What are sustainable plastics? A review of interrelated problems and solutions.

Gonella, S.[a,*]; de Gooyert, V.[a]

[a] Institute for Management Research, Radboud University, Houtlaan 4, 6525 XZ, Nijmegen, the Netherlands

[*] Corresponding author; Heyendaalseweg 141, 6525 AJ, Nijmegen, the Netherlands; sara.gonella@ru.nl; +31 631132704

There is increasing attention to the sustainability issues related to plastics: greenhouse gases are released during their production and end-of-life management; millions of tonnes of plastics leak every year, causing environmental and health risks; when collected, plastics are often disposed of in landfills or incinerated; most recycled plastics are downcycled into a lower value product.

Conversely, plastics are affordable and versatile, and their use has been widely adopted in various sectors and industries. Plastics even have sustainability credit in some applications. For instance, food packaging is essential to our modern lifestyle and significantly reduces food spoilage. Alternative materials may not be as good at preserving food, may be less safe from a contamination point of view, may be more expensive, and may not necessarily be more sustainable.

The aim of this study is to provide a comprehensive overview of the sustainability problems associated with plastics and the solutions that are currently found in the literature. The study contributes to several discussions by showing how different problems and solutions are interconnected and influence each other, whereas they are usually analysed in isolation. As there is still no common definition of "sustainable plastic", this study will check what this expression is associated with in the literature, e.g. a specific technology or concept.

The search is based on scientific review and overview articles and grey literature, such as reports from international organisations, NGOs and consultancy firms. The selected documents are coded using an open and axial coding approach. The aggregated variables are linked together by causal links, finally obtaining a qualitative System Dynamics model, following a procedure similar to that proposed by Eker & Zimmermann (2016) and Gürsan & de Gooyert (2021). The model highlights the feedback mechanisms that determine the (un-)sustainability of the system, the impacts that different interventions have on the plastics value chain, and the thematic areas that require further investigation to advance the transition towards sustainability.

Solutions discussed in the literature as potentially enabling a sustainable plastics transition range from bioplastics, recycling technologies, carbon capture and utilisation, banning single-use plastics, behavioural changes, etc. Most research to date has focused on technical solutions to one aspect of the problem; however, technologies do not operate in isolation, but are embedded in a complex socio-economic context. The widespread adoption of each solution would have different impacts and consequences on the plastics industry (new investments of different types and sizes might be required) and on the wider world system (e.g. large-scale production of bioplastics might have an impact on land use).

Alternative solutions could compete with each other for resources, funding and investment. Channelling a large amount of investment into one technology could create a new lock-in situation, which would make it difficult to switch (again) to a different, more sustainable technology, should it become available in a few decades. Taking effective measures against the unsustainability of the plastics system requires large-scale applications, but not all emerging technologies may have the

potential to still be sustainable if brought to a large scale. It is therefore necessary to assess the impacts a new socio-technical system could have, to avoid causing undesirable side effects, perhaps even worse than those of the previous system. This study differs from many previous researches in its multidisciplinary and comprehensive approach to the topic of plastics and sustainability.

Eker, S., & Zimmermann, N. (2016). Using textual data in system dynamics model conceptualization. Systems, 4(3). https://doi.org/10.3390/systems4030028

Gürsan, C., & de Gooyert, V. (2021). The systemic impact of a transition fuel: Does natural gas help or hinder the energy transition? Renewable and Sustainable Energy Reviews, 138. https://doi.org/10.1016/j.rser.2020.110552