Hi, in this short lecture we will look at the role of packaging in sustainability. Over the next few minutes we will unpack three key aspects. What packaging actually does in our food system, how it affects environmental impacts across the whole life cycle, what sustainable packaging can look like. By the end, you should be able to see beyond plastic, bad, paper, good and think in terms of systems and trade-offs. Packaging is often seen as the villain of sustainability, especially when we picture plastic waste in oceans or overflowing bins. But this is only part of the story. Packaging can also prevent food from being wasted, protect quality and safety and reduce overall environmental impact. The real challenge is understanding when packaging causes harm and when it becomes part of the solution. Let's start with the basic functions of packaging. First, containment. Packaging keeps products together, prevents leaks and contamination. Second, protection. By controlling exposure to mechanical damage, light, humidity, temperature or microbes, packaging helps extend shelf life, keeping food safe and edible for longer. Third, convenience. The design influences how easy it is to open, reseal, portion and store. Fourth, communication. Labels provide legal and nutritional information. Finally, packaging supports logistic and trade. It allows efficient stacking on pallets, transport in containers and handling in automated warehouses and retail. All of these functions have sustainability implications, both positive and negative. In many food products, packaging represents only a small share, and 95% of greenhouse gas emissions come from food. However, packaging is highly visible, so it often dominates public perception. Take a VRAB cucumber as an example. We tend to focus on the plastic film, rather than the energy, water, land and transport needed to grow and deliver the cucumber. However, plastic is there for a reason. Insufficient protection can lead to food loss and waste. Packaging decisions are therefore shaped by food-related, socioeconomic and environmental drivers, with the goal of reducing emissions and resource use. Policymakers and industry shape the system through regulations, targets and infrastructure. So to make packaging truly sustainable, we must look at the whole system, the product, the packaging and the supply chain. How consumers use and dispose of it is also very important. To understand sustainability, we use a life cycle perspective. Impacts start with materials and production, extracting oil for plastics, cutting trees for paper, mining metals and converting them into films, trays, bottles or cans. This uses energy and generates emissions. Next is transport and use. Heavier or bulkier packaging means higher transport emissions. Poorly designed packs can lead to early spoilage of food. At the end of life, packaging can be recycled, incinerated for energy, landfilled or unfortunately littered into the environment. The design of the pack and the local collection system strongly influence which pathway is most likely. Sustainable packaging aims to reduce impacts at all these stages, not just at the bin. Here, one of the most important messages is about trade-offs. As I mentioned in the food system slide earlier, the environmental footprint of the food is much larger than that of the packaging. Here you see meat, dairy and imported fruit for example. They can have a high climate impact per kilogram. Thus, if usage of slightly more complex packaging material reduces food waste significantly, the total environmental impact may actually go down. Of course, this is not a free pass to over-package everything. The challenge is to optimize total impact. Choose packaging that is just sufficient to protect and preserve the product while being efficient in materials and compatible with recycling or reuse systems. So, what can we actually do to design more sustainable packaging? Here are the most known four R's of sustainability. First, reduce. Use less material, eliminate unnecessary layers and optimize shapes and sizes to lower resource use from the start. Second, reuse. Design packaging that can be refilled or returned, such as deposit bottles, reusable crates or refill systems. These solutions work best when logistics and consumer behavior are well aligned. Third, recycle. Select materials that are widely collected and recycled. Avoid problematic combinations and ensure that labels, caps and adhesives do not interfere with recycling processes. And finally, reading. Explore new formats and systems, including edible coatings and digital solutions that reduce both packaging and product waste. Together, the seed strategies help keep materials in use and

minimize landfill. When discussing materials, debates often become emotional. Paper is good, plastic is bad. In reality, every material has advantages and disadvantages. Plastics can be lightweight and have excellent barrier properties, which is great for long shelf life and low transport emissions, but they can cause persistent pollution, if not managed properly. Paper is renewable and often perceived as more natural, but can require more mass for the same protection and may need coatings or laminates that complicate recycling. So the right question is not which material is good or bad, but what does this product actually need in terms of barrier and shelf life? How will the consumer dispose of the pack? What collection and recycling systems exist in this region? What happens to hood waste if the pack fails? So the sustainable choices depend on these context-specific answers. Let's close with three key takeaways. First, packaging is neither a villain nor a hero. It creates environmental impact, but it also protects food and helps prevent waste. Second, sustainability requires a systems perspective. We must consider the product, the packaging and the entire supply chain, not just what ends up in the bin. And third, real progress depends on design behavior and policy working together to reduce both plastic waste and food waste.