

# Transition pathways towards circular greenhouse horticulture

NVTL 2023

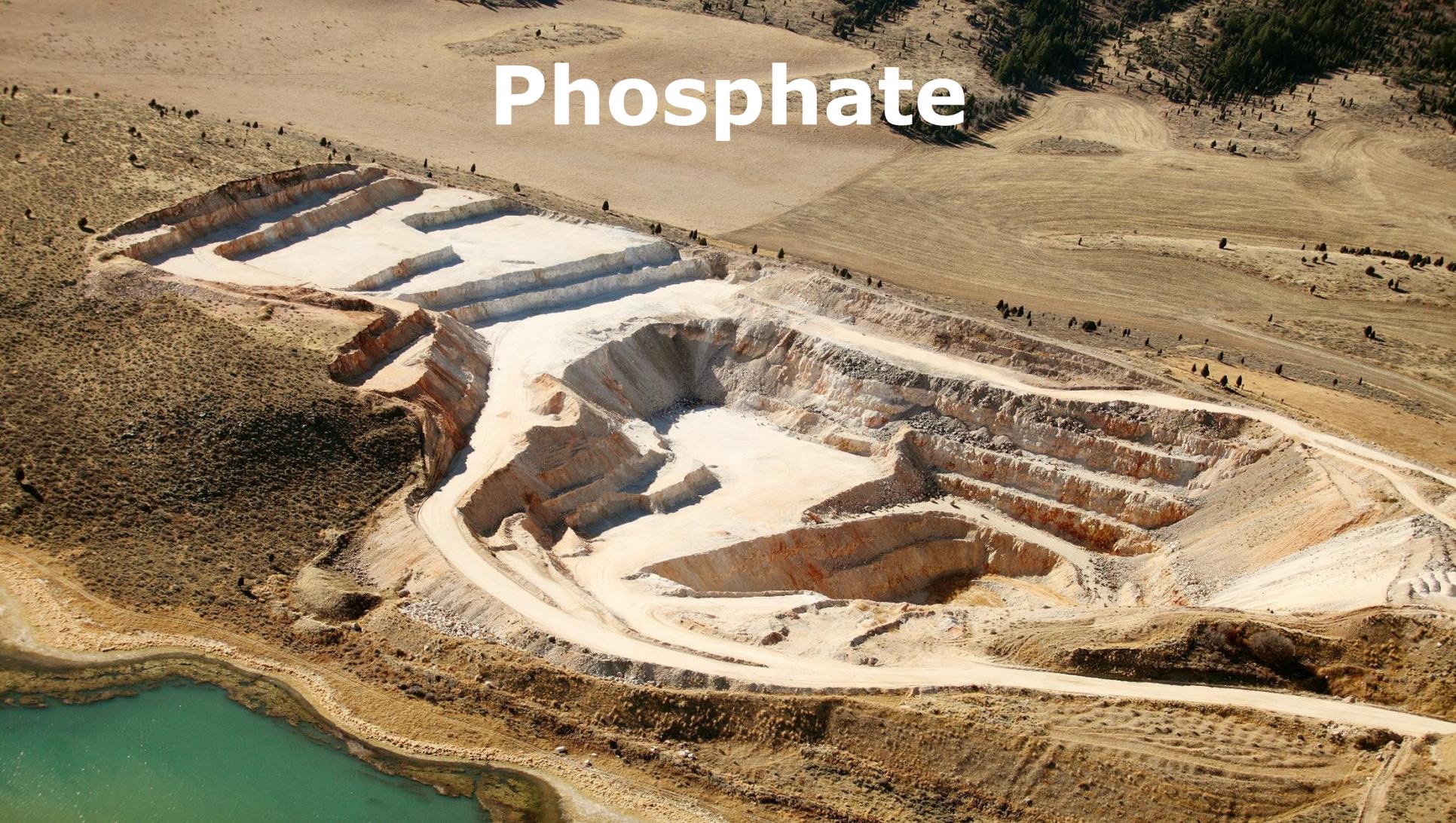
Alexander Boedijn



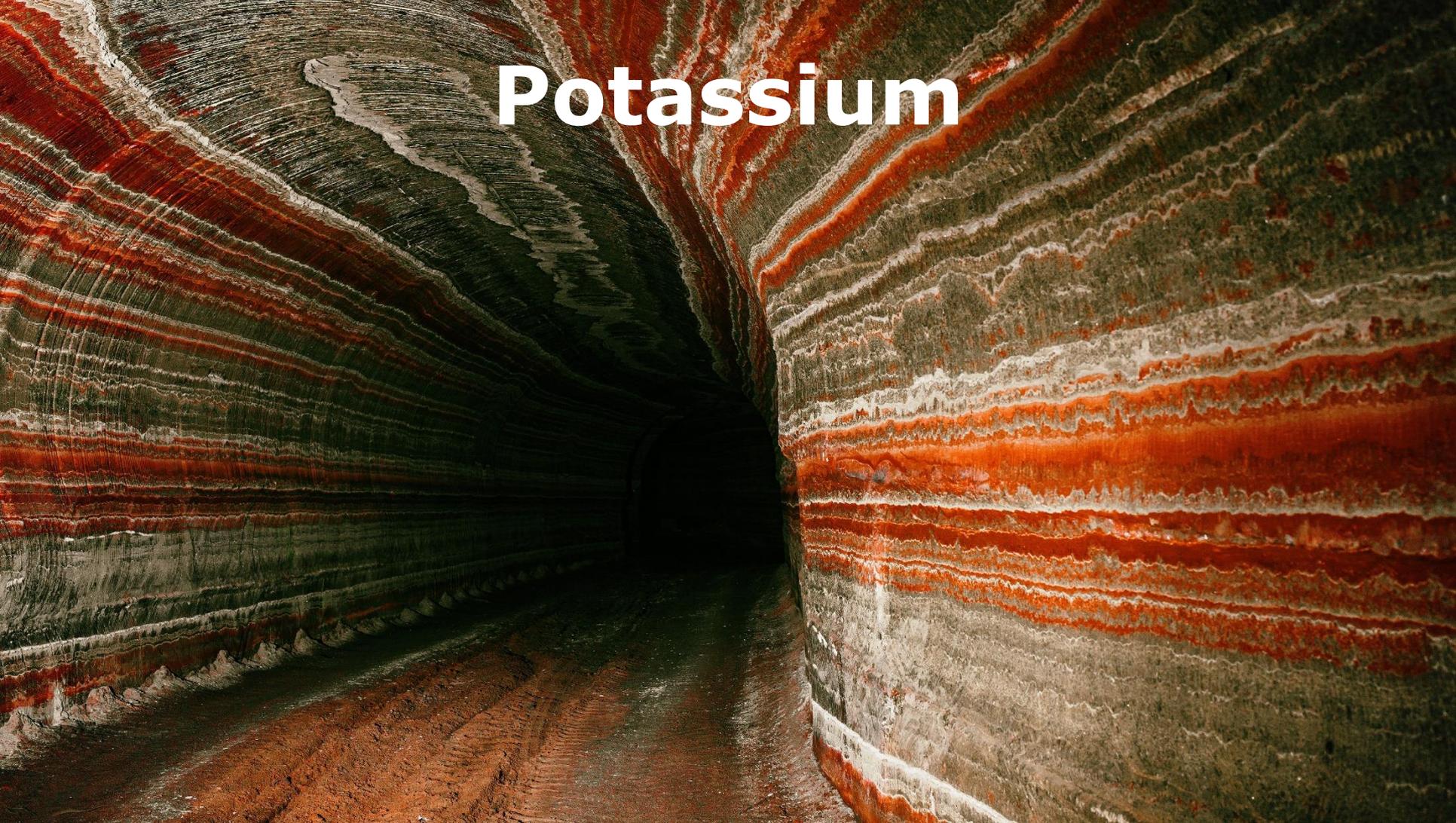
# Greenhouse Horticulture Metabolism

- Water
- Fertilizers
- CO<sub>2</sub>
- Growing media
- Biomass
- Plastics
- Plant protection products
- Cleaning products
- Removable coatings
- Paper products
- . . .

# Phosphate



# Potassium



# Natural gas



# Basalt



# Peat



**oil**



# Groundwater

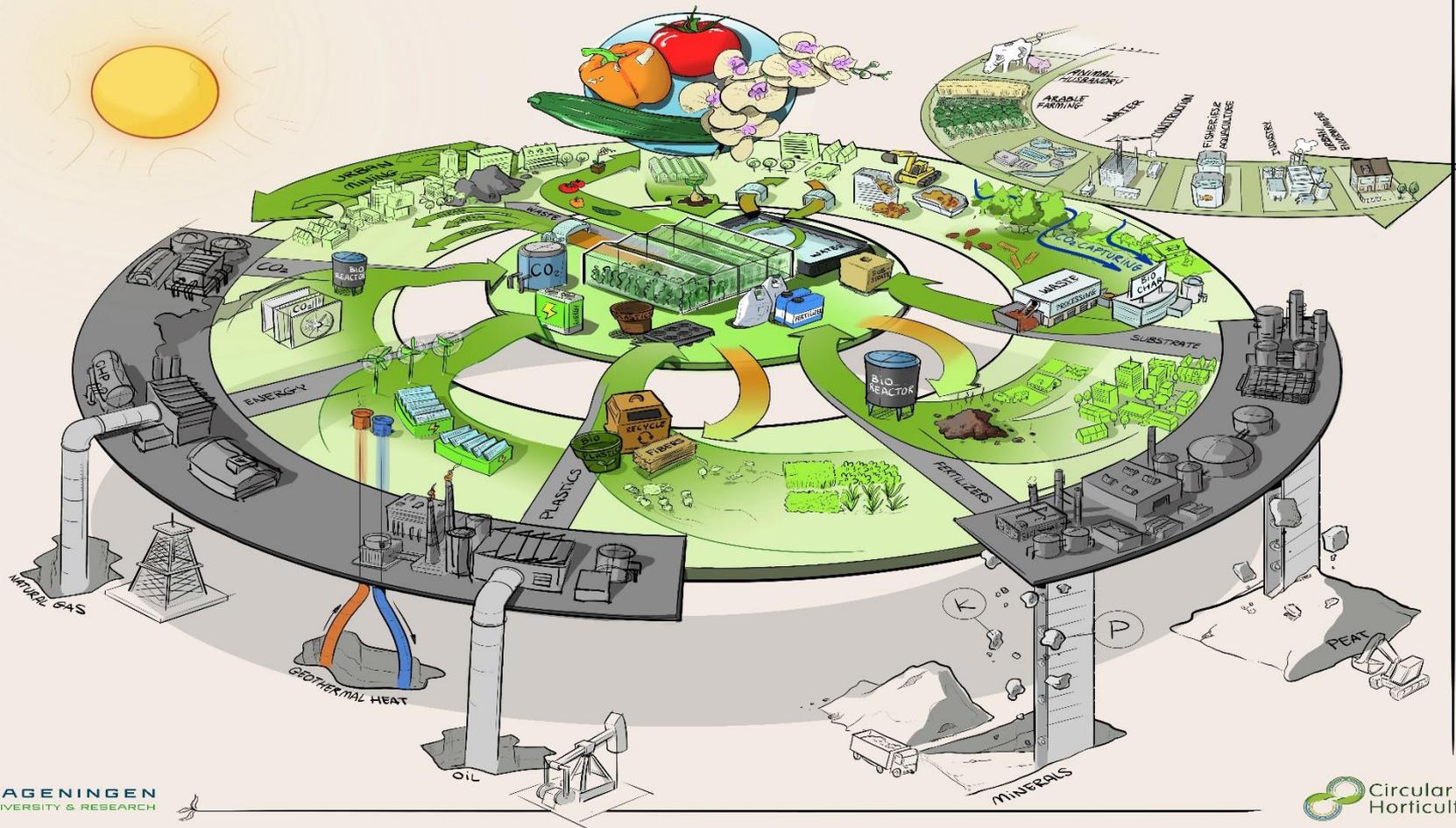


# Biomass

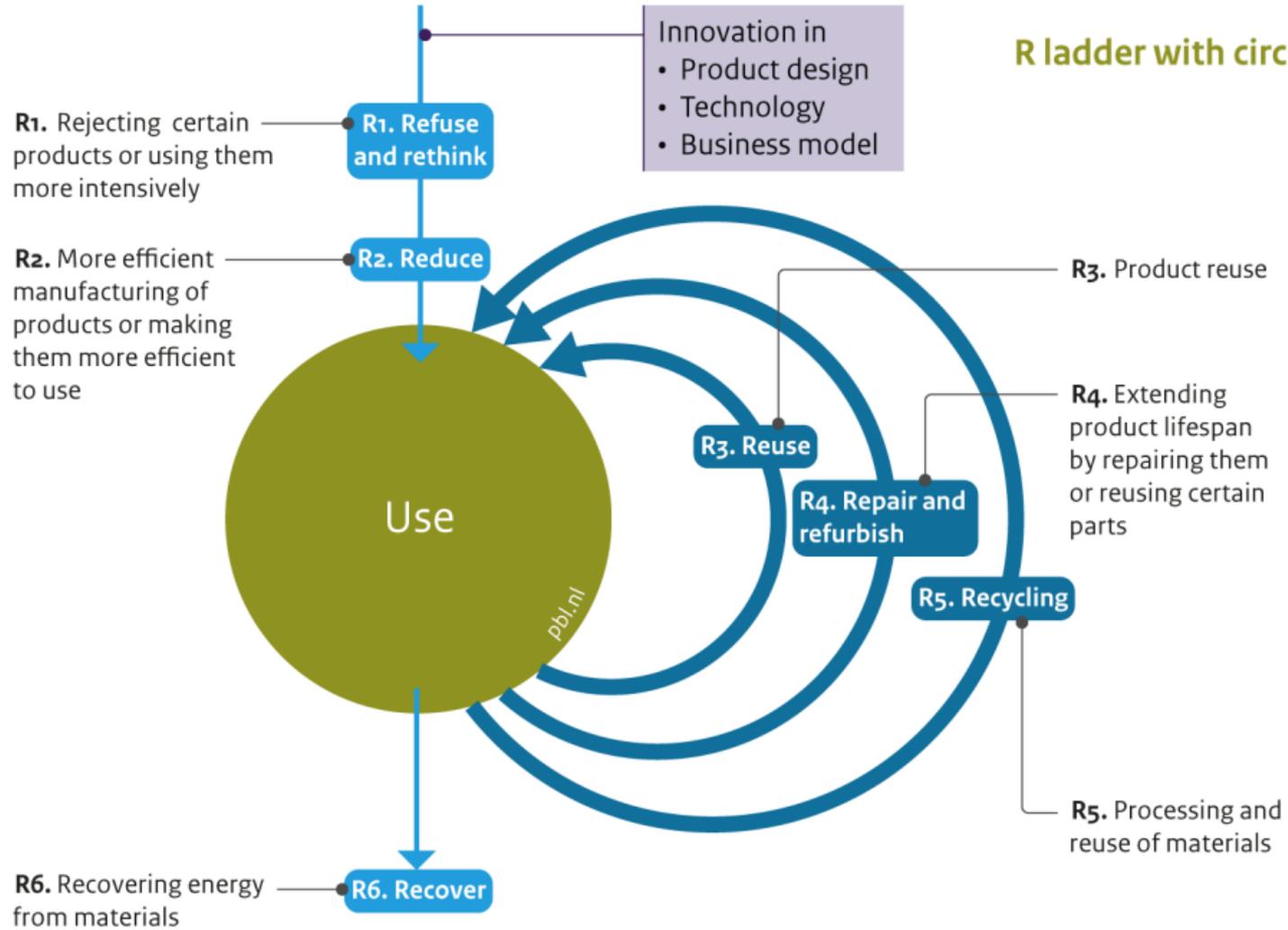
A large pile of green biomass sticks, possibly sugarcane, is shown. The sticks are bundled together with blue and white strings. The word "Biomass" is overlaid in white text in the upper center of the image. In the background, there are some red tomatoes and a green cap.

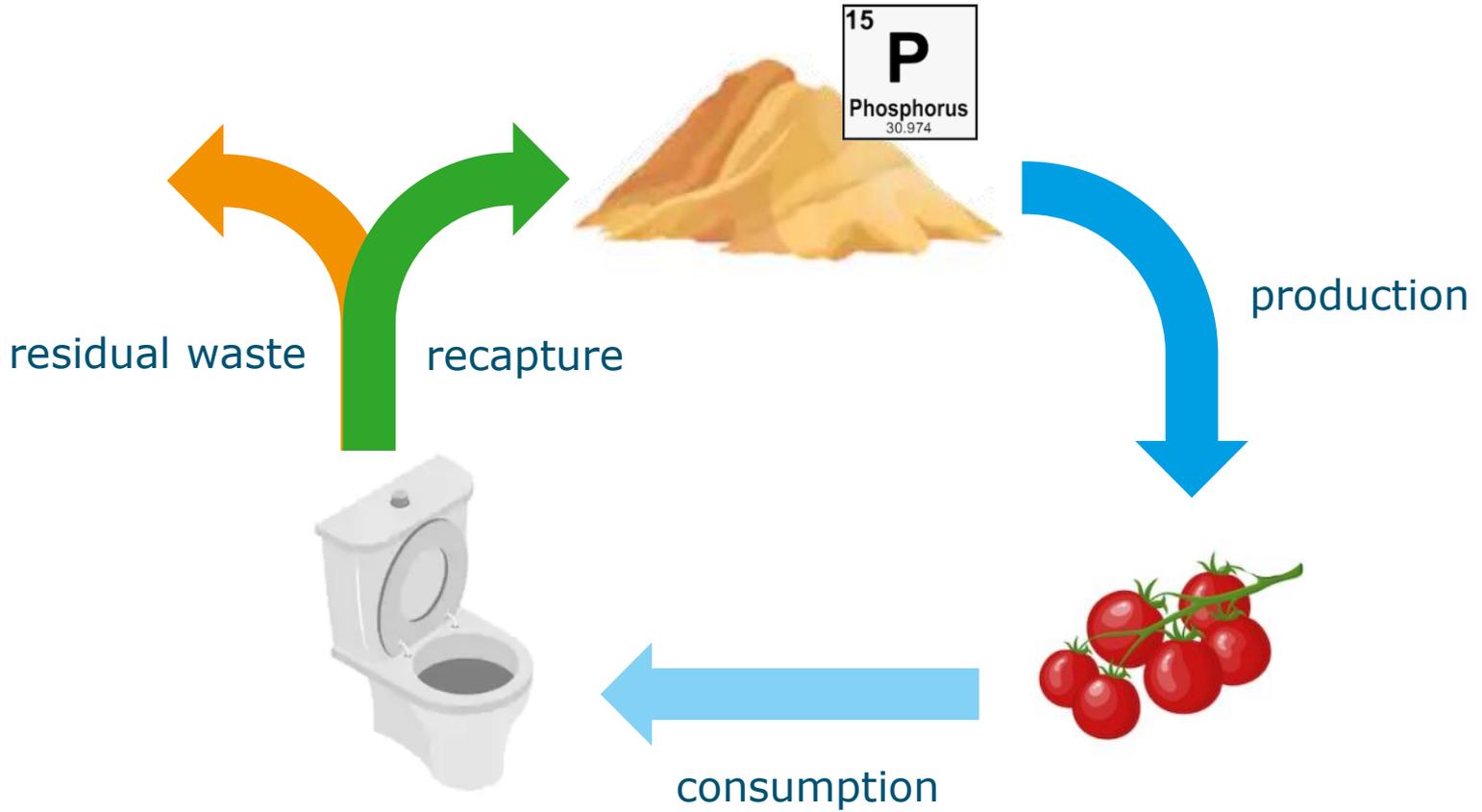
# GREENHOUSE HORTICULTURE IN THE CIRCULAR ECONOMY

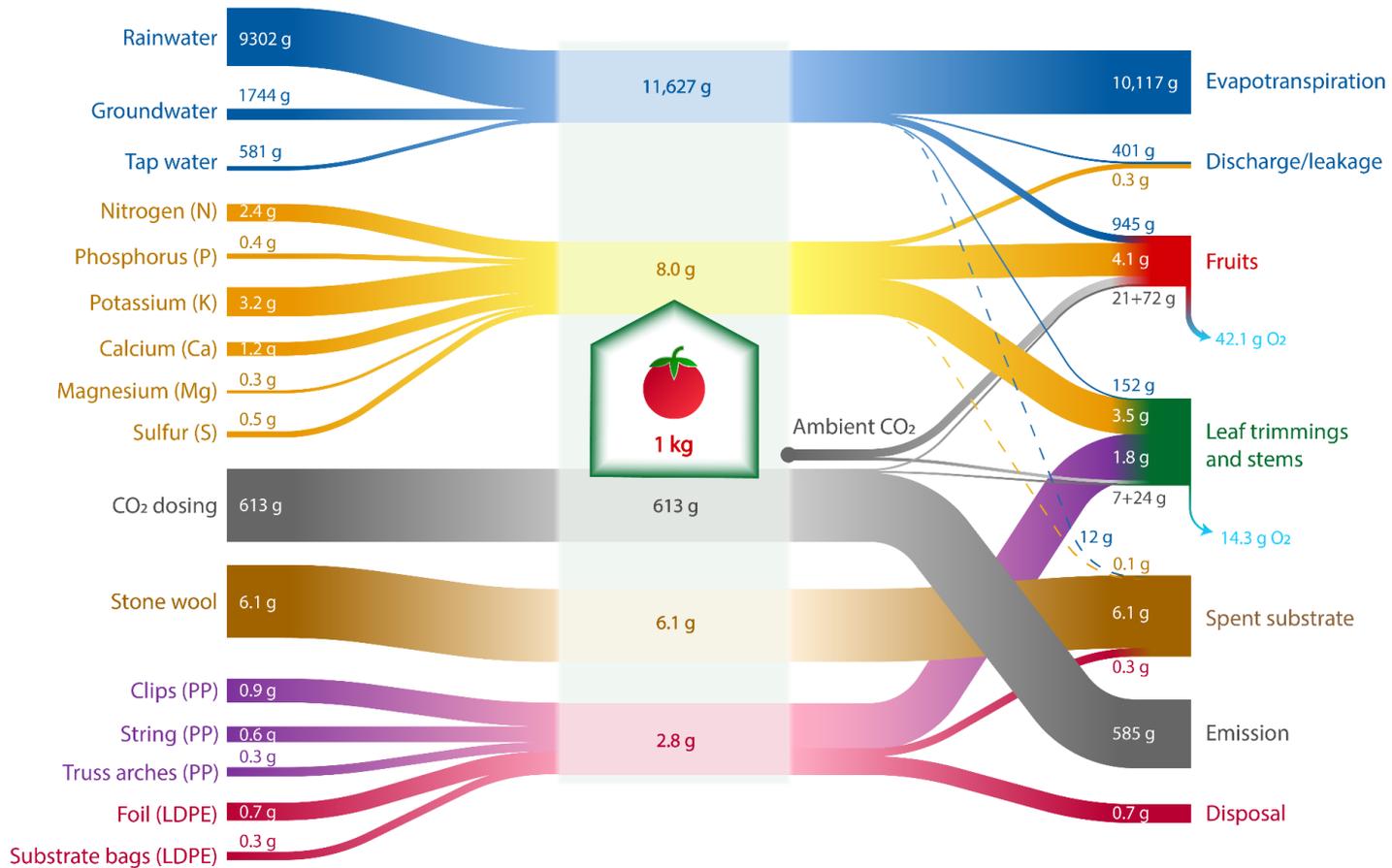
EFFICIENT, CLEAN AND CONNECTED



# R ladder with circularity strategies







Source: Van Tuyll et al. (2022)

# In case of tomatoes...

Several plastic products are used in a tomato greenhouse that have an important function but at the same time cause a plastic pollution and create a bottleneck for biomass valorisation





# A stakeholder challenge!

- Growers (past behaviour, risk perception and economics)
- Government (regulations, social dilemma's, risk perception)
- Waste processing companies (economics, resources, regulations)
- Supply companies
- Innovative 'biomass' companies

Solution is definitely not (only) technological...



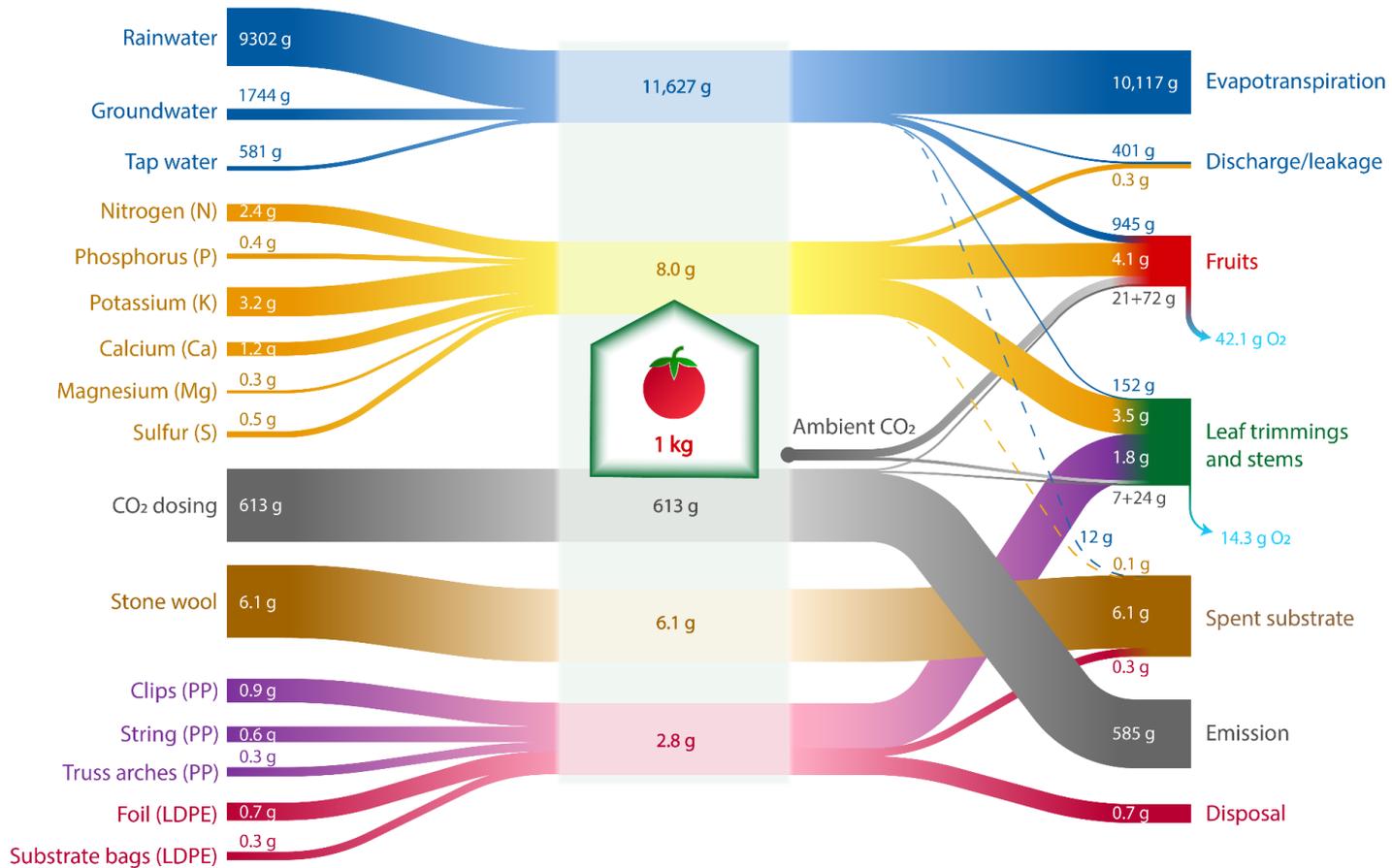
# Plastics

- **Refuse:** Stop using plastics when a product function has little added value or can be easily replaced by something durable.
- **Rethink (Return logistics and –design):** Avoid single-use product design and keep products in use.
- **Substitute (Biobased & Compostable):** Depending on function and EOL fossil based plastics can be replaced by biobased and/or compostable alternatives.
- **Recycle:** Designing mono-material products and organizing mono-material waste flows.



# Biomass

- **Setting up total-use value chains:** Cascading from high- to low value products. For instance extracting protein (rubisco), then minerals for fertilizer and then using the fibers.
- **Change in system design & grower practices:** a grower does not only produce tomatoes but also high quality and 'clean' biomass: stems and leaves.



Source: Van Tuyl et al. (2022)

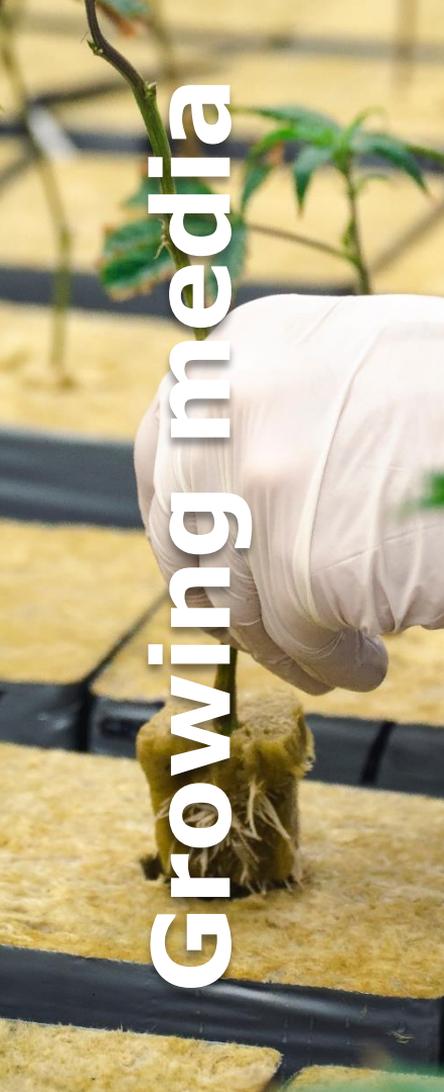
Afvalverwerker steeds meer grondstofleverancier

## Circulaire glastuinbouw: substraatmat wordt grondstof voor bakstenen

Onder Glas | VAKBLAD ONDER GLAS | 25 oktober 2018

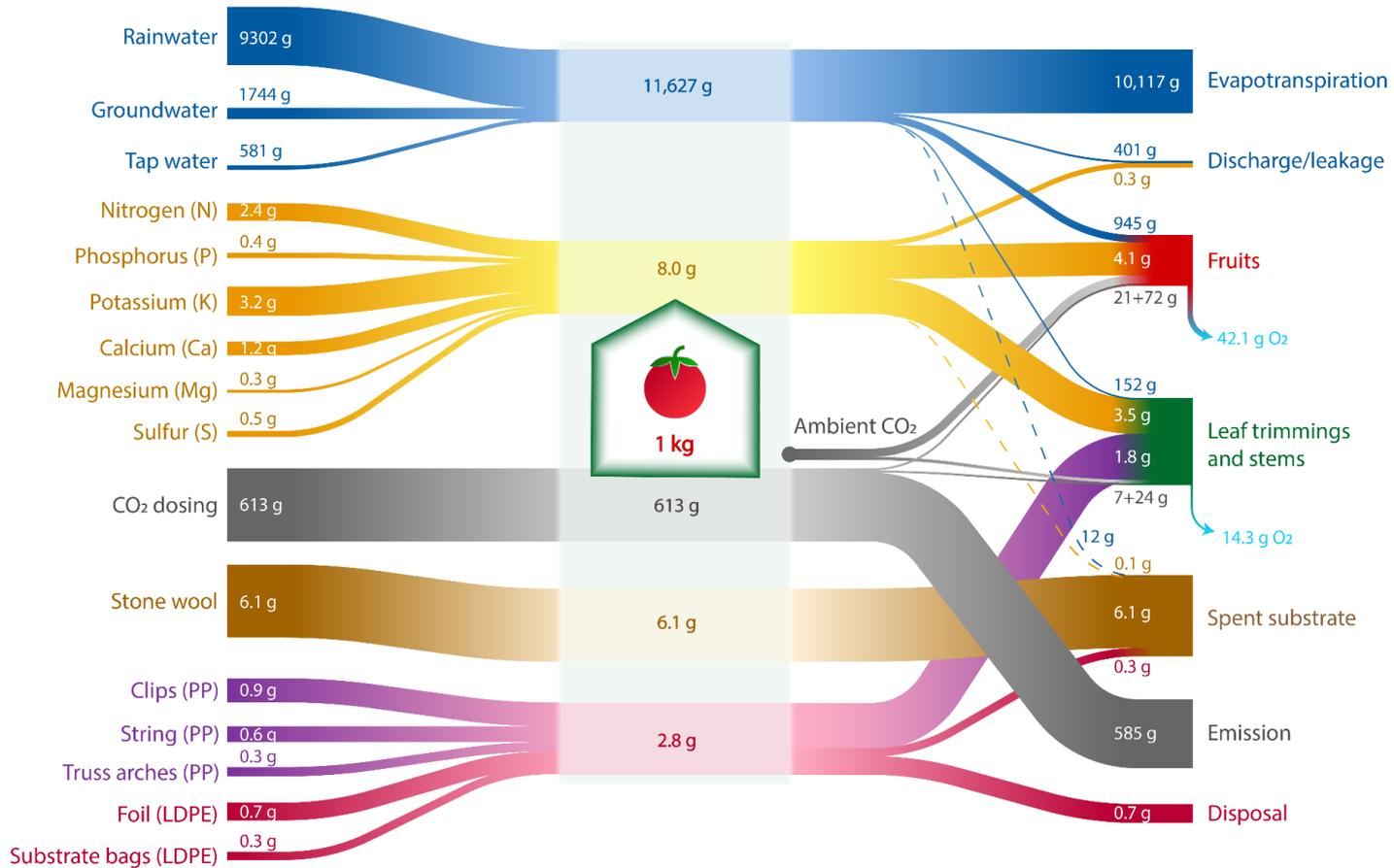


Tekst: Roger Abbenhuijs, beeld: LD Photography



# Growing media

- **Refuse:** Designing growing systems that do not require any growing media.
- **Reduce:** Increase product lifespan.
- **Recycle:** From residual flow to new growing media; improving the grade of recycling.
- **Substitute:** Shifting towards alternative (raw) materials that have a lower environmental impact and/or have a higher potential for (local) reuse.



Source: Van Tuyl et al. (2022)



- **Reduce:** Increase resource use efficiency in the greenhouse; currently  $>90\%$  of dosed  $\text{CO}_2$  leaves the system as GHG emission.
- **Reuse/Substitute (short term):** utilize  $\text{CO}_2$  from existing fossil sources (industry, waste incineration, container ships).
- **Reuse/Substitute (longer term):** utilize short-cycle  $\text{CO}_2$  from non-fossil sources: DAC and biomass

Check out: *Carbon Dioxide Enrichment for Greenhouses in a Decarbonised Future* by Van Tuyl et al. (2022)

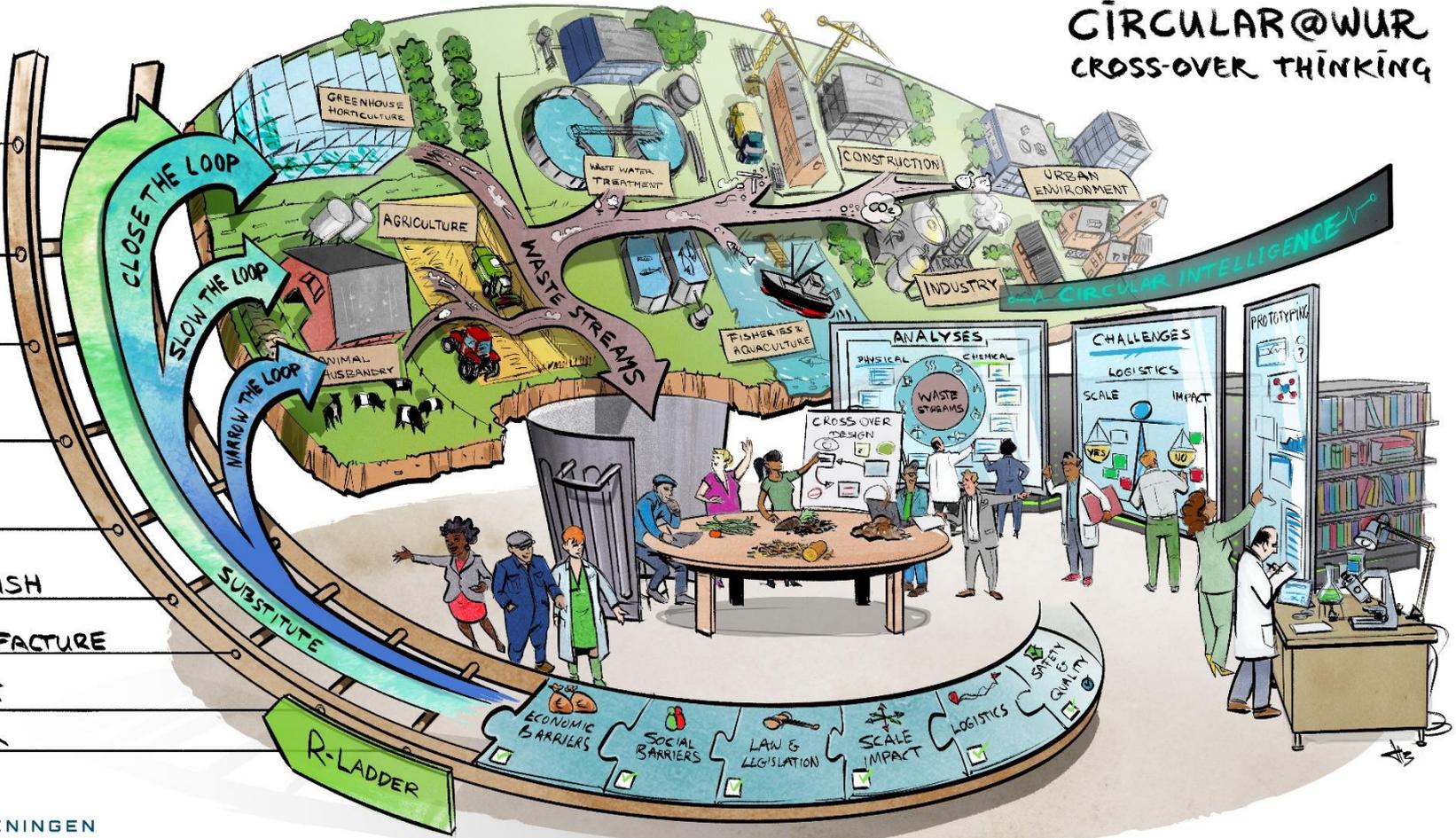
# What are Cross-overs?

Cross-overs are (new) connections between two or more sectors based on the exchange and reuse of material flows in order to decrease the input of raw materials and/or to decrease the production of waste.

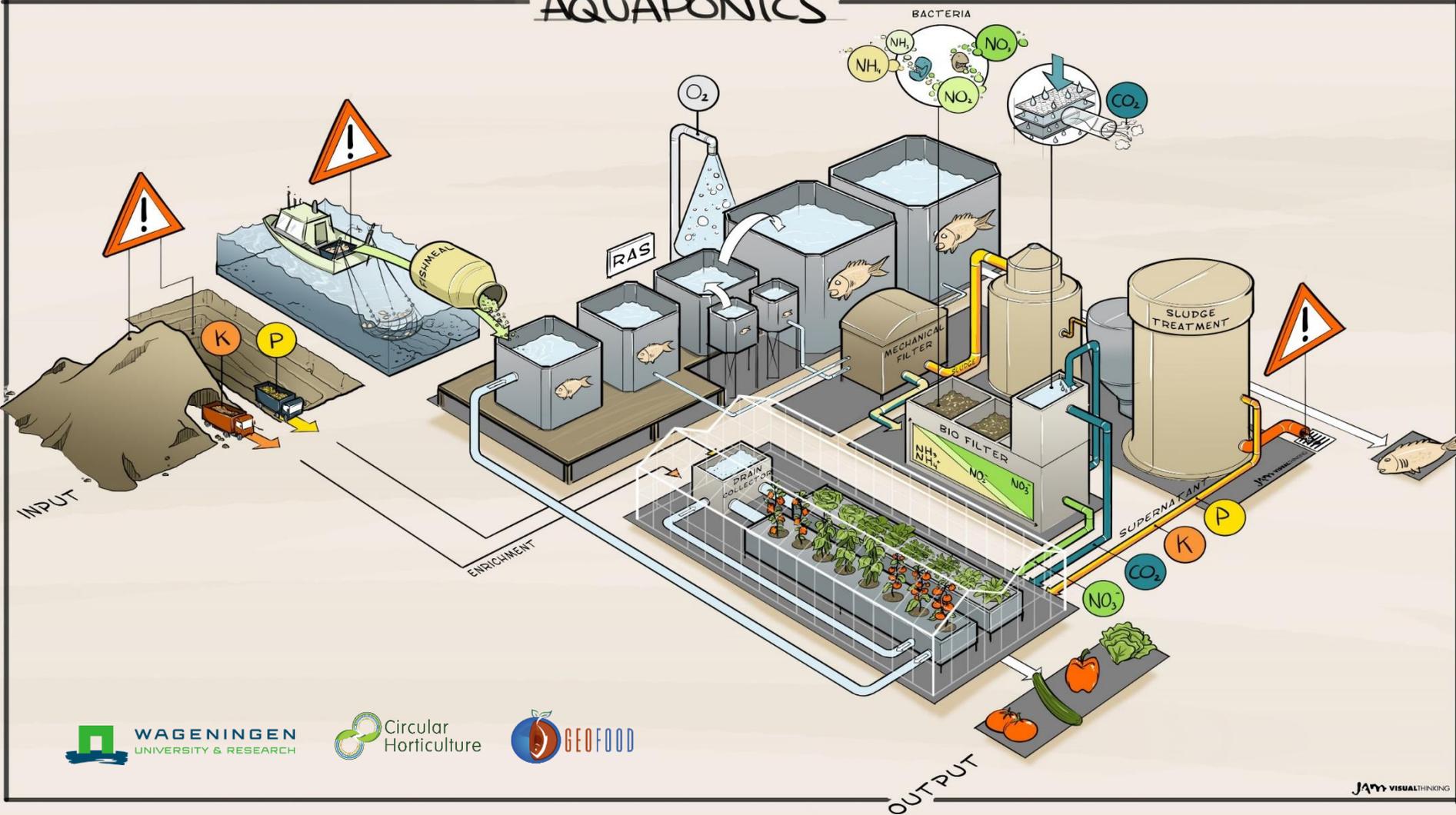
**Basically: The residual- or waste flows of one process should become resources for other systems.**

# CIRCULAR@WUR CROSS-OVER THINKING

- REFUSE
- RETHINK
- REDUCE
- REUSE
- REPAIR
- REFURBISH
- REMANUFACTURE
- RECYCLE
- RECOVER

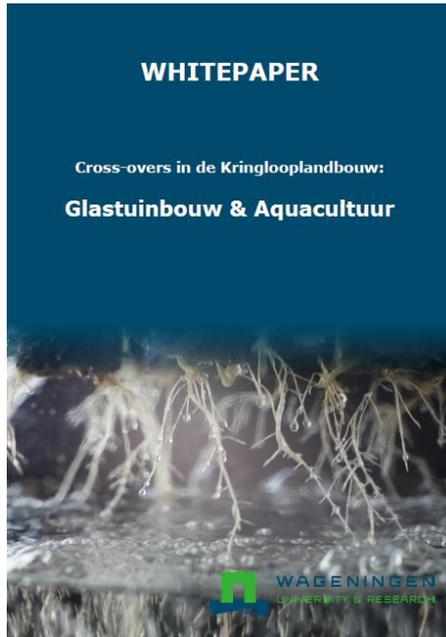


# AQUAPONICS

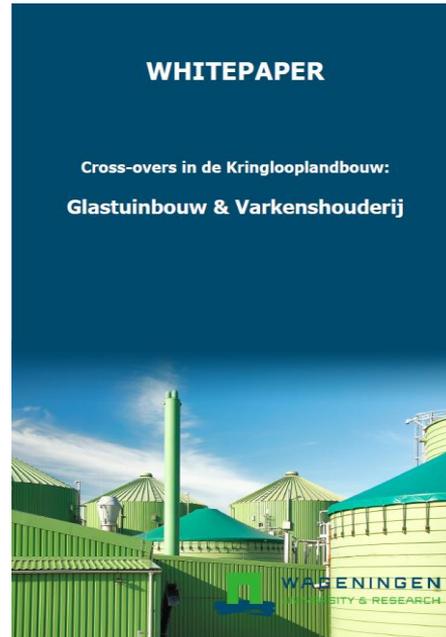


# Cases we worked on

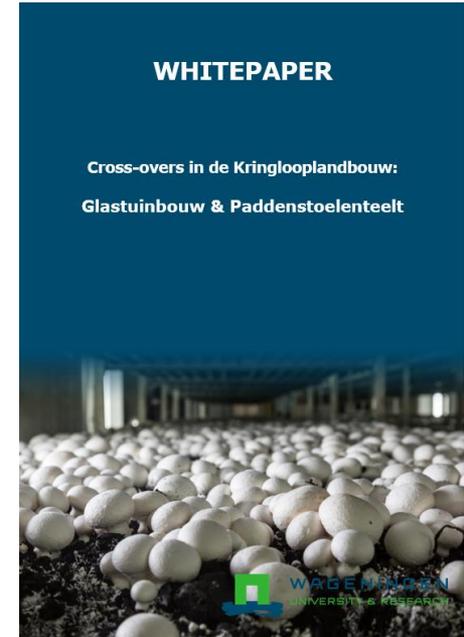
## Horticulture & Aquaculture



## Horticulture & Pig farming



## Horticulture & Fungiculture



# Questions?

Alexander Boedijn

[alexander.boedijn@wur.nl](mailto:alexander.boedijn@wur.nl)

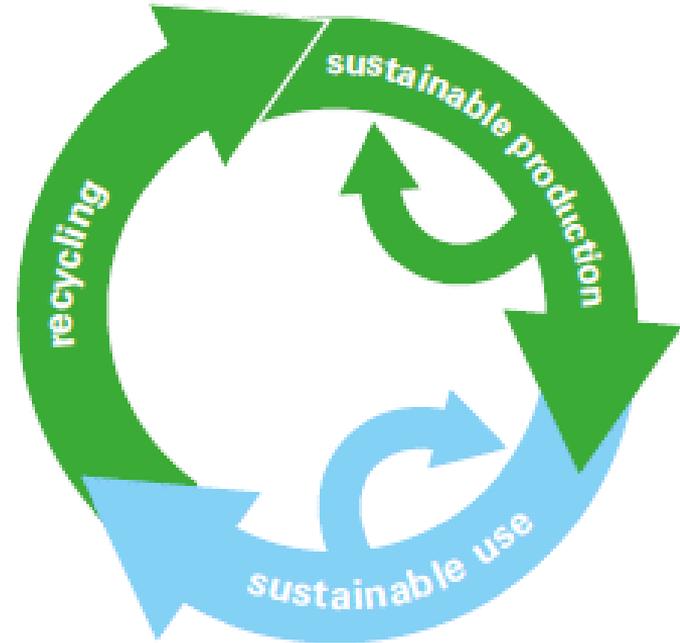
Alexander van Tuyll

Chris Blok

Cecilia Stanghellini

and many more...

## CIRCULAR ECONOMY



# Sources

“Tunnel, multicolor fragment of potassium salt mine’s wall, Belarus” by Sergejus Michalenko/Shutterstock

“Aardgastank in de raffinaderijindustrie” by tonton/Shutterstock.com

“Ruwe olie uit oliebron” by Anan Kaewkhammul/Shutterstock.com

“Verschillen tussen lineaire, keten- en circulaire economie” by Raad voor de leefomgeving en infrastructuur from the report Circulaire Economie: van wens naar uitvoering (2015)

“Fishing boat on green water, aerial drone view” by Sergey Muhlynin/Shutterstock

“An aerial view of an open pit phosphate mine” by B Brown/Shutterstock.com

“An agricultural digger on a mound of peat which has been extracted from the Somerset Levels in the UK” by cparrphotos/Shutterstock.com

“The water flowing artesian well from the land when the ground water hole drilling machine installed for the water supply” by Theeraphong/Shutterstock.com

# Sources

“Modern greenhouse with tomato plants. Beautiful background” by Roman Zaiets/Shutterstock.com

“Greenhouse horticulture in the circular economy” by Wageningen University & Research in collaboration with JAM Visual Thinking

“R ladder with circularity strategies” by Hanemaaijer, A. et al. (2021), Integral Circular Economy Report 2021, Assessment for the Netherlands, The Hague: PBL Netherlands Environmental Assessment Agency

“Deep water culture hydroponic system close up” by Ivan Karpov/Shutterstock.com

“Cannabis Cultivator Transplanting Baby Marijuana Plant in Rockwool Cube” by OpenRangeStock/Shutterstock.com

“Plastic pellets . Plastic raw materials in granules for industry. Transparent polyethylene pellets by StanislauV/Shutterstock.com

“Cross-overs by design” by Wageningen University & Research in collaboration with JAM Visual Thinking

# Sources

“Aquaponics” by Wageningen University & Research in collaboration with JAM Visual Thinking

“Various tanks from a biogas plant” by Wolfgang Jargstorff/Shutterstock.com

“Champignons growing on a mushroom farm. Mushroom production industry” door  
Kartinkin77/Shutterstock.com