Sustainable Logistics in integrated food production and supply systems-taking a System Dynamics perspective

Centre for Logistics and Traffic
Joint Centre Urban Systems
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Structure

- Theoretical Background and Motivation
  1. Climate Change Impact
  2. Water-Energy Food Nexus from Supply Chain Perspective

- Sustainable Economy and Sustainable Society

- Case Study
  1. ILoNa (Innovative Logistics for Sustainable Lifestyles)
Climate Change Impacts on Environment

1. Agriculture
2. Water Resources
3. Energy
4. Forest
5. Coastal Areas
6. Human Health
7. Species and Nature

River flow
Snowpack
Hydroelectric power
Floods
Drought
Agriculture
Habitat
Delta Levees
Groundwater
Water Quality
Water Use
Sustainability in the Food Supply Chain

- Sustainable Economy
  - Urban Supply Chains
  - Food Production Chains
- Sustainable Farming
- Water – Food – Energy Nexus

Sustainable Society
Dynamics in the WEF Nexus
Ministry Funded Project „Global Change 4+1“

Goals and Interests

Different social, economic, environmental goals and interests related to

Water  Energy  Food

Managing the Nexus

Scenario Development

Evidence  Response Options

Stakeholder Dialogue

Resource Base

Land  Water  Energy

Capital  Labour

Drivers

Lifestyles

Population growth

Urbanization

Diversifying and changing diets

Cultural and societal beliefs and behaviours

Climate Change

Drivers

Governance

Sectoral policies and interests

Industrial development

Agricultural Transformations

Technology and Innovation

FAO, 2015, modified
Impact of Pop. growth and lifestyles on WEF

Energy Security
- Energy Demand
  - Fossil Fuel Access
  - Power Gen Supply
- Population growth
- Lifestyles
- Water Demand
  - Water Availability (time and space)
- Food Security
  - Resources
  - Governance
  - Infrastructure
  - Resilience
  - Storage
  - Alternatives
  - Production
  - Import
  - Export
  - Water
  - Energy
  - Sanitation
  - Health
  - Well-being
  - Irrigation
  - Food Processing

- Energy from waste
- Bio-fuels
- Desalination
- Heating
- Transportation
- Treatment
- Hydropower
- Cooling
- Irrigation of bio-fuels

Smith-Gillespie, 2014; FAO, 2015, World Bank 2013, modified
Impacts of Climate Change Projection on WEF

Global temperature change (relative to pre-industrial level)

- **0°C**: Reference scenario
- **1°C**: Average-case reduces rainfall
- **2°C**: "Worst-case" reduces rainfall
- **3°C**: Falling yields in many developed regions
- **4°C**: Falling crop yields
- **5°C**: Decrease in water availability

**Food**
- Possible rising yields in some high latitude regions
- Falling yields in many developed regions

**Water**
- Glaciers disappear
- Sea level rise in coastal cities
- Decrease in water availability

**Energy**
- Additional electricity demand (MWh)
- Additional GHG Emissions (tonne CO₂)
- Coal production
- Electricity generation
- Desalination
- Irrigation

Storage volume levels in reservoirs in Mauritius under three climate change scenarios (in million cubic meters), and under the "worst-case" climate change scenario, there is an extra electricity demand for water and hence also verified GHG Emissions; Source: Howells et al., 2013
Water Energy Food Nexus and its Supply Chains
Summary

Sustainable Economy

- Urban Supply Chains
- Food Production Chains

Sustainable Farming

Water – Food – Energy Nexus

Sustainable Lifestyles
Demand and supply forces affecting the farm-level agricultural system

Anwar et al., 2012
European Call Horizon 2020

- Work Programme Part: Food security, sustainable agriculture and forestry, and inland water research
GAIN concept, design of the Big Data Platform
Sustainable Urbanisation Global Initiative

Food-Water-Energy Nexus

Joint Call for Proposals

Project Full Title: Decentralization of Urban Food-Water-Energy System under Deep Uncertainty

SIRIUS
SIRIUS Approach

Data input and local specificities → Scenario development → Objectives and requirements of stakeholders and policy makers

Algorithms and core computational models:
- Assessment of Resilience
- Assessment of Efficiency
- Resource use accounting

Simulation-based scenario assessment

Possible future outcomes

- External events, Uncertainties, Risks
- Policy Input
Summary

Sustainable Economy

- Urban Supply Chains
- Food Production Chains

Sustainable Farming

Water – Food – Energy Nexus

Sustainable Lifestyles
Ecological Economics Conceptual Model on Urban-Industrial Systems

Natural Capital

Urban-Industrial System

Supply Chain Scope

Deposits of degraded Resources

Solar Energy

ESGS – Ecosystem Goods and Services
S = Sourcing of Materials
P = Production/Manufacturing
D = Distribution (Transport, Storage, Turnover)
R = Retailing
B = Buying
U1 = Primary Use
U2 = Secondary Use/Rebuy
U3 = Tertiary Use of modified upcycled products
C = Recycling of materials

Krumme and Melkonyan, 2016
Summary

- Sustainable Economy
  - Urban Supply Chains
  - Food Production Chains
  - Sustainable Farming

- Sustainable Lifestyles
  - Water – Food – Energy Nexus
Current Project
ILoNa (Innovative Logistics for Sustainable Lifestyles)

How should innovative logistics services be designed in order to promote sustainable lifestyles of consumers?

What kind of changes from consumers should be undertaken in order to support sustainable logistic structures?

Integration of the social-economic and ecologic aspects

„Sustainable“ Decision and Action
Interdisciplinary

**Communicational Studies**
Definition of the target groups and Communication strategies

**Social- and Economics**
Social Trends, Consumer Responsibility, Sharing Economy

**Economics and Engineering**
Integrative Supply Chain Models, System Dynamics, Business Models

**Environmental Studies**
Ecologic Footprinting, Sustainability accounting, Ecological Economics

**Cognitive Psychology**
Decision processes of the consumers

- SCHACHINGER (Biological Food Distribution in Wien)
- FIEGE (Online Commerce - Fashion)

**SCIENCE**

**Economy**

**INNOVATION PLATFORM**
Sustainable Lifestyles and their Impact on Logistics

- Production rate
- Number of Suppliers and Products
- Transport: Capacity and Lot Size
- Transport Frequency
- Transport Distances
- Vehicle Technology
- Storage time and packaging
- Warehouse location
- Click & Collect
- Free House
- Package Station
- Distribution strategy
- Transport Distances
- Demand
- Service Level
- Price and Comfort Sensitivity
- Residence and Mobility
Applied methodology of causal diagrams and participatory system mapping

Structure of the modelling:

- Model „E-Food Case Study”
  - Supply Chain (Last mile)
  - Sustainability
  - Consumer’s lifestyle

**Input Workshop “Practice”**

- Identification of problems
- Description of the system
- Mapping - Main task in Workshop

“Participatory Systems mappings” Methodology

- Creation and Completion of the CLD
- Post-processing the basic CLD (Digitalisation)

Exploratory research, Systemic thinking

Input: Project members internal Workshops
Participatory System Mapping

Parties

Success Factors

Barriers

Means to implement sustainable Logistics for Sustainable Lifestyles
Key Points

- Selection of Sustainable Distribution Channels
- Solutions for Sharing Economy
- Visualisation and communication of Sustainability impacts of Logistics configuration
Selection of Sustainable Distribution Channels

Comparison Portal
- Image - Campaign
- Convenience
- Not Finding the Appropriate selection
- Cold Chain
- Fast/Slow
- "Only Highest Quality"
- Online - Channel, Full - Assortment
- High-Pricing/ Low-Pricing
- Incentives to "More Consumption"
- Competitive C&C for Delivery Service
- Convenience

Communication Strategies/Measures

Barrier

Selection of Sustainable Distribution Channels

Actors
- "Parents"
- "Elderly"
- Producer
- Supermarket
- Urban Space
- Inner City Housewife/husband

Success Factors
- Click & Collect (C&C) (Accomodation and Working Place) -Pre-packed Packages
- Reduced Assortment i.e. Corner Shop
- Fast/Slow
- No Classical Personal "Parcel Shipment"
- "Steady Trade"
- "Food Assembly"
- "Aldi" - Offers
- Show - Room
Sustainable Distribution

Actors
- Click & Collect Professionals
- Parents
- Inner City (housewives)
- Producers
- Supermarket
- Elderly
- Urban Space
- Parents
- Elderly
- Producers
- Supermarket

Communication Strategies
- Comparison Portal
- Image Campaign

Success Factors
- Pre-Packed Packages (accommodation and working place)
- Reduced Assortiment
- Fast/slow
- Classical but personal parcel shipment
- No appropriate selection
- High/low pricing
- Full assortiment
- Incentives to more consumption
- Steady Trade

No

Steady Trade

Food Assembly

Uncertain

Reduced Assortiment

Fast/slow

Classical but personal parcel shipment

No appropriate selection

High/low pricing

Full assortiment

Incentives to more consumption

Pre-Packed Packages (accommodation and working place)
Sharing Economy

Stationary Platform

Addon Services

Assortment Size

Flexibility (Reliability)

Legal Frameworks

Communication Strategies/Measures

Barrier

Sharing Economy

Actors

Customer

Service Provider

Retailer (Distributor)

Local Authority

Success Factors

Trust

Localisation

Operator Model

Reputation Mechanisms

Price

Distribution Model

Mixed Services
Visualisation and communication of Sustainability impacts of Logistics configuration

- Labeling "Certificate"
- Compensation
- Information
- "Sustainability" Button
- Special Measures (Click & Collect)
- Accomodation

- Willingness to pay for Sustainable Products
- Information Scarcity
- Convenience
- No Transparency
- Competitive Situation

- Communication Strategies/Measures

- Visualisation & Communication of Sustainability Impacts from Logistics Configuration

- Actors
  - Customer
  - Logistics Provider
  - Producer
  - Distributor (Stationary, Online)
  - Applied Researcher(s)
  - NGO
  - Local Authority
  - Media
  - Consumer Direct

- Success Factors
  - Measurability "Sustainability Factors"
    - Possibility to choose Logistics Provider
    - Willingness to pay for Sustainable Products
    - Personalized Information "Target Groups"
    - Transparency
    - Differentiation Product and Supply Chain
    - Motivation

- Barrier
Further Steps

1. Scenario development
2. Simulation runs for various scenarios
3. Development of business models based on SD analysis
Rationale of the approach

- Material Flow Analysis, definition of parameters at each SSCM
- Modelling of Economic Loss
- Advanced EF
- Quantitative/Qualitative Analysis with System Dynamics

Sustainability Gaps

- Resilience guided
- DNM
- Water Energy Food Supply Chain Infrastructure Model (Structures + Services)
- Data analysis for (A) each stage of the supply chain infrastructure and depending services as well as (B) emerging properties of the entire network
- Modelling & Simulation utilizing System Dynamics

Counter Measures

- Scenario development for stages/ synergistic fragments of the supply chain based on demographic changes, climate change, economic development applying system dynamics, agent based simulation models
- Design Guidelines
- „Green Economy“ Frameworks

Policy Recommendations
# Cooperation Partners (Target Countries)

<table>
<thead>
<tr>
<th>South Caucasus, Armenia/ Georgia</th>
<th>South America, Brazil</th>
<th>North-Africa, Egypt</th>
<th>East-Africa, Kenya</th>
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</thead>
<tbody>
<tr>
<td>• Yerevan State University, Faculty of Economics; University of Agricultural Research; Ministry of Nature Protection, Armenia, and office of UNDP in Armenia and Georgia; Ministry of Environmental Protection, Georgia, National Environmental Agency; National Hydrometeorological Service of Armenia.</td>
<td>• Federal University of Rio de Janeiro, Coppe, Graduate Studies and Research in Engineering, Transport Engineering and Supply Chains.</td>
<td>• Arab Academy of Science and Technology in Alexandria; Renewable Energy and Sustainable Development.</td>
<td>• Kenyatta University Nairobi; Physical Geography and Agro-Climatology; Kenya Agricultural Commodity Exchange Limited.</td>
</tr>
<tr>
<td><strong>Research Profile:</strong> Economic analysis/modeling of climate change impacts on agricultural production sector and water management issues. Supply purposes investigated are mainly dedicated to national consumption markets.</td>
<td><strong>Research Profile:</strong> Organic Production and Supply Systems under Climate Change with respect to a) GHG emission mitigation for supply chain infrastructures for Rio de Janeiro, b) eco-efficiency analysis of soy export corridors for the international market, c) competitive organic supply chains (energy/food) in respect to tradeoffs/synergies.</td>
<td><strong>Research Profile:</strong> a) Regional bio-energy/renewable energy production and supply systems and conflicting regional climate change impacts, b) energy supply for the megacity Alexandria and its greater coastal region.</td>
<td><strong>Profile:</strong> Regional food production and supply systems under climate change, particularly for a) sources for urban supply of the centrally “inland” located metropolis Nairobi, b) impacts on international production and supply systems for agricultural commodities on the global market.</td>
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Further Scientific Companion Institutions

- Prof. Dr. Malcolm O. Asadoorian, Environmental Economics, Regis Colleague at Harvard University, USA
- Prof. Dr. Raimund Bleischwitz, Environmental Economics, BHP Bilton Chair in Sustainable Global Resources
- Prof. Dr. em. Gerd Förch, Integrated Watershed Management, Makerere University, Kampala/Uganda (visiting Professor DAAD Herder Programme at College of Agriculture and Environmental Sciences)
- Prof. Dr. John D. Groesbeck, John R. Kuhn Professor of Business and Economics, Missouri Southern State University, USA
- Prof. Dr. Arjen Hoekstra, Water Management, University of Twente, Netherlands, Advisor to e.g. UNESCO and the World Bank; founder and chairman of the Water Footprint Network (WFN)
- Prof. Dr. Riccardo Manzini, Director of the "Food Supply Chain Center & LAB", ALMA MATER STUDIORUM - Bologna University, Italy;
- Prof. Dr. Antonella Samoggia, Agricultural Sciences, Rural economy and evaluation, agri-environmental measures, ALMA MATER STUDIORUM - Bologna University, Italy
- Prof. Dr. Uwe Schneidewind, Wuppertal Institute for Climate, Environment and Energy, Germany, President; i.a. Member of the German Advisory Council on Global Change and the Club of Rome
- Prof. Dr. Metin Türkay, Koc University, Turkey; Director of the KOÇ-IBM Supply Chain Research Center
- Prof. em. Dr. Bert de Vries, Global Change & Energy/ Sustainability Science, Member of the Intergovernmental Panel on Climate Change (IPCC)
- Prof. Dr. Ying Zhao, Agricultural Economics, Northwest Agriculture and Forestry University, Shanxi, China (College of Natural Resources and Environment)
- Prof. Dr. W.H.M. Zjim, Production & Supply Chain Management/ Operations Research, University of Twente, Netherlands (Co-Chair of the Alliance for Logistics Innovation through Collaboration in Europe (ALICE)
Partnering International Policy & Stakeholder Organization:

- **Food and Agriculture Organization of the UN (FAO),** Italy (Dr. Aslihan Arslan, Natural Resource Economist, Agricultural Development Economics Division)

- **United Nations Economic and Social Commission for Western Asia (ESCWA),** Lebanon (Prof. Dr. Yasser Dessouky, Renewable Energy Expert in the ESCWA)

- **Regional Center for Renewable Energy and Energy Efficiency (RCREEE),** Egypt (Tareq Emtairah, Hind Il Idrissi)

- **United Nations Development Programme (UNDP),** Armenia (Dr. Diana Harutyunyan, Energy Efficiency and Climate Change Program Coordinator)
Thank you for your Attention