# Optimization of the Critical Infrastructure Sector - Food Safety and Food Security Through Blockchain

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**Abstract:** The study of critical infrastructures in Romania is necessary to surpass the generalist approach, which has been preferred so far in the few specialized studies that have been carried out. Of course, a general view on the sectors, subsectors or criteria that qualify certain entities as critical infrastructure was extremely necessary in order to identify the effects of affecting the activities of these entities or to set up plans for crisis management or clear procedures for their routine operation. But for a country in order to become competitive and to succeed beyond the current level, it is necessary to approach the critical infrastructure subsectors in order to identify and propose new ways to optimize them, especially by incorporating the latest technologies. In this paper we aim to address the need to optimize the traceability of food products using blockchain technology, respectively a chain of blocks that stores information, which once received a timestamp can no longer be modified.
**Keywords:** blockchain, food products, traceability of good products, critical infrastructure

## INTRODUCTION

The increase of complexity in the contemporary society has brought fundamental challenges to ensure the national security and the daily safety of the citizen. Today, we are discussing not only about the traditional military threats, but also about a series of threats to the welfare of the citizen and the social order.

Institutions responsible for ensuring daily needs such as water, food, heat, light, transport have become more and more significant, but at the same time, as technologies have increased in complexity and breadth, their vulnerability has been become obvious. A relatively small number of resources and people aggressively directed at them could have effects difficult to estimate or to combat. On the other hand, at present there is an amazing movement of people, resources, capital, which are connected through cross-border transport routes. The threats against them, included in the category of asymmetrical threats, can endanger the good functioning of the company and can give rise to social movements that determine fundamental transformations of the community.

The need to protect these institutions was understood by each state, but also by the supranational structures that were concerned with identifying the best solutions that would ensure the safety and security of the people.

## ROMANIAN CRITICAL INFRASTRUCTURES

Slowly, these types of institutions were labeled as critical infrastructures, the pioneer of their definition being the United States who promoted this concept in the preamble of *„Executive Order No. 13010 for the Protection of Critical Infrastructure"* (July 15, 1996). There, it was specified that „Certain national infrastructures are so vital that their incapacity or destruction would have a debilitating impact on the defense or economic security of the United States." Proving vision, the Presidential Commission for Critical Infrastructure Protection has joined the computers field next to electricity and communications, considering them to be those elements on which the whole industry depends.

Subsequently, *the Presidential Directive (PDD) no. 62 - „Protection Against Unconventional Threats to Homeland and American Overseas"* and *the Presidential Directive (PDD) no. 63 „Critical Infrastructure Protection", promulgated on May 22, 1998* had as an objective the regulation of this area.

Only in 2004 was adopted the first critical infrastructure protection initiative, *Communication on Critical Infrastructure Protection in the fight against terrorism*, with the aim of managing terrorist threats in case of critical infrastructures, and in 2005 was released *the Green Paper on the European Critical Infrastructure Protection Program (PEPIC)* and *the Critical Infrastructure Warning Information Network (CIWIN).*

The main European document in the field of critical infrastructures *The Council Directive 114 of 8 December 2008 on the identification and designation of European Critical Infrastructures*, offers a framework for the protection of critical infrastructures which was subsequently taken over and customized to the internal situation of each member countries.

According to Council Directive 2008/114 / EC, art. 2a, critical infrastructure is „an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact on a Member State as a result of the failure to maintain those functions. „

Therefore, in *Emergency Ordinance 98/2010*, Romania defines the concept of critical infrastructure at its turn, considering it to be: „an element, system or component located in national territory which is essential for the maintenance of the vital functions of society, health, safety, security, social or economic well-being of persons and whose disruption or destruction would have a significant impact at national level as a result of the inability to maintain those functions".

Therefore, the Romanian definition of critical infrastructure is a transposition of the European approach, being conceptualized by reference to the safety and security of the citizen. The identification of the sectors and sub-sectors specific to the critical infrastructures was achieved having this criterion as an organizing factor.

Ordinance 98/2010 lists a number of ten sectors for critical infrastructures: Energy (1. Electricity, including nuclear power - capacities and installations for production, storage / storage, distribution and transport networks, 2. Petroleum and petroleum derivatives - capacities and installations for extraction / production, refining, treatment, storage, distribution and transportation through pipelines, terminals, 3. Natural gases and natural gas derivatives - capacities and installations for extraction/ production, refining, treatment, storage, distribution and transport through pipelines, terminals, 4. Mineral resources), Information and communications technology (1. Systems, networks and communications services, 2. Systems for data processing, processing and storage, including electronic public services, 3. Information security infrastructures, 4. Systems and networks communications for the state code, 5. Radio broadcasting infrastructures -tv, 6. Postal services nationwide), Water supply (1. Supply of drinking water, 2. Water quality control, 3. Water quality monitoring and control), Food (1. Production and supply of food, ensuring food safety and security), Health (1. Medical

and hospital care, 2. Medicines, sera, vaccines, products pharmaceuticals, 3. Biolaborators and bioagents, 4. Emergency medical services and health transport), National security (1. Country defense, public order and national security, 2. Integrated system for state border security, 3. Defense industry, production capacities and installations and storage), administration (1. Services and administration, 2. Emergency services), transport (1. Road transport, 2. Rail transport, 3. Air transport, 4. Naval transport), Chemical and nuclear industry (1. Production, processing, storage and use of chemicals and nuclear materials and radioactive, 2. Product pipelines/Hazardous chemicals), Space and research (Space).

Within these sectors and subsectors, numerous institutions that meet the criteria for defining critical infrastructures may be identified. They have to work with the precautions and attention necessary to carry out their activity without any syncope.

As it is not possible to have an inclusive analysis of all critical infrastructures, we intend to analyze in this paper the food safety and security subsector from the perspective of how contemporary technological developments can contribute to the optimization of its specific activities. After a brief review of the meaning of the concepts of food safety and food security, we will try to explain how the new technology, especially blockchain may help the process.

## THE CONCEPT OF ENSURING FOOD SAFETY AND SECURITY:

The innovations in the field of digital communications and technologies, nanotechnology and biotechnologies have multiple applications nowadays. We may even formulate the hypothesis that there is a directly proportional correlation between the importance of a particular field for social life and the number of innovations it absorbs. Having the same reasoning, the field of traceability of food products should fully benefit from each of these cutting-edge technologies.

Animal biometrics (which can collect and transmit information in real time), precision agriculture (air and soil sensors, crop sensors, satellite imaging that allow substantial savings and increased productivity through optimized agribusiness treatments differentiated by digital technologies), synthetic biology (which uses programming methods in biology for remediation of biological systems), genetic technologies are just a few examples of variables that can impact the rhythm, quality, cost and impact of food production. For example, it is estimated that by 2028, synthetic biology will be able to produce different types of food *[Policy Horizons Canada, 2014]*.

In these conditions of permanent change of the status-quo and of a fierce innovation-based competitiveness of countries, a fundamental condition of good governance is the ability to meet the food needs of the population, under conditions of maximum safety and with minimum costs, especially as optimal exercise of this function is reflected in other important sectors such as population health, food routine and culinary habits developed.

Ensuring food production, as a classic function of agriculture, makes it play a central role in contemporary societies *[Andrei, Mieilă and Panait, 2017; Istudor et al., 2014]*, mobilizing important financial and labor resources. Food production is closely correlated with the availability and quality of the natural resources it uses and is dependent on at the same time, having a decisive impact on the quality of population's health and the food model it develops.

The Common Agricultural Policy is concerned with these topics, and among the objectives assumed, ensuring food safety and security occupies a priority place *[Andrei and Darvasi, 2012; Turek Rahoveanu and Turek Rahoveanu, 2013; Greer, 2017]*.

When discussing the concept of food safety and security, it is preferred to use the term rather than each concept separately, as their meaning are often overlapping or confused *[Hanning et al., 2012]*.

The meanings of the concept of food safety have undergone mutations caused by the changes in the agricultural paradigms, by the ownership of agricultural lands, by the supply-

demand dyad and by the regulation of the price mechanisms of the agri-food products *[Pinstrup-Andersen, 2009]*. Still, food security is a complex goal that applies to all food products, whether of animal or vegetable origin, regardless of how they are processed, the distribution chain or the target markets for them *[Post, 2006; Aoki, 2011; Strauss, 2014]*.

Sustainable development of the global economy is impossible to be imagined in the absence of food security *[Zanin et al., 2017, King et al., 2017]*, because the interdependencies of regional markets have reached a level difficult to imagine in the past. Any problem that has arisen in a community can have repercussions on the population from all corners of the world. An unsafe food product may be the source of difficult to manage pandemics and traceability may be an important part of solution in such cases. Situations like this have generated numerous crises worldwide, with serious effects such as panic in communities, boycotting of certain industries due to population fear. The management of these crises required significant human, financial and logistical expenditure, persuasive communication plans, additional advertising budgets *[Lesenciuc and Nagy, 2008, Dima and Vlăduțescu, 2018]*.

Therefore, the global dimension has become a constant of studies regarding food safety and security, and this approach is present also in Romanian studies *[Ene, 2009; Neagu, 2015]*.

Being aware of the amplitude of the subject, we will continue to approach, in a narrowed perspective, one aspect of the range of possibilities that the future offers us, respectively how the ICT industry can contribute to improving the food safety and security sector by using blockchain technology for optimization of food traceability.

## BLOCKCHAIN TECHNOLOGY

Blockchain technology, which has begun to be talked about in the last decade, is not a fundamentally new technology, but just an innovation of a technology that was founded in the 1950s by Hans Peter Luhn, an IT engineer from IBM. He has created the hashing algorithm, which has since become a key component of blockchain technology *[Stevens, 2018]*. But what is this technology and what is it used for?

Blockchain is that digital technology that is profoundly changing the way the world works today. Anyone who has bought a home, registered a car or transacted business knows how complicated the bureaucratic processes that govern such situations are. In short, blockchain technology redefines all these processes and, along with them, many other processes in our daily lives *[Gupta, 2020, 3]*. However, to be very clear, when we talk about blockchain, we are not referring to Bitcoin, but to technology that manages applications like Bitcoin and extends far beyond Bitcoin.

It is true that Bitcoin has favored the development of blockchain technology, but at blockchain we have to think like of an operating system, such as Microsoft Windows or MacOS, that manages Bitcoin applications. The blockchain offers the means of recording transactions, in the form of a common register, which can be used to record any transaction and to track the movement of any asset, tangible / intangible / digital *[Gupta, 2020, 6]*. For example, with the help of blockchain technology, financial transactions can be settled in minutes instead of days. Also, blockchain technology is used to help companies manage the flow of goods and make appropriate payments, or it can facilitate manufacturers to share their production processes with manufacturers of specific equipment to optimize their business.

Blockchain looks like a common, immutable registry that facilitates the process of recording transactions and tracking assets on a professional network. An asset in such a network can be tangible (a house, a car, money, land) or intangible (patents, copyrights, brands) *[Gupta, 2020, 7]*. Virtually any type of asset can be tracked and traded using blockchain technology. This reduces the risk of operations, trading costs and minimizes the efforts of everyone involved.

An example where blockchain technology has proven useful is in the food industry. In this area, the blockchain ensures high transparency

of food production and trading processes, so that it contributes to improving food security, reducing food waste, preventing food fraud and ensuring the sustainability of our food. Given the importance of this technology for the food industry, in particular for ensuring food safety and security, we intend to highlight how blockchain contributes to the fulfillment of these desires by ensuring the transparency of the production processes and the tracking of food traceability.

## FOOD PRODUCTION AND BLOCKCHAIN TRACEABILITY

Economic processes and global trade are becoming increasingly difficult to imagine without the use of blockchain technology. Every industry, including the food industry, seems to consider blockchain a revolutionary power, a technology that could significantly change that field.

When we think about our food supply, we realize that we don't know many things that if we knew, we would be shocked. The World Health Organization estimates that nearly 1 from 10 people get sick every year due to the consumption of contaminated food *[WHO, 2015]*. The global demand for food has become so vast and complex that it is almost impossible for producers and retailers to guarantee the provenance of their products. Thus, both producers and food traders will be tempted to profit by introducing counterfeit or questionable products into the circuit. Such practices are by no means a novelty if we think about how, in the 17th century, some traders doubted milk with water or added chalk to bread to squeeze as much profit as possible.

Although the technology used in the food industry has improved, similar methods used in the 17th century can still be found today. Here we can remember the food fraud scandals such as that of UK horse meat in 2013 *[Guardian, 2016]*, that of peanut butter with Salmonella in 2009 (Andrews, 2009) or the latest scandal surrounding two of the largest meat production companies in Brazil *[Economist, 2017]*. Such outrageous events naturally draw attention to food safety and security and the measures that need to be taken to prevent them from recurring. For food producers and traders who end up in such situations, the consequences can be serious. The cost of a food fraud verdict can be up to 15% of the company's annual revenue, not to mention the damages to the brand reputation that are inevitable (PWC).

The financial crisis of 2008, which led to the lowering of public confidence in the banking sector, led the specialists in this field to seek technological solutions to control the gaps in this field and regain people's confidence. This approach is also valid for other areas of activity such as the food industry. Just as it was necessary to regain people's confidence in the banking system, so too do producers and traders in the food industry need to regain and maintain consumer's confidence. This is why the search of specialists in this field should be focused on keeping industrial processes and specific commercial transactions under control using the most advanced technologies, such as the blockchain.

But according to Racheal Botsman (2015), in the implementation of new technologies, everything starts with a progressive understanding of trust. Moving from a trusted institutional system to another distributed system is not a simple one because, says Botsman, *institutional trust is not designed for the digital age*. To support his idea, Botsman presents the blockchain as an example of a trusted, distributed digital technology system that, she says, has huge potential for the food industry. Such a system is extremely useful in complex supply chains, as it increases trust and ensures compliance with processes and transactions. The Economist (2015) rightly called the blockchain *The Trust Machine*.

The benefits of this technology for the food industry are not hard to estimate. For food manufacturers, the use of blockchain technology means that food products that pass through the supply chain can no longer be altered before they reach the buyer. For consumers, blockchain technology guarantees that the food they buy is exactly what the label says it is.

Thus, blockchain technology takes the power of information from the hands of producers and

traders and puts it in the hands of the consumers *[Hui 2016]*. By using a special barcode and a smart mobile phone, consumers can scan the label of a product and get a complete history of that food. This is extremely important, especially to discover those gray areas of food traceability, such as identifying the country of origin. This is a very important aspect regarding the origin of food products which can be very difficult identified. For example, a producer can claim to process Romanian pork, and he actually brings imported pork that he can only process in Romania. However, using blockchain technology, this falsification of the origin of processed pork cannot be done anymore, because it helps to record every interaction with such an item by assigning a digital certificate, which cannot be changed or falsified in order to hide the true origin and movement of that product.

Well-intentioned companies need to see blockchain technology as an extremely high advantage and opt for such digital solutions. Companies can no longer rely on the use of sludge-type terms, such as selling healthy or producing bio, the new generation of consumers needs new assurances regarding the quality of the food they consume. We believe that blockchain is a technology that provides a way to substantiate these new guarantees, which can contribute to increasing customer confidence in those companies that consistently provide quality food.

## CONCLUSIONS

The purpose of this paper is to advocate for the implementation of cutting edge technologies in the field of critical protection. To this end, we have exemplified by studying the safety and security of food products supporter and how its performance can be optimized using the blockchain technology.

The food market nowadays is increasingly volatile and full of distrust in the quality of food. Therefore, we believe that the introduction of blockchain technology brings an innovative plus from this point of view by adding an additional level of security for the food industry. We also believe that those companies that will use the blockchain will purchase an insurance policy that is extremely useful in interacting with their customers. Unfortunately, those companies that will reject this approach will take on a risk that could prove extremely harmful at some point.

### REFERENCE LIST

Andrei, J.V. and Darvasi, D. (2012) Perspectives and Challenges in financing the new Common Agricultural Policy: a new paradigm. Journal of Food, Agriculture and Environment, 10(1), 1018–1022

Andrei, J.V., Mieilă, M. and Panait, M. (2017) Transformations of the Romanian agricultural paradigm under domestic economic policy reforms: An analysis during 1960–2011. Land Use Policy, 67, 288–297

Andrews, J. (2009) Peanut Butter Outbreak: Three Years On, Still No Resolution for Some, Food Safety News, 16.04.2012, disponibil pe Internet la adresa: https://www.foodsafetynews.com/2012/04/2009-peanut-butter-outbreak-three-years-on-still-no-resolution-for-some/#.WD7mSqKLTpI

Aoki, K. (2011) Food Forethought: Intergenerational Equity and Global Food Supply - Past, Present, and Future. Wisconsin Law Review, 2011(2), 399–478

Botsman, R. (2015) The Changing Rules of Trust in the Digital Age, 20.10.2015, available at https://hbr.org/2015/10/the-changing-rules-of-trust-in-the-digital-age

Dima, I.C. and Vlăduțescu, Șt. (2018). Persuasion elements used in logistical negotiation: Persuasive logistical negotiation, Saarbrucken: Lambert Academic Publishing

Drăgoi, M.C., Andrei, J.V., Mieilă, M., Panait, M., Dobrotă, C.E. and Lădaru, R.G. (2018) Food Safety and Security in Romania – An Econometric Analysis in the Context of National Agricultural Paradigm Transformation. Amfiteatru Economic, 20(47), 134-150

Ene, C. (2009) Securitatea alimentară–coordonate şi implicaţii. Ploiești: Editura Universităţii Petrol-Gaze din Ploieşti.

Greer, A. (2017) Post-exceptional politics in agriculture: an examination of the 2013 CAP reform. Journal of European Public Policy, 24(11), 1585–1603

Grierson, J. (2016)., Three men charged over UK horsemeat scandal, 26.08.2016, The Guardian, available at https://www.theguardian.com/uk-news/2016/aug/26/three-men-charged-over-uk-horsemeat-scandal

Gupta, M. (2020) Blockchain for Dummies, 3rd IBM Limited Edition, available at https://www.ibm.com/account/reg/ro-en/signup?formid=urx-16905

Hanning, I.B., O'Bryan, C.A., Crandall, P.G. and Ricke, S.C. (2012) Food Safety and Food Security. Nature Education Knowledge, 3(10), 9

Hui, A. (2016) In today's market, your food chooses you, 10.10.2016, available at https://www.theglobeandmail.com/news/national/how-the-food-industry-is-using-canadians-changing-eating-habits-to-market-to-different-generations/article32316327/

Istudor, N., Ion, R., Sponte, M. and Petrescu, I. (2014). Food Security in Romania-A Modern Approach for Developing Sustainable Agriculture. Sustainability, 6(12), 8796–8807

King, T., Cole, M., Farber, J.M., Eisenbrand, G., Zabaras, D., Fox, E.M. and Hill, J.P. (2017). Food safety for food security: Relationship between global megatrends and developments in food safety. Trends in Food Science & Technology, 68, 160–175

Lesenciuc, A. and Nagy, D. (2008). Role of communication in crisis management. Defense Resources Management in the 21st Century, available at http://conference.dresmara.ro/conferences/2008/10_Lesenciuc_Adrian.pdf

Naughton, D. The Growing Global Epidemic of Food Fraud, disponibil pe Internet la adresa: http://vimeo.com/nsfinternational/declan

Neagu, I.R. (2015) Securitatea versus siguranța alimentară. Revista de investigare a criminalității, 1, 171

Pinstrup-Andersen, P. (2009) Food security: definition and measurement. Food Security, 1(1), 5–7

Policy Horizons Canada. (2014). Meta Scan 3 – Emerging Tehnologies. Capitolul: Agricultural and Natural Manufacturing Technology. Accesat la: https://horizons.gc.ca/en/2014/03/01/metascan-3-emerging-technologies/, in 01.02.2020

Post, D.L. (2006). The precautionary principle and risk assessment in international food safety: how the world trade organization influences standards. Risk Analysis, 26(5), 1259–1273

Stevens, H. (2018) Hans Peter Luhn and the Birth of the Hashing Algorithm, available at https://spectrum.ieee.org/tech-history/silicon-revolution/hans-peter-luhn-and-the-birth-of-the-hashing-algorithm?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed:+IeeeSpectrumComputing+(IEEE+Spectrum:+Computing)

Strauss, D.M. (2014) Food Security and Safety. In: K. Ludlow, S. Smyth and J. Falck- Zepeda, (eds.) Socio-Economic Considerations in Biotechnology Regulation, 37. 109–123, New York: Springer

Turek Rahoveanu, A. and Turek Rahoveanu, M.M. (2013) Socio-economic development prospects of rural areas in the context of application of LEADER Program in Romania. Scientific Papers. Series 'Management, Economic Engineering in Agriculture and rural development', 13(4), 295–302

Zanin, L.M., da Cunha, D.T., de Rosso, V.V., Capriles, V.D. and Stedefeldt, E. (2017) Knowledge, attitudes and practices of food handlers in food safety: An integrative review. Food Research International, 100(Part 1), 53–62

*** (2017) A meat scandal in Brazil damages two of its biggest firms, 25.03.2017, The Economist, available at https://www.economist.com/business/2017/03/25/a-meat-scandal-in-brazil-damages-two-of-its-biggest-firms

*** PWC. Food supply and integrity services, available at https://www.pwc.com/gx/en/services/food-supply-integrity-services.html

*** The Economist, The trust machine, 31.10.2015, available at https://www.economist.com/leaders/2015/10/31/the-trust-machine

*** World Health Organization, WHO's first ever global estimates of foodborne diseases find children under 5 account for almost one third of deaths, News release, December 2015, available at https://www.who.int/en/news-room/detail/03-12-2015-who-s-first-ever-global-estimates-of-foodborne-diseases-find-children-under-5-account-for-almost-one-third-of-deaths