

# Digital twins:

## The next frontier in fresh-produce cold chains

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### Introduction

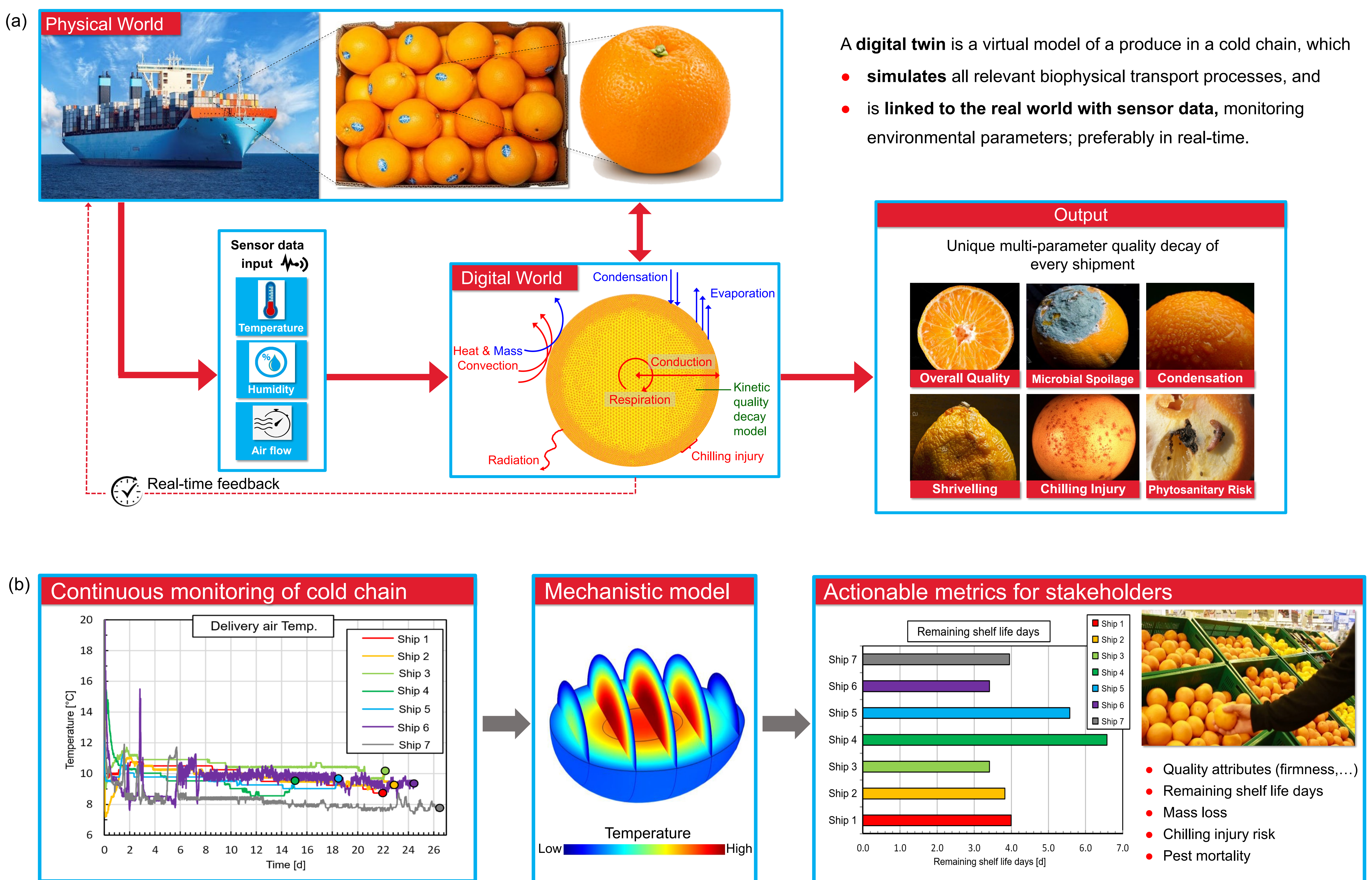
- Fresh produce require refrigerated transport and storage to prolong the shelf life
- Every shipment experiences a **unique cooling history and quality evolution**
- This complicates logistics at the retailer and leads to unnecessary losses



### Research Questions

- How can **monitoring** in cold chains be effectively used to **foresee** the **unique quality evolution** of a fresh produce?
- How can **digital twins** quantify the **invisible quality losses** taking place in these cold chains, and **mitigate** them?

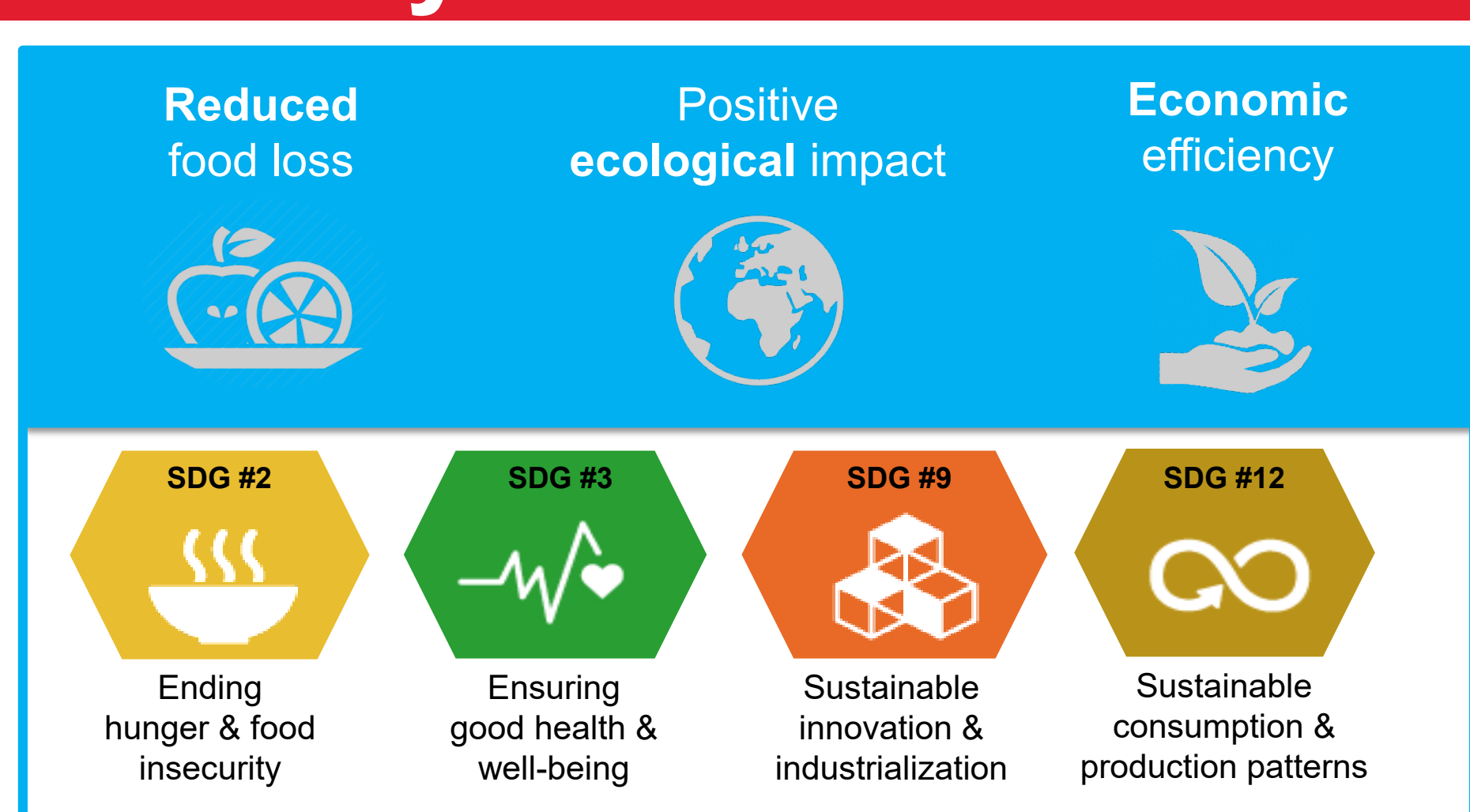
### Research Approach and Outcomes



(a) Concept of digital twin highlighting the key elements, viz. (i) monitored sensor data from actual cold chains, (ii) the digital twin based on mechanistic modeling, and (iii) the link between the digital twin and its physical counterpart. The output or key performance indicators captured by the digital twin are indicated in the box on the right;

(b) Case study of digital twinning in an actual cold chain using monitored delivery air temperature in maritime-freight transport to predict the remaining shelf life days for mango (adapted from Defraeye et al., 2019a, 2019b).

### Food System Relevance



### References

- 1) Defraeye, T., Tagliavini, G., Wu, W., Prawiranto, K., Schudel, S., Kerisima, M. A., ... & Bühlmann, A. (2019). Digital twins probe into food cooling and biochemical quality changes for reducing losses in refrigerated supply chains. *Resources, Conservation and Recycling*, 149, 778-794.
- 2) Defraeye, T., Shrivastava, C., Verboven, P., Berry, T., Schudel, S., Bühlmann, A., ... & Rossi, R. (2019). Digital twins are coming! Will we need them in fresh-produce supply chains? *Trends in Food Science and Technology* (in preparation).

### Acknowledgements

