D7.4 Standard Response Procedures Document

Deliverable number	**D7.4**
Deliverable title	**Standard Response Procedure Document**
Nature [1]	**R**
Dissemination Level [2]	**PU**
Author (email) Institution	Dimitrios Tsarpalis (**dimitris.tsarpalis@resilienceguard.ch**) **RG**
Editor (email) Institution	**Dimitrios Vamvatsikos (divamva@mail.ntua.gr)**
Leading partner	**RG**
Participating partners	**RG, RED**
Official submission date:	**30/11/2021**
Actual submission date:	**13/07/2022**

[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

[2] **PU**=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services), **CI**=Classified, as referred to in Commission Decision 2001/844/EC

Modifications Index	
Date	Version
04/07/2022	0.1 First version of the Deliverable 7.4
13/07/2022	0.2 Final version

This work is a part of the HYPERION project. HYPERION has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no 821054.

Content reflects only the authors’ view and European Commission is not responsible for any use that may be made of the information it contains.

ACRONYMS AND ABBREVIATIONS

ARIO	Adaptive Regional Input-Output
BCS	Business Continuity Strategy
B2B	Business-to-Business
B2C	Business-to-Consumer
CC	Climate Change
CH	Cultural Heritage
FDN	Final Demand Node
FPA	Funding Prioritization Analysis
GVA	Gross Value Added
IOT	Input-Output Table
HRAP	Holistic Risk Assessment Platform
SSA	Sector Shutdown Analysis
VDT	Vendor Dependence Table
3PL	Third-party Logistics

Table of Contents

Table of Figures

Table of Tables

Executive Summary

Deliverable D7.4, namely “Standard Response Procedures Document”, documents the work undertaken in Task 7.3 “Assessing response actions and establishing Standard Response Procedures”.

A comprehensive methodology to assess the impact of different Standard Response Procedures is proposed, aiming to assist local/regional authorities and external actors during risk mitigation planning and decision-making and ultimately to enhance the organizational and economic resilience of Cultural Heritage (CH) communities under various hazards. These response actions can be a part of the Community Emergency Plan of the CH society, which corresponds to the actions undertaken by the involved agencies to mitigate the immediate aftermaths of a disaster, such as management and deployment of first responders or early warning and information of citizens at-risk. However, such actions are typically designed and managed by the pertinent civil protection mechanisms, which are capable of discerning the actual needs and weaknesses of the community under crisis. On the other hand, this deliverable focuses on the post-disaster restoration process of a CH community from an economic point of view, by defining *a hierarchy of criticalities* according to which an optimal funding prioritization strategy can be derived. To accomplish this, an event-agnostic Funding Prioritization Analysis (FPA) is proposed, which is discretized into a series of hypothetical “what-if” scenarios named Sector Shutdown Analyses (SSAs). Each SSA comprises the reduction of the production capacity of a selected business sector by a certain magnitude (e.g., by 50%) and a certain time duration (e.g., three months), while the rest business sectors are assumed to be fully operational in terms of facility and infrastructure disruptions. Consequently, the socioeconomic model developed in Task 5.5 and integrated into the Holistic Risk Assessment Platform (HRAP) engine of HYPERION is employed to derive the estimated total indirect losses of the community for each SSA. Finally, based on these total community losses, the involved agencies can derive the aforementioned hierarchy of criticalities and use it to settle an objective fund prioritization strategy. The key steps of the proposed FPA are showcased in the socioeconomic model of the city of Rhodes by assuming three levels of Business Continuity Strategy (BCS) exploitation for each critical business sector, to highlight the effect of the BCSs to the robustness and rapidity of the entire CH community.

1 Introduction

1.1 Background

Deliverable D7.4 “Standard Response Procedures Document” summarizes the work undertaken in Task 7.3, namely “Assessing response actions and establishing Standard Response Procedures”. The work in Task 7.3 proposes a comprehensive methodology to establish Standard Response Procedures that could enhance the socioeconomic and organizational resilience of a Cultural Heritage (CH) community under a spectrum of Climate Change (CC) or non-CC aggravated hazards. This can be accomplished by the execution of the event-agnostic Funding Prioritization Analysis (FPA), which is discretized into a series of hypothetical “what-if” scenarios named Sector Shutdown Analyses (SSAs). The SSAs are conducted by using the socioeconomic model that was developed before in this project in Task 5.5, namely “Socioeconomic, Community and Organizational Resilience Framework/Engine” and was consequently integrated into the Holistic Risk Assessment Platform (HRAP) engine of HYPERION. Moreover, the presented FPA utilizes the Business Continuity Strategies (BCSs) developed in Task 7.2 “Assessing Business Continuity Model and Adaptation Strategies”, offering the choice of selecting different levels of community resilience.

1.2 Scope and objective

The overall objective of Task 7.3 is to assess the impact of different response actions to the restoration process of a community after an adverse event. While the importance of an efficient Community Emergency Plan is highlighted, it is recognized that such plans are more suitable to be designed and managed by the pertinent civil protection mechanisms, as they have deeper understanding of the actual needs and weaknesses of the community under crisis. On the other hand, this deliverable focuses on the post-disaster restoration process of a CH community from an economic point of view, by exploiting the socioeconomic model of HYPERION to assess the effectiveness of several Community Recovery Plans. By performing a series of event-agnostic “what-if” scenarios (i.e., the SSAs), municipal authorities and external actors will be able to derive a funding prioritization strategy based on the actual economic impact of disruptions on critical infrastructure and services operating within the community. In addition, when feeding real time now-casting of forecasting data into the HRAP, one can turn in fact the “what-if” scenarios to an early or rapid damage assessment system, enabling operators to assess in real-time the expected supply bottlenecks and demand outages, providing thus the unique capability to initiate efficient response actions, right after (in case of now-cast data) or even before (in case of forecast data) the occurrence of the catastrophic event.

1.3 Definition of Standard Response Procedures

Standard Response Procedures comprise sets of pre-defined actions needed to be undertaken by an organization when its normal operations have been interrupted by an adverse event. Such protocols are essential components of a Business Continuity Plan as, when executed successfully, they can enhance business resilience by accomplishing the following objectives: (a) protect the disrupted facilities/departments from further damages, (b) prevent propagation of failure to the non-disrupted facilities/departments, and (c) hasten the post-event recovery processes. Standard Response Procedures can be a part of organization's Emergency Response Plan, which delineates the management of resources and responsibilities to achieve objectives (a) and (b). For instance, a fire escape plan contains all the steps that have to be followed by the office managers and the personnel of an organization to achieve prompt evacuation of the building, prevent uncontrolled fire spread, and ultimately secure life safety. In addition, Standard Response Procedures may also correspond to the Recovery Plan of an organization, which comprises strategic guidelines for rapid post-event recovery, by defining the priority at which critical facilities of the organization should be restored.

Accordingly, the concept of Standard Response Procedures can be extended for larger systems like CH communities, states, or even countries. Therein, resilience objectives (a) and (b) are handled by the so-called Community Emergency Plan (Perry and Lindell, 2003), which refers to the actions undertaken by the involved agencies (e.g., CH managers, local/regional authorities, Member States) to mitigate the immediate aftermaths of a disaster and ultimately protect human life. Such actions involve management and deployment of first responders (e.g., policemen, firefighters, emergency medical technicians), early warning and information of citizens at-risk, restoration of critical infrastructure and lifeline services (e.g., roads, bridges, electricity network), etc. Community Emergency Plans are typically designed and executed by the pertinent civil protection mechanism of the community (e.g., the ministry of climate crisis and civil protection), which has a deeper understanding of its actual needs and weaknesses during a crisis.

On the other hand, the current Deliverable D7.4 deals with the post-disaster restoration process of a CH community (i.e., objective (c) of the Standard Response Procedures), by utilizing a quantitative methodology to assess the effectiveness of several Community Recovery Plans. This will allow municipal authorities or external actors (e.g., insurance companies, federal government) to derive a funding prioritization strategy based on the economic importance of the critical business sectors operating within the CH community. For this purpose, the proposed Funding Prioritization Analysis (FPA) utilizes the socioeconomic model developed in Task 5.5 “Socioeconomic, Community and Organizational Resilience Framework/Engine” to estimate actual economic losses due to supply and demand outages. Thus, before analyzing the key steps of the proposed FPA, we shall first delve into the main aspects of the socioeconomic model.

2 Proposed Methodology for Standard Response Procedures

2.1 Description of socioeconomic model

2.1.1 Simplified business taxonomy

The socioeconomic model developed in Task 5.5 and consequently reported in D5.5 "HYPERION resilience framework" is founded on the Adaptive Regional Input-Output (ARIO) model that was initially proposed by Hallegatte (2008) for simulating failure propagations due to supply and demand outages. The model is built upon a business taxonomy approach, which involves the aggregation of the individual businesses that operate on a local community to distinct business sectors (see Table 1 for the proposed business taxonomy assumed to be representative for the city of Rhodes). The importance of each business sector to the local economy is reflected by its annual Gross Value Added (GVA), whose distribution over the year is nonuniform for businesses operating in the tourism industry, in which case it experiences a peak during the high season. Along with the identification of the supply business sectors, the socioeconomic model employs the following five potential customer categories, that are called "Final Demand Nodes" (FDNs): 1. Residents, 2. Tourists, 3. Government, 4. Investments, and 5. Exports. While both "Residents" and "Tourists" comprise the local consumption component of an economic system, they are treated separately due to their substantially different consumption profile and hence impact on the CH region.

2.1.2 Performance index decomposition

To assess the capacity of a business sector to absorb the initial shock, respond, and adapt in order to maintain its functionality and hasten recovery (Franchin and Cavalieri, 2014), i.e., its resilience, the socioeconomic model employs for each sector an index that is called performance index (*PerfIdx*). Herein, *PerfIdx* is defined as the ratio between the reduced GVA of the business sector following the occurrence of a hazard event and its GVA under ordinary operating conditions. Evidently, *PerfIdx* is a multi-variant time function that depends not only on the operability of the considered business sector, but also on the socioeconomic impacts of the disaster on the CH site. To depict the individual socioeconomic factors affecting the performance of a business sector, *PerfIdx* is discretized into three distinct components:

a) The infrastructure index (*InfraIdx*), which measures the reduced production/service capacity of a business sector due to "infrastructure damages". As infrastructure damages we define herein all the factors that hamper the operability of a business unit except supply outages, as those are treated separately by the *InputIdx*. Therefore, *InfraIdx* is calculated as the percentage of the fully operating business units belonging to a particular business sector at a given time step.
b) The input index (*InputIdx*), which captures the propagating effect of supply outages, according to the so-called, **Vendor Dependence Tables** (VDTs). VDTs are tools frequently used in Business Continuity to evaluate the dependence of an organization to its vendors. Assuming that the organization has *N* vendors, its

corresponding VDT comprises *N* lines, where each line contains a series of indices that capture the progressive (over time) loss of productivity of the investigated business sector due to complete supply disruption from a particular vendor, ranging from 1 (to denote full productivity) to 5 (to denote no productivity). VDTs can also be defined for FDNs, expressing their adaptive consumption behaviour to disturbances on essential supplies and services (e.g., Figure 4 shows the VDT assumed for the "Tourists" FDN for the city of Rhodes).

c) The output index (*OutputIdx*), which measures the propagating reduction of the demand during the recovery phase. *OutputIdx* is mainly related to (i) the intermediate business-to-business consumption and (ii) the FDN demand (e.g., tourists, residents, etc.). Herein, both components (i) and (ii) are considered by propagating the reduced demand via a so-called **Input-Output Table (IOT)**. The IOT is a *N*x*N* matrix (*N* is the total number of business sectors plus the number of FDNs), in which each cell o_{ij} represents the normalized consumption of goods of business sector *i* by business sector (or FDN) *j*. Thus, each row of the IOT sums to 1, i.e., $\sum_{j=1}^{N} o_{ij}$ for *i* = [1, *N*].

   Finally, at each time step, a distinct set of (*InfraId*x, *InputIdx*, *OutputIdx*) is calculated for each business sector, following a hybrid (macro/microscopic) methodology to account for cascading failures and socioeconomic impacts. Ultimately, the overall performance index *PerfIdx* is calculated as the minimum value of its three key sub-indices:

$$PerfIdx = \min(InfraIdx, InputIdx, OutputIdx) \tag{1}$$

2.1.3 Available Business Continuity Strategies

Business Continuity Strategies (BCSs) comprise sector-wide plans which, when widely adopted, can enhance business survivability and enable the critical processes of CH communities to continue operating at least to the minimum needed extent, when those are impacted by CC or non-CC aggravated hazards. In the socioeconomic model of HYPERION, there are five distinct BCSs available to increase the functionality (i.e., the *InfraIdx*) of a business sector (BCS0 to BCS4). BCS0, namely the "do-nothing" strategy, corresponds to the absence of comprehensive risk mitigation planning and the pertinent business sector can only increase its functionality by exploiting the available overproduction capacities. BCS1 involves "reciprocal agreements", which are deemed to be mutual actions signed between local businesses of similar size that operate within the same sectors to allow for a resilience load balancing. Suitable for service-based businesses, BCS2 is related to a "work-from-home" framework and essentially involves the orientation of several employees to work from their own premises. On the other hand, BCS3, namely "business traffic redistribution" strategy, is more suitable for large organizations operating on a series of interchangeable physical assets, which can satisfy increased demand requests if needed. Finally, The BCS4 is the insurance, a strategy that is always recommended for risk mitigation as it can reduce both the indirect and the direct losses of a disaster. Two insurance approaches are currently available, these being the "traditional indemnity" and the "innovative parametric" insurance. Deliverable 7.3 "BC Models and Adaptation

Strategies assessment report" offers a detailed discussion on the advantages and drawbacks of each proposed BCS, along with a complete methodology on how to integrate them in the context of the socioeconomic tool of HYPERION.

2.2 Proposed Funding Prioritization Analysis

Let us assume a catastrophic event that impacted the facilities of *N* business sectors of a local community, and a total amount of x_i (*i* = 1,…,*N*) capital is required per business sector for rehabilitation works. Moreover, let us assume that the whole cost $X = \sum_{i=1}^{N} x_i$ of reconstruction is paid by an external actor (e.g., by governmental aid) and that the construction and manufacturing sectors can repair a total of $a \cdot X$ capital per month. For example, if a = 1/12, then the total time needed for the community to fully repair its facilities and critical infrastructure is equal to twelve months (i.e., one year). While a fixed amount of $a \cdot X$ capital can be restored per month, its distribution over the individual business sectors may be nonuniform. For example, the local/governmental authorities of a CH community that attracts a lot of tourists may choose to give priority to the rapid restoration of the "Accommodation" business sector rather than the "Agricultural" one, especially if the disaster occurs during high season. On the other hand, for communities with extended industrialization, it might be more efficient to prioritize sectors related to manufacturing processes and warehousing activities.

Herein, it is assumed that for a given damage event, the optimal funding prioritization strategy is the one that results in the lowest total indirect losses in the community. Thus, by using the socioeconomic model of HYPERION, one may realize a series of "what-if" scenarios in which the restoration of selected business sectors is prioritized, by distributing them a larger portion of the $a \cdot X$ monthly funds. Consequently, the socioeconomic tool can inform the involved agencies regarding the impact of their choices in a quantitative way, assisting risk management and decision-making procedures. While this approach can offer a deep understanding of the overall impact of different funding strategies, it is event-specific, requiring the knowledge of the exact amount of x_i capital needed per business sector for restoration purposes, which is not available during pre-event risk mitigation planning. Moreover, such information may also not be available after the occurrence of a disaster, as comprehensive post-event inspections and insurance assessments are needed for estimating the actual repair costs per sector, a procedure that may take months or even years.

To tackle the above issues, an event-agnostic approach is proposed herein, namely the Funding Prioritization Analysis (FPA), which is a comprehensive tool to enhance community's preparedness and assist local and regional agents to better understand the critical components of the supply and demand chain. FPA is based on the execution of a series of hypothetical disaster scenarios, in which the functionality of a selected business sector is reduced to *InfraIdx* < 1.0 (e.g., 0.5) for a pre-defined duration (e.g., two months), while all the remaining sectors are assumed to be fully operational in terms of *InfraIdx*. Then, the socioeconomic model calculates the total indirect losses of the community in terms of % of community's annual GVA, which stem from (i) the reduced productivity of the selected sector, (ii) the supply disruptions produced to the other sectors, and (iii) the demand outages of the FDNs.

An example of this Sector Shutdown Analysis (SSA) is illustrated in Figure 1 for the "Wholesale trade". In the left side of the figure, the downtime diagram of the wholesale sector is depicted, where its *InfraIdx* is reduced to 0.5 for a total of 90 days. In the right side of the figure, one may find the resulting total indirect losses to the community (more than 10% in this example), as yielded by the failure propagations (i) to (iii).

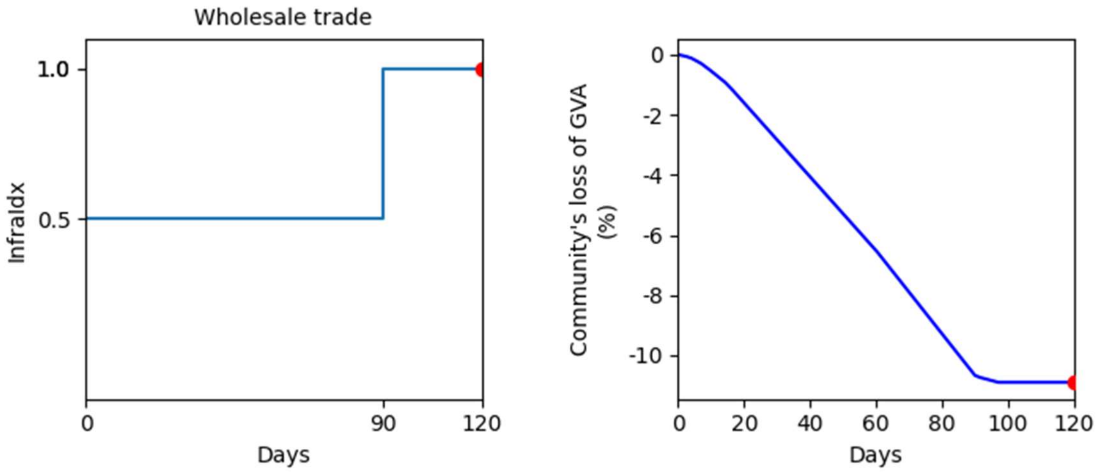


Figure 1: Example of Sector Shutdown Analysis (SSA) for the "Wholesale trade" sector.

Finally, the proposed FPA assumes that the restoration of critical infrastructure and lifeline services within the community (e.g., road transportation, electricity, water) should always be prioritized, as their disruptions compromise not only the normal operation of local businesses but also the residents' and visitors' quality of living. In this regard, they belong to the top tier of the hierarchy of criticalities and will not be tested under SSA. On the other hand, critical services outside the community, like water or air transportation networks should be included in the FPA, as the comprise essential components of the supply chain.

3 Funding Prioritization Analysis of the city of Rhodes

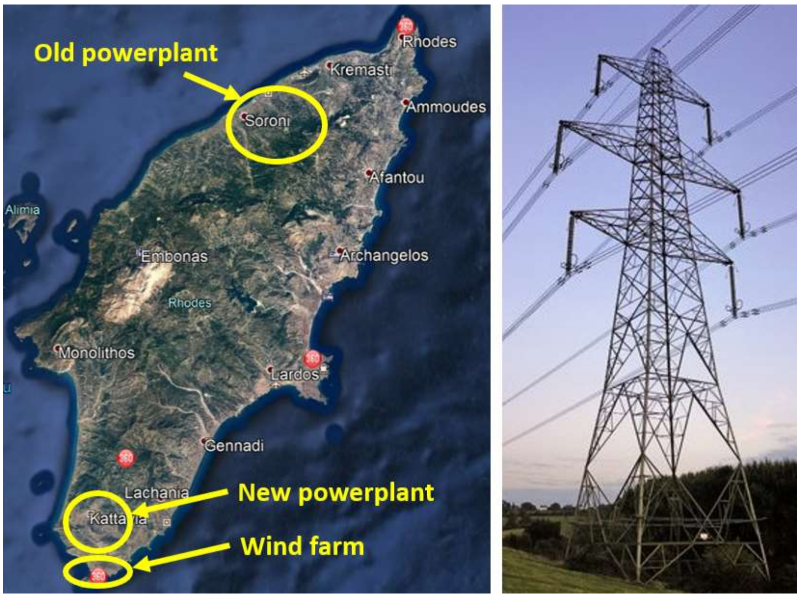
3.1 Socioeconomic model of the city of Rhodes

In order to demonstrate the proposed FPA for applications on CH sites, the historical city of Rhodes was selected, which is the principal city of the island of Rhodes with approximately 50,000 inhabitants based on the latest 2020 demographics ("Rhodes", 2022). It also constitutes one out of the four demo sites that were considered by the HYPERION project, comprising several CH assets with significant natural beauty and historical value. The most famous CH asset is the citadel of Rhodes (Figure 2), built by the Hospitallers, and is one of the best-preserved medieval towns in Europe, which in 1988 was designated as a UNESCO World Heritage Site. Apart from its historical importance, Rhodes is also a coastal town hosting the main marine port of the island and, as a result, it has become a popular international tourist destination. Such characteristics shall be considered during the execution of the FPA, by realizing a socioeconomic model that is representative of the actual local community of Rhodes. A detailed description of the four key steps followed to construct the socioeconomic model of the city of Rhodes is provided in the subsequent sections.

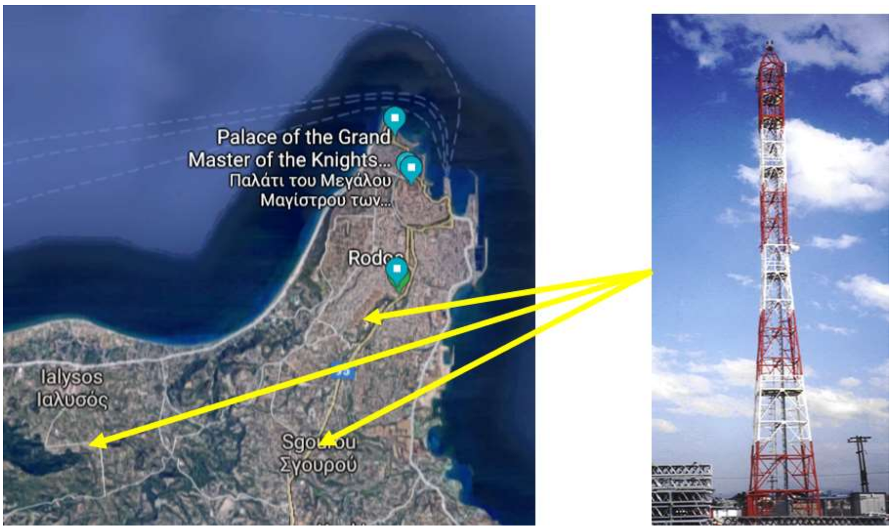
Figure 2: View of the citadel of Rhodes, which is a UNESCO World Heritage Site (photo courtesy of "Fortifications of Rhodes").

3.1.1 Critical infrastructure

The first step to realize the socioeconomic model of the city of Rhodes was to identify the four critical infrastructure networks: (i) the power generation, transmission & distribution network, (ii) the telecommunication network, (iii) the water & sewage network, and (iv) the transportation network. Figure 3(a)-(d) schematically illustrates each one of the aforementioned networks and their spatial distribution across the island of Rhodes. Electric power in Rhodes is generated primarily by two powerplants, i.e., an old one located near the capital city and a new one located in the far south part of the island. Secondarily electricity is also produced by a wind farm that is located near the new powerplant (see Figure 3(a)). On the other hand, the telecommunication network comprises several lattice towers which are mostly located in the north part of the island (Figure 3(b)). Drinking water is transmitted to the city of Rhodes from the Gadoura lake through a main water line, whereas wastewater is collected into the sewage treatment plant that is located nearby the city of Rhodes (see Figure 3(c)). Finally, the transportation network (see Figure 3(d)) comprises the road network, the marine port (inside the city), and the airport (located near the city). It should be noted that for the island of Rhodes, no distinction was required between the cargo and non-cargo marine port. Yet, this might not be the case of other sites.

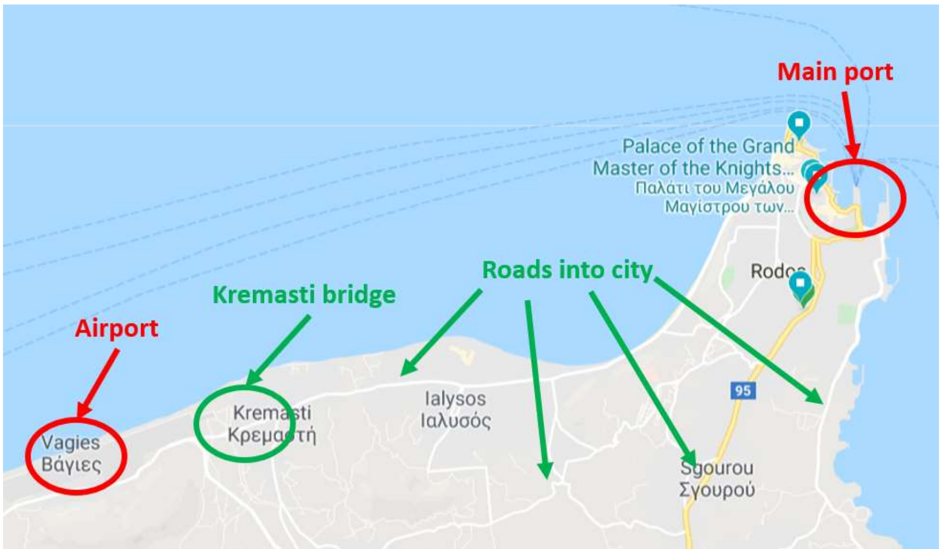


(a)



(b)

(c)



(d)

Figure 3: Schematic layout of the critical infrastructure networks for the city of Rhodes: (a) the power generation, transmission & distribution network, (b) the telecommunication network, (c) the water & sewage network, and (d) the transportation network.

3.1.2 Business taxonomy

The influence of tourism to the structure of Rhodes' economy can be highlighted by comparing the annual GVAs of city's most important business sectors. This step comprises the aggregation of the individual firms operating within the city of Rhodes into compact business sectors, by defining the so-called business taxonomy. In particular, we employed a combination of the 1-digit (19 business sectors) and 2-digits business classification (73 business sectors) of the NACE rev. 2 taxonomy (Eurostat, 2008) to define a simplified taxonomy that consists of 23 business sectors. The identified business sectors were those with the highest GVAs, while the rest were aggregated for simplicity to a single sector, namely "Other services". The adopted business taxonomy that is deemed to be representative for the city of Rhodes is given in Table 1, along with the annual GVAs of each one of the defined business sectors, using the economic data provided by the Hellenic Statistical Authority (ELSTAT).

Based on Table 1, the "Wholesale trade" business sector comprises the most critical one (i.e., the one with the highest GVA) for the city of Rhodes, an observation that is anticipated to hold for the majority of the developed societies, since almost all organizations rely on their vendors for the supply of essential goods and utilities rather than on directly purchasing them from e.g., the manufacturers or on directly producing them. The next most important sector for the city of Rhodes is the "Real estate activities" sector, which includes both the real estate agents and the incomes from the rental and sale of premises. The third critical sector is the "Retail trade", which is the final link in the supply chain from producers to consumers and comprises grocery stores, gift shops, supermarkets, etc.

Regarding tourism, sectors like the "Accommodation" (hotels, BnBs, etc.), "Food and beverage" (restaurants, bars, etc.), and "Creative, arts and entertainment activities" (theaters, cinemas, museums, etc.) reflect a large percentage of the city's overall annual GVA (a total of 16%). The aforementioned "Retail trade" sector could also be considered as a tourism-based industry, as there are many small retail shops within the historical city whose annual profits vastly depend on tourist arrivals during high season, while many of them are even closed during low season. On the other hand, sectors such as "Manufacturing" or "Agriculture" are less important in terms of annual GVA, which indicates that Rhodes relies on external vendors for essential supplies, mainly via marine transportation.

Table 1: Business taxonomy for the city of Rhodes (23 business sectors).

#	Full Name	GVA (€ mill.)	GVA (%)
1	Wholesale trade, except of motor vehicles and motorcycles	112.80	13.81%
2	Real estate activities	93.99	11.51%
3	Retail trade, except of motor vehicles and motorcycles	64.10	7.85%
4	Accommodation	60.15	7.37%
5	Food and beverage services	50.31	6.16%
6	Education	44.65	5.47%
7	Human health and social work activities	36.22	4.43%
8	Business, scientific and technical activities	33.77	4.13%
9	Warehousing and support activities for transportation	28.41	3.48%
10	Wholesale and retail trade and repair of motor vehicles and motorcycles	24.27	2.97%
11	Financial services and insurance activities	23.27	2.85%
12	Manufacturing	23.00	2.82%
13	Creative, arts and entertainment activities	20.18	2.47%
14	Agriculture, forestry, fishing	12.44	1.52%
15	Water transport	34.30	4.20%
16	Land transport and transport via pipelines	32.33	3.96%
17	Electricity, gas, steam and air conditioning supply	31.85	3.90%
18	Public administration and defense; compulsory social security	21.52	2.63%
19	Construction	12.13	1.49%
20	Media and communication	10.54	1.29%
21	Air transport	9.48	1.16%
22	Sewerage, waste collection, treatment and disposal activities; materials recovery, remediation activities and other waste management services	7.38	0.90%
23	Other services	29.64	3.63%
SUM		816.71	100%

3.1.3 Vendor Dependence Tables

Following the derivation of Rhodes' business taxonomy, the next step is to identify the interdependence among the individual business sectors, which can be expressed by their pertinent VDTs. Herein, a series of preliminary VDTs were constructed on account of our judgement, yet more refined ones can be obtained in the future by utilizing expert elicitation methods. Nevertheless, a lot of effort was put to respect the specific socioeconomic characteristics of the city of Rhodes, by determining the key critical sectors that affect (a) the supply chain of essential products and services and (b) the adaptive behaviour of the final demand, namely the residents and tourists.

As Rhodes is an isolated island with limited manufacturing and agricultural activity, most essential supplies are imported from other parts of Greece, mainly using cargo ships that disembark their freight in the main marine port. From this point, the wholesalers and regional agencies receive the products in bulk and store them either into their own premises or into rented storage units inside a warehouse. The latter method belongs to the so-called third-party logistics (3PL) management, in which an organization (e.g., a wholesaler) outsources elements of its distribution, warehousing, and fulfillment services (Marasco, 2008). As a result, the “Wholesale trade” depends, in an extent, on the “Warehousing and support activities for transportation” sector, however the actual percentage of 3PL is not known. By examining the annual GVAs in Table 1, it is concluded that wholesale industry produces 4 times the GVA of the warehousing sector, thus it is expected that the percentage 3PL is not dominant. For simplicity, it is assumed that 50% of the wholesalers rely on 3PL, which is expressed in the VDT of “Wholesale trade” by assigning a “3” index in the row that corresponds to the warehousing sector.

The final link in the supply chain of Rhodes is the “Retail trade” sector. Typically, retailers purchase goods in large quantities from the wholesalers, and then sell them in smaller quantities to the consumers. Thus, a strong dependence between wholesale and retail trade was given in the VDT of the latter, by assigning a “5” index in the row of the former (i.e., Condition 5, total loss of productivity). However, to account for the effect of stocking capacities of the retail stores (e.g., the storage racks inside a supermarket), this “5” index is reached after two weeks of not receiving input from the wholesale sector. Other critical sectors that can be classified as FDN-oriented, also known as Business-to-Consumer (B2C) sectors, are the “Accommodation” and “Food and beverage services”. The functionality of the “Accommodation” sector only partially depends on other sectors (e.g., for BnBs, food products are required for the breakfast services), which was reflected in its VDT by “delaying” the occurrence of Conditions 2-5.

Two Business-to-Business (B2B) sectors that are crucial for the whole community of Rhodes are the “Business, scientific and technical activities” and “Financial services and insurance activities”. Indeed, even small firms require a certain level of B2B services to maintain their critical operations, such as accounting, engineering, marketing, and consulting services. However, these two B2B sectors commonly do not employ heavy infrastructure facilities to deliver their services, and thus a “supply bottleneck” is hard to occur. Essentially, their *InfraIdx* is very unlikely to decrease lower than e.g., 0.8, with the only exception of a sectorial strike. However, a strong dependence was given to the VDTs of the other business sectors, but one should be cautious when interpreting the results of the FPA. A detailed discussion on this issue is given in the following sections.

#	Tourists	0h	1h	2h	4h	8h	12h	1d	2d	4d	1w	2w	1mo	2mo	∞
3	Accommodation	1	1	1	1	1	2	3	4	5	5	5	5	5	5
4	Food and beverage services	1	1	1	1	1	2	2	3	4	4	5	5	5	5
2	Retail trade, except of motor vehicles and motorcycles	1	1	1	1	1	2	2	3	4	4	5	5	5	5
14	Water transport	1	1	1	1	1	1	2	2	2	2	2	2	3	3
20	Air transport	1	1	1	1	1	1	2	2	3	3	3	4	5	5
9	Wholesale and retail trade and repair of motor vehicles and motorcycles	1	1	1	1	1	1	1	1	1	1	1	2	2	2
12	Creative, arts and entertainment activities	1	1	1	1	1	1	2	2	2	3	3	3	3	3
0	Wholesale trade, except of motor vehicles and motorcycles	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	Real estate activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	Education	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	Business, scientific and technical activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Warehousing and support activities for transportation	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	Financial services and insurance activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	Manufacturing	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	Agriculture, forestry, fishing	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	Construction	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	Other services	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	Human health and social work activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Land transport and transport via pipelines	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	Electricity, gas, steam and air conditioning supply	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	Public administration and defense; compulsory social security	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	Media and communication	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	Sewerage, waste collection, treatment, etc.	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Figure 4: VDT used for the “Tourists” FDN (city of Rhodes).

Finally, a VDT was constructed for each of the five final consumers (i.e., the FDNs), which reflect their adaptive response on supply and service disruptions. For instance, Figure 4 shows the VDT used for the "Tourists" FDN. Obviously, a strong dependence was given on the "Accommodation" sector, assuming that after one day of not being able to stay on a rooming unit, 50% of the tourists will leave the city (Condition 3). Moreover, as most tourists visit Rhodes for holiday vacations, disruptions on restaurants, bars, retail stores, etc. are deemed to affect their satisfaction and consequently impact the reputation of the entire city. Herein, it was assumed that if the "Food and beverage" or the "Retail trade" businesses are closed for two weeks, the tourists will be discouraged to visit Rhodes, ultimately cancelling their trips or seeking for another destination (Condition 5). Regarding the transportation network, the marine port and the airport are essentially the two available options for the external visitors to reach the city of Rhodes. Based on pre-COVID19 statistical data, during 2019 a total of 5,542,223 passengers visited Rhodes via airplane (Fraport), 694,589 via ferries, and 308,194 during cruise vacations (Elime). Thus, in the "Tourists" VDT more importance was given to the "Air transport" sector rather than on the "Water transport". Lastly, a "delaying" behaviour was adopted, in which when the disrupted *InputIdx* received by the tourists increases (e.g., the hotels repair several rooming units), a total of seven days is required for the tourists to follow this beneficial condition and increase their *InfraIdx*.

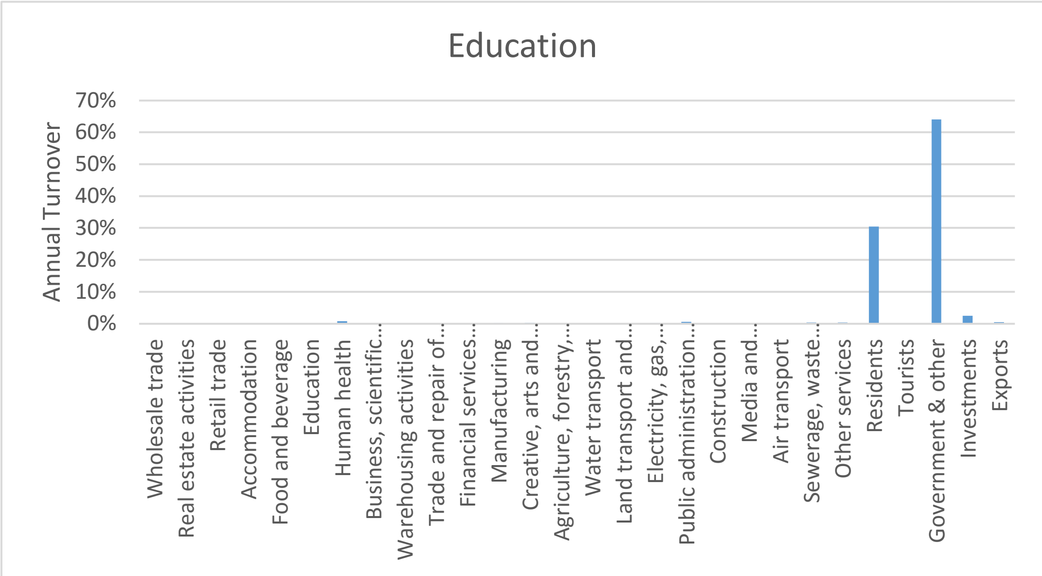
3.1.4 Input-Output Table

The final step for the construction of the socioeconomic model of Rhodes comprises the definition of community's IOT. While VDTs express supply dependences, the IOT reflects the number of commodities (in terms of capital) that each business sector sales to other sectors. In the case study of Rhodes, the resulting IOT is a 28x28 matrix (23 business sectors plus 5 FDNs), in which each cell $o_{i,j}$ represents the consumption of goods (or services) of business sector *i* by business sector (or FDN) *j*. Moreover, it can be normalized so each row of the IOT sums to 1, i.e., $\sum_{j=1}^{N} o_{i,j}$ for *i* = [1, *N*]. Herein, the normalized IOT of Greece (Timmer et al., 2015) was used to propagate backwards the demand disruptions, however some adjustments were introduced since Rhodes does not follow exactly the same B2B and B2C economic profile of the entire country.

Some indicative rows of the normalized IOT used for the city of Rhodes are shown in Figure 5(a)-(d), by means of bar charts. As the annual turnover of the "Wholesale trade" (sector #1) highly depends on the sales of the "Retail trade" (sector #3) a value of 0.6 was given to cell $o_{1,3}$, while the rest cells of row #1 were adjusted proportionally (Figure 5(a)). Accordingly, it was assumed that 50% of the annual turnover of the "Retail trade" comes from selling products or services to the "Residents" and "Tourists" FDNs (FDNs #24 and #25, respectively), which, considering a 50-50 share, resulted in $o_{3,24}$ = 0.25 and $o_{3,25}$ = 0.25 (Figure 5(b)). Figure 5(c) shows the sectorial decomposition of row #6 of the adopted normalized IOT, which corresponds to the "Education" sector. As expected, most incomes of sector #6 stem from the "Government" FDN (FDN #26), specifically $o_{6,26}$ = 0.64, since in Greece the expenditures of almost all public education institutes (e.g., primary and secondary schools, universities) are covered by government funds. Moreover, the "Residents" FDN also plays an important role on the annual turnover of the "Education" sector, as in Greece there are several private tutoring schools that operate in parallel with the public education ($o_{6,25}$ = 0.30). Contrarily to education, the "Accommodation" sector (sector #4) relies almost solely on the "Tourists" FDN to produce revenue and, thus, a $o_{4,26}$ = 0.83 was adopted.

(a)

(b)



(c)

(d)

Figure 5: Bar charts corresponding to the rows of normalized IOT used for the city of Rhodes, showing the rows of (a) the "Wholesale trade", (b) the "Retail Trade", (c) the "Education", and (d) the "Accommodation" business sectors.

3.2 FPA assuming low community resilience

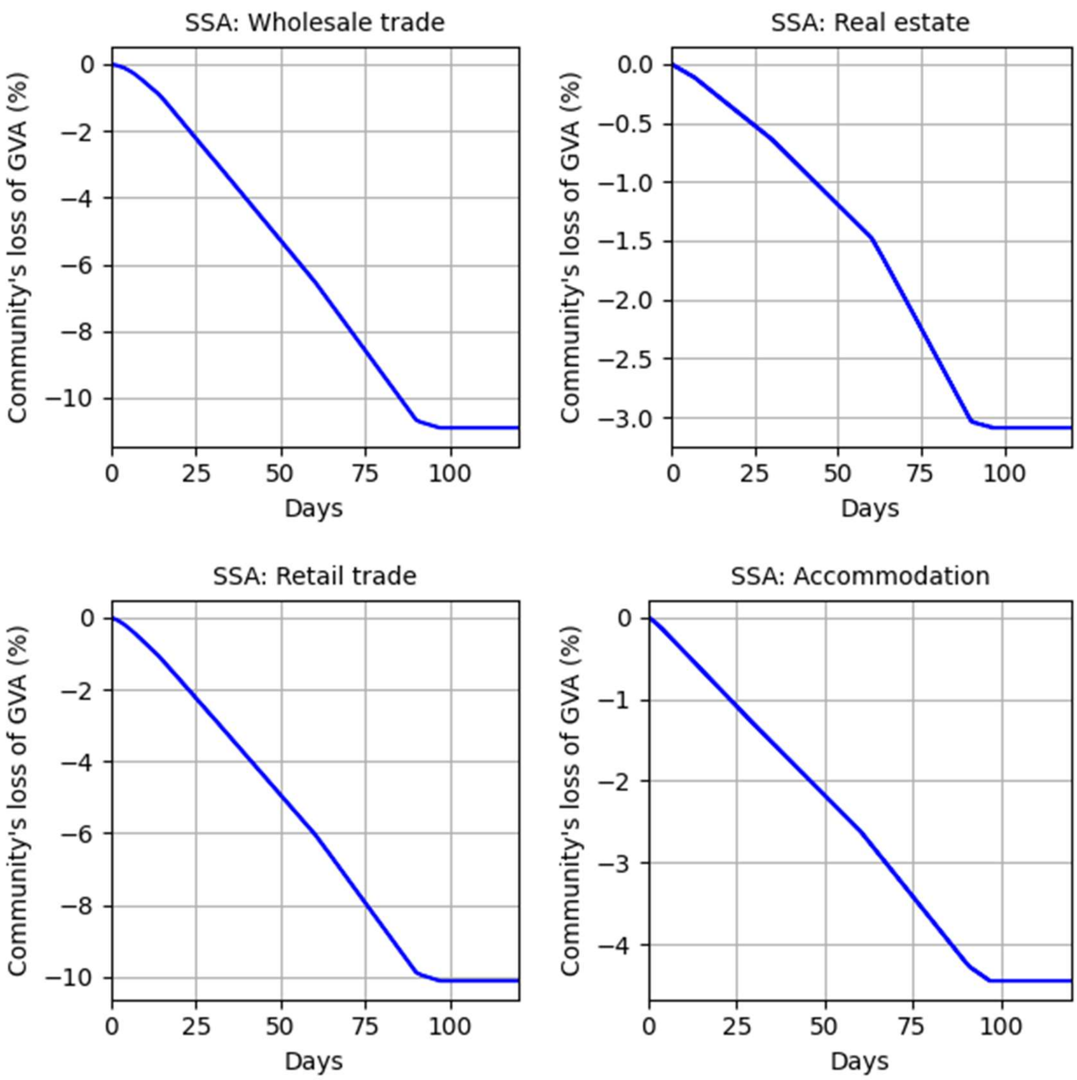
Following the construction of the socioeconomic model of Rhodes, the next step of the FPA comprises the execution of a series of hypothetical disaster scenarios to assess the importance of each business sector, namely the Sector Shutdown Analyses (SSAs). In each SSA_i, the *InfraIdx* of the pertinent business sector *i* was reduced to 0.5 for three months (June, July, and August) and the expected indirect losses were calculated by the socioeconomic model. Consequently, a *hierarchy of criticalities* was defined, in which the most critical business sector was the one whose SSA led to the highest total indirect losses in the community, expressed in % of city's annual GVA. As previously mentioned, business sectors that correspond to intra-community critical infrastructure and lifeline services, such as human health, water and power distribution, waste disposal, etc. were disregarded. Essentially, their importance to the local community of Rhodes is so high that the regional/municipal authorities should always prioritize their rapid restoration. On the other hand, the water and air transportation infrastructure were included in the FPA, as the marine port and the airport were considered as components of the supply chain whose functionality does not directly impact the critical operations inside the city of Rhodes.

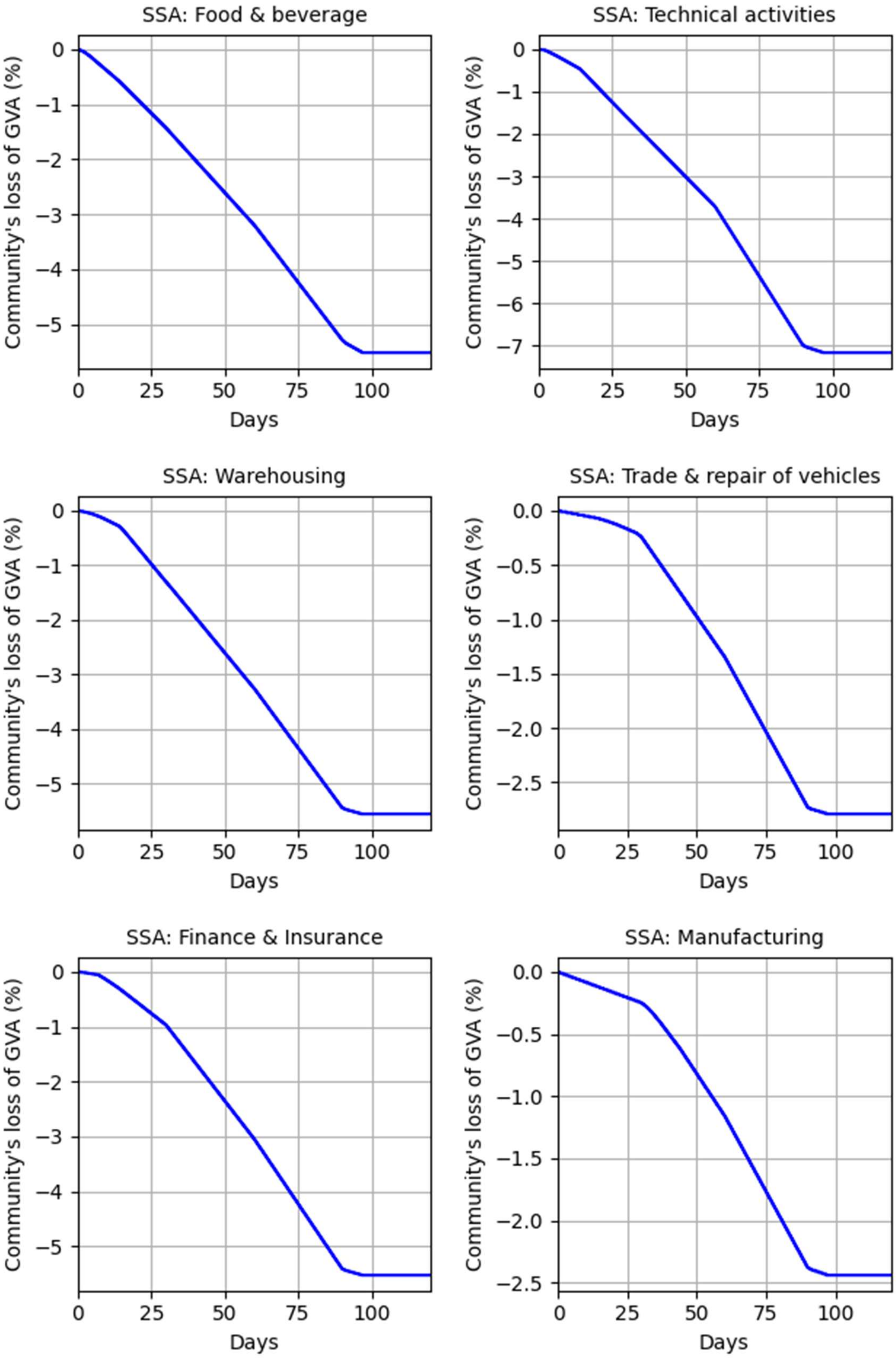
Ultimately, the 14 business sectors employed in the FPA of the city of Rhodes are given in Table 2. Column 1 of the table contains the indices (per Table 1) of the pertinent sectors, while Column 2 their "short names", which will be used in the following charts for illustration purposes. Columns 3 to 6 summarize the available overproduction and assumed BCSs of each business sector. Evidently, in this realization of the socioeconomic model of Rhodes, none of the tested business sectors demonstrated overproduction capacities or employed comprehensive BCSs to mitigate facility disruptions. While this *low community resilience framework* is quite pessimistic and probably does not reflect the actual socioeconomic profile of Rhodes, it was considered herein for instructive purposes, while more realistic assumptions are showcased in the following sections.

Table 2: Business sectors employed in the FPA of the city of Rhodes, assuming low community resilience.

#	Short Name	Overproduction	BCS1	BCS2	BCS3
1	Wholesale trade	x1.0	+0.0	0%	x1.0
2	Real estate	x1.0	+0.0	0%	x1.0
3	Retail trade	x1.0	+0.0	0%	x1.0
4	Accommodation	x1.0	+0.0	0%	x1.0
5	Food & beverage	x1.0	+0.0	0%	x1.0
8	Technical activities	x1.0	+0.0	0%	x1.0
9	Warehousing	x1.0	+0.0	0%	x1.0
10	Trade & repair of vehicles	x1.0	+0.0	0%	x1.0
11	Finance & Insurance	x1.0	+0.0	0%	x1.0
12	Manufacturing	x1.0	+0.0	0%	x1.0
13	Arts & Entertainment	x1.0	+0.0	0%	x1.0
14	Agriculture, forestry, fishing	x1.0	+0.0	0%	x1.0
15	Water transport	x1.0	+0.0	0%	x1.0
16	Air transport	x1.0	+0.0	0%	x1.0

The results of the 14 SSAs are summarized in Figure 6, showing the time histories of total indirect losses in terms of % of city's annual GVA. One can observe that in all SSAs the rate of GVA loss increased with time, as the individual business sectors within the community progressively experienced supply outages. In the SSAs of some sectors only few days were required for the loss rate to maximize (e.g., the "Wholesale trade" and "Water transport" sectors), which indicates that severe supply bottlenecks (i.e., Conditions 4 or 5 in the VDTs) propagated rapidly in the entire community. On the other hand, the SSAs of the "Real estate" or "Technical activities" sectors experienced a sudden increase of loss rate after approximately two months, which shows that the local firms were more tolerant to disruptions in these sectors.




SSA: Food & beverage
SSA: Technical activities
SSA: Warehousing
SSA: Trade & repair of vehicles
SSA: Finance & Insurance
SSA: Manufacturing
Community's loss of GVA (%)
Days
0
25
50
75
100

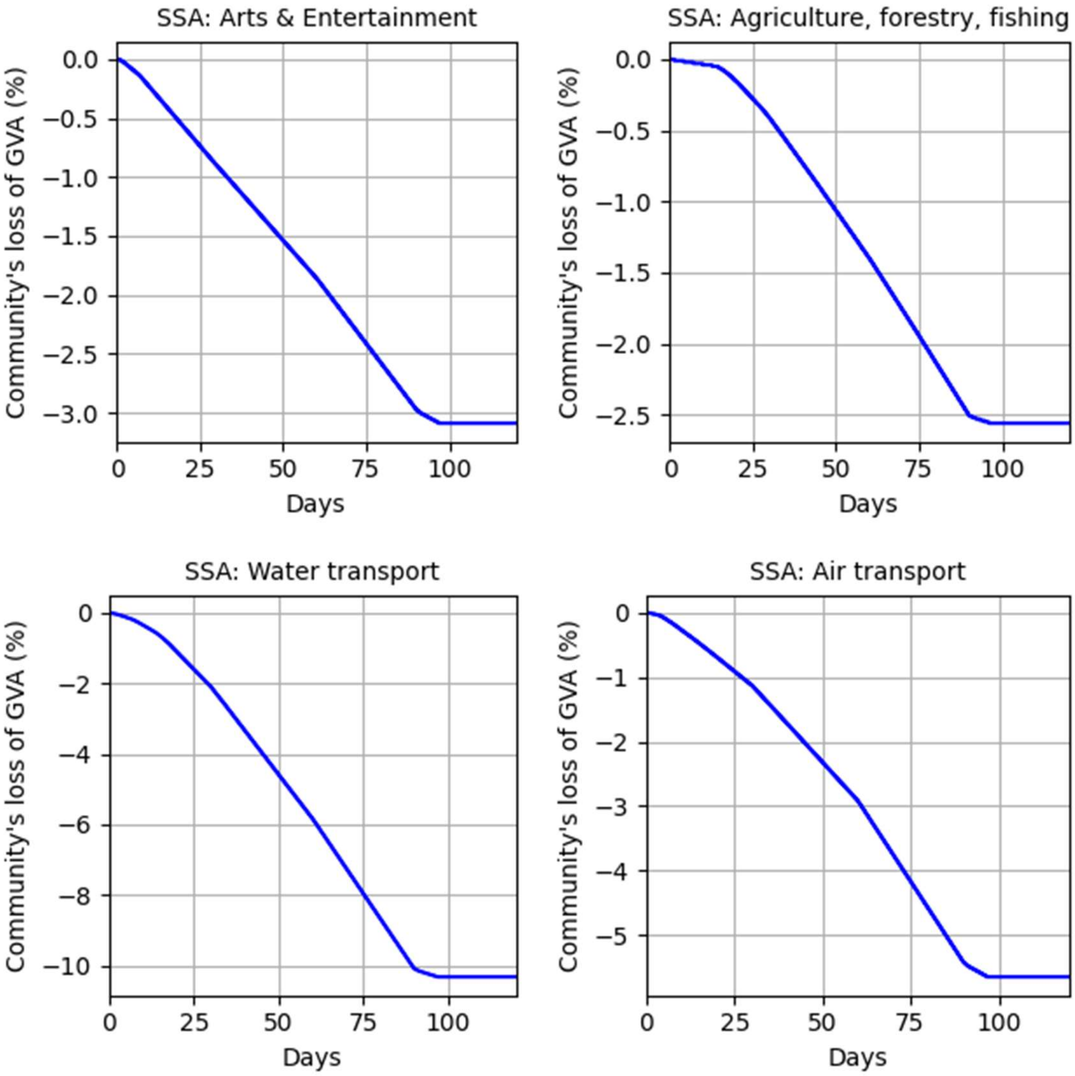


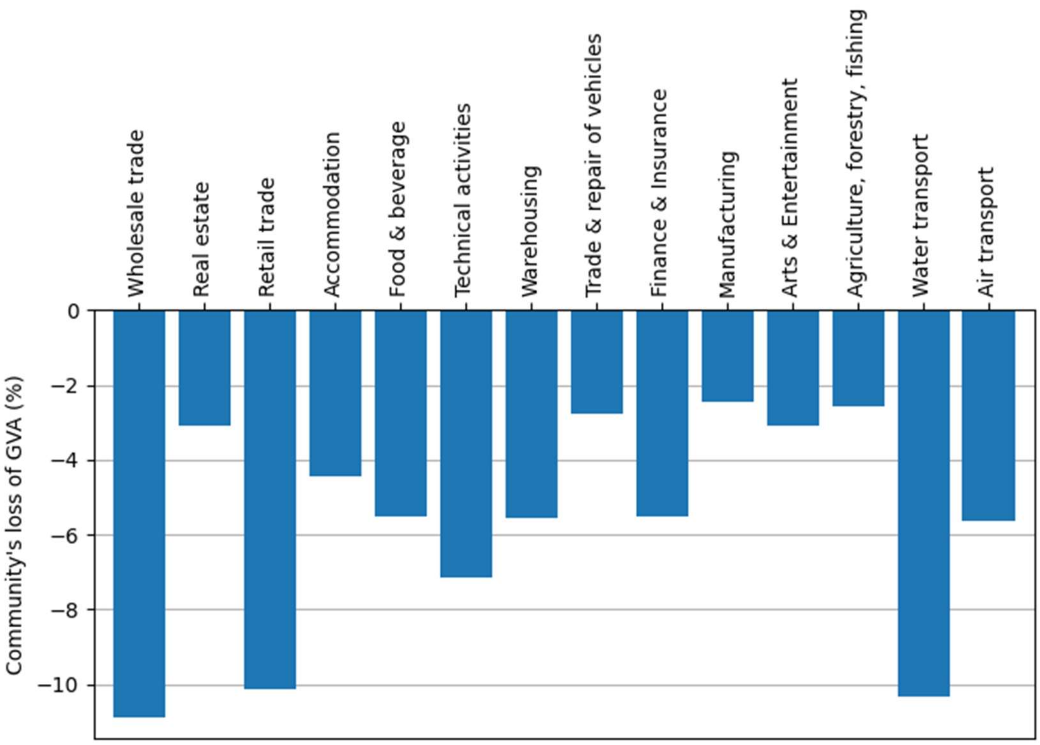
Figure 6: SSAs of the 14 business sectors employed in the FPA of the city of Rhodes, showing the time histories of total indirect losses in terms of % of city's annual GVA (low community resilience).

The final step of the FPA comprises the comparison of the total indirect losses calculated by the 14 SSAs, which can be visually conducted by means of bar charts, as shown in Figure 7(a). Evidently, the most critical sectors of Rhodes are the "Wholesale trade", "Water transport", and "Retail trade", which resulted in total indirect losses equal to 10.9%, 10.3%, and 10.1% of city's annual GVA, respectively. To better understand their importance, if the *InfraIdx* of all business sectors were simultaneously reduced to 0.5 for three months, the total indirect losses would have been (1-0.5)·3/12 = 12.5% of city's annual GVA. In other words, disruptions in these sectors resulted in supply and demand outages of such magnitude that the economy of the entire city was paralyzed. Closely related to the wholesale trade is the "Warehousing" sector, whose SSA resulted in total indirect losses equal to 5.6% of city's GVA, about half of that of wholesale trade's. This outcome was expected based on the assumption made during the construction of the socioeconomic model that 50% of the wholesalers employed a 3PL policy.

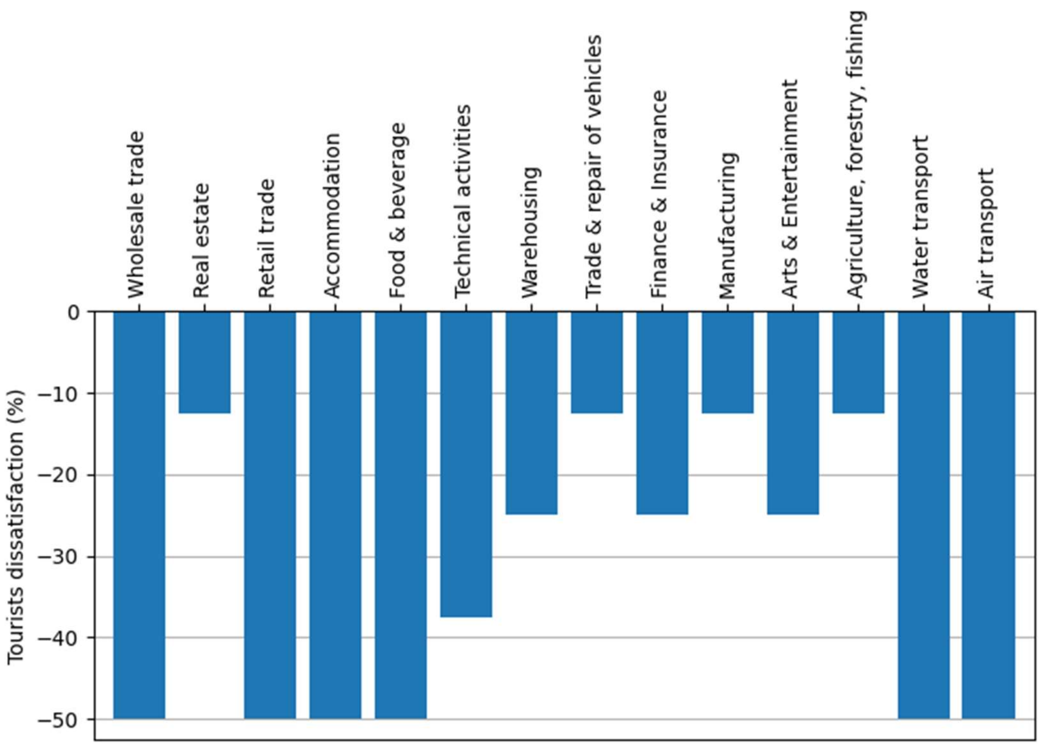
Next in the hierarchy of criticalities comes the “Technical activities” sector, with total indirect losses equal to 7.2% of Rhodes’ annual GVA. This sector along with the “Finance & Insurance” industry (whose FPA resulted in total indirect losses equal to 5.5% of city’s annual GVA) deliver essential B2B services that inevitably affect the functionality of all industries, even if in their VDTs a delay of two months was typically assumed before reaching Condition 5. However, as explained before, such B2B services can easily exploit BCSs to increase their productivity (e.g., work-from-home) or be imported by businesses outside the examined CH site (e.g., from the neighboring islands). Nevertheless, policy makers should always give sufficient heed to critical B2B industries during fund distribution after an adverse event, in order to allow them to continue operating a least to a minimum required degree, which will also support the functionality of other important sectors like the “Wholesale trade” or “Retail trade”.

Another key component in the supply and demand chain is the airport of the island, located near the city of Rhodes. While the “Air transport” sector occupies only the 1.7% of city’s annual GVA (Table 1), its SSA resulted in total indirect losses equal to 5.7% of Rhodes’s annual GVA, placing it fifth in the hierarchy of criticalities. These economic losses were mostly related to demand outages rather than on supply disruptions, as tourist arrivals highly depend on the airport (more than 80% use airplane as mode of transportation). To better elaborate this dependence, the *tourists’ dissatisfaction* of each SSA is given in Figure 7(b) by means of bar charts. Essentially, dissatisfaction is defined as 1.0 minus the minimum *InfraIdx* of the “Tourists” FDN that was recorded during the SSA. Evidently, the SSA of the “Air transport” sector scored the highest tourists’ dissatisfaction equal to 50%. Thus, while the airport does not generate important income for the local community of Rhodes, in case of a catastrophic event the regional managers and decision-makers should prioritize the rapid restoration of airport’s infrastructure, as the consequent indirect losses are expected to be high, especially during high season.

Two FDN-oriented sectors are the “Food & beverage” and “Accommodation” services, whose SSA produced total indirect losses equal to 5.5% and 4.5% of city’s annual GVA, respectively. The economic impacts of the former were greater, as shutdowns of bars restaurants, cafes, etc. affect not only the consumption behaviour of the tourists but also of the residents. In general, disruptions in these two sectors did not result in any supply bottlenecks of essential products and services, however they highly impacted the “Tourists” (tourists’ dissatisfaction of SSA equal to 50%, Figure 7(b)) and “Residents” FDNs, propagating demand outages in the entire city. Finally, sectors related to manufacturing and agriculture were found to be less critical for the city of Rhodes, as essential products are imported via the marine port rather than produced locally.



(a)



(b)

Figure 7: Bar charts from the SSAs conducted for the city of Rhodes, showing (a) the total community indirect losses and (b) the maximum tourist dissatisfaction (low community resilience).

3.3 FPA assuming moderate community resilience

The previously presented FPA adopted a low community resilience framework for the city of Rhodes, in which the local businesses could not exploit any overproduction capacities or BCSs to increase their functionality (i.e., their *InfraIdx*) after a catastrophic event. However, such assumptions may not reflect appropriately the actual socioeconomic structure of Rhodes, as most businesses rarely operate in their full production capacity and labor and, hence, they are often able to increase their production during a crisis. For instance, if an event forces 20% of the bars and restaurants of the city to shut down, the *InfraIdx* of the "Food & beverage" sector can be preserved higher than 0.8, by increasing the productivity of the non-disrupted firms. Accordingly, if 25% of the engineers, lawyers, and accountants are not able to operate from their typical workplaces e.g., due to structural damages to the premises of their company after an earthquake, the *InfraIdx* of the "Technical activities" sector can be maintained at satisfactory levels by exploiting the work-from-home strategy (BCS2).

Table 3: Business sectors employed in the FPA of the city of Rhodes, assuming moderate community resilience.

#	Short Name	Overproduction	BCS1	BCS2	BCS3
1	Wholesale trade	x1.25	+0.0	0%	x1.0
2	Real estate	x1.0	+0.0	35%	x1.0
3	Retail trade	x1.25	+0.0	0%	x1.0
4	Accommodation	x1.1	+0.0	0%	x1.0
5	Food & beverage	x1.25	+0.0	0%	x1.0
8	Technical activities	x1.0	+0.0	35%	x1.0
9	Warehousing	x1.25	+0.0	0%	x1.0
10	Trade & repair of vehicles	x1.25	+0.0	0%	x1.0
11	Finance & Insurance	x1.0	+0.0	35%	x1.0
12	Manufacturing	x1.0	+0.0	0%	x1.25
13	Arts & Entertainment	x1.1	+0.0	0%	x1.0
14	Agriculture, forestry, fishing	x1.0	+0.0	0%	x1.25
15	Water transport	x1.0	+0.0	0%	x1.0
16	Air transport	x1.0	+0.0	0%	x1.0

To clarify the above, the FPA of the city of Rhodes was reconducted by employing a *moderate community resilience framework*, which assumed increased overproduction and BCS sector capabilities, as shown in the last four columns of Table 3. In general, an overproduction factor equal to x1.25 was adopted for most critical sectors of the supply chain (e.g., wholesale, retail, warehousing), with the only exception of the marine port and the airport, in which no redundancies were foreseen. Essentially, it was assumed that the traffic of passengers and cargo is fully determined by the available infrastructure of the sector e.g., if one out of the two runways of the airport are closed, then the *InfraIdx* of the "Air transport" sector will drop to 0.5 without any ability to increase (e.g., by reducing the time needed for landing and departure or adding additional flights to the non-disrupted runway). On the other hand, a low overproduction factor equal to x1.1 was employed in the "Accommodation" business sector, as during high season most hotels are fully booked, leaving a limited number of available rooming units to accommodate the increased demand. Finally, it was assumed that 35% of the businesses comprising essential B2B sectors (i.e., "Real estate", "Technical activities", and "Finance & Insurance") could switch to remote working if necessary (i.e., BCS2).

The updated results of the FPA with moderate community resilience are depicted in Figure 8. Evidently, "Water transport" was found to be the most critical business sector of Rhodes, with its SSA resulting in total indirect losses equal to 10.3% of city' annual GVA. Other key components of the supply chain such as the "Wholesale trade", "Retail trade", and "Warehousing" sectors were still on the top tier of criticalities, however their impact to economy of Rhodes was mitigated thanks to the ability of the non-disrupted firms to overproduce. Finally, enhanced behaviour was also reported in the SSAs of the essential B2B sectors, thanks to their ability to exploit BCS2. Specifically, the total indirect losses of the "Technical activities" and "Finance & Insurance" sectors were reduced from 7.2% and 5.5% to 4.7% and 3.6% of Rhodes' annual GVA, respectively.

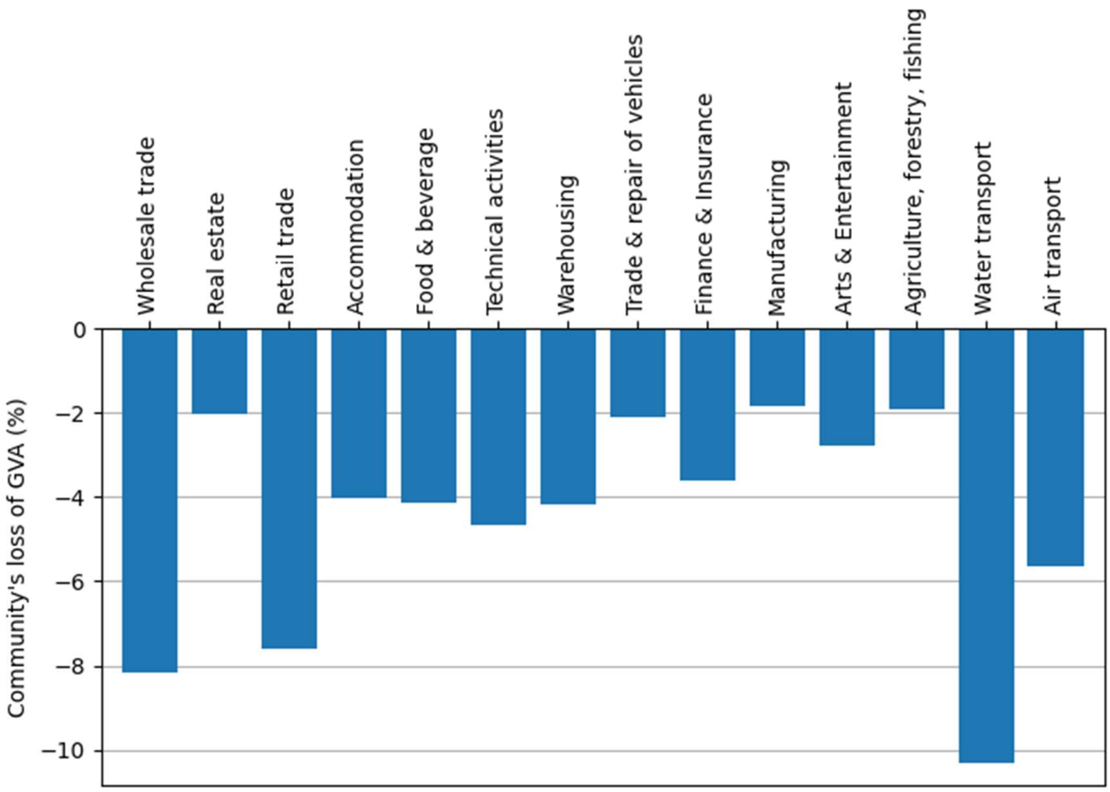


Figure 8: Bar charts from the SSAs conducted for the city of Rhodes, showing the total community indirect losses (moderate community resilience).

3.4 FPA assuming high community resilience

Finally, FPA was conducted for the city of Rhodes by assuming a high community resilience framework. The adopted overproduction and BCS sector capabilities are shown in Table 4. Herein, an overproduction factor equal to x1.35 was used for the wholesale, retail, and warehousing sectors, while again no redundancies were foreseen for the marine port and the airport. Contrarily to the low or medium resilience concepts, intra-municipality reciprocal agreements (BCS1) were adopted for the "Accommodation" business sector, allowing its *InfraIdx* to increase by +0.25 when required by transferring business traffic to the nearby villages. Finally, it was assumed that 65% of the businesses comprising essential B2B sectors (i.e., "Real estate", "Technical activities", and "Finance & Insurance") could switch to remote working if necessary (BCS2).

Table 4: Business sectors employed in the FPA of the city of Rhodes, assuming high community resilience.

#	Short Name	Overproduction	BCS1	BCS2	BCS3
1	Wholesale trade	x1.35	+0.0	0%	x1.0
2	Real estate	x1.0	+0.0	65%	x1.0
3	Retail trade	x1.35	+0.0	0%	x1.0
4	Accommodation	x1.0	+0.25	0%	x1.0
5	Food & beverage	x1.35	+0.0	0%	x1.0
8	Technical activities	x1.0	+0.0	65%	x1.0
9	Warehousing	x1.35	+0.0	0%	x1.0
10	Trade & repair of vehicles	x1.35	+0.0	0%	x1.0
11	Finance & Insurance	x1.0	+0.0	65%	x1.0
12	Manufacturing	x1.0	+0.0	0%	x1.35
13	Arts & Entertainment	x1.1	+0.0	0%	x1.0
14	Agriculture, forestry, fishing	x1.0	+0.0	0%	x1.35
15	Water transport	x1.0	+0.0	0%	x1.0
16	Air transport	x1.0	+0.0	0%	x1.0

The FPA results for the city of Rhodes with high community resilience are shown in Figure 9. Like in the low or moderate resilience FPAs, "Water transport" was found to be the most critical business sector of Rhodes, with its SSA resulting in total indirect losses equal to 10.3% of city' annual GVA. However, the "Wholesale trade", "Retail trade", and "Warehousing" sectors, while still being on the top of the hierarchy of criticalities, the impact of their SSAs to the economy of Rhodes was significantly reduced thanks to the available overproduction offered by the non-disrupted businesses. Similarly, improved results were reported for the B2B sectors of "Technical activities" and "Finance & Insurance", where the capability of 65% of the businesses to switch to remote working vastly reduced the vulnerability of the entire community of Rhodes to extreme hazards. In general, high level of business resilience can enhance the response of an entire community to CC or non-CC perils, as funds can be concentrated into the restoration of specific critical assets, ultimately enhancing community's robustness and rapidity.

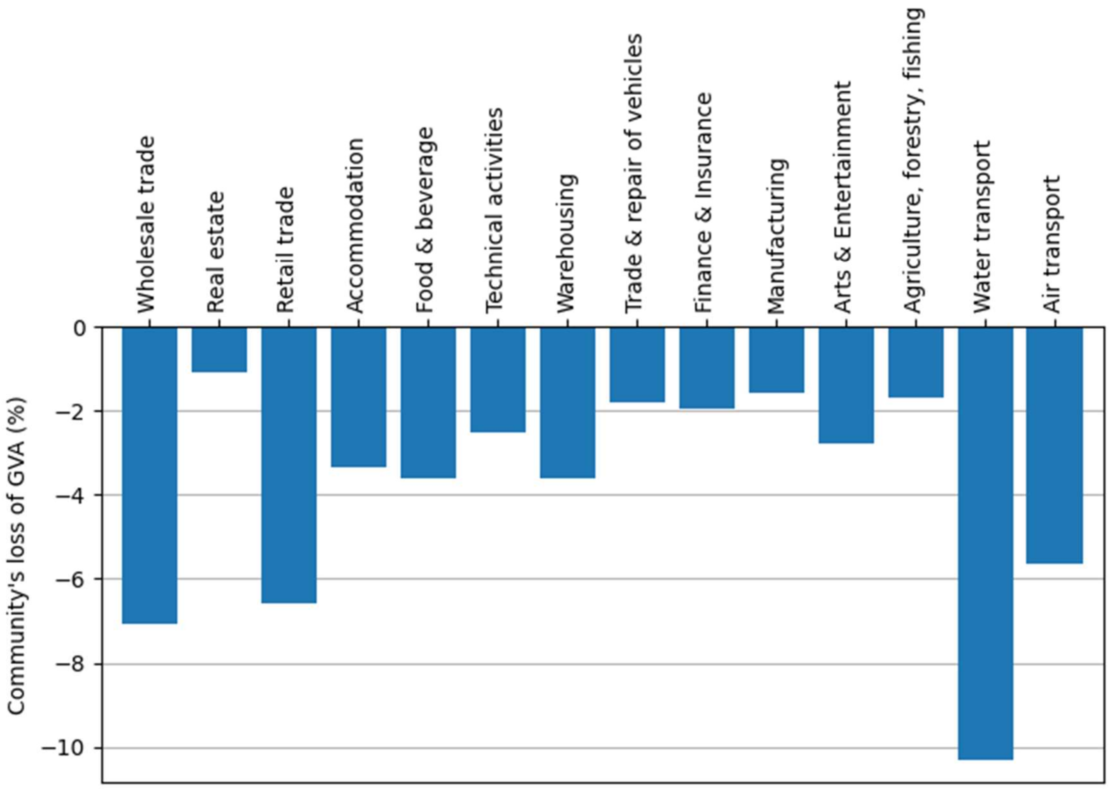


Figure 9: Bar charts from the SSAs conducted for the city of Rhodes, showing the total community indirect losses (high community resilience).

4 Conclusions

A comprehensive methodology to assess the impact of different Standard Response Procedures was examined within Task 7.3 and were summarized in Deliverable 7.4, namely “Standard Response Procedures Document”. The proposed methodology was designed to assist local/regional authorities and external actors during risk mitigation planning and decision-making by defining *a hierarchy of criticalities*. To accomplish this, an event-agnostic Funding Prioritization Analysis (FPA) was implemented, which comprised a series of hypothetical “what-if” scenarios named Sector Shutdown Analyses (SSAs) to assess the importance of each business sector. The SSAs were conducted in the bases of the socioeconomic model that was developed in Task 5.5 of HYPERION and is fully supported by HRAP. Based on the total community losses estimated for each SSA, one can derive the aforementioned hierarchy of criticalities and use it to settle an objective fund prioritization strategy. The key steps of the proposed FPA were demonstrated using the socioeconomic model developed for the historical city of Rhodes. The FPA highlighted that the most critical sectors were related to the key elements of the supply chain, namely the marine port, airport, wholesale, and retail. Moreover, important B2B sectors were also found to play a significant role in the functionality of the entire CH community, especially when no BCSs were adopted. By considering a moderate or high resilience community framework, the importance of the marine port became the dominant infrastructure that could potentially lead to the complete paralysis of Rhodes’ economy. In general, high level of business resilience were ascertained to enhance the response of the entire community to CC or non-CC perils, as reconstruction funds could be efficiently concentrated into the restoration of specific critical assets, ultimately enhancing community’s robustness and rapidity.

5 References

Elime, https://www.elime.gr/index.php/rodos

ELSTAT, www.statistics.gr

Eurostat (2008). *NACE Rev. 2: Statistical classification of economic activities in the European Community*, Luxemburg. ISSN 1977-0375

Fortifications of Rhodes (2022). In *Wikipedia*. https://en.wikipedia.org/wiki/Fortifications_of_Rhodes

Franchin P., Cavalieri F. (2014). *Probabilistic assessment of civil infrastructure resilience to earthquakes*, Computer-aided Civil and Infrastructure Engineering, **30**. https://doi.org/10.1111/mice.12092

Fraport, https://www.fraport-greece.com/ell/texnognosia-kai-ypiresies/aerometafores/epibatiki-knisi

Hallegatte S. (2008). *An adaptive regional input-output model and its application to the assessment of the economic cost of Katrina*, Risk Analysis, **28**(3), 779-799. https://doi.org/10.1111/j.1539-6924.2008.01046.x

Marasco A. (2008). *Third-party logistics: A literature review*, International Journal of Production Economic, **113**(1), 127-147. https://doi.org/10.1016/j.ijpe.2007.05.017

NAIC, https://content.naic.org/

Perry R.W., Lindell M. K. (2003). *Preparedness for Emergency Response: Guidelines for the Emergency Planning Process*, Disasters, **27**(4), 336–350. https://doi.org/10.1111/j.0361-3666.2003.00237.x

Rhodes (city) (2022). In *Wikipedia*. https://en.wikipedia.org/wiki/Rhodes_(city)

Timmer M.P., Dietzenbacher E., Los B., Stehrer R., de Vries G.J. (2015). *An illustrated user guide to the world input-output database: The case of global automotive production*, Review of International Economics, **23**(3), 575-605. https://doi.org/10.1111/roie.12178