutes. The main studied parameters of convective cells were the height of cloud formations (Echo Tops), reflectivity and vertically integrated liquid (VIL), hail indices (Hail Index). The radar analysis was supplemented by data provided by the European lightning detection network Blitzortung, (https://www.blitzortung.org/en/historical_maps.php?map=10) and the radiosonde measurements were acquired following the analysis of the COSMO model.

RESULTS AND DISCUSSION

a) Synoptic situation

Synoptic map of Europe (Fig. 1), on 19.06.2016 shows the Azoric anticyclone with a central pressure of 1033 hPa, in the western half of Europe, with the ridge extended to the northeast of the continent, carrying maritime subpolar air, coupled with the depression area of North Atlantic origin centered in Finland, simultaneously with the advection of hot and humid air extended over central Europe. The studied area is located in the separation surface between the two air masses highlighted by the high potential equivalent temperature gradient. The flow of hot and humid air from the Mediterranean Sea was the triggering synoptic ingredient that led to the formation of increased atmospheric instability on 19.06.2016. Following this synoptic context, the supercellular storm was formed, manifested by abundant precipitation, strong wind and large hail, a very rare meteorological phenomenon in the studied area that can occur once every 10 years.

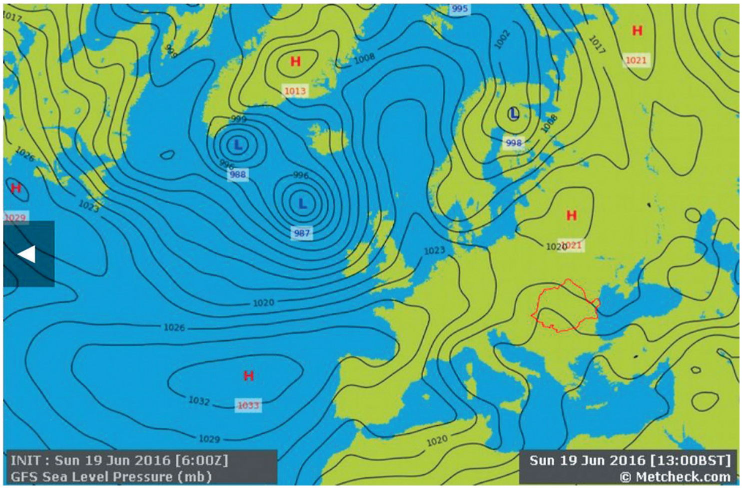

Fig. 1
Synoptic map of Europe pressure on 19.06.2016, 13:00 BST, GFS model analysis
Source: (https://www.metcheck.com/WEATHER/gfscharts_archive.asp)

b) Mesoscale situation

At an altitude of 500 hPa, on June 19, the geopotential map of Europe shows the ridge of North African origin in the southeast of the continent with geopotential values of 584 dmgp. The instability is accentuated on the tropospheric column due to the extension of the Icelandic cyclone trough to the central basin of the Mediterranean Sea presented by a cut-off structure of 568 dmgp (Fig. 2-a).

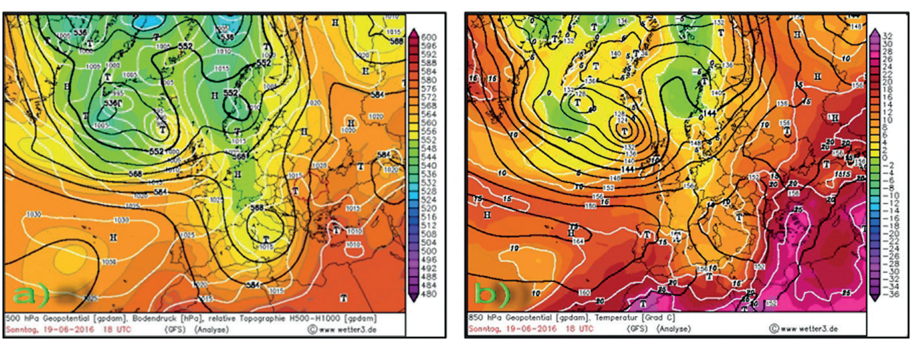

Fig. 2
GFS model analysis for Europa at 19.06.2016, 18:00 UTC,
a) Geopotential map at level of 500 hPa, b) Temperature map at level of 850 hPa.
Source:(http://www1.wetter3.de/archiv_gfs_en.html)

The area of interest is located on the ascending slope of the plateau, inside the contact surface between the cold and humid air mass penetrated from the west due to the Azores anticyclone on the ground, the hot and dry air mass at altitude, present in south-eastern Europe. cold air mass due to the altitude trough detached from the Icelandic cyclone. In this synoptic context within the discontinuity line, the thermo-baric gradient intensified being favored by the moist air mass transported by the ridge of the Azores anticyclone, finally conditioning the formation of the studied supercell. According to the GFS model, the values of the equipotential temperature at the level of 850 hPa, on June 19, at 18:00 UTC, are determined by the advection of a warm air mass from North Africa of 25° C, loaded with moisture over the Mediterranean Sea, associated with the valley. of the Icelandic cyclone of 10° C, which transports cold air, doubled by the Azoric anticyclone through the ridge extended to southeastern Europe (Fig. 2-b). This area is highlighted by the potentially high equivalent temperature gradient being oriented from northeast to southwest, starting with southern Ukraine, western Romania, Serbia and southern Italy.

At the level of 300 hPa, in the upper troposphere, from the analyzes of the ALARO numerical model, there is an extended warm ridge with a geopotential value of 952 dmg in the area of interest, having a slight increase of the gradient value in the geopotential field up to 954 dmg at 18:00 UTC. In the thermal field the temperature increased by about 2° C, these conditions ensuring a surplus of ascendancy to the convective phenomena in this area. This configuration of association of the lower level jet with the jet from the upper troposphere favors the development and maintenance of the activity of convective cells (Blaga, 2015).

c) Analysis of satellite images

The infrared image captured by Meteosat 08 illustrates the accentuated vertical development of cloud formations, the estimated temperature at the top of cloud systems being approximately (- 65° C), (Fig. 3-a) on June 19, 2016 at 17:00 UTC.

To monitor the tendency of the convective system to move, the High Resolution Visible (HRV) images from 17:20 UTC were analyzed, from where the trajectory of the mesoscale convective system can be observed, which was from SW to NE, as well as its evolution along the route, where the most developed cells had a cloudy roof of 10-12 km. In the image (Fig. 3-b) the green arrow indicates the overshooting of the analyzed supercell that has climbed up to 15 km, and the blue star indicates the position of the studied area.

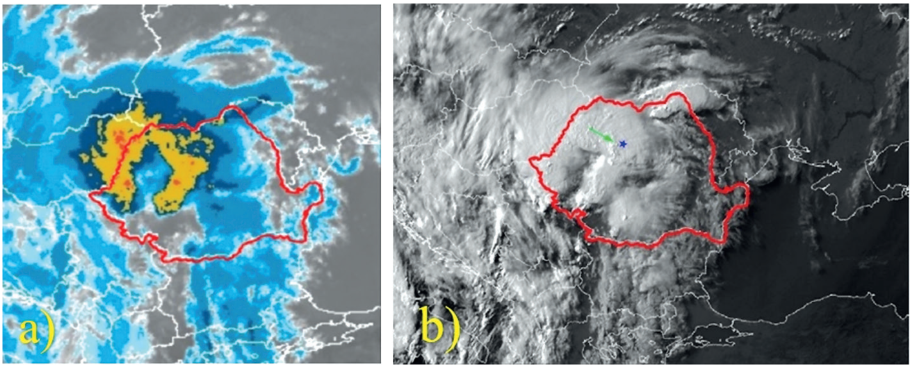

Fig. 3
Images provided by Meteosat 08,
a) infrared at 17:00 UTC, b) High Resolution Visible (HRV) at 17:20 UTC.
Source: (ANM Archive)

d) Analysis of electric discharges and precipitation

A method for monitoring thunderstorm activity is by remote sensing, such as lightning detection networks. A number of thunderstorm climatologies have been based on lightning detection networks at national, continental, or global scales (Betz et al. 2009; Pohjola and Mäkelä 2013; Virts et al.2013; Wu et al. 2016;Galanaki et al. 2018; Zhang et al.2018). The electrical activity was intense throughout the trajectory of the convective cells, but the peak was recorded between 17:00 - 17:30 UTC, very close to the studied area (Fig. 4-a).

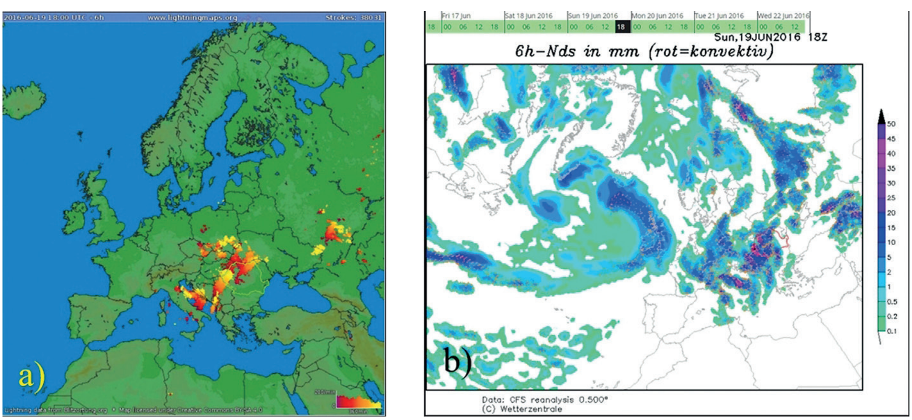

Fig. 4
GFS model analysis for Europa at 19.06.2016, 18:00 UTC,
a) Lightning distribution. *Source: (https://www.blitzortung.org/en/historical_maps.php?map=10),*
b) Precipitation area. *Source: (https://www.wetterzentrale.de/reanalysis.php?jaar=2016&maand=6&dag=19&uur=1800&var=4&map=1&model=cfsr)*

The synoptic situation presents a convective system with a particularly fast evolution (Fig. 4-b), with an accentuated atmospheric instability, which had supercellular characteristics, associated with torrential rains that locally exceeded 40-50 l/square meters and medium-sized hail. Convective storms had the trajectory of movement from SW to NE.

e) Analysis of the aerological diagram and instability indices

June 19 brought together all the synoptic ingredients needed to trigger extreme phenomena specific to increased atmospheric instability. The instability on the entire tropospheric column is due to the interaction of the Icelandic Cyclone basin extended to the center of the Mediterranean Sea and the North African ridge in southeastern Europe of the Azoric anticyclone. The COSMO limited area model presents for the area of interest indices of instability in the altitude survey on 19.06.2016, with the following values: Total Totals Index (TTI) values increased to 55-57, indicating the possibility of tornadoes, values Convective Available Potential Energy (CAPE), were over 2100 J/kg indicating pronounced instability, Lifted Index (LI) values, decreased to - 7° C, values associated with extreme instability and extreme large storms, K Index values (KI) reached 38-40, indicating a probability of 80-89% storm. The Skew-T aerological diagram, dated 19.06.2016, at 18:00 UTC (Fig. 5), shows the visualization of the basic transformations of atmospheric energy by the vertical evolution in the Earth's atmosphere of the dew point curve (left), of humidity (middle) and temperature (right). The difference between the temperature graph curve and the dew point graph indicates the value of air mass humidity, level by level. The smaller the space, the more humid the air. If the curves overlap, they correspond to 100% saturated air and condition the appearance of clouds (Fig. 5a). The graph shows on the left the standard pressure levels defined by the International Civil Aviation Organization (ICAO) and on the right is the force and direction of the wind, a half barb corresponds to 5 knots or 10 km/h, 1 barb corresponds to 10 knots or 20 km/h and a triangle to 50 knots or 100 km/h. The graph shows the vertical shear of the wind below 1500 m, this being an indicator of the formation of convective storms. This figure represents a COSMO environmental sounding model, together with the equivalent hodograph in the upper right corner (Fig. 5b), representing the wind speed and direction as well as the shear, in relation to the height. At the same time, there is a dry layer at low levels below 1500 m, a wet layer at medium levels and a drier range between 500 and 400 hPa levels, which favor the instability of the atmosphere. The isotherm of 0 degrees at 3500 m, is an exact indicator for the appearance of medium and large hail, which in association with the CAPE index with extremely high values, favored the maintenance of ice particles inside the cloud for a long time, resulting in large hail.

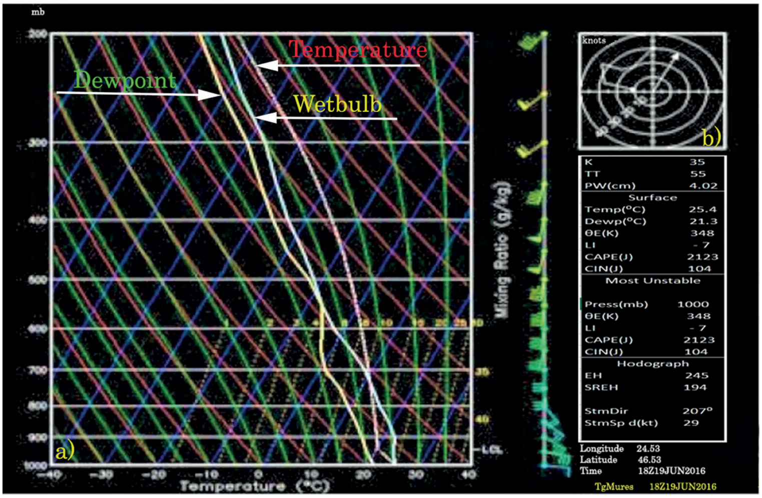

Fig. 5
COSMO model analysis Skew T diagram for Târgu Mureș at 19.06.2016, 18:00 UTC
a) environmental sounding model, b) hodograph
Source: (ANM archive)

f) Radar data analysis

Climatological aspects of (severe) thunderstorms can also be studied using national radar networks (Davini et al. 2011; Cintineo et al. 2012; Kaltenböck and Steinheimer 2015). From a convective point of view, June was very active, especially in the second half of the month when violent storms occurred in most areas of the country due to intense cyclogenesis in central and northwestern Europe, due to the contrast between the cold air mass in the central part and the advection of warm air in Eastern Europe, favored by the ridge of the Azoric anticyclone. In the early stages, convective phenomena manifested themselves in the west of the country, where supercellular systems could be observed. These turned into convective systems (arc echoes) that eventually formed a storm line. The trajectory of a mesoscale convective system is usually with lines of thickness 300-850 hPa or in general the movement of convective cells in a convective system is deflected to the right of the wind from average levels by about 30° and at a speed lower than this, on average 70% (Merritt and Fritsch, 1984).

Initially, the cells of the mesoscale convective system had a southwest-northeast trajectory and then a slight eastward rotation. The supercell was detected at 16:20 UTC, at a distance of over 90 km west of the S-band Doppler WSR-98D radar from Bobohalma meteorological radar (RDBB), and traveled approximately 145 km, with an average speed of 50 km/h and a lifespan of almost 3 hours. In the reflexivity field at an elevation of 2.4 degrees, at 17:16 UTC, (Fig. 6), the mesoscale convective system is in the maximum development phase, presenting values of 70 dBz and takes the form of an arched echo. The white circle indicates the study area.

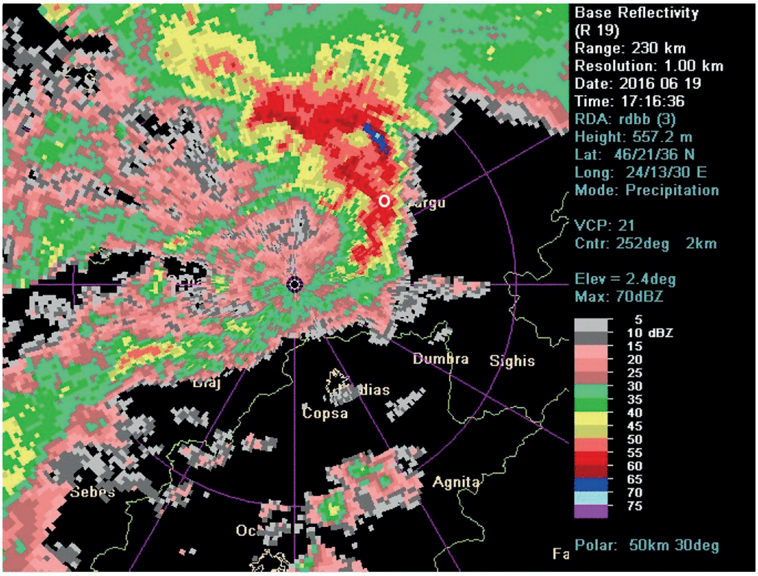

Fig. 6
Reflexivity field at 2.4 degree elevation, 19.06.2016, 17:16 UTC, Bobohalma meteorological radar (RDBB).
Source: (ANM Archive)

Fig. 7
Supercell at the city limit.

Reflectivities larger than 55 dBZ are often attributed to hail (Geotis, S.G., 1963). The radar data were also confirmed by the measurements made at the local meteorological station, where the amount of precipitation reached 40 l/square meters, hail with a diameter of 2-3 cm fell and the wind gusts reached 70 km/h. For România, Carbunaru (2014) and Reckerth (2015) correlated some radiolocation parameters of Cumulonimbus clouds which produced hail falls. Figure 7 shows the magnitude of the phenomenon just before it hit the city.

CONCLUSIONS

Thunderstorms, particularly severe events accompanied by large hail, damaging wind gusts, tornadoes, or flash floods, pose a considerable risk to society (Brooks 2013; Papagiannaki et al. 2013; Terti et al. 2017; Papagiannaki et al. 2017). Between June 18-20, 2016, in the southern and central-eastern part of Europe, supercellular structures and the extreme meteorological phenomena associated with them were reported. For such an extreme phenomenon to form, a combination of factors is needed. On June 19, 2016 all the conditions necessary for the formation of a storm of such intensity were met in the area of Târgu Mureș. We cannot say that it was a tornado, but according to the analysis regarding the damage produced, it was concluded that there was an extremely violent downburst with an estimated wind speed of 150 km/h. Recently research on the phenomenon has intensified in order to understand and be able to explain their properties (Solari, 2014, 2020).

At ground level, conditions were formed for the overlap of the hot and dry air mass stationed on the Romanian territory, with the mass of cold and humid air through the western advection of the Azores anticyclone ridge. In altitude, the geopotential gradient increased following the interaction exerted by the Azores ridge located in the southeast of the country and the Icelandic depression, amplifying the descent of cold air. The western half of the country was in the area of interference between the two air masses. The advancement of hot and humid air provided by the low level jet played a decisive role in increasing the instability and the potential of severe weather. It is unusual for such extreme storms to persist in our region for several days.

If the potential energy of a convective system is provided by surface heating caused by solar radiation, it will take several hours, but if the potential energy supply is made at the synoptic scale, by humidity in the middle troposphere, continuous flow of cold air in the upper troposphere, associated with wind shear, then the lifespan can be extended to a few days, as in this case. The evolution of the studied supercell reached its peak on the afternoon of June 19th. This study tried to identify the causes and processes that favored the evolution of convective systems between June 18-20, but especially the case of the supercellular system and the storm line of June 19 in Târgu Mureș area, to improve the methods of issuing warnings in case such extreme phenomena, which in the future will be more numerous.

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MEASURING SURFACE URBAN HEAT ISLAND IN RESPONSE TO POPULATION DENSITY BASED ON REMOTE SENSING DATA AND GIS TECHNIQUES: APPLICATION TO PRISHTINA, KOSOVO

Albert BERILA [A], **Mimoza DUSHI** [B*]

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Abstract

Urban areas, compared to rural areas, have much more visible characteristics of their climate, such as higher surface and air temperatures, and large spatial variation – within the city – of meteorological parameters. The study aimed at investigating the phenomenon of the Surface Urban Heat Island (SUHI) over the Municipality of Prishtina, Kosovo. The SUHI was investigated based on the relationship between Land Surface Temperature (LST) estimated from Landsat 8 Thermal Infrared Sensor (TIRS) band with population density using Geographic Information System (GIS). To understand the relationship between population density and Land Surface Temperature (LST), we performed a correlation analysis. This analysis showed a strong positive relationship with a value of r = 0.768005, emphasizing the strong role that the population has in creating areas that generate the SUHI effect. Also, the results of the study clearly showed that built-up areas and bare surfaces are responsible for generating the SUHI effect, while vegetation and water bodies minimize this effect by creating freshness. The study showed that Land Surface Temperature increases with the increase of impervious surfaces, which is related to the increase of population density. Maps in which the identification of the SUHI effect is presented can be a very useful tool for urban administration as well as for urban planning policies for the latter to be directed exactly in those areas where this phenomenon is present and causes a range of concerns for citizens.

Key words

GIS, Remote Sensing, SUHI, LST, population density, Municipality of Prishtina.

INTRODUCTION

In many scientific studies around the world, in recent times and decades, one thing that stands out with great importance – at the center of many studies – is climate variability and climate change. We are witnessing that, currently, from various an-

A University of Prishtina, 10000, Prishtina, Republic of Kosovo
https://orcid.org/0000-0003-0754-269X
albert.berila@outlook.com

B* University of Prishtina, 10000, Prishtina, Republic of Kosovo
https://orcid.org/0000-0002-1853-6829
mimoza.dushi@uni-pr.edu (corresponding author)

thropogenic/natural activities, our planet is experiencing significant environmental changes. Human – since its first appearance – has tried to use/adapt all the riches of our planet constantly depending on the emergence of his needs. We are very aware that the human is part of the planet Earth/nature, but it should also be noted that, unlike other living things, human has made and continues to make radical changes around, thus creating the cultural environment (Isufi and Berila, 2021).

Recently, global urbanization – in much of the world – is undergoing extraordinary expansion as a result of massive population growth (Berila and Isufi, 2021b). A fair/correct development of urbanization means positive urbanization, but when this does not happen, negative effects appear on human health and in our environment (Morefield et al. 2018; Berila and Isufi, 2021b). All this massive increase in urbanization can not pass without any negative effect. Some of the negative effects include increased density of built-up areas; replacement of natural surfaces with artificial surfaces (an increase of impervious surfaces); lack of green spaces etc. The causes that have influenced the cities to have higher temperatures than their suburban areas are human and industrial activities that take place in urban areas, then buildings, concrete, and asphalt. All these changes have influenced the appearance of a phenomenon called UHI. The term UHI was first used in 1818. The notion of UHI represents the phenomenon in which the urban surface and atmospheric temperature are higher compared to the surrounding environment – suburban areas (non-urban) (Wang et al. 2017). Nowadays more than 50% of the world's population lives in urban areas and with the current trend, the number of people who will live in urban areas will increase day by day. Thus, it is expected that by 2030 more than 60% of people will live in these areas and, 1 in 3 people will live in cities that will have at least half a million inhabitants (UN, 2016). Therefore, it should be rightly said that the UHI phenomenon is a global concern, which will threaten the functioning and population of our cities (Mohajerani et al. 2017) and, not only that, negative actions and implications will also appear in urban planning; air pollution; human health and comfort; but also in energy management (Peres et al. 2018).

The UHI effect occurs when the land cover is transformed, mainly when replacing agricultural lands and natural vegetation with surfaces that are impervious, such as asphalt, concrete, roofs, walls of buildings (Buyantuyev and Wu, 2009), etc. The effects of UHI are quite negative and include increased energy consumption, increased emissions of air pollutants, increased emissions of greenhouse gases, damage to water quality, and the creation of harmful environmental conditions that negatively affect health and human comfort (EPA, 2017).

Urbanization processes and improper and unplanned urban planning is the cause of the UHI effect (Nuruzzaman, 2017). Such processes create dense buildings and surfaces with asphalt and concrete, which have heat-retaining capabilities (Harlan and Ruddell, 2011; Mavrogianni et al. 2011). In the end, the result of all this is the increase in high heat emissions (Santamouris et al. 2011) and increasing the demand and need for energy in order to cool the buildings. In addition, a direct active role in enhancing the UHI effect is played by the increase in density and height of buildings on both sides of the road creating what is known as urban road canyons; reduction of areas planted with vegetation (lack of green areas); increasing use of low albedo materials (high heat absorption) (Taha, 1997); reduction of wind speed due to the geometric shape created as a result of the construction of buildings in the city (O'Malley et al. 2014), etc. The study of this phenomenon is extremely important. Understanding the origin and consequences of this phenomenon and finding ways to prevent the expansion and intensity of it should be a priority for city managers and urban planners.

Urban Heat Island phenomena can be studied in three urban layers (Fabrizi et al. 2010; Sherafati et al. 2018):

1) Canopy Layer Heat Island (CLHI) – this layer lies approximately at the average height of buildings and is determined by measuring the air temperature at a height of 2 m above the ground. The CLHI has usually measured through sensors mounted on fixed meteorological stations (Nichol et al. 2006; Schwarz et al. 2012; Smoliak et al. 2015; Clay et al. 2016).
2) Boundary Layer Heat Island (BLHI) – lies above the CLHI layer and can reach a thickness of up to 1 km. It is measured using special platforms, such as radiosondes and aircraft (Voogt, 2008; Sherafati et al. 2018).
3) Surface Urban Heat Island (SUHI) – difference in radiant temperature between urban and non-urban surfaces. The measurement/determination of this layer is done using thermal remote sensors (Voogt and Oke, 2003).

Accurate measurement of the UHI effect can be done through meteorological stations. However, accurate data obtained from thermometers placed at ground stations cannot be used due to spatial constraints. More precisely, the reason for the small/insufficient number of the spatial distribution of meteorological stations and their inhomogeneity has made the data obtained insufficient to study the UHI effect. The SUHI and UHI phenomena are closely related to each other and, simply put, the SUHI represents an indirect assessment of UHI (Schwarz et al. 2012). In the scientific literature, there are a series of scientific papers which show that to study the SUHI phenomenon they have used LST, while to study the UHI phenomenon, usually, air temperature data have been used (Voogt and Oke, 2003; Despini et al. 2016; Pour and Voženílek, 2020). The development of Remote Sensing has made it possible for the SUHI phenomenon to be studied through the calculation of LST and, that is why in our study we have chosen to analyze the SUHI phenomenon. Due to functions such as data management, calculating, analyzing and creating an important database, geospatial technology offers great support in such research

(Berila and Isufi, 2021a) as the measurement of the SUHI phenomenon.The difference between CLHI and BLHI compared to SUHI is that atmospheric UHIs (CLHI and BLHI) are higher at night (have higher values), while surface UHIs (SUHI) are higher (larger) during the day (Roth et al. 1989; Yuan and Bauer, 2007). All dry urban surfaces and those that have a low albedo value (absorb heat) have the ability to heat more (have a higher temperature) than the air temperature. Therefore, based on this, the values of SUHI will not only be higher during the day but, consequently, the intensity of SUHI will be greater during the summer season compared to other seasons. It is precisely the dry weather conditions and the changes in solar radiation that cause such a thing to come/appear (Oke, 1987). Given all the above effects that the SUHI phenomenon can cause, for people to live in areas that are healthy, suitable for living, and sustainable in urban terms, good governance and urban planning are necessary. Such a thing cannot be done if the city administrators do not have an idea of how to identify SUHI. Given that the areas where the phenomenon SUHI appears create great concerns for residents, it is more than necessary to direct all urban policies in these areas in order to reduce such a phenomenon as much as possible.

The increase in carbon emissions and the appearance of climate change is due to the increase in the number of urban inhabitants – variability in consumption and production patterns (UNHABITAT, 2016). The most affected by a series of negative events, such as pressure/housing needs, increased pollution, and traffic jams are developing countries (Lee and Chang, 2011; Mubea et al. 2011; Kityuttachai et al. 2013; Berila and Isufi, 2021b). Another very important thing to note which is the cause of urbanization and strengthening of urban morphology is the loss of biodiversity – irreversible loss (Sudhira et al. 2003; Kamusoko and Aniya, 2007; Kamusoko et al. 2009; Liu et al. 2011; Moghadam and Helbich, 2013; Berila and Isufi, 2021b). Normally, such a process of urbanization, without distinction, includes the cities of the Republic of Kosovo – with special emphasis on Prishtina. Urban growth has occurred in it as a result of natural population growth, migration, and economic development (Berila and Isufi, 2021b).

In our paper the main purpose is to see whether the SUHI phenomenon is empowered in the cadastral zones that have the highest population density; to be able to identify all areas affected by this phenomenon by creating a connection between the atmosphere and LST. Our other goal is to help the Municipality of Prishtina by identifying all areas facing and endangered by the SUHI phenomenon, in order to take action against this phenomenon as soon as possible – for the population to live as healthy as possible.

STUDY AREA

Prishtina is the capital and largest city of the Republic of Kosovo, which lies in the north-eastern part of the country, while within the Balkan Peninsula, it occupies a central position – very convenient (Fig. 1).

About 523 km^2 is the surface of the Municipality of Prishtina. It lies in the morphological plan of Kosovo and represents an alluvial plan covered with sediments of lakes, and geologically it is a tectonic depression, which has risen long Oligo-Miocene changes (Municipality of Prishtina, 2013; Isufi and Berila, 2021). Cold winters, hot summers, with a 600 mm average of rainfall per year, make the climate continental (Municipality of Prishtina, 2013; Isufi and Berila, 2021). The average annual air temperature is 9.9ºC. The highest monthly average air temperature in Prishtina appears in July at 19.8ºC, while the lowest average air temperature appears in January at -1.4ºC (Pllana, 2015). The average annual rainfall is around 600 mm, with the highest monthly average in May and November (68 mm), while the lowest monthly average reaches in February (36 mm) (Pllana, 2015).

In this area, the hilly-mountainous relief occupies the eastern, northeastern, and southeastern parts. The western part has an altitude of 535-580 meters. In general, the slope of the terrain is low – excluding the eastern part (Municipality of

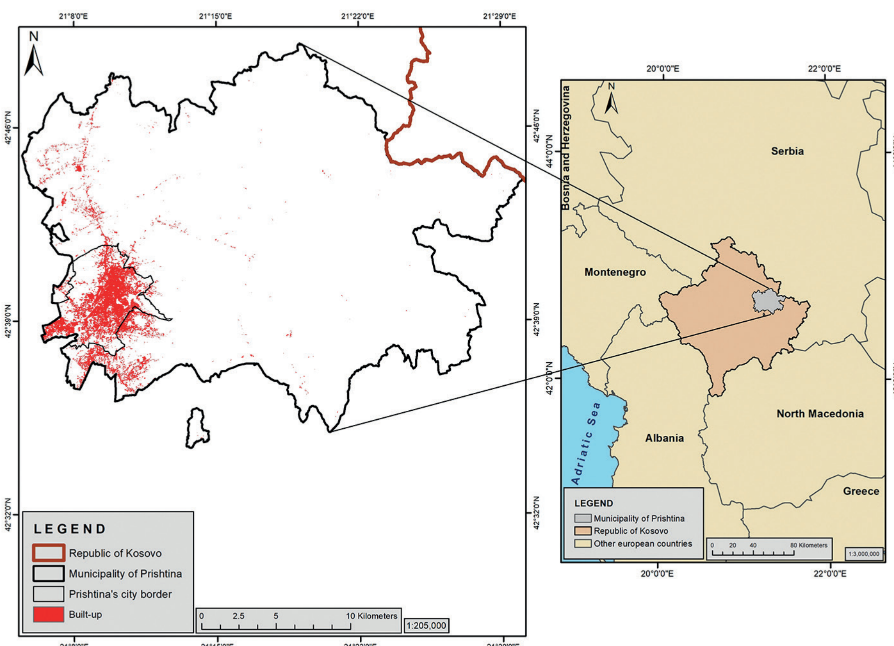

Fig. 1
Location of the study area
Source: Compiled by authors

Prishtina, 2013; Berila and Isufi, 2021b). In addition, this area is also known as the largest administrative, economic and cultural center in Kosovo (Fig. 2). This area has a total of 216,870 inhabitants – referring to the official statistics of 2019 (KAS, 2020). It is worth noting that this area has undergone a major change (transformation), both socially and physically. Unplanned constructions in many areas of the city, the expansion of settlements around the city, and the expansion of the urban area are the reason for such changes to be more visible. After the last war in Kosovo ('99), 11% of Kosovo's population has migrated within the country. The main segment is concentrated around Prishtina, which has gained 23% of all in-migrants (KAS, 2012). As a result of such developments, there was a need for housing, there was a high increase in population density, increased demand for apartments, etc. Finally, the lack of implementation of the municipal development plan due to corruption and political interference also served this uncontrollable development (Berila and Isufi, 2021b).

In many parts of the world, the migration of population from rural to urban areas has created rapid changes towards urban development. In the Republic of Kosovo, such changes, with a special emphasis, have occurred in the last 20 years. The population has migrated from rural to urban areas, and from peripheral are-

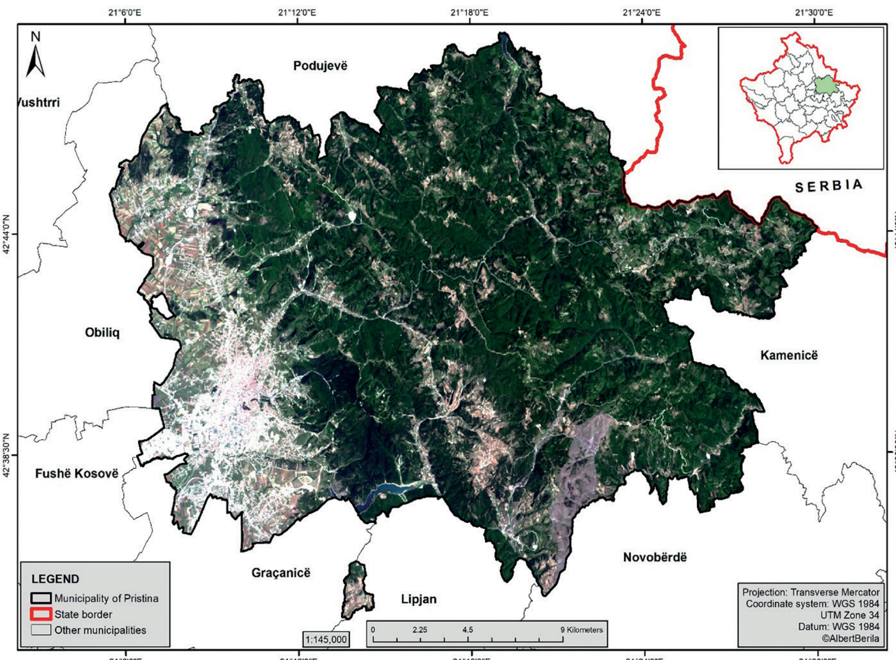

Fig. 2
Satellite image of Prishtina – Landsat 8
Source: Compiled by authors

as to those large cities – especially in Prishtina (KAS, 2014; Isufi and Berila, 2021). The reasons why people decided to leave heading to the capital of Kosovo had to do with finding a better job, getting a better education, and, ultimately, creating a better life. Unfortunately, Kosovo's institutions have been totally unprepared for all these socio-economic developments (Isufi and Berila, 2021).

To this day, it is worth noting that the capital continues to face quite large challenges, which have caused it a lot of trouble. It is about unbalanced development, loss of agricultural land, major problems in infrastructure, and other social problems (Isufi and Berila, 2021).

DATA AND METHODS

Cloud-free Landsat 8 Operational Land Imager/Thermal Infrared Sensors (OLI/TIRS) satellite image for 2nd July 2019 of Path 185 and Row 30 with 0% cloud cover was acquired from the United States Geological Survey (USGS) and used to calculate the Land Surface Temperature (LST). The Landsat 8 satellite was successfully launched on 11 February 2013 and deployed into orbit with two instruments onboard (Valizadeh Kamran et al. 2015): the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS), which jointly produce a multispectral image consisting of 11 spectral bands. OLI collects nine spectral bands including a pan band: bands 1-4 correspond to the visible part of the electromagnetic spectrum, bands 5-7 and 9 to near-infrared and shortwave infrared regions of the spectrum (Taloor et al. 2021) (all of these have a spatial resolution of 30 m) (Jeevalakshmi et al. 2017); band 8 is panchromatic, taking images in the wide visible wavelength range (0,503-0,676 μm) with 15 m spatial resolution. These bands allow obtaining various kinds of information on the characteristics of the land surface, including vegetation cover. Two spectral bands for infrared wavelength are collected by the TIRS instrument. In previous sensors (TM and ETM +), these were covered by a single band: band 10 (TIRS 1, 10.6-11.19 μm) and band 11 (TIRS 2, 11.5-12.51 μm), both with 100 m spatial resolution (Tab. 1) (NASA, 2018). In terms of tracking/analyzing climate and environmental issues, the Landsat database has proven to be quite useful to use (Alavipanah et al. 2010; Adeyeri et al. 2017; Mfondum et al. 2016; Narayan et al. 2016). It should be noted that to formulate surface-atmosphere connections, a key factor is LST (Dickinson, 1983; Adeyeri et al. 2017; Sobrino et al. 2004b; Sobrino et al. 2003; Sobrino et al. 2004a).

Fig. 3 shows the work steps in a general way, while the details for each step taken will be presented in the following sections. As can be seen from Tab. 2, the image used in our study was cloudless. Given that the above image is downloaded for free, it makes it more cost-effective and much more efficient. This data, after downloading, was georeferenced and cut only for our study area (analysis is easier – less load in our software – ArcGIS 10.5) (Berila and Isufi, 2021b).

Tab. 1 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) (Landsat 8) spectral bands

Spectral Band	Wavelength (µm)	Spatial Resolution (m)
Band 1 – Coastal/Aerosol	0.435-0.451	30
Band 2 – Blue	0.452-0.512	30
Band 3 – Green	0.533-0.590	30
Band 4 – Red	0.636-0.673	30
Band 5 – NIR	0.851-0.879	30
Band 6 – SWIR 1	1.566-1.651	30
Band 7 – SWIR 2	2.107-2.294	30
Band 8 – Panchromatic	0.503-0.676	15
Band 9 – Cirrus	1.363-1.384	30
Band 10 – TIRS 1	10.60-11.19	100
Band 11 – TIRS 2	11.50-12.51	100

Source: Compiled by authors

Tab. 2 Characteristics of the satellite image used in this study

Sensor type	Date	Path/row	Cloud cover	Spatial resolution	Format	Source
Landsat 8 OLI/TIRS	2019/07/02	185/30	0%	30 m	Tiff	https://earthexplorer.usgs.gov/

Source: Compiled by authors

In Landsat 8 sensor satellite images, thermal data is stored in the form of digital numbers (DN). These numbers represent cells (pixels) that have not yet been calibrated into units (Käfer et al. 2020) that make sense (meaningful units). After taking satellite images, the first process or task is to return the digital numbers to radiance. The following equation was used to convert DNs to spectral radiance (USGS, 2019) in the Landsat 8 TIRS sensor (Guha and Govil, 2020; Berila and Isufi, 2021b):

$$L_\lambda = M_L \times Q_{cal} + A_L \qquad (1)$$

where:
L_λ is TOA spectral radiance ($Watss/(m^2 \times srad \times \mu m)$), M_L is Band-specific multiplicative rescaling factor from the metadata, Q_{cal} is Quantized and calibrated standard product pixel values (DN), A_L is Band-specific additive rescaling factor from the metadata (Guha and Govil, 2020; Berila and Isufi, 2021b). The metadata of the satellite image is presented in Tab. 3.

Although from the beginning of its operation TIRS has proven to be stable, still there were some elements (objects) that are hung in the image like errors in cali-

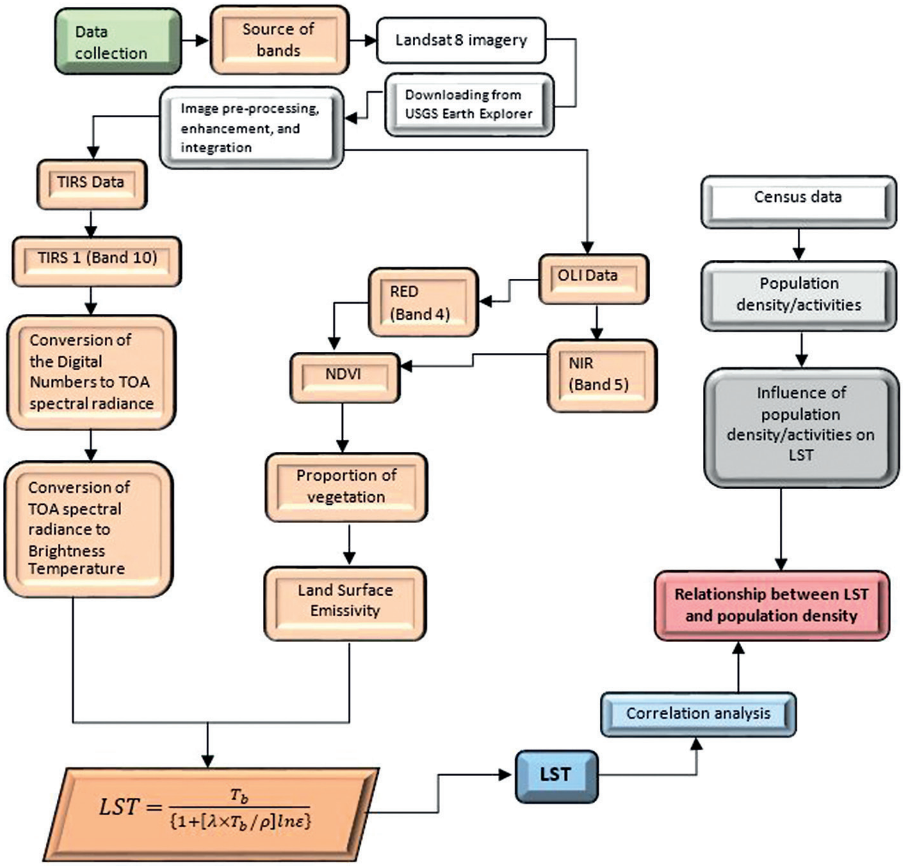

Fig. 3
Flowchart depicting methodology
Source: Compiled by authors

bration and banding (Montanaro et al. 2014). Such a thing is caused by stray light effects. The impacts of these 2 effects are smaller in band 10 compared to band 11. Based on the numerous analyzes and studies that have been done, it has been concluded that band 10 of TIRS data is better and should be used instead of band 11. This, due to the good performance shown by band 10 (Montanaro et al. 2014; Adeyeri et al. 2017). For this study, TIRS band 10 was used.

Calculation of brightness temperature

The next step is to use the constant values given in the metadata in order to convert the spectral radiation to brightness temperature (T_b). In order to convert the radiance to brightness temperature, equation (2) has been used in the study (Isaya Ndossi and Avdan, 2016; USGS, 2019):

$$T_b = \frac{K_2}{\ln\left[\frac{K_1}{L_\lambda}+1\right]} \qquad (2)$$

where:
T_b is the at-sensor brightness temperature [K], L_λ is the spectral radiance of thermal band 10 $[Wm^{-2}sr^{-1}\mu m^{-1}]$, K_1 is the band-specific thermal conversion constant from the metadata and K_2 band-specific thermal conversion constant from the metadata. The same equation is used for all sensors. The K_1 and K_2 values may vary depending on the sensor and the wavelengths by which the thermal bands operate (Isaya Ndossi and Avdan, 2016). The values of K_1 and K_2 can be obtained from the metadata file of the scene.

Tab. 3 Metadata of the satellite image

Band	Variable	Description	Value
10		Thermal band	
	K_1	Thermal constant	774.8853
	K_2		1321.0789
	M_L	Band-specific multiplicative rescaling factor	3.3420E-04
	A_L	Band-specific additive rescaling factor	0.10000

Source: Compiled by authors

Estimation of land surface emissivity

To calculate the LST, it is necessary to evaluate the emissivity of the land surface (LSE) through the NDVI method (Jiménez-Muñoz et al. 2006; Valizadeh Kamran et al. 2015). $d\varepsilon$ is the effect of the geometrical distribution of natural surfaces and internal reflections (Sobrino et al. 2004a; Igun and Williams, 2017). To calculate the emissivity we rely on the following equation (Guha and Govil, 2020):

$$d\varepsilon = (1 - \varepsilon_s)(1 - F_v)\, F_{\varepsilon_v} \qquad (3)$$

where ε_v is vegetation emissivity, ε_s is soil emissivity, F_v is fractional vegetation and F is a shape factor whose mean is 0.55 (Igun and Williams, 2017; Sobrino et al. 2004a; Guha and Govil, 2020).

$$\varepsilon = \varepsilon_v \times F_v + \varepsilon_s (1 - F_v) + d\varepsilon \qquad (4)$$

where ε is emissivity. From Equations (3) and (4), ε may be determined by the following equation (Yuvaraj, 2020):

$$\varepsilon = 0.004 \times F_v + 0.989 \qquad (5)$$

The proportion of vegetation (F_v) is calculated based on the following equation (Wang et al. 2015):

$$F_v = \left[\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right]^2 \quad (6)$$

The following equation is used to calculate NDVI with the help of Landsat visible (band 4) and NIR (band 5) images (Yuvaraj, 2020):

$$NDVI = \frac{NIR - R}{NIR + R} = \frac{band\ 5 - band\ 4}{band\ 5 + band\ 4} \quad (7)$$

where NIR and RED are the near-infrared and red band pixel values respectively (Alemu, 2019). The value of NDVI ranges between -1.0 and 1.0 (Alemu, 2019). High NDVI values indicate healthy vegetation while low values indicate less or no vegetation.

Calculation of LST

The final step of estimating the LST is as follows (Weng et al. 2004; Alemu, 2019):

$$LST = \frac{T_b}{\{1 + [\lambda \times T_b / \rho] \ln \varepsilon\}} \quad (8)$$

Where:
λ is the wavelength of emitted radiance by Landsat 8 which is 10.8 (given by NASA), ε is the land surface emissivity, and ρ is given by the following equation (Yuvaraj, 2020):

$$\rho = h\frac{c}{\sigma} = 14388\ \mu m\ K \quad (9)$$

where h is Planck's constant (6.626×10^{-34} Js), σ is the Boltzmann constant (1.38×10^{-23} J/K), and c is the velocity of light (2.988×10^8 m/s) (Alemu, 2019).

RESULTS AND DISCUSSION

In our study area, from the spatial distribution of LST, it was observed that the pixels with high LST values correspond to the areas which have little or no vegetation cover. Such areas are bare surfaces and built-up areas. Whereas, the pixels that recorded the lowest LST values were those that corresponded to the surfaces where the vegetation and water bodies stood out. So, the high values of LST stand out in the areas that do not have vegetation and such a thing is best seen in Figure 4.

Figure 4 shows that LST values range from 296,485 K to 317,848 K. The pixels with the highest LST values lie in the western part of our study area in which the vast majority of built-up areas are located. Also, pixels with high values are clearly seen in the southern part because in this area are found bare surfaces, which are considered as one of the generators of the SUHI phenomenon.

The relationship between LST and population density is very important to understand. The lowest values of LST have dense vegetation as well as water bodies.

While, on the other hand, the highest values of LST have the built areas. Also, it is very important to note that high LST values have bare surfaces. This is because the solar energy that falls on this type of surface is completely absorbed by a thin layer of it. Therefore, if the bare surface is compared to the water body, then the bare surface will heat up much more due to its lower specific heat capacity. Thus, if we make a comparison between natural and artificial surfaces (built-up areas) we will notice that the latter conserve solar energy while natural surfaces maintain low temperatures due to greater reflection of radiation.

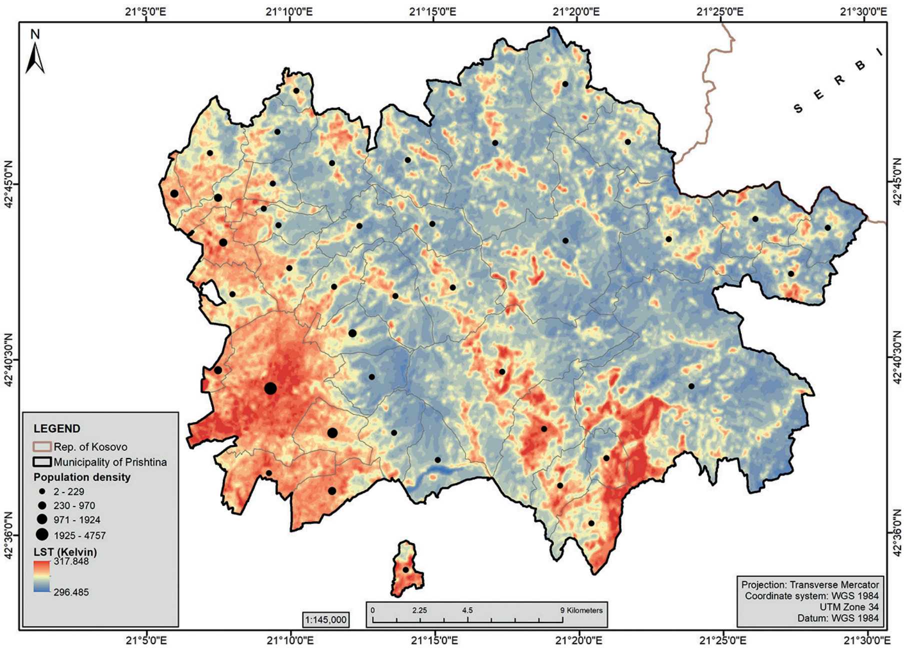

Fig. 4

Spatial distribution of LST and population density of Prishtina

Source: Compiled by authors

The upward trend of LST with increasing population density is shown in Figure 5. The values of the correlation coefficient (r) between LST and population density is 0.768005 showing a strong positive correlation. So, in other words, the areas in which the population density is high, will inevitably cause an increase in LST values due to the activities undertaken. In these areas, the population, as a result of high density, made a number of changes as a result of increasing demand. The most striking changes are the substitution of natural materials with artificial ones and the excessive use of low albedo materials. All these actions are done as a result of an irregularity in the planning of the city. If such a situation continues like this, the values of LST will continue to grow, endangering the health of the population of Prishtina.

Kosovo, like other countries in the region, faces environmental pollution and environmental degradation. This bad condition causes an extremely large amount of greenhouse gases to accumulate. The large number of human activities (commercial, industrial, vehicles, etc.) that take place in Prishtina causes the level of pollution to be high – consequently the level of greenhouse gases increases. This high level of these gases makes the long-wave radiation not be able to leave but stay on the ground causing the LST values to increase.

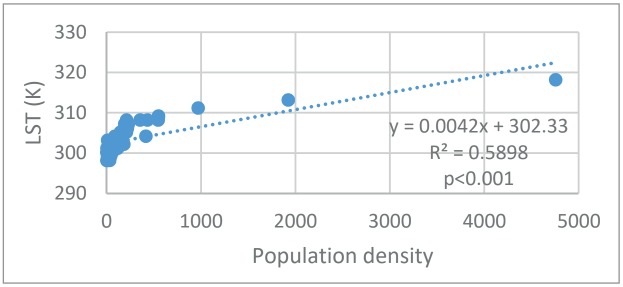

Fig. 5
Scatter plot between LST and population density
Source: Compiled by authors

For the sake of significant political, social, and economic changes during certain periods of time, Prishtina has experienced fluctuations in economic, cultural, and social development. Today Prishtina faces many challenges in managing its territory and resources. In legal terms, the inadequacy of programs addressing planning and environmental issues has led to uncontrolled urban expansion and changes in the physical environment. Developmental challenges in terms of the physical environment are mainly related to the natural environment and environmental degradation such as pollution and degradation of the environment, insufficient and irrational use of natural resources, usurpation of agricultural land for construction purposes, agricultural land loss, urban flood and uncontrolled and unplanned urban expansion. The biggest environmental challenge of the Municipality of Prishtina is the irrational use of natural resources, which results in pollution and degradation of the environment, which is affecting the further strengthening of the SUHI phenomenon. The unplanned development of agricultural land resulting from the use of it for construction with impervious materials has resulted in a major loss – it should be borne in mind that any change and replacement of natural to artificial areas only contributes to the deterioration of the situation with SUHI.

The impact and importance of vegetation on the earth's surface is extraordinary and can never be minimized. First, it affects the albedo of the earth, and, secondly it affects the LST. Vegetation, in the area where it appears, affects the freshness of the environment or, more precisely, cools the environment and reduces the concentration of CO_2 in the atmosphere, thus reducing the SUHI effect (Ebenezer et al. 2016). Therefore, the greater use of green areas will help in countering the SUHI phenomenon. Illegal construction in urban and rural areas results in uncontrolled urban expansion that must be prevented in order to achieve better development. If the uncontrolled urban expansion in Prishtina continues, the generations to come will have even more serious problems with the SUHI phenomenon.

CONCLUSIONS

This study of ours shows very clearly the spatial distribution of LST and its difference throughout Prishtina. Making the overlap in the LST map of population density, it is clear that the latter has an extraordinary role (main role) in increasing the surface temperature of the earth, strengthening the intensity of the UHI phenomenon, and, thus, creating the microclimate of Prishtina.

The data of Landsat 8 OLI and TIRS, dated 2 July 2019 were used to evaluate the SUHI effect through the spatial model of LST and its relation with population density. For the whole territory of Prishtina, LST showed a strong relationship with vegetation, highlighting the great role that vegetation has in reducing the SUHI effect. High positive correlation values were shown by the analysis of the correlation between LST and population density. Thus, once again, the strong role that the population has with its activities in further strengthening the SUHI effect is emphasized. SUHI areas were identified through the determination of LST. These areas spread mainly along the western part due to the built-up areas and in the bare surfaces in the southern part. Based on the results of the study, we conclude that responsible for generating the SUHI effect in Prishtina are the high population density and bare surfaces.

For many scientists around the world, but also for many environmental planners, assessing the SUHI effect is now the main concern given the growing trends of urbanization and urban temperature as well as the adverse effects they cause on the population globally. The importance of environmental greenery in urban planning should always be emphasized because vegetation has the ability to reduce the SUHI effect. For many cities around the world, the problem with the SUHI effect is a very sensitive issue because these cities have been facing it for a long time. In each city, administrators must take a series of steps regarding land planning and use, creating cool areas within the city with the sole purpose of promoting sustainable development and improving the lives of citizens.

This study shows how SUHI maps can provide an extraordinary tool to identify areas in which the SUHI effect is very high and causes concern to the people living there. Furthermore, municipal administrators can take a series of mitigation measures against the SUHI effect, such as materials with a high albedo, creation of green and cool areas, application of green roofs, and a series of other actions which will lead to a better life.

In order to make the right/correct addresses and assess the issue of microclimate, and also to maximize the impact that the UHI effect has on the city and its inhabitants, the results of such types of studies should be taken very seriously because can be quite helpful in minimizing such negative effects.

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MOBILIZATION AND AUTONOMIZATION STAGES OF MARXIST DISCONTINUITY IN CZECHOSLOVAK GEOGRAPHICAL THOUGHT

René MATLOVIČ [A*], Kvetoslava MATLOVIČOVÁ[B]

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Abstract
The Marxist discontinuity in geographical thought, which we pointed out in our previous work (Matlovič, Matlovičová 2020), is a specific case. It was caused by geopolitical changes after World War II, when Czechoslovakia came under the influence of the Soviet Union. This led to the onset of the communist regime in 1948 and the subsequent fundamental transformation of the political establishment, the economic system and socio-cultural life, which did not bypass the field of education and science. It was mainly the ideological indoctrination of science and higher education by dialectical and historical materialism of the Soviet type (Marxism-Leninism) and the subordination of education and research to the power interests of the Communist Party. We consider this paper only as an introduction to the study of this issue. Its aim is to identify the initial manifestations of the onset of Marxist discontinuity in Czechoslovak geography, to point out its main actors and at the same time to identify possible convergent and divergent features of this onset in Czech and Slovak geography. As a theoretical and methodological framework for our research, we have decided to base our paper on the Latour-Barnes model of changing scientific discipline.

Key words
Czechoslovak geography, dialectical and historical materialism, geographic thought, marxist discontinuity, sovietisation.

INTRODUCTION

The Marxist discontinuity in geographical thought, which we pointed out in our previous work (Matlovič, Matlovičová 2020), is a specific case. It was caused by geopolitical changes after World War II, when Czechoslovakia came under the influence of the Soviet Union. This led to the onset of the communist regime in 1948 and the subsequent fundamental transformation of the political establishment, the economic system and socio-cultural life, which did not bypass the field

A* Institute of Geography, Slovak Academy of Sciences, Štefánikova 49, 814 73 Bratislava, Slovakia
https://orcid.org/0000-0002-8935-6462
geogmatl@savba.sk (corresponding author)

B University of Prešov, 17. novembra 1, 080 01 Prešov, Slovakia
https://orcid.org/0000-0001-9635-4177
kvetoslava.matlovicova@unipo.sk

of education and science. It was mainly the ideological indoctrination of science and higher education by dialectical and historical materialism of the Soviet type (Marxism-Leninism) and the subordination of education and research to the power interests of the Communist Party. We consider this paper only as an introduction to the study of this issue. Its aim is to identify the initial manifestations of the onset of Marxist discontinuity in Czechoslovak geography, to point out its main actors and at the same time to identify possible convergent and divergent features of this onset in Czech and Slovak geography. As a theoretical and methodological framework for our research, we have decided to base our paper on the Latour-Barnes model of changing scientific discipline.

CURRENT STATE OF THE ISSUE AND ITS CONCEPTUAL FRAMEWORK

In the existing geographic literature of Slovak provenance there are no works that reflect the onset of Marxist discontinuity in Czechoslovak geographical thought. References to this discontinuity are found only in more broadly oriented survey works (Matlovič, Matlovičová 2015, 2020). In the foreign literature, this issue is solidly elaborated in Hungary (Győri 2015, Győri, Gyuris 2012, 2015, Gyuris, Győri 2013). These authors have characterized the sovietization of geography as a discontinuity in Hungarian geographical thought and have applied a postcolonial analytical scheme to its study (Győri, Gyuris 2012). Their approach was criticized by Z. Ginelli (Gyimesi) (2018), who pointed out that this approach, emphasizing the discontinuous nature of sovietization, ignores important continuities and international trends. In his view, it risks leading only to a self-centred case study of political dictatorship (Ginelli 2018, p. 53). Also relevant to our analysis are works on changes in geographic thought in the Soviet Union in the inter- and post-war period (Shaw, Oldfield 2008, Oldfield, and Shaw 2015). In Slovakia, there are well-known studies concerning the Sovietization of historical science (Hudek 2010, 2017). Hudek (2017, p. 339) explains the notion of sovietization of higher education institutions by saying that "the aim of all the changes implemented after 1948 was to imitate as closely as possible the higher education system operating in the Soviet Union".

We have adopted the Latour-Barnes model of disciplinary change as the basic theoretical and methodological framework for our research, which has been applied in the analysis of the emergence of regional science (Johnston 2006, p. 286). The model distinguishes four processes that characterize the different stages of discontinuity or paradigmatic transition within a scientific discipline. In our research, the first two stages of mobilization and autonomization are relevant. Mobilization presupposes the existence of an individual or initiating group of proponents that draws attention to a new agenda or paradigm. The innovativeness, necessity and superiority of the new paradigm over previously established approaches is emphasized. Initially informal and gradually formal media - e.g. articles, conference papers, etc. - are used to persuade other colleagues within the community. The next stage is autonomization, in which the promoters of the new paradigm invite other colleagues to adopt, assimilate and further elaborate this concept. The aim is to disseminate the new paradigm as much as possible, which also implies the involvement of students, thus triggering the need for educational reform (Johnston 2006, p. 286-7).

At these two stages, several policy strategies are employed in the paradigmatic change of the discipline of science (Johnston 2006 for a closer look). The politics of denigration is highly assertive and built on a mutual rejection of the paradigm of competing camps, claiming that the competitive/alternative project is inappropriate and lowers the status of the discipline of science. The politics of critique is less assertive than the first strategy and is built on finding the strengths and weaknesses of paradigms in order to prove the superiority of one's project over the competing one. The politics of dismissal is built on the rapid rejection of certain elements of established practices in the scientific discipline that are identified as unviable. This creates a free space for a new paradigm. The policy of silence is used when the rejection of a new paradigm is assumed. The policy of ignoring prevents the wider diffusion of new ideas, which as a consequence leads to the new paradigm not being discussed as an alternative/alternative option. The politics of accommodation pragmatically accepts the new paradigm and incorporates it into the discipline's portfolio. The politics of unity is an expanded version of the previous strategy, emphasizing the commonalities of competing projects and seeking consensus to counter threats from outside the scientific discipline (Johnston 2006 in Matlovič and Matlovičová 2015, p. 20). Another feature of discontinuities in the thought of the scientific discipline is its relation to generational change. New streams of thought are adopted and promoted initially by members of the younger generation. Gradually, as their generation becomes established in the field, they become professors, journal editors, and textbook authors, bringing their way of thinking to the fore (Aitken, Valentine 2006, p. 2).

In our work we focus on the stages of mobilization and autonomization within the onset of Marxist discontinuity in Czechoslovak geographic thought, i.e. in the period from the rise of the communist regime in 1948 to the early 1960s, when the new Marxist paradigm was already fully established. The manifestations of the onset of Marxist discontinuity will be traced through a content and discursive analysis of articles published during the period under study in the two most important geographical periodicals in Czechoslovakia – *„Sborník Československé společnosti zeměpisné"*, published in Prague, and *„Geografický časopi*s", published in Bratislava. In addition, we will highlight the results of key conferences devoted to the reflection on Marxist discontinuity.

CZECHOSLOVAK GEOGRAPHY BEFORE THE ONSET OF MARXIST DISCONTINUITY

Czechoslovak geography entered the period after the Second World War significantly weakened. In 1945, there were only three workplaces where scientific research and university training of future geography professionals was carried out. These were at the universities of Prague, Brno and Bratislava. The understaffed Institute of Geography of the Slovak Academy of Sciences and Arts in Bratislava was still applied to a small extent. The largest workplace was the Geographical Institute of Charles University in Prague, which was in the post-war years divided into four departments – concerned with anthropogeography (headed by J. Doberský), physical geography (headed by J. Kunský), the geography of Slavic countries (headed by J. Král) and cartography and mathematical geography (headed by B. Šalamon) (Häufler 1967). At the university in Brno the situation was complicated because during the Second World War the leading geographers F. Koláček, B. Hrudička and F. Říkovský were murdered by the nazis. In the post-war period, the Brno Institute of Geography was headed by F. Vitásek. In Bratislava, the head of the Geographical Institute was J. Hromádka. After his departure to Prague in 1946, M. Lukniš took over his role after a short provisional period. The Institute of Geography of the Slovak Academy of Sciences and Arts (*Slovenská akadémia vied a umení*) gradually strengthened the number of staff employed there, in the second half of the 1940s, when D. Polakovič, E. Šimo, J. Hanzlík and E. Mazúr came there. The institute was led externally by J. Hromádka, however it was in fact led by M. Lukniš and later by E. Šimo (Žudel 1993). In 1949, the scientific journal "*Geographia Slovaca*" began to be published at the Institute. In the years 1950-1952 it changed its name to "*Zemepisný zborník SAVU*" and since 1953 it became known as Geographical Journal (GJ) "*Geografický časopis*" (Ira et al. 2020, p. 393) as the most important scientific periodical in Slovak geography. Since the late 1940s and in the 50s, new geographical workplaces were gradually established, which were mainly focused on teacher training (e.g. in Prague, Bratislava, Brno, Pilsen, České Budějovice, Olomouc, Prešov, Banská Bystrica, Nitra). From the previous period, small geographical workplaces at economic universities in Prague and Bratislava have also been preserved. An important platform for geographers was the Czechoslovak Geographical Society "*Československá společnosť zeměpisná*", an institution based in Prague. In 1946 S. Nikolau left the leadership of this institution after he was accused of collaborating with the Nazis and was replaced by J. Pohl - Doberský. Since 1894, the institution has been publishing a scientific journal Proceedings of the Czechoslovak Geographical Society (PCSGS) "*Sborník Československé společnosti zeměpisné*" (Jeleček, Martínek 2007). In Slovakia, Slovak geographical society (*Slovenská zemepisná spoločnosť*) was founded in 1946 as a branch of the *Czechoslovak geographical society*, headed by J. Hromádka (Jeleček, Martínek 2007).

Czechoslovak geographic thought was shaped by the influence of several European schools, whose roots go back to the Berlin centre, where the tradition was started by C. Ritter. The most significant influences on Czechoslovak geographers were the German school (F. Ratzel, A. Penck, F. von Richthofen, A. Hettner), the French school (Vidal de la Blache, J. Brunhes, R. Blanchard, A. Demangeon, E. De Martonne, P. Deffontaines), the Anglo-American school (W.M. Davis, Herbertson), the Polish school (L. Sawicki) and the Serbian school (J. Cvijić). In physical geography, the most developed was geomorphology, whose thinking reflected the geographic cycle theory of W.M. Davis (J. V. Daneš), although geomorphological concepts among Czech geographers also had the geomorphological concepts of A. Penck (V. Dědina), E. De Martonne (J. Moschelesová) and the karst geomorphologist J. Cvijić (J.V. Daneš) (Häufler 1967). The first stage of the development of anthropogeography was associated with the deterministic concept of Ratzel (V. Dvorský) (Häufler 1967). Later, the influence of the American school (J. Moschelesová) and especially the French school of geographical possibilism (J. Král, J. Hromádka) increased (Král, Kondracki 1951, Häufler 1967, Trávníček 1984).

THE ONSET OF SOVIETIZATION OF UNIVERSITIES IN CZECHOSLOVAKIA

The Communist Party took power in Czechoslovakia in February 1948. The main milestone in defining the nature and mission of the educational system in Czechoslovakia was the IX Congress of the Communist Party of Czechoslovakia (CPC) in May 1949, during which the main goals of building socialism in the political, economic and cultural spheres were set. The Minister of Education Z. Nejedlý, in his speech at this congress, unambiguously determined that the ideological basis of education in schools in the Czechoslovak Republic is and must be Marxism-Leninism, as the only "scientific doctrine" (Gabzdilová 2018, p. 111). The principle of partisanship, i.e. total identification with and support for the current policy of the Communist Party, came to the fore. This also entailed considerable instability, which was manifested in the cyclical changes of this policy and its consequences for the functioning of universities and science (Hudek 2017).

Academic self-governance in universities has been replaced by a centralist-bureaucratic model of governance. In 1950, a new Higher Education Act was adopted, which brought about significant changes in the organisation of higher education and marked a departure from the pre-Central European system of higher education. Universities were placed under the authority of the State Committee for Higher Education. In 1951, the position of cadre officers was established in the universities, reporting directly to the Ministry and controlling personnel policy in relation to staff and students. In the organizational structure, institutes and seminaries were replaced by departments on the Soviet model. Ideological indoctrination with Marxism-Leninism began to take place as early as the academic year 1948-49, when lectures in social sciences began to be implemented in all faculties. Among the lecturers on the topic "*our people's democracy on the road to socialism*" was also geographer Jozef Fraňo (Gabzdilová 2018, p. 113). From 1951, ideological indoctrination was provided by Marxist departments, which were established at each university and had their own cabinets at each faculty. Three types of Marxist departments were established in universities - the department of the foundations of Marxism and Leninism, the department of political economy, and the department of dialectical and historical materialism. Taking courses in Marxism-Leninism became compulsory for all university students in Czechoslovakia (Urbášek, Pulec, 2012). The departments of historical and dialectical materialism, where the questions of the struggle against bourgeois ideologies, the questions of the communist revolution and the questions of the nature of scientific laws were elaborated, had a key position in our context (Sirácky 1957, p. 12). Another institution for the promotion of the experiences and results of Soviet science was the Czechoslovak-Soviet Institute, which was founded in 1950 in Prague.

As a result of the onset of Sovietisation of universities in Czechoslovakia, persecutions began, leading to personnel purges among professors and students. Leading geographers were also victims. At Charles University, Jiří Král[1] was made to prematurely retire in 1948, and at the University of Political and Economic Sciences in Prague, J. Hromádka was sent into retirement in 1951 (Matlovič 2018). The emergence of the communist regime also affected the activities of the Czechoslovak Geographical Society. In 1950, its publishing licence was withdrawn. The publishing of the scientific journal was taken over by the publishing house "*Prírodovedecké nakladateľstvo"* and later in 1952 by the publishing house of the Czechoslovak Academy of Sciences (*Nakladateľstvo Československej akadémie vied)*. The 1950-1952 volumes were published with a delay. The journal became subject to censorship and propaganda articles on ideological issues began to be printed (Jeleček, Martínek 2007).

The adoption of the new Higher Education Act resulted in changes in the organisational structure of the departments. The Institute of Geography of Charles University was abolished in 1950 and replaced by the Department of Geography. In 1953 the department was divided into the Department of Economic and Regional Geography and the Department of Cartography and Physical Geography (Häufler 1967). Similar changes occurred in Bratislava, where the institute was replaced in 1950 by the Department of Geography, which was divided into the Department of Physical Geography and the Department of Economic Geography in 1952 (Matlovič

1 According to J. Kral's notes preserved in the archives, this was based on a false accusation of collaboration with the Nazis, which he attributed to his two colleagues. In 1966, J. Král was rehabilitated.

2018). Similarly, in Brno, the Institute of Geography disappeared in 1950 and the Department of Geography was established. The training of geography teachers at the faculties of education and their branches was separated from the universities after the 1953 reform into separate professionally oriented colleges, which experienced a rather extensive development. Scientific activity at universities was weakened, following the Soviet model, by the establishment of the Czechoslovak Academy of Sciences (CSAS) in 1952 and the Slovak Academy of Sciences (SAS) in 1953, which incorporated the Institute of Geography of the Slovak Academy of Sciences and Arts. The Department of Economic Geography was established at the Institute of Economics of the CSAS in 1954. The Institute of Geography of the CSAS in Brno with a workplace in Prague was subsequently established by finally merging several departments in 1963 (Jeleček et al. 2006).

After February 1948, the preparation of the reform of higher education according to the Soviet model began. A reform commission was set up to prepare a new study of geography, and the curricula at the individual universities in Prague, Bratislava and Brno were to be gradually harmonised. In the academic year 1949-50, the first two years of students were already studying according to the new curricula. A broader scientific training in physical geography and cartography was prescribed for the professional study of economic geography, and the problems of general economic geography were divided into a number of sub-subjects so that they could be covered in more detail. In 1952, separate lectures on geography of industry, geography of agriculture, population geography and demography were introduced. The geography of settlements was more strongly oriented towards cities and industrial centres. Courses on economic cartography, economic statistics and the history of the national economy were introduced. As Soviet economic geography developed strongly in connection with rayon (regional) planning, lectures and exercises were supplemented by lectures on spatial planning. Textbooks on these subjects were not available in Czechoslovakia, so textbooks by Soviet authors were used. This was the second part of N.N. Baranský's school methodology, which was published in 1954 in an expanded edition. The geography of industry was taught according to P.N. Stepanov's textbook from 1950 and based on Kolosovsky's 1947 concept of territorial-production complexes, the geography of agriculture and geography of settlements were taught according to the manuals of J.G. Sauskhin from 1947 and A.N. Rakitnikov from 1948. An important role was played by scientific works and monographs, which became a model for the research of a particular territory by the Marxist method. Of particular importance was the monograph by I. M. Maergojz on Czechoslovakia from 1954, in which the principles of the Soviet rayon school of regional planning were applied (Korčák 1955, pp. 182-183).

Czechoslovak geography was somewhat isolated in the international context. Contacts with geographic departments in Western countries were severed. Paradoxically, contacts with Soviet geographers were also initially insufficient. This can be illustrated by the fact that the first Soviet geographer to visit Charles University after the onset of the communist regime was J. Demidovich as late as 1953, and visits by Czechoslovak geographers to the Soviet Union were delayed even more. This meant that Marxist methodology was only slowly applied, especially in economic geography (Häufler 1967).

THE EMERGENCE OF MARXIST DISCONTINUITY IN CZECHOSLOVAK GEOGRAPHY

The emergence of Marxist discontinuity in Czechoslovak geographic thought can be traced through articles in the two most important geographic periodicals published in Czechoslovakia – Proceedings of the Czechoslovak Geographical Society (PCSGS) and Geographical Journal (GJ). In line with the Latour-Barnes model of the disciplinary change, this way of setting the agenda of a new paradigm is typical of the stage of mobilisation and, to some extent, autonomisation. At the same time, this approach allows us to show the differentiated course and pace of the emergence of Marxist discontinuity in the environment of Czech and Slovak geography.

The Mobilizing and Autonomizing Phase of Marxist Discontinuity in Czech Geography and its Actors

The first manifestation of the emergence of Marxist discontinuity in Czechoslovak geographic literature can be considered to be the propaganda article by V. Häufler and M. Střída *Za marxistickou geografii* (For Marxist Geography), which appeared in the main section of articles in PCSGS as early as 1950.[2] The authors of the article represented the young generation, which at that time was just beginning its academic career. Vlastislav Häufler (1924-1985) has just started as an assistant professor at Charles University in Prague after his studies in 1945-1949. He was one of J. Doberský's pupils. His whole career was connected with the Charles University of Prague. He habilitated in 1958 and was appointed professor in 1966. He became one of the leading figures of Czechoslovak geography and was head of the Department of Economic and Regional Geography from 1960-1980. Miroslav Střída (1923-2008) also studied at the Faculty of Natural Sciences in Prague in 1945-48. He spent a year at the Sorbonne in Paris and worked as an editor in a natural science publishing house. In 1952-1955 he was an assistant at the Prague University of Economics and Business, then worked at the Department of Economic Geography of the Institute of Economics of the Czechoslovak Academy of Sciences, which in 1963 became

2 After the publishing rights of the Czechoslovak Geographical Society were withdrawn, the publication of the PCSGS was in crisis. For these reasons, the following issues were published with a time delay. The mentioned article was therefore not published until 1951.

part of the newly founded Institute of Geography of the Czechoslovak Academy of Sciences (J. Martínek, M. Martínek 1998). These proponents of Marxist discontinuity already in the introductory part of the article used the discourse of the politics of denigration and decisive detachment from the previous approaches, which is demonstrated by the following position of theirs: "*if we want to put Czechoslovak science at the service of progress and building, we must also understand our tasks in a combative way, step firmly and without hesitation on a new path and relentlessly put an end to what in the past the bourgeois theoreticians and the so-called non-political pure scientists put on our science*." Implicit in this position is a critique of positivism. The authors saw the starting point in a clear orientation towards Soviet geography: '*...to find a common voice with Soviet geographers. Their geographical science, already growing out of socialist roots, shows us unmistakably, even this time, the path we must take...in order to place Czechoslovak geography on the scientific foundations of Marxist thought*' (Häufler, Střída 1950, p. 1). In the next part of the article, the authors applied the discourse of the politics of critique in relation to the various schools of geographical thought in Western countries. The first criticism was directed towards geographical determinism and its misuse for the imperialist aims of Nazi Germany through the living space concept (*Lebensraum*). In criticizing the French anthropogeographical school, the authors were unable to formulate their own arguments, but relied on Soviet geographers. This is illustrated by the statement: *'the French school of anthropogeography, so vividly praised even by some of our geographers, suffers from serious flaws, if we look at it in the light of the facts that emerge from the discussions of the Soviet geographers*' (Häufler, Střída 1950, p. 21). In the next section, they criticized the idealism and subjectivism of geography, reflecting the following view: .... *this applies to bourgeois geography, where there is a chaos in the methods, boundaries and tasks of this science, which has long persisted and which cannot be resolved except by adopting a materialist world view and dialectical method*" (Häufler, Střída 1950, p. 4). The authors also pointed out that the classics of Marxism, such as Marx, Engels, Plekhanov, attached great importance to the study of the geographical environment and its influence on the material existence and economic activity of mankind. The ideas in their works (e.g. Capital: A Critique of Political Economy, Dialectics of Nature, The Development of the Monist View of History) were considered so fundamental that "*they can be regarded as a guiding force for all scientific activity in the field of geography*" (Häufler, Střída 1950, p. 4). Finally, they emphasized the contribution of the works of Lenin and Stalin to the development of geography, formulating the opinion, "*Stalin, with his directives for the building of socialism and now communism, for the reshaping of nature, directly determines the tasks of Soviet geography*" (Häufler, Střída 1950, p. 5). The article goes on to characterise Soviet geography. In an attempt to increase the weight of their argument, the authors help themselves by introducing attempts to reflect Marxism in the other schools of bourgeois geographies. They mention the Polish geographer S. Nowakowski (1928) and a group of progressive French geographers at the Sorbonne in Paris led by P. George. However, they immediately needed to point out that much greater achievements in this endeavour had been made by the Soviet school of geography (Häufler, Střída 1950, p. 5). Among the concrete achievements of Soviet geography, they mentioned the original conception of Markov, who combined Davis's theory of the geographical cycle with Penck's morphological analysis on the basis of dialectical materialism. The authors did not avoid characterizing the controversies that arose in Soviet geography. These included criticism of the supporters of the concept of geography according to the German geographer A. Hettner in the interwar period and a second wave of criticism by several geographers in the pages of the journal *Voprosy geografii* in 1947 and 1948 for their misunderstanding of the dialectical nature of the evolution of the geographical environment. In the final part of the article, the authors discuss the state of Czechoslovak geography. They invoked the discourse of the politics of dismissal, which is well illustrated by the following statement in relation to the interwar period: '*Czechoslovak geographical science thus proved that it stood with both feet on the idealistic platform of chaotic and impotent bourgeois science, and that together with it, it turned a blind eye to the harsh realities of predatory capitalism and robber imperialism on one hand, and to the deplorable situation of the oppressed masses on the other*' (Häufler, Střída 1950, p. 7). The authors also advocated a personnel purge, as evidenced by the following statement: '*Czechoslovak geography has so far suffered from organisational and ideological deficiencies, the result of the long-standing influence of Western schools. The removal of reactionary factors has brought about a partial recovery...those who today work in leading positions in geography recognise the correctness of the orientation towards progressive Soviet science and the necessity of working by the method of dialectical and historical materialism*" (Häufler, Střída 1950, p. 7).

J. Doberský was involved in the promotion of Soviet geography in his 1951 article "The Achievements of Russian and Soviet Geography". Josef Pohl-Doberský (1888-1967) differed from previous authors by belonging to an older generation. He studied geography and history at the university in Prague in 1909-1914. He worked as a secondary school professor. In 1927 he was habilitated in anthropogeography, in 1937 he was appointed an extraordinary professor and in 1946 a full professor. His career peaked after the Second World War. In 1946 he became a chairman of the Czechoslovak Geographical Society for ten years and in 1950-1952 he was the director of the Geographical Institute of Charles University in Prague. In 1946 he changed his surname from the German Pohl to Doberský, after the village he was from (Dobré near Dobruška in Eastern Bohemia). At the same time, from an agrarian (a member of the Republican Party of Agricultural and Farming People), he became a communist. He played an important role in the political purges that adversely affected the fate of prof. Jiří Král. He was actively involved in political agitation concerning Soviet geography and the socialist village (Martínek 2012). In the article in question, he used the discourse of the politics of denigration to discredit old Russian geography and to highlight the merits of Soviet geography. This is illustrated by the following statement of his: '... *while Russian geographers during feudalism and capitalism mostly served government policy in the conquest of new colonies and prepared the ground for new military expeditions and imperialist conquests linked to commercial interests in the continuous exploitation of new territories for the benefit of the tsarist court, feudal circles and trading companies, Soviet geographers engaged themselves in the service of the economic and cultural development of the whole society, and geography became a pillar of the economic reconstruction of the Soviet Union*" (Doberský 1951, p. 29). J. Doberský also addressed the theme of the rise of Marxist discontinuity in his lecture in December 1954 on the occasion of the 60th anniversary of the Czechoslovak Geographical Society. He expresses it as follows: "*...our geography has also opened a new period of its development. It is no longer a science for science's sake and a planless creative work, but a science aimed at the concrete tasks of the socialist construction of our republic, guided by the desire to apply to us the virtues of Soviet geography, based on the advanced methods of dialectical and historical materialism*" (Doberský 1955, p. 162).

A flagrant manifestation of the policy of accommodation was in 1953 the of articles on the importance of the works of J. V. Stalin for geography. This is the study by M. Blažek "The importance of the work of J.V. Stalin's "Economic Problems of Socialism in the USSR" for Czechoslovak economic geography" and M. Macka's article "The Significance of the Work of J.V. Stalin for Czechoslovak Economic Geography". Miroslav Blažek (1916-1983) belonged to the middle generation. He studied geography in 1934-1939 at the university in Brno. He was a pupil of F. Koláček. In the early phase of his career, he worked in practice, where he was involved in regional planning and in the issue of the resettlement of the Czech borderland after the expulsion of the Germans. In 1951 he joined the Prague University of Economics and Business, where he was habilitated in 1952 and appointed professor in 1964. In 1967 he moved to the Geographical Institute of the Czechoslovak Academy of Sciences in Brno, where he built up the Department of Economic Geography). Miroslav Macka (1924-1984) belonged to the young generation of emerging geographers. He was a graduate of geography at the university in Brno. After his studies, he worked first at the Faculty of Education in Brno from 1948 and at the Faculty of Natural Sciences from 1953. From 1963 he worked at the Geographical Institute of the Czechoslovak Academy of Sciences in Brno (J. Martínek, M. Martínek 1998). Blažek (1953, p. 1) identified Stalin's fundamental contribution as his thesis that natural and social laws are identical in quality and are the result of objective processes. This implied an imperative to study not only the laws of development of the geographical environment, but also the laws of social development and its manifestations in the geographical environment. He attributed a cardinal role to the laws of political economy, in particular the laws of the distribution of productive forces in the geographical environment. In the next section, he highlighted the law of proportionality of social development identified by Stalin, which he linked in particular to spatial and regional proportionality. Related to this, according to him, was the need for the application of geographical knowledge in regionalisation and regional (rayon) planning (Blažek (1953, p. 3). M. Macek's article was a reaction to the death of J.V. Stalin and is an example of totally uncritical adoration of this dictator. This is illustrated by the statement in the introduction: *'comrade Stalin's work, in which he brilliantly and creatively develops the basic lessons of the classics of Marxism-Leninism and of his great teacher V. I. Lenin...is the cornerstone and textbook of the Marxist and dialectical method of work and the materialist world view serving as a battle weapon for all scientists, thus also in the field of geography, not only in the Soviet Union, but throughout the world*." (Macka 1953, p. 65).

In addition to domestic authors, the editors of the PCSGS helped in the promotion of Marxist discontinuity with articles by foreign authors. These were a study by the French geographer J. Tricart "*Geomorphology and Marxism*" from 1952 and an article by the Eastern German geographer Sahne "*Towards a Socialist Theory of Economic Geography*" from 1955.

In addition to the main articles section, several articles were published in the informative section of PCSGS. We can also mention M. Střída´s information (1954) on the tasks of geography on the basis of the conclusions of the 10th Congress of the Communist Party of Czechoslovakia. According to him, geography was to cooperate in solving the basic problems of the development of the national economy, which were the expansion of the raw material and energy base, the increase in agricultural production, the increase and improvement of the production of consumer goods, the increase in the performance and level of railway and automobile transport, and the consolidation of economy as a condition for raising the standard of living of the population (Střída 1954, p. 216).

Not all Czech authors were such ardent promoters of the new paradigm of dialectical and historical materialism and the sovietization of geography. We can also find authors who kept a certain distance even though they were aware of the necessity to adapt to the new reality. Among them was Jaromír Korčák (1895-1989), who, like Doberský, belonged to the older generation of geographers. He studied geography at the Charles University in 1914-1922 and worked in the State Statistical Office, where he was influenced by A. Boháč and focused on demography. V. Láska inspired him to deal with the use of mathematical methods in geography. In 1951 he joined Charles University, where he was appointed professor and head of the Department of Economic and Regional Geography until 1960. Due to the theoretical and methodological contribution of his works, he is considered to be the founder of the Albertov School of geography (J. Martínek, M. Martínek 1998,

p. 243). J. Korčák (1955), reflecting on the development of economic geography in the post-war decade, drew attention to the pitfalls that resulted from the state of Soviet geography. This is illustrated by his point: "*the methodology of economic geography is still a subject of debate in the Soviet Union, which is carefully followed in our departments of economic geography*". He was thus responding to Bujanovsky's criticism of the work of Saushkin (Korčák 1955, p. 181).

The differentiation of Czechoslovak geographers' attitudes towards the Marxist discontinuity is well illustrated by the content of the papers and discussions at the first scientific conference held in Czechoslovakia after the communist regime took power. It was a conference of geography researchers held on 8-10 October 1953 at the chateau in Liblice near Mělník. It was attended by 62 experts. It was the first opportunity to reflect on the sovietization of Czechoslovak geography and the onset of Marxist discontinuity in geographical thought. The main papers were delivered mostly by representatives of the older generation. They mostly limited themselves to paying attention to the achievements of Soviet geographers within the framework of the issues discussed. This was the character of the papers by B. Horák and M. Stadtler on historical geography, F. Vitásek on physical geography and J. Krejčí on the application of geographers in practice. J. Korčák (1954, p. 44) in his report on regional geography reflected the works of Soviet geographers, especially N. N. Baransky and J. G. Saushkin, and accepted dialectical materialism as the methodological basis for regional geography. J. Hromádka was rather restrained in his report on economic geography, which provoked a reaction among some participants as if he had used the discourse of the politics of ignorance. This is evident from his opinion: *'it is to the credit of Soviet geographers that the theoretical side comes to the fore in comparison with previous practice. Discussions are coming up, opinions are being refined. The development of geography is entering a new phase. I conclude that we have neither the space nor the time to discuss these issues here. Other meetings are needed to focus on this issue alone...*" (Hromádka 1954, p. 34). Hromádka went on to reflect on the debates in contemporary Soviet geography[3], stressing the need for close collaboration between physical geography and anthropogeography, thus defending Saushkin. It should be noted that Hromádka did not respect the new norm and continued to use the term anthropogeography. In another part of his paper he even suggested that the French school of geography should be followed, which illustrates his point: *'the works of economic geography are governed by the same principles as the whole of geography. I conclude that the principles laid down by De Martonne and Brunhes suit us best*" (Hromádka 1954, p. 35), which was in stark

3 These were apparently discussions about which Czechoslovak geographers had information from the periodical *Za marxistickou geografii. Výběr z diskuse sovětských zeměpisců*, published in 1951 by the natural science section of the Czechoslovak-Soviet Institute. It was a selection of translations of the above mentioned discussions, which also concerned the reflection of French geography by Soviet geographers (Hanzlík 1952, p. 158).

contrast to the advocated orientation towards Soviet geography. Hromádka also pointed out in his report that the older generation of Czechoslovak geographers had been shaped initially by the German school of geography, had subsequently encountered the French school of geography as well as the American school, and had also been inspired by Polish and Serbian geography (Hromádka 1954, p. 34). During the discussion, several participants reacted critically to his paper - V. Häufler for his methodological aspect, M. Blažek for the fact that he evaluated the given questions from the positions of bourgeois science, J. Doberský, for his lack of mention of dialectical and historical materialism, and for Hromádka's overemphasis on the French anthropogeographical school. Doberský considered it necessary to rely on the experience of Soviet geographers as models for Czechoslovak economic geography. In his reply to Doberský, Hromádka stated that even Soviet geography had not discarded everything that came from the pre-revolutionary era, and pointed out that Russian translations of important French geographical works had been published in the Soviet Union, and in his approach, he was merely following Soviet models. In response to the discussion, a Slovak geographer A. Šíma shared Hromádka's view of the tasks of economic geography and pointed out that the different views of Hromádka Blažek were rooted in different orientations to the various currents in Soviet geography. Šíma was inclined to N.N. Baransky's conception, thus considering it correct to study the natural environment in economic geography from an economic point of view (Hromádka 1954, pp. 36-39). Already from this discussion certain differences in the acceptance of the Marxist discontinuity between geographers from the Czech regions and geographers whose careers were connected with Slovakia emerge.

Mobilization and Autonomization Phase of Marxist Discontinuity in Slovak Geography and its Actors

Compared to the Czech countries, the onset of Marxist discontinuity in Slovakia was delayed. To some extent, this was related to the leading persons who determined the strategic formation of Slovak geography and were not among the ardent protagonists of this change. The authority of Jan Hromádka (1886-1968), who educated the first generation of Slovak geographers, played a special role here. Hromádka began studying geography at the university in Prague in 1910-1914, where he was shaped by V. Švambera, J.V. Daneš and V. Dvorský. After his studies were interrupted by World War I, he completed his studies with Prof. F. Štůla at the Comenius University in Bratislava in 1926. In 1930 he habilitated and began teaching at Comenius University as a private associate professor. In 1931-1932 he completed a study stay at the Sorbonne in Paris, which greatly influenced his orientation towards the French school of regional geography. In 1938-1946 he was a professor at the University of Bratislava, where he was the director of the Institute of Geography at a university in 1939-1946, while he also headed the Institute of Geography of the Slovak Academy of Sciences and Arts (SAVU). In 1946 he went to Prague to the University College of Business, but he continued to lecture in Bratislava until 1948. In 1951 he was forced to retire for ideological reasons. His career was reactivated in 1954-1956, when he worked at the Department of Economic Geography of the Institute of Economics of the Czechoslovak Academy of Sciences. During his Slovak tenure he educated several leading geographers. He habilitated M. Lukniš for physical geography in 1946 and A. Šíma for economic geography in 1950 (Matlovič 2018). Michal Lukniš (1916-1986) studied geography in Bratislava in 1938-1942. After his studies, he worked as an assistant to prof. Hromádka at a university in Bratislava. In 1946 he was habilitated and in 1956 he was appointed professor. In 1952-1960 he was the head of the Department of Physical Geography. Under the influence of Hromádka, Lukniš initially devoted himself to regional geography. In the early 1950s he transferred the focus of his research activities to geomorphology. It was the more pronounced inclination towards physical geography that was the strategy of many geographers who did not want to explicitly submit to the onset of Marxist discontinuity. Lukniš eventually returned to regional geography after 1974, when he moved to the newly established Department of Regional Geography. Anton Šíma (1908-1976) graduated from the university in Bratislava in 1943. He worked as a secondary school teacher in Banská Bystrica and Bratislava. In 1946 he began teaching at the College of Commerce in Bratislava and in 1952-1958 he was head of the Department of Economic Geography at Comenius University in Bratislava. His research was mainly devoted to the geography of tourism, the development of which was not favoured after the emergence of the new communist regime. In 1958 he was reassigned to the job of a librarian and from 1959 onwards he taught at secondary schools (Lukniš 1976).

The delay in the emergence of Marxist discontinuity in Slovakia was due to a number of factors. The Communist Party did not enjoy as much support here as in Czech part of state[4]. The first wave of purges hit the universities less intensely, not least because the Slovak academic community was still small in number and interconnected by relations of state solidarity. The communists relied on non-violent persuasion of the scientific community to apply the principles of Marxism-Leninism. The latter tried to adopt, at least formally, dialectical and historical materialism (Hudek 2017). At the Institute of Geography Slovak Academy of Sciences and Arts, research activities came to attention in 1950, when the Institute's research plan for 1951 was criticized by I. Kuhn from the Slovak Planning Office. He reproached it for not addressing the current needs of society and recommended that the Institute's staff should take models from the work of Soviet geographers and familiarise

4 Elections in 1946 in Slovakia were won by the Democratic Party, unlike in the Czechia, where the Communist Party dominated.

themselves with the correct methodology. The Institute modified the plan, abandoned the preparation of a map of Slovakia's tourism and instead included the elaboration of an economic geography of Slovakia based on the work of the Soviet geographer N.N. Baransky. In the end, this plan was not implemented because, paradoxically, the Slovak Planning Office did not make the necessary data available to the Institute (Žudel 1993).

The situation at the universities changed after the Hungarian Revolution of 1956, when the so-called working intelligentsia was suspected of supporting liberalisation efforts and opposition sentiments. The Communist party authorities pushed for the restoration of a strict class principle, which was intended to purge universities and research institutions of politically unreliable people. Instead of professional aspects, political and ideological criteria came to the fore. In 1957-1958, another wave of personnel purges began, directed against the pre-revolutionary intelligentsia, which was to be replaced by a new generation of workers educated in the socialist spirit (Hudek 2017, pp. 350-351). These processes led to the fact that the former head of the Department of Economic Geography at Comenius University in Bratislava, A. Šíma, had to leave and was replaced by K. Ivanička. A number of other workers were forced to leave, some of whom found employment at the Academy of Sciences, where conditions were more tolerant, especially in relation to religious people.

In the Geographical Journal (GJ) "Geografický časopis", during the period of our study, no article was published in the main section of research articles which explicitly promoted the emergence of Marxist discontinuity and whose diction could be compared with the works of the ardent promoters of Marxism in Czech geography. The first article published in the main section that reflected the works of Soviet geography was E. Šimo's 1952 article on the great plan for the transformation of nature in the Soviet Union and the participation of Soviet geographers in its implementation. In 1955 an article written by the Hungarian geographer T. Mendöl was published, concerning the current state of geography in Hungary. There is only a modest mention in it of the need for adequate time for Hungarian geographers to adopt Marxism-Leninism and to apply it in their works, a change that has not yet been completed (Mendöl 1955, p. 130). In 1958, an article by K. Ivanička on the subject, methods and development directions of industrial geography was published. In it, Ivanička (1958, p. 27) only mentions in passing the conclusions of the XXth Congress of the Communist Party of the Soviet Union. He admits the need to use the results of bourgeois geography and gives a fairly balanced overview of the developmental directions of industrial geography in the individual countries without a strong emphasis on Soviet geography. The article is characterized by factuality and does not contain a propagandistic vocabulary as found in the articles of the aforementioned Czech geographers (Ivanička 1958). In 1960, in the main studies section of the GJ, there appeared a balance article on the development of

Slovak geography over the last 15 years. It is interesting that no author signed it, but it was published as editorial material. By comparing it with other articles published in that period (Ivanička 1962, 1963), it is possible to see the handwriting of K. Ivanička behind it. Ivanička (1962) appreciated the contribution of J. Hromádka to the development of Slovak geography. However, he criticized the generation of his pupils working at universities for persisting in the positions of the ideology of positivism. He blamed them for their isolation from political events and real life. In his view, they were at odds with the new reality and were actively preventing the reconstruction of geography on the basis of Marxism-Leninism. This attitude of theirs was manifested in the undefined geography graduates who only became acquainted with the new problems of our society in practice. According to him, this situation persisted until 1954, when it began to change gradually thanks to the merit of the young generation. His following opinion shows that at the beginning of the 1960s he considered the transformation of Slovak geography to be already complete: "*The concept of the old positivist school began to clash with the new current of progressive, Marxist-oriented geography, represented by young economic geographers. The intense ideological struggle lasted for several years, with the result that the external effect of the work done in economic geography is less than in physical geography. The ideological struggle in economic geography was on the whole confined to the universities. In fact, it has already been decided. Today in Slovakia, we have a healthy core of ideologically mature economic geographers, which is a guarantee that the development of economic geography will go in the right direction* (Kolektív 1960). Similar conclusions can be found in another article by K. Ivanička (1963, p. 15), where he criticized geographical determinism for its connection with social Darwinism and for its use to mask the political and economic expansion of imperial powers. In addition, Ivanička also rejected geographical nihilism for completely underestimating the impact of the geographical environment on society. He took a lenient attitude towards geographical Possibilism and the French school, in which one can identify influences mediated by J. Hromádka. He identified the inclination of geographical possibilism towards positivism as a problematic aspect, for which he eventually also dismissed it as unscientific. For these reasons, he recommended paying attention to the Marxist view (Ivanička 1963, p. 16).

In the informative section of the GJ several articles appeared in this period - e.g. on the promotion of geographical knowledge in the Soviet Union (Martinka 1951), on the results of Soviet geography in individual disciplines (Kurpelová 1952,Dub 1953, Bučko 1954), on the views of Soviet geographers on new directions in French geography (Hanzlík 1952), on the tasks of the Soviet Geographical Society on the basis of the conclusions of the XIXth International Geographical Society (Hanzlík 1952), on the role of the Soviet Geographical Society in the development of geography. Congress of the Communist Party of the Soviet Union (translation of the original article by E. Šimo from 1953), the results and findings of a study tour in the

Soviet Union (Hanzlík 1958a), and the development of economic geography in the Soviet Geographical Society over the last 40 years (Hanzlík 1958b). These articles are written in a factual style without propagandistic ballast. In 1957, an extract from a paper by E. Hruška was published with the topic on the tasks of economic geography in the Second Five-Year Plan of the Czechoslovak Socialist Republic, which he delivered at a conference in March 1956 at the Economic Institute of the Czechoslovak Academy of Sciences in Prague. Hruška (1957, p. 50), drawing on Soviet experience, drew attention to the key role of economic geography in raising the scientific level of spatial plans for the deployment of productive forces.

An important conference on theoretical issues of geography was held in Bratislava in June 1961. It essentially completed the stage of the domestication of dialectical and historical materialism in Slovak geography. This is evident from the wording of the final resolution: '*Czechoslovak geography essentially overcame geographical determinism, which relied in its philosophical conception on mechanical materialism... what differed from geographical determinism was the geographical school, which, on the philosophical foundations of positivism, rejected the older theses on the conception of geography and oriented itself towards detailed territorial research. This school unnaturally separated science from social events. In the inter-war period, there were also views that overestimated the study of form, especially in so-called anthropogeography. Czechoslovak geography successfully overcame even these false conceptions. Soviet geography played an important role in this development*" (Kolektív 1963, p. 223).

In Slovakia, Koloman Ivanička (1929-2014) was most prominently involved in the emergence of Marxist discontinuity, who studied at the Comenius University in Bratislava in 1949-1952 and later at the University of Warsaw in 1952-1954 under prof. S. Leszczycki. He completed his doctoral studies at Charles University in Prague under prof. J. Korčák in 1959. In 1960 he was habilitated, in 1964 he was appointed an extraordinary professor and in 1975 a full professor. His career culminated in 1958-1974, when he was head of the Department of Economic Geography at Comenius University and in 1969-1970 he was a visiting professor at the University of Kent in the USA. However, his rapid career and contacts with American geography caused him problems in the workplace, where he no longer held a leading position from the mid-1970s onwards. In 1993, he went from Comenius University and in the following years built new departments at Matej Bel University in Banská Bystrica and other universities and institutions that focused on strategic planning and global studies. Within the Institute of Geography of the Slovak Academy of Sciences, the onset of Marxist discontinuity was reflected in particular by two staff members who seemed to have been tasked with this task because of their management functions at the time. Ján Hanzlík (1925-1995), who graduated in geography at the university in Bratislava. In 1949, while still a student, he joined the Institute of Geography of the Slovak Academy of Sciences and Arts, where he headed the Department of Economic Geography from 1953 to 1963. Eduard Šimo

(1923-?), who graduated in geography and history at the university in Bratislava in 1946, was another employee of this institute. In 1948 he joined the Institute of Geography, where he worked until 1953. In 1949-1952 he was the deputy administrative director of the Institute. From 1954 he worked at the Institute of Hydrology and Hydraulics of the Slovak Academy of Sciences.

FROM ANTHROPOGEOGRAPHY THROUGH SOCIETAL GEOGRAPHY TO ECONOMIC GEOGRAPHY

The rejection of anthropogeography was a significant manifestation of the onset of Marxist discontinuity. In 1949, at Charles University and in the following years at other institutions, the term ceased to be used. This was mentioned by Häufler and Střída (1950), who stated "*...in the last year, on the basis of the Soviet understanding of geography, it was possible to proceed in our country to the liquidation of anthropogeography as a bourgeois science of human society in a geographical environment and to lay the foundations of societal geography*". (Häufler, Střída 1950, p. 8.). According to them, societal geography (in Czech "*společenská geografie*") differs from anthropogeography in content and method. In terms of content, it concentrates on the study of the distribution of the productive forces, i.e. the means of production and people, and also examines the interventions by which society alters the geographical environment. In terms of method, it differs by moving away from examining from various idealistic perspectives to the materialistic foundations of society (Häufler, Střída 1950, p. 8). On May 31, 1950, a meeting of the working collective of societal geography at Charles University in Prague was held. Its members were the staff of the I. Department (for societal geography) of the Institute of Geography of Charles University. The subject of the meeting was the solution of current problems, especially the application of Marxism-Leninism methods in societal geography. The collective consisted of J. Doberský, O. Vrána, V. Häufler, O. Čepek, J. Dosedla, J. Kolář, V. Letošník and M. Střída (Doberský 1951). However, the term societal geography did not catch on. The term economic geography became more prominent. In a balance article published in the GJ in 1960, behind which the manuscript of K. Ivanička can be identified, was this development reflected as follows: *"Since 1948, a contradiction between the old conception of geography and the new requirements of practice and teaching has been formed. This was especially true of anthropogeography, which in its methodology, its approach to the problems studied, and its overall focus was still linked to the interwar period. Most anthropogeographers were unfamiliar with dialectical materialism and political economy. Soviet geographical works came to us in insufficient quantity and were studied mostly superficially.... Anthropogeography, both in its form and content, became an obstacle to further development. It did not study the distribution of productive forces, in which it often saw the main moments of the development of society, but on the other hand it paid too* *much attention to the effect of the environment on society. Its difference from the conception of the subject of study by economic geography, which already in form focused on the main moments of society's life, i.e. on production and, depending on the productive forces and states of production, on other problems in the field of superstructure, was becoming more and more obvious. For these reasons, in the people's democratic countries, following the example of the USSR, both the term anthropogeography and its focus began to be abandoned, and the main emphasis was given to economic geography, understood primarily as the geography of production*" (Redakcia 1960, p. 81-2).

Members of the older generation, however, perceived these developments somewhat differently. This is well represented by the opinion of J. Hromádka, presented at the conference in 1953 in Liblice: *"....economic geography has reached the same position in anthropogeography as geomorphology has reached in physical geography. Most recently, it has even claimed a superior position, seeking to take over other branches of general anthropogeography as well as regional geography into its field*" (Hromádka 1954, p. 31).

CONCLUSION

In our paper we have pointed out the manifestations of the emergence of Marxist discontinuity in Czechoslovak geographic thought. As a theoretical-methodological framework for our investigation, we applied the Latour-Barnes model of the disciplinary change. On the basis of content and discursive analysis of texts published in the two most important geographical periodicals, *Sborník Československé společnosti zeměpisné* and *Geografický časopis*, we found differences in the course of the mobilization and autonomization stages of the Marxist discontinuity in Czech and Slovak geography. In Czech geography, the onset occurred practically immediately after the onset of the communist regime in 1948. This is evidenced by the rejection of anthropogeography at Charles University in 1949 and a series of propaganda articles published in the most important Czech geographical periodical. The leading participants of this phase were predominantly members of the young generation of Czech geographers - V. Häufler, M. Macka, M. Střída. From the older generation, J. Pohl - Doberský and from the middle generation M. Blažek were more prominent. In Slovakia, the onset of Marxist discontinuity was delayed, which was related to the influence of several factors. One of them was the great authority of J. Hromádka, who educated the first generation of Slovak geographers. Hromádka did not show much effort to accept the new paradigm, which resulted in his gradual marginalisation. Most of his pupils either only formally tried to register the onset of the sovietization of Slovak geography, or preferred to focus on physical geography, which was not affected by the ideological indoctrination of Marxism. After the tightening of the personnel policy and the purges at Slovak universities in 1957-1958, Marxism managed to take root in Slovak geography as well, and

K. Ivanička, as a representative of the rising generation of geographers, was the one who contributed most to this. However, discursive analysis of the texts shows that even he did not use such a militant and propagandistic vocabulary as his Czech counterparts at the beginning of the 1950s. The onset of Marxist discontinuity led to the rejection of anthropogeography and its replacement by economic geography, whose main task was to investigate the distribution of productive forces within the conceptual framework of dialectical and historical materialism. Applications of economic geography in regional and spatial planning were also developed.

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ASSESSING THE ECONOMIC IMPACT OF TOURISM AND VERDICT ECOTOURISM POTENTIAL OF THE COASTAL BELT OF PURBA MEDINIPUR DISTRICT, WEST BENGAL

Aditi ACHARYA [A*], Ajey Kumar PATHAK [B], Biraj Kanti MONDAL [C], Pratik DASH [D], Tuhin BHADRA [E]

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Abstract
The study focused on the economic impact of tourism and ecotourism potential. The present submission attempts to record community perspectives and to analyze the nature of impact, status of tourism and potentiality of ecotourism of the coastal belts of Purba Medinipur district, West Bengal, by employing primary survey and secondary database along with the application of various statistical methods and geoinformatics technique. An investigation of CRZ (Coastal Regulation Zone) norms provides maximum violation along the coastline of Mandermoni beach in the 'No Development Zone', because of establishments of beach resorts and hotels of above 58.40%. Furthermore, the SWOC (Strength-Weakness-Opportunity-Challenges) analysis of the beaches of the Dakshin Purushottampur village coastal belts revealed that Soula and Changasuli have vivid and varied natural strengths for ecotourism. To assess the economic impact of tourism, the exploratory factor analysis (EFA) of the variables using principal component analysis (PCA) provided four factors from 18 variables representing 78.76%, 68.02%, 38.18% and 2.78% dissent. The critical analysis employed in the current endeavor revealed that the potentiality of ecotourism of the coastal belts of Purba Medinipur district and it will helps in the formulation of the future plans, strategic improvement and prospective road map heading towards the development of sustainable tourism.

A* Department of Geography, Adamas University, Kolkata-700126, India
https://orcid.org/0000-0001-8408-8836
aditidst@gmail.com (corresponding author)

B ICAR - National Bureau of Fish Genetic Resources, Dilkusha PO, 226002 Lucknow, India
https://orcid.org/0000-0002-8496-4514
birajmondal.kolkata@gmail.com

C Department of Geography, Nataji Subhas Open University, Kolkata, India
https://orcid.org/0000-0002-5010-0224
pathakajey@gmail.com

D Department of Geography, Khejuri College, Purba 721431 Medinipur, India
https://orcid.org/0000-0001-5290-2784
pratik.bidyut@gmail.com

E Department of Geography, Adamas University, 700126 Kolkata, India
https://orcid.org/0000-0003-0493-2078
tuhin.bhadra@adamasuniversity.ac.in

Key words
Tourism development, exploratory factor analysis, PCA, SWOC, CRZ.

INTRODUCTION

Globally, tourism has immense significance in improving the economic sector. Thus, this sector is growing very fast and new forms of tourism are approaching in a more attractive way. Among the various tourism, ecotourism is known for its sustainability and it came in reaction of traditional mass tourism. Mass tourism, which is a part of a historical construction and the most significant travel trend now a day, involves a huge group of people going to the same place often at the same time (Theng et al., 2014). It has been observed that due to massive concentration of visitors, the mass tourism affects economic, social, cultural and ecological factors in the host country. Undoubtedly, from mass tourism, an enormous amount of positivity comes and revenue is incurred, but in many cases, the impact of mass tourism has often negative. Though the mass tourism generates the interesting volume of tourism revenues in terms of jobs and economic growth, it leverages other problems locally like, revenue leakage and distribution. Not to mention that, the overcrowding caused by mass tourism affects the environmental balance too. Because of these reasons, alternative tourism approaches are being developed and the more emphasis is given to sustainable tourism development. Ecotourism involves the responsible travel to the natural areas, conserving the environment, and improving the well-being of the neighbouring people. Ecotourism is a form of tourism involving visiting of the fragile, pristine, and relatively uninterrupted natural areas often intended as a low impact and petite scale. Thus, the present study is intended to the economic impact of tourism as well as ecotourism potential in the coastal regions of India. Worldwide, many studies have been done in the past to evaluate the economic impact of tourism in the host countries. In many cases, studies were finished using the economic models of input-output analysis (Fletcher, 1989) and more recently investigating the resident's perceptions of the economic effects on their lives and communities. Ecotourism has been perceived widely as a nature based form of tourism embodying the virtuous traits that standard commercial mass tourism lacks. Earlier, much attention was paid to what constitutes the ecotourism and to substantiate numerous concepts and definitions exist (Ballantine and Eagles, 1994, Blamey, 1995; Bottrill and Pearce, 1995; Buckley, 1994; Koščová and Koščová, 2017; Sumarmi et al., 2021). In totality, ecotourism is a form of nature based tourism that strives to be ecologically, socio-culturally and economically sustainable while providing opportunities for appreciating and learning about the natural environment or specific elements thereof. Since the ancient times, tourism is one of the important industries for economic development, especially in the developing countries, significantly having a large contribution towards earning of foreign exchange, gross domestic products and employment opportunities (De Kadt, 1992). The tourism industry of India is one of the most significant contributors to the world's GDP, ranking 7th as reported by the World Travel and Tourism Council. The state West Bengal of India has a great platform and portfolio of diverse tourism, and ecotourism has come up in terms of sustainable and alternative tourism deviating from mass tourism as it has enormous potential to cultivate and produce revenue, as they come up in recent years (Abed et al, 2011; Bunruamkaew, 2011; Reihanian et al, 2012; Dowling, 2013; Darabkhani, et al, 2014; Mihret and Yohannes, 2015). The present study area, i.e. coastal belts of Purba Medinipur district is a popular tourist destination and often considered as one of the most notable place for mass tourism over the couple of years. Still, most of the tourists of these areas are unsatisfied with the existing tourism infrastructure and often look for some alternative tourism in new as well as better forms. This development of fresh initiatives should be the integration of local populace and natural environment, both, for sustaining tourism in this area that provides the opportunity for ecotourism.

There are some works related to the impact analysis and ecotourism on the other places (Kumari et al., 2010; Mitra et al., 2013; Dandapath and Mondal, 2013; Banerjee, 2014; Bhaya and Chakrabarty, 2016; Ghosh and Ghosh, 2019), but no previous works have been done in this area before. Thus, the present study is designed for developing future tourism based on the ecosystem sustainability by focusing on conservation of the nature and local traditional culture and providing opportunities to the local inhabited community by implementing geoinformatics and statistical processes. Therefore, to assess ecotourism potential and economic impact of tourism in Dakshin Purushottampur village of Purba Medinipur, Strength-Weakness-Opportunity-Challenges (SWOC) analysis was carried out for all the available tourist spots and stratified random sampling technique was adopted for the household survey to collect the data in the current effort. Moreover, based on the local resident perceptions, an effort was completed to assess positive as well as negative economic impacts of tourism development in this region. Furthermore, an investigation was done to assess the level of violation of the Coastal Resource Zone (CRZ) norms in the beaches. The prime aim of the current effort is to evaluate the economic impact of tourism and the verdict of the ecotourism potential of the coastal belts of Purba Medinipur district. The significance of the current study lies in the fact that Purba Medinipur district, especially the Dakshin Purushottampur village is facing a tremendous dilemma of being one of the most notable place for mass tourism, which is experiencing rapid tourism development since past 20 years and hoping for an alternative tourism aspect. The statistical analysis attempted in the present submission will definitely be able to nailed out the nature of impact, status of tourism and find out the potentiality of ecotourism of the coastal belts of Purba Medinipur district and it will lead the region to the future of sustainable tourism.

OBJECTIVES

To assess the nature of impact of tourism by recording community perspectives and to portray the potentiality of ecotourism in the coastal belts of Purba Medinipur district, West Bengal.

DATA AND METHODS

Study Area

The present study includes the coastal blocks of Purba Medinipur district, West Bengal, covering parts of Ramnagar-I and II and Contai-I and Deshopran blocks, extending from 21˚36′40″N to 21˚53′37″N latitude and 87˚28′57″E to 87˚53′15″E longitude. Purba Medinipur district lies to the south of the Tropic of Cancer and the Bay of Bengal forms the southern boundary (Fig. 1). Physiographically, this is a coastal tract of Bay of Bengal. The Medinipur coastal belt belongs to the western part of Hugli River historically and geographically forms a contiguous part of deltic Sundarbans and is of immense global importance (Chakraborty, 2010). According to the Department of Tourism, Govt. of West Bengal, significant tourist spot on this coastal belts are New Digha, Old Digha, Mandarmoni, Sankarpur and Tajpur, which are manifest as imperative commercial areas.

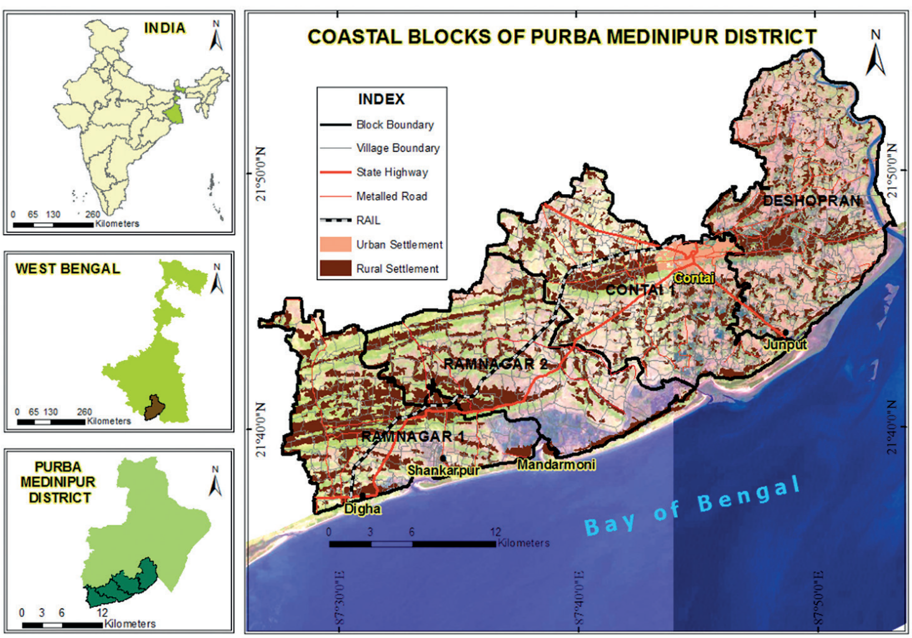

Fig. 1
Location of the study area with the transport infrastructure and settlement focus

The coastal stretch of this district constitutes part of the meso-tidal Balasore-Contai coastal plain. This region is geographically characterized by the presence of successive rows of dunes and beach ridge with intervening clayey tidal flats due to fluctuations in the sea level during the Holocene time. The ancient dune belt running from west to east stretches over Paniparul to Contai and indicates the position of the ancient strand line (about 6000 Y.B.P.) in the coastal tract of West Bengal (Chakrabarti, 2010). There are several discrete tidal creeks in the coastal tract of this district, viz. Ramnagar Khal, Jhalda creek and Pichaboni Khal. These tidal creeks physically divide the Purba Medinipur coastal plain (Digha-Junput) into four sectors; Digha, Shankarpur-Chandpur, Dadanpatrabar and Junput from west to east. Out of these, only new and old Digha area has few facilities to afford the tourist influx. It is mentioned as the 'Brighton of the East' in one of Warren Hastings' letters (1780 AD) to his wife. His writings about Digha slowly started giving exposure to this place. Afterwards, the Digha beach resort was developed after independence by the initiation of West Bengal's Chief Minister Dr. Bidhan Chandra Roy. The main attraction of Digha is the flat, hard beach, which stretches for miles and it is considered as one of the widest beaches in the world.

Methodology

The current study followed suitable methodological steps for the collection of primary data and employment of secondary data, which was illustrated by the graph (Fig. 2):

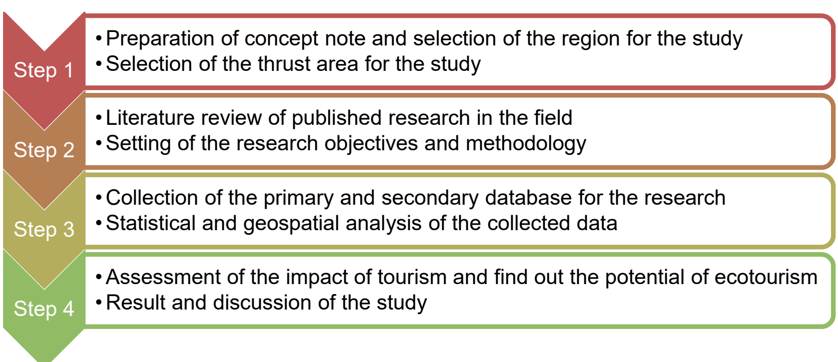

Fig. 2
Structural framework of the study

Data collection

A structured questionnaire-based survey form was designed to collect the data and explore the local resident's perceptions on the economic impacts of tourism development in Dakshin Purushottampur village. The collected data were analyzed in three sections; concept, respondent's background and statement about tourism impact. The respondents were given 18 questions on economic impacts of tourism based on a 5 point Likert scale where 1 represented "strongly disagree" and 5 represented "strongly agree". The sample size was selected using the methodology proposed by Yamane (1967), which is explained below:

$$n = N / [1+N (e^2)]$$

(Where n = Sample size, N = Population size, e = Level of precision)

By assuming 95% confidence level and ±5% precision level, the number of population in the Dakshin Purushottampur village (N=2,394) was used in the calculation and sample size of 150 respondents was obtained. During the data collection, the stratified random sampling approach was used to select the respondents that represented the whole group of the population living in three different types of age group within the Dakshin Purushottampur village. The sampling structure was designed to obtain a better degree of representatives from the local residents and achieve a broad range of representatives from the whole population of that village. The actual population in every district is based on the 2011 census data published by the Government of India. Therefore, based on the 150 sample size (one sample from one household), data collected from January to April 2018 was done through face-to-face interviews with the selected respondents (Tab. 1). A spot check was done at the survey locations to confirm the validity of the survey. In totality, after four months, 145 questionnaire forms from 150 respondents were collected, one respondent representing one household and selected for further analysis, as the five questionnaire forms were eliminated due to improper reply by the respondents in the given questionnaires.

Tab. 1 Stratified sampling frame of the study area

Location	No. of Household	Population	Stratified Random sampling	Sample size
Dakshin Purushottampur	476	2394	2394 x 150	150

Source: Authors

SWOC analysis

Purba Medinipur coastal belt has many places of tourist interest and therefore it often encourages mass tourism by providing attractive and friendly environment. To assess the satisfaction level of the tourists on the available facilities provided to them, a factor-wise satisfaction index was intended and areas requiring special attention were identified. This was done by identifying all the available spots and then analyzing the characteristics of the spots by SWOC analysis. Taking a good number of factors listed (Tab. 2), the SWOC analysis was carried out based on the weighted score. The analysis includes scope for improvement by including more options of strategic management to provide sustainable ecotourism.

Tab. 2 Factors of SWOC analysis

Strengths (S)
S1-Existing Transport facility (mainly major pucca road to beach distance); S2- Scenic Beauty; S3- Beach length (max.); S4- Beach to village distance; S5- Cyclone rescue centre from natural disaster, distance form beach; S6- Existing infrastructure facility (like electricity, toilet, drinking water) S7- Cultural perspective (local cultural occasion); S8- Tourist interest for ecotourism (mainly people visiting Digha, Shankarpue, Mondarmoni, Tajpur); S9- Nearest town/railway station distance; S10- By road nearest Town distance
Weaknesses (W)
W1-People's interest in other occupation (like seasonal tourism/other); W2- People perspective, mainly willingness for tourism; W3- Local people' interest (mass/ eco-tourism); W4- Local people educational structure; W5- Local people occupational structure; W6- Local people's satisfaction for their income; W7- Local people's interest for skill upgradation and capacity building (tourism perspective)
Opportunities (O)
O1- Seasonal tourism (December to march); O2- Temporary accommodation facility (tent); O3- Biotoilet; O4- Filtered drinking water; O5- Beach beautification (lighting and seating, temporary); O6- Solid waste and sewage treatment plant; O7- Open the canteen and tent delivery for food; O8- Water sports (boating, ski); O9- Sun bath facility; O10- Sea food; O11- Local handicraft workshop / documentary film on fisherman/ photography
Challenges (C)
C1- Medical and other facility; C2- Sanitation and cleanness; C3- Police and administrative help; C4- Online weather forecasting monitor; C5- Security alert

Principal Component Analysis and Exploratory Factor Analysis

The mass resident's perception for assessing impacts of tourism development has been examined in several studies in the recent years. In this regard, principal component analysis (PCA), which is a dimension / variance reduction technique, shares many similarities with exploratory factor analysis (EFA). Here, the variables of PCA have been chosen based on the importance and their liability for ecotourism potentiality as found from some literature (Abed et al, 2011; Kumari et al., 2010; Bhaya and Chakrabarty, 2016; Mirhat and Yohannes, 2015; Reihanian et al., 2012).As the considered variables are going to analyze the economic impact and scope of ecotourism, thus all these are grouped into four factors, like economic benefits, higher cost of living, support to local economy and economic barriers. For economic impact analysis (EIA) of tourism development, EFA of event variables was completed using the PCA method to examine the effect of different events on the economy of the tourist spot beaches in Dakshin Purushottampur village. In the analysis, the local tourism industries from the perspective of both, direct and indirect impacts were considered. It includes employment, value added and revenue generated by the tourism industry or a supplier to the industry as well as the market segments of the tourism industry (hotels, vacation homes and timeshare properties). This method was used in the present study to assess the economic impact. For ordinal variables used in PCA include a wide range of Likert scales, like- 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree. There are a few methods to detect sampling adequacy: the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy for the overall data set; and the KMO measure for each variable. For PCA analysis, Statistical Package for Social Sciences (SPSS) software (Version 20) was used.

RESULTS

Demographic attributes

Before going into the detail analysis of economic impacts of tourism in the study area by SWOC analysis or factor analysis, it is imperative to know the demographic attributes to better understand the nature of inhabiting community and their perceptions. Therefore, the variation of population growth and population increasing

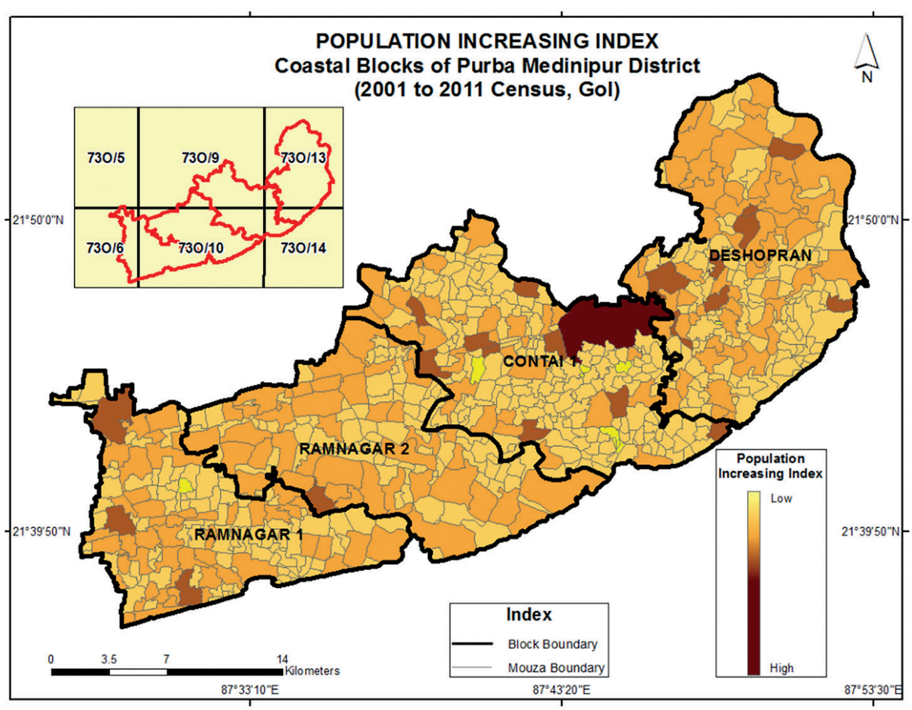

Fig. 3a
Population Increasing Index

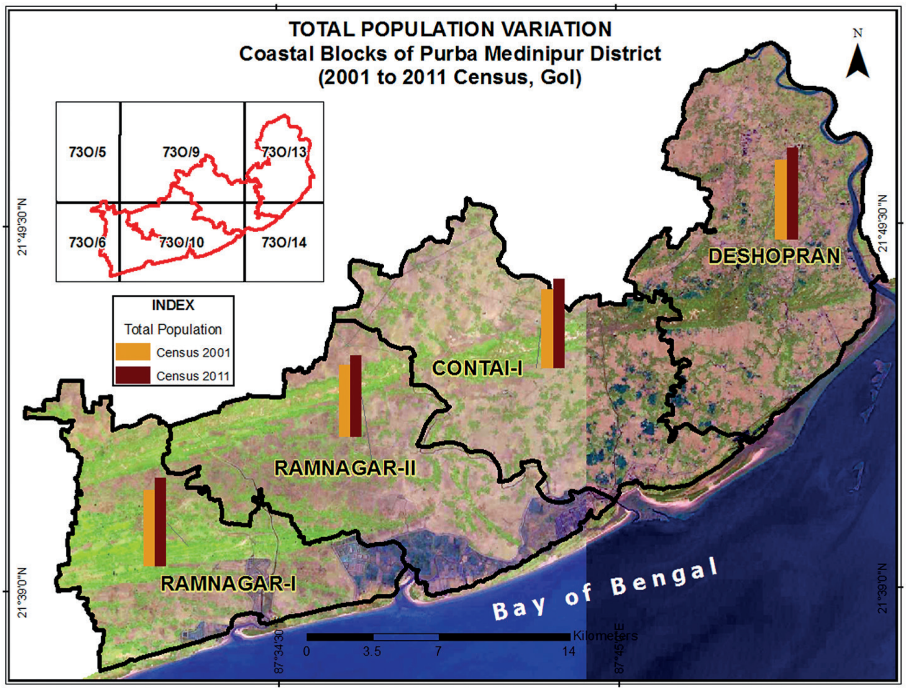

Fig. 3b
Total Population Variation

index from 2001 to 2011 census of the study area at nose level (lowest administrative unit) was spatially mapped and analyzed. From the figures (Fig. 3a and 3b), it could easily be understood that the population increasing trend is continuing in the mouzas close to beach area to facilitate the tourism by the inhabited community and through which they can earn good revenue. According to census 2001 to 2011 report, level of urbanization increased to 3.35% due to the natural growth as well as migration of rural population to the nearest urban places for better income opportunity, mostly related to tourism. The illustrated map reveals that the changes observed in the population increasing pattern is closely related to tourism because near about 1 lakh of foreign and about 25 lakh of domestic tourists visit this coastal tourist spot every year.

Characteristics of respondents

A total of 145 respondents were involved in this study, of which 66.9% were male and 30.1% were female (Tab. 3). The age of the respondents ranged from 20 to 60 years and above also. The highest number of respondents age group varies between 20 and 40 years (49.66%). About 42.07% respondents were of the ages between 41 and 60 years; and 8.28% respondents were 60 years and above. An analysis on profession of the respondents was also conducted and it revealed that 6.21% as student; 33.79% as fisherman; 30.34% as fisherman and per day worker; 8.28% as farmer; 16.55% as per day worker and 4.83% in other professions. In respect of academic attainments of respondents, the highest academic attainment was bachelor degree viz. Bachelor in Arts and Bachelor in Technology. Some respondents have academic attainment of primary level and below. A factor analysis of the respondents (n=145) is presented in a table (Tab. 2) and this table provides the educational, professional and monthly income details on different types of respondents. A large number of respondents (83.4%) have monthly income ranges from Indian Rupee (Rs.) 4000 to 8000. The respondents having income more than Rs. 8000 are meager.

Tab. 3 Respondents' profile

Variables	n (145)	%	Variables	n (145)	%
Gender			Profession		
Male	97	66.90	Student	9	6.21
Female	48	33.10	Fisherman	49	33.79
Age			Fisherman and Per Day worker	44	30.34
20-40	72	49.66	Farmer	12	8.28
41-60	61	42.07	Per Day worker	24	16.55
60 above	12	8.28	Other	7	4.83
Education			Monthly income		
Primary school or lower	15	10.34	Under 4,000 Rs.	13	8.97
Secondary school	59	40.69	Rs.4,000 to 6,000	63	43.45
High school	57	39.31	Rs.6,000 to 8,000	58	40.00
Higher Education (B.A. and B.Tech)	14	9.66	More than Rs.8,000	11	7.59

Source: Authors

Perception of respondents on impact of tourism

The perception of respondents about positive economic impacts of tourism development was evaluated and it provides a mean value of 4.36 (Tab. 4). The analysis also revealed that most respondents agree that 'tourism improves local economy' (mean= 4.17) and 'local residents earn greater income' (mean= 4.83). The lowest mean value (3.33) was found for 'gain of the local people from rent'.

Tab. 4 Respondents' perception of the positive economic impact

Positive impacts to economy	Mean	S.D.	Rank	Variability
Local residents intension for greater income	4.83	0.67000	1	13.87
Improvement of local economy	4.17	0.84984	2	20.38
Open up new business opportunities	4.33	0.62361	3	14.40
Local peoples' income from selling local products	4.25	0.73598	4	17.32
Bringing more investment in local areas	3.83	0.47140	5	12.31
Increase in tax revenues	3.75	0.54006	6	14.40
Local employment opportunity	3.75	0.35355	7	9.43
Improvement in public utilities infrastructure	3.67	0.42492	8	11.58
Local peoples' income through rent	3.33	0.71686	9	21.53
Scale: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				

Source: Authors

Onwards, the perception of respondents about negative economic impacts from tourism development was also carried out and it provides aggregate mean value of 2.45 (Tab. 5), which is almost 50% of the aggregate mean value of positive economic impacts from tourism. The respondents agree that 'tourism increases price of land' (mean= 3.25), and 'increases local residents' cost of living' (mean= 3.08). The lowest mean value is found for 'jobs may pay low wages' (mean= 1.42).

Tab. 5 Respondents' perception of the negative economic impact

Negative impact to economy	Mean	S.D.	Rank	Variability
Increase in price of land	3.25	0.20412	1	6.28
Increase in local residential cost of living	3.08	0.11785	2	3.83
Competition for land with other economic uses	3.00	0.35355	3	11.79
Increase in price of goods and services	3.00	0.40825	4	13.61
Increase in road maintenance and transportation system costs	2.58	0.31180	5	12.09
Requirement of specialized labour for tourism related services	2.33	0.23570	6	10.12
Profit goes to foreign investors	1.92	0.65617	7	34.18
Cost for additional infrastructure (water, power, etc.)	1.50	0.70711	8	47.14
Jobs may pay low wages	1.42	0.58926	9	41.50
Scale: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				

Source: Authors

Outcomes of Principal Component Analysis (PCA) and Exploratory Factor Analysis (EFA)

Furthermore, 18 items describing the economic impact of tourism development were subjected to the EFA using PCA. The Barlett's Test of Sphericity showed a statistical significance with the Kaiser-Mayer-Olkin value of 0.731, exceeding the recommended value of 0.6 to conduct a factor analysis (Hair et al., 1995).

1st Factor - Economic benefits: The factor analysis was prepared to investigate the perceptions of respondents on the economic impacts of tourism development in Dakshin Purushottampur village. As shown in table (Tab. 6), the first factors of "economic benefits" loaded with six sub-factors were analyzed. The analysis suggested that factors in the 1st phase 'local people incomes from selling local products', 'improvement of local economy' and 'local residents' intention for greater income' are in the similar trend in the 2nd phase also.

Tab. 6 Factor analysis of 'Economic benefits'

Major Factor	Sub Factors	Rotated Component Matrix		Initial Eigen values		
		1st Phase (Barrier 0.90)	2nd Phase (Barrier 0.80)	Total	% of Variance	Cumulative %
Economic benefits	Local residents intension for greater income	0.118	0.967	4.081	68.019	68.019
	Local people income from selling local products	0.949	-0.155	1.021	17.022	85.04
	Bringing more investment in local areas	0.825	0.283	0.477	7.952	92.992
	Improvement of local economy	0.954	0.146	0.225	3.755	96.747
	Local employment opportunity	0.788	0.411	0.168	2.794	99.541
	Open up new business opportunities	0.837	0.22	0.028	0.459	100

Source: Authors

Plotting the variables/sub-factors of 1st phase and 2nd phase into 'x' and 'y' axis respectively as component 1 and 2, a graph was prepared using PCA as the extraction method on rotation basis (Varimax with Kaiser Normalization) preparing the component matrix (Fig. 4a). Here both positive and negative ranges of each variable were taken into consideration and it was found that all the variables are positive, except the variable 2, i.e. the income of local people from selling local products, which is negative. It means that tourism generates numerous economic benefits to the local residents of beaches. However, there is a threat, if no variation comes in the local product in the 2nd phase, because of its decreasing trend. The 2nd phase has considerable impact by 'local resident's intention for greater income' and those people who are promoted by the tourism will be deteriorated day by day, if the local level skill labors are not created.

2nd Factor - Higher cost of living: The second factor of "higher costs of living" includes four sub-factors; 'increase in price of land', 'increase in the price of goods and services', 'increase in the local residential cost of living' and 'Competition for land with other economic uses' (Tab. 7). In the 1st phase, 'increase in the price of land' and 'increase in the price of goods and services' and the 'competition for land with other economic uses' are in the increasing trend, which continues in the 2nd phase. Plotting the variables/sub-factors of 1st phase and 2nd phase into a graph using PCA as the extraction method (Fig. 4b), it reveals that here all the variables are positive. It means that tourism increases costs of living for the local residents of the beach and makes it higher. In the 1st phase, the 'increase in the price of land' and 'increase in the price of goods and services' are the reasonable factors for 'competition for land with other economic uses' in the 2nd phase and thereby create the land diversity.

Tab. 7 Factor analysis of 'Higher cost of living'

Major Factor	Sub Factors	Rotated Component Matrix		Initial Eigen values		
		1st Phase (Barrier 0.90)	2nd Phase (Barrier 0.90)	Total	% of Variance	Cumulative %
Higher costs of living	Increase in price of land	0.711	0.419	2.697	67.424	67.424
	Increase in price of goods and services	0.911	0.197	0.752	18.807	86.231
	Increase in local residential cost of living	0.955	0.132	0.44	10.991	97.222
	Competition for land with other economic uses	0.197	0.965	0.111	2.778	100

Source: Authors

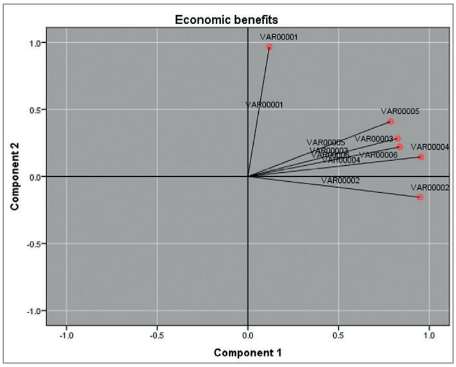

Fig. 4a
Factor analysis of economic benefits

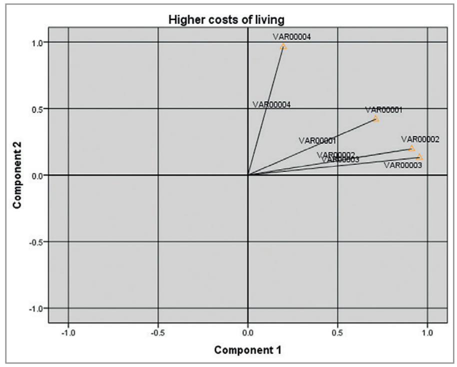

Fig. 4b
Factor analysis of higher costs of living

3rd Factor - Support to local economy: The final factor "supports local economy" was analyzed (Tab. 8) with three sub-factors; 'local peoples' income through rent', 'improvement in public utilities' infrastructure' and 'increase in tax revenues'. It reveals that most of the variables are positive in both the phases and the trend of factors 'increase in tax revenues' and 'local people income through rent' is same in 1st and 2nd phase both. Further, the factor 'tax revenues' is seen getting incised in the 1st phase, therefore 'local people income through rent' increased in the 2nd phase. It signifies that the tourism support the local economy to a great extent and development of ecotourism will able to enhance this support as the local community involved largely and this will also improve their household infrastructure and allied incentives.

Tab. 8 Factor analysis of 'Support to local economy'

Major Factor	Sub Factors	Rotated Component Matrix		Initial Eigen values		
		1st Phase (Barrier 0.90)	2ndPhase (Barrier 0.80)	Total	% of Variance	Cumulative %
Support the local economy	Local peoples' income through rent	0.311	0.944	2.363	78.762	78.762
	Improvement public utilities infrastructure	0.806	0.5	0.469	15.635	94.397
	Increase in tax revenues	0.942		0.168	5.603	100

Source: Authors

4th Factor - Economic barriers: The third factor of "economic barrier" was analyzed (Tab. 9) using five sub-factors; 'cost for additional infrastructure (water, power, etc.)', 'jobs may pay low wages', 'requirement of specialized labour for tourism-related services', 'profit goes to foreign investors' and 'increase in road maintenance and transportation system costs'.

Tab. 9 Factor analysis of 'Economic barriers'

Major Factor	Sub Factors	Rotated Component Matrix			Initial Eigen values		
		1st Phase (Barrier 0.80)	2nd Phase Barrier 0.80)	3rd Phase (Barrier 0.90)	Total	% of Variance	Cumulative %
Economic barriers	Cost for additional infrastructure (water, power)			.987	1.909	38.18	38.18
	Jobs may pay low wages	.848	-.125	.290	1.372	27.43	65.61
	Requirement of specialized labour for tourism related services	.920	.125		0.951	19.019	84.629
	Profit goes to foreign investors	.309	.834		0.504	10.077	94.706
	Increase in road maintenance and transportation system costs	-.352	.796		0.265	5.294	100

Source: Authors

The 'profit goes to foreign investors' factor has an increasing trend in the 2nd phase also. The other factor 'increase in road maintenance' and transportation systems costs' shows the negative trend in the 1st phase and positive trend in the 2nd phase. Thus, in this context, the planning should consider development and barriers. The 2nd phase is promoting local investors and this phase includes threat, which is 'profit goes to foreign investors'. That is why 'cost for additional infrastructure (water, power, etc.)' is increasing in the 3rd phase.

The principal component analysis of all the four components as described in the tables (Tab. 6, 7, 8 and 9) provides the eigenvalues exceeding to vary between the factors respectively (Tab. 10). This table highlights the factors responsible for creating economic impact by tourism development in different phases from economic benefit leading to higher living cost, next to economic cost and finally supporting the local economy.

Tab. 10 Exploratory factor analysis of four factors using principal component analysis

Factor of participation problem	Factor loading			
	1	2	3	4
Economic benefits				
Local residents intension for greater income	0.967			
Improvement of local economy	0.954			
Local people income from selling local products	0.949			
Open up new business opportunities	0.837			
Bringing more investment in local areas	0.825			
Local employment opportunity	0.788			
Higher costs of living				
Competition for land with other economic uses		0.965		
Increase in local residential cost of living		0.955		
Increase in price of goods and services		0.911		
Increase in price of land		0.711		
Support to local economy				
Local peoples' income through rent			0.944	
Increase in tax revenues			0.942	
Improvement in public utilities infrastructure			0.806	
Economic barriers				
Cost for additional infrastructure (water, power, etc.)				0.987
Requirement of specialized labour for tourism related services				0.920
Jobs may pay low wages				0.848
Profit goes to foreign investors				0.834
Increase in road maintenance and transportation system costs				0.796

Source: Authors

Analysis of violation of Coastal Regulation Zone norms in beaches

The violation of Coastal Regulation Zone (CRZ) norms was reintroduced in 2011 and it was found more in Old Digha than New Digha. The beach resorts and hotels are found in the NDZ of Old Digha. The violation of CRZ was also observed in the Sankarpur coast, where coastal erosion is already a problem (Fig. 5a). The violation is apparently less in Tajpur, but the construction is still going on by diminishing the sand dunes beyond NDZ. The maximum violation of CRZ regulation was found along the coastline of Mandermoni as most of the beach resorts and hotels (above 80%) are developed in the NDZ area. The study area has massive influxes of tourists, often in a relatively small area, evade a huge impact. As a consequence, beach resorts and hotels are established and cover about 20.51% of the total CRZ area, which has tremendous detrimental effects in the long turn. Most of such beach resorts and hotels are situated in the Mandermoni coastal belt, which covers about 58.54% area of NDZ (Fig. 5b). Currently, these tourist spots are gradually developing, consequencing rapid and incessant sea beach erosion, which gradually causing the retreat of shoreline, as a result of which the people and place are in jeopardy. In this area, the tourism developmental activities, like building and road construction, concretizing embankment, vehicular movement, waste disposal, water usage, land use conversion incorporating the development of beach recreational facility and urbanization impose a negative impact on the target environment that includes land, aquatic life, air, noise etc. All these brunt on the land setting are changing the land use and land cover type, habitat loss, loss of species, deforestation, land degradation, change in groundwater level and beach erosion, which in totality increases the overall vulnerability of these beaches by violating the CRZ norms.

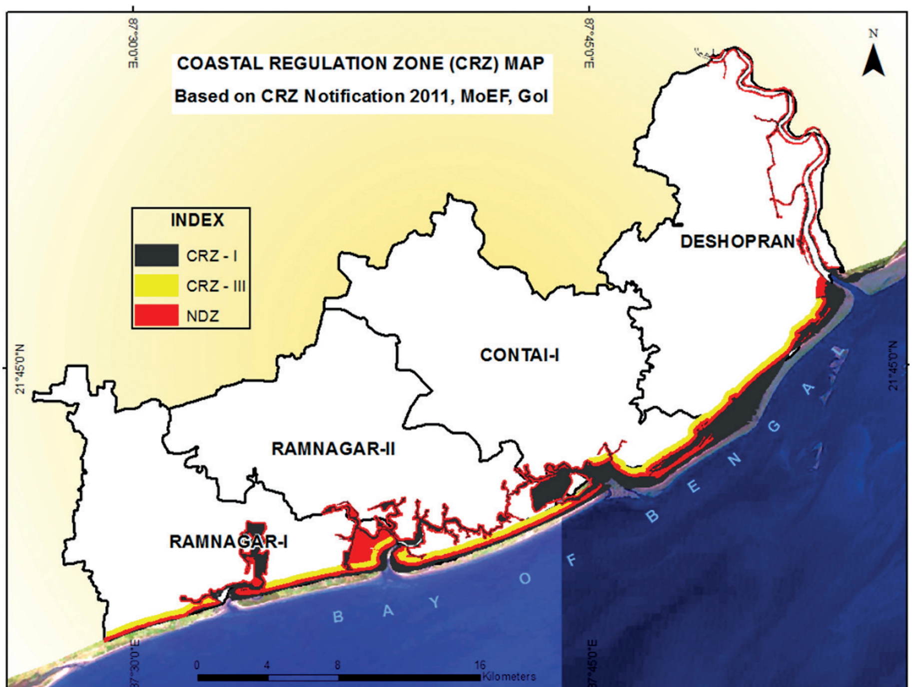

Fig. 5a
Coastal Regulation Zones (CRZ);

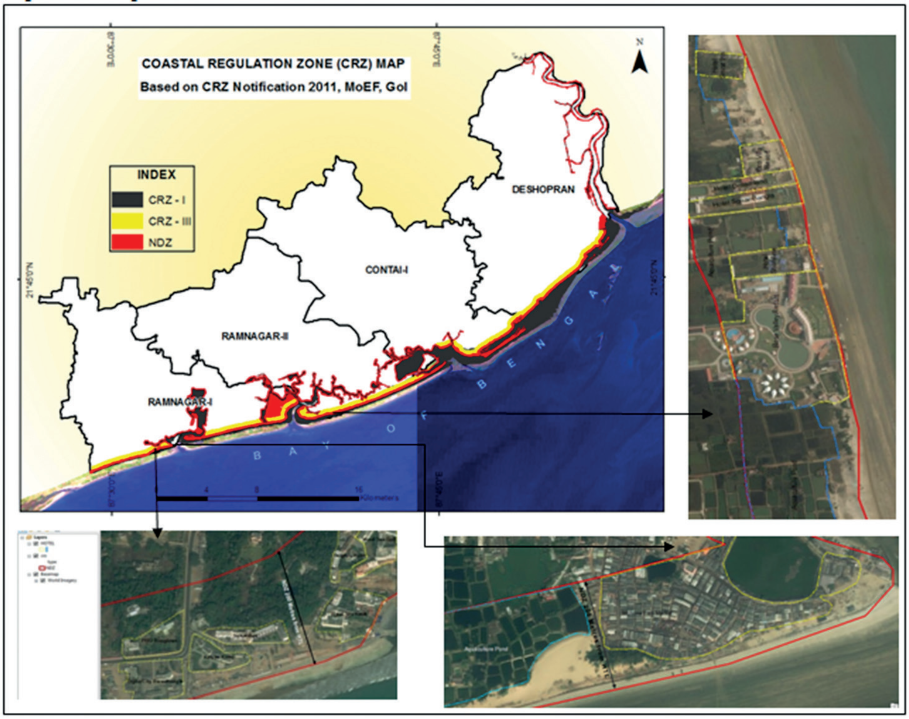

Fig. 5b
Encroachment in CRZ area

SWOC analysis of beaches

In the coastal belts of Purba Medinipur, the study of the satisfaction level of tourists on the available facilities reveals that tourists are satisfied with the existing facilities at New Digha, Old Digha, Shankarpur, Tajpur and Mondermoni. A general dissatisfaction with the drinking water facility, parking and conveniences facilities was observed.

Therefore, it is necessary to expand the scope of recreational facilities as these places get overcrowded during the peak seasons. Thus, to find out the alternate tourist spot, firstly it is necessary to identify all the available spots. As shown in the figure (Fig. 6), local names of the available beaches from the western side are Jaladha, Soula and Changasuli, Haripur, Junput, Bhogpur and Bankiput. Among these, Jaldha is presently suffering from the coastal erosion. Further, Haripur, Junput, Bhogpur, and Bankiput are fully covered with sandy clay and the beach communication from the nearest Contai town is poor. The well-established tourism destination with a variety of natural attractions and unique culture of local people having antique culture are the strengths of Soula and Changasuli beaches. The major drawbacks of these beaches are the lack of infrastructure and fundamental facilities.

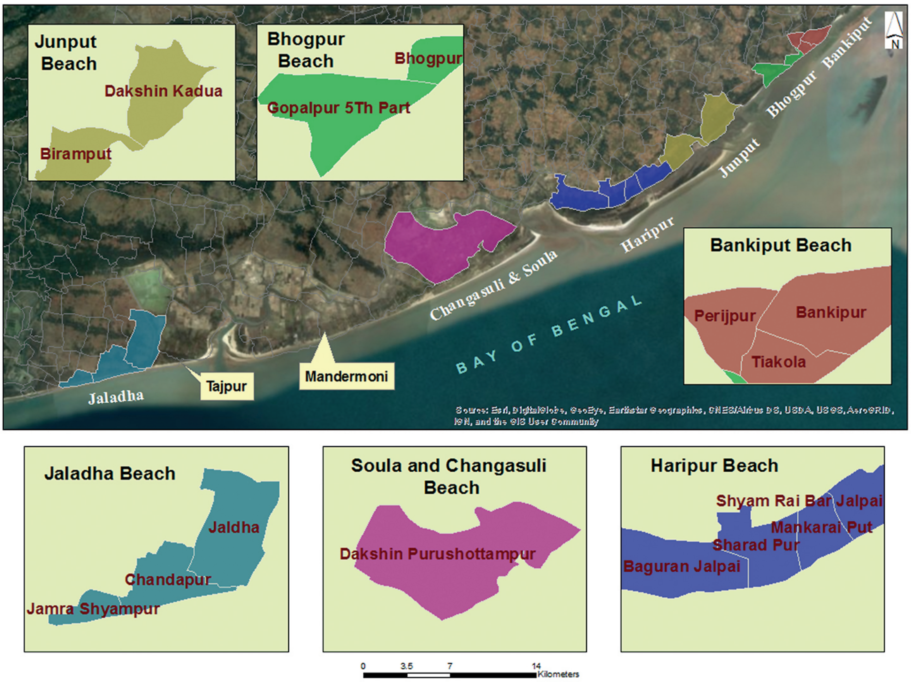

Fig. 6
Beaches of tourist interest

The Strength-Weakness-Opportunity-Challenges (SWOC) analysis was employed to depict the overall scenario of the economic impact of tourism and potentiality of ecotourism in the area. It reveals that these spots could be the first well-established tourism destination. The other most potential features of these beaches are their beach length, which is nearly 5 km, the distance from beach to village (Dakshin Purushottampur), which is about 150 m; the distance from the nearest town Contai, which is about 11 km (the road is under construction); a complete sandy beach suitable for water sports and Barunimela at Poush Sankrinti. These strengths are performing as the special attractions for tourists. The calculated values are plotted into a figure (Fig. 7), which displays the result of the SWOC analysis and highlights that Soula and Changasuli beaches have the greatest potential for sustainable ecotourism and strategic management. The other most significant places of potentials are Junput, Habibpur and Bankiput.

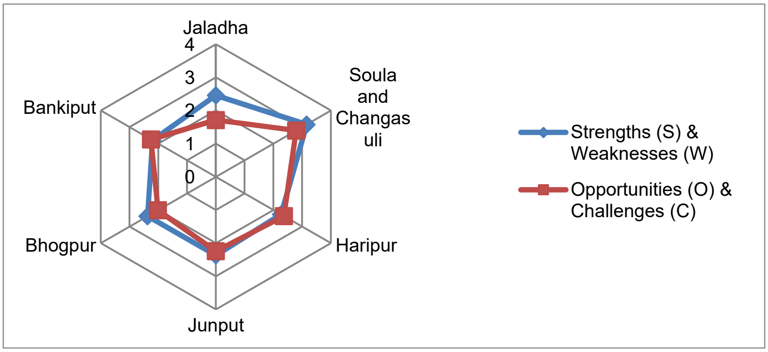

Fig. 7
SWOC analysis of different beaches

DISCUSSION

The SWOC analysis to find the ecotourism potential in the beaches of Dakshin Purushottampur village revealed that Soula and Changasuli, though lacks the infrastructure and fundamental facilities, they could be well-established as the tourism destinations with a variety of natural attractions and unique culture of local people having antique culture as major strengths. In other words, these beaches have utmost potential and resources for ecotourism development compared to the other beaches. By doing a factor analysis of the perceptions of the residents towards the impact of tourism on economic growth, it had been discovered that the respondents have a strong positive perception towards 'local residents earn greater income', 'improves local economy', 'increases price of land' and 'increases local residents cost of living'. This is because of the earlier fact that tourism was the most significant industry in the beaches of Dakshin Purushottampur village and local residents had more income from selling their products to tourists and their willingness of working in the tourism related jobs. The socio-cultural impact of tourism development on these coastal beaches have corroborated that local residents perceive tourism as a contributor for generating income; besides supporting them to upscale their education and skills.

The coastal tourism has already been identified by the government as a niche area with the potentiality to create employment opportunities for local communities and the other stakeholders and suggested that it should be viewed as a key growth sector. There are other studies, which highlight not only the environmental, socio-cultural, and economic impacts of tourism on societies and individuals (Ap and Crompton, 1998; Perdue et al., 1999; Spencer and Nsiah, 2013); but also the degree and nature of a local person's perception with tourism and tourists. These studies have found that that the tourism has a potent effect on their lives and the community both. In addition, the benefits and costs of tourism perceived by members of host communities were examined in several case studies such as Uganda (Lepp, 2007), Greece (Haralambopoulos and Pizam, 1996; Trakolis, 2001), Spain (Burns and Sancho, 2003; Pérez and Nadal, 2005), Belize (Alexander, 2000), Fiji (King, et al., 1993), British Columbia in Canada (Cooke, 1982), Arizona in the USA (Madrigal, 1993), Turkey (Var et al., 1985), and the Bahamas (LaFlamme, 1979), the Tanzania (Zacharia and Andindilile, 2020) and Uttarakhand Himalaya in India (Sati, 2020). Recognizing the importance of tourism activity for economic growth, many regional, national and international organizations are promoting tourism, defending its role and observed it as an instrument of economic development (UNCTAD, 2011; UNWTO, 2015; WTTC, 2010). However, few studies suggest that the tourism activity is not only brings the improvement in socio-economic conditions, instead it leads to a decrease in the society's welfare level (Lee and Brahmasrene, 2013, Sahli and Nowak, 2007, UNDP, 2011).

Thus, it is to wrap up that tourism in the current study area was regarded as a significant revenue generating industry for local residents and the development of ecotourism industry was recommended. However, the study observed some negative impacts on the local community, due to the increase in the 'prices of land and housing' and 'local resident's cost of living such as food, water and electricity bills'. In addition, from the respondent's view, tourism contributes to mass tourism, generating overcrowding of people, traffic congestion and overloading of key infrastructure such as water and power supply networks. Still the ecotourism is suggested based on the ecosystem sustainability by focusing on conservation of the nature and local traditional culture and providing opportunities to the local community in the decision making process. Besides, Digha is the only major tourist resort of West Bengal and it receives about 43% of the tourist flow of West Bengal. About one lakh foreign and 25 lakh domestic tourists visit this coastal belt throughout the year. Mandarmoni beach is a spectacular beach, which is named after the thousand of red crabs that crawl on the sands resembling the 'Mandar' flow. Shankarpur is a virgin beach as yet is a recent discovery. On the basis of environment, considering the rate of beach erosion at Shankarpur, the New Digha center can be developed as 'all weather beach resorts while Shankarpur may be developed as 'Winter beach resort' (for November-March). With the prime attraction of pristine sea beach fringed with a dense forest of tamarisk trees, Tajpur became the latest addition to the tourist map of Bengal.

CONCLUSIONS

The present study illustrates that tourism in the beaches of the Purba Medinipur coastal belts provides benefits to the local communities, involved in the tourism directly or indirectly. The ecotourism potential in the beaches of Dakshin Purushottampur village revealed that though Soula and Changasuli though lacks the infrastructure and fundamental facilities, they could be well-established tourism destinations with a variety of natural attractions and unique culture of local people having original and ancient culture as major strengths. In other words, these beaches have maximum potential and resources for ecotourism development compared to other beaches. The limitations of the study are limited sample size; selected variables of PCA and factors of SWOC analysis; thus it can be stated that the outcomes may be differ from other variables. Using of geoinformatics technique and factor analysis in the study, the positive economic impacts from the tourism were discovered, and they truly depicted by the perceptions of local communities. Furthermore, it revealed from the outlook of the residents towards economic impacts suggest that, respondents have a strong positive attitude towards the idea that 'local residents earn greater income', which 'improves local economy', 'increasing price of land' and henceforth increases the standard of living and 'increases local residents cost of living'. Finally, it is stated from the critical analysis employed in the current endeavour using statistical methods and geoinformatics that development in tourism proves beneficial for developing the local economy along with the increment in the local income. Moreover, the ecotourism has enormous potentiality heading towards sustainable tourism development, formulation and execution of apposite plans, strategic improvements leading to a prospective road map of the coastal belts of Purba Medinipur district.

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KÖPPEN-GEIGER CLIMATE SYSTEM CLASSIFICATION AND FORECASTING IN THAILAND

Nutthakarn PHUMKOKRUX [A*]

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Abstract
Köppen-Geiger Climate Classification system (KGC) is one of well-known climate classification method with only rainfall and temperature values. This study aims 1) to update current total monthly rainfall, average monthly temperature and KGC map of 1987 – 2019 period and 2) to predict total monthly rainfall, average monthly temperature and KGC map of 2020 – 2060 and 2061 - 2100 period. The study was extracted by gathering total monthly rainfall and average monthly temperature from 104 meteorological stations over Thailand then cooperated with GIS process to classify and present climate type of 1987 – 2019. Moreover, Beijing Climate Center Climate System Model version 1.1 (BCC-CSM1.1) was used to forecast rainfall and temperature value to determine climate zone of Thailand of 2020 – 2060 and 2061 – 2100 period. The results of present period illustrated that Thailand climate was classified into three types: dry-winter characteristics (Aw) as a major climate, following by Tropical monsoon climate (Am) and Dry-winter humid subtropical climate (Cwa). In contrast, predicted values displayed only "Aw" and "Am" appearing in the mid and late twenty-first century, respectively. "Aw" climate covered the most area of Thailand with 90.14%, 91.85% and 96.37% while "Am" climate covered 8.77%, 8.15% and 3.63% for present, mid, and late twenty-first centuries period, respectively of a small area of Eastern part and almost half Southern region. Furthermore, "Am" climate was also predicted to appear in east side of Northeast region in 2020 - 2060 period whereas "Cwa" was appeared in small area of Northern region in 1987 – 2019 period. The up-to-date maps of rainfall, temperature value and KGC zone can be evidences to remind about climate change and support the future work.

Key words
Köppen-Geiger Climate Classification, Climate Change, Rainfall Variability, Equatorial Climate and Climate of Thailand

INTRODUCTION

Climate change is an important issue which all global sectors concern about. This problem is started to talk wildly after industrial revolution period due to an increasing of CO_2 and deforestation including an increasing of population. These major causes lead the land Surface Temperature and ocean temperature rising (Berila and Dushi, 2021). Moreover, these causes also lead the global temperature increasing

A* Ramkhamhaeng University, Department of Geography, Bangkok, 10240, Thailand
https://orcid.org/0000-0003-4224-6220
ph.nutthakarn@hotmail.com, ph.nutthakarn@ru.ac.th (corresponding author)

more than 1 °C in 150 years past. (Jedlák, 2013; Neukom et al., 2019) In the same way, Thailand had to face with this issue, e.g., an increasing of air temperature in summer of Thailand and a longer drought period. (Phumkokrux and Rukveratham, 2020) Climate change issue also affects to agricultural activities, water reservation, health, ecosystems, social economy, and climate system, however; an intensity of the effects depended on variety of Thailand's topography. (Kisner, 2008)

The first global climate classification map has invented to define and discuss about climate system in each region in 1900 by a Russian-German geographer, meteorologist, climatologist, and botanist, named Wladimir Peter Köppen. (Köppen, 1900; Köppen, 1901) Moreover, Thornthwaite claimed in 1943 that Köppen got an inspiration from the theory of Swiss French botanist, named Augustin Pyramus de Candolle who has separated vegetation into 5 main groups by focusing on only temperature and precipitation (moisture). (Thornthwaite, 1943) These are the major factors which directly affect to variety of vegetation and ecosystems in the world thus these can be used to classify global climate into 5 major global climate groups (30 sub-types climate zone) (Sanderson, 1999; McConnell and Steer, 2015) Then, a German meteorologist and climatologist named Rudolf Oskar Robert Williams Geiger worked with Köppen to develop the climate classification in 1954 and 1961, called Köppen-Geiger Climate Classification system (KGC). (Geiger, 1954; Geiger, 1961) Therefore, the average monthly temperature, average seasonal temperature average monthly precipitation, total annual precipitation are simple statistical data which can define climate boundaries in any region for KGC (Chen and Chen, 2013)

Although there are many theories to classify climate zone by other climate experts, Köppen-Geiger Climate Classification system (KGC) is still widely present in many textbooks including in Thailand. Therefore, improvement of KGC maps is necessary to display and access easily in digital form. There are 3 famous recent versions of KGC maps which has published in 20th century period to present the updated world climate, produced by 1) Kottek et al. (2006) created a map based on CRU TS 2.1 and VASClimO V1.1 for monitoring air temperature and precipitation in monthly values, respectively at 0.5°-degree latitude/longitude grid with the factors data in 1951-2000 from about 7000–17,000 meteorological stations, 2) Peel et al. (2007) published a KGC map in global scale at 0.1 x 0.1 degree latitude/longitude grid, using climate parameters from 4279 observation stations then, the map is performed by raster interpolation technique (spline) and 3) Chen and Chen (2013) produced map at 0.5 x 0.5 latitude/longitude grid using average monthly temperature and precipitation data of 1901–2010 from Global Historical Climatology Network version 2 (GHCN2) and the Global Surface Summary of Day (GSOD). Moreover, there are 2 recent research groups, studied and published future KGC maps using various climate modelling, which are 1) Kriticos et al. (2012) presented the future KGC maps using air temperature, precipitation, and relative humidity datasets from CRU CL2.0 and WorldClim then, using IDW technique to analyse and present the maps. And 2) Beck et al. (2018) forecasted KGC map in the period of 2071–2100 using historical and future data of average monthly temperature and total monthly precipitation from Coupled Model Intercomparison Project Phase 5 (CMIP5) then, modelled with Representative Concentration Pathway 8.5 (RCP8.5). However, climate zone analysis in country scale may be difficult to identify and analyse climate change issue from previous KGC world map thus these following researchers tried to adapt KGC method to define climate zone and summarize climate issues in each small area. e.g., Diaz and Eischeid (2007) also applied KGC method to monitor climate zone in the western United States. Alvares et al. (2014) focused on updated KGC map in Brazil using climatological data from 2,950 stations. The rainfall and temperature maps were produced with resolution at 100 metres, cooperated with geographical coordinates and altitude. While the final climate map of Brazil was performed with a high spatial resolution at 1 hectare. and Sarfaraz et al. (2014) produced KGC map of Pakistan which has different climate types depending on different altitude to 8,611 metres from MSL, using air temperature, precipitation, and altitude datasets of 1981-2010 from 59 meteorological stations then, generated maps by IDW technique.

As all mentioned above inspired the author to study a climate zone by using KGC theory in country scale of Thailand thus, the objectives of the study are 1) to update current total monthly rainfall, average monthly temperature and KGC map of 1987 – 2019 (present period) by gathering climatological data from 104 meteorological stations and 2) to predict total monthly rainfall, average monthly temperature and KGC map of 2020 – 2060 and 2061 – 2100 (mid and late twenty-first century period) by gathering historical and future climate factors datasets from BCC-CSM1.1 (in CMIP5). The maps can be supported the future work to monitor and plan to cope with climate change issues in Thailand.

OBJECTIVES

1) To update current total monthly rainfall, average monthly temperature and KGC map of 1987 – 2019 (Present period).
2) To predict total monthly rainfall, average monthly temperature and KGC map of 2020 – 2060 and 2061 - 2100 (mid and late twenty-first century period).

KÖPPEN-GEIGER CLIMATE CLASSIFICATION SYSTEM (KGC)

The Köppen-Geiger Climate Classification system (KGC) is an easy method to determine world's climate zone without complex and expensive equipment. The KGC collects only near-surface air temperature and precipitation data in each area. (Kottek et al, 2006; de Sá Júnior et al., 2012) The KGC method use English alphabet and number as a climatic symbol in each region. The steps of KGC consideration are following: 1) the first letter is a capital English alphabet which is referred to the major climate in each region such as "A" defines to Equatorial or Tropical climates, "B" refers to Arid or Dry climates, "C" adverts to Warm or Mesothermal climates, "D" mentions to Cool or Microthermal climates, "E" adduced to Polar climates and "H" refers to Highland climates. 2) the second letter, it is small English alphabet which is referred to the volume of precipitation in each season. In case of "A", "C" and "D" types, "f" refers to constantly moist rainfall through months of a year, "m" mentions to monsoon rain and short dry period, "w" and "s" adverts to long dry period usually in winter and summer respectively but rarely found in any area for "s". However, the second letter in case of "B" and "E" is a capital English alphabet, refers to specific climates such as "S" refers to Steppe or Semiarid climate and "W" is True desert or Arid climate, "T" adduces to Tundra climate and "F" refers to Ice cap climate. And 3) the third letter can identify characteristic of temperature in summer in case of "C" and "D" such as "a", "b", "c" and "d" can represent that the temperature is hot, warm, mild, and cool in summer, respectively. However, the third letter for "B" is used to analyze the specific climate which are: "h" for hot and dry climate and "k" represents cold and dry climate. (Rohli and Vega, 2008) The detail of KGC can be described in the Tab. 1 and 2.

DATA AND METHODS

Study area and Meteorological data

This project focused on total area of Thailand, which is located at latitudes between 5° 37′ N - 20° 27′ N and longitudes between 97° 22′ E - 105° 37′ E, covered about 518,000 square kilometres in Southeast Asia. (Department of Mineral Resources, 2016). Thailand is separated to 5 meteorological regions by meteorological criterion, which are 1) Northern region consists of 15 provinces with high mountain ranges which are located from north to south direction, alternated with the valley. The highest peak of Thailand can be found in this region, up to 2,560 metres above mean sea level at Doi Inthanon. 2) Northeast region covers 20 provinces with plateau as a dominant topography (Slanting from west to east direction). There are three high mountains which are located as a barrier between northern, central, eastern part of Thailand and Cambodia with the peak at 400 – 1,300 metres above mean sea level which can block any humidity from the closest ocean. 3) Central region covers 18 provinces with large plain as a notable topography and the south side is located next to Gulf of Thailand. The small mountains can be found, however; the highest mountain also can be found around west side as a barrier of Thailand and Myanmar with the highest peak up to 1,600 metres above mean sea level. 4) Eastern region consists of 8 provinces, which is located next to Gulf of Thailand at west and south side. The outstanding topography is undulating plain. And 5) Southern region covers 16 provinces, which is flanked with Gulf of Thailand and Andaman Sea thus, so much humidity and rainfall can be found. There are high mountains which are located from north to south direction, are separated this region into two sides (West side next to Andaman Sea and East side closed to Gulf of Thailand). The topography of Thailand and study area maps are presented in Fig.1(a). Moreover, air temperature and precipitation value are so high through year with average annual temperature about 25-27 °C and total annual precipitation about 1,200 – 1,600 mm per year. (Meteorological Department of Thailand, 2016)

Data, Equipment and Methodology

The necessary data were separated into 2 types, which are: observation data and prediction data. Unfortunately, Unfortunately, there were difficut to collect perfect data of Average monthly temperature values (T_{am}) and total monthly precipitation or rainfall values which were used as observation data (P_{tm}) in long period (more than 40 year record) in many meteorological stations due to imperfect from recording and technical problems thus, T_{am} and P_{tm} of the present period were collected from just previous 33 years (1987 – 2019). The data were prepared by 104 meteorological stations under Meteorological Department of Thailand covering all 5 regions of Thailand. The detail of meteorological station is illustrated in Fig. 1(b) and Tab. 3

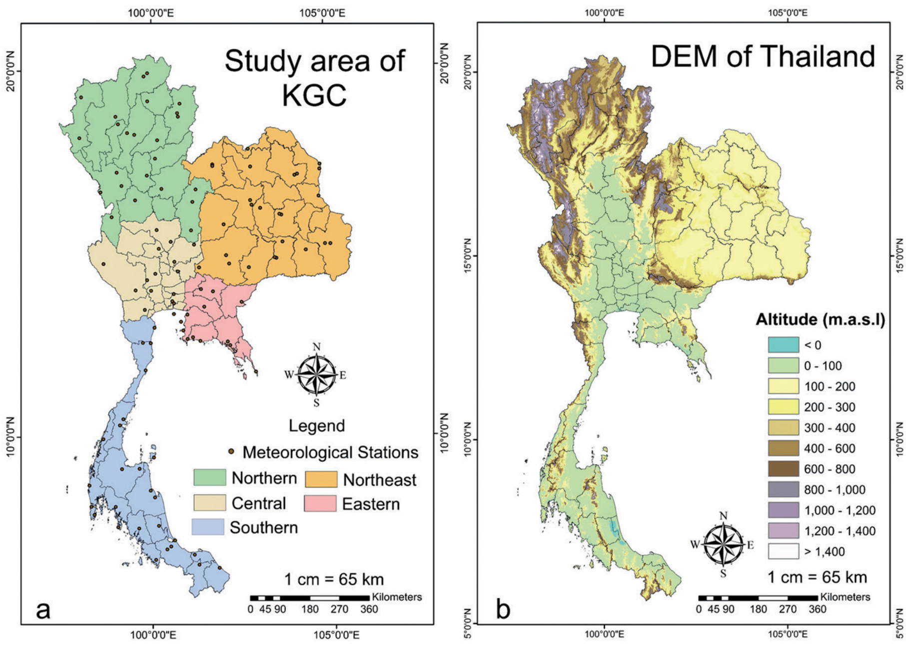

Fig. 1
(a) Study area and (b) Digital elevation model of Thailand
Source: Own creation

Tab. 1 Description of KGC major climate type for first letter

1st	Climate description	Criteria Specifics
A	Equatorial or Tropical climates	- Coldest month (T_{am}) ≥ 18
B	Arid or Dry climates	- P_{aa} < 10 x $P_{thershold}$
C	Warm or Mesothermal climates	- 18 > Coldest month (T_{am}) ≥ 0 - Hottest month (T_{am}) ≥ 10
D	Cool or Microthermal climates	- Coldest month (T_{am}) < 0 - Hottest month (T_{am}) ≥ 10
E	Polar climates	- Hottest month (T_{am})< 10
H	Highland climates	- Climate characteristics changes by altitude

Source: Peel et al. 2007; Rohli and Vega 2008

Tab. 2 Description of KGC sub climate type for Second and Third letter

2nd	3rd	Criteria Specifics
f		- P_{am} ≥ 60 through year
m		- P_{am} < 60 short period in winter - Driest month (P_{am}) ≥ a = 100 – (P_{ta}/ 25)
w		- P_{am} < 60 short period in winter - Driest month (P_{am}) < a = 100 – (P_{ta} / 25)
s		- P_{am} < 60 short period in summer (rarely found)
	a	- Hottest month (T_{am}) ≥ 22
	b	- Hottest month (T_{am}) < 22
	c	- Fewer than 4 months (T_{am}) ≥ 10
	d	- Fewer than 4 months (T_{am}) ≥ 10 and Coldest month (T_{am}) < - 38
S		- P_{aa} < 5 x $P_{thershold}$
W		- P_{aa} ≥ 5 x $P_{thershold}$
	h	- Hot and dry (T_{aa}) ≥ 18
	k	- Cold and dry (T_{aa}) < 18
T		- 0 ≥ Hottest month (T_{am}) > 10
F		- Hottest month (T_{am}) < 0

Source: Peel et al. 2007; Rohli and Vega 2008

*Note: Temperature defines as °C, Precipitation determines as mm, Tam = average monthly temperature, Taa = average annual temperature, Pam = average monthly precipitation, Paa = average annual precipitation, Pta = total annual precipitation, Pthreshold = varies depending on the following rules (if 70% of Paa arises in winter then Pthreshold = 2 x Taa, if 70% of Paa arises in summer then Pthreshold = 2 x Taa + 28, otherwise Pthreshold = 2 x Taa + 14). Summer (Winter) in North hemisphere defines as April to September (October to March) for South hemisphere is adverse.

Tab. 3 Details of meteorological station in Thailand

Meteorological Regions	No. of Provinces	No. of Stations
Northern	15	24
Northeast	20	25
Central	18	16
Eastern	8	13
Southern	16	26
Overall	77	104

Source: Meteorological Department of Thailand, edited by the author

Prediction data was extracted by Beijing Climate Centre Climate System Model version 1.1 (BCC-CSM1.1) which is in the fifth phase (AR5) of Coupled Model Intercomparison Project Phase 5 (CMIP5), invented by Beijing Climate Centre (BCC) and China Meteorological Administration (CMA). The model provided physical, chemical, and biological values from the atmosphere, ocean, land, and sea-ice components (Gao et al., 2012; Wu, 2012; Xin et al., 2013a; Xin et al., 2013b; Zhang and Wu, 2012) thus, this model was used to predict the average monthly temperature and total monthly precipitation (rainfall) values of 2020 – 2100 period. Moreover, the SD GCM V 2.0 software (Statistical Downscaling of General Circulation Models Version 2.0) which is provided by Agricultural and Meteorological Software (2018), was used to extracted meteorological values from the model with 3 statistical downscaling methods (Gudmundsson et al., 2012) which are the Delta, the Quantile Mapping (QM) (Panofsky and Briar, 1968) and the Empirical Quantile Mapping (EQM) (Boe et al., 2007). BCC-CSM1.1 (historical) and BCC-CSM1.1 (RCP85) provided the data from 1850 - 2012 and 2006 – 2300, respectively. RCP85 was provided under the high emissions, no mitigation concept thus it would be modeled and gave a obviously point of view about danger climate change situation expectially if emissions such as CO_2 which can lead air temperature increaing and impact directly on human health could not be reduced. (Xin et al., 2013; Mihincău et al., 2019; Lyon et al., 2020)

However, the period of meteorological data for prediction process in this study was 1987 – 2019 and 2020 - 2100, extracted by "historical mon atmos Amon r1i1p1 v1 pr", "rcp85 mon atmos Amon r1i1p1 v20120705 pr" for precipitation and "historical mon atmos Amon r1i1p1 v1 tas" and "rcp85 mon atmos Amon r1i1p1 v20120705 tas" for air temperature. The data of this model can be accessed at The German Climate Computing Center (DKRZ: Deutsches Klimarechenzentrum GmbH) by http://cera-www.dkrz.de/WDCC/ui/Entry.jsp?acronym=BCB1hi for historical data and http://cera-www.dkrz.de/WDCC/ui/Entry.jsp?acronym=BCB1r8 for future data. However, Mean Absolute Error (MAE), Mean Absolute Percentage

Error (MAPE), Root Mean Square Error (RMSE), R-squared correlation (R2), Pearson coefficient and Index of Agreement are used to investigate the accuracy between observation data and prediction data from the model as presented in equation (1) – (6).

$$MAE = \frac{\sum_{i=1}^{n}|X_{exp,i} - X_{obs,i}|}{n} \quad (1)$$

$$MPAE = 100\,x\,\frac{1}{n}\sum_{i=1}^{n}\frac{X_{obs,i} - X_{exp,i}}{X_{obs,i}} \quad (2)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{X_{exp,i} - X_{obs,i}}{X_{obs,i}}\right)^2} \quad (3)$$

$$\rho = \frac{\sum_{i=1}^{n}(X_{exp,i} - \bar{X}_{exp})(X_{obs,i} - \bar{X}_{obs})}{\sqrt{\sum_{i=1}^{n}(X_{exp,i} - \bar{X}_{exp})^2 \sum_{i=1}^{n}(X_{obs,i} - \bar{X}_{obs})^2}} \quad (4)$$

$$r = \frac{n(\sum_{i=1}^{n} X_{exp,i}X_{obs,i}) - (\sum_{i=1}^{n} X_{exp,i})(\sum_{i=1}^{n} X_{obs,i})}{\sqrt{[n\sum_{i=1}^{n}(X_{exp,i})^2 - (\sum_{i=1}^{n} X_{exp,i})^2][n\sum_{i=1}^{n}(X_{obs,i})^2 - (\sum_{i=1}^{n} X_{obs,i})^2]}} \quad (5)$$

$$d = 1 - \frac{\sum_{i=1}^{n}(X_{exp,i} - X_{obs,i})^2}{\sum_{i=1}^{n}(|X_{exp,i} - \bar{X}_{obs}| + |X_{obs,i} - \bar{X}_{obs}|)^2} \quad (6)$$

Whereas; $X_{obs,i}$ refers to meteorological observation data, $X_{exp,i}$ refers to meteorological prediction data from the model, r is Pearson's correlation coefficient, ρ is Spearman's rank-order correlation, d is index of agreement. For MAE, MAPE and RMSE, the lowest values indicate that observation agree with prediction data, however; Pearson's correlation coefficient, Spearman's rank-order correlation and Index of Agreement focus on highest value (a range from 0 – 1). Moreover, administrative boundaries of Thailand (level 0 for country and level 1 for province) were composed and updated on 9 November 2019 by Information Technology Outreach Services (ITOS) with funding from USAID in vector shapefile format. (Retrieved from https://data.humdata.org/dataset/thailand-administrative-boundaries). Geographic Information System: GIS was cooperated with administrative boundaries of Thailand to analyse and present the results in form of maps. However, GIS programme calculated the area of Thailand around 516,085.376 square kilometres (different from the Thailand's area reference of Department of Mineral Resources (2016) about - 0.37%). Furthermore, the average monthly temperature and total monthly precipitation (rainfall) values of 1987 – 2019 and 2020 – 2100 period were gathered to classify climate types by following the rule of KGC in Table 1 and 2. Then, Raster interpolation is one of GIS methods, were used to distinguish and represent the results by using Inverse Distance Weight (IDW) for the total annual rainfall maps and Kriging for the average annual temperature maps and KGC classification maps of Thailand (with output cell size at 400 and Number of Point at 12). Furthermore, the trend of any changes is performed by excel programme with Simple Linear Regression Analysis method which was an easy method to model the relationship between independent and dependent variable, the objective is to predict the value of an output variable (or response) based on the value of an input (or predictor) variable as presented in equation (7). Although, Simple Linear Regression Analysis method still has a drawback like due to climate variables forecasting is too difficult to find an appropriate trend analysis method to work with fluctuate-data, this method was still used by many researchers in climatology field to analyse and discover a clear image of trend of climate variable changes including air temperature and precipitation. (Baltagi, 2002; Batima et al., 2005; Klamár et al., 2019; Ongoma et al., 2021).

$$y = \beta_0 + \beta_1 X + \varepsilon \qquad (7)$$

Whereas y is the predicted value of the dependent variable (y) for any given value of the independent variable (X). β_0 is the intercept, the predicted value of y when the X is 0. β_1 is the regression coefficient – how much we expect y to change as X increases. X is the independent variable (the variable we expect is influencing y). ε is the error of the estimate, or how much variation there is in our estimate of the regression coefficient.

RESULTS AND DISCUSSION

Temperature and Precipitation Forecasting of Thailand for 2020-2061 and 2061-2100 period

Average monthly temperature (T_{am}) and total monthly precipitation (P_{tm}) of the mid twenty-first century (2020-2060), and the late twenty-first century (2061-2100) period were predicted by SD GCM V 2.0 software. Moerover, the programme cooperated with BCC-CSM1.1 (historical) for historical prediction and BCC-CSM1.1 (rcp85) for future prediction under high emissions and no mitigation concept, ran under three statistical downscaling methods (Delta, EQM, and QM). The result was presented that EQM was the appropriate method which could be used to forecast T_{am} and P_{tm} with lowest Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE) and highest R-squared correlation (R^2), Pearson coefficient and Index of Agreement as illustrated in Tab. 4. The accuracy values of T_{am} , predicted by EQM method at 0.86, 3.25, 1.17, 0.74, 0.86, and 0.89 for MAE, MPAE, RMSE, R2, Pearson coefficient and Index of Agreement86.76, 145.42, 0.30, 0.55 and 0.69, respectively. In addition, the values for P_{tm} prediction reported at 86.76, 145.42, 0.30, 0.55 and 0.69, respectively.

Tab. 4 Accuracy comparison of three statistical downscaling methods for average monthly temperature prediction from BCC-CSM1.1 model

Methods	MAE	MPAE	RMSE	R2	Pearson coefficient	Index of Agreement.
Average monthly temperature of Thailand						
Delta	1.23	4.71	1.66	0.45	0.67	0.36
EQM	**0.86**	**3.25**	**1.17**	**0.74**	**0.86**	**0.89**
QM	0.88	3.30	**1.17**	**0.74**	**0.86**	**0.89**
Total monthly rainfall of Thailand						
Delta	102.37	-	172.62	0.26	0.51	0.65
EQM	**86.76**	-	**145.42**	**0.30**	**0.55**	**0.69**
QM	93.79	-	156.94	0.27	0.52	0.67

Source: Own creation, cooperated with SD GCM V 2.0 software.

Temperature of Thailand in 1987-2019, 2020-2061 and 2061-2100 period

According to the Köppen-Geiger Climate Classification system, the first step of the theory focused on air temperature to determine the first letter as major climate zone (Capital English alphabet). Therefore, total monthly average temperature (T_{am}) of present period (1987 – 2019), the mid twenty-first century (2020-2060), and the late twenty-first century (2061-2100) period were collected from 104 meteorological stations over Thailand, predicted by BCC-CSM1.1 model, to analyse the changes and determine climate zone. The T_{am} of all stations was in range of 13.5 – 37.3 °C in present period. The most stations had the minimum T_{ma} equal or higher than 18 °C thus, the first letter was defined as "A" Equatorial or Tropical climates. However, some minimum T_{ma} which was lower than 18 °C and equal or higher than 0 °C appearing in some meteorological stations in Northern region especially, some stations in Chiang Rai, Phayao, and Tak provinces. Therefore, these could be classified as "C" Warm or Mesothermal climates. In contrast, T_{ma} of the mid twenty-first century, and the late twenty-first century period reported at 19.0 – 29.4 °C and 19.0 – 29.6 °C, respectively. Therefore, only "A" Equatorial or Tropical climates could be found in these periods. Specific detail of Thailand's temperature could be described by drawing the maps using Kriging technique, reported in °C Unit as presented in Fig. 2(a-c), the red tones refer to hotter temperature and yellow tones refer to cooler temperature. The highest average annual temperature (T_{aa}) of these three periods was found in Central part, gradually dropped in the next area which connected to Eastern part, Southern part, Northeast part, and Northern part, respectively. The supported reason of this phenomenon is the Central and Eastern of Thailand has so much urban activities than others, couples with the location of the regions is in low latitude and get much of an effect of sun ray. These configurations can lead the effect of heat rising. However, Southern of Thailand is different due to the location of area is between Andaman Sea and Gulf of Thailand, which can reduce the air temperature by a lot of humidity. Moreover, a different of T_{aa} of the mid twenty-first century and the late twenty-first century period was discovered by comparison with 1987 – 2019 data (based period), reported in °C Unit (+ value means the data of the year is higher than based period and - value refers in contrast) as presented in Fig. 2(d-e). Most of stations in both periods predicted gave higher T_{aa} values than based period; however, the magnitude of changes in the late twenty-first century (0.0 to +0.3 °C) was higher than the mid twenty-first century (-0.2 to +0.1 °C). The results indicated that the T_{aa} values tend to be warmer in near future due to CO_2 and other emission rising with no mitigation policy (according to RCP85 scenario output). Furthermore, the T_{am} trend of all regions in these three periods were similar by climbing at all but different in magnitude as illustrated in Tab. 5

Tab. 5 Linear regression analysis for average annual temperature of each region over Thailand

Region	Regression Equation		
	1987-2019	**2020-2060**	**2061-2100**
Northern	y = 0.0254x + 25.739 R^2 = 0.4163	y = 0.0032x + 25.59 R^2 = 0.142	y = 0.004x + 26.259 R^2 = 0.606
Northeast	y = 0.0217x + 26.469 R^2 = 0.2517	y = 0.0028x + 26.217 R^2 = 0.0906	y = 0.0035x + 26.934 R^2 = 0.5514
Central	y = 0.017x + 27.927 R^2 = 0.2307	y = 0.0035x + 27.738 R^2 = 0.1726	y = 0.0034x + 28.321 R^2 = 0.5748
Eastern	y = 0.0166x + 27.681 R^2 = 0.3182	y = 0.0039x + 27.578 R^2 = 0.2645	y = 0.0032x + 28.072 R^2 = 0.5773
Southern	y = 0.0132x + 27.271 R^2 = 0.3215	y = 0.0029x + 27.283 R^2 = 0.3884	y = 0.0032x + 27.586 R^2 = 0.7452

Source: Own creation

The Average monthly temperature graph of Thailand over these three periods were presented in red line graph form, read from y – left side axis as illustrated in Fig. 3 (a) 1987 – 2019, (b) 2020 – 2061, and (c) 2061 – 2100 period to explain the air temperature situation in each month. T_{ma} of present period was gradually increasing from January (in winter) and hit the peak in April (in summer) due to the sun ray is always perpendicular Thailand surface (Srivanit and Jareemit, 2020), lead so much heat concentration over the surface especially in the land. After that, the T_{am} was gently dropping and hit the lowest point in December (winter) due to winter solstice effect in north hemisphere (Jansri and Ketpichainarong, 2020). The temperature situation of the mid twenty-first century, and the late twenty-first century period resemble present period situation; however, the magnitude of change was lower than present period. This situation could be summarized that the air temperature would be high over the year and not be change so much in each month in the future.

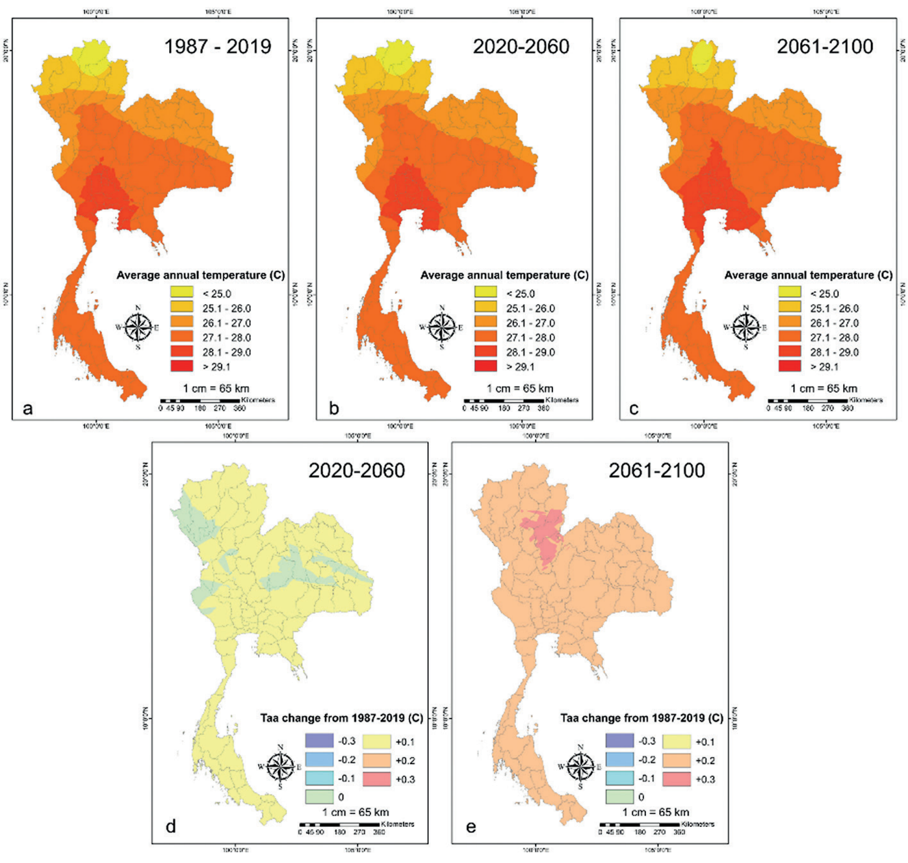

Fig. 2

Average annual temperature over Thailand maps of (a) 1987 – 2019, (b) 2020 – 2061, (c) 2061 – 2100 period, A change of Average annual temperature over Thailand compared with 1987 – 2019 period of (d) 2020 – 2060, and (e) 2061 – 2100

Source: Own creation

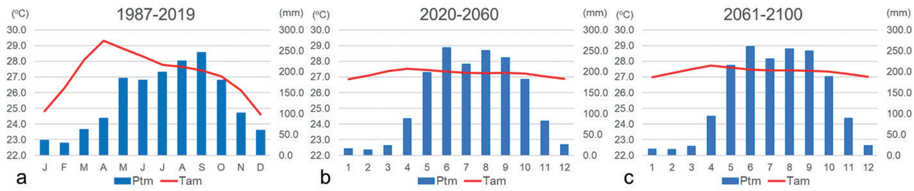

Fig. 3

Average monthly temperature and precipitation over Thailand of (a) 1987 – 2019, (b) 2020 – 2061, and (c) 2061 – 2100 period

Source: Own creation

Rainfall of Thailand in 1987-2019, 2020-2061 and 2061-2100 period

The rainfall mapping of present period (1987 – 2019), the mid twenty-first century (2020-2060), and the late twenty-first century (2061-2100) period was discussed in Fig. 4(a-c), were drawn by collecting total monthly rainfall in mm unit from 104 stations over Thailand, predicted by BCC-CSM1.1 model, cooperated with IDW technique. The blue tones refer to the less rainfall and the pink tones refer to the more rainfall. Moreover, Maximum, Minimum, and Mean values of total annual rainfall of each region over Thailand demonstrated in Tab.6. The pattern of rainfall distribution of these three periods were similar, the most rainfall distributed in Southern region with supported reason that the wet area of Southern of Thailand was affected from the location which is located next to two seas and get an influence from southwest monsoon in mid of May to mid of October then, northeast monsoon passes through until mid of February. The notable highest rainfall distributed around Sa Mui and Pha Ngan islands in Surat Thani province, and the bottom of the region in Songkla, Satun and Yala provinces. This was synonymous with the work of Limsakul, Singhruck, and Wang (2017). Eastern region also had the notable rainfall values with supported argument that the dominant wet area of eastern region appeared around the bottom area of the region which is in the front of Chanthaburi mountain range and next to gulf of Thailand, especially in Chanthaburi and Trat provinces because of humidity and affectation from southwest monsoon in mid of May to mid of October, the values of Chanthaburi and Trat provinces were significantly higher than Southern region (Thai Meteorological Department, 2015). Next is Northeast region, the rainfall always low in this area due to this area is far from the nearest sea. (Thai Meteorological Department, 2015) However, the outstanding moist area figured at the east side of region then gradually dryer to west side of region because of an effect from summer thunderstorm which happens around February to May and tropical cyclones which always pass through the area around May to October (Thai Meteorological Department, 2015). Following by Northern of Thailand, the distinctive moist area emerged at the small area of the upper of region (around Chiang Rai province) then, gentry dryer to lower of region. This phenomenon might be affected from 1-2 tropical cyclones which always pass through the upper area first then, this reason lead humidity sending to collect in forest to encourage producing of rainfall. Although, other area in this region got a little effect from tropical cyclone and the location of the area which is far from the sea lead the area has less chance to get the high rainfall, mountain topography also encourages humid air rising to the top of mountain, created clouds and rain falling to the area (Thai Meteorological Department, 2015; Komori et al., 2018). For the last region, the wet area of Central of Thailand was pointed out around upper side of region (around Chiang Rai province). Moreover, it was found in small area around north of Kanchanaburi province. The reason for this situation is the effect of southwest monsoon which always pass through the area in mid of May to mid of October and the location of Kanchanaburi province is not much far from nearest sea. Therefore, these can let much humidity pass through the area by gaps between mountains. However, inside area of region has less humidity, lead the area drier (Thai Meteorological Department, 2015; Limsakul, Singhruck, and Wang, 2017). Moreover, a different of P_{ta} of the mid twenty-first century and the late twenty-first century period was exploreed by comparison with 1987 – 2019 data (based period), reported in percentage value to make clearly understand (+ value means the data of the year is higher than based period and - value refers in contrast) as presented in Fig. 3(d-e). Both of changes were predicted that the most area of Thailand (except Northeast region) tend to have less rainfall value than based period (-17.7% to 16.3% for the mid twenty-first century and -15.9% to 25.0% for the late twenty-first century); however, the magnitude of changes were different. Rainfall value of the most area of Thailand in the late twenty-first century tends to have higher values than the mid twenty-first century except in the upper-Southern region. This situation was synonymous with a research study of Komori et al. (2018). The results indicated that total rainfall of Thailand tend to be higher in near future, but this cannot confirm that there is no chance to get more rainfall value in every month which is enough to change the climate type.

Tab. 6 Max, Min, and Mean of total annual rainfall of each region over Thailand

Region	1987-2019			2020-2060			2061-2100		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Northern	6.7	2287.5	1220.7	661.8	2304.1	1207.3	625.9	2739.3	1273.5
Northeast	574.1	2995.9	1372.4	652.0	4050.3	1518.0	749.6	4064.1	1594.3
Central	513.2	2675.8	1154.7	583.9	2249.3	1138.2	520.3	2668.6	1219.0
Eastern	419.6	6463.3	1463.2	717.7	6845.6	1363.1	569.7	6916.9	1512.8
Southern	585.6	5883.8	2077.1	586.8	5292.2	2023.2	453.3	5344.5	2026.8

Source: Own creation

The total monthly rainfall graph of these three periods were similar, the trends were rising from the beginning of the year and hit the peak around rainfall season (June to September) then, the trend gradually dropped down by end of year. The dry months appeared around winter as presented in Fig. 3(a-b). Furthermore, the P_{ta} trends of all regions in present and the late twenty-first century periods were similar by rising at all but different in magnitude; however, P_{ta} trends of all regions in the mid twenty-first century periods were increasing in Northern, Central and Eastern region whereas the trends tend to be decreased in Northeast and Southern region as illustrated in Tab. 7

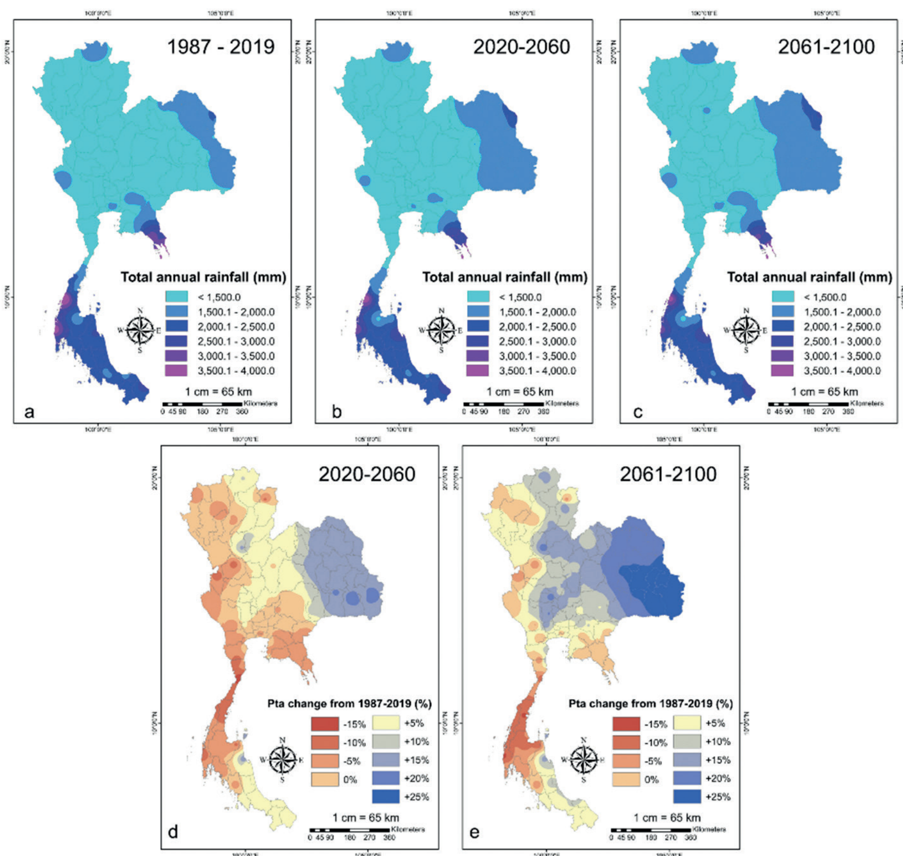

Fig. 4

Total annual rainfall over Thailand maps of (a) 1987 – 2019, (b) 2020 – 2061, (c) 2061 – 2100 period, A change of Total annual rainfall over Thailand compared with 1987 – 2019 period of (d) 2020 – 2060, and (e) 2061 – 2100

Source: Own creation

For the second step, total monthly rainfall of these three periods of each month in each station were analysed to determine the second English lowercase letter to get sub-climate type by following the rules in Tab. 2. The sub-climate type of "A" Equatorial or Tropical climates defined to two classes: Tropical savanna climate with dry-winter characteristics (Aw) and Tropical monsoon climate (Am) whereas sub-climate type of "C" Warm or Mesothermal climates could be classified as Dry – winter humid (Cw).

Tab. 7 Linear regression analysis for total annual rainfall of each region over Thailand

Region	Regression Equation		
	1987-2019	2020-2060	2061-2100
Northern	y = 2.2883x + 1220.1 R^2 = 0.0171	y = 0.1322x + 1242.6 R^2 = 8E-05	y = 1.4268x + 1290.3 R^2 = 0.0084
Northeast	y = 2.6853x + 1381.3 R^2 = 0.0296	y = -0.3865x + 1581.2 R^2 = 0.0003	y = 5.2434x + 1561.4 R^2 = 0.0665
Central	y = 2.8711x + 1160.5 R^2 = 0.0291	y = 1.714x + 1144.4 R^2 = 0.0119	y = 3.348x + 1202.6 R^2 = 0.0338
Eastern	y = 4.1023x + 1855.3 R^2 = 0.0491	y = 2.2231x + 1738.6 R^2 = 0.0085	y = 5.9654x + 1781.5 R^2 = 0.035
Southern	y = 9.0459x + 1980.8 R^2 = 0.0986	y = -0.8292x + 2087.2 R^2 = 0.0012	y = 1.8599x + 2039.8 R^2 = 0.0057

Source: Own creation

Köppen-Geiger Climate Classification system of Thailand in the present period (1987 – 2019)

Following the KGC rules as in Tab. 1 and 2, the KGC could be classified as Tropical savanna climate with dry-winter characteristics (Aw) and Tropical monsoon climate (Am) and Dry – winter humid (Cw) for present period (1987-2019). Therefore, characteristic of temperature in summer for Northeast region needed to be identified by operation as in Tab. 2. The results indicated that the most months of some station which were classified to "C" climate type, had T_{am} value equal or higher than 22 °C in the hottest month in each year. Therefore, the climate could be defined as "Cwa" or Dry-winter humid subtropical climate. Köppen-Geiger Climate Classification map of Thailand in present period was created by kriging method then illustrated in Fig. 5 (a). Pink, Brown, and Yellow scale refers to "Cwb", "Aw", and "Am" climate, respectively. However, there were just 8 years only in Phayao station (Phayao province) had T_{am} value lower than 22 °C in the hottest month in each year to classify the climate as "Cwb" or Dry-winter subtropical highland climate. This climate could not be classified as KGC climate in the area. "Aw" climate was the main sub-climate of the country which was appeared around

90.14% of Thailand with the evidence that all months had the T_{am} higher than 18 °C and P_{tm} were lower than 60 mm, was found around 4-5 months around November to March except in Southern region (P_{tm} were lower than 60 mm around 1 month) as presented in Fig. 6 (b-f). Proportion of Aw climate by KGC method in Thailand of present period were illustrated in Tab. 8(a). The results displayed that Aw was covered 100% of Northeast part (32.50% of Thailand), and Central part (13.76% of Thailand), respectively. However, it was overspread at 96.45% of Northern part (29.15% of Thailand) except Phayao Provinces, small-upper area of Lampang province and small-lower area of Chiang Rai province. Moreover, it also distributed in 80.04% of Eastern part (5.68% of Thailand) around the area behind Chanthaburi mountain range and 55.17% of Southern part (9.05% of Thailand).

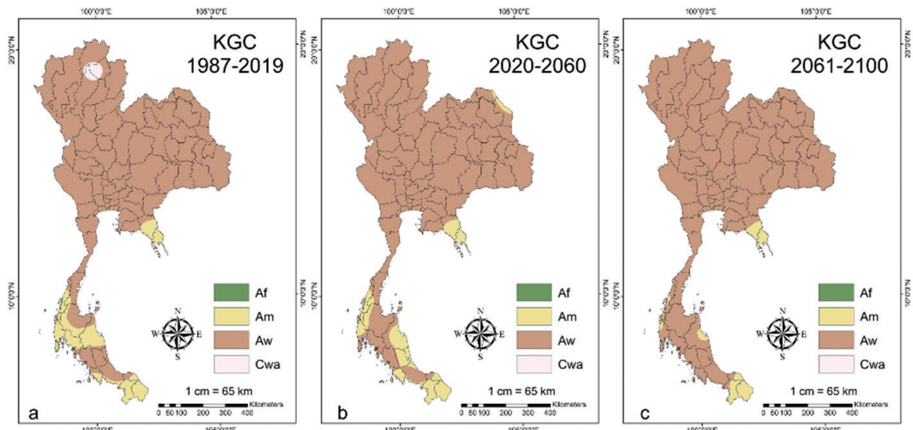

Fig. 5
Köppen-Geiger Climate Classification map of Thailand (a) 1987 – 2019,
(b) 2020 – 2061, and (c) 2061 – 2100 period
Source: Own creation

"Am" climate was found at 8.77% of Thailand territory with the evidence as presented in Fig. 6 (g-h) that T_{am} of each month was higher than 18 °C and P_{tm} of 1 – 2 months were lower than 60 mm. The results displayed that Aw was covered 19.96% of Eastern part (1.42% of Thailand) between front of Chanthaburi mountain range and next to Gulf of Thailand. Moreover, P_{tm} rapidly increased from the beginning of year and hit the peak around rainy season due to southwest monsoon which brings so much humidity to area. It also found 44.83% of Southern part (7.35% of Thailand) in alomost half area of region, respectively. P_{tm} was stably high all year due to southwest which allows humidity to area in rainy and winter season. However, northeast monsoon also brings humidity (rainfall) to the area, less than southwest monsoon. "Cwa" climate appeared at 3.55% of Northern region (1.07% of Thailand) as illustrated in Tab. 6(b) around Phayao Provinces, small-upper area of Lampang province and small-lower area of Chiang Rai province with the evidence as presented in Fig. 6 (a) that T_{am} of the coldest months were lower than 18 °C with the hottest months were higher than 22 °C and P_{tm} of 1 – 5 months were lower than 60 mm. The supported reason is the stations in these areas are located in high altitude above mean sea level, coupled with slope mountain ranges topography with forests which can collect humid and make the air temperature cooler, lead the air rising to the top thus, the air temperature would be lower than low altitude.

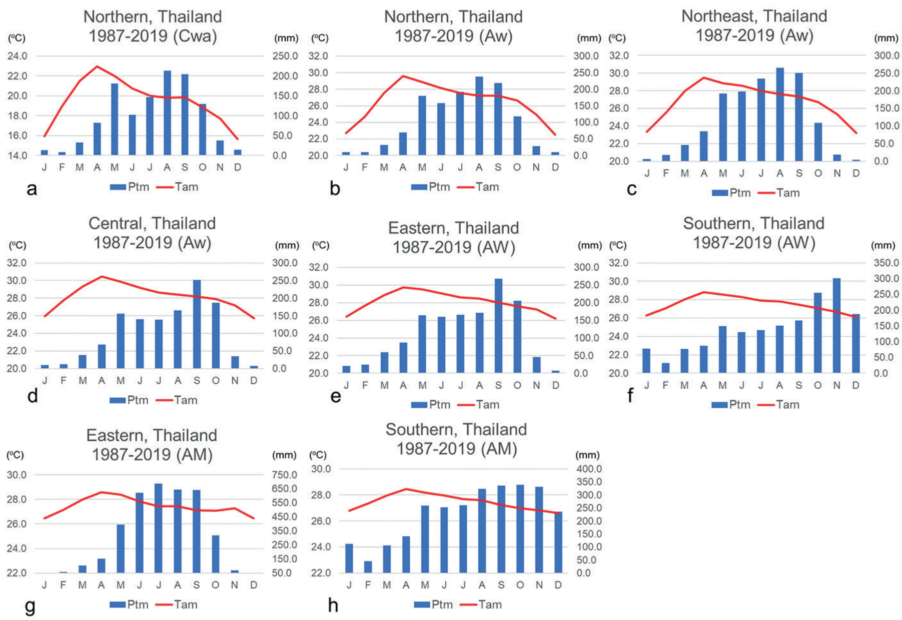

Fig. 6

Total monthly rainfall and Average monthly temperature values of Thailand in 1987 – 2019 period (a) Cwa in Northern region, (b) Aw in Northern region, (c) Aw in Northeast region, (d) Aw in Central region, (e) Aw in Eastern region, (f) Aw in Southern region, (g) Am in Eastern region, and (h) Am in Southern region

Source: Own creation

"Cwb" climate or Dry-winter subtropical highland climate and "Af" climate or Tropical rainforest climate were seldom discovered in some year of present period around the small-upper area of Northern of Thailand for "Cwb" and in the small-bottom area of Southern of Thailand. Unfornumately, these two sub climates could not be displayed when focusing on this through long study's period. In summarisation, the results were coincident with the study of Beck et al. (2018) that Thailand had "Aw" as a main sub climate, following by "Am" in Eastern and Southern area of Thailand. Moreover, "Cwa" was still concurrently discovered in a small area of Northern of Thailand.

Tab. 8(a) Proportion of Aw and Am by KGC method in Thailand of 1987 – 2019

Regions	Area (km²)	Aw			Am		
		Area (km²)	Area (%) of region	Area (%) of Thailand	Area (km2)	Area (%) of region	Area (%) of Thailand
Northern	156,005.20	150,462.74	96.45	29.15	-	-	-
Northeast	167,740.60	167,740.60	100.00	32.50	-	-	-
Central	71,033.99	71,033.99	100.00	13.76	-	-	-
Eastern	36,654.54	29,337.92	80.04	5.68	7,316.62	19.96	1.42
Southern	84,651.05	46,698.17	55.17	9.05	37,952.88	44.83	7.35
Total of Thailand	516,085.38	465,273.43		90.14	45,269.50		8.77

Tab. 8(b) Proportion of Cma by KGC method in Thailand of 1987 – 2019

Regions	Area (km²)	Cma		
		Area (km²)	Area (%) of region	Area (%) of Thailand
Northern	156,005.20	5542.46	3.55	1.07
Northeast	167,740.60	-	-	-
Central	71,033.99	-	-	-
Eastern	36,654.54	-	-	-
Southern	84,651.05	-	-	-
Total of Thailand	516,085.38	5542.46		1.07

Source: Own creation

Köppen-Geiger Climate Classification system of Thailand in the mid and late twenty-first century period (2020 – 2060 and 2061 – 2100)

T_{am} and P_{tm} of mid and late twenty-first century period (2020 – 2060 and 2061 – 2100) were predicted by SD GCM V 2.0 software, cooperated with BCC-CSM1.1 (historical) for historical prediction and BCC-CSM1.1 (rcp85) for future prediction under high emissions and no mitigation concept to get climate classification change characteristics details if all emissions still high, ran under three statistical downscaling methods (Delta, EQM, and QM). After that, all data were run under KGC theory following as Tab.2 and 3. Then, KGC maps of mid and late twenty-first century period were created by kriging method, operated in GIS programme as presented in Fig. 5(b-c) with Brown and Yellow scale refers to "Aw", and "Am" climate, respectively. The KGC results of these two periods were similar predicted in term of "Cwa" was disappeared by air temperature rising in Northern part of Thailand. This can be awareness about

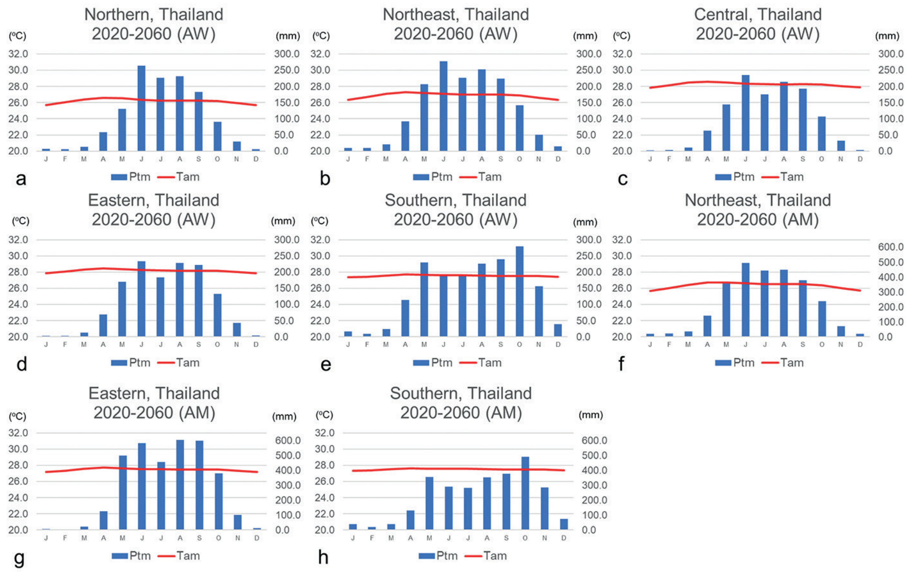

Fig. 7

Total monthly rainfall and Average monthly temperature values of Thailand in 2020-2060 period (a) Aw in Northern region, (b) Aw in Northeast region, (c) Aw in Central region, (d) Aw in Eastern region, (e) Aw in Southern region, (f) Am in Northeast region, (g) Am in Eastern region, and (h) Am in Southern region

Source: Own creation

global warming situation in this region. Therefore, only "Aw" and "Am" climates could be found in these two period but the extended area of each types were different. "Aw" Climate was still the major sub-climate type of Thailand according to mid and late twenty-first century period; however, it extended area more than mid twenty-first century period. The area of "Aw" were predicted around 91.85% and 96.37% of Thailand area for mid and late twenty-first century with the predicted evidence that all months had the T_{am} higher than 18 °C and P_{tm} were lower than 60 mm, was found around 4-5 months around November to March. Proportion of Aw climate by KGC method in Thailand of present period were illustrated in Tab. 9 and 10. The results represented that Aw was covered 100% of Northeast part (32.50% of Thailand), and Central part (13.76% of Thailand), respectively in mid and late twenty-first century period. However, it was overspread at 80.04% of Eastern part (5.68% of Thailand) and 82.89% (5.89% of Thailand) for mid and late twenty-first century period respectively, around the area behind Chanthaburi mountain range. Moreover, it also distributed around 61.35% of Southern part (10.06% of Thailand) and 85.35% of Southern part (13.99% of Thailand) for mid and late twenty-first century period respectively. It also appeared in Northeast of Thailand with 98.81% of area (32.12% of Thailand) for mid twenty-first century while

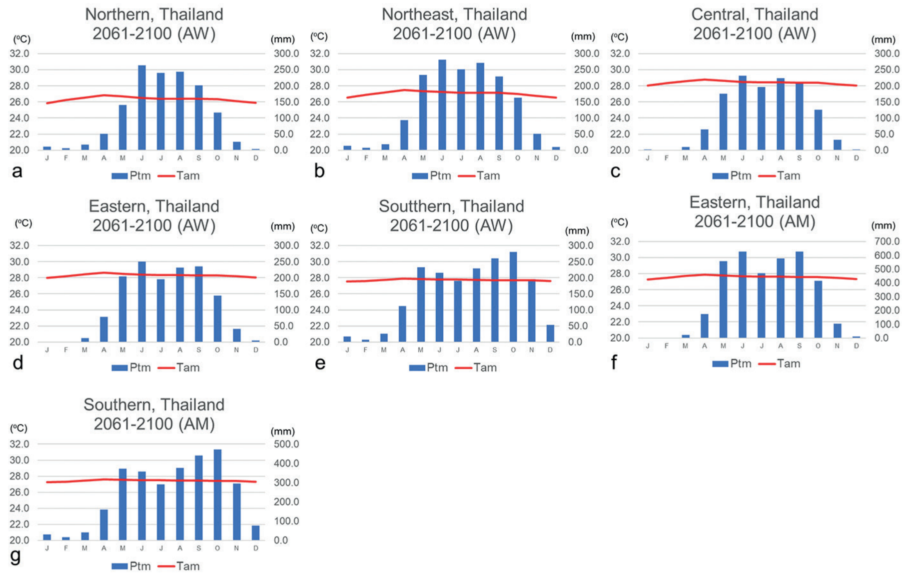

Fig. 8

Total monthly rainfall and Average monthly temperature values of Thailand in 2061-2100 period (a) Aw in Northern region, (b) Aw in Northeast region, (c) Aw in Central region, (d) Aw in Eastern region, (e) Aw in Southern region, (f) Am in Eastern region, and (g) Am in Southern region

Source: Own creation

it appeared at 100% of area (32.50% of Thailand) for late twenty-first century. Proportion of Am climate by KGC method in Thailand of present period were illustrated in Tab. 9 and 10. "Am" climate was still predicted to appear likely in almost same area of present period; however, the area tended to be smaller period by period. It covered about 8.15% and 3.63% of Thailand area for mid and late twenty-first century period, respectively with the predicted evidence that all months had the T_{am} higher than 18 °C and there were P_{tm} lower than 60 mm around 3-4 months around December to March. The results displayed that "Am" was covered 19.96% of Eastern part (1.42% of Thailand) for mid twenty-first century and 14.65% (2.40% of Thailand) for late twenty-first century period, between front of Chanthaburi mountain range and next to Gulf of Thailand. It also found at 38.65% of Southern part (6.34% of Thailand) in alomost half area of region for left, right, and bottom of area in mid twenty-first century whereas it was predicted to drcrease to 14.65% of region (2.40% of Thailand) around small area of right side and bottom of area in late twenty-first century period. Although rainfall values were stably high all year due to southwest and northeast monsoon effect which can lead more humidity and rainfall pass through the land, and even

In late twenty-first century had predicted rainfall values which were higher than mid twenty-first century, the dry months were still predicted and appeared in some months and some area. Therefore, this discontinuous highly rainfall would not enough to encourage the same climate type still appearing in the area.

In summarisation, the results were synonymous with the study of Kottek et al. (2006), Peel et al. (2007) and Chen and Chen (2013), represented that Thailand climate was compatibly classified into Equatorial or Tropical climates (A group) with two sub-climate types: Tropical savanna climate with "Aw" or dry-winter characteristics (major sub type) and "Am" Tropical monsoon climate (minor sub type).

Tab. 9 Proportion of Aw and Am by KGC method in Thailand of 2020 - 2060

Regions	Area (km^2)	Aw			Am		
		Area (km^2)	Area (%) of region	Area (%) of Thailand	Area (km2)	Area (%) of region	Area (%) of Thailand
Northern	156,005.20	156,005.20	100.00	30.23	-	-	-
Northeast	167,740.60	165,746.30	98.81	32.12	1,994.25	1.19	0.39
Central	71,033.99	71,033.99	100.00	13.76	-	-	-
Eastern	36,654.54	29,337.92	80.04	5.68	7,316.62	19.96	1.42
Southern	84,651.05	51,934.24	61.35	10.06	32,716.81	38.65	6.34
Total of Thailand	516,085.38	474,057.70		91.85	42,027.69		8.15

Source: Own creation

Tab. 10 Proportion of Aw and Am by KGC method in Thailand of 2061 - 2100

Regions	Area (km^2)	Aw			Am		
		Area (km^2)	Area (%) of region	Area (%) of Thailand	Area (km2)	Area (%) of region	Area (%) of Thailand
Northern	156,005.20	156,005.20	100.00	30.23	-	-	-
Northeast	167,740.60	167,740.60	100.00	32.50	-	-	-
Central	71,033.99	71,033.99	100.00	13.76	-	-	-
Eastern	36,654.54	30,382.09	82.89	5.89	6,272.45	17.11	1.21
Southern	84,651.05	72,250.92	85.35	13.99	12,400.13	14.65	2.40
Total of Thailand	516,085.38	497,412.80		96.37	18,672.58		3.63

Source: Own creation

SUMMARY AND CONCLUSIONS

Köppen-Geiger Climate Classification system (KGC) is an easy method to determine climate zone in Thailand by using observation data of 1987 – 2019 (the present period), coperated with BCC-CSM1.1 model to predict climate type in 2020 – 2060 (the mid twenty-first century period) and 2061 – 2100 (the late twenty-first century period). Moreover, RCP85 scenario of BCC-CSM1.1 model was selected to model the air temperature and precipitation under releasing of high emissions (easpecially CO_2) and no mitigation process concept to present the impacts under the worst situation. Futhermore, EQM was a appropriate statistical downscaling method to predict climate variables data, with the lowest MAE, MPAE, RMSE and the highest R^2, Pearson coefficient and Index of Agreement. GIS and Raster interpolation process were used to present climate zone with output cell size at 400 and Number of Point at 12. The results illustrated that high average monthly temperature (T_{am}) concentrated in the middle of Thailand then decreased in the next area thus, the lowest temperature always found in Northern of Thailand due to high altitude and forests effect for these three study periods. The predicted average monthly temperature (T_{am}) of the mid and late twenty – first century were higher than the present period due to an increasing of CO_2 and other emission with no any policy (according to RCP85 scenario work). The precipitation values were obviously high around the area which is located between front of Chanthaburi mountain range and the gulf of Thailand in Eastern region whereas in Southern region also had high rainfall due to monsoon effects. Moreover, upper side of Northeran and right side of Northeast region also had high rainfall due to tropical cyclone but the concentration was not steady in all months. Predicted P_{tm} values were increasing around half-right side of Thailand period by period. Unfortunately, this phenomenon was not enough to shift the climate type in the most area of Thailand. The summarization results of two periods were synonymous with the study of Kottek et al. (2006), Peel et al. (2007),Chen and Chen (2013), and Beck et al. (2018) indicated that Thailand climate was classified into Equatorial or Tropical climates (A group) with two sub-climate types: Tropical savanna climate with dry-winter characteristics (Aw) as a major sub climate, found in all regions and covered the most area of Thailand and Tropical monsoon climate (Am) as a minor sub climate in almost one – fifth of Eastern which was located next to the gulf of Thailand, and it dispersed in southern region. However, Dry-winter humid subtropical climate (Cwa) was discovered in small-upper area of Northern region, it would be predicted to dissappear in the mid and late twenty-century period. Moreover, Tropical rainforest climate (Af) and Dry-winter subtropical highland climate (Cwb) were seldom discovered in some year around the small area of the bottom of Southern of Thailand for Af and around in small – upper area of Northern region; however, this could not be classified as sub-climate type when focusing on long period.

Therefore, Thailand has just two classes of climate (Aw and Am climate). There was an interesting question asked by Sanderson (1999): *"Is it not time for modern atmospheric scientists to develop a "new" classification of world climate?"* the results from this study demonstrate that climate is changing all the time due to natural and human effects. Therefore, climate monitoring and prediction are essential to remind climate issues and support future research.

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TERRITORIAL ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC ASPECTS OF PLANNED CZECH HIGH-SPEED RAIL CONSTRUCTION

Milan VITURKA[A], **Vilém PAŘIL**[B*], **Jiří LÖW**[C]

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Abstract

The aim of this article is to present the results of the evaluation of selected aspects of the construction of high-speed railway routes (HSR) in the Czech Republic through stimulation and sustainability criteria. The first criterion is focused on assessing potential conflicts of the proposed routes with protected areas of European importance and territorial systems of ecological stability of the landscape of supraregional importance, and the second criterion on assessing the degree of their connection to the territorial systems of centres and axes of development affecting the regional quality of the business environment. The explanatory power of these criteria is guaranteed by their theoretical framing of the original integration theory of sustainable regional development, connecting territorial systems of socio-economic development with territorial systems of ecological stability of the landscape. The acquired knowledge can be used practically for evidence-based identification of the importance of individual HSR routes and optimization of their localization.

Key words

high-speed rail, assessment, regional development, stimulation, sustainability

INTRODUCTION

It should be noted at the outset that the assessment of the potential territorial aspects of the planned high-speed rail/HSR construction is a very complicated matter and is often discussed by the public. In addition to the high construction costs, this fact reflects the political rhetoric about its extraordinary benefits for the socio-economic development of states and their regions. However, academic studies

A Faculty of Economics and Public Administration, Masaryk University, Brno, Czech Republic
https://orcid.org/0000-0002-0036-9823
viturka@econ.muni.cz

B* Faculty of Economics and Public Administration, Masaryk University, Brno, Czech Republic
https://orcid.org/0000-0001-9623-1935
vilem@mail.muni.cz (corresponding author)

C LÖW & spol., s.r.o., Vranovská 102, 614 00, Brno, Czech Republic
https://orcid.org/
lowaspol@lowaspol.cz

have shown mixed results and this conclusion is suitably complemented by the following quote: "Nevertheless, we cannot conclude whether it is the HSR connection that creates growth or whether it is the anticipated growth in these areas that attracts infrastructure investment" (see e.g. Vickerman et al., 1999; Ministry of Transport of the Czech Republic, 2013; Blanquart, Koning, 2017). In other words, neither ex-post studies do not allow a causal relation to be established between HSR and growth, especially since HSR lines have often coincided with motorway system expansions (Ministère de l'Ecologie, du Développement Durable et de l'Energie, 2015). Practical examples of non-fulfilment of the original ideas about significant positive effects of investments in transport infrastructure on regional development can be found especially in Italy and Belgium (Bray, 1992), and more recently in East Germany. This risk must therefore also be taken into account in the case of the HSR construction, which is generally expected to increase the competitiveness of "environmentally friendly" rail transport.

OBJECTIVES

The aim of this article is to assess selected aspects of the construction of HSR in the Czech Republic through stimulation and sustainability criteria, where stimulation is evaluated through business environment change on the micro-regional level while sustainability is evaluated via impact assessment on Natura 2000 network and territorial system of ecological stability.

In this context, a territorial view of the evaluation of the effectiveness of HSR construction is presented, reflecting its system anchoring in the socio-economic development of regions and focused on assessing of potential environmental and economic aspects of the planned construction of a HSR network in the Czech Republic is further discussed. The project envisages the construction of a HSR network in the form of a so-called fast connections / FC (FC in contrast to standard HSR with operation of 200 and more km / h often include modernized conventional lines with a speed of 160 to 200 km / h - in the following text is preferred HSR designation). Specifically, the following planned FC routes are analysed: Route 1 Prague – Jihlava - Brno (connection of the Route 2 →Vienna) - Přerov - Ostrava → Katowice, Route 3 Prague - Pilsen → Munich and Route 4 Prague - Ústí n. L. → Dresden (SŽDC, 2018).

THEORETICAL FRAMEWORK

In current literature there is vast research on aspects of regional development connected to construction of HSR systems. The most common subject of transport geography literature regarding construction of HSR is related to the problem of accessibility; e. g., Ureña et al. (2009) focuses on intermediate cities in Spain (Zaragoza, Cordóba) and France (Lille) and develops a multilevel analysis at national, regional, and local levels examining HSR's selective capacity to increase accessibility. The effects are not always positive; e.g. Jiao et al. (2012) shows the HSR network in China will bring about substantial improvement in accessibility and lead to national time-space convergence, but will also increase the inequality of nodal accessibility between eastern, central, and western regions, or between cities with different population sizes. In South Korea, long-term properties assessment discovered internal inequality in many regions, which got even worse than the stage before construction of the HSR (Kim, Sultana, 2015). Another criticism comes from the U.S. pointing out that HSR proposals are hub-and-spoke designs, benefitting the hubs more than spokes, and that the economic development effects of HSR are small and uncertain (Levinson, 2012). In Spain the greatest improvements in accessibility concentrate near HSR stations, whereas intermediate locations suffer from comparatively lower accessibility benefits, and furthermore negative territorial cohesion properties appear if the HSR ultimately results in a more polarized spatial distribution of accessibility levels (Ortega et al., 2012). Regarding the economic cohesion effects of the HSR network there, it seems that regional economic disparity has been decreased since the development of HSR in China and it has promoted regional economic convergence especially significantly in the East and North (Chen, Haynes, 2017). Cheng et al. (2015) examine changes in accessibility and provide evidence on changes in specialisation for both main cities and their hinterlands and confirm that the properties differ widely and that the process of convergence and divergence differs at different stages of economic development.

Broad research literature related to HSR points to a varying range of negative environmental effects or externalities, usually connected to vibration (Connoly et al., 2016), energy and CO_2 emissions (Rozycki, 2003), life cycle costs (Banar, Ozdemir, 2015), specific natural species (Clauzel et al., 2013), noise (Xiaoan, 2004), safety (Noronha et al., 2015) or comparison to air travel (Socorro, Viecens, 2013) or road transport (Barrientos et al., 2019). Few of these studies are focused on landscape or natural sites protection. The first such study is provided by De Santo and Smith (1993), who studied effects on wildlife resulting from placement and construction in the short-term, and habitat removal and fragmentation in the long-term as a consequences of transport corridor construction. Kim and Lee (2014) use a spatial decision support system to pinpoint the changes in the natural landscape as well as the physical environment, trying to solve relevant methodological limits. In China, Zhang et al. (2020) provided evidence of increasingly fragmented spatial patterns found in both urban and rural development. A strategic planning approach is presented by Carvalho et al. (2017) who conclude that a Strategic Environmental Assessment approach is, in the future, potentially most beneficial if developed before any HSR project to first determine if HSR is really necessary and strategically justifiable to the achievement of both environmental and sustainability objectives. On the other hand, there is a lack of studies filling the gap in HSR research combining strategic assessment of potential regional economic aspects together with aspects of environmental protection, aimed at landscape connectivity and fragmentation in one consistent methodological approach. There are only a few studies evaluating both regional and landscape characteristics. For Spain, the GIS based approach of TITIM (Territorial Impact of Transport Infrastructure Measuring) has been performed, harmonizing landscape and accessibility characteristics (Ortega et al., 2014). These questions represent the main research area of our paper.

DATA AND METHODS

The main priorities of the evaluation of the planned construction of the HSR presented below are environmental sustainability (focused on landscape fragmentation) and stimulation of regional development (focused on socio-economic differentiation of territories), the links between which are often considered by the public to be contradictory or even controversial. Accordingly, the basic philosophy of our article is to contribute to research on issues related to the exploitation of potential opportunities and the reduction of potential threats associated with this strategic objective. From a broader perspective, our approach is based on the original methodology of multi-criteria evaluation of the effectiveness of investment projects verified by the example of Czech motorway and expressway construction projects (Viturka, Pařil, 2015), which includes a total of five criteria: usefulness (economic aspects), relevance (technical aspects), integration (social and political aspects), stimulation (economic aspects) and sustainability (environmental aspects). Last two criteria fulfil the focus of our study and are examined deeply. The irreplaceable importance of multicriteria approaches, based on non-monetary indicators allowing a fair comparison of the production of positive and negative externalities, primarily stems from the limited possibilities of monetary expression of various effects of public projects focused, contrary to private projects, on multi-target users.

Regarding our second field of research focus based on sustainability our analysis is based on several datasets. The basic dataset includes general geographical information on Czech Republic for geographical information systems in the Czech Republic (Arc ČR, 2020). To assess potential conflicting areas for planned HSR development in the Czech Republic it was necessary to most updated plans of detailed potential HSR routing in the geographical corresponding with the most recent versions of Czech Railway Administration (SŽDC, 2018). The second data cornerstone of landscape sustainability analysis is based on data from Nature Conservation Agency of the Czech Republic as key responsible administrative body for landscape and natural protection. The data provided for analysis are of two types. First is covering all areas included in the European landscape and natural protective system of Natura 2000 in the area of Czech Republic (AOPK, 2020) corresponding with analogic data from European Environmental Agency (EEA, 2020). The second landscape dataset cover Territorial System of Ecological Stability in the Czech Republic on supraregional level (AOPK, 2020). This system is highly corresponding with European ecological network system (Jongman, 2004, Jones-Walters, 2007, Jongman et al., 2011) and its main function is to provide continuous network of naturally protected elements. Based on data described above for further analysis we used a simple GIS-based topological overlay method using "line in polygon overlay" to identify conflicting points and we even used "polygon in polygon overlay" with a five-hundred-meter buffer zone for the planned high-speed line to be able to determine the range of the impact in relevant natural sites.

Quality transport infrastructure is one of the inescapable factors influencing socio-economic development, territorial division of labour and population mobility at all hierarchical levels. In this context, the results of the regional assessment of the quality of the business environment (QBE), showing strong links to GDP, were effectively used as an explanation framework for the analyses of potential developmental aspects of the planned construction of the HSR. Relevant information published in a few studies, mainly from 1998 to 2010, made it possible to draw up the first systematic model of the development potential of the regions of the Czech Republic (Viturka et al., 2010). Assessment of QBE is based on 16 factors interpreting the investment preferences of companies operating in the manufacturing industries and higher market services, defined and valued on the basis of the results of international surveys. These factors were divided into six groups, identified as business, labour, infrastructure, regional, price, and environmental factors (in order of importance). The acquired knowledge was then generalized in the original integration theory of sustainable regional development, interpreting the effect of the laws of developmental and hierarchical differentiation of socio-economic systems, the logical consequence of which is the creation of territorial systems of centres and axes of regional development. This theory follows in some respects the theory of polarized development (Boudeville, 1996; Friedmann, 1996) or the microeconomic theory of competitiveness and the endogenous theory of economic growth (Porter, 1998; Romer, 2010). From a practical point of view, it can be stated that firms realize a trade-off between agglomeration and dispersion forces and choose the location that maximizes their market potential. The application of the approach described above has made it possible to place the analysis of the effectiveness of HSR construction into a broader, relatively stable framework formed by causal dependencies between the quality of the business environment and investment attractiveness (and consequently between the quality of the social environment and residential attractiveness).

POTENTIAL IMPACTS OF THE PLANNED HSR NETWORK ON ENVIRONMENTAL DEVELOPMENT OF REGIONS

Part of the evaluation of the effectiveness of planned infrastructure projects is, of course, the assessment of their environmental aspects (with special regard to the perception of aspects on climate change and biodiversity protection), which is necessary for creating the most objective strategies for sustainable development. The intensity of aspects is amplified by metropolisation tendencies associated with the growth of population density and the necessary increase in infrastructure capacity, which leads to the emergence of conflict zones with negative aspects on the health of the population. In our case, the main attention is focused on the assessment of the construction of the HSR network in terms of the most significant direct aspects. Thus, neither GHG emissions with strong links to climate change are considered, which is more appropriate to assess compared to other modes of transport, nor are emissions from the production of energy and its transport to the point of consumption (well-to-tank). Regarding the relative importance of direct negative externalities produced by transport, in terms of their monetization, the greatest importance is attributed to accidents (European Commission, 2019). Noise pollution and air pollution are at an average level, and damage to the biotope occupies the lowest important position from this purely economic point of view.

Higher levels of meaning are clearly achieved by those externalities that have a negative impact on human life and health, or on the living environment or agriculture (climate change). These are mainly externalities related to air pollution and noise. However, the first of these is only marginally affected by the planned HSR networks, because the negative effects on air pollution are offset by shifting part of the demand from road to rail, which leads to significant emission reductions, especially in heavily urbanized regions. Conversely, the impact of the HSR on noise pollution is very significant, as in this respect a significant deterioration of the situation, and thus the quality of life, is observed for groups of the population living or working in its immediate vicinity. E.g. on the HSR section operated in Taiwan, “69% of residents highly annoyed” are within 100 meters of the railway body (Tsai et al., 2019). Despite the increased noise, which can be seen as a kind of toll on the possibility of faster transport, the speed still increases the competitiveness of HSR with individual car transport, especially in the case of transport over a distance of 200 km or more (Körner, 2013). To this end, it is worth noting that according to Czech legislation, the night-time permissible limit for outdoor noise is at the level of 50 dB, but the recommended WHO limit is only 40 dB. Depending on the nature of the relief and placement of residential buildings, the increased noise level in the vicinity of the HSR can be observed up to a distance of almost 500 meters from the centre of the railway body (Sarikavak, Boxall, 2019). In this regard, for the purpose of assessing the aspects of the planned HSR network, a buffer zone of 500 meters from the railway body was used, which reliably takes into account the most critical zone of the potentially noise affected population (in order to maintain methodological consistency, this zone was used analogously even in other analyses dealing with the aspects on nature and landscape and its fragmentation). The distribution of the population in the vicinity of the planned HSR routes was determined on the basis of the most detailed analysis from the Czech Statistical Office according to the so-called basic settlement units in combination with mapping land use according to CORINE land cover (RSO, 2020 →CORINE, 2018). The results of the analysis show that the number of inhabitants exposed to excessive noise in connection with the implementation of the HSR network is between 286 and 686 thousand, depending especially on the length and method of solving delays in the metropolitan areas of Prague, Brno and Ostrava. It is therefore very important for these sections that the noise component is considered when planning the route, because a well-thought-out technical design can significantly reduce the noise level.

Damage to natural ecosystems appears to be a less important category, which corresponds to the indirect nature of their effects on humans (human health is logically monetized more significantly than the health of natural ecosystems or plant and animal species). However, it should be noted that the health status of ecosystems (reflecting the effects of negative externalities on habitats) and their interconnectedness (reflecting the degree of their fragmentation) are a major factor influencing other externalities, such as air pollution and climate change. The mentioned problem of fragmentation of the natural environment is exemplified by The Theory of Island Biogeography (MacArthur, Wilson, 1963), which generalizes the fact that island ecosystems located closer to the mainland have more plant or animal species than isolated and remote islands. Analogously, it is generally true that larger natural units have a higher degree of biodiversity than smaller natural units, which reflect the mutual distance or the level of interconnectedness of ecosystems.

An important component of the assessment/perception of the environmental aspects of potential construction and subsequent operation of HSR is, of course, the comparison of this mode of transport with other transport alternatives. The results of this comparison are shown in Figure 1, which shows that rail transport achieves significantly lower levels of environmental impact than road transport, both in passenger transport and in freight transport. To this end, it is worth noting that, according to the available information, high-speed rail is the least onerous means of transport, even compared to standard rail transport, including diesel traction (European Commission, 2019).

The following text presents the specific results of the evaluation of the environmental aspects of the construction of HSRs in the Czech Republic with emphasis on landscape and nature protection systems of supra-regional significance and their fragmentation. For the above reasons, the following protection systems are considered in this analytical section: Natura 2000 created in the European Union, including the so-called Special Areas of Conservation (SAC, Council Directive on

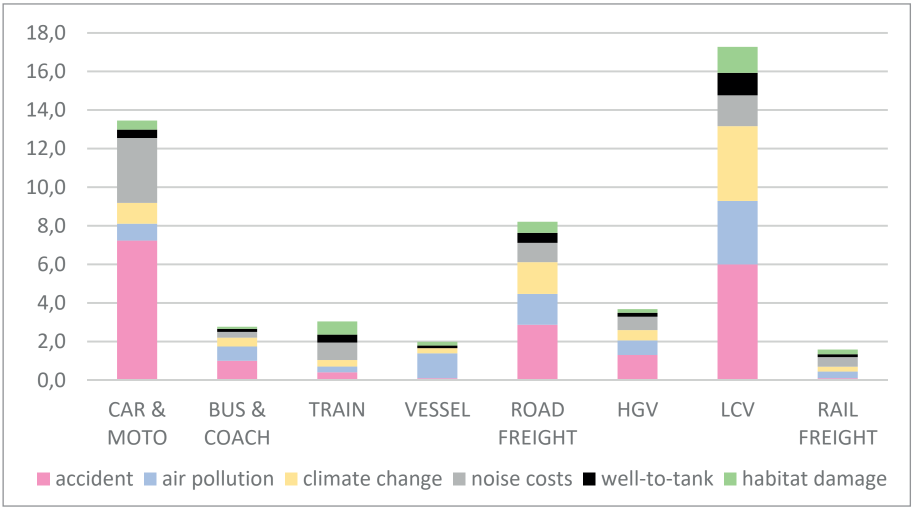

Fig. 1
Comparison of the relative importance of the environmental burden according to the nature of externalities (in Eurocent / passenger km)
Source: European Commission, 2019.
Note: HGV – heavy goods vehicle, LCV - light commercial vehicle.

habitats) and Special Protection Areas (SPA, Council Directive on the conservation of wild birds), and the hierarchically highest supra-regional component, i. e. relevant biocentres and biocorridors of the Czech territorial system of ecological stability (TSES). In accordance with the hierarchical importance of individual protection systems, the following weights were assigned to individual components: Natura 2000 – weight 2, supraregional TSES – weight 1. The identified potential conflicts, according to particular HSRs, are clearly listed in Table 1 and showed in Figures 2 (impacts on TSES and impacts on Natura 2000 areas – SPA and SAC). From an absolute point of view, the most significant environmental aspects were identified in the case of the longest Route 1, followed by routes 4, 2 and 3.

Tab. 1 Potential conflicts of the planned HSR with Natura 2000 and TSES and their weighted assessment according to the potential aspects on sustainable development/SD

HSR	SAC	SPA	TSES		final
			biocentres	biocorridorss	
HSR1	13	2	3	9	1
HSR2	4	1	1	2	3
HSR3	3	0	1	4	4
HSR4	6	1	2	4	2

Source: authors.

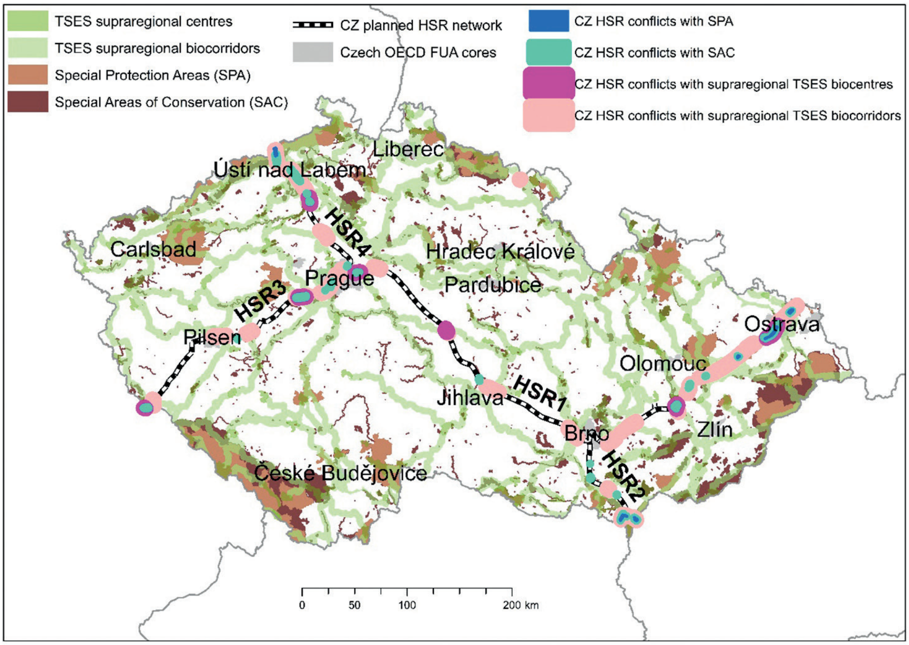

Fig. 2
Potential conflicts of the planned HSR network with Natura 2000
(SAC and SPA and supraregional TSES)
Source: Arc ČR, 2020; SŽDC, 2018; AOPK, 2020.

From the point of view of spatial complexity of delimitation of HSR routes conditioned by technical limits of longitudinal inclination and radius of curves, macro-relief of landscape and further protection of the most valuable parts of the landscape with significant direct and indirect links to overall quality of the social environment are crucial. According to the first point of view, it is possible to divide the Czech Republic into two basic parts. The first one of them consists of the "Czech Basin" bordered on all sides by mountains, where the structurally significant terrain elevation ranges from about 150 m on Route 4, to over 350 m on Route 1, to 360 m on Route 3. The second part consists of the Moravian valleys, where the total elevation of Routes 2 and 1 in the line from the border with Austria through Brno to the border with Poland reaches approximately 160 m. Routes 1 and 3 must therefore rise tens of kilometres in front of ridges. This can be overcome by tunnels, which is the most advantageous solution in terms of landscape, however this is done with the expenditure of increased construction costs (if the proposed routes cross wide alluviums, it is often necessary to build long flyovers). In addition to the problem of landscape fragmentation, it is also necessary to mention the negative aspects on the landscape, especially related to specially protected areas (diversion of HSR routes from these areas is very difficult or in some cases impossible due to the necessary size of the railway curves).

POTENTIAL IMPACTS OF THE PLANNED HSR NETWORK ON REGIONAL ECONOMIC DEVELOPMENT

In this section, in accordance with the topic, the main attention is focused on the infrastructural factor of the quality of roads and railways. Its evaluation emphasizes the achieved level of connection of regional centres at NUTS 3 level to the most functionally important segments of the road and railway network with a decisive role in long-distance transport (Viturka et al., 2010). In terms of the comparative importance of road and rail transport, based on available statistical information and technical parameters of infrastructure (especially transport performance and division of labour in freight and passenger transport, expressed in tonne-kilometres and passenger-kilometres) and taking into account current developments, a ratio is set at 5.5:1. This ratio was then used to perceive potential development aspects induced by the construction of the HSR. In this respect, the semantic position of long-distance roads was expressed, using weighting coefficients defined in accordance with their technical and operational parameters, as follows: motorway 1.0, expressway 0.9, 1st class roads of international importance according to the European Agreement on main roads with international traffic 0.5, and other 1st class roads 0.375. In the case of railways, all lines were included in the evaluation, with the exception of end routes, with preference being given to Europe-important railways or transit railway corridors (TRC) included in the Trans-European Network (TEN-T), and other lines subject to the European Agreements on international railway lines (AGC) and on the most important international combined transport (AGCT) routes, including connecting lines. The significant position of the railway lines was taken into account using weighting coefficients related primarily to double-track lines (for single-track lines the respective weights were halved) as follows: TRC 1.0, remaining lines AGC + AGCT 0.6, connecting lines 0.55, and other lines 0.5. As part of the QBE assessment, the quality factor of roads and railways was assigned a semantic weighting of 8% in accordance with the analysis of investment preferences and taking into account the achieved level of economic development of the Czech Republic (for comparison of the semantic weighting, which deal with infrastructural factors of information and communication technologies and proximity of airports, which is 6 resp. 4%).

Through the application of the methodology described above, the relevant regional centres (in the case of the Olomouc region it is a significant traffic junction Přerov, located in contrast to Olomouc on the planned HSR) were assigned corresponding point values. The original data relating to the 2010-time horizon have been converted to current data. The data in Table 2 shows that Prague, followed by

Ostrava, Brno, and Pilsen, which were included in the 1st classification group (the remaining regional capitals together with Přerov, fall into the 2nd group), occupies the best position. Thanks to the expansion of the motorway and TRC network, only Ústí n. L and Přerov with the highest share of the railway component showed a more significant improvement in position (improvement by 8% and 13%, respectively). For indicative estimates of potential aspects of HSR on the position of selected centres, a compensation coefficient of 1.35 was used, reflecting the difference between the average line speed of about 150 km/hr on TRC (taking into account the planned technical modifications of the lines) and at a real average speed of approx. 200 km/hr on the planned HSRs. With regard to speculative considerations with significantly higher speed parameters, it is worth noting that, according to a sample survey of 14 HSRs operating within the EU on only two lines, the average speed exceeded 200 km/hr (European court of auditors, 2018).

Tab. 2 The position of regional centres within the network of roads and railways and the potential impact of HSR construction

centre	original values		updated values		estimated values with HSR	
	total	share of rail in %	total	share of rail in %	total	share of rail in %
Prague	49.75	9.9	50.05	10.2	54.10	16.8
Pilsen	25.80	9.5	26.95	13.1	29.65	21.0
Ústí n. L.	19.25	22.1	20.75	20.5	23.45	29.6
Jihlava	16.65	5.1	16.65	5.1	19.35	18.3
Brno	29.55	13.4	29.90	13.2	33.95	23.6
Ostrava	30.95	9.9	31.20	9.8	33.90	17.3
Přerov	*12.75*	23.5	*14.40*	20.8	*17.10*	28.4

Source: authors.

The planned HSR network connects 6 of the 13 regional capitals, performing the function of development centres thanks to the above-average level of QBE. The analyses show that within the relevant regional capitals, the largest improvement in the quality factor of roads and railways with adequate aspects on investment attractiveness can be expected in the case of Jihlava (16%) followed by Brno (13.5%) and Ústí n. L. (13%) and the smallest improvement in the case of Pilsen (10%), Ostrava (8.5%) and Prague (8%). From the point of view of aggregate regional values of QBE, however, this improvement does not play a too significant role (Jihlava by 1.3%, Brno by 0.9%). To this end, it is worth noting that the real aspects of building the HSR network on the redistribution of transport demand will be significantly affected by road transport competition (Chmelík, Květoň, Marada, 2010). From a territorial point of view, it is clear, that the HSR will deepen the interconnections of the development centres concerned (especially between Prague as a metropolis of supranational importance (separate region NUTS 3) and Brno and Ostrava as secondary metropolises together with Pilsen). These diverse links correspond in direction to the development axes identified on the basis of positive QBE deviations from the theoretically relevant values derived from the population size of micro-regions, i.e. administrative districts of municipalities with extended powers/MEP supplemented by Prague (Viturka et al., 2010). Development axes generally function as the main channels for extending spread effects from development centres to their surroundings. The long-term effects of these links are organically linked to the establishment of development axes stimulating both quantitative and qualitative development of labour (confirmed by negative statistical links with the unemployment rate) and residential (construction of houses and flats as the most important component of investment activities) markets.

The above findings then were used to perceive the development aspects of the planned HSR routes, based on their directional correspondence with development axes of national importance - type A axes, supplemented by development axes of regional importance - type B axes (see figure 3). To this end, it should be noted that these stimuli are loose in cases where the planned sections of the HSRs pass through less urbanized MEP regions. The methodology used is based on the evaluation of the position of the affected regions through representative indicators of unemployment rate/UR and completed dwellings per 1000 inhabitants/CD - in both cases these are the borderline figures 2016 and 2020 (ČSÚ, 2020). In this respect, the best position is occupied by the Route 3 corresponding to the West Bohemian developed axis of type A Prague - Pilsen, which together with the adjoining axis type B Pilsen - Domažlice integrates Prague with a total of nine MEP regions. All these regions showed positive deviations from the national average in the case of UR. In the case of CD two regions showed negative deviations. The second place is occupied by Route 1, which can be divided into the Brno and Ostrava components. Parts of the East Bohemian developed axis of type A Prague - H. Králové in the section Prague – Kolín, supplemented by the axis of type B Kolín - Čáslav, and the Czech-Moravian developed axis of type A Prague - Brno in the section Jihlava - V. Meziříčí, correspond to the Brno component. The Ostrava component is formed by a part of the East Moravian, partially developed axis type A Brno – Zlín in the section Brno - Vyškov and a part of the declining central Moravian axis type A–Brno - Ostrava in the section Lipník n. B. - N. Jičín (its declining importance is evidenced by the negative population development of Ostrava). From an overall point of view, Route 1 includes Prague together with 20 MEP regions. In the case of UR, a total of 12 regions (including Prague) showed positive deviations from the average while negative deviations were shown by 9 regions (including regional cities of Ostrava and, somewhat surprisingly, Brno). In the case of CD, 10 regions showed positive deviations from the average and 11 regions (of which 8 are part of Ostrava component) negative deviations. The Brno component shows clearly better characteristics. The third position, indicating continued deprivation, is occupied by Route 4 Prague - Ústí n. L. This route, which corresponds in direction to the only partially developed North Bohemian axis of type A, Prague - Ústí n. L., includes Prague and 4 MEP regions. In terms of the examined indicators, negative deviations in the ratio of 3 to 2 for UR and 2 to 3 for CD. The worst position of Route 2, consisting of only 4 MEP region including Brno corresponds to its primary role as a prospective connection of the Czech and Austrian HSR networks. The ratio of positive and negative deviations was 1 to 3 for UR and 3 to 1 for CD.

The results show that within the group of the most important settlement agglomerations of the Czech Republic, the capital city of Prague clearly generates the strongest development stimuli as the only established metropolis of supranational importance, followed by Pilsen. The shift of Brno to the third position is conditioned mainly by persistent imbalances on the labour market. On the other side are Ostrava together with Ústí n. L. with a long-term negative development trajectory threatening the potential benefits of HSR. From a general point of view, the constitution of systems of development centres and axis in interaction with

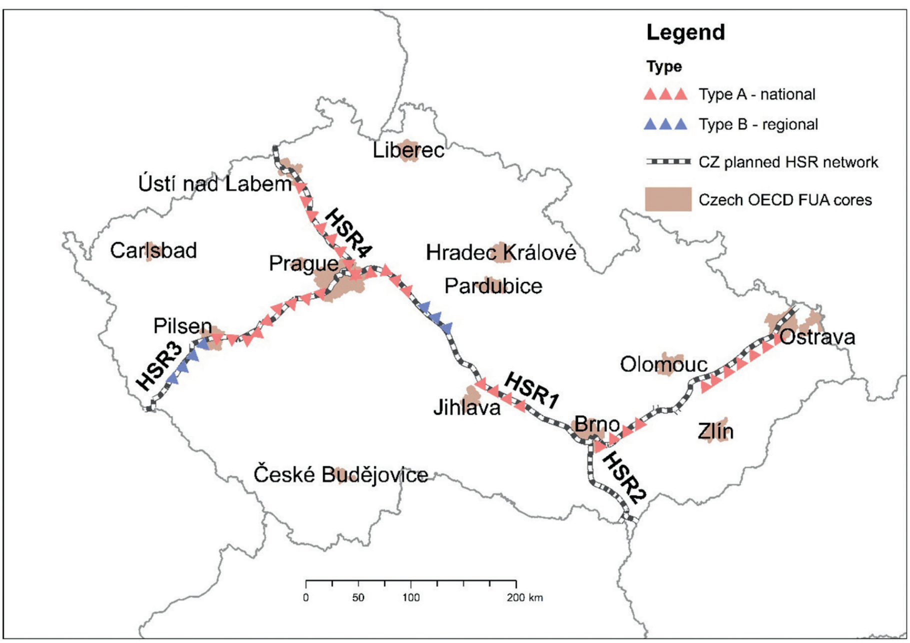

Fig. 3
Coincidence of the planned HSR construction with development axes of national and regional importance
Source: authors.

their semantic position and involvement into global production networks can be considered a conditio sine qua non of the successful activation of stimulation functions of individual HSR routes.

RESULTS AND DISCUSSION

The synthesis of the results of the performed analyses is based on the elementary method of point evaluation, based on which the order of individual HSR routes is compiled. This approach is relatively close to the practical decision-making of entities interested in the projects, or stakeholders, and from the point of view of the multicriteria evaluation method it is thus considered standard (see e. g. SUDOP et al., 2013). From a broader point of view, the significant advantage of the analyses presented above is their theoretical anchoring, which makes it possible to link the evaluation of projects with the general laws evolution of the development of social and natural systems. The final synthesis shows that the best overall position is held by HSR number 3 Prague – Pilsen → Munich, followed by HSR 1 Prague – Jihlava – Brno – Ostrava → Katowice, HSR 4 Prague – Ústí n. L. → Dresden and the "connection" HSR 2 Brno → Vienna (for more detailed information see Table3). The general importance of the planned HSR routes for regional development is demonstrated by the fact that the current share of the population within directly

Tab. 3 Evaluation of the planned HSR construction according to the criteria of stimulation and sustainability and their overall position

criterion	HSR 1	HSR 2	HSR 3	HSR 4
stimulation	2	4	1	3
sustainability	4	2	1	3
total	2	4	1	3

Source: authors.

affected regions is around 36% of the total population of the Czech Republic. From an international point of view, it is interesting to compare HSR 3 and 4 providing a prospective connection to the German HSR network. In this respect, despite difficult physical-geographical conditions generating high construction costs (planned tunnel under the mountains Krušné hory with a length of about 26 km), for political and functional reasons HSR 4 connecting Prague with the German capital Berlin is preferred. However, according to the criteria analysed above, route HSR 3 appears to be more beneficial. This fact should be carefully considered in conjunction with the evaluation of the position of the two routes under the other criteria, and only on this basis should the optimal priorities for the construction of the HSR network be definitively established. Regarding the ongoing discussion on the construction of the HSR, it should be noted that it is largely focused on political proclamations about its great economic benefits or purposeful discussions on the exact location of routes. Significantly less attention is paid to fundamental issues, such as the overall vision of HSR construction (which is documented, e.g., by non-systemic changes in the structure of main routes) or the absence of discussion on several critical issues (e.g., the use for freight transport).

CONCLUSIONS

Finally, the assessment of regional effects of the construction of express transport infrastructure is one of the important topics of regional economic research (within Central Europe, e.g., Seidenglanz et al., 2021). From the point of view of the Czech Republic, two facts can be considered essential in this context: long-term lag of motorway construction and significant delays in starting HSR construction due to the risk of gradual reduction in subsidies from European Union funds. For the evaluation of development projects, the CBA analysis is usually used, which, however, due to its reductionist nature (orientation towards monetary indicators) to a certain extent supports the preference for unilateral approaches. In our opinion, this shortcoming can be effectively addressed by means of a multi-criteria analysis of project effectiveness, the broader theoretical anchoring of which makes it possible to link project evaluation with the evolution of natural and social systems. In this context, we also consider it necessary to emphasize that inappropriate choice of an investment project cannot be counteracted by its effective implementation (an illustrative example is the construction of new motorways motivated by efforts to support economic convergence of lagging regions, which, however, has not often been achieved due to the low competitiveness of local firms). In this context, it is appropriate to recall that, precisely for the purpose of system-based prevention of the implementation of socially less beneficial or even harmful projects, standardized tools Environmental Impact Assessment and Territorial Impact Assessment have been created (European Union, 2015). These instruments emphasize a comprehensive and timeless approach that takes into account, in addition to traditionally preferred economic growth, other dimensions of social development, such as sustainability, social cohesion and the quality of territorial governance (Medeiros, 2014). By combining the assessment of two different criteria of stimulation and sustainability, we also discuss possible changes of economic and environmental relations of the capital Prague to other regions regarding the protection of transnational and supra-regional importance ecosystems. This approach creates a practical framework for applying the concept of so-called "sustainable convergence" as a tool for solving the not very convincing results of applying traditional methods. In this context, it is appropriate to state, e.g., long-term experiences from Slovakia, where significant regional disparities are not handled effectively enough (Matlovič, Matlovičová, 2011). Therefore, we ask another research question, what is the current role of the capital city or metropolitan cities in the regional system of the Czech Republic, and how will the construction of HSR change it from an economic and environmental point of view concerning the phenomenon of suburbanization and regional development. In the case of motorways and expressways, e.g., Lechowski (2021) showed an indirect effect on population redistribution in the Łodz metropolitan area). Our research indicates there can be a significant effect even in constructing the HSR system.

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