HOW GLOBAL WARMING HAS AFFECTED AGRICULTURE IN A TRANSYLVANIAN CITY. CASE STUDY: SIGHIȘOARA

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ABSTRACT

The phenomenon of global warming is by no means new and this is the challenge of the century. It affects the entire planet, from Greenland, where about 11 trillion ice has been lost, according to CNN, to Romania where agricultural crops suffer due to lack of rainfall, according to local media and data provided by the National Institute of Statistics. While areas destined for agriculture suffer, in Romania, in Mureş County people discuss how they can remedy this issue. Thus, for Sighişoara, a city in this county, projects that focused on climate change were implemented.

It is however necessary for the local population to understand the impact of climate change on the agricultural areas, the severity of the production loss but also the resulted land vulnerability. It is also important to promote environmental-friendly technologies (including geophysical survey of the top layer - Chitea and Ioane, 2020) which can help farmers to know better the soil properties and to take actions accordingly (Ioane et al., 2018) using in an efficient way the water resources and fertilizers (when necessary).

This paper aims to explain how agricultural areas in Sighişoara suffer, to analyze the decline in agricultural production and to propose viable solutions to combat this phenomenon that Sighișoara farmers are experiencing.

Keywords: Sighişoara, Global warming, Agriculture, Climate change, Economy

INTRODUCTION

Global warming is the phenomenon of increasing average temperatures recorded in the atmosphere in the immediate vicinity of the ground and the oceans. Most scholars believe that this phenomenon began during the industrialization period (in the late nineteenth century), but measurements made people aware the issue had only begun in the 1960s, the first proof being offered by the measurements of CO_2 concentrations in the atmosphere in Mauna Loa, Hawaii (Figure 1).

The CO_2 emissions are considered to be the main causes of global warming, the greenhouse effect is triggered by the increase of the concentration of CO_2 in the atmosphere.

The effects of global warming are manifesting on all the layers of our planet:

- ❖ In the atmosphere: increase in vaporization, modification of precipitation regime and number of storms;

- On the hydrosphere: rising ocean and sea levels due to melting polar caps;
- The lithosphere is influenced by the increase in soil temperature, which leads to lower soil moisture content or even aridness. In severe cases, high temperatures extended over a longer period of time, may deteriorate the top layer so severely that the soil can no longer fulfill its basic functions, being at the same time more prone to erosion
- The biosphere is influenced indirectly by the local destabilization of the climate and the deregulation of the seasons.
- The anthroposphere is directly influenced by all these changes, resulting changes in land productivity as a consequence of the climate; the effect of extreme phenomena on human settlements, the appearance of genetic mutations (favored by the climate change) for certain types of viruses and microbes that can affect populations (Franks and Hoffman, 2012).

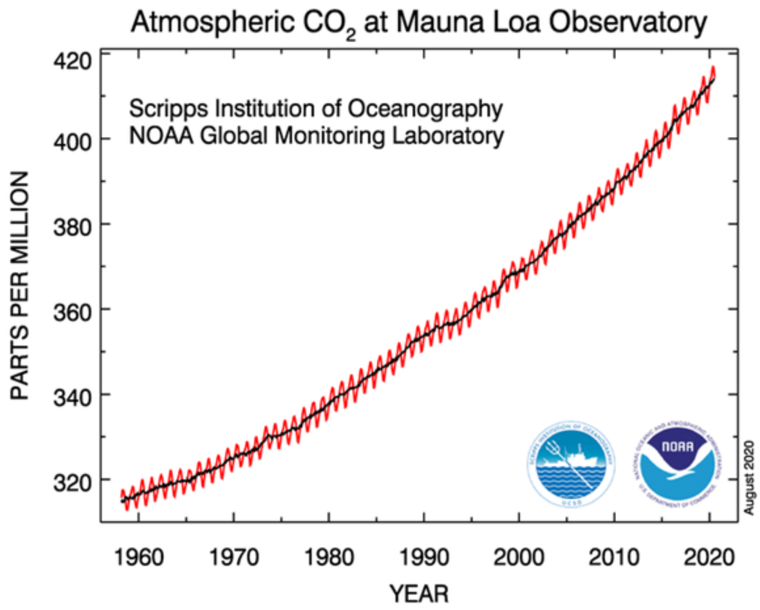

Figure 1 - Atmospheric carbon dioxide as measured at the Mauna Loa Observatory, (Figure source NOAA/ Scripps Institution of Oceanography, LINK 1)

The climate change due to global warming manifests itself differently in Europe, being strongly related to the geographical area.

Thus, Central and Southern Europe are increasingly facing heatwaves, vegetation fires and drought (Feyen et al, 2020). The Mediterranean area is experiencing an increase in the aridity index, which makes it vulnerable to drought and forest fires. Northern Europe is experiencing an increase in humidity and the occurrence of winter floods (Feyen et al, 2020).

Urban areas, which currently hosts 80% of Europe's total population, are affected by heatwaves, floods, rising sea levels.

METHODS OF MEASURING AND MONITORING THE CLIMATE CHANGE

The spatial distribution of climatic parameters is mostly determined by the relief, which is the main factor that determines the particularities of the local and regional climate (Ciulache, 2004).
Among the morphological and morphographic characteristics of the relief, altitude has the most important role in the spatial conditioning of climatic parameters.

Air temperature is the main climatological element with a major impact on the Earth-atmosphere energy balance. It is measured two meters above the ground with the help of several types of instruments: ordinary thermometers, minimum, maximum and thermograph installed in meteorological shelters on the platforms of weather stations (Ciulache and Ionac, 2003).

The territorial distribution of air temperature is described by several climatic parameters obtained by statistical processing of the data series: averages, extreme values, duration of intervals with different characteristic values (Geicu, 2008).
The average daily air temperature results by averaging the temperature values recorded at the four observation terms 1:00, 7:00, 13:00, 19:00. Day-to-day temperature variations can be relatively large, characterizing the diurnal climate cycle (Ciulache, 2004).
Atmospheric precipitation represents hydrometeors that fall from clouds and reach the earth's surface in solid, liquid, or simultaneously in both forms
The snow layer is the climatic parameter that appears exclusively in the cold season, is strongly conditioned by the air temperature, the negative values and the solid precipitation regime. Due to its physical properties of reflecting most of the solar radiation, it has major importance in the spatial distribution of the air temperature value, the albedo values for the snow-covered surfaces being over 0.8 (Stroeve and Nolin, 2002). The snow layer through its persistence over time can also produce the phenomenon of thermal inversion specific to the low areas of the intramontane depressions and the corridors of the main rivers. (Ciulache, 2004)
The duration of the Sun's brightness is the time interval expressed in hours and tenths of an hour during a day when the Sun is shining (Ciulache, 2004). This indicator is used in agrometeorological analyzes to delimit areas with solar energy potential. Among the climatic phenomena that have a significant influence on water resources are the deficit and excess of precipitation. In Romania, both drought and excess rainfall constitute climatic risks with special effects on agriculture.
The effects of climate change in agriculture are reflected in the expansion to the north of areas favorable for certain agricultural crops, modification of flowering and harvest periods, increasing the need for irrigation of crops in southern and south-eastern Europe, and reduced productivity in some crops due to heatwaves and droughts, mainly in central and southern Europe (EEA, 2012). (EEA, 2012)

RESULTS

Among the positive implications that resulted from the awareness of the climate change has on agriculture we can mention the development of several technologies for carbon capture and storage, large-scale interest in the use of renewable energies (wind-solar), for the energy-efficient usage and in general the effort of reducing greenhouse gas emissions.

From the perspective of the measurements made on solar radiation and wind energy, the municipality of Sighișoara is located as follows (Jelescu et al, 2019):

- in the fourth area for solar energy, having a potential between 1200 and 1300 kWh/m^2/year, considered as a good potential for solar power applications;
- in the third area for wind energy, a good wind potential being considered when the average annual wind speed is around 5.5 m/s.

For the study of climatic indices were used data recorded in the period 1978-2019 at the closest meteorological station (Târgu Mureș), located 40 km from Sighișoara.
The average annual temperature graph resulted for this period (Figure 2) in the Mureș area it is noticed a general growth trend with the accentuation of the growth in the period between 2000-2019. If in 1978 the average annual temperature was 8.1 °C, in 2018 and 2019 resulted in a value of 11.3° C, respectively in 2019 an average of 11.1 °C.

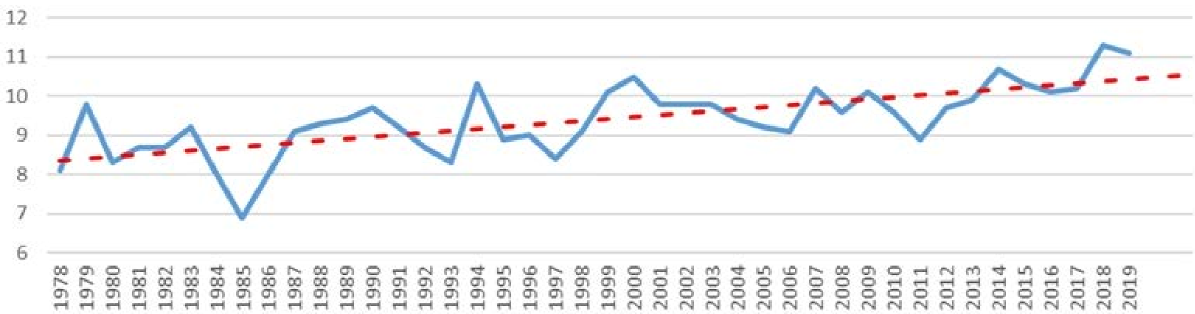

Figure 2 - Average annual temperature recorded at Târgu Mureș station between1978-2019 (Based on the data from LINK 2)

Analyzing the average, maximum and minimum annual temperatures recorded for Târgu Mureș station (Figure 3) it can be noticed that the minimum annual temperature did not register significant jumps in that period (variation of only 1,2°C), instead, the maximum annual temperature variation (4.5°C) is considered significant. In 1978 there was a maximum temperature of 13.4 ° C and in 2018-2019 a temperature of 17.8-17.9 °C.

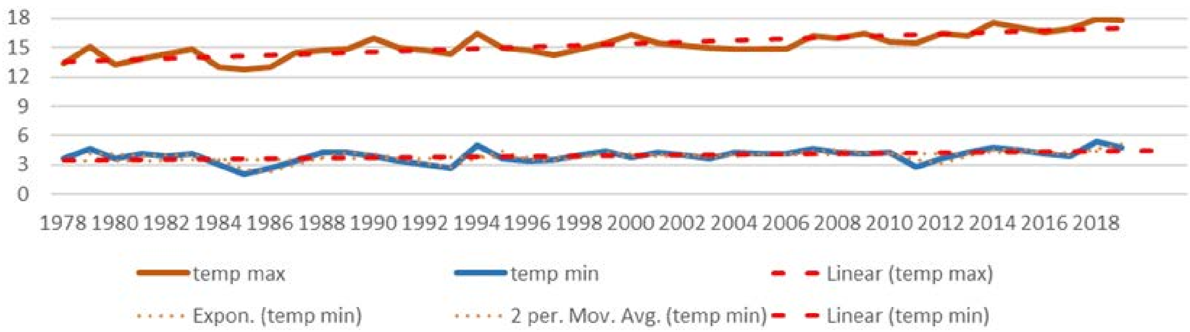

Figure 3 - Maximum and minimum annual temperature at the Târgu Mureș station between 1978-2019 (Based on the data from LINK 3)

Analyzing the number of rainy days recorded at the Târgu Mureș weather station (Figure 4), the trend shows an increase in the number of rainy days along with an increase in temperature. This is an indicator of climate change in the area and a shift from a dry continental temperate climate to a humid continental temperate climate.

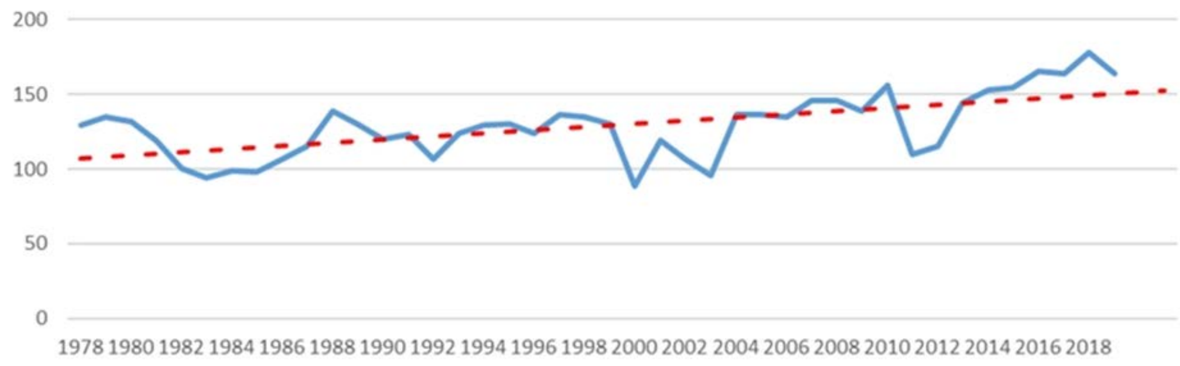

Figure 4 – Number of days with rain - Târgu Mureș station between 1978-2019
(Based on the data from LINK 4)

Regarding the extreme phenomena that can be counted by the number of days with snow and the number of days with storms, following the analysis of the data registered at the Târgu Mureș weather station (Figure 5), it can be observed that the number of snowy days remained on a constant line during the analyzed period, while the number of stormy days has increased. If in the period 1978-1982 there were an average of 31 days of storms, during the period 2015-2019, resulted in an average of 43 days per year of storms.

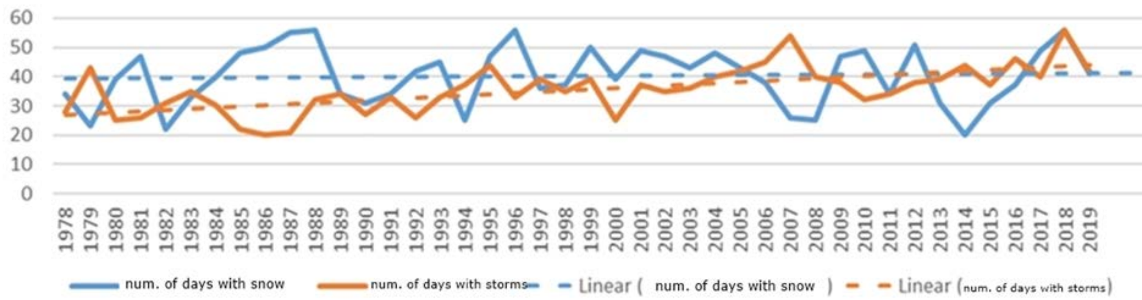

Figure 5 - Number of days with storms and hails at the Târgu Mureș station between 1978-2019
(Based on the data from LINK 5)

One consequence of these climate changes is the emergence of non-autochthonous crop groups. An example of an acclimatized crop is that of lavender which is specifically a Mediterranean plant, but, in the last years, started to be cultivated on the surrounding hills of Sighișoara (Figure 6).

Figure 6 - Lavender field near Sighișoara, Mureș

The increase in temperature also accentuated the extreme phenomena of drought and floods, thus affecting, even more, the agricultural production. Sighișoara City and its surroundings have been severely affected by the catastrophic floods from 1970-1975 (the flood signs are mounted on the facades of buildings in Sighișoara on the street Morii and street Zaharia Boiu). The phenomenon of floods in the Sighișoara area was possible to be reduced due to the undertaken works in the area of the Târnava Mare river. Moreover, there is much work to do in order to find proper measurements for dealing with drought and periods of heavy rainfall. During 2011 - 2013 a severe drought was faced, which lead to low hay production, but low hay production was also reported for the year 2014, despite being a rainy year (Mehedin, 2014).

The variation of average temperatures led to the shortening of vegetation periods for different crops, such as autumn wheat, corn or fruit species. But not only cultivated species are affected by these climate changes but the whole nature. “Long-term, a migration of the forest area at altitudinal level is expected, the forest will migrate from the plain area to occupy new areas in the alpine hollow” (Papp, 2011).

An example of these "migrations" of the forest consists of the advance of the species of willow and hornbeam in the area currently occupied by oaks and holm oaks from the Breite (protected area of national interest corresponding to International Union for Conservation of Nature - IUCN category IV - mixed nature reserve). Hornbeam seedlings prevent the natural regeneration of oak, having negative influences on the vigor of secular oaks. The effects of hornbeam reforestation can be seen at the current edge of the forest surrounding the plateau. At a distance of about 100 m inside the forest, you can see many secular trees that did not survive the expansion of the forest (Hornbeam is an invasive species and stifles secular oak on the Breite plateau).

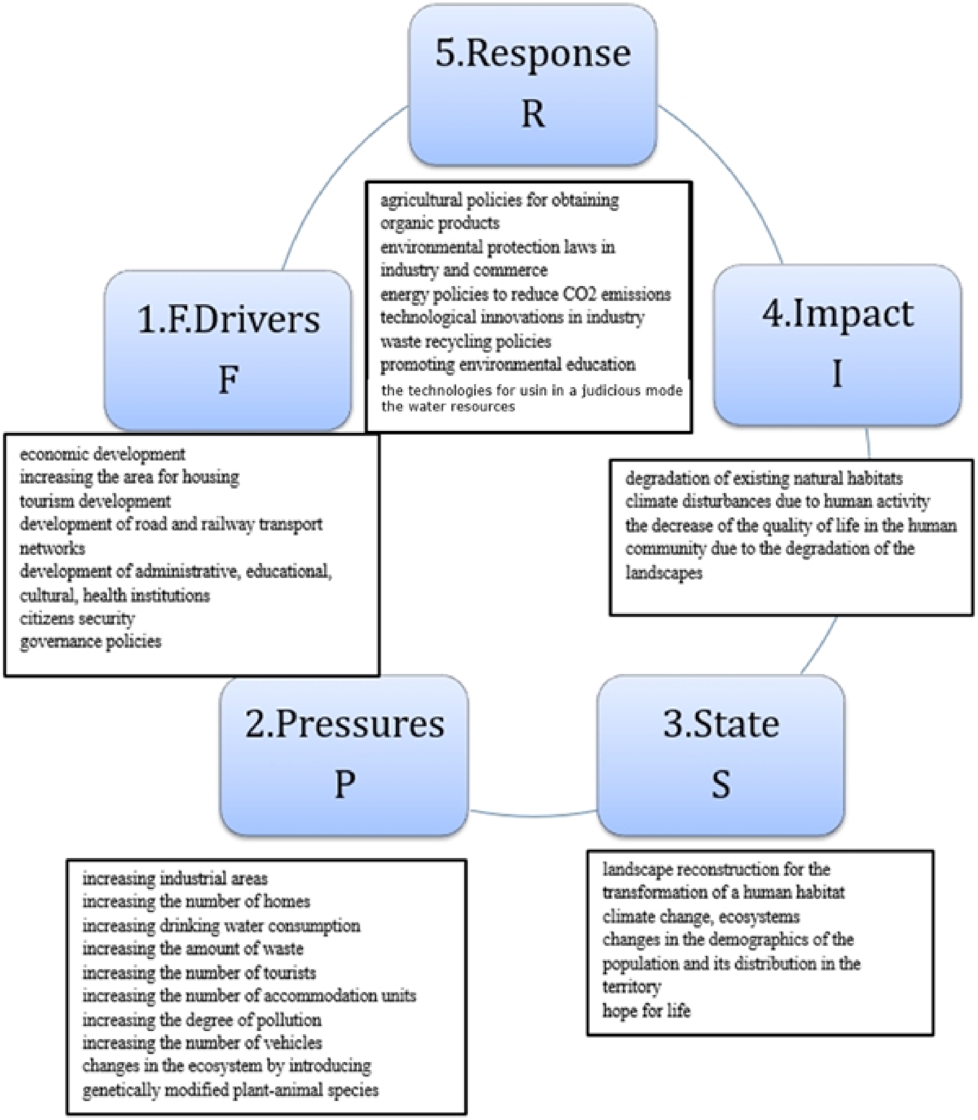

Figure 7 - The analysis of the effects given by the climate changes in the Sighișoara area, according to the DPSIR model

CONCLUSIONS

Climate change has an extremely important influence on socio-economic dynamics, has different consequences on the development of human settlements. Global warming is considered to have a negative effect on human society, and humanity, in turn, understood its impact on the global climate. To highlight the link between the environment and anthropogenic activity, several concepts have been constructed that connect the two facets of the world in which we live. One of these is the concept of DPSIR (Driver- Pressure- State- Impact- Response). The DPSIR concept was developed to identify and illustrate the links between the environment and the actions of human society. It was made on the basis of the cause-effect principle in the society-environment relationship as well as the environment-society reaction due to the interdependence of the components. The DPSIR methodology was created by the European Environment Agency in 1999 for the purpose of integrated environmental analysis in various economic activities. The five areas of the DPSIR model which create a chain reaction are: *Driving Forces, Pressure, Condition, Impact* and *Answer*. *The DSPR analysis for Sighișoara area is presented in* Figure 7.

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