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LOCALISING THE THREATS DUE TO CLIMATE CHANGE IN MOUNTAIN ENVIRONMENTS

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Abstract

Global climate change is expected to have severe impacts in particular on Alpine regions with climate dependent economies and a vulnerable environment. Usual environmental risk like torrents floods and avalanches are supposed to increase. The current employment pattern might be disrupted by climate change. In particular local Alpine communities and districts will feel the effects. An attempt is done to quantify the expected losses due to climate change on a local level. Losses are estimated by diminished income for the winter tourist industry. As the pace of warming is still unknown three scenarios of warming are provided. Local decision makers should be enabled to judge the economic magnitude of the problem and to develop counter strategies against climate change.

Keywords: climate change, economic modelling, regional planning, natural hazards, tourism.

Introduction

Global climatic change has been an ongoing research topic for more than 15 years. However, little has been done to bring adequate awareness to decision makers on a local level. Impacts in Alpine regions will occur first on the local level resulting later on in over regional problems. Usually the local decision makers are not aware of how global climate change can affect the local life and how to take it into account at various planning processes.

Alpine regions are particularly vulnerable to the impacts of global climatic change both from an economic and environmental perspective.

Ahead of 40 years ago, most Alpine regions made a living from subsistence agriculture. Nowadays agricultural income is only a small proportion of the income in tourism. In Austria 8.4 % of the gross national income is directly earned by tourism (Österreich Werbung, 1992). In addition about 20% of

GNP are indirectly generated by tourism. Approximately 80% of this tourism are in mountainous areas. Half of the income comes from winter tourism.

Economic development became also possible due to expensive safety-constructions to reduce typical Alpine environmental risks such as torrents, floods and avalanches. Due to global climate change natural hazards could increase severely. Additional installations of safety constructions such as flood-, torrent- and avalanche protections become necessary. However, it is questionable if most of the Alpine communities will be able to afford them, because revenues from winter tourism are shrinking with the increase of temperature.

Global climate change models harvest results on a large grid and are not directly applicable in local planning processes. However, if global climate change is a key issue in Alpine regions, local decision makers should have a simulation tool to imagine the possible consequences of climate change. Our approach to do this was to construct an interdisciplinary model of one Austrian mountainous district -- the Hermagor district in the Eastern Alps -- and to test the sensitivity of the climate dependent parameters. Our aim was to develop three sub models of the same region describing the development in time over the same period (1951 to 1991) and to give long-term forecasts (2021) for each of them:

- a "population-economic" sub model
- a "land use sub model"
- a "hydrological" sub model.

Our goal is to find out the major relations among these three sub models and to construct a unifying model of the region. We hope that general considerations concerning our model construction are useful for other regions as well.

In this paper we mainly deal with the "population-economic" sub model of the district. First we characterise the region of study. Second we mention other global climate change impacts not taken into account in the "population-economic" sub model, mainly an expected increase of natural hazards. Third we introduce our "population-economic" model. We give some basic theoretical considerations and also some simple examples of possible runs of our model. Consequences of global climate change on the number of population working in different sectors are then estimated. In the final section we mention options for policy discussions that might help local decision makers to take appropriate strategies against possible threats of global climate change.

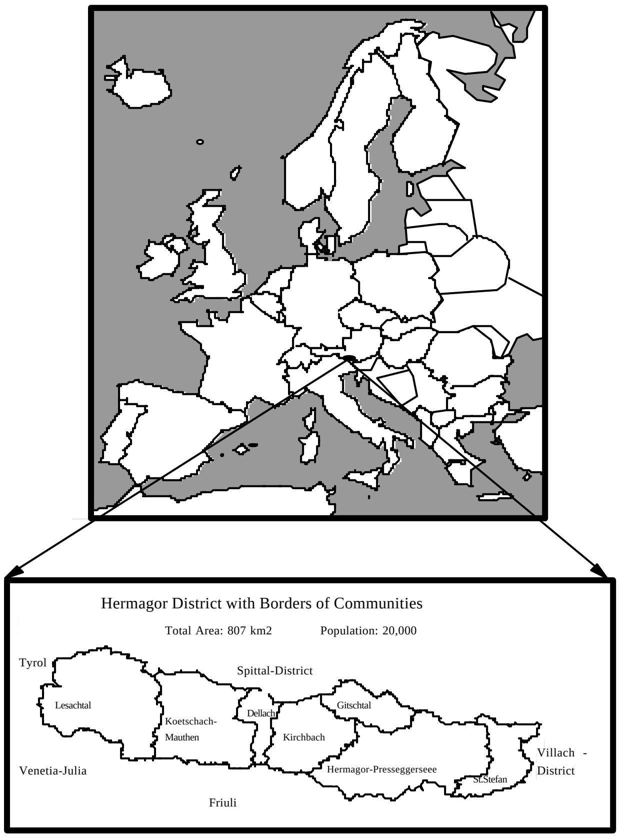
Characteristics of Hermagor District and Observed Climate Change

General

The Hermagor district covers 807 km^2 with a population of 20,000 people. This is about 1% of the area of Austria and 0.25% of the Austrian population. The district is divided into seven communities (Dellach, Gitschtal, Hermagor, Kirchbach, Kötschach, Lesachtal, St. Stefan). It covers the valley of the river Gail (Lesach- and Gailtal), flowing west to east and the Gitschtal, north of the Gailtal. The lowest point is at 450 m and the highest point is 3,200 m above sea level. The timberline is at 1850 m altitude.

Figure 1 shows the situation of Hermagor district in Europe and its separation into communities.

Location of Hermagor in Europe



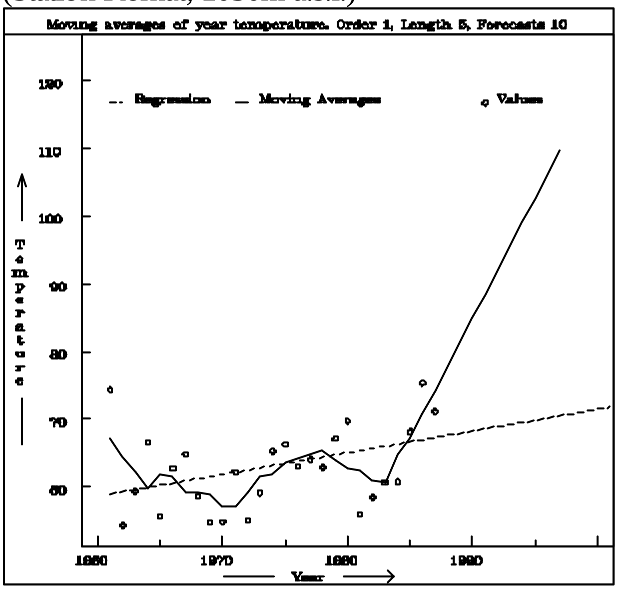
Originally agriculture was the main source of income. Nowadays it is tourism and the service sector. With 1.5 million guest-nights more than 1% of the Austrian tourism counting 130 million guest-nights in 1991 are in this area. The gross local product is US $ 234 million. The average income is less than 80% of the Austrian average. There is a lack of work opportunities for people with higher education. At the same time there is a demand for seasonal work. Most farmers in the eastern part of the district having better access to the main economic centres Villach and Klagenfurt have also a second job. Tourism supports the local agriculture which in turn provides the maintenance of cultural landscape, which is an important resource for mountain tourism.

The main environmental problems are caused by the constructions of ski tracks and other infrastructure for winter sports (mainly at the Naßfeld skiing resort, where recently a snow making plant was built), and constructions of forest roads. Both activities contribute to soil erosion and de stabilisation of the Alpine landscape. Almost half of the district (47%) is covered by a productive forest. Therefore a good natural protection against environmental hazards exists. Marginal agricultural land is afforested and contributes to a further stabilisation of the landscape against natural hazards, but is at the same time diminishing the variety of the cultural landscape. The elimination of wetlands for agricultural purposes was leading to a loss in biologic diversity. Air pollution and forest die-back were only registered in the east nearest to the industrialised centres. Water pollution and domestic waste problems are in connection with the increase of tourism and became a problem during the last decades. A sewage treatment plant is under construction.

Observed climate change

In comparison to the global increase of surface temperature which is reported to be 0.3 to 0.6 degrees Celsius during the last 100 years (IPCC, 1992), the rate of change in Hermagor district between 1961 and 1991 was 0.9 degrees Celsius. This is much higher than the global average. However, there is only one continuos measurement station available for the whole district and we could not proof the rate of increase of the neighbouring stations.

Figure 2: Surface temperature increase in Hermagor (Station Kornat, 1050m a.s.l.)



Source of data: Austrian Meteorological Service (1992)

The plain line shows the five years averaged mean temperature curve of Kornat, a station in 1050 m altitude. The dotted line explains the trend. The temperature scale is 0.1 degree Celsius[1].

[1]It is the only station of Hermagor district describing temperature. It should be mentioned that the last 30 years showed a general warming tendency and that the time series are too short to proove or disproove the assumption of climate change.

Expected consequences due to global warming for Hermagor

Impacts on economy

Some major economic and environmental disturbances can happen. Their magnitude will depend on the rate of change. It might start with a decrease in tourist revenues in winter and additional costs for snow making equipment and infrastructure. Later on, additional environmental safety constructions are needed, which will demand higher investments. During the last years already some US $ 40 million were spent on snow making equipment at Naßfeld skiing resort, the main winter tourist place of the district.

Impacts on ecosystem

The natural vegetation in particular the high alpine protective forest is endangered. The capacity for retaining soil moisture and soil erosion, cleaning of water, or the resilience against pests depends on the rate of warming. Some species can live within a relative broad temperature range, while others are more sensitive to slow temperature change. First the variety of plants may decrease, later on also more robust tree- and plant species (which might have initially an increase in area and number) might be pushed out from their acceptable range of temperature and large scale destabilisations might become the consequences. Particular in Hermagor, where we have a high percentage of forest and therefore a good natural protection which can buffer non benign environmental impacts, climate change could show more non benign impacts than in areas with scarcer vegetation cover.

Extreme precipitation is expected to increase. Gordon (1992) anticipates a tripling of extreme precipitation events and dry periods for Europe in the mid latitudes. These are conditions under which vegetation suffers of permanent environmental stress, leading to a decreased resilience. Simultaneously extreme runoff will increase and alter the number and severity of catastrophes. Each damage will diminish the future vulnerability of the entire ecosystem of the district.

There might be a serious gap between diminishing funds available from local income (see next chapter) and the increased demand in safety constructions (see conclusions). A dilemma occurs: the magnitude of observed damage does not yet justify major investments into additional safety constructions, but at the time when damage will turn out, it could ruin the entire economy of the district. During the last 27 years (1965 to 1991) the annual damage due to catastrophic events was 21 times less than US $ 1 million, 5 times less than US $ 2 million and one time in 1966 over US $ 7 million, which would correspond to a today's catastrophe of US $ 25 million damage. In comparison to the earnings the damage was in the worst case some 11% of the district income and usually under 1%.

The population-economic sub model of Hermagor

General

We constructed a baseline local development scenario for the "population-economic" sub model, then rerun it with change of the key parameters affected by warming. The difference of the runs should then quantify the relative importance of the global climatic change. Similar approaches are planned for the "land-use" sub model and the "hydrological" sub model.

In order to develop an interdisciplinary model of Hermagor district we have to link these more specific sub models (which could themselves be split into even more desegregated sub-sub models) and then try to unify them to the general model in the final stage. Further on we introduce some ideas and results concerning economic-population model.

Population part

First we describe briefly the non-linear population regression model. According to the historical data (collected in 1951, 1961, 1971, 1981) and to the general experience from the region we use the following curves for different sectors:

1) logistic curve for relative number of people working in services
2) decreasing logistic curve for relative number of people working in agriculture
3) exponential function of negative quadratic function (Gaussian curve) to fit the relative number of people working in industry
4) linear trends for people working in business and others sectors.

The relative numbers (relative to number of inhabitants in the district) where considered. The software GAMS (Brooke, Kendrick, Meeraus 1988) was used for parameter estimates with the following results (by *Time* we mean *(Year-1951)/10+1*):

People (Agric&Forest,Year) $= 0.453 - 0.453/(1 + 6.582*0.475^{Time})$
People (Industry, Year) $= ex(-1.34 + 0.276*Time - 0.064*Time^{2})$
People (Services, Year) $= 0.303/(1 + 10.347*0.452^{Time})$
People (Bus.&Trans, Year) $= 0.062 + 0.021*Time$
People (Others, Year) $= 0.166 + 0.017*Time$.

In order to get estimates for the absolute numbers of people working in different sectors we have to multiply right hand sides of previous equations with the number of inhabitants in given *Time*. The following residuals for relative numbers were obtained for the years 1951 - 1981:

	1951	*1961*	*1971*	*1981*
Agric&Forests	-0.002	0.006	-0.007	0.004
Industry	-0.003	0.008	-0.008	0.002
Services	0.003	-0.005	0.004	0.000
Business & Transport	0.003	-0.003	-0.002	0.002
Others	-0.004	0.009	-0.008	0.002

For the purpose of this paper we used only the data concerning the whole district Hermagor. In fact, there are significant differences between smaller political units of the district communities. This was proven using ANOVA (Analysis of Variance) which is explained shortly in APPENDIX. Hence the strategy derived here for the "global scale" of Hermagor district can be done separately for "local scale", i.e. communities. This can bring different results for different communities. From the "global" point of view our results are, however, valid. Since the data for 1991 will not be available until Oct. 1993, we had to give forecasts for this year instead of using the real data.

Joining population and economy

In this paragraph we introduce a deterministic dynamic linear model which we use for the description of the economical and demographic behaviour of our region. We use the following notation:

$\boldsymbol{GLP}^t$ - vector, whose *i*-th co-ordinate is a value of *GLP* (Gross local product - i.e. Gross national product produced in Hermagor district) produced in the *i*- th sector at time *t*, *i*Ú{Agriculture, Industry, Services, Business, Others}.

$\boldsymbol{INC}^t$ - vector of average incomes per capita at time *t*. *i*-th co-ordinate is related to the *i*-th sector again.

$\boldsymbol{POP}^t$ - vector of number of inhabitants at time *t* dependent on the *i*-th sector.

$\boldsymbol{P}^t$ - square matrix (5x5 in our case). The *ij* element of this matrix is the fraction of $GNP^t{}_j$ which get an average person in the *i*-th sector.

$\boldsymbol{Z}^t$ - square matrix (5x5 in our case again). The *ij* element of this matrix is the amount of US $ produced by a man in the *j*-th sector which will be evaluated as the part of $GLP^t{}_i$.

$\boldsymbol{Q}^t$ - square matrix. On the *ij* position there is the amount of US $ produced by a man from the *j*-th sector which will become real income of an average man in the sector *i*.

The elements of defined matrices and vectors we will denote by small italics with sub indices, e.g. $p^t{}_{ij}$ denotes the element in the *i*-th row and *j*-th column of the matrix $\boldsymbol{P}^t$.

Under this notation we suppose the following dynamics in economy.

$$\begin{aligned} \boldsymbol{Z}^t.\boldsymbol{POP}^t &= \boldsymbol{GLP}^t \\ \boldsymbol{P}^t.\boldsymbol{GLP}^t &= \boldsymbol{INC}^t \qquad \qquad (1) \\ \boldsymbol{POP}^{t+1} &= c.\boldsymbol{INC}^t, \end{aligned}$$

where c is some constant. Here the linear relation between $\boldsymbol{POP}^{t+1}$ and $\boldsymbol{INC}^t$ can be considered since the time difference in our case is ten years. If the time difference would be smaller then more general relation should be taken into account. Generally, a change of ***POP*** reflects changes in ***INC.*** The reflection is almost zero on the beginning becoming linear after some time. A continuous case would need more deep considerations which are not of our main interest now. In the model (1) the elements of matrices $\boldsymbol{Z}^t$ and $\boldsymbol{P}^t$ are of main importance. In fact, our model supposes a closed system with respect to income and output. If we would relate this model to geographically more complex areas, the matrices would become more dimensional matrices, etc. The structure of the matrices reflects general relations between different sectors of the studied region. Estimation of elements of these matrices is of course the major task. It depends on the data available and on our experience with the region. Local policy scenarios can be very substantial for the structure of these matrices. In the next paragraph we give a small example how this model can be used for estimating the change of the population development under global climate change. We will show how to measure this change having only very small information about the region at our disposal. We will assume the very special structure of the model matrices, which is not true in real life. However, our results can give rough estimates of a behaviour of the local economy in the region.

Simple example of use of previous model - Estimate of effect of global climate change

According to values from Jeglitsch (ÖROK 1989), taking AS 10 as exchange rate for US $ 1 we estimate GLP for Hermagor district in 1991 as US $ 234 millions . Further on we suppose according to standard economic development during last years annual increase of Gross Local Product about *GLP*=0.01.

Taking global warming into account we must estimate the change of income for the region. In this paper we consider only economic changes so we do not deal with possible consequences for land use or hydrology, etc. According to the daily temperature data since 1961 (Fig. 2: station Kornat - 1050 m high) we found statistically significant increase of temperature in the Hermagor district. This increase is 0.00007 Celsius degrees per day (standard deviation of this estimate is 0.00001 degree). This gives annual change of temperature of 0.0255. However, as it is well known that doubling of CO_2 will cause warming about 3 Celsius degrees. In this paper we therefor give forecasts till 2021 under three different situations. Under optimistic scenario that global warming will remain on the same level as during last 40 years (for Hermagor district a non-linear trend in warming was not proven statistically) we get 0.75 degrees warming in. Under the pessimistic scenario (doubling of CO_2) we get 3 degrees warming and under middle scenario we consider here 1.5 degree change of temperature for 2021. For our model the major effects of temperature change concern tourism. This is caused by change of snow level due to an increase of the frostline.

Table 1: Average number of days with mean under 0° C from 1851 to 1950

Altitude	100 year mean from Eastern Alps	0.75 degree increase	1.5 degree increase	3 degrees increase
400	77	68	60	27
600	90	84	77	60
800	101	95	90	77
1000	110	106	101	90
1200	120	115	110	101
1400	130	125	120	110
1600	144	137	130	120
1800	163	155	144	130
2000	178	170	163	144

Source: Aulitzky (1985) concerning the annual mean temperature value in the Eastern Alps for 1851-1950 and WMO\UNEP (IPCC 1990) for the expected increase of the frostline.

From this table we get the average change of winter tourists nights as the average of differences between first and other columns. Hence we get for optimistic scenario 7.5 days difference, 14.7 days for middle and 31.8 days for double CO_2 scenario. We take average length of season as the number of days with mean under 0 at the 800m altitude. Different definitions may be taken here according to the information from the district or community - related variable we denote by *LES* (Length of Season). Under our definition we get shortened length of season under optimistic scenario about 7%, 15% in the case of middle scenario and finally 31% under pessimistic scenario. Income per 1 winter tourist night we assume to be US $ 70 and we have 530,000 of winter tourist nights in the district. Hence the income from winter tourism can be estimated as US $ 37,100,000 which will be shortened according to the mentioned proportions to US $ 34,503,000, US $ 31,535,000 or US $ 25,599,000 respectively.

We use this previous information for our model computations. Since we don't have too much detailed information at our disposal we have to assume special structure of our matrices. In our simplification we assume that our economical sectors behave independently. That means all matrices $\boldsymbol{Z}^{t}$ and $\boldsymbol{P}^{t}$ we suppose to be diagonal. We consider the following values:

$$p^{t}_{ii} = \frac{c^{t}_{1}}{pop^{t}_{i}}, \; i = \mathbf{1,\dots,5},$$

$$z^{t}_{ii} = c^{t}_{2}, \; i = \mathbf{1,\dots,5},$$

where $c^{t}_{1,2}$ are some real constants. It's easy to interpret these values as that GLP in some economic sector is linearly dependent on number of people working in the sector (first equation of (1)) and income of an average person in the *i*-th sector is some part of GLP produced in this sector which is proportional to $1/POP_i$. Now we take our estimates of population in different sectors gained from non-linear regression analysis. These values taken at time $t+1$ we use to estimate $\boldsymbol{GLP}^{t}$ through the equations (1). This backward procedure help us to extrapolate $\boldsymbol{GLP}^{t}$ for the years 1991, 2001, 2011. Now we subtract the estimate losses of GLP in services according to the considerations in the beginning of this paragraph. These are our new data and the equations (1) must be recomputed now in the forward direction. We use FAMULUS system for our computations. Its language is very closed to Pascal and it has nice possibilities of graphics and graphs exports. This program predicts number of inhabitants working in different sectors in the three following decades under three scenarios as was described above. The results are drawn on fifteen pictures. The pictures in one column correspond to five given economical sectors under one scenario. We give these pictures below. By solid line we denote the fit of population in different sectors in the past (till 1981). By --- we denote the situation without global climate change and by -.-.- we denote the situation under the global climate change.

Figure 3: Forecasts for people living from agriculture under optimistic, middle and pessimistic warming scenario in 2021

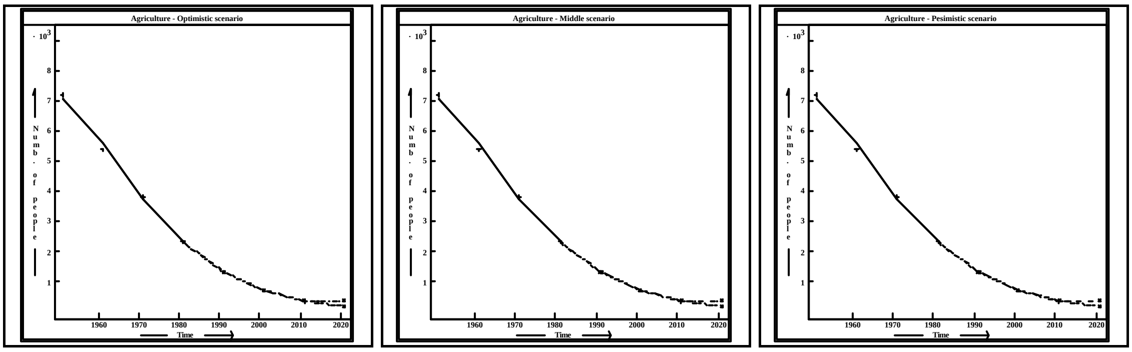


Figure 4: Forecasts for people living from industry under optimistic, middle and pessimistic warming scenario in 2021

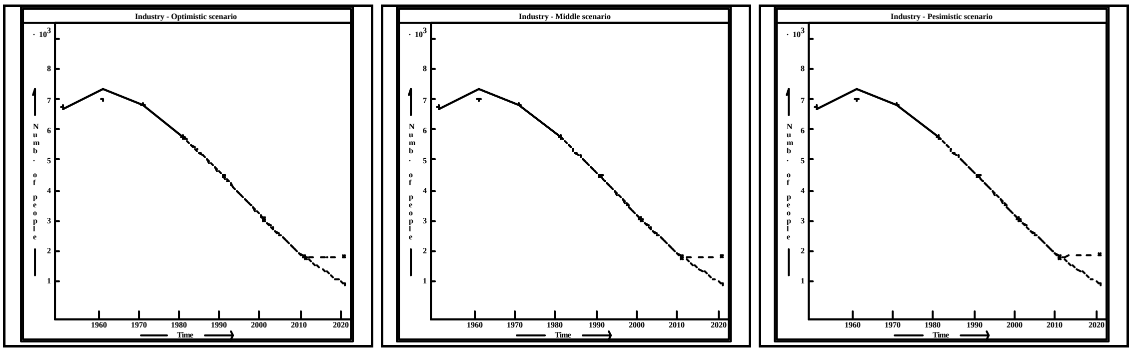


Figure 5: Forecasts for people living from service (mainly tourism) under optimistic, middle and pessimistic warming scenario in 2021

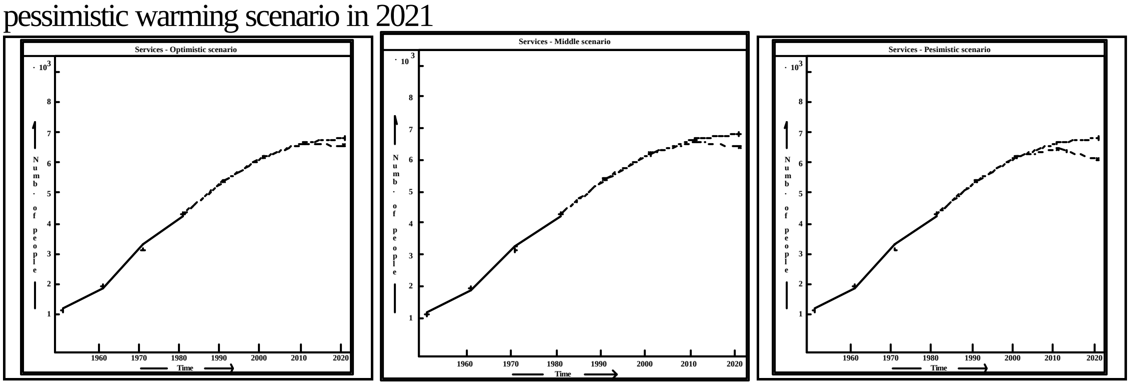


Figure 6: Forecasts of people living from trade under optimistic, middle and pessimistic warming scenario in 2021

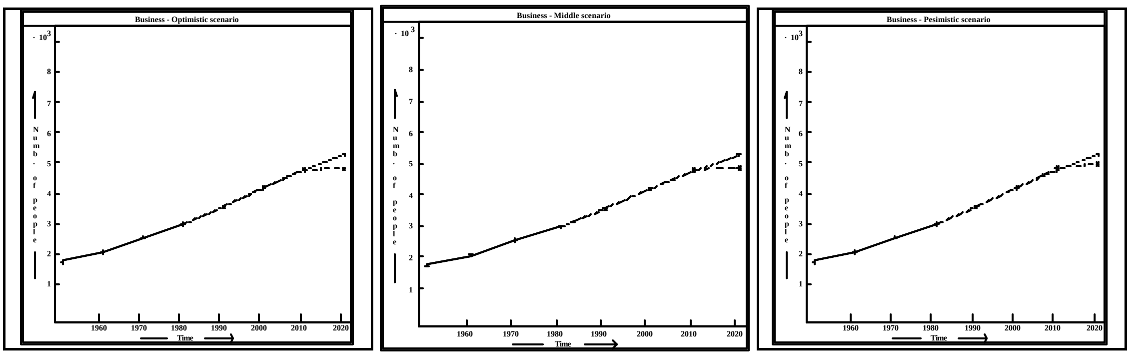
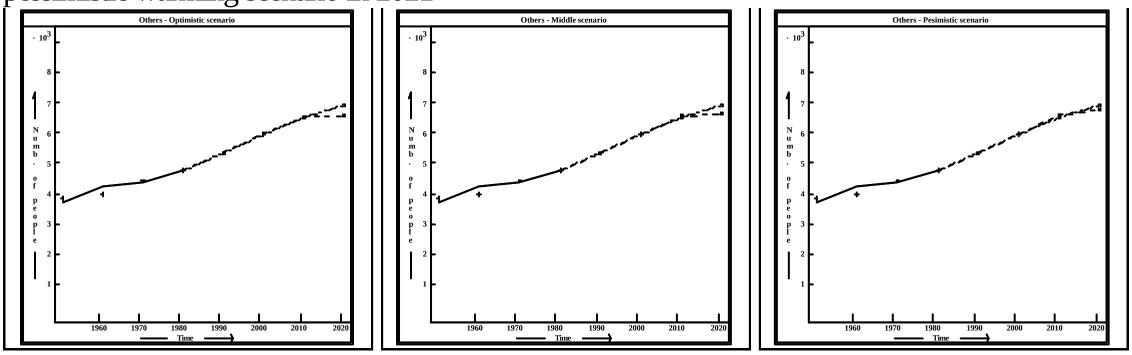


Figure 7: Forecasts of people living from "others" (including unemployment) under optimistic, middle and pessimistic warming scenario in 2021



Source of data in Fig. 3 to 7: Austrian National Statistical Office. Forecasts FAMULUS Software.

Possible consequences are clear from the pictures. However, we must be careful in our considerations specially due to the relations between different sectors. Taking more detailed data or possibly the local politicians expertise we can construct model matrices in more detail and hence our results would be more reliable and not too rough.

Conclusions and Policy Discussion

Changes in the Employment Structure of Population

As Hermagor district is highly dependent on winter tourism climate change will have an impact on the employment structure. According our calculation tourism and service sector will experience a decrease of the current trend, while more people might be forced to be dependent on agriculture due to decreased job opportunities elsewhere. In addition also unemployment (included in "Others" sector) might rise in Hermagor.

Local strategies against climate change: mitigation or adaptation

Having considerably losses in mind local politicians should be motivated to think about possible countermeasures. There are two main options: to mitigate the production of greenhouse gases, the widely identified source of global warming or to adapt to modified environment conditions. Both of the strategies impair considerable uncertainties and the numbers given reflect the present situation and not necessarily future conditions.

a) Strategies to counter emissions of greenhouse gases

Taking the Austrian average carbon emissions of 2t C per person and assuming an equal distribution of every person, Hermagor emits 40,000 t C . If a currently often discussed carbon tax would be introduced, some US $ 170 should have to be paid for one ton of emitted C in a OECD country (Messner S., Strubegger M. 1991). Some US $ 6,800,000 or 3% of the GLP should be paid. Another option currently under discussion is emission trading between countries with high costs to mitigate carbon emissions like Austria and countries with comparatively low costs if both countries agree. This could decrease the cost of mitigating CO_2 production to less than 1% of the GLP.

b) Strategies to adapt to modified environment

As the number of extreme events (days with extreme precipitation and days with droughts) is expected to increase, the current safety measures are not supposed to be sufficient in the future. Approximate estimates give us an area of 400 ha or 0.5% of the total area additionally needed for safety constructions and a price of US $ 600,000 to over built one hectare. This yields that some 240 million US $ are required for this purpose or some 5% of GLP for 20 years. This option does not really seem practicable if the annual damage is in average less than 1% of the GLP. However, in the long run average annual damages of up to 10% of GLP can not be excluded and this option might become realistic at a more severe stage of warming.

c) Policy Recommendation at Current Situation

According to the magnitude of losses due to our presented calculations, the modified income of the Hermagor district would not justify compensation payments for greenhousegas emissions within Austria. Also a stronger increase of safety constructions due global climate change does not seem appropriate yet. The option most desirable and cost efficient is the investment into mitigation strategies outside of Austria. This option assumes an informed public who is ready to undertake measures against climate change at an early stage. Therefore it seems desirable if local decision makers will get more involved into the ongoing climate change discussion and start to play an active role.

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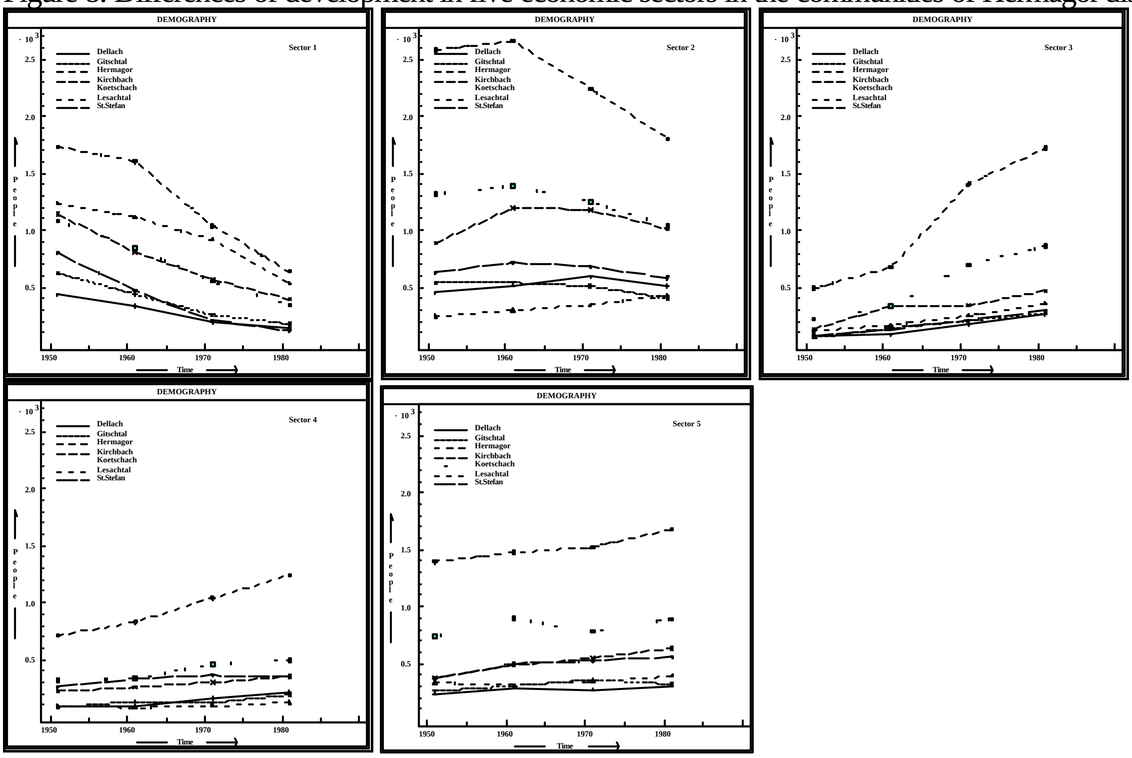
APPENDIX - ANOVA results for population study

In this paragraph we give a description of how population behaves in different communities of the Hermagor region. The question of the major importance is now whether there are significant differences in between different communities. If there are any then the economical model given in equations (1) should be taken for all the communities jointly but the relations between communities would have to be conserved. This means that instead of two dimensional matrices we should use three dimensional one which will preserve the substantial economic structure of the whole region. More detailed data are then needed to study the possible development of the whole region in the general global context.

Figure 8: Differences of development in five economic sectors in the communities of Hermagor district.



Source: Data from Austrian National Statistical Office.

The positive correlation between time and number of people working in "Services", "Business & Transport", and also "Others" sector can be observed. On the other hand negative correlation is quite clear between time and people working in "Agriculture". An umbrella type dependency of people working in "Industry" on time is also obvious. It is clear from the pictures also that the time dependencies of numbers of people working in some specific sector are almost the same for all the communities. The significance of different factors in the population-economic sub model can be studied using three way ANOVA (ANalysis Of VAriance). The brief description of the model is to be given now. The general structure can be expressed as

$$Y = a + b + c + d + e + f + g + noise$$

where

Y - number of people working in some economical sector
a - common effect (for all times, communities, economical sectors)
b - effect of economical sector
c - effect of time
d - effect of community
e - common effect (interactions) of time and economical sector
f - common effect (interactions) of economical sector and community
g - common effect (interactions) of time and community.

The numerical results of ANOVA analysis can be found in the following table.

ANALYSIS OF VARIANCE TABLE 1 - ALL FACTORS		
factor	F-ratio	Prob.>F
d (community)	153.96	0
c (time)	0.21	0.8909
g (time & community)	0.08	1
b (economical sector)	81.95	0
f (sector & community)	8.29	0
e (sector & time)	11.91	0

After this first ANOVA analysis we exclude sequentially the most significant factors getting the final conclusion. It was proved that effect of time and common effect of time and community are really statistically non significant for the given model. This means that time effects can be studied only in common with effects of the economic sectors. The non significance of the time & community effect was already mentioned. For any sector it explains the almost same functional dependency of people working in the sector on the time independently on the region (see pictures 1,2,3,4,5). Before imposing the non-linear regression we used regression linear in parameters which on the other hand enabled us to use standard backward elimination technique to throw out the zero valued parameters. Due to the lack of place we mention only results here without technical details (these details can be found in Breiling (1993).

1) There are the overall decreasing tendencies in numbers of people working in agriculture in time. The decrease is compensated by the increase of relative number of people working in services and business. In industry there was the strong increase of relative number of people working in till the seventies. After that there appeared a slight decrease. The trends in the time were proved statistically to be linear in time, excluding the development of people working in industry and services. In these two economical sectors the quadratic term was significantly non zero. Moreover, the analysis of the residuals of our model showed that although there was a rapid increase of the percentage of people working in services. Nowadays there is a moderate calming down of this trend. From this follows that instead of a quadratic curve for fitting the time development the logistic one could be used. This will give more precise forecasts. Also in agriculture the decreasing logistic curve would provide better results.

2) There is significant positive difference in relative numbers of people working in "Business & Transport" between the Hermagor community and other communities excluding St. Lorentzen community. This can be explained easily since Hermagor is a local capital of the region. Moreover there is also positive difference concerning the people working in the "Services" between Hermagor and other communities excluding the Kötschach-Mauthen community. From other significant differences there is a larger relative number of people working in "Agriculture" in Lesachtal and Kirchbach comparing with other communities. Dellach and Gitschtal have the same structure of percentage of people working in different economical sectors.

The previous mentioned facts can be used for constructing matrices in a general economic model according to (1). These facts proved that separate studies of local communities can be significantly different.