

# Critical Resilience and Sustainability Function Deployment

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*Abstract:* - The paper introduces a novel tool, Critical Resilient and Sustainability Function Deployment (CRSFD), aimed at integrating management systems and enhancing business performance. CRSFD represents an advancement from the Quality Function Deployment (QFD) method. Its primary objective is to provide a comprehensive perspective on business key factors, emphasizing resilience and sustainability considerations. This approach enables the identification of organizational weaknesses and offers recommendations for improvement. Moreover, potential responses are meticulously assessed in terms of their costs and benefits, aiming to optimize the company's ability to maintain resilience and sustainability.

*Key-Words:* - Integrated Management System, Key Performance Indicators, Quality Function Deployment, House of Quality, Resilient and Sustainable Development Goals, Total Quality Management, Continuous Improvement.

Received: May 22, 2023. Revised: March 5, 2024. Accepted: March 23, 2024. Published: April 19, 2024.

## 1 Introduction

The starting point of the study is a comprehensive literature review examining the progression of Integrated Management Systems (IMSS), according to various perspectives and standards such as sustainability, quality, and social-ethical considerations. There is a lack of consensus and a clear correlation between IMSS and company performances, particularly concerning their resilience, despite the potential benefits.

The primary aim is to reengineer the Quality Function Deployment (QFD), one of the Total Quality Management tools. The goal is a global evaluation of the company's "attitude" at swiftly comprehending and responding to challenging situations.

Thanks to the expertise, experience, and competence of managers, the initial step is the selection of appropriate Key Performance Indicators (KPIs), tailored to the specific market. Those indicators describe the current situation and offer recommendations for improvement.

The innovative proposed approach is named Critical Resilient and Sustainability Function Deployment (CRSFD), based on the Improving Cycle DMAIC -Define, Measure, Analyze, Improve, and Control.

The final goal is to suggest possible reactions able to maximize the company's capacity to be resilient and sustainable.

Unlike other existing methods, the proposed one links Sustainable and Resilient goals in a single global vision, allowing each company/organization to focus on those goals considered the most important, evaluating the impact of their choices on all the aspects of interest.

The proposed methodology shows general characteristics that allow its application to different sectors. In particular, the authors are applying it to the evaluation of potential environmental impact due to the introduction of electric vehicles in private and public fleets.

The present work is based on the conference article by the same authors, presented at the 2nd International Conference on Sustainable Mobility Applications, Renewables and Technology, SMART2022, [1]. In the above article, the general proposed methodology was presented, without the suggestion of real possible solutions. Starting from the results of the above article, the present study investigates real solutions able to reach resilient and sustainable goals.

## 2 Integrated Management Systems

Integrated Management Systems often focus on aspects such as quality, occupational health, and safety, environmental issues, etc., [2]. However, there isn't a universal understanding of integration, and different integration approaches and

management systems are feasible, [3], [4], [5]. Additionally, Risk Analysis often plays a role in implementing Integrated Management Systems, [6], [7]. Evaluating costs and benefits and overcoming resistance to change, [8], [9], are crucial aspects of this integration process, which may involve the entire organization or specific segments, with different levels of integration, [10]. Numerous case studies across various industries, [11] and countries [12], demonstrate different approaches [13] and company sizes, [14], [15].

There is a growing interest in sustainable aspects, leading to the integration of social-ethical considerations with management-organizational principles, [16], [17], [18], [19]. Despite the evident benefits of integration, its impact on business performance remains unclear, [20], [21], [22]. The principal conclusion is that beyond economic-financial factors, a company's sustainability and resilience are equally vital.

### 3 Value Analysis Techniques

Many quality tools allow one to undertake a structured and measurable path in terms of quality effectiveness and efficiency. Value Analysis techniques are the main tools for relating functions to the product structure and its cost. Within them, Quality Function Deployment is a Total Quality Management (TQM) tool, [23], through which the Customer's needs are translated into a product structure and through which the development of the architecture begins.

QFD is a method widely adopted across diverse sectors, it offers a systematic approach to delineate customer requirements and translate them into actionable plans. Those customer needs, defined as the Voice of the Customer (VoC), are synthesized into a matrix known as the "House of Quality", facilitating the translation of customer needs and expectations into technical specifications, of qualitative customer considerations into quantitative process parameters through a graphical methodology, [24].

### 4 New Decisional Drivers

While the QFD approach has been applied since the 1980s, today, new drivers are influencing the evaluation of processes, with a focus on two critical criteria: Resilience and Sustainability.

Resilience is a concept from structural mechanics denoting a material's ability to withstand damage and recover; it has evolved over the past 50

years to other fields such as psychology, ecology, sociology, and urban planning. ISO has recently introduced the concept of "Organizational Resilience", highlighting an organization's ability to adapt to a changing environment and deliver its objectives, [25]. Resilience may be considered as a forward step concerning previous risk-based Management approaches (where potential threats were reviewed and mitigated) insofar as novel attention is paid to the recovery process.

Incorporating resilience into management involves considering factors such as robustness, redundancy, and recovery speed. Robustness measures the system's ability to withstand external damage; while redundancy reflects the availability of alternative resources; recovery speed determines the system's ability to restore functionality post-disruption.

Metrics play a crucial role in implementing resilience-based strategies in management, [26], [27], particularly in logistics for inbound and outbound aspects.

The United Nations proposed a strategic plan to achieve the 17 Sustainable Development Goals (SDGs) of the 2030 agenda, [28]. Resilience in enterprises concerns in particular SDG9 (Industry, Innovation, and Infrastructure) and SDG11 (Sustainable Cities and Communities). However, resilience and sustainability impact various SDGs such as SDG8 (Decent Work and Economic Growth), SDG3 (Good Health and Well-being), SDG15 (Life on Land), and climate change mitigation efforts (SDG13).

The recent pandemic and the following Russian-Ukrainian war have underlined the strategic role of logistics in global economics and the urgent need for more sustainable and resilience-based strategies to manage fossil fuel costs and environmental impact.

### 5 The Integrated Tool

The QFD methodology adopts a matrix structure resembling a house, called "House of Quality" (HoQ), as illustrated in Figure 1, [29]. The primary objective of the HoQ is to convert both objective and subjective quality criteria into quantifiable and measurable metrics. It begins by prioritizing both expressed and implicit customer desires or needs. The HoQ is divided into 9 distinct sections, known as Rooms.

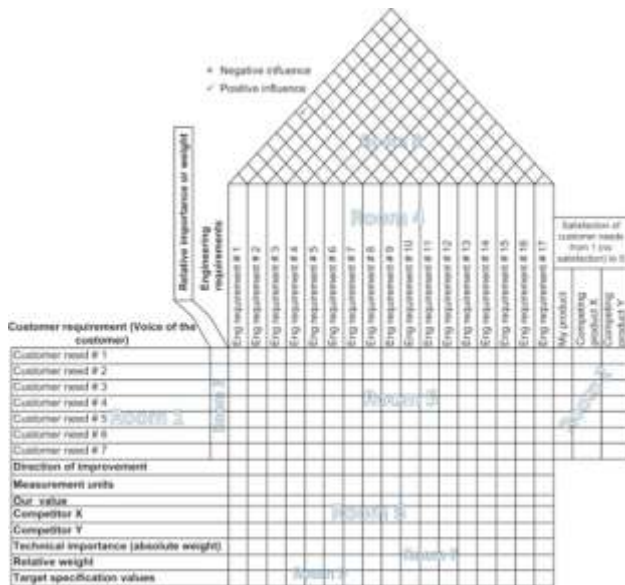


Fig. 1: The House of Quality matrix

A novel Integrated Management System tool has been derived from the House of Quality: the House of Resilience and Sustainability (HoRS), in Figure 2 and Table 3 (Appendix). The primary objective of HoRS is to highlight the crucial factors contributing to an organization's success in a resilient and sustainable manner. Therefore, it is necessary to identify all fundamental aspects (needs) considered essential for achieving resilience and sustainability.

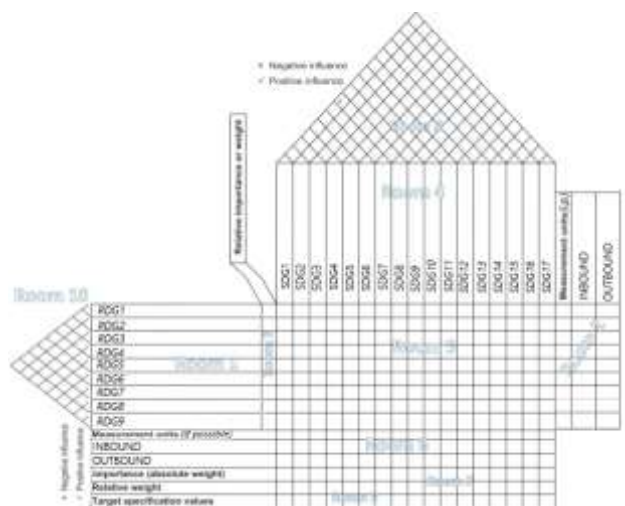


Fig. 2: The House of Resilience and Sustainability matrix

Starting from Sustainable Development Goals (SDGs) outlined by the United Nations in the strategic plan of the 2030 agenda, a total of 17 sustainability needs plus 9 resilience needs were identified, as detailed in Table 2 (Appendix). Additionally, several sub-needs were identified for resilience criteria, resulting in a total of 40 potential

development goals (17 SDGs plus 23 RDGs). The outcome of this approach and tool is the formulation of recommendations aimed at enhancing the organization's resilience and sustainability, stressing weaknesses and adhering to SMART criteria: Specific, Measurable, Assignable, Realistic, and Time-related, [30].

HoRS presents 10 rooms instead of the 9 ones of HoQ:

**Room 1** is dedicated to housing the Resilience Development Goals (RDGs).

**Room 2** defines measurable units for RDGs. Additionally, this space is used for analyzing the impact area: Inbound or Outbound.

**Room 3** serves to assess the relative importance of RDGs for the company, using a scale from 1 (low importance) to 5 (high importance).

**Room 4** is dedicated to housing the Sustainability Development Goals (SDGs).

**Room 5** illustrates the relations between RDGs and SDGs, using a scale from 1 (very weak) to 9 (very strong).

**Room 6** defines measurable units for SDGs. Additionally, this space is used for analyzing the impact area: Inbound or Outbound.

**Room 7** focuses on quantifying and ranking the Sustainable Development Goals (SDGs) according to their importance, using the following equation:

$$W_{j=1,\dots,m} = \sum_{i=1,\dots,n} R_i \times S_{ij} \quad (1)$$

where  $W_j$  represents the absolute weighting for the  $j$ -th SDG,  $n$  is the number of Resilience Development Goal (RDG),  $R_i$  is the priority assigned to the  $i$ -th RDG,  $m$  is the number of Sustainable Development Goals (SDG), and  $S_{ij}$  denotes the weighting assigned to the relationship between the  $j$ -th SDG and the  $i$ -th RDG.

**Room 8** illustrates the interrelationships among SDGs, whether positive or negative.

**Room 9** shows the targets set by the development team, considering factors such as weighting, cost etc.

**Room 10** illustrates the interrelationships among RDGs, whether positive or negative.

## 6 Critical House of Resilience and Sustainability - Chors

According to Deming's cycle for continuous improvement, PDCA (Plan-Do-Check-Act), a deeper analysis of each of the 17 Sustainability needs (SDGs) and the 9 Resilience needs (RDGs)

listed in Table 2 (Appendix), is realized to identify possible solutions/actions.

An example of the NEED SDG1 No Poverty is given in Table 1.

Table 1. Sample of Resilience and Sustainability Matrix

ID Action	SOLUTIONS/ACTIONS
1	Enquire on the family financial condition of logistic personnel to identify critical cases and design supporting actions
2	Check compliance between Local Socio-Economic Descriptors and personnel wages
3	Promote higher interaction with trade unions and labor representatives
4	Foster external suppliers and vendors adopting SDG 1 complying policies

One hundred possible solutions/actions for the forty sub-needs are shown in Table 4 (Appendix).

Subsequently, a CRITICAL analysis of the possible actions is realized thanks to the introduction of a cost/benefit index. Starting from the evaluation of the specific solution cost, the following index, called Sustainable Resilient-Cost Performance Index (SR-CPI), allows to maximize benefits for the company in terms of Sustainability and Resilience:

$$SR-CPI = C_{tot} / W_{tot} \quad (2)$$

where  $C_{tot}$  is equal to the total cost evaluated for all the considered solutions/actions chosen by the company and  $W_{tot}$  is the total weight, the sum of all  $W_j$  related to the above-considered actions, evaluated according to (1).

By fixing a budget for  $C_{tot}$ , different combinations of solutions/actions might be considered by the company, with different values of SR-CPI. Consequently, the combinations with the lower values of SR-CPI should be chosen, which means lower costs with bigger benefits in terms of Sustainability and Resilience. Therefore, the previous index becomes the decisional support to drive the choice of the best solutions/actions for a SMART company, meaning “intelligent” and able to understand and react quickly, especially in difficult situations.

## 7 Conclusions and Developments

This paper has a dual objective:

- To introduce a novel approach, named CRSFD, combining Resilience and Sustainability into Quality Function Deployment;

- To aid companies in understanding and responding swiftly, particularly in challenging circumstances.

In pursuit of those objectives, a new tool has been proposed, as the evolution of the Total Quality Management tool - Quality Function Deployment. Additionally, a new index has been formulated to optimize benefits and minimize costs in the pursuit of Sustainable and Resilient goals.

The next phase of research will involve real-world case studies to validate the proposed tool, and its efficacy and explore potential enhancements. Notably, the authors are currently utilizing it to analyze the environmental impact of integrating electric vehicles into both private and public transportation companies. This research area has garnered significant attention, as evidenced by recent publications in WSEAS Transactions on Business and Economics journals, [31], [32].

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### **Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)**

- Alessandro Silvestri carried out the literature review and the methodological approach.
- Mauro D'Apuzzo analysed needs, and sub-needs (SDG and RDG) and suggested solutions/actions in detail.

### **Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself**

No funding was received for conducting this study.

### **Conflict of Interest**

The authors have no conflicts of interest to declare.

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## APPENDIX

Table 2. Needs/Sub Needs of Sustainability and Resilience

ID Need	ID Sub-Need	Criteria	NEEDS	Inbound	Outbound
1	1	Sustainability	SDG 1 No Poverty	X	
2	2	Sustainability	SDG 2 Zero Hunger	X	
3	3	Sustainability	SDG 3 Good Health and Well-Being	X	
4	4	Sustainability	SDG 4 Quality of Education	X	
5	5	Sustainability	SDG 5 Gender Equality	X	
6	6	Sustainability	SDG 6 Clear Water and Sanitation	X	
7	7	Sustainability	SDG 7 Affordable and Clean Energy	X	
8	8	Sustainability	SDG 8 Decent Work and Economic Growth	X	
9	9	Sustainability	SDG 9 Industries and Infrastructures (resilient and sustainable)	X	X
10	10	Sustainability	SDG 10 Reducing Inequalities among Countries		X
11	11	Sustainability	SDG 11 Sustainable Cities and Communities	X	
12	12	Sustainability	SDG 12 Responsible consumption and production	X	X
13	13	Sustainability	SDG 13 Climate Action	X	X
14	14	Sustainability	SDG 14 Life below water	X	
15	15	Sustainability	SDG 15 Life on land	X	
16	16	Sustainability	SDG 16 Peace Justice and Strong Institution		X
17	17	Sustainability	SDG 17 Partnership for the Goals	X	X
18	18	Resilience	RDG1: Supply Risk: Delivery Delays	X	X
18	19	Resilience	RDG1: Supply Risk: Product quality risk	X	X
18	20	Resilience	RDG1: Supply Risk: Supplier Disruptions		X
19	21	Resilience	RDG2: Financial Risk: Liquidity Risk	X	X
19	22	Resilience	RDG2: Financial Risk: Financial Crisis	X	X
19	23	Resilience	RDG2: Financial Risk: Credit Risk	X	X
20	24	Resilience	RDG3: Natural Risk: Climate Change	X	X
20	25	Resilience	RDG3: Natural Risk: Natural Disasters	X	
20	26	Resilience	RDG3: Natural Risk: Natural Resource Shortage		
20	27	Resilience	RDG3: Natural Risk: Epidemics/Pandemics	X	
21	28	Resilience	RDG4: Process Risk: Production Capacity Breakdown	X	X
21	29	Resilience	RDG4: Process Risk: Facility Disruption	X	X
21	30	Resilience	RDG4: Process Risk: Logistic Risk	X	X
21	31	Resilience	RDG4: Process Risk: Strikes	X	X
22	32	Resilience	RDG5: Demand Risk: Price Risk	X	X
22	33	Resilience	RDG5: Demand Risk: Demand Fluctuation	X	X
22	34	Resilience	RDG5: Demand Risk: Market Disruption		X
23	35	Resilience	RDG6: Information Risk: Information Distortion	X	X
23	36	Resilience	RDG6: Information Risk: Cyber-Attacks	X	X
24	37	Resilience	RDG7: Law and Cultural Risk: Legal Risk	X	X
24	38	Resilience	RDG7: Law and Cultural Risk: Cultural Risk		X
25	39	Resilience	RDG8: Law and Cultural Risk: Trust Risk	X	X
26	40	Resilience	RDG9: Lean Risk: 8 Process Wastes Risk	X	

Table 3. HoRS

x Negative influence  
 ✓ Positive influence

Relative importance or weight

	Relative importance or weight																	Measurement units (i.p.)		
	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	INBOUND	OUTBOUND	
Room 10																				
RDG1																				
RDG2																				
RDG3																				
RDG4																				
RDG5																				
RDG6																				
RDG7																				
RDG8																				
RDG9																				
Measurement units (if possible)																				
INBOUND																				
OUTBOUND																				
Importance (absolute weight)																				
Relative weight																				
Target specification values																				

Room 1

Room 2

Room 3

Room 4

Room 5

Room 6

Room 7

Room 8

Room 9



Table 4. Suggested Solutions for Each Need and Sub-Need

ID Need	ID Sub-Need	ID Action	SOLUTIONS/ACTIONS
1	1	1	Enquire on family financial condition of logistic personnel to identify critical cases and design supporting actions
1	1	2	Check compliance between Local Socio-Economic Descriptors and personnel wages
1	1	3	Promote higher interaction with trade unions and labor representatives
1	1	4	Foster external suppliers and vendors adopting SDG 1 complying policies
2	2	5	Promote among inner personnel SDG 2 complying habits such as "food bank" related activities
3	3	6	Promote sustainable transport modes (cycling also with E-bike and walking) in personnel commuting trips
3	3	7	Check for health conditions in workspace
3	3	8	Promote additional services for inner personnel (Health Insurance, Gym etc.)
3	3	9	Foster external suppliers and vendors adopting SDG3 complying policies
4	4	10	Promote among inner personnel SDG 4 complying behavior by establishing scholarships devoted to staff and staff's relatives
5	5	11	Promote Gender Equality among personnel by modifying recruitment policies
5	5	12	Foster external suppliers and vendors adopting SDG5 complying policies
6	6	13	Develop or improve modern wastewater treatment systems
6	6	14	Foster external suppliers and vendors adopting SDG6 complying policies
7	7	15	Reducing internal energy needs by improving energy efficiency
7	7	16	Shifting towards renewable energy sources
7	7	17	Foster the use of e-transport and low-carbon footprint modes
7	7	18	Foster external suppliers and vendors adopting SDG7 complying policies
8	8	19	Check compliance between Local Socio-Economic Descriptors and personnel wages
8	8	20	Check for health conditions in workspace
8	8	21	Promote additional services for inner personnel (Health Insurance, Gym, Nursery, Baby-sitting etc.)
8	8	22	Foster external suppliers and vendors adopting SDG8 complying policies
9	9	23	Promote LCA (Life Cycle Analysis) for inbound/outbound logistic processes
9	9	24	Foster the use of e-transport and low-carbon footprint modes
9	9	25	Improve accessibility for the dispatch of by-products
9	9	26	See ID from 53 to the end
9	9	27	Foster external suppliers and vendors adopting SDG9 complying policies
10	10	28	Foster suppliers and sources from Developing Countries
10	10	29	Foster external suppliers and vendors adopting SDG10 complying policies
11	11	30	Check for environmental impact on external communities
11	11	31	Re-organize transport supply routes to minimize impact on external communities
11	11	32	Foster the use of e-transport and low-carbon footprint modes
11	11	33	Foster external suppliers and vendors adopting SDG11 complying policies
12	12	34	Promote LCA (Life Cycle Analysis) for inbound/outbound logistic processes
12	12	35	Promote Circular Economy and re-use of by-products and equipment
12	12	36	Foster external suppliers and vendors adopting SDG12 complying policies
13	13	37	Promote LCA (Life Cycle Analysis) for inbound/outbound logistic processes
13	13	38	Shifting towards renewable energy sources
13	13	39	Re-design conditioning systems for guarantee reliable cold-chain
13	13	40	Foster external suppliers and vendors adopting SDG13 complying policies
14	14	41	Develop or improve modern wastewater treatment systems
14	14	42	Re-organize transport supply routes to minimize impact on sea and rivers
14	14	43	Foster external suppliers and vendors adopting SDG14 complying policies
15	15	44	Check for environmental impact on external natural reserves and wildlife
15	15	45	Re-organize transport supply routes to minimize impact on natural reserves and wildlife
15	15	46	Foster external suppliers and vendors adopting SDG15 complying policies
16	16	47	Promote sources from stable and democratic countries
16	16	48	Prevent infiltration of criminal associations in inbound and outbound logistic processes
16	16	49	Foster external suppliers and vendors adopting SDG16 complying policies

ID Need	ID Sub-Need	ID Action	SOLUTIONS/ACTIONS
17	17	50	Involve personnel and labor representative in the SDG decision making process
17	17	51	Involve external suppliers and vendors in the SDG decision making process
17	17	52	Foster external suppliers and vendors adopting SDG17 complying policies
18	18	53	Create digital twin of inbound and outbound processes for diagnostics
18	18	54	Promote near sourcing
18	19	55	Create digital twin of inbound and outbound processes for diagnostics
18	19	56	Multi-sourcing
18	20	57	Foster external suppliers and vendors adopting Supplying Risk Audit procedures
19	21	58	Diversification of Financial Asset
19	22	59	Diversification of Financial Asset
19	23	60	Diversification of Financial Suppliers
20	24	61	See ID from 37 to 40
20	25	62	Check for seismic/hydrological/climate resistance of workspace
20	26	63	Multi-sourcing
20	27	64	Check for health and cleaning procedures
20	27	65	Promote smart working
20	27	66	Foster external suppliers and vendors adopting health and sanitation complying procedures
21	28	67	Create digital twin of inbound and outbound logistic processes for diagnostics
21	29	68	Create digital twin of inbound logistic processes with LCCA for diagnostics and preventive maintenance
21	30	69	Create digital twin of inbound logistic processes with LCCA for diagnostics and preventive maintenance
21	31	70	Promote higher interaction with labor unions and representatives
21	31	71	Check compliance between Local Socio-Economic Descriptors and personnel wages
21	31	72	Check for health conditions in workspace
21	31	73	Foster external suppliers and vendors adopting fair labor policies
22	32	74	Multi-sourcing
22	33	75	Improve communication in the supply chain
22	33	76	Inventory and Capacity Buffers
22	34	77	Promote Multi-sourcing in information collection
23	35	78	Promote Multi-sourcing in information collection
23	35	79	Create digital twin of inbound and outbound logistic processes for diagnostics
23	36	80	Improve IT Services
23	36	81	Shift to multiple cloud services
24	37	82	Improve Legal Services
24	37	83	Provision for legal issues
24	37	84	Improve Insurance services
24	37	85	Foster external suppliers and vendors with strict legal agreements
24	38	86	Manufacturing Network Diversification
24	38	87	Multi-outsourcing
24	38	88	Improving Dissemination and Advertising of commitment in addressing SDGs among communities and stakeholders
25	39	89	Create digital twin of inbound and outbound logistic processes for diagnostics
25	39	90	Improving Dissemination and Advertising of commitment in addressing SDGs among communities and stakeholders
25	39	91	Binding external suppliers and vendors with a code of conduct
25	39	92	Multi-Outsourcing
26	40	93	Defects elimination; lost of production factors (material, energy, labor etc.)
26	40	94	Overproduction elimination; lost of production factors (material, energy, labor etc.)
26	40	95	Waiting elimination; lost of time and reaction speed
26	40	96	Transportation of materials elimination; lost of production factors (material, energy, labor etc.)
26	40	97	Inventory elimination; lost of production factors (material, energy, labor etc.) and lost of time and reaction speed

<b>ID Need</b>	<b>ID Sub-Need</b>	<b>ID Action</b>	<b>SOLUTIONS/ACTIONS</b>
26	40	98	Motion of people elimination; lost of time and reaction speed
26	40	99	Non-utilization of talent; lost of competences and opportunities of improving
26	40	100	Extra processing elimination; lost of production factors (material, energy, labor etc.)