Appendix. **Smart Tools Reducing Environmental, Landscape and Climate Changes**

*1.1. Environmental Assessments System*

One of the tools supporting the decision-making process and spatial planning is the EA system, which is a mandatory requirement in the EU. It enables the presentation of information on the potential environmental effects of planned activities, plans, programmes, and policies in a complex and systematic way, and determines the possibilities of avoiding or minimising adverse effects.

Its essence is to prevent threats and present choices best for the environment. An EA consists of SEA and EIA/LVIA. This system ensures public participation in decision-making processes to strengthen sustainable development. However, it is constantly improved upon.

1.1.1. Strategic Environmental Assessment

SEA is a procedure for assessing the environmental impacts of the implementation of strategic documents, allowing the inclusion of environmental aspects into the main flow of the decision-making processes, aiming to make the future development sustainable, and a crucial instrument of the integration of environmental protection with industry policies (Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 1998).

Fischer (2002) encourages the use and practice of the integrative and flexible nature of SEA and its potential to avoid wasting environmental and financial resources. He defines five main advantages of SEA: wider scope than EIA for considering alternatives, effects and uncertainty; active influence on the pro-ecological formulation of plans, programmes and policies through combining economic, ecological and social aspects; improving EIA through simplification and shortening of procedures, impact assessment that cannot be identified at the individual project level; systematic and effective consideration of issues related to environmental protection at a higher level of the decision-making process; and increasing support for policies, plans and programmes due to social participation. In sum, SEA supports creating policies, plans and programmes according to the idea of sustainable development.

1.1.2. Environmental Impact Assessment

EIA is a procedure for identifying and assessing potential environmental impacts resulting from the construction and operation of planned activities for consideration when making a decision. EIA, a formal requirement for activities harmful to the environment, is a multistep, multi-criteria, interdisciplinary procedure, helping to make conscious and balanced decisions. EIA serves decision-makers, authorities, investors, designers and society to gain information related to the character of activity, endangered natural resources and values, the magnitude and significance of potential environmental impacts and the possibilities of their avoiding or minimising. Its interdisciplinary nature and systematic approach guarantee that the information on possible effects is objective, broad and transparent. Public participation, allowing open decision-making and considering alternatives, enabling choices best for the environment, are crucial aspects of EIA.

1.1.3. Landscape and Visual Impact Assessment

LVIA, an element of EIA, is directly related to landscape protection, which investment processes may threaten. A few methods are related to landscape protection under EIA: Visual Resource Management and Scenery Management System in the USA, Visual Management System and Visual Landscape Planning in Australia, Visual Landscape Inventory in Canada, and Landscape Character Assessment in the UK. They differ in the number of steps, chronology, the scope of detail and topics discussed, but some elements are fixed. They include a description of the planned activity in terms of landscape and visual impacts, description of endangered landscape and visual resources and identification of landscape and visual impacts, defining the zone of visual influence, representing the number and type of endangered users, assessment of landscape impacts significance, and defining mitigation measures. One of the goals of LVIA in England is to provide a landscape framework for planning policies, decisions steering development, landscape change monitoring and new initiatives concerning landscape (Countryside Commission, 1994).

Techniques under LVIA have been significantly improved over the years (Department for Planning and Infrastructure, 2007; Galliano & Loeffler, 2000; Grant, Clarke, & Lynch 2010; ICF International, Avenue Design Partners, 2015; Manyoky, Wissen, Heutschi, Pieren, & Grêt-Regamey, 2014; Landscape Institute, 2011; Scottish Natural Heritage, 2014, 2017; The Landscape Institute and the Institute of Environmental Management & Assessment, 2002, 2013). New possibilities, also in Poland, are being created thanks to the latest generations of digital tools, improving the effectiveness of landscape impact prediction (Ozimek, 2019), landscape view analyses and studies of zones of visual influences (Ozimek, Ozimek, & Łabędź, 2012), and landscape absorbency studies (Ozimek & Ozimek, 2009). The necessity of continuous development of methodologies related to landscape and visual assessment is becoming a prerequisite for sustainable development success (The Landscape Institute and the Institute of Environmental Management & Assessment, 2002; Trew, 2002).

Accurate image simulations of planned investments in the landscape are easy to perceive and make it possible to present problems suggestively and understandably for all recipients (Landscape Institute, 2011). They clearly illustrate the nature and scale of visual threats, which facilitate their understanding. Enriching LVIA with computer techniques is essential to improve the effectiveness of EIA. Modelling and digitisation may enhance the effectiveness of landscape protection, being one of the important aspects of ecological planning and design. However, one should be aware that even the most advanced and professional computer visualisations in three-dimensional space alone are insufficient. As highlighted, LVIA is just one element of the entire EIA procedure. Computer visualisations could not be used as a sole source of information because they give only part of ​​the investment impact on the landscape and visual aspects. They do not consider a number of factors that are important in landscape perception, like traffic, sounds, light reflections, etc. (Landscape Institute, 2011). Therefore, they should be treated only as an aid and analysed along with other information.

*1.2. Life Cycle Assessment*

LCA is a standardised analytical tool in the Eco-Management and Audit Scheme (EMAS), based on ISO 14001, aiming at enhancing EIA at different stages. LCA allows the environmental impacts caused by investment processes connected with products and activities to be assessed based on analysing the product lifetime, from raw material extraction, transport and processing, construction stage, object use, renovation, up to its demolition and waste recycling or waste storage. Every investment activity is tested ‘from the cradle to the grave’ in terms of material and energy consumption and emissions into the environment. It provides knowledge on all environmental effects which might happen at every life stage of products and activities. Many researchers indicate the growing role of LCA in housing stocks, especially for tall buildings, for which vast amounts of materials and energy are needed. Environmental effects, such as CO2 emissions and the energy demand of eco-neighbourhoods analysed within LCA are much lower than in standard neighbourhoods, which has been proven in a comparative analysis in Europe (Nematchoua, Orosa, & Reiter, 2019). It means that the use of LCA may considerably influence sustainable development by selecting environmentally friendly construction materials and insulation techniques and promoting new construction technologies.

The EU policy tends to support and implement circular economies and to extend LCA. This fact contributes to minimising resource consumption and waste production, as well as energy efficiency, and reducing greenhouse gas emissions, among others, through recycling.

*1.3. Material Flow Analysis*

The MFA method is used to study and limit the demand for materials and energy arising from development. It is based on a “*systematic assessment of the flows and stocks of materials within a system defined in space and time*” (Brunner & Rechberger, 2004, p. 3). This may refer to a region, city, or individual object. MFA can show the flow of materials and energy in dynamic and long-term perspectives and predict future energy demands and possible environmental impacts of development, such as emissions associated with energy consumption. It allows identifying flows of waste, environmental loadings and their sources early enough to take proper decisions on further development (Brunner & Rechberger, 2004). This is why it may serve to support decision-making. MFA plays an essential role in environmental, resource and water-quality management, waste and wastewater treatment, resource conservation and recovery, product design and LCA (Brunner & Rechberger, 2004; Islam & Huda, 2019). Through analysing and assessing the changes associated with material and energy consumption, MFA may be used to plan more sustainable development (Albelvi, Kwan, & Rezgui, 2017; Li, Beeton, Halog, & Sigler, 2016).

MFA facilitates easier identification of inefficiencies in the use of resources (Guaita, García, Villanueva-Rey, Moreira, & Feijoo, 2018). The knowledge of the demand for natural resources (materials, water, energy) is necessary to assess future development (Albelvi et al., 2017). It means that development should be limited by the natural resources available. Therefore, MFA can be treated as an “*analytical tool useful for quantifying flows, stocks and substances…helpful in supporting environmental policies*” (Tazi, Kim, Bouzidi, Chatelet, & Liu, 2019, p. 200).

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