

SUPPLEMENTAL MATERIAL

The test (with model answer) used to measure students' systems thinking abilities in geography. This is supplemental material with the article: Cox, M., Elen, J. & Steegen, A. (2017) 'Systems thinking in geography: can high school students do it?', *International Research in Geographical and Environmental Education*, available on: <http://dx.doi.org/10.1080/10382046.2017.1386413>.

This is a translation of the original test, which is in Dutch. The accompanying instruction sheet is included on this first page. A model answer on the question is provided in blue. A detailed scoring guide can be requested from the authors.

This test is part of a study examining systems thinking in geography. You do not need background knowledge. This test measures your ability to understand relations in a system. The results will be processed anonymously. For the study it is important to achieve a good idea on your ability to understand the relations. Therefore, we ask you to read the instructions carefully and work individually.

This test contains several items. A text is provided for items 1 and 2 and a second text for items 3 and 4. If it is asked to draw a diagram based on this text to visualize the relations between the different variables, please take the following rules into account:

- **Each variable can only be used once in your diagram.**
- **You visualize the relation between variables with arrows.**
- **Use a + or - to visualize whether it is a positive relation (an increase of variable A leads to an increase of variable B, or a decrease of variable A leads to a decrease of variable B) or a negative relation (an increase of variable A leads to a decrease of variable B, or a decrease of variable A leads to an increase of variable B)**

A brief example is shown in the box below.

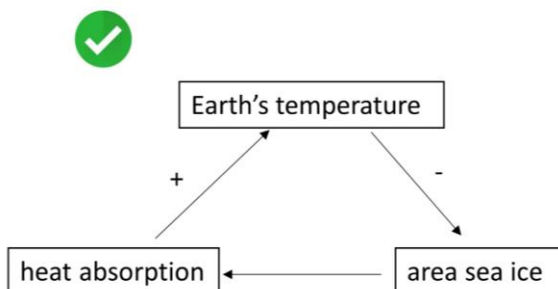
You have 30 minutes to complete this test.

Good luck!

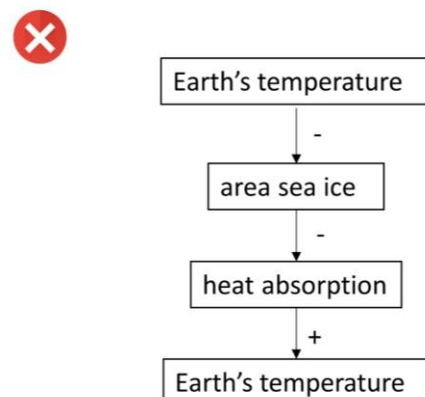
Example:

If the earth's temperature is rising, the area of sea ice will decrease faster. Due to a lower area of sea ice, the earth will absorb more heat because there is less ice that will reflect sunlight. Therefore Earth's temperature will increase further.

Good example



Bad example



Item 1 & 2

Read the article below 'How climate change contributes to the flow of refugees to Europe'.

How climate change contributes to the flow of refugees to Europe

While Europe is struggling with the largest refugee crisis since the second World War, experts are warning that climate change will only increase the influx of refugees.

Drought, poverty, mass migration, civil war

Large parts of Syria were suffering from extreme drought between 2006 and 2011. According to climatologists, this drought became worse due to climate change. The drought caused an increase of poverty and a mass migration towards urban areas, as shown in a recent report published in the journal Scientific American.

"This drought, and the bad management of it by the regime of Assad, has both contributed to the migration of 2 million Syrians", says Francesco Femia of the American center for Climate and Security. "This intern migration has on its turn contributed to the social unrest, which caused the civil war. The civil war led to a flow of migrants towards Europe. What happened in Syria, will probably play a role elsewhere as well."

Economic growth and global warming

The migrants who arrive in Europe are in the age group of the active population, which mean they can have an economical contribution in the country of destination. Certainly in regions like Western Europe, with a strong ageing population, this is happening. A relative large share of the population is older than 65 years old. If the migrants are able to integrate and become active on the labour market, they can contribute to an economic growth. An economic growth can cause a thriving industry and an increase in the number of companies. Probably this increase in companies will led to a higher emission of greenhouse gasses, which contribute to global warming. So, it remains the question how such developments can happen in a sustainable way.

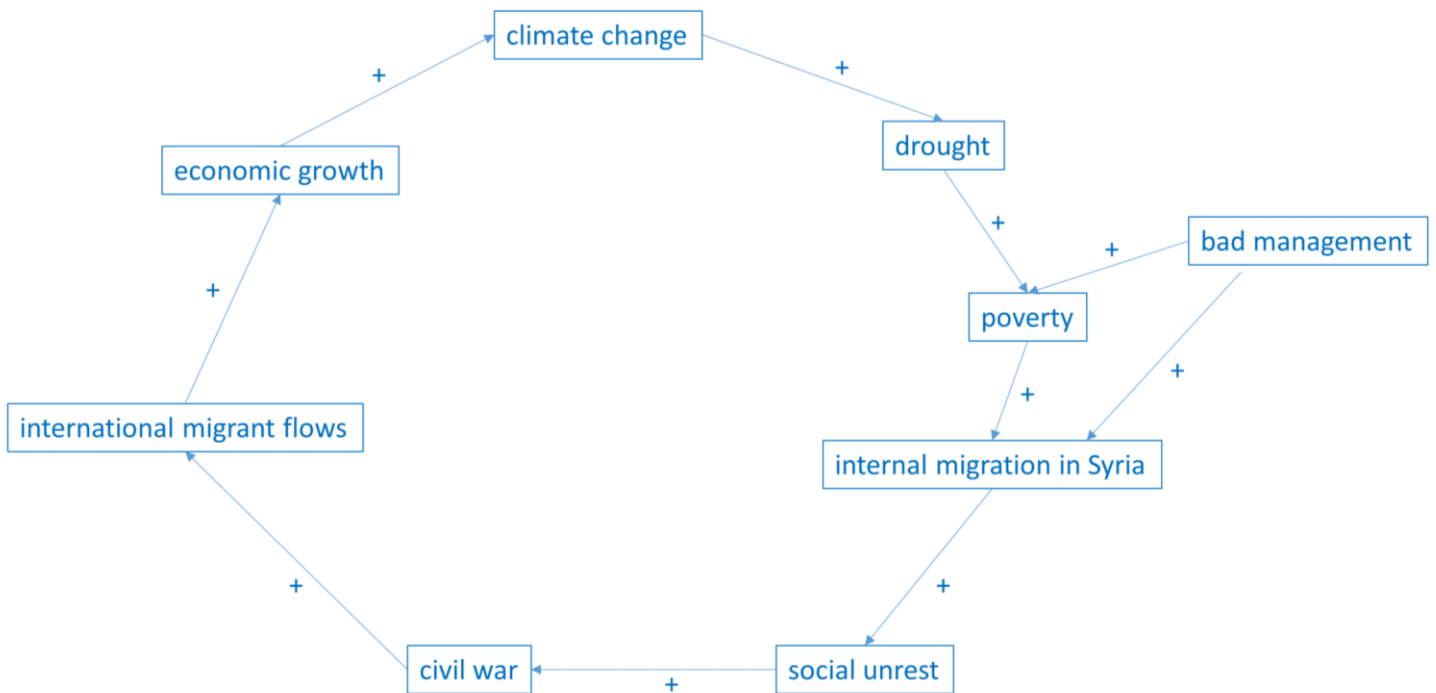
(Source: own text in combination with a newspaper article (Beernaert, 2015))

1) **Construct a diagram** with the variables below from the text. The diagram should be an answer on this question

Why is climate change both a cause and a consequence of the migrant flow to Europe?

Use the following variables in your diagram. Each variable has to be used only once.

- Global warming
- Social unrest
- Economic growth
- International migrant flow
- Bad management
- Drought
- Poverty
- International migration in Syria
- Civil war



2) **Describe in words** why social unrest in Syria can contribute to an increase in economic growth in Western Europe.

The social unrest in Syria caused the civil war which made people flee away. Part of these refugees arrive in Western Europe. They can contribute to the economic growth in Western Europe as most of these refugees are in the age group of the active population.

Item 3 & 4

Read the text below and respond to the question on the next page.

People normally only choose for a journey by air plane if they have enough money. If the welfare in Belgium increases, more people will travel quite far by air plane to countries in Africa, South-East Asia or America. This tourism can have a positive local effect, because jobs are created which would not exist without tourism. People who might be unemployed otherwise, have an income now. These incomes are often not high, but it contributes to the increase of the welfare and prosperity of these people.

However, not only welfare determines how far and how often we travel. There should be the possibility to do this, and it is important to inform people on possible destinations. The last decennia, these transport possibilities and the spread of information only increased due to globalization.

There is also a downside to the increasing number of air plane travels. A large share of the CO₂ emissions in tourism comes from air plane travel. The emissions of these and other greenhouse gasses contributes to global warming, which has its own consequences, as shown in the map below.

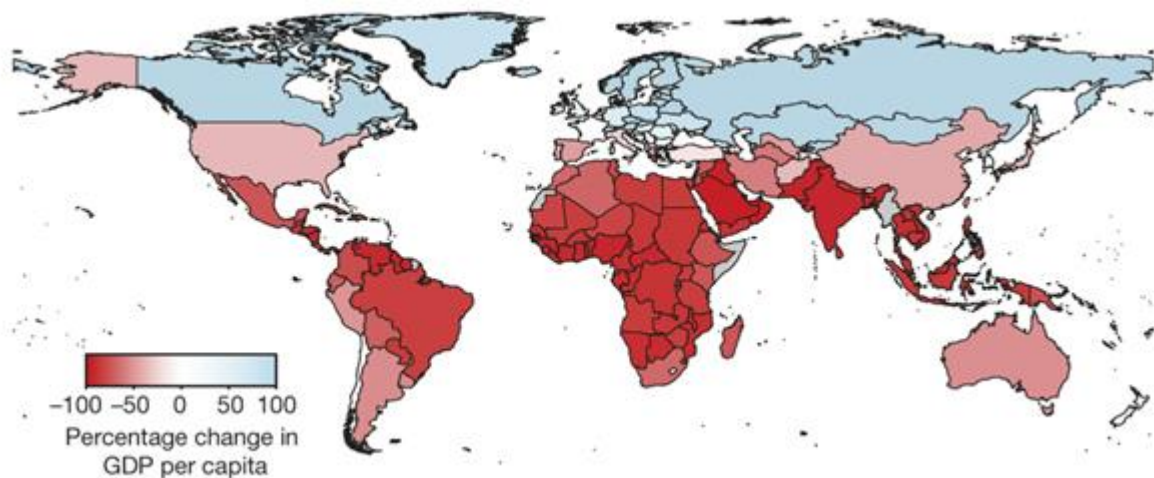
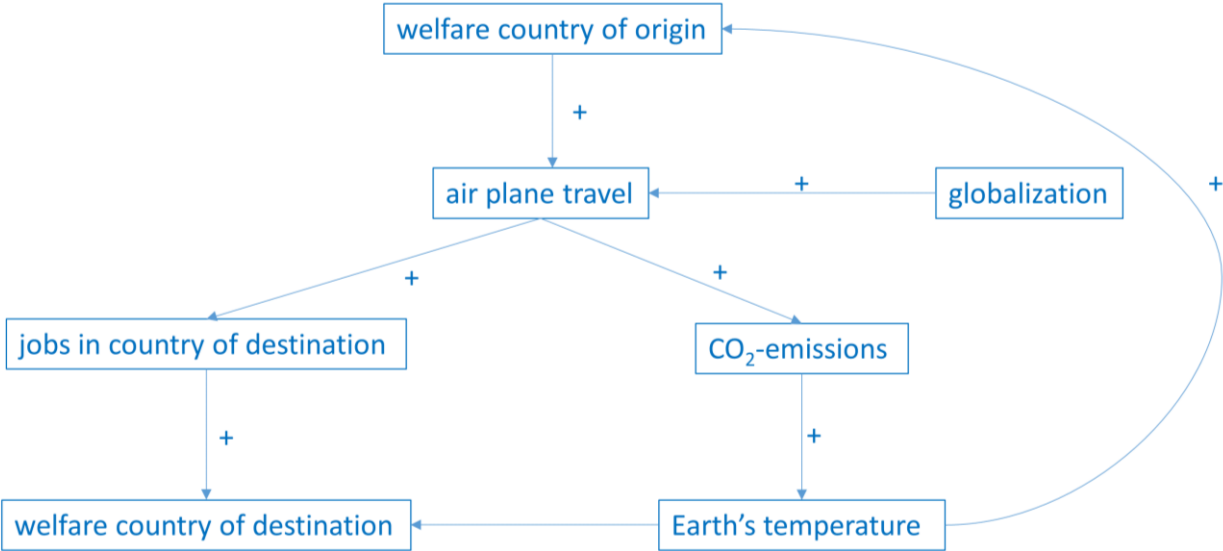


Figure 1: Change in GDP per capita (= Gross domestic product per person) in 2100 compared with a world without climate change. (Figure reprinted by permission from Macmillan Publishers Ltd: Nature (Burke, Hsiang, & Miguel, 2015), copyright (2015))

Construct a diagram with variables from the text and information from the figure. The diagram should be an answer on this question.

What causes an increase in the number of air plane travel and what effect does it have on the welfare in the country of origin and on the welfare in the country of destination?



This is the end of the test.

Thank you for your cooperation!

References used in this test

Beernaert, L. (2015). Hoe klimaatverandering bijdraagt aan de vluchtelingestroom naar Europa. Retrieved from <https://www.demorgen.be/buitenland/hoe-klimaatverandering-bijdraagt-aan-stroom-van-vluchtelingen-naar-europa-b54c1e83/>

Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, 527(7577), 235–239. <http://doi.org/10.1038/nature15725>