# Executive Summary for Policymakers

Knowing the limits of the planet to provide resources and absorb pollutants is directly linked to debates on the limits to growth. Environmental thresholds or tipping points can lead to abrupt changes in the services provided by the ecological system, which, aside from causing undesirable shifts in balance for ecosystems, can have adverse impacts on economies, people, and humanity at large.

This study analysed environmental thresholds and associated indicators for monitoring unsustainable trends caused by human activity that could lead to the exceedance of environmental thresholds in Europe. Attention is also given to the existence of danger zones that would provide accurate warning with lead times long enough to allow decision makers to react and pre-empt the crossing of critical thresholds.

Following an identification of an initial list of 7 areas with known threshold behaviours[1] – human exposure to toxic chemicals, fisheries, freshwater quality (focus on eutrophication), freshwater quantity, land use/land use change and soil erosion, and non-renewable resource use – the team in collaboration with the DG Environment and the EEA selected the following 4 threshold issues for in-depth analysis:

- **Freshwater quality with a focus on eutrophication**: a well-understood process by which the nutrient balance of freshwater bodies shifts toward nutrient surpluses as a result of effluents from agriculture, industrial processes, and smaller-scale domestic sources. Eutrophication is a widespread and persistent problem in European water bodies. Thresholds with respect to nutrient influx and concentration exist but vary in time and space.
- **Water quantity:** the availability of sufficient water resources to meet human and ecological demands. Europe is experiencing increasingly frequent and severe water shortages, not only in the Mediterranean region, where the number of droughts has increased over the past 30 years, but also in formerly unaffected areas. Thresholds exist for the amount of water use and its impacts, but their values have not been quantified with scientific certainty.
- **Soil erosion** is defined as the wearing away of the land surface by rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic forces that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere. Despite the increasing extent and severity of soil erosion in Europe and worldwide, this issue is largely absent from the public debate.
- **Non-renewable resource use:** the use of natural resources which do not replenish over geological time spans. Humanity's rapidly growing consumption of these resources is causing severe environmental damage, including land use changes and the production of toxic waste and emissions to air and water. A threshold perspective to the use of non-renewable resources is relatively new. In this study, it focuses on the question whether the current levels of per capita domestic consumption of non-renewable resources is causing air emissions which are beyond an environmental threshold for those air emissions?[2]

[1] Please note that climate change was excluded because it is already much better known than other issues.

[2] A linear link between the amount of resource use and environmental impacts (which may pass a threshold) can only be established for some non-renewable resources. The best known example is the use of fossil fuels for combustion and the resulting impact on climate change. This was excluded from the study due its objective to look at other issues than climate change.

The table below shows the indicators this study suggests in order to monitor thresholds in the four issues of concern and summarises known values for thresholds (where they exist) and the availability of data to calculate them at an adequate level of resolution within the territory of the EU.

| **Threshold theme** | **Suggested threshold indicator** | **Available threshold values** | **Data availability** |
|---|---|---|---|
| Water quality | Ratio of observed maximum concentration of nitrogen to maximum allowable concentration of nitrogen<br>Ratio of observed maximum concentration of phosphorus to maximum allowable concentration of phosphorus<br>Ratio of observed daily load to Total Maximum Daily Load of nitrogen<br>Ratio of observed daily load to Total Maximum Daily Load of phosphorus | 50 mg N/l (Nitrate Directive)<br>Watershed-specific thresholds for permissible N and P concentrations as a result of WFD implementation. | EU27 countries and annual (and more frequent) time series data available from national or sub-national water quality monitoring databases; EEA Waterbase; WISE; EIONET, WFD for boundary values of water quality classes;<br>Increase in spatial resolution required in some countries and local areas with high eutrophication pressures |
| Water quantity | Maximum blue water consumption<br>Maximum green water consumption<br>Maximum non-renewable water use<br>Groundwater quantitative status<br>Hydrological pressures on streams | No threshold values have been defined so far | Water Footprint Network – on an aggregated level (modelled); also planned for new Eurostat Standard Tables by 2012 (partly measured partly modelled data); EXIOPOL database available from 2011 for 44 countries and regions (measured and modelled data) |
| Soil erosion | Estimated soil loss by water (rill, inter-rill, and sheet) erosion vs. Tolerable soil erosion rate<br><br>Complementary indicator: Total estimated soil loss by water, tillage and wind erosion vs. Tolerable soil erosion rate | Upper limit of tolerable soil erosion (equal to soil formation): ca. 1.4 t/ha/year; lower limit: ca. 0.3 t/ha/year (for hill slope soils overlying hard rock parent material); average tolerable erosion rate: 1 t/ha/year for mineral soils under a precautionary approach | European soil database for rough estimation of areas most at risk of erosion; CORINE land cover, climate data from models (e.g., MARS), and digital elevation data. More high-resolution and frequently updated data needed as input to models. Estimated 17.5% of EU's soil erode at rate exceeding 1 t/ha/yr. |
| Non-renewable resources | $DMC_{non\text{-}renewable}$ per capita in relation to $SO_2$, $NO_x$, $NH_3$, and NMVOC emissions | Thresholds of national emission ceilings (for $NO_x$, $SO_2$, $NH_3$, NMVOC) exist; but derived thresholds for $DMC_{non\text{-}renewable}$ per capita have not yet been defined | DMC data available from EUROSTAT; non-renewable share of DMC can be calculated from available DMC data by material group; Data on national $SO_2$, $NO_x$, $NH_3$, and NMVOC emissions available for all 27 Member States since 2006. |

The study has several **important findings**:

- Knowledge and data availability are still incomplete for specifying thresholds in the EU. While all selected areas exhibit threshold behaviour supported by scientific theory and empirical observations, the current state of knowledge and regular data collection is still too patchy and data quality too uncertain to allow specifying actual threshold values (adjusted for local or regional conditions) for the EU. More research and, most importantly, collection of data on the past and current status of ecosystems (watersheds, lakes, etc.) and the use of their resources are needed. Bearing these limitations in mind, the findings of this study show mixed results for the state of thresholds in the four areas of investigation:

    - **Water quality**: Estimates generated from the EEA's WaterBase indicate that serious exceedances of nitrogen and phosphorus concentrations in European waterbodies are relatively rare. The watershed-specific threshold for permissible nitrogen concentrations of 50 mg/l $NO_3$ was not exceeded in any EU country. Time series at individual sites and at aggregated river or lake level show that eutrophication has declined in many countries over the past 20 years but it stagnating or increasing in others (Eastern EU, areas with intensive agriculture and livestock cultivation).
    - **Water quantity**: Using the EEA's Water Exploitation Index (WEI) to assess the current ratios of blue water extraction per available total freshwater resources at the national level in Europe shows that Belgium, Bulgaria, Cyprus, Germany and Spain reach the water scarcity threshold of 20%. Malta's ratio exceeds 100%, indicating that water demand has to be satisfied through withdrawals from non-freshwater (desalination, treated wastewater, etc) or non-renewable sources, or through imports. Note, however, that this indicator focuses on blue water[3] abstraction, and takes neither green water[4] sources nor water consumption into consideration. We hence suggest a set of indicators covering all the important aspects of water: blue and green water consumption as well as non-renewable water use. This can be complemented by establishing thresholds for impacts of water use, for example for the widely-used indicators "groundwater quantitative status" and "hydrological pressures on streams"
    - **Soil erosion**: On average, approximately 17.5% of soils in EU are eroding at a rate exceeding the estimated threshold of 1 t/ha/yr for mineral soils. However, the geographical distribution and severity of soil threats varies across Europe because natural factors such as climate, soil type and topography have a critical influence on the type and impact of soil threats. In comparison to other European regions, Mediterranean regions are most affected by various soil threats such as soil erosion, decline in soil organic matter, soil salinisation, landslides and desertification. With the impacts and evidence of climate change accumulating in recent years, the problem of soil erosion is likely to increase in the future.
    - **Non-renewable resources**: Many EU Member States exceed their national emission ceilings for $SO_2$, $NO_x$, $NH_3$, and NMVOC emissions. However, it was not possible at this stage to demonstrate the existence of any linear relation between national emission ceilings (thresholds) and per capita non-renewable DMC levels over time. Therefore, the suggested proxy threshold indicator "$DMC_{non\text{-}renewable}$ per capita in relation to $SO_2$, $NO_x$, $NH_3$, and NMVOC emissions" does not allow deriving a clear answer to the question which non-renewable resources should be reduced or managed differently when a certain air emissions threshold is surpassed.

[3] Blue water: water in freshwater lakes, rivers and aquifers
[4] Green water: Water stored in soil or vegetation

- Identifying danger zones remains a challenge due to the generally high level of uncertainty. In the case of soil erosion, for example, thresholds can be exceeded during sudden events such as extreme weather, which are difficult to predict well in advance and even more difficult to manage or control (e.g., hurricanes, droughts, flash floods).

The study concludes that exceeding environmental thresholds in the selected areas is likely to result in unforeseen, costly and possibly irreversible changes in ecosystem equilibria (e.g., soil erosion) that humankind is relying on to meet its economic, social, and aesthetic needs. The European Commission should therefore promote threshold research with the goal to fill the significant gaps in reliable and timely information about current trends, estimated threshold values, and their associated danger zones. Specifically, **immediate actions** should include:

- Developing a searchable repository of existing threshold research for researchers and policy analysts.
- Identifying areas of high priority according to (a) likelihood of exceedance of thresholds in the near future and (b) areas with least amounts of empirical and theoretical knowledge; and developing an action programme on how to address both (a) and (b).
- Better integrating threshold-related aspects into environmental data collection procedures at the European level, undertaken by EUROSTAT, EEA and other EU bodies.
- Increasing the visibility and funding amounts for European threshold-related research.
- Strengthening the relevance of threshold monitoring and research at the global level.