



Sustainable Food Security: Systemic Innovation in Agriculture

Prevention of food waste in retail industry

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AGENDA

- Short Bio
- Sustainable Development Goal 2: End Hunger
- Food Security
- Measuring Food Security
- Sustainable and Resilient Food Security
- Systemic Innovation
- Examples of Systemic Innovation
- Migros Projects

SHORT BIO

- I have been working as an R&D Program Manager in Migros Tic. A.Ş. for 10 years.
- I received my B.Sc. degree in Chemical Engineering and M.Sc. degree in Information Systems from METU (Ankara, Turkey) in 1998 and 2001 respectively.
- Prior to joining Migros in 2014, I worked in Oyak Gn.Md. as a system analyst for 4 years and in Ctech Ltd. as a R&D Quality and Test Director for 7 years.
- My main research areas include dynamic programming and simulation, mathematical modeling and optimization, supply chain management and sustainable agriculture.

About Migros

MİGROS



+3272 Stores

in all 81 cities

60,000 employees

TL 75 billion sales

2000+ suppliers



The only food retailer listed in BIST Sustainability Index for

9 years in a row



Included BIST Corporate Governance Index since 2015

MİGET

Turkey's **biggest** integrated meat-processing plant
62,000 tons production capacity

10M loyal households
Money Card
18M active cards



Best retailer of the country 19 years in a row



MİGROS **yemek**

MİGROS **sanalmarket**

macro **online**

MİGROS **hemen**
Hemen kapıda.

taze Direkt
.com



Introduced **more than 100 innovations** in the retail market

Migros R&D at a Glance

(31 October 2023)

Field of Activity:

Process, Software and Solution
Development in the Retail Industry

Founded:

13.09.2013



R&D Projects

Completed **171 projects**

Ongoing **39 projects**

R&D Location: **1.906 m²**
(Migros GM-Ataşehir)



289 R&D Staff

- 240 Researchers
- 6 Technicians
- 43 Support Staff

- 4 PhD Graduate
- 4 PhD Student
- 66 Masters Graduate
- 30 Masters Student
- 138 Bachelor's Graduate
- 37 Bachelor's Student. (SMARTER)
- 10 Associate Degree – High School

M
**Migros R&D
Center**

**10th Year of
Activity**

Nationally Funded Projects

- TÜBİTAK Applications **16** (1501, 1505, 1509, 1707, 1601)
- Completed **10** (1501, 1505, 2209-BİDEB)
- Ongoing **1** (1601)



International Project Experience

- EU Applications **33** / Accepted **9** - Above Threshold **10**
- Completed **2** (Horizon 2020)
- Ongoing **7** (Horizon 2020, PRIMA, Horizon Europe)



Intellectual Property Rights:

- Patent/Utility Model/Trademark in the application process: **43** (2 PCT, 1 FM)
- Patent Registrations: **15** (1 PCT, 1 FM)
- Trademark Registrations: **6**



Publications and Declarations:

- Publications: **22**
- Declarations: **70**

Collaborations: 100+

- **UNIVERSITIES:** Akademic Consultancy, Project Collaboration, Thesis/Article, Event Collaboration, Postgraduate/Certificate Education, Training, Part-Time Student Training
- **R&D FIRMS, OTHER ORGANIZATONS, INITIATIVES:** Project Cooperation, Technical Consultancy, Sponsorship, Training, Membership, Mentoring etc.



Sustainable Development Goals

- The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.
- The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all.
- They address the global challenges we face, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.
- The 17 SDGs are integrated—they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability.
- The 17 Goals are all interconnected, and in order to **leave no one** behind, it is important that we **achieve them all by 2030**.
- Countries have committed to prioritize progress for those who're furthest behind.
- The SDGs are designed to end poverty, hunger, AIDS, and discrimination against women and girls.
- The creativity, knowhow, technology and financial resources from all of society is necessary to achieve the SDGs in every context.






Sustainable Development Goals

In 2015 United Nations (UN) published the Sustainable Development Goals (SDG2030), a collection of interlinked global goals aiming “eradicating poverty in all its forms and dimensions, including extreme poverty” and “achieving sustainable development in its three dimensions - economic, social and environmental -”.



SDG2: Zero Hunger

“SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture, aka, zero hunger” comprises the following targets to be achieved by 2030: (1) Universal access to safe and nutritious food, (2) End all forms of malnutrition, (3) Double the productivity and incomes of small-scale food producers, (4) Sustainable food production and resilient agricultural practices (4) Maintain the genetic diversity of food production.

TARGET	2-1	TARGET	2-2	TARGET	2-3	TARGET	2-4	TARGET	2-5
									
UNIVERSAL ACCESS TO SAFE AND NUTRITIOUS FOOD		END ALL FORMS OF MALNUTRITION		DOUBLE THE PRODUCTIVITY AND INCOMES OF SMALL-SCALE FOOD PRODUCERS		SUSTAINABLE FOOD PRODUCTION AND RESILIENT AGRICULTURAL PRACTICES		MAINTAIN THE GENETIC DIVERSITY IN FOOD PRODUCTION	

What is food security?

The definition was formerly made in World Food Summit in 1996:

“food security is achieved when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life”.

This definition implies four important targets:

- Enough food shall be available either by imports or by production;
- Food shall be accessible by everyone;
- Food shall be both nutritious and safe.
- Lastly, “at all times” entails both sustainability and resilience of food systems.

Public sources for measuring regional/national food security

- *Global Food Security Index*
- *Global Food Hunger Index*
- Common Agricultural Policy Indicators
- SDG Tracker

Global Hunger Index

The Global Hunger Index (GHI) is a tool that measures and tracks hunger globally as well as by region and by country. GHI uses datasets of Food and Agricultural Organization (FAO), UNICEF, World Bank and WHO and published by Welthungerhilfe annually.

1. **UNDERNOURISHMENT:** the share of the population that is undernourished (that is, whose caloric intake is insufficient);
2. **CHILD WASTING:** the share of children under the age of five who are wasted (that is, who have low weight for their height, reflecting acute undernutrition);
3. **CHILD STUNTING:** the share of children under the age of five who are stunted (that is, who have low height for their age, reflecting chronic undernutrition);
4. **CHILD MORTALITY:** the mortality rate of children under the age of five (in part, a reflection of the fatal mix of inadequate nutrition and unhealthy environments)

First published in 2012 by the intelligence unit of the Economist, Global Food Security Index (GFSI) consists of a set of indices from 113 countries. GFSI created a common framework to benchmark the food security at country level. It measures the four indicators as:

- (1) FOOD AFFORDABILITY:
- (2) FOOD AVAILABILITY
- (3) FOOD QUALITY AND SAFETY
- (4) NATURAL RESOURCES AND RESILIENCE

GFSI mainly use the Datasets of WTO, UNEP, FAO, World Bank, World Economic Forum and OECD.

Food Affordability

#	Indicator & Sub indicator	Weight
1	AFFORDABILITY	32.4%
1.1	Change in average food costs	18.5%
1.2	Proportion of population under global poverty line	20.4%
1.3	Inequality-adjusted income index	9.3%
1.4	Agricultural import tariffs	20.4%
1.5	Food safety net programmes	25.0%
1.5.1	Presence of food safety net programmes	25.0%
1.5.2	Funding for food safety net programmes	25.0%
1.5.3	Coverage of food safety net programmes	25.0%
1.5.4	Operation of food safety net program	11.1%
1.6	Market access and agricultural financial services	35.3%
1.6.1	Access to finance and financial products for farmers	35.3%
1.6.2	Access to diversified financial products	29.4%

Food Availability

#	Indicator & Sub indicator	Weight
2	AVAILABILITY	32.4%
2.1	Sufficiency of supply	26.3%
2.1.1	Food supply adequacy	73.3%
2.1.2	Dependency on chronic food aid	26.7%
2.2	Agricultural research and development	9.1%
2.2.1	Public expenditure on agricultural research and development	50.0%
2.2.2	Access to agricultural technology, education and resources	50.0%
2.3	Agricultural infrastructure	14.1%
2.3.1	Crop storage facilities	17.6%
2.3.2	Road infrastructure	29.4%
2.3.3	Air, port and rail infrastructure	29.4%
2.3.4	Irrigation infrastructure	23.5%
2.4	Volatility of agricultural production	15.2%
2.5	Political and social barriers to access	12.1%
.....
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Food Safety and Quality

#	Indicator & Sub indicator	Weight
3	QUALITY AND SAFETY	17.6%
3.1	Dietary diversity	20.3%
3.2	Nutritional standards	13.6%
3.2.1	National dietary guidelines	26.5%
3.2.2	National nutrition plan or strategy	23.5%
3.2.3	Nutrition labeling	23.5%
3.2.4	Nutrition monitoring and surveillance	26.5%
3.3	Micronutrient availability	25.4%
3.3.1	Dietary availability of vitamin A	33.3%
3.3.2	Dietary availability of iron	33.3%
3.3.3	Dietary availability of zinc	33.3%
3.4	Protein quality	23.7%
3.5	Food safety	16.9%
3.5.1	Food safety mechanisms	32.1%
3.5.2	Access to drinking water	42.9%
3.5.3	Ability to store food safely	25.0%

Natural Resources and Resilience

#	Indicator & Sub indicator	Weight
4	NATURAL RESOURCES & RESILIENCE	17.6%
4.1	Exposure	21.1%
4.1.1	Temperature rise	25.0%
4.1.2	Drought	22.9%
4.1.3	Flooding	20.8%
4.1.4	Storm severity (annual average loss)	8.3%
4.1.5	Sea level rise	22.9%
4.2	Water	14.0%
4.2.1	Agricultural water risk – quantity	80.0%
4.2.2	Agricultural water risk – quality	20.0%
4.3	Land	14.0%
4.3.1	Land degradation	60.0%
....	
4.5	Sensitivity	10.5%
4.5.1	Food import dependency	60.0%
...	
4.7	Demographic stress	7.0%

How Does GHI Relates To GFSI

GFSI and GHI are different models of food security:

- Global Food Security Index concerns the systemic **capability** of countries securing food to their citizens.
- The Global Hunger Index (GHI) is a tool that measures and tracks hunger globally as well as by region and by country.
- While GFSI measures the capability of every country with respect to food security the GHI directly measures the severity of hunger in countries, i.e. **actual status**.

How Does GHI Relates To GFSI

The result of linear regression made with the main indicators (affordability, availability, food safety and quality, natural resources and resilience) and the GHI are as follows:

Result of linear regression:

$GHI = 44 - 0.24 \text{ Affordability} - 0.04 \text{ Availability} - 0.20 \text{ Food Safety and Quality}$

$R^2=0.76$

When used this model GHI predictions of Turkey in 2021 and 2022 are 10.15 and 12,212 respectively. The actual GHI scores of Turkey are <5.

Food safety net programs of affordability dimension is of the greatest importance in securing the food.

The important question is: Are safety net programs provides a sustainable solution for achieving food security.

How Does GHI Relates To GFSI

GHI = 44 - 0.24 Affordability - 0.04 Availability - 0.20 Food Safety and Quality

According to our initial results of an ungoing publication:

- Despite of the fact that, availability seems as an insignificant parameter of food security, the results show that the countries invest on food availability improve their GHI scores particularly:
 - Irrigation Infrastructure
 - Food waste and loss program
 - Dietary diversity and nutritional quality

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What can retailers do?

What shall retailers do to cope with the food security problem:

- The traditional approach of the food retailing industry is «discounts» including promotions such as «Buy 2 pay 1» which results in higher food waste rates at household consumption.
- We need systemic approaches, a.k.a. Pareto improving or Pareto optimal policies for improving the «total payoff of the all agents»
 - Contracted agriculture encapsulating smart FAIR (findable, accessible, interoperable, and reusable) agriculture practices
 - Promote local production
 - Promote high-impact innovative agricultural practices
 - Improve traditional food waste measures

VERTICAL AGRICULTURE



BIOFRESHCLOUD - PRIMA PROJECT

1. We aim to improve the waste rate of strawberry, tomato and grapes with a digitalized solution.
2. Reatilers are also responsible of the household waste and nutritional quality at home.
3. Our aim is:
 - ▶ to provide products with a sufficient shelf life so that they consume the products at home with good quality,
 - ▶ Reduce our food waste rate,
 - ▶ Do not compromise the revenue.

DYNAMIC PRICING

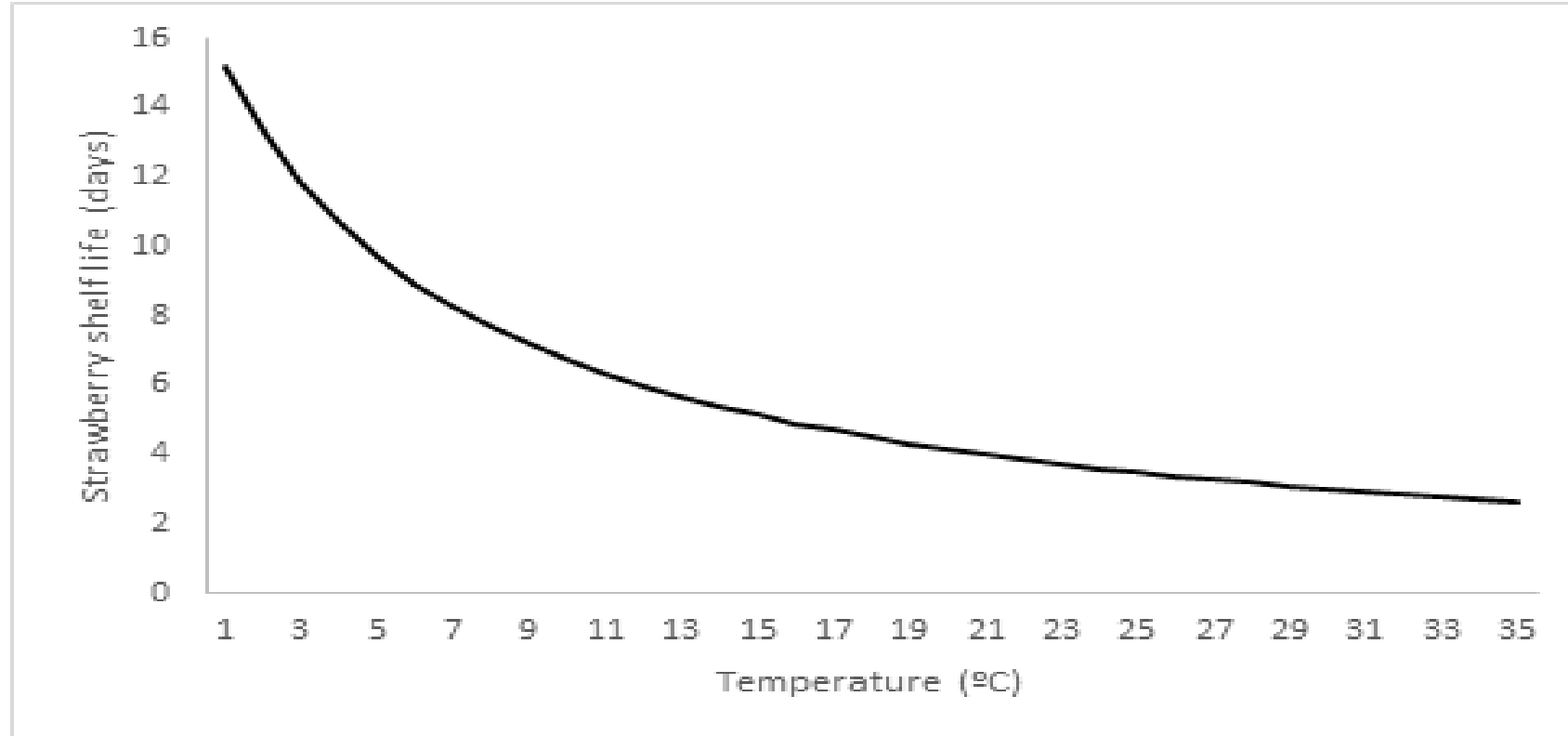
- ▶ The optimal price of a product depends on not only qualitative characteristics of the product but also state of the inventory.
- ▶ Classical pricing:
 - ▶ Malaga - New York : 1000 Euro
 - ▶ Malaga - Madrid : 100 Euro
- ▶ Dynamic Pricing
 - ▶ Malaga - New York : Anything between 50 Euro and 5000 Euro
 - ▶ Malaga - Madrid: Anything between 50 Euro and 5000 Euro
- ▶ Price of a domestic flight can be as high as an international flight due to the fact that the demand is stochastic.

BELLMAN EQUATION

$$v_t(x) = \max_{a \in A_{X_t}} \{R_{t,a}(x) + \sum p_{t,a}(x, y)v_{t+1}(y)\},$$

where $v_T(x) = R_T(x)$ and $v_t(x)$ is the expected optimal value for a tail subproblem from t to T

QUANTITATIVE MICROBIOLOGY



PROBLEM DEFINITION

- ▶ The problem contains the food chain stages of fruits passing from the following stages: (1) Harvesting (2) wholesaling (3) Distribution centers and (4) Store selling.
- ▶ Considering that the products are highly affected by the external environment, especially in summer, critical measurement points are: (1) DM quality input control (2) Interim inspection for products stored in DM for more than 7 days and (3) The control to be carried out while being shipped to the store.
- ▶ The problem is to reduce the food waste of the tomato which is nearly 10% at the beginning. The waste of the products occurs upon the end of the shelf life of the product, largely due to the supply-demand difference in the store. In the project a decision chart will be proposed based on the monitoring and the control system developed during the project.

MODEL

Stage t	Vector X		Controller admissible action
Product commissioned	Ambient conditions ω	Product State X	
Product arrived at Main DC	Transportation conditions and duration, mass loss (%), foodscan measure	Freshness (F), Predicted Shelf life (E)	
Product repackaged at Main DC	Storage conditions and duration	Freshness (F), Predicted Shelf life (E)	$\Pi=\{\text{FIFO, FEFO, LIFO, LEFO}\}$
Product loaded to the truck and left the Main DC	Ambient conditions	Freshness (F), Predicted Shelf life (E)	
Product arrived at DC1	Transportation conditions and duration, mass loss (%), foodscan measure	Freshness (F), Predicted Shelf life (E)	
Product repackaged at DC1	Storage conditions and duration	Freshness (F), Predicted Shelf life (E)	$\Pi=\{\text{FIFO, FEFO, LIFO, LEFO}\}$
Product loaded to the truck and left DC1	Ambient conditions	Freshness (F), Predicted Shelf life (E)	
Product arrived at DC2	Transportation conditions and duration, mass loss (%), foodscan measure	Freshness (F), Predicted Shelf life (E)	
Product repackaged at DC2	Storage conditions and duration	Freshness (F), Predicted Shelf life (E)	$\Pi=\{\text{FIFO, FEFO, LIFO, LEFO}\}$
Product loaded to the truck and left DC2	Ambient conditions	Freshness (F), Predicted Shelf life (E)	
Product received at the retail store	Transportation conditions and duration, mass loss (%)	Freshness (F), Predicted Shelf life (E)	
Product sold or perished	Store conditions	Freshness (F), Predicted Shelf life (E)	$\Pi=\text{Discount rate}$

SOLUTION

PARAMETERS						DSS RECOMMENDATION	
Remaining time to closure	Remaining time to store delivery	Product lot (kg)	Product lot (rem. Shelf life)	Product lot (kg)	Product lot (rem. Shelf life)	Lot 1 discount	Lot 2 discount
5 hours	10 hours	20	5	40	7	0%	0%
5 hours	10 hours	40	5	40	7	0%	0%
5 hours	10 hours	60	5	40	7	25%	0%
5 hours	10 hours	80	5	40	7	25%	0%
5 hours	10 hours	100	5	40	7	50%	0%





THANK YOU