Engineering Planetary Health: Inclusive Innovation

By Thomas S. Woodson

The world is going through immense change at the global scale and it is impossible to solve these problems by only developing solutions in wealthy countries, by wealthy scientist and for wealthy people. The innovations to solve global challenges must be inclusive. People from marginalized groups are central to developing lasting solutions that solve challenges at global proportions. This brief presentation discusses two challenges facing global health, namely population and poverty, and how we can use the ladder of inclusive innovation to solve problems that impact global planetary health.

Global Challenge: Population

To understand global planetary health, it is necessary to know global population trends. The current global population is about 7.5 billion people and most of those people live in Asia, 4.5 billion people (United Nations, 2017). Both China and India's populations are over a billion and they will remain very populated places over the next century. However, most of the population growth in the next 100 years will occur in Africa. Today, Africa only has about 1.2 billion people but by 2100, it will have about 4.6 billion people. Africa's population will rival Asia's as being the largest in the world (United Nations, 2017).

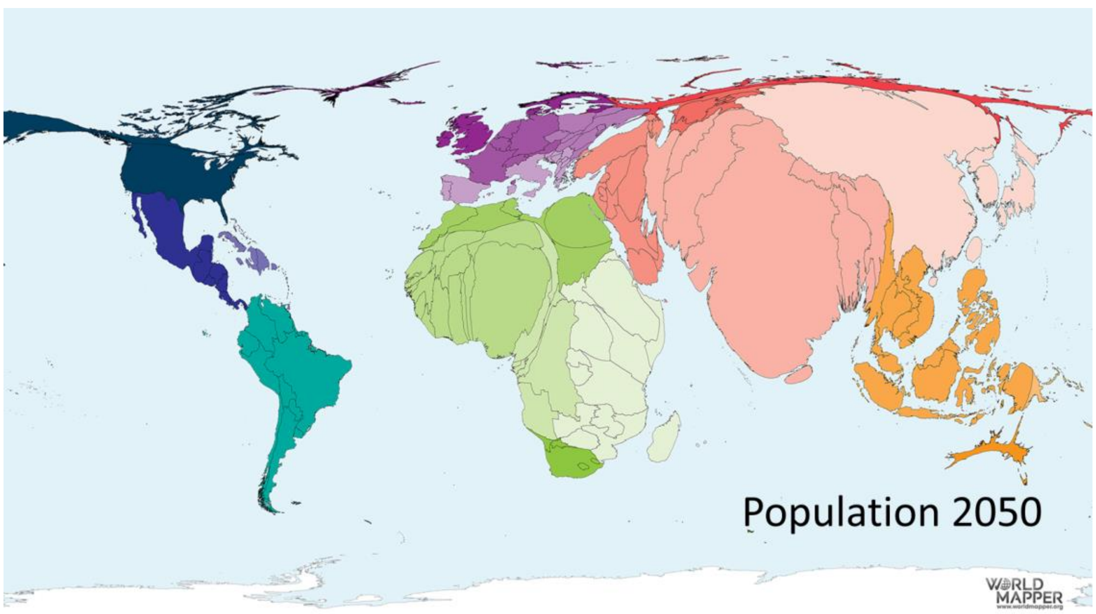

Figure 1: World map showing population. Source: https://worldmapper.org/

A rising population is not a doomsday scenario. In the late 1700's, Thomas Robert Malthus predicted that the world would have a food crisis because populations grow exponentially, yet food supplies grow linearly (Malthus, 1798). However, Malthus's predictions were quickly dispelled by advancements in agricultural chemistry (Krohn & Schäfer, 1983). New agriculture techniques and technologies, like fertilizer, dramatically increased food supplies (Trewavas, 2002).

Second, Malthus overestimated population growth. The population will not grow forever. As countries get wealthier, their birthrates drop. Many countries, like Japan and Iceland, face serious demographic challenges (United Nations, 2017). Although Malthus's dire predictions may not come true, if the global population grows over 10 billion people, the world must figure out new ways to reduce waste, manage its resources, and resolve conflicts.

Global Challenge: Poverty

Global poverty is a good news, bad news story. Extreme poverty has dropped over the past two centuries (Rosling, Rosling, & Rönnlund, 2018). For most of human history, 90% of people lived in extreme poverty and were subsistence farmers who were heavily dependent upon their crop yields. If there was a bad year or a drought, a whole community would starve to death. Now less than 10% of the world lives in extreme poverty and the global median income is $9,733 (Phelps & Crabtree, 2013; Rosling et al., 2018).

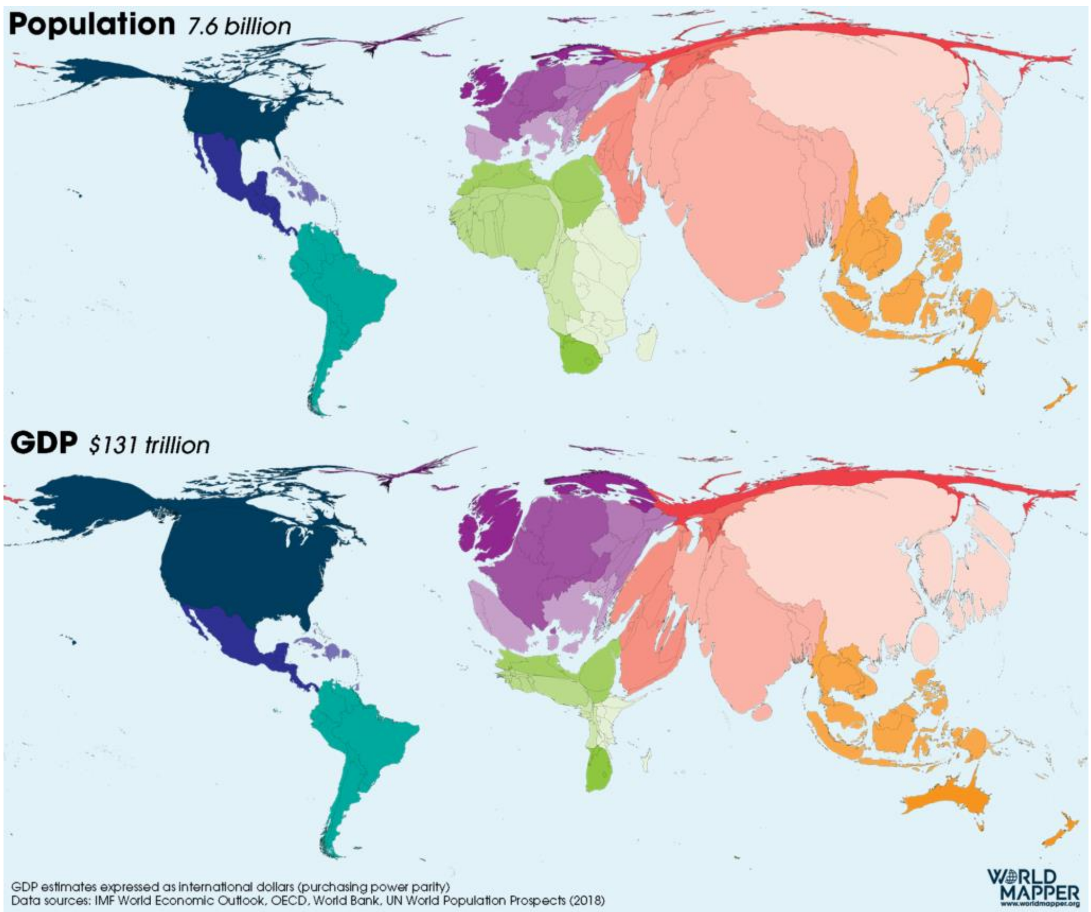

Figure 2: World map showing population vs GDP. Source: https://worldmapper.org/

However, there are still 746 million people in extreme poverty. This is a lot of people and the last mile of eradicating poverty will be the hardest. The economic and political reforms that helped billions of people living in extreme poverty may not work for the last 746 million people.

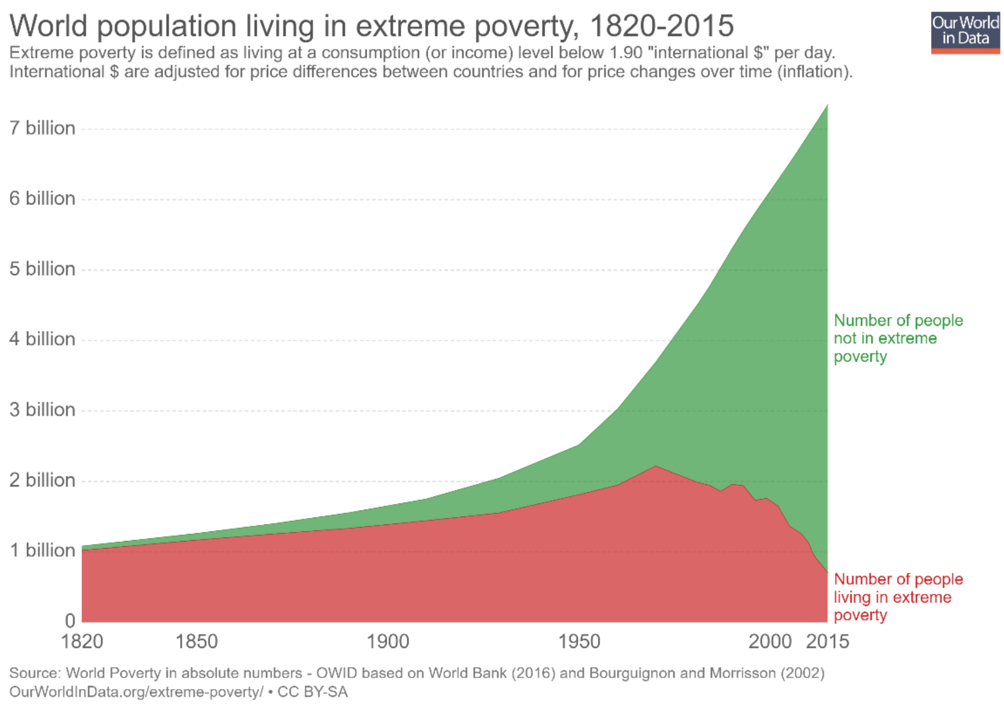

Figure 3: Graph showing global poverty levels from 1820 until today. Source: https://ourworldindata.org/

Moreover, eradicating poverty only exacerbates challenges with planetary health. As low-income people join the middle class, they move to a bigger house, drive cars, have cellphones, use air conditioning and begin to live middle class lifestyles. Carbon dioxide emissions dramatically increase as individual's become middle class (Roberts & Grimes, 1997). As poverty rates in low income countries decrease, carbon dioxide emissions will rise. Decreasing poverty and moving people to the middle class is an essential goal, but it can have negative consequence for global health.

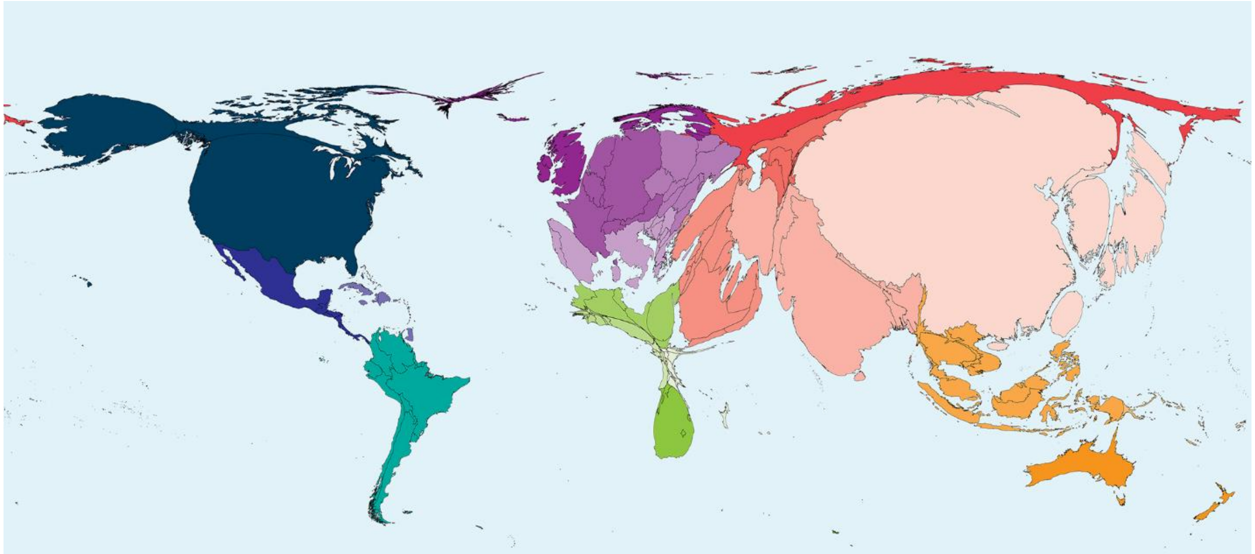

Figure 4: Map showing global carbon dioxide emissions. Source: https://worldmapper.org/

For the planet to be sustainable, scientists and engineers need to develop innovative solutions to solve planetary problems. We need new solutions to grow food, provide energy, and cool our homes. Scientists are frantically developing green technologies and food supplies to sustain the world throughout the 21st century. However, traditional innovation models and processes have many flaws that prevent innovation from solving global challenges.

One problem with traditional innovation models is that inequality is inherent in the system (Altenburg, 2009; Cozzens & Kaplinsky, 2009; Heeks, Foster, & Nugroho, 2014; Papaioannou, 2014). The products and processes that are developed are normally made by companies with a profit motive. Companies want to sell new gadgets and innovations to make money. There is nothing immoral about developing great technologies that are profitable, but it can increase inequality because companies primarily focus on people who can afford their innovations. The poor, and especially the extreme poor, are overlooked.

A second issue with many innovations is that they fix a short-term problem but create other problems in the long-term. For example, innovations can displace old technologies and create more waste. New innovations also strain social, political and family life, but those risks are not fully considered. Innovators tend to underestimate the negative consequences of their technology and are overly optimistic about the benefits.

New innovations have a particularly challenging time solving planetary health problems because planetary health is a classic “tragedy of the commons” problem. The commons are a space or resource that everyone can use, like fishing in the oceans. When people act in their own self-interest, there is an incentive to overuse the resource to the final detriment of everyone (Hardin, 1968).

Traditional policies and tools that encourage innovation do not fix these market failures. It is not possible to research, design, patent, market, and sell enough materials to fix the tragedy of the commons. Scientists, engineers and policy makers need to rethink their approach.

Figure 5: Comic of about tragedy of the commons. Source: https://blogs.ntu.edu.sg/hp3203-2017-29/tragedy-of-the-commons/

Inclusive Innovation

Given the problems with traditional innovation to solve planetary health, scholars and policy makers must push for inclusive innovation. Inclusive Innovation is "the means by which new goods and services are developed for and/or by those who have been excluded from the development mainstream; particularly the billions living on lowest incomes" (Heeks, Amalia, Kintu, & Shah, 2013).

A good way to model inclusive innovation is with the ladder of inclusion innovation developed by Richard Heeks (Heeks et al., 2013, 2014). This ladder has 6 rungs that represent various levels of inclusion. As you move up the ladder, the degrees of inclusion deepen, and the innovation has a broader impact. The first three rungs focus on an artefact, like the water pump or the cell phone. The last three rungs move beyond an artefact and consider how the innovation is developed and its impact on the broader society. The framework expands our understanding of engineering for planetary health and can help find ways to improve the likelihood that we'll successfully develop innovations that will improve planetary health.

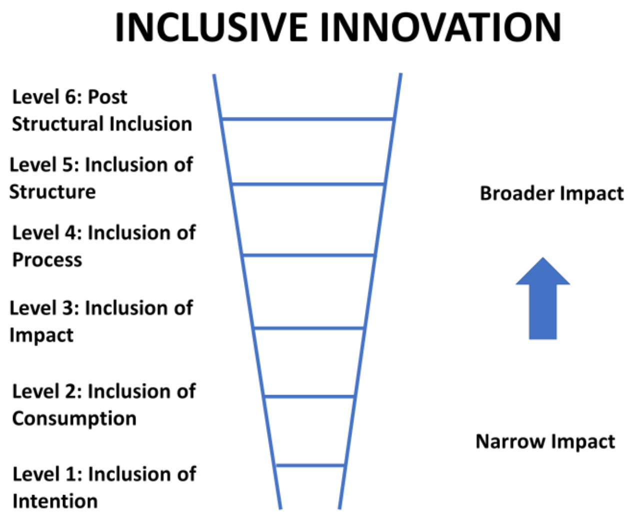

Figure 6: Ladder of Inclusive innovation. Adapted from (Heeks et al., 2013, 2014)

Rung one-Inclusion of Intention

At this rung, only the intentions of the innovators must be inclusive. There is no requirement that the innovation works or reduces inequality. Sadly, many innovations start and stop at this level. If all the innovations for planetary health remain at this level, nothing will happen.

Rung two-Inclusion of Consumption

At this rung, the innovations must be used by the marginalized community, but they do not need to be effective. Over the past 10 years, I've seen many innovations that are on this rung. The innovation was consumed, but it had no lasting impact, and in some cases, the innovation caused more harm. Again, if innovations for planetary health remain at this rung, then the world community will not successfully solve challenges facing planetary health.

Rung three-Inclusion of Impact

Innovations on this rung have a positive impact on the livelihoods of an excluded group. These innovations begin to improve planetary health because the innovations have a positive benefit. The challenge for scholars and policymakers is measuring the short and long-term benefits of innovations. Many technologies start off strong, but over time, the technology breaks and cannot be easily repaired. Also, there are many deleterious cultural and societal impacts of technology that only appear after years.

An example of a technology with a major impact on marginalized groups is mobile phones and mobile banking. In Kenya, the system M-Pesa allowed people to send money through text message to relatives across the country (Mas & Morawczynski, 2009). The previous system was terribly broken. Kenyans used bus drivers or friends to carry money for them. In this system, money was easily lost or stolen, and it was very slow. M-Pesa bypasses these problems and allows users to directly transfer money to other people over long distances.

Rung four-Inclusion of Process

At this rung, the marginalized community is involved in making the innovation. This step is crucial for an innovation to be successful. Even though engineers and innovators might know that they should work with the community to get things accomplished, often they do not get input into their innovations. Rather, the innovator tinkers in a lab and then shows up to a community with a solution to solve all their problems.

One of my research goals is to improve engineering education so that engineers are better trained to do community engagement. In our community engagement workshop, we focus on three things, looking beyond the technology, listening and empowering the community (Harsh et al., 2017).

To improve planetary health, marginalized communities need to design, make and use the innovations. If marginalized communities are not actively involved in contributing to planetary health, then it is unlikely that the innovations will be used and beneficial.

Rung five-Inclusion of Structure

Rung 5 is interesting because the attention shifts from the innovation artefact to examining systems that impact inclusive innovation. The current science and technology innovation system has many mechanisms that create inequality. For example, the current patent and world trade protocols do not encourage inclusivity and equitable growth. Rather they create a race to the finish line to be first to create and patent an innovation and then extract all the value while the patent gives the innovators an exclusive monopoly (Woodhouse & Sarewitz, 2007). The Bayh-Dole Act, which gives universities the intellectual property of publicly funded research, exacerbates the race to patent by turning publicly funded R&D into private wealth (Powell, Owen-Smith, & Colyvas, 2007). The Bayh-Dole act is loved by innovators and universities, but it could increase inequality.

In the context of Global Planetary Health, what does it mean to create a structure that is inclusive? There are good examples of the world working together to make structural reforms that encourage equality. Publishers are changing their policies on scientific publishing to let scientists from low-income countries access the articles. There are more open source journals and many science funding agencies require that research be published in journals that the public can access. Some low income countries, especially India, have pushed back on pharmaceutical patents that prevent them from using the technology in their societies (Barnes, 2003).

At the local level, many people are involved in programs to diversify STEM programs. Stony Brook University is at the forefront of many of these initiatives (www.stonybrook.edu/commcms/cie/). When we encourage women, under-represented minorities, and people with disabilities to pursue STEM careers, we can help make innovation more inclusive.

Rung six-Post structural inclusion

Rung 6 is the hardest level of inclusive innovation to achieve and it is hard to measure success. At this level, the frame of knowledge and discourse about inclusive innovation and planetary health must change. In some respects, there are already post structural changes for planetary health. There are fewer skeptics of climate change and more discussions on mitigation techniques. An increasing number of communities around the world are experiencing horrible weather events and there is growing demand to fix the problem.

Despite these few changes, the paternalistic and derogatory treatment of people and ideas from low income countries must change. Marginalized communities have a wealth of knowledge and many have learned to live sustainably with their surrounding environments. Many people in wealthy countries could not survive without luxuries, such as electricity and running water, while people in rural and low-income communities can survive off the land. Some of these communities will be the most resilient against extreme weather and natural disasters. Innovators and scientists need to better value this knowledge.

Conclusion

Engineering Planetary Health will require a shift in the way scientists and engineers approach innovation. It will be impossible to solve global challenges unless the innovation process is more inclusive. Inclusive innovation is achievable, but it does not happen automatically. Engineers must listen to their community partners, look beyond technical solutions, and empower marginalized groups. They must change their approaches to education and rethink many of the current structures that guide the innovation system. If everyone is not involved in solving planetary health problems, then we will all fail.

Literature

Altenburg, T. (2009). Building Inclusive Innovation Systems in Developing Countries: Challenges for IS Research. In B.-Å. Lundvall, K. Joseph, C. Chaminade, & J. Vang (Eds.), *Handbook on Innovation Systems and Developing Countries – Building Domestic Capabilities in a Global Setting*. Cheltenham: Edward Elgar.

Barnes, S. (2003). Pharmaceutical Patents and TRIPS : A Comparison of India and South Africa. *Kentucky Law Journal*, *91*(4).

Cozzens, S. E., & Kaplinsky, R. (2009). Innovation, Poverty, and Inequality: cause, coincidence or co-evolution? In *Handbook of Innovation Systems and Developing Countries*.

Hardin, G. (1968). The Tradegy of the Commons. *Science*, *162*(3589), 1243–1248. https://doi.org/10.1126/science.162.3859.1243

Harsh, M., Bernstein, M. J., Wetmore, J., Cozzens, S., Woodson, T., & Castillo, R. (2017). Preparing Engineers for the Challenges of Community Engagement. *European Journal of Engineering Education*, *42*(6), 1154–1173. https://doi.org/10.1080/13549839.2014.965672.Cozzens

Heeks, R., Amalia, M., Kintu, R., & Shah, N. (2013). Inclusive Innovation : Definition , Conceptualisation and Future. In *Academy of Innovation and Entrepreneurship* (pp. 1–24). Oxford.

Heeks, R., Foster, C., & Nugroho, Y. (2014). New models of inclusive innovation for development. *Innovation and Development*, *0*(February 2015), 1–11. https://doi.org/10.1080/2157930X.2014.928982

Malthus, T. (1798). *An Essay on the Principle of Population*. Retrieved from https://books.google.com/books?hl=en&lr=&id=sR0jURl1yq8C&oi=fnd&pg=PA3&dq=malthus&ots=40Z_EMjOr8&sig=SxiLPQF7DkNIaduNm2ex5Rl0KW0

Mas, I., & Morawczynski, O. (2009). Designing mobile money services lessons from M-PESA. *Innovations: Technology, Governance, Globalization*, *4*(2). Retrieved from http://www.mitpressjournals.org/doi/abs/10.1162/itgg.2009.4.2.77

Papaioannou, T. (2014). How inclusive can innovation and development be in the twenty-first century? *Innovation and Development*, *4*(2), 187–202. https://doi.org/10.1080/2157930X.2014.921355

Phelps, G., & Crabtree, S. (2013). *Worldwide , Median Household Income about $10,000*.

Powell, W. W., Owen-Smith, J., & Colyvas, J. A. (2007). Innovaton and emulation: lessons from american universities in selling private rights to public knowledge. *Minerva*, *45*, 121–142. https://doi.org/10.1007/s11024-007-9034-2

Roberts, J. T., & Grimes, P. E. (1997). Carbon intensity and economic development 1962–1991: A brief exploration of the environmental Kuznets curve. *World Development*, *25*(2), 191–198. https://doi.org/10.1016/S0305-750X(96)00104-0

Rosling, H., Rosling, O., & Rönnlund, A. (2018). *Factfulness: Ten Reasons We're Wrong about the World--and why Things are Better Than You Think*. Retrieved from https://books.google.com/books?hl=en&lr=&id=fpZNDwAAQBAJ&oi=fnd&pg=PR9&dq=factfulness&ots=-YK2KB49vw&sig=neGCTpxrsQfYnoED_8c0Oei1wXk

Trewavas, A. (2002). Malthus foiled again and again. *Nature*, *418*(6898), 668–670. https://doi.org/10.1038/nature01013

United Nations. (2017). *World Population Prospects: The 2017 Revision*. New York.

Wolfgang Krohn and Wolf Schäfer (1983). Agricultural Chemistry: The Origin and Structure of a Finalized Science, in: *Finalization in Science – The Social Orientation of Scientific Progress.* Edited and co-authored by Wolf Schäfer. Dordrecht, Boston, and London, D. Reidel Publishing Co. (Boston Studies in the Philosophy of Science, vol. 77), pp. 17-52.

Woodhouse, E., & Sarewitz, D. (2007). Science policies for reducing societal inequities. *Science & Public Policy (SPP)*, *34*(2), 139–150. Retrieved from 10.3152/030234207X 195158data