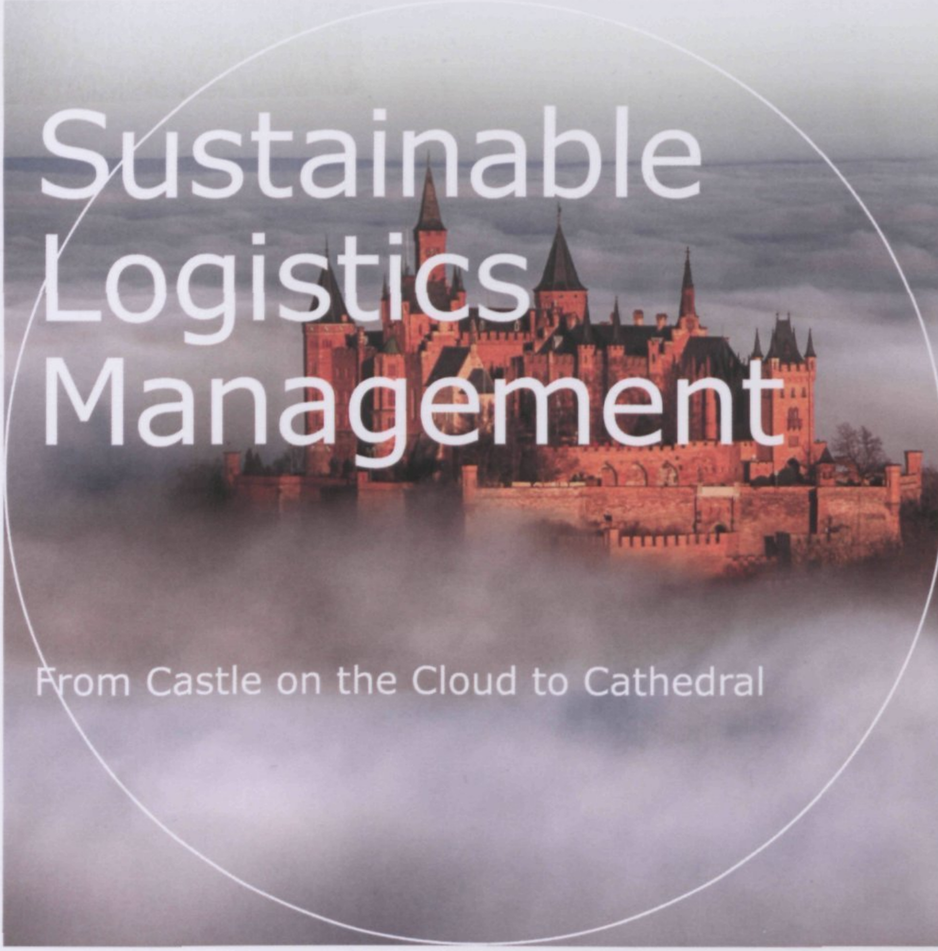
Sustainable Logistics Management



From Castle on the Cloud to Cathedral

Prof. dr J.M. Bloemhof-Ruwaard

Inaugural lecture upon taking up the post of Personal Professor in the Operations Research and Logistics Group at Wageningen University on 8 January 2015

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Rector Magnificus, colleagues, family and friends,

In this inaugural lecture, I would like to take you to the fast growing field of Sustainable Logistics Management; a sustainable logistics system that is economically viable, socially acceptable and without emissions or waste. It may sound or look too good to be true. Where to begin and how to proceed? Is it realistic, what are the costs, isn't this way too difficult?
That is the reason why I start with a castle on the cloud. The castle of Hohenzollern in Germany (see cover, photo: Shutterstock) represents the ideal image of a castle in the time of the Medieval Knights. What is the ideal image of Sustainable Logistics Management (in short SLM)?

A castle on the cloud

Sustainable Logistics Management (also known as Sustainable Supply Chain Management) is a rather new phenomenon in the field of Operations Management and Operations Research, originating some 10 years ago (Brandenburg et al., 2014). This field integrates the two concepts 'Sustainability' and 'Logistics Management'.

Sustainable (from the Latin Sustinare) means enduring. This comes back in the famous definition of Brundlandt (1987) defining a sustainable development as a development which meets the needs of current generations without compromising the future. This definition has been operationalized by Elkington (2004), stating that firms should focus not only on the maximization of shareholder wealth or economic value, but also on the environmental and social value that they add or destroy in order to achieve environmental security and social equity. The overlap of the three elements of human (people), ecological (planet) and economic (profit) perspective is known as sustainability. This concept is called the Triple Bottom Line, or more popular the People, Planet and Profit perspective.

Logistics Management deals with all activities that plan, implement and control the efficient and effective flow and storage of goods, services and related information between the point of origin (raw materials) and the point of consumption in order to meet customers' requirements (Council of Logistics Management, 1986). Customers' requirements can relate to the quality of the product, speed of delivery, price, but also to no child labor, no use of the rain forests, being carbon-neutral etc. Traditional logistic activities are freight transportation, production planning and scheduling, inventory control and network design.
In order to avoid disposal after the point of consumption, a whole new stream of activities is necessary to make sure that valuable materials, components but also minerals or energy will not be lost. This requires collection, testing and some disassembly before going into the steps of waste management: reuse, repair, refurbish, remanufacture, recover and recycle. Figure 1 illustrates the forward and reverse processes in the chain.

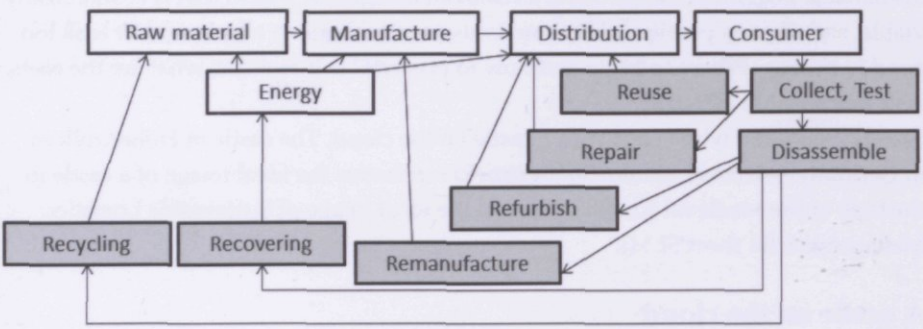

Figure 1. Forward and reverse activities in Sustainable Logistics Management

The field of Sustainable Logistics Management can be applied in many sectors, but is especially relevant in the area of fresh and food supply chains (see also Akkerman et al., 2010). Food logistics management is complicated by an intrinsic focus on product quality. The way in which food quality is controlled and guaranteed in the network is of vital importance for the chain performance (Van der Vorst et al., 2009).

A castle on the cloud in the field of Sustainable Logistics Management needs to deal with the logistics processes in a sustainable way. Some examples:

1 Zero emission in freight transportation; This can only become true if the electricity originates from a green source such as wind or solar energy. At the moment, initiatives start all over the world. In California, USA, sustainable freight pathways to zero and near-zero emissions are explored (Air Resources

Board, 2015). Zero-emission drivetrain technologies have been developed for on-road heavy-duty freight vehicles (Den Boer et al., 2013) and 100% solar-powered and wind-powered cargo ships make their way through the seas (e.g. the Turanor Planet Solar, Eco Marine Power, Green Marine and the Dutch Ecoliners).

2 The "No waste network" is an initiative of the ministry of Economic Affairs to avoid food spoilage and optimally valorize residual streams. At the moment about 1/3 of the food produced is not used for human consumption (www.nowastenetwork.nl).

3 The Kalundborg eco-industrial site in Denmark started already in 1961 to extract value from by-products by exchanging waste resources between companies and communities located nearby to reuse, recycle and reduce waste. It is still one of the few working examples in the world showing that it is difficult to design such eco-industrial parks in practice (www.symbiosis.dk) .

4 3D Printing will lead to a reduction of waste and transportation, but at the moment still at a low scale and very high costs.

5 Finally, Green Cloud Computing (IT solutions help to automate transportation planning to reduce emissions and costs and they help to reduce resource usage by streamlining processes). RFID tags can carry energy footprint related information etc.

These examples are still castles on the cloud. They ask for action.

Building cathedrals

In the middle ages, building cathedrals was a process of trial and error. Architectural theories had not been developed to the level needed. Still, this did not stop architects, clergyman and construction workers to start building. With creativity and perseverance, they created the most amazing buildings which have last already for hundreds, even thousands of years. Figure 2a shows the Aachen Cathedral, one of the oldest cathedrals in Germany built by Charles the Great. Inspired by the Dutch book of Quakernaat (2011) "Ga Kathedralen Bouwen", I want to illustrate the development of Sustainable Logistics Management using the examples of some famous cathedrals from all around the world. For me, the cathedral is a symbol for everything that you believe in, so you start without knowing in advance if you will succeed in the end.

Cathedrals are real eye-catchers. The Pokrov or Basilius cathedral in Moskow with its onion shaped towers is the most important eye-catcher of the Red Square (Figure 2b). It is an architectonic master piece. The cathedral has been built in the 16th century. In 1848 the cathedral got its well-known exuberant colors. When Jozef Stalin in 1912 gave the order to demolish the cathedral because it blocked the way for one of his big parades, a large protest arose. The architect stood at the steps of the building and threatened to kill himself. Even Eleanor Roosevelt offered to take down the building and bring it to the United States to rescue it. Together, this resulted in the continued existence of the cathedral, which is now a UNESCO World heritage site.

Also in Sustainable Logistics Management, not knowing the optimal end situation and the way how to get there should not stop us from trying. We need to start building cathedrals. Problems encourage creativity. What problems are most urgent, and ask for our creativity? My motivation for this field is found in urgent societal issues like food spoilage, scarcity of raw materials and energy sources, and environmental emissions.

Figure 2a. Aachen Cathedral, Germany (photo: Peter Letmaethe)

Figure 2b. Pokrov Cathedral Moskow, Russia (photo: Shutterstock)

The agrifood chain has become long and complex. Most food products end up far from where they have been produced. According to Rabobank (2014), this internationally oriented system is responsible for 70% of total water usage, 40% of the land's surface area and 30% of all energy use worldwide. Moreover, along this chain about 30-50% of the food that is produced will not be used for human consumption (so called food spoilage). Figure 3 shows that most food is lost at the stage of production and consumption, but processing, packaging, storage and logistics play a significant role.

The main hotspots that relate to sustainability are the impacts on energy and material: the agrifood sector accounts for 20% of the global greenhouse gas emissions. Fresh food products need to be preserved throughout storage and transportation and processed food needs to be conserved as long as possible. This requires intensive heating and cooling and the use of specific packaging. Growing world population will lead to a higher demand for non-renewable resources including minerals, energy sources, water, land and metals. In the future, if we use scarce metals in the same amounts as we do now, expectations are that e.g. silver is exhausted within 30 years, indium (used in laptops) within 11 years, copper in 60 years and so on (Table 1). The price for these resources is already increasing. This scarcity will have a huge impact on the supply chain: Available material will be more difficult to get, at higher costs, in more vulnerable areas. A solution for this issue is to look into renewable resources and the reuse of non-renewable resources. Clean air, clean water and clean soil already become scarce. The same holds for fossil fuels.

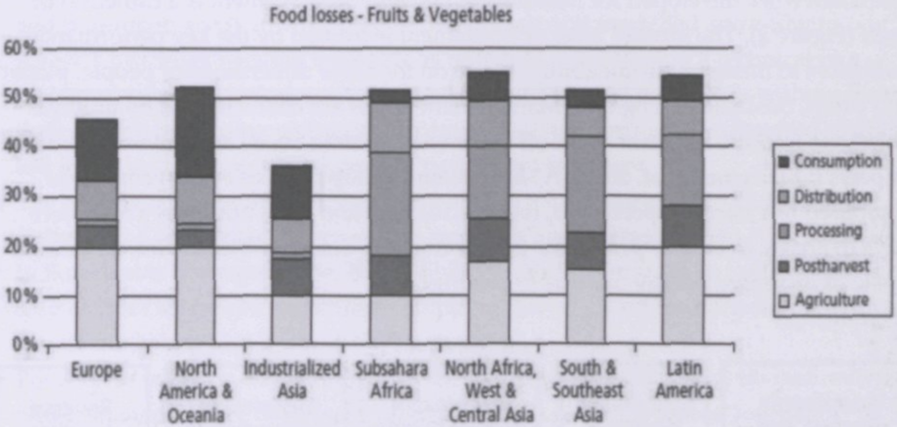

Figure 3. Food losses in the chains of fruits and vegetables (FAO, 2013)

Table 1. Scarcity of resources (PWC, 2013)

Resource	Remaining time (years)
Coal	200
Oil	60
Iron	132
Silver	17-30
Copper	28-60

Table 2. CO_2 emissions in freight (Defra, 2011)

Transport mode	G CO_2e/tonkm
Air (short-haul)	1760
Air (long-haul)	610
Van	541
Heavy Good Vehicles	129
Rail	32
Sea (general cargo)	11

Logistics and Supply Chain Management are activities with a major impact on the economy, society and natural environment. The World Economic Forum (2009) estimates logistics activity accounts for 6% of the total amount of CO_2 emissions produced by human activities. One of the options to reduce the amount of

greenhouse gasses is to shift to transport modes with less emission (Table 2). However, most low-emission transport modes like rail or sea take more time, or are less flexible, so adaptations in the supply chain are necessary.
Each cathedral can be divided in three levels: the fundament, the main body of the building, called the nave, or the ship and thirdly the towers.

The framework developed for Sustainable Logistics Management is a cathedral in itself (Figure 4). The ground level or fundament is formed by the key performance indicators to measure sustainability, based on the three dimensions of people, planet and profit. Sustainable Logistics Management issues are characterized by multiple objectives as there is a clear trade-off between economic, social and environmental impacts (Quariguasi et al. 2008). A slow steaming ship reduces carbon emissions compared to a normal speed ship, reduces fuel use and costs but takes a few more days to arrive. In case of perishable goods, this may result in less service, more food waste or increased energy use due to cooling.

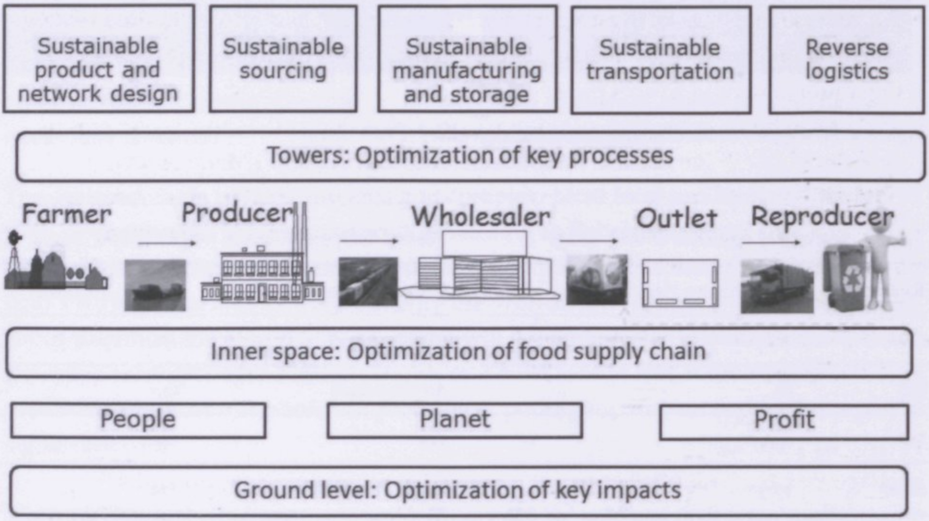

Figure 4. Framework for Sustainable Logistics Management

The next level, the nave or the ship of Sustainable Logistics Management deals with the integral optimization of the supply chain: Integral decision making on processes in forward and reverse supply chains is necessary; finding solutions is not one-dimensional. In logistics, the improvement options are not on a detailed process level (e.g. on the farm or at retail level), but focus on the coordination of processes and flows.

The towers are the specific logistic activities that can be optimized. Sustainable Logistics Management asks for new solutions in the area of product and network design (Eskandarpour et al. 2015), sourcing, manufacturing and storage, transportation (Soysal et al., 2015) and reverse logistics (Zeimpekis et al. 2015).

Some eye-catchers for the topics in Sustainable Logistics Management:

- For product design, you can think of the concept of Cradle to Cradle (McDonough and Braungart, 2002), in which the human industry is modelled according to nature's processes viewing materials as nutrients circulating in a technical or a biological cycle. Technical nutrients can be used over and over again without losing their quality by reusing and recycling; biological nutrients can be disposed of after use in the soil, without damaging the natural environment.
- The topic of sustainable sourcing might lead to a more regional or local sourcing policy and a preference for re-useable materials and energy sources.
- In Sustainable Transportation, the flexibility to shift from truck to rail and inland ship or from air freight to container shipping (the so-called multimodal or synchro-model transportation) is one of the eye-catchers.
- For reverse logistics, an eye-catcher is the Fleischmann et al. (1997) invited review paper on quantitative models for reverse logistics in the European Journal of Operational Research. This paper is a key paper in this area which has been cited almost 600 times in the Web of Science Core Collection and almost 2000 times in Google Scholar. The research in Closed-Loop Supply Chain Management originates mainly from the EU project REVLOG (coordinated by the Erasmus University Rotterdam team). This project has been the start of a network of researchers with more than 100 members, meeting every year.

I would like to move now from what has been done in the past to actual building activities at the moment.

Work in process

Santiago de Compostella (Figure 5a) is one of the most important Christian pilgrimage places. Pilgrims from all over Europe end their walking tour, the Camino de Santiago here to see the grave of the Apostle Jacob. The tradition of the pilgrimage started already in the time of Charlemagne (around the year 800) but is still very lively with about 10.000 people per year. From all European countries, so-called Jacobi routes go to Spain and France, forming a network. Starting from the Netherlands the route is about two to three thousand kilometers long. Most pilgrims take this route in three phases to finish the trip; often exhausted, with swollen ankles, blisters etc. but they reach their aim.

Figure 5a. Santiago de Compostella, Spain (photo: G. and H. Bloemhof)

Figure 5b. Cathedral of Pisa, Italy. (photo: J.M. Bloemhof)

Figure 5b shows another symbol of ongoing activity. The only reason cathedrals still exist is because they are in a permanent state of reconstruction. You may have had the experience during your holidays that it is not possible to make a nice picture of a cathedral without scaffolding.

The famous Leaning Tower of Pisa belonging to the Cathedral of Pisa started to slope down almost directly after the construction in 1173. In 1964 the Italian government asked for help to make sure the tower did not collapse. The tower even has been closed for safety reasons. Renovation made it possible to reduce the slope and after 10 years to open the tower for the public. An evaluation of experts showed that the tower will not collapse for the first three centuries: The tower is safe again.

One of the aims of my research is to develop a general methodology (a roadmap) for users in different circumstances and various stages of sustainability. We have developed conceptual models (Bloemhof et al., 2015) to understand the sustainability performance of logistics (especially food logistics), and mathematical models and tools to evaluate and improve the sustainability performance of supply chains.
I identify three phases to be taken in Sustainable Logistics management to address the key question on how to develop a zero-waste, zero-emission supply chain scenario without damaging necessary economic prosperity (Figure 6).

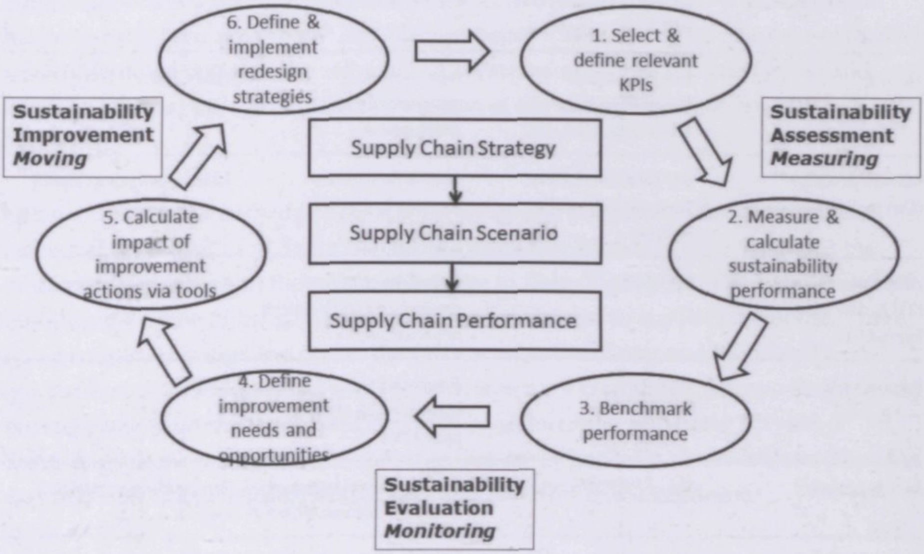

Figure 6. Stepwise approach for Sustainable Logistics Management

First, *sustainability assessment* needs to answer the question "how sustainable is my supply chain" using relevant key performance indicators. At the moment, no commonly accepted indicators or minimum standards exist to proof "sustainability" (FAO, 2012). Required measures will change in time due to the dynamic nature of supply chains and will change in priority as governmental regulations and the company strategy can change (Hassini et al. 2012).

Second, *sustainability evaluation* answers the question "where do I want to go" by comparing the performance of the food supply chain with a benchmark. Benchmarks

Table 3. ORL Research projects of recent years (2009-2015)

PhD & Project	Partners	Research Aim	Sector
Joao Quariguasi	*Erasmus University Rotterdam (RSM) TU Braunschweig*	*Development of eco-efficient supply chains*	*Electronic and Electronical Equipment*
Le Thi Kim Oanh	*WU-Environmental Technology*	*Selection of municipal solid waste technologies*	*Waste Management in large cities*
Xiaoyun Bing (TIFN-PPR)	*WUR-FBR, RWTH Aachen, TUE*	*Optimization models for waste collection*	*Post-consumer plastic packaging waste*
Mehmet Soysal (SALSA)	*WU-BEC, UNIBO, UGENT, UNAM, UFV, RTRS and companies*	*Improvement scenarios for LA-EU food chains*	*Beef and Soy*
SCALE	*EFFP, Cranfield University, Artois University, DHL-UK*	*Improvement of sustainability by collaboration*	*Food Chains*
Marlies de Keizer (DaVinc3i)	*TU Eindhoven, Flora Holland, VGB and partners*	*Innovative logistics concepts and models*	*Flowers and potted plants*
Aleksander Banasik (TIFN, Valorisation of byproducts)	*WU-FPE*	*Optimization of food chains by multiple criteria optimization*	*Bread and mushrooms*
Wenjuan Mu	*WU-APS*	*Benchmarking sustainability of dairy production*	*Milk*
Jochem Jonkman	*WU-FPE, ISPT partners*	*Design optimal pathways for processing materials*	*Processed Food (mango, sugar)*
Heleen Stellingwerf	*Free University, ArgusI, Superunie*	*Sustainable Logistics by collaboration concepts*	*Food Retail Chains*

result from legislation, certification schemes, pressure from society or societal responsibility of the firm itself. Multiple-objective optimization models can show decision makers which goals can be obtained (at which costs) and which are not yet reachable (see e.g. Oglethorpe, 2010).

Thirdly, *sustainability improvement* needs to answer the question "how to redesign the logistic chain to move from my current to my preferred performance". In this step, business performance and economic gains need to be balanced with environmental and social performance. Detailed logistic network models are necessary here to come to a redesign of supply chain strategies.

In order to keep the field of Sustainable Logistics in good shape, it is important that people continuously improve and deepen the knowledge in this field. This is why I am very grateful to my co-authors and PhD students (see Table 3 for an overview of recent projects in the Operations Research and Logistics Chairgroup).

An integrating science

In many cathedrals you will find different styles as they took over a few hundred years to be built, with different subsequent architects. Each architect could do only so much during his working life and the successor often had a different taste.

The Cathedral of Salamanca in Spain (Figure 7a) is an interesting building as authorities wanted the new cathedral to blend with the old one. The old cathedral has been built between the 12th and the 14th century in gothic style. The new cathedral was constructed between the 16th and 19th centuries in two styles: late Gothic and Baroque without the subsequent destruction of the old cathedral as normally happened.

Often, building of a cathedral was started without a full plan on how to complete the cathedral. The Basilica di Santa Maria del Fiore (also known as the Duomo) is the dominating cathedral in the center of Firenze in Italy (Figure 7b). The assignment for building the dome of the cathedral was to use no beams to support the dome. There was a contest to design the dome: the price was endless fame and a reward of 200 golden florins (comparable to two years income for a craftsman). Filippo Brunelleschi moved away from the traditional concepts of architecture and came up with a technology that enables an arch of a scale that never has been shown before. The idea was new and overwhelming and at first was received with skepticism.

Figure 7a. Cathedral of Salamanca, Spain (photo: G. and H. Bloemhof).

Figure 7b. Basilica di Santa Maria del Fiore, Italy (photo: J.M. Bloemhof).

The field of Sustainable Food Logistics Management is an integrating science; it builds upon traditional supply chain management theories, using insights from life cycle assessment, biorefinery, food technology, chemical engineering, industrial engineering etc. The foundation is in applying advanced analytical methods for decision making, tailor made for the characteristics of food.

Management Science is an interdisciplinary branch of applied mathematics dealing with optimal decision planning. It is also known as The Science of Better, because it uses various scientific research based principles, strategies, mathematical modeling and numerical algorithms to arrive at optimal or near optimal solutions to complex decision problems. It has two disciplines: Operations Management (with the focus on management) and Operations Research (with the focus on mathematical modelling and optimization), which both are essential for solving complex problems in the life sciences. Within the Life Sciences, many authors have contributed to the improvement of sustainability at a process level. However, the full potential of sustainability cannot be reached without integrating these processes in a supply chain, taking into account the logistic activities necessary to use and reuse products (Figure 8). The field of Sustainable Food Logistics Management can act as a bridging science area between the beta and gamma science fields (and within the gamma science field) within Wageningen University and gives lots of opportunities to collaborate with other logistic disciplines in the Netherlands and beyond.

Integrating sustainability in supply chain models increases the complexity of these models significantly asking for a multidisciplinary approach. The time of the low hanging fruit, easy and obvious solutions, has passed. So, multidisciplinary models need to be developed to map the complex relations between actors in modern supply chains, to assess the overall sustainability performance of a supply chain, and to

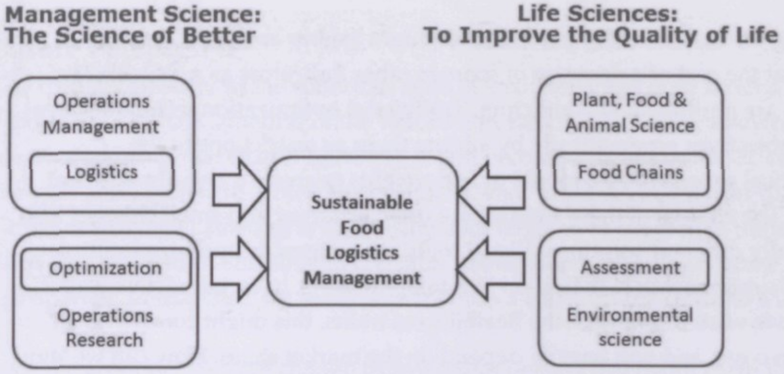

Figure 8. Integration in Sustainable Food Logistics Management

model the impact of improvement options on this performance. Like the commissioners in Firenze, I want to start a contest, with endless fame as a price on how to cope with this complexity and these are some of the puzzles we came across:

- As the sustainability of supply chains encounters many issues, it is difficult to compare various alternatives among each other. In the example in Figure 9, you see a comparison between relevant sustainability key performance indicators for the choice between truck, rail and inland ship (Bloemhof et al.,2011). Radar diagrams (or spider webs) might be a way to represent the variety within sustainability performance.

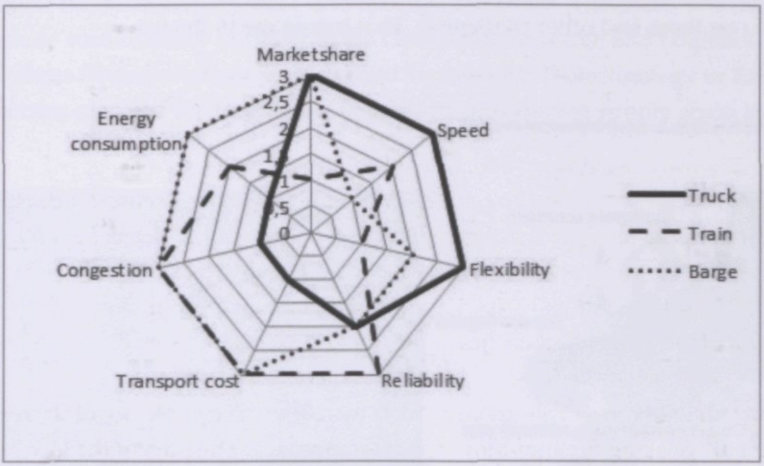

Figure 9. Radar diagram for multimodality choice

- Improving the sustainability performance might lead to an increase in one indicator at the cost of a decrease of score in other indicators as sustainability objectives are multiple and conflicting. Traditional optimization techniques treat multiple objectives pragmatically by adding them as restrictions to the mathematical programming model or use weights to create a one-dimensional objective. The choices of these weights are often arbitrary and small changes lead to drastically different solutions. Visual tools can be used to optimize multiple objectives simultaneously (based on Pareto optimality), in an interactive way. Suppose, we want to improve the flexibility of trains, this might come with an increase in costs, and will heavily depend on the market share. How can we show the consequences of improvement changes on the various key performance indicators and their mutual relationships in optimization models and sustainability dashboards?
- Trade-off relationships between multiple objectives are observed by Pareto frontiers presenting the cost of being sustainable (Figure 10). If we know the current sustainability performance and we can represent this with one of the stars in the picture, it is easy to see that more efficient solutions can be found by moving either downwards or leftwards towards the so-called Pareto-curve. But what if we have more than two dimensions: how can we calculate (or at least estimate) the Pareto-curve, and how can we find improvement options that really result in a move towards this Pareto curve (Mavrotas, 2009). A quantitative foundation of analytical multi-objective optimization models will contribute to this theory building. The national network of Mathematical Decision making (the LNMB) could be a nice platform for coping with these issues. I hope to work together with many of you on these and other challenges. That brings me to the future perspective.

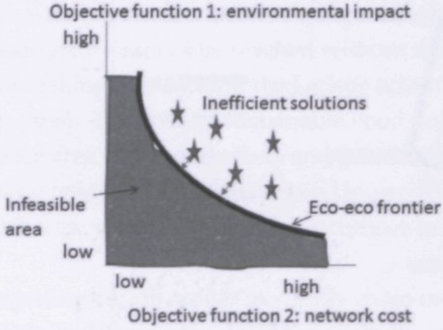

Figure 10. Pareto efficiency curve

Future Perspective

The Christ Cathedral in the American state of California was built around 1977 and 1980 as the Crystal Cathedral of the Reformed Church in America, known from its massive television services (Figure 11). It will become a Roman-catholic cathedral in the year 2016, therefore, a nice illustration of what to expect in the near future. The Christ or Chrystal cathedral is built using a lot of glass, to symbolize transparency. I hope that the field of Sustainable Logistics Management will also become that transparent. In that case, we really moved from a castle on the cloud to a cathedral!

I see the economy concept change from a linear perspective (from Farm to Fork) towards a circular economy based on biomass materials. To meet the future challenges on sustainability and efficiency, biomass materials must be converted into valuable products. Sustainable production, transportation and processing of food and bio-based products gets increased attention in the global research agenda (European Commission, 2014). Future food supply chains are challenged to increase productivity, but also to supply energy and other biobased products without compromising on resources availability and resource efficiency. This requires a biobased circular economy, i.e. encompassing the sustainable production of biomass and its conversion into food, feed, biobased materials and bio-energy (Figure 12).

To ensure sustainable logistics in practice, students are the main stakeholders. So, the near future is built by our students. Logistic managers in food related companies will deal more and more with sustainability issues like multiple transport modalities, carbon tax, resource efficiency and spoilage reduction. Therefore, it is important to include sustainability thinking in the Operations Research and Logistics courses. Students from disciplines such as Food Technology, Biotechnology or Environmental Sciences can gain very important insights by introducing supply chain models and

Figure 11. Christ Cathedral, USA (photo: P. Knippels/C. Bosveld).

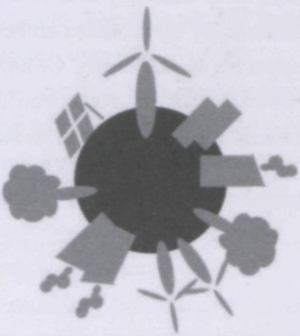

Figure 12. Biobased Circular Economy (Logo EWG Sustainable Supply Chains)

learn about quantitative optimization models related to their background. The course Sustainability in Food Chains has been developed just a couple of years ago, with the focus on integrating food processing solutions with supply chain solutions. The Center for Biobased Economy has started with a bachelor minor on "Biobased Transition" with a base course on Biobased Economy and a course on the logistics in biobased supply chains. I believe in the added value of these interdisciplinary courses and I am very happy that Wageningen University supports the development of this kind of courses.

Innovative breakthroughs can be expected while working with a group of excellent researchers and strong relations with industry. Some of my castles on the cloud of which I hope they will become cathedrals in the near future:

- New acquisition that I hope will lead to the next integrative step of research:
  1. Developing a framework to design optimal crop rotation and supply chain management in the biobased economy to come to a low carbon economy , together with the Agricultural Economics and Rural Policy group and the Plant Production Systems group of Wageningen University; an excellent opportunity to target fundamental scientific questions in the field of Crop Science, Economics of Biotechnologies and Logistics Management;
  2. A beta-gamma integrated approach to understand sustainable management of low-valued organic residues from the urban environment and agricultural processing industries together with the group Biobased Chemistry and Technology.
- The European Working Group on Sustainable Supply Chains within the Association of European Operational Research Societies, founded by Erwin van der Laan, Grit Walther and myself in 2014 will provide ample possibilities for networking, joint acquisition and joined research.
- Together with industry and consultancy companies, it would be interesting to see if sustainability standards can become an integral part of decision support. I see also opportunities for the "Cloud", referring to the possibilities in big data and the internet of the future. Apps could be developed that translate the insights of science into hands-on decision support for customers.

Words of Gratitude (Dankwoord)

The last cathedral of this inaugural lecture can be found in Brasilia in Brasil (Figure 13). Its shape can be interpreted as hands that stretch out upwards. In front of the building, you find the statues of four evangelists. In the church, four angels guard from above. I would like to finish this inaugural lecture by thanking my helping hands, the evangelists of sustainable logistics management and my guardian angels. For this, I would like to switch to Dutch.

Figure 13. Cathedral of Brasilia, Brasil. (photo Shutterstock)

Allereerst dank ik het College van Bestuur en de directie van de Social Science Group van de Wageningen Universiteit voor het in mij gestelde vertrouwen. Ruim vijf jaar geleden kwam ik naar Wageningen om als eerste in de Leeuwenborch te starten als "tenure-tracker" in het traject naar persoonlijk hoogleraar. Ik heb veel hulp en interesse ondervonden van de directie, van het bestuur van de onderzoeksschool WASS en HR in het traject naar mijn benoeming.

De academische wereld heeft ook haar generaties. Ik kijk met warme herinnering terug naar mijn jaren als Econometrie-student en student-assistent bij de Operations Research groep aan de Erasmus Universiteit Rotterdam, waarbij de eerste samenwerking met de 'godfather' op dit gebied, Luk van Wassenhove is ontstaan. Nadat ik mijn scriptie heb kunnen schrijven op INSEAD, de business-school in Fontainebleau, Frankrijk, bracht hij mij in contact met Paul van Beek en Leen Hordijk, hier allebei aanwezig. Dit driemanschap heeft de wondere wereld die wetenschap heet voor mij geopend. De begeleiding tijdens mijn promotie-periode hier in Wageningen, van mestproblemen tot papierrecycling, is mij dierbaar.
Na mijn promotie begon de periode als 'werkende-moeder'. Een kleine aanstelling aan de Rotterdam School of Management met daarnaast de zorg voor 3 opgroeiende kinderen, die intussen allemaal boven mij uitsteken. Naast de onmisbare steun van

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