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Applied Wargaming- a tool for Integrated Disaster Risk Management

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Abstract: The study introduces a historical perspective on the evolution of disaster risk management, highlighting the shift in focus from a reactive response to disasters to an integrated and proactive management of risk reduction. The importance of applied wargaming is pointed out as a dynamic and effective tool for experiential learning and the improvement of strategic decision-making skills in complex situations.

The development of the "General Belgrano" wargame carried out in 1999 is herein described, which focuses on the flood simulation of the city of Goya, Argentina, in 1998. The objective was to assess potential responses and risk management strategies before, during and after the disaster, involving various actors and government agencies.

The article focuses attention on the lessons learned from the exercise and the importance of awareness-raising, the integration of risk reduction into development policies, the comprehensive assessment of the disaster cycle, and the inter-agency collaboration. Finally, it emphasizes the potential of new technologies to improve the efficiency and effectiveness of future emergency management.

Keywords: disaster risks management, applied wargaming, simulation, floods, experiential learning, strategic decision-making, interinstitutional coordination, risks reduction.

1. INTRODUCTION

Applied wargaming combines simulation with the "active" participation of actors to address complex and challenging situations. It is a dynamic and effective methodology whose main purpose is achieving experiential learning and improving individual and collective expertise to learn, practice and increase responsiveness to simulated real-world situations.

Wargaming allows participants to interact with VUCA scenarios (volatile, uncertain, complex, and ambiguous), taking on specific roles and training strategic decision-making under pressure, resource management, problem solving and effective communication, thus simulating the complexity and stresses of reality.

Examples include government crisis simulations, disaster management exercises, and corporate strategic decision-making training.

Paraphrasing (Perla & McGrady, 2011) (Perla, Markowitzl, & Weuve , 2004) applied wargaming offer us a promising means to prepare decision-makers in the complex and uncertain environments that the pace and depth of change, in the global dynamics, are driving at ever more dizzying speeds and in ever more surprising directions.

They focus on the human beings who make decisions and deal with the consequences of those decisions, but not on the action of real forces.

If we accept the notion of the three domains of real warfare (Alberts, 2001) (physical, informative and cognitive) and adapt them to these new scenarios, then the wargame designer must somehow condense that real universe into the game universe. It does so by combining the six dimensions of war games (time, space, forces, effects, information, and command) to form three interconnected network topologies: operational, informative, and command.

These topologies are the interfaces and engine through which players enter and transform the game universe. The measure of game realism is how well the relationships that players have with these topologies reflect the relationships that real-world decision makers have with real-world domains.

2. A HISTORIC INSIGHT

To understand the relevance of applied wargaming in the context of natural disasters, and in particular the case that will be presented, it is essential to consider the historical evolution of risk management of this type.

In the 1960s, responses to events such as earthquakes, floods and eruptions were approached from the perspective of physical or "hard" sciences, integrating disciplines such as seismology, volcanology, meteorology, etc. (Gellert-de Pinto, 2012). However, these approaches considered disasters as isolated events from their social context.

From the years 1970-1980, as it was pointed out by (Gellert-de Pinto, 2012), the probability of loss began to be calculated, recognizing that disasters were not simply natural events, but were related to extreme physical impacts that also affected the social and economic aspects. Thus, we begin to understand that risk is not synonymous with natural hazards and therefore that disasters are related to extreme physical impacts (Rosales-Veítia, 2021).

This approach introduced the notion of risk as a function of threat and vulnerability, which marked a significant shift in the understanding of disasters. Thus, emerged in 1980, what (Sanahuja Rodríguez, 1999) calls "the prototype conceptual model of risk" that defines risk as the product of threat and vulnerability. This equation is used to make it understood that disaster risk is the result of a dynamic and dependent relationship between these two factors.

It was not until 1980 that the social sciences addressed vulnerability as a determining factor in the cause of disasters or the formation of risks, incorporating society as an active factor in the formation of risk (Gellert-de Pinto, 2012) through economic, social, political and environmental processes specific to society in general or to certain social groups and their environment.

This development culminated on 11 December 1987, with the adoption of Resolution 169 of the 42nd United Nations General Assembly, which proclaimed the 1990s the "International Decade for Natural Disaster Reduction" (IDNDR), thus launching the systematic efforts of the international community to reduce the risk of disasters. (UNDRR, 2021)

This document was the first of its kind in the world to focus more on actions that can be taken before disasters occur, rather than on the trend of ex post facto response. (Molin Valdés, 1997)

It basically posits that disasters are an unresolved development problem, as they manifest themselves mostly in areas where there has been unplanned

population growth. The position of the relationship between the natural and the structural organization of society emerges. (Rosales-Veítia, 2021)

In this sense, and according to (Molin Valdés, 1997), the goal of the Decade was: "To reduce, through concerted international action, particularly in developing countries, the loss of life, material damage and social and economic disruption caused by natural disasters".

In other words, the risks of disasters that are conceived during this period are purely natural and the reduction efforts revolve around them. Therefore, the knowledge, technology and experience gained to observe and monitor the threats begins to be applied as a strategy for reducing exposure to them.(Rosales-Veítia, 2021).

During the "Decade", the occurrence of disasters was associated with natural threats to human settlements, and States should therefore take steps to assess, monitor and, to the extent possible, contain disasters.

Between 1980 and 1985, global floods affected areas inhabited by 185 million people, leaving some 20 million homeless and causing some 30 000 deaths. (PAHO, 1990)

According to the Regional Report on Disaster Risk Assessment in Latin America and the Caribbean of the United Nations Office for Disaster Risk Reduction between 1997 and 2017, one in four disasters worldwide occurred in the Latin American and Caribbean region. Nine out of every ten people affected by these disasters were affected by weather events (mostly floods, some of which could have been predicted). Seven out of ten disaster deaths were caused by geologic hazards (mainly earthquakes) (UNDRR, 2021)

In addition, Latin America and the Caribbean, with updated data, is the second most disaster-prone region in the world (1 205 natural disasters). It is estimated that 53% of global economic losses from climate-related disasters occurred in Latin America and the Caribbean, representing only 9% of the world's population, and where 340 million people live in cities that are highly vulnerable to disasters. Disaster losses are also estimated at 1.5% of regional gross domestic product (GDP) in Latin America and the Caribbean (United Nations Office for Disaster Risk Reduction (UNDRR), 2021, Regional Assessment Report on Disaster Risk in Latin America and the Caribbean). (Girot Pignot, 2021)

FIGURE 1
Evaluation Report Regional Report on Disaster Risk in Latin America and the Caribbean.

Source: UNRDD/RAR

Many of its effects stemmed from a lack of planning, preparedness and preventive action. Failure to develop the capacity to react to the imminence of the risk or to be prepared to take rapid and effective action transformed the risk into a disaster.

In developing countries, these phenomena tend to be much more severe, and the challenges to disaster prevention arise from a variety of factors. These include the lack of conviction among planners and government officials about the value of comprehensive disaster reduction plans, the lack of trained disaster preparedness personnel leading to a lack of understanding of these plans, the absence of disaster prevention education in educational programs, difficulties in maintaining effective monitoring and reporting systems for potentially severe but infrequent disasters, the lack of reliable documentation of disaster experiences and contingency plans, the limitation of disaster reduction activities to post-disaster assistance programs only in the aftermath of disasters, integration into economic development plans, lack of cooperation between neighboring countries facing similar risks, urban growth that concentrates populations in highly vulnerable areas, poor understanding of the benefits and cost-effectiveness of preventive measures, and subjective perceptions of the costs of disaster preparedness and the prohibition of certain activities as preventive measures (PAHO, 1990).

Over time, these losses have ceased to be merely a temporary interruption in the development of a particular country to a continuous decline in national wealth. While the average loss may be equal to or less than 1% of the annual gross

domestic product (GDP) of a country with high social and economic development, the losses experienced by developing countries are proportionally greater and, in some cases, have amounted to 100% of annual GDP.

That is why an integrated and multidisciplinary approach was needed at that Assembly to achieve positive results.

3. COORDINATION OF EMERGENCY RESPONSES IN ARGENTINA: OPTIMIZATION OF GOVERNMENT ACTION

By the end of 1998, the Argentine National State, as lesson learned from the coastal floods of that same year, from the experience gained by the National Commission for the Recovery of Areas Affected by Climatic Emergencies (CONAREC) (1998) - as a body for coordinating the National State's response to disasters, and considering the country's geographical, meteorological, climatic, geological, and demographic features - as well as the country's level of industrial development, which indicated that many cities and vast regions were affected by disasters, took the initiative of establishing a coordination forum to ensure the National State's capacity and efficiency in dealing with such emergencies.

Thus, on 4 November 1999, Decree No. 1250/99 (1999) was promulgated, establishing the Federal Emergency System (SIFEM) within the office of the Chief of the Cabinet of Ministers, with the following objectives:

- Form a coordination forum aimed at preventing or reducing loss of life, property damage, and social and economic disruption caused by natural or man-made phenomena.
- Improve governance by establishing coordination at the national, provincial and local levels of all competent sectors, through the formulation of policies and the definition of coordinated and comprehensive courses of action to prevent, mitigate and assist from the National State those affected by emergencies, optimizing the allocation of resources.

SIFEM was conceived as a state policy, which should transcend political boundaries and bring together all those responsible at the three State levels to respond to and prevent emergency or disaster situations.

4. WARGAMING APPLIED TO DISASTER RISK MANAGEMENT: FLOODS IN THE CITY OF GOYA, PROVINCE OF CORRIENTES, ARGENTINA

Prior to the signing of the Federal Emergency System (SIFEM) creation decree, the "General Belgrano: Floods in the City of Goya of April 1998, Province of Corrientes, Argentina" wargame was held in October 1999. This exercise took place at a time when SIFEM had not yet been formally established, and all the bodies that would later make it up were convened.

This wargame marked a step forward in anticipation of the decree promulgation that would set the framework for emergency management at the national level.

The Ministry of Defense, through the Joint Chiefs of Staff, organized this exercise and it was carried out at the Argentine Naval War College, which set up and directed the development of this simulation.

This initiative was presented as a crucial milestone in preparing and structuring disaster response at the national level, enabling strategic anticipation and a deeper understanding of the challenges and capacities required to deal with emergencies such as the 1998 floods in Goya, Corrientes.

5. DISASTER MANAGEMENT VS. INTEGRATED DISASTER REDUCTION MANAGEMENT

It is noteworthy that, at the time, the model applied focused on Disaster Management, an approach that prioritized response to and mitigation of the effects of disasters once they had occurred. This approach was based on reactive actions to respond to emergencies and reduce their immediate impacts on the affected population and infrastructure.

However, since then there has been a significant evolution towards the Integrated Disaster Reduction Management (GIRD) approach. Unlike the previous model, GIRD is based on preventive and proactive actions that seek to reduce both vulnerability and exposure to disaster risks.

This expanded approach incorporates preparedness, prevention and recovery measures, prioritizing long-term planning, early risk identification, education and public awareness, as well as strengthening community and government capacities to address challenges more comprehensively.

The main difference lies in the paradigm shift from a reactive response to a more holistic management that seeks to address the root causes of vulnerability to disasters, involving various sectors and promoting a more preventive and sustainable approach. This shift is reflected in a greater focus not only on

immediate disaster response, but also on risk reduction and building long-term resilience in communities and institutions.

6. DEVELOPMENT OF APPLIED WARGAMING

The Disaster Risk Management Applied Wargaming "General Belgrano" focused on a specific case of natural disaster: the flood that affected the city of Goya in the province of Corrientes, Argentina, in April 1998.

In 1998, the city of Goya experienced devastating flooding of the Paraná River. This disaster seriously affected the lives of the population, causing significant damage to infrastructure, economic losses, and the massive evacuation of residents.

The losses were substantial in all sectors: housing, infrastructure, services, natural resources. The service most frequently affected was transportation: 70% of the times a disaster occurred, transport routes–ways, roads, bridges, railways– were, permanently or temporarily, affected or rendered inoperable or resulted in the interruption of public services.

Another hard-hit sector is agricultural production, which has lost millions in pastures, crops (mainly cotton, sorghum, maize, rice, soybeans, sunflower, wheat, citrus fruits, tobacco, alfalfa), horticulture, and livestock.

The chronicles of the time were dramatic. Both national and provincial media covered what was anticipated to be a historic flood comparable to that of 1911 and 1965.

One of the federal capital's newspapers described the following

> "In Goya, no one remembers a flood like this. The stories of the shipwrecked compete in drama with the figures. In the area, there have already been 7 dead, 1.5 billion lost in crops, and 40,000 evacuees. San José's church in Goya was used as a center that now houses 120 evacuees. Most have lost everything." (2018)

Wargame Overall Objective

The overall objective was to implement the methodology of Applied Wargaming in this scenario, i.e. to simulate and assess possible risk management strategies and responses before, during, and after a disaster, the 1998 flood in Goya on this occasion.

It included coordinating rescue efforts, allocating resources, communicating with the population, and long-term planning for recovery.

Specific Objectives

Specific objectives were:

- Train the organization in disaster management (flood).
- Exercise decision-making processes.
- Allow the assessment of plans and test modes of action. (Organization, Modes of Action, Communications, Logistics, among others).
- Allow the assessment of interagency coordination and response.
- Train in the relationship with mass media.
- Allow the alteration of the situation to reorient or modify courses of action or to come up with different alternatives.
- Use efforts efficient, effective, and economically (HR, material resources, financial resources and response time).
- Allow each decision-making level to monitor the actions taken.
- Evaluate, analyze and draw conclusions for the optimization of plans and training.

Wargaming Design and Development

Regarding wargame design, the six dimensions of wargaming were taken into account: time, space, forces, effects, information, and command to form the three interconnected network topologies: operational, informative, and command.

Wargaming Dimensions

- Time: It was developed over a simulated period representing the weeks before and after the floods of April 1998 in the city of Goya, ranging from the early warning to the recovery phase.
- Space: The simulation was carried out in the specific area of the city of Goya, affected by these floods. The topography, urban infrastructure, evacuation routes, and critical areas affected by floods were taken into consideration.

  This area is in the coastal region of Argentina defined as the region formed by the provinces of Santa Fe, Formosa, Chaco, Entre Ríos, Corrientes, and Misiones.
- It covers an area of 494,487 km2 (17.1% of the country's total area) and comprises 1,103 departments in the 6 provinces. The region accounts for 20.76% of the country's total population, or about 7.5 million inhabitants (table 1) as shown in image 1 (Celis, 2006).

- Forces: SIFEM-based agencies, various actors and institutions, such as local authorities, rescue services, emergency personnel, the civilian population, NGOs, and government agencies at the local, provincial and national levels joined the involved actors envisaged in GADE. Each of them had their specific roles and resources to mitigate, respond and recover from floods.
- Effects: It allowed the assessment and simulation of flood impacts in terms of damage to infrastructure, human losses, displacement of people, resources needed for relief and recovery, as well as economic and social repercussions.
- Information: Realistic and simulated information was provided on climate, weather forecasts, water levels, available resources, responsiveness, evacuation plans, early warning systems, and coordination among the various actors involved.

Meteorological and hydrological data were taken during the weeks leading up to the floods in Goya, which showed a climate pattern characterized by abnormally high rainfall in the region. Persistent and significant rainfall was recorded in areas close to the rivers draining in the Goya area, increasing water levels progressively.

The steady increase in rainfall generated a hydrological scenario of growing concern. Rivers in the vicinity of Goya, such as the Paraná River and the Uruguay River, experienced a progressive increase in their levels, reaching heights that exceeded normal values for that time of year. These high water levels were early signs of a potential flood risk.

In 1998, three significant events occurred simultaneously: the persistence of the "El Niño" phenomenon, the persistence of high levels of atmospheric humidity on the coast and the arrival of autumn with the usual local seasonal changes.

It brought about an overflow of the Paraná River, recording in Goya a maximum of 7,07 m (May 7, 1998), which is the second most relevant record in the historical record series, as well as an excessive 500 mm accumulated rainfall (March 6, March 20, April 11, and April 15, 1998).

As the weeks went by, hydrometeorological reports indicated a continuous increase in rivers water height, raising concern among local and regional authorities. Measurements and projections indicated that the predicted rainfall could aggravate the already critical situation, alerting to the

FIGURE 2

Disasters in the Coastal Region of Argentina

Image 1
Coastal Region

Table 1
Coastal Region, Population, and Area

Province	Area (km²)	Population	Departments	Inhab. / km²
Corrientes	81.199	930.991	25	10.6
Chaco	99.633	984.446	24	9.9
Entre Ríos	78.781	1.158.147	16	14.7
Formosa	72.066	486.559	9	6.8
Misiones	29.801	965.522	17	32.4
Santa Fe	133.007	3.000.701	19	22.56
Total región	**494.487**	**7.526.366**	**110**	**15,22**

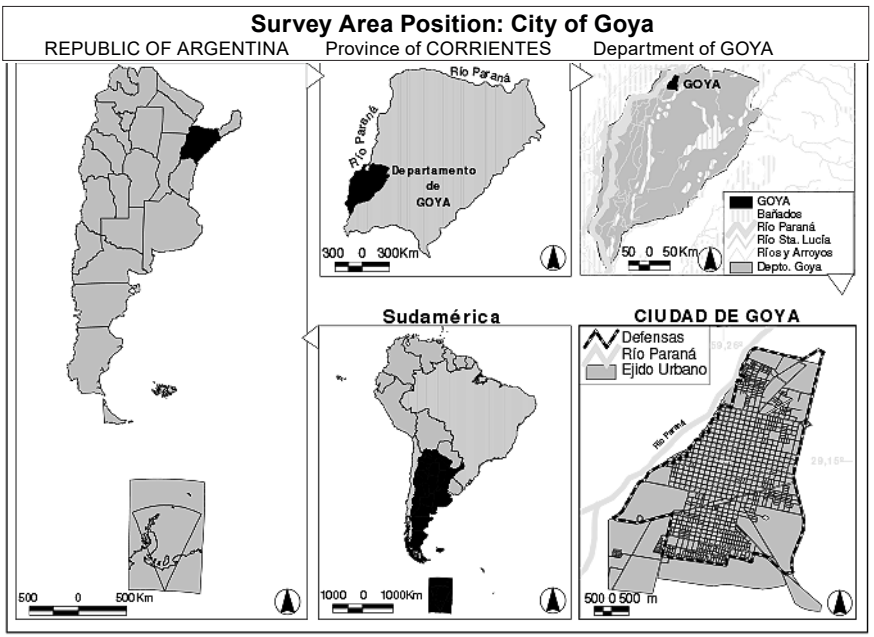
3

4 New departments established as of 1995 are not considered in DesInventar database. Therefore, 2 de abril (Chaco) and San Salvador (Entre Ríos) departments are not listed.
Data from the National Institute of Statistics and Censuses.

Source: National Institute of Statistics and Census of Argentina.

FIGURE 3

Map of Urban Susceptibility to Floods.



Source: (Soldano, Girau, & Goniadzki, 2007)

possibility of overflow and the consequent flooding threat in the city of Goya and surrounding areas.

The early warning period marked a milestone in preventive measures and the activation of emergency protocols. As the rivers reached alarming levels, evacuation actions were implemented and efforts to monitor and communicate with the population were intensified.

During the post-flood phase, recovery became the priority. Damage assessments were carried out, assistance programs were implemented, and efforts were made to rehabilitate the affected infrastructure and services with the aim of restoring normalcy to the city of Goya after the impact of floods.

- Command: Participants took on leadership roles, ranging from local authorities to representatives of government agencies, and they had to make strategic decisions, coordinate efforts, allocate resources, and direct flood response operations.

7. LEARNED LESSONS AND A LOOK INTO THE FUTURE

The "General Belgrano" wargame not only provided a strategic advance for emergency management, but also left fundamental lessons to guide the future of integrated disaster risk reduction management.

The simulation marked a milestone by providing an interactive and realistic platform to understand challenges and capabilities given extreme natural events. This set a significant precedent in the preparation and structuring of the national response to emergencies, evidencing a transition to a more comprehensive approach to disaster reduction.

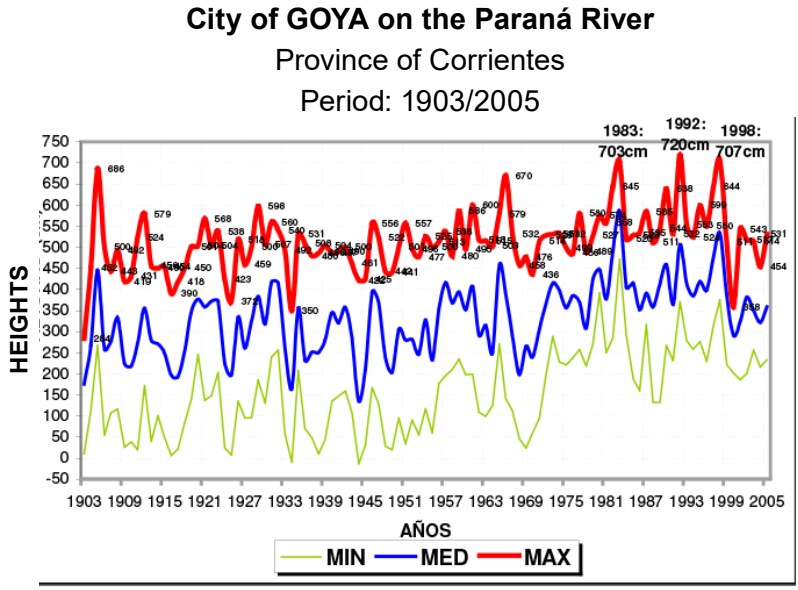
In turn, the importance of raising awareness of natural risks, the integration of risk reduction into development policies, the comprehensive assessment of the disaster cycle and the collaboration among different actors stand out among the valuable lessons learned.

Looking ahead, the new technologies and developments used in "applied wargaming" for such scenarios will be expected to further boost the efficiency and effectiveness of emergency management.

These advances will be a valuable tool as they will enable faster and more accurate decision-making, improve strategic planning and emergency responsiveness, and promote synergy and real-time information exchange during crisis situations by facilitating interagency coordination that will have a positive impact on strengthening early warning systems, optimizing resources and

FIGURE 4

Hydrograph showing maximum, mean, and minimum annual readings for the historical record series of the Goya hydrometric scale



Source: INA (Soldano, Girau, & Goniadzki, 2007)

budgets, promoting education and public awareness, and fostering teamwork and coordination between agencies and sectors.

In short, the future of emergency management looks towards a deeper integration of advanced technologies and a collaborative approach that builds on past experience to better anticipate and manage the challenges of future catastrophic events.

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