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Developing Public Policy Options for Access to Drinking Water in Peripheral, Disaster and Polluted Rural Areas: A Case Study on Environment-Friendly and Conventional Technologies

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Abstract: Peripheral, disaster and polluted rural areas (PDP rural areas) are generally perceived as a "Cinderella" of water public policy measures, deepening the rural-urban cleavage in terms of opportunities for a decent life. The main goal of the study is to develop public policy options regarding the supply of safe drinking water in Romanian PDP rural areas. The main instrument to achieve it is an ex-ante policy analysis of three solutions: a conventional technology, based on chlorine, a green technology using an advanced oxidation process with bio-filter (O3BioFilter), and "do nothing". Environment protection, social equity, technical performance, economic efficiency and political feasibility were the criteria selected for analysis, within a focus-group. Several qualitative and quantitative methods were used: evaluation matrix, weighted cost-effectiveness and break-even point. The results of the first two indicate that the O3BioFilter has the best score, but not much higher than the conventional alternative (10% higher), revealing a possible path-dependency to familiar technologies. This analysis is not a ready-made solution valid in any case, nor a direct indication of "the best choice", but a decision tool in the adoption and implementation of sustainable water public policies.

Keywords: drinking water; public policy; peripheral; disaster; advanced oxidation; bio-filter; chlorine; environment; economic performance

1. Introduction

Peripheral, disaster and polluted rural areas (hereinafter named PDP rural areas) are generally perceived as a "Cinderella" of water public policy measures, deepening the rural-urban cleavage in terms of opportunities for a decent life. Therefore, the present study focuses on a specific problem, taken less under scientific debate: public policy options on the access to drinking water in Romanian PDP rural areas in the context of sustainable development. The image and identity of Romania is overlapping and largely identifying with the rural areas, because almost 30% of its working force is employed in agricultural activities, while the average in Western European Union countries is 4%–5% [1]. Although rural revitalization, particularly in disadvantaged and peripheral areas, is a strategic objective for Romanian policy-makers [2], concrete and sustainable public policy measures are still needed.

The poor access to water supply is often a result of poor public policies and management practices, and there is significant disagreement over the approach to addressing the problem [3]. Building upon the demographic and the environmental (geographical) context and considering the infrastructure data, perspectives upon three public policy options on the access to drinking water were developed (a conventional one—chlorination; a green one—using an advanced oxidation process and bio-filter; and the "Do nothing" alternative) and taken under a six-step public policy analysis.

The paper's starting point was based on the simple, but also comprehensive Robert Burger's definition of public policies: "policies made by governments on behalf of their citizenry" [4]. William Jenkins offers a more detailed definition of public policy, understood as "a set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within a specified situation where these decisions should, in principle, be within the power of these actors to achieve" [5]. Romanian legislation defines public policies as all activities developed by the central specialized public administration in order to solve the identified problems of public policies and to ensure the necessary developments in a certain area [6]. The generic meaning of the "public policy" was used in the study, which can be understood as "policies as labels of field activity", "policies as specific proposals", "policies as products", "policies as theories and models", "policies as processes", and so on [7].

2. Goals and novelty

In the context of environment-health public policies, the main goal of the study is to develop public policy options regarding the supply of safe drinking water in PDP rural areas in Romania. The main instrument to achieve it is an ex-ante analysis of three options: (a) using a conventional technology, based on chlorine; (b) using a green technology; and (c) applying "do nothing" alternative.

The design of the study brings to the forefront a bi-dimensional analysis (economic and technical) of three options intended to outline solutions regarding the supply of drinking water to the citizens, which were not integrated, until now, in the context of a public policy scientific debate. This paper addresses a gap in the literature, as there is a paucity of studies on drinking water policy alternatives in Romania, despite the paramount importance of the subject. Although abundant research is dedicated to various aspects of drinking water treatment [8–10], including a similar dual perspective (economic–technical and/or conventional–green), the joining of a conventional and an environmentally friendly technology in the framework of a public policy analysis dedicated especially to PDP rural areas in Romania gives originality to the present paper. In general, three types of impact—economic, social and environmental—are analyzed in order to have a sustainable public policy, and here the first one was taken under scrutiny. The other two are not the object of the present investigation due to the very high complexity and length that an integrated approach would require. The economic performance of the drinking water treatment technologies were evaluated through several quantitative and qualitative economic methods (the evaluation matrix, the break-even point and the weighted cost-effectiveness method), along with the consideration of the "Do nothing" option. Motivation for this approach resides in the fact that each policy choice must be supported by an economic assessment which aims to evaluate the effects that the implementation of the presented solutions could have. Extensive impact analyses are used to evaluate likely costs, social consequences, and possible effects on the environment that a particular solution would generate. Just as no one judges the performance of a surgeon based on his knowledge, but on the outcome of the surgery [11], the success of a public policy is reflected in the viability of the solutions it proposes and in its results.

3. Methods

An ex-ante analysis in six steps of the drinking water public policy, based on Patton and Sawicki "Quick basic policy analysis" model [12], was performed. A conceptual lens clarifies the terminology used, justifies the character of public policy of proposed measures, selects the evaluation criteria based on the current scientific trends and indicates the appropriate quantitative and qualitative methods to be used. The theoretical framework was drawn from extensive literature on the topic-relevant scientific papers and legal documents.

Three policy options (chlorine based technology, oxidation process plus bio-filter technology and "Do nothing" option) were assessed using qualitative and quantitative methods: evaluation matrix, weighted cost-effectiveness, and break-even point. The criteria necessary for the evaluation of all policy options were selected after a focus group session with twelve participants, two from each of the groups considered important for the study: public authorities, water companies, water potabilization technologies providers, non-governmental organizations (NGOs), academia, and consumers. They received a list with eight criteria: environment protection, social equity, technical performance, economic efficiency, political feasibility, the fact that the technology was already implemented in other communities, presentation by producers/sellers, contribution to tourism development, plus an open-ended option to be filled in with other opinions; these were selected according to scientific literature and previous discussions with stakeholders. The participants to the focus group were asked to express their opinion about which criteria are the most relevant and should be used when they evaluate and choose among various options regarding the access to drinking water (by ranking the criteria on places from 1 to 8, 1 for the most important and 8 for the least important). The average scores were: technical efficiency: 1.58, economic efficiency: 2.67, social equity 3.58, environment protection 3.92, political feasibility: 4.83, contribution to tourism development: 5.92, already implemented in other communities: 6.25, and presentation by producers/sellers: 7.25. The following five criteria were retained: environment protection, social equity, technical performance, economic efficiency and political feasibility. Next, the most relevant stakeholders in the evaluation process of a public policy choice were selected: public authorities, water companies, providers of water potabilization technologies, and NGOs. Three representatives from each group (summing, thus, twelve people) were requested to evaluate each criterion on a scale from 1 to 10 (where 1 represented the weakest grade/evaluation and 10 the best one). Their evaluations were based on subjective and professional criteria. People were contacted by email and phone to request their participation and to offer them information about the purpose of the study, their tasks, and instructions about how to perform the evaluation. An information sheet with technical and economic performance of chlorine and oxidation plus bio-filter technologies (named O3BioFilter, which is not a real commercial name of any product), was generated, based on the data provided by SC ICPE Bistrita SA (and contained the figures presented in Tables 1–3). This was given to the subjects and they were requested to use it in the evaluation process. The participation to the study was voluntary, the acceptance rate was 60%, and anonymity of the answers was granted to ensure higher objectivity.

4. Theoretical framework

The setting of the research goal (to develop public policy options regarding the supply of safe drinking water in Romanian PDP rural areas) revealed the need to identity in the scientific literature the most reliable definitions, concepts and models to attain it, which are exposed hereinafter and constitute the pillars of the research design. Thus, a number of authors [12–15] identify in the course of drafting of a public policy several basic steps, but, it has to be mentioned at the outset, that there is no standard model of policy-making process. The structure of the present analysis was designed after Patton and Sawicki "Quick basic policy analysis" model [12], (Figure 1), which defines the public policy analysis as a six-steps process: definition of the problem, determination of evaluation criteria, identification of alternative policies, evaluation of alternatives, and their comparison and evaluation (the steps that were not mandatory were represented in dotted line; the other steps must be followed in the established order to perform an accurate analysis).

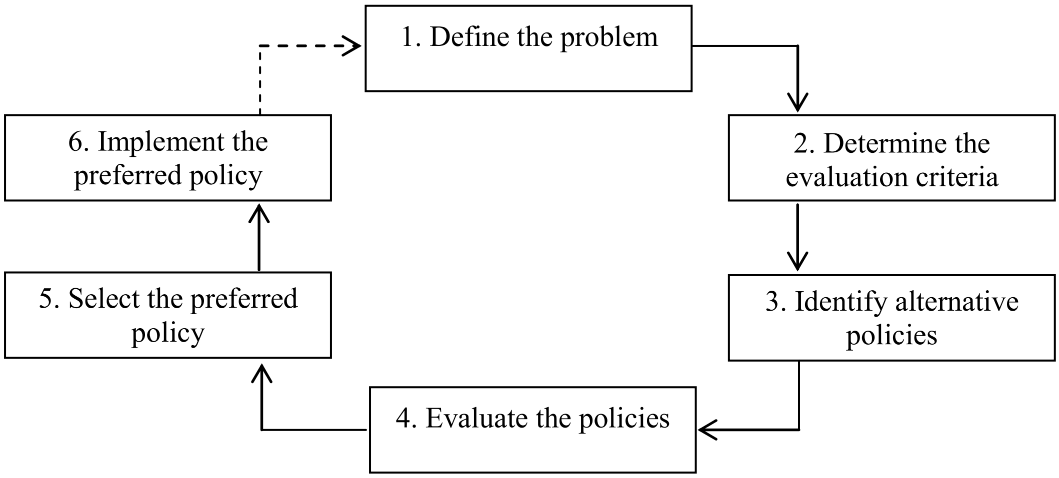

Figure 1. Public policy analysis in six steps [12].

The research results are based on technical, environmental, economic, social, and political performance evaluations and they have the function to help policy-makers in assessing the impact of future initiative or the effectiveness of past measures (in the field of providing access to drinking water in PDP rural areas). The point of view stating that the evaluation is a process by which a program performance is measured and by which solutions to the existing problems are identified [16] was adopted here. Economic evaluation of the policy is a mandatory step in the formulation of public policies and it was incorporated in author's demarche for reaching the research objective. In the analysis of proposed public policy options, economic rationality and the rational choice theory were put at the foundation of the approach, leading to the use of the evaluation matrix, the break-even point and the cost-effectiveness analysis. Practically, the basic element of rational models of public policy analysis is the application of economic analysis to their elaboration. The rational model is generally regarded as effective, due to its systematic character and well-defined purpose, and it has also proved to be adequate for the present analysis. Geoffrey Hodgson [17] believes that in the process of public policy making rationality is the "standard of wisdom". The economic evaluation of policy alternatives on water treatment in PDP rural areas is essential because, depending on the outcome and identified costs, a decision for a specific alternative is made and, consequently, it will be transformed in a public policy proposal. Thomas Dye [18] stresses the importance of rational models and he emphasizes the systematic comparison of alternatives followed by the choice of the one that leads to attain the targeted objective with less cost. In general, rational models of policy-making are perceived as "inhibitors" of political subjectivity (of decision makers' propensity to choose policy goals based on their political interests and values), because the public policy becomes rational by following the decision-making procedures set by these models [19].

5. Results and Discussion

5.1. Defining and Analyzing the Public Policy Issues

The understanding, diagnosis, and presentation of the policy problem as clear, precise, and comprehensive as possible were pursued in this stage. Scientific evidence to describe the nature, extent, and causes of the identified problem was gathered. The affected group of people and the key players who, by law, must be, would be, or might be involved in solving the discovered problem were also identified.

Defining the problem. The problem is the existence of people with limited or with no access to drinking water in PDP rural areas of the NW Development Region of Romania. Providing access to drinking water in peripheral, disaster and polluted rural areas of the NW Development Region of Romania was considered as an appropriate name of the public policy. In order to ensure a common understanding of the above public policy problem, the following meanings are assigned and provided:

a. Population. It includes the whole number of people or inhabitants in a region.

b. Peripheral areas. The meaning of the concept of peripheral areas should not be understood only from a geographical, territorial, point of view, but also from an economic and social perspective. This part of the countryside is at the economic and productivity periphery and, most often, at the social deprived outskirts of the agricultural or forestry system [20]. Therefore, the peripheral areas will include both the social and economic less favored areas and the remote areas. The remote areas are those where the communities are isolated, located at a distances of 3 to 5 km from the nearest village with the following facilities: primary school, sanitary point, and food and non-food shops [21].

c. Disaster areas. They comprise areas affected by natural or technological disasters (floods from breakage of dams and heavy and lasting rains, river flooding, droughts, landslides, earthquakes, *etc.*) which strike a community that is no longer able to organize itself, making necessary the intervention of central/local public administration.

d. Polluted areas. These are places where contamination of water sources is above the legal limits. Access to safe drinking water must be provided to all polluted rural areas, regardless of the exceeding level of the legal limits. According to Sencovici [22], low contamination means an overpassing below 0.5%, moderate is between 0.5%–1%, high is between 1%–5%, very high is between 5%–10%, and excessive is over 10% of the legal thresholds established for each of the identified pollutants. Even if deteriorations manifest usually at local or regional level, most of the time, the expected consequences are global, and environmental decline impacts upon human security and welfare [23].

The general objective of the proposed policy measure is to provide safe drinking water public services in PDP rural areas. The NW Development Region of Romania could be considered as a pilot project. The supply of drinking water public services includes catchment, treatment, and distribution. The quality parameters of the water must meet the legal requirements. The supply to the final users has to be continuous and at an acceptable pressure; but high turbidity [24], interruptions and lack of pressure are currently encountered in rural areas. The coverage should be of 100% of the inhabitants in targeted areas and the service must be provided in a sustainable manner: minimizing the negative impact on environment and society, and maximizing the positive one. A fair price must be adopted, both for suppliers and for beneficiaries. Water tariffs have become an important tool in achieving economic efficiency, environmental sustainability, and social equity [25]. Political feasibility and social fairness must be timely correct: one should always take advantage of political statements and commitments related to health-environment public policies assumed through national governmental programs or EU and international mandatory requirements; also, a public service must be provided at the historically right moment—when the population needs it. Therefore, the implementation of the proposed policy measure has to be achieved in the shortest time possible and within the timeframe established ("no longer than dd.mm.20yy").

Argumentation of perceiving the limitation/lack of access to drinking water in PDP rural areas of the NW Development Region as a matter of public policy. Starting from Dunn's definition [26], who sees public policy issues as values, needs or unachieved opportunities that, even if they are identified, can be resolved only through public action, we will argue that the lack of drinking water is a problem that can be solved only by public intervention. Thus, the access to drinking water was considered as a matter of public policy, in light of the following indicators [27]: (i) extent; (ii) intensity and (iii) duration of the problem.

(i) The extent of the problem.

The number of people affected relative to a geographical area indicates the extent of the problem (17% of the rural localities [28]). The direct beneficiaries of our policy are all the inhabitants of the

PDP rural areas of the NW Development Region, and the indirect beneficiaries are all people enjoying a balanced environment and the positive consequences derived from the fact that a population is healthier and it spends less money on alternative drinking water sources—at least all the population of that region.

In the following, several demographic, environmental (geographic), and infrastructure data will better define the problem, gaining insights about the public policy problem, justifying the choice for PDP areas, and introducing the premises for drinking water clean technologies.

The North West Development Region of Romania has 34,159 km^2, accounting for 14.3% of the total area of the country. From a physical-geographical point of view, 28% of it is made of mountain groups, considered as less favored areas. The natural environment of the region has the shape of an amphitheater that descends from East to West, bordered by the Eastern Carpathians in the North-East and by the Apuseni Mountains in the South-West [29]. Soil and climatic conditions, geographic location and the topography of the region favored the emergence and development of a great diversity and valuable habitats, as many were declared as protected areas, of national or European and international interest [30]. There are 88 protected areas of community importance (Natura 2000). Of these, 71 are Sites of Community Importance (SCI), with a total area of 610811 ha, covering 17.88% of the region; 17 Special Protection Areas (SPA), laying on 391816 ha, covering 11.47% of the region. The Rodnei Mountains Biosphere Reserve is a protected natural area of international importance, established a long time ago, in 1932. Currently, the Biosphere Reservation covers 47,227 ha, of which 8200 ha are fully protected areas, 11800 ha are buffer zones, and 24000 ha represent transition zones. There are approximately 170 protected areas of national importance, of which: 3 scientific reserves; 2 national parks (Rodnei Mountains National Park and Călimani National Park); 59 monuments of nature; 104 natural reserves; 2 natural parks (Apuseni Natural Park and Maramures Mountains Natural Park) [31].

Therefore, the richness of the natural heritage and the need to preserve it impose the choice of the most sustainable alternatives for producing drinking water. Among all the choices available on the market, the cleanest technologies were considered.

The rural area of the region covers 29286 km^2, representing 85.73% of the total area. Communes are of varying sizes, with an average population of 3060 inhabitants [28]. In the NW Region, there are still villages, hamlets and isolated non-electrified households, concentrated especially in the Apuseni Mountains and the Northern mountain area. The network of public drinking water is insufficiently developed to meet the needs of the rural population, although according to the 2011 census, 82.63% of rural localities have a public distribution network for drinking water. For instance, groundwater pollution in Maramures County, due to non-ferrous residuum infiltrations, seriously jeopardizes health, even in the areas with conventional networks, because some treatment facilities are inadequate or old. In the rural Transylvania Plateau, water resources are reduced and undrinkable because of gas domes and salt deposits. In rural areas, waters are often polluted with nitrates, microorganisms, and pesticides due to the poor management of waste, outdoor latrines, inadequate designed septic tanks, and agricultural activities and, therefore, consumption of contaminated water can cause serious health problems [32]. Moreover, most urban treatment plants were made over 25 years ago; they are now in an advanced degree of wear and tear, while having an insufficient treatment capacity for the wastewater. Consequently, these areas need urgent works for a centralized water supply.

Basically, the problem of ensuring drinking water is becoming imperative, particularly in peripheral mountain areas. We are dealing with a region characterized by a degree of rurality higher than the national average, with a population widely dispersed, by a development model and by geographic characteristics that contribute to the isolation of many communities. In fact, accessibility constitutes one of the major weaknesses of the region [28].

(ii) The intensity of the problem.

The number of people who are concerned about solving the problem shows its intensity. Drinking water in PDP rural areas is a matter of social, economic, and environmental public policy, and can be addressed only through public action [26]. It requires the intervention of the central public administration: Romanian Ministry of Environment, Water and Forests, Romanian Ministry of Health, Romanian Ministry of Regional Development and Public Administration. An important role rests with the Regional Planning Committee (RPC), made up of decision-making representatives of county councils, of prefectures and of the decentralized services of the central public institutions. The civil society representatives, such as NGOs in the field of environment, health and human rights, are important actors in lobbying for, drafting and implementing political measures concerned with the access to drinking water. Even if access to safe water sources and wastewater treatment considerably improved since Romania's accession to EU (in 2007), especially in urban areas, these are still stringent problems in PDP rural areas, requiring a fast and sustainable solution.

(iii) The duration of the problem.

This expresses the extension in time and the way it has evolved over the years. The lack of access to drinking water has two roots: (a) water scarcity, lack of water sources, due to climate changes, intensive use for economic activities and natural water distribution; and (b) contamination of existing water sources by industrial (especially mining) and agricultural activities. Scientific evidence of the problematic access to safe water sources goes back in the second half of the twenty century (mainly caused by the intensive industrialization and by the large use of chemicals in agriculture during the communist period).

The access to drinking water can be also discussed in terms of deficit and excess [33]. Excess perspective: at regional level, 28% of the territory is covered by mountains and shelters. Deficit perspective: too much poverty in the mountain areas requests for central and collective initiatives, instead of individual solutions; too few European funds are dedicated to remote, polluted and disaster areas, in an already low absorption national level (Romania absorbed only 34% in 2013) [34].

5.2. Determination of the Evaluation Criteria for the Public Policy

Equity, efficiency, and political feasibility are the three criteria helping in comparing, measuring, and selecting among options, guiding most often the making of policy decisions. They have been considered as "obligatory criteria of political judgment" [35,36]. In the present study, it was decided to include "environmental protection" as well, among the other commonly used criteria. The choice resides on mandatory requirements of Directive 98/83/CE on the quality of water intended for human consumption [37] which introduced the obligation to control the presence of trihalomethanes (THMs) in water supply systems. It is a step towards recognizing the importance of environmental and human health protection in the context of promoting the sustainable development of the twenty first century society. This vision is in line with the four fundamental strategies for combating water quality problems, which can form the basis of policy solutions: (a) prevention of pollution; (b) treatment of polluted water; (c) safe use of waste water; (d) restoration and protection of ecosystems [38,39].

In general, evaluation criteria are used to weight policy alternatives or to judge the merits of existing or proposed policies [40]. The scientific literature offers a plurality of criteria for evaluating public policy proposals. Michael Kraft and Scott Furlong [40] also consider liberty/freedom, effectiveness, social acceptability, administrative, and technical feasibility. Stigmatization, trade-offs, substitutability or target efficiency are other discussed criteria [41].

The equity, efficiency, political feasibility, and environmental protection were used to assess the worth of the present public policy measure aimed at addressing social problems that warrant public action.

Equity is often viewed as synonymous with social justice. The springs of the under analysis proposal regarding the access to water have a strong social equity nature. Equity means that similarly situated people should be treated equally [42]. People from urban and rural areas should be treated equally in terms of the access to drinking water. How fairly is this service distributed? How much of this need is covered? Statistical data say that most people from isolated, contaminated or disaster areas are in need of this service. The needs of individuals and groups are always multi-dimensional and different and equity is not necessarily seen as a way through which equal amounts of a good or service should be provided to that individual or group, but rather that a fair amount should be provided [42]. The value systems and the understanding of the same need and of the consequent equity differ over time and places, leading to different priorities. Thus, a century ago, in the same geographical area, the problem of the access to safe water was a shallow one, while food security, territorial security, and social fairness through the abolition of the feudalistic economic and social patterns were the core action lines. Nowadays, concern for human rights, environment protection, and for securing the chances to a sustainable future places the water issue on the forefront of political discourses. Water is now perceived as the most important resource, becoming a fearful conflict source [43] and a transversal topic for all policy sectors, from environment to military security. Provision of drinking water in remote, disaster and polluted areas is a mean to alleviate poverty, to protect human health and environment, to stop rural exodus and to build resilience to climate changes. It is acknowledged that one the most important effects of climate change regards water: beside the risk of more uneven precipitation patterns throughout the continent, an increase of dry periods is predicted [44].

Efficiency. On a public policy level, efficiency means maximizing the difference between total benefits and total costs of a policy. Policies that achieve more of a desired goal at a less cost are more efficient than those that achieve the same goal at a greater cost or less of a goal at the same cost [42,45].

Political feasibility refers to the extent to which officials accept and support a policy proposal [36]. Due to the changing and challenging economic and political context, it is always difficult to determine the political feasibility in Romania. Taking into account this reality, the authors suggest the implementation of the proposed policy program at an administrative micro-level for a community of 2000 people. According to Richard Caputo [36], pilot projects are more politically feasible than the full-scale adoption for the entire Romanian PDP rural areas. He argues that experimental failures, if they occur, are less risky politically, whereas unsuccessful programs for which positive outcomes have been advertised previously to implementation could prove politically disastrous [36]. We can affirm that there are premises of its feasibility stemming from legal obligations (Directive 98/83/EC, Governmental Emergency Ordinance 195/2005), national strategies statements (Romania's National Strategy for Rural Development 2013–2020–2030) or Governance Program for 2013–2016. Therefore, the policy recommendation on accessibility to drinking water is justified as lawful, plausibly argued, equitable, and entailing efficient use of resources [36].

Environmental protection. The environment is a shared resource; therefore, we all take part in its protection task and exercise the right to a healthy environment and, eventually, the right to life through an ecologically balanced environment. The political thinking in terms of sustainable development is governed by the principle of integration (article 11 of Treaty of Functioning the European Union [46]), meaning that any policy proposal and decision must take into account environmental issues. Principle of integration imposes to the competent public authorities the obligation to assess their actions in accordance with the ecological requirements [47]. Due to the fact that eco-efficiency should be measured and compared against objectives set by policies and strategies [48], a greener alternative was taking into account in the present research.

5.3. Identifying Alternative Policies to Provide Access to Drinking Water in PDP Rural Areas of the NW Development Region of Romania

The whole process of analysis of a public policy revolves around choices. In the process of identifying the possible and feasible alternatives, information obtained from in-depths interviews with mayors of communes and water experts, the analysis of the *status-quo* and of scientific literature were used. The following options were identified and compared:

(a) A conventional one, based on chlorine, due to the "path dependency" syndrome;

(b) A green one, because of the obligation to respond to the stringent need of environment protection in the NW Region;

(c) "Do nothing" (the present situation will continue unchanged);

(a) Immanuel Wallerstein declares that “Change is eternal. Nothing ever changes” [49], guiding us, therefore, to the question “How much progress has been made in the field of making drinking water technology more environmentally friendly?” The treatment and distribution of safe drinking water is one of the greatest achievements of the last century, which saved millions of lives, but it is still missing in many parts of the world, as the World Health Organization estimates that almost one billion people lack access to an improved supply [50]. Disinfection with chlorine is crucial to water safety, and has uncontestable advantages, such as destroying pathogenic organisms and preventing the proliferation of slime bacteria, molds, and algae in water supply reservoirs. Water treatment with chlorine is the most common process in the NW Region, being used by the majority of the public water treatment stations. In fact, the chlorination is currently the most extended system for disinfection throughout the world [51]. In conventional plants, in order to reduce pollutants (ammonium, iron, manganese, organic substances, *etc.*) in highly loaded waters, an additional treatment is needed, such as ozonification, reverse osmosis, and ions exchange. In the present case, the conventional technology means a chlorination based technology with an ozonification stage. For the chlorine based conventional technology, ozonification requires a large capacity ozone generator, of 100–200 g/h, while for the plants where bio-filters are used (such as O3BioFilter) these pollutants are reduced in bio-filters and the ozone generator capacity is lower, of 50 g/h. Although chlorination remains the central pillar of waterborne disease prevention, its weaknesses cannot be disregarded and it must be rationally and open-minded addressed. The major disadvantage of disinfection with chlorine is the chemical by-products of trihalomethanes category, which result from the reaction of chlorine with organic matter from water, chloroform, and dichloromethane (considered to be carcinogens [52,53]).

(b) Raising awareness about the need for environmental conservation and preservation, along with the existence of legal provisions, have brought as a result the establishment of strict requirements for wastewater treatment plants as well as drinking water plants in the view to diminish the negative impact on environment and human health. One major objective of Directive 98/83/EC is to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean (article 1, alignment 2). A way to achieve this desideratum was by imposing the obligation to control the presence of trihalomethanes in water supply systems. The secondary by-products from THMs category are one of the major disadvantages of disinfection with chlorine. Therefore, a green technology was selected among the available ones, based on its economic and technical efficiency and on its environmental impact: automatic modules for drinking water using an advanced oxidation process and bio-filter (O3BioFilter). The main reason for choosing a technology based on ozone and bio-filter is that it does not generate toxic by-products, which are specific for chlorine water treatment [53]. Additionally, this technology was preferred over other green technologies based on experts’ recommendations and due to the fact that a preference/acceptance of public local authorities for it was identified: it was already selected and implemented in two counties—Gorj and Dolj. The O3BioFilter technology consists of a pressurized aeration step, a pre-oxidation step with oxidants resulted from electrochemical treatment, a bio-filtration, and a disinfection step. Drinking modules use electrolysis in pulsating currents for pre-oxidation, so the vast majority of pollutants dissolved in water may be oxidized and then detained in the stage of bio-filtration. Monitoring and control of the bio-filtering process are made applying specialized software that can predict future states of the process and develops adaptively correction algorithms. Bio-filters have a vertical construction, working under pressure, increasing efficiency and reducing the mounting area. One of the main advantages of this solution is that O3BioFilter supports contaminated waters in higher concentrations than other similar products (both foreign and national) available on Romanian market, that accept inlet ammonium concentration below 3 mg/L. Many of the water sources in selected areas have higher concentrations of pollutants, making impossible the use of these technologies. Additionally, the price of the other solutions is significantly higher. Other advantages of the O3BioFilter compared to the conventional alternative are included in Tables 1–3.

Table 1. Comparative general characteristics of chlorine and O3BioFilter drinking water stations.

Parameter	Chlorine Based Technology	O3BioFilter
It is adapted to field conditions of the remote, polluted and disaster areas; it supports contaminated waters with iron ions, hydrogen sulfide, arsenic, manganese, ammonium, nitrites, nitrates, humic acids, pesticides, herbicides, petroleum products, residues of drugs, and cosmetics.	No	Yes
It reduces disease incidence or epidemics caused by the possible induction of specific diseases by the consumption of improperly processed water, with hardly quantifiable results and major effects on people (especially children).	Yes	Yes
Less expensive costs than other methods, included for hardly accessible water sources.	Yes	Yes
It reduces accidental pollution caused by improper handling of chemicals used for drinking water treatment. The risk is practically zero because all the oxidants are generated "in situ" for O3BioFilter.	No	Yes
It generates no odor.	No	Yes
The lifespan of the system.	> 10 years	>15 years
It is very safe, being fully automatic, there is no need for special measures. It does not require a human operator, providing a valuable advantage in its implementation in the mentioned areas.	Yes	Yes
It has a higher adaptability to customer needs: flow, charge, space, *etc.*	No	Yes
It does not present high levels of toxic secondary by-products (see Table 2)	No	Yes

Table 2. Performances of chlorine and O3BioFilter drinking water stations for raw water with heavy loads of pollutants, compared to legal limits [54].

Parameter	Concentration Obtained with a Station Using Chlorine (mg/L)	Concentration Obtained with O3BioFilter (mg/L)	Maximum Allowed Concentration (Laws 458/2002, 311/2004; mg/L)
Ammonium	0.2–1	0.2	0.5
Nitrite	0.5	0.1	0.5
Nitrate	10–50	10	50
Oxidability (CCOMn-potassium permanganate method)	3–5	3	5
Iron	0.2	0.1	0.2
Manganese	0.05	0.03	0.05
Aluminum	0.1–0.2	0.1	0.2
Sulfates	250	150	250
Residual chlorine	0.33	0.2	$\geqslant$0.1 $\leqslant$0.5

Table 3. Consumption of chemical reagents and electric power of chlorine and O3BioFilter technologies [55,56].

Consumptions	Chlorine Technology (Drink Water Flow: 20m^3/h)		O3BioFilter (Drink Water Flow: 20 m^3/h)	
Consumption of chemical reagents	Chlorine	0.8–1 mg/L	Chlorine	0.3 mg/L *
	Aluminum sulfate	30–200 mg/L	Aluminum sulfate	No
	Chlorine dioxide	2–3 mg/L	Chlorine dioxide	No
	Polyelectrolyte	0.1–0.5 mg/L	Polyelectrolyte	No
	Calcium hydroxide	5–20 mg/L	Calcium hydroxide	No
Consumption of electric power **	6.75 kW/h		4.5 kW/h	

* Chlorination is compulsory in Romania (to ensure water safety along the pipes network), according to Romanian standard on the design, execution and operation of water supply and sewerage systems of localities (Indicative NP 133/2013); ** The energy used for water transportation from the capture point to the treatment plant and for drinking water distribution in the network was not taken into account; due to the fact that ozone generator capacity is much lower the case of O3BioFilter compared to the conventional technology (as the necessary ozone quantity is lower), O3BioFilter consumes less energy.

(c) Among the policy alternatives [12,57], "do nothing" option is also counted, being preferred by many risk averse decision-makers, who are often unable or unwilling to work for a specific goal or to assume responsibilities, wanting to avoid failure, or by those who prefer to save money or to invest in other directions. The "business as usual" and "do nothing" are perceived as overlapping terms. However, according to Therivel [58], business as usual is seen as a continuation of the present *status-quo*, of keeping going with the existing strategic action or lack thereof. The "do nothing" alternative assumes no new strategic action and no continuation of any previous existing one. Nevertheless, when a new strategic action is being proposed (and no other existed previously), the business as usual and do nothing alternative are the same [58], as it is in the present study.

Policy options (a) and (b) are compared to a reference scenario, (c), and represent changes from that scenario. In relation to the introduction of drinking water to PDP rural areas, "do nothing" option means keeping the population without access to this resource, with long-term negative consequences, especially social and environment related.

5.4. Evaluation of the Alternative Public Policies

It is argued that public policy alternatives assessment should not be very large, nor very sophisticated, nor should it involve a large amount of information [59]. Usually, both types of evaluation methods (quantitative and qualitative) are used. There is a very broad array of evaluation tools and methods that can be used for a public policy proposal, such as analytical hierarchy process (AHP), Delphi technique, evaluation matrix, *etc.* AHP assesses one idea on multiple criteria and structures them according to their relative importance. It is mainly a group technique and it is similar to Paired comparison analysis (the latter being used when priorities are not clear and the options are completely different, which was not our case). Because AHP is more sophisticated than other methods, and appropriate for solving very complex problems, it was not preferred here. Delphi technique is a systematic forecasting method which depends on opinions of independent experts, being similar with Consensus mapping; although they were both attractive from the outcome and use of expert group point of view, they were rejected because they required a pre-training stage, not suitable for our demarche due to financial and time costs. The evaluation matrix is destined to evaluate an idea in accordance to several factors or criteria, enabling the user to quickly identify the strengths and weaknesses of the options and select the best one.

(i) The evaluation matrix was preferred because it is suitable in the case of subjective criteria, frequently present in health and environment public policies. Evaluation matrix will help decision makers to evaluate, compare and, finally, select a solution to how to supply drinking water in PDP rural areas. In this case, it evaluates a number of three options (conventional, O3BioFilter, and "do nothing") against a number of five criteria (environment protection, equity, technical performance, economic efficiency, and political feasibility).

Table 4 indicates the performance level of each criterion for each policy option, as it was evaluated by every participant (1 = the weakest performance, . . . , 10 = the highest performance).

The final score for each policy option was calculated as an average of the average evaluation given by the twelve participants to each criterion. The winner was O3BioFilter technology (8.8 points; Table 4), but only by a small difference (10% higher), revealing a possible path-dependency on familiar technologies, accompanied by a weak power of interest for innovation and environment protection and, maybe, a lack of trust, information or misunderstanding of the cleaner technology. However, all groups recognized the O3BioFilter option as the most environmentally friendly. In the case of social equity, public bodies understood it from a broader perspective, that of choices between various destinations of the funds (education, water, job creation *etc.*), indicating that access to safe water in remote, polluted and disaster rural areas is not yet the top priority. A similar preference pattern is revealed by the weighted cost-effectiveness method.

(ii) Weighted cost-effectiveness method was chosen instead of cost-benefit analysis because many benefits of public policies are difficult to be measured in terms of money, being the case of health and environment. Moreover, the idea of assigning a monetary value to nature or life itself is considered meaningless and ethically wrong by some people, giving space to non-monetary evaluations. The participants were requested to assign importance to each criterion, from 1 to 10 (1 = the lowest importance, . . . , 10 = the highest importance; Table 5).

The weighted average scores of each policy option were calculated and the O3BioFilter technology accumulated the highest one (79 points, 34% higher than the "Do nothing" option and 13% higher than the chlorine technology; Table 6). Some of the most frequently used evaluation criteria in the day-by-day practice are the price and the total economic costs, therefore, they were included in the cost-effectiveness analysis. Obviously, when only price or the sum of the economic costs (excluding environmental, social, and political costs under the form of their monetary value) are included in the calculations, the "Do nothing" option is the winner. The second best option within this approach is O3BioFilter, exceeding by 29% the chlorine technology, when the price is taken into account, and by 47%, when we refer to total costs (economic, fixed, and variable, see Table 7).

(iii) The break-even point method indicates the point at which total cost and total revenue are equal or the point from where the activity becomes profitable, giving an indication about the economic performance. The break-even point was selected because it is largely used in public administrations and it allows a quick evaluation of options. The following formula was applied to determine the break-even point: $Q \times P = FC + (VC \times Q) \Rightarrow Q = FC / (P - VC)$, where Q = quantity sold, P = selling price (per unit; unit = cubic meter = m^3), FC = fix costs, VC = variable costs (per unit; unit = cubic meter).

The variable costs were obtained considering the scenario of a full working capacity. For both stations, this means an annual drinking water flow of 175,200 m^3/year (20 m^3/h $\times$ 24 h/day $\times$ 365 days/year). This capacity exceeds by 83% the community's annual average need, calculated based on official reports to 96,000 m^3/year (2000 inhabitants $\times$ 48 m^3/pers./year [60]). The surplus can be sold to other potential beneficiaries or the production capacity could be restrained, with a consequent cost reduction. The break-even point methods indicate that the O3BioFilter is more efficient, as it requires the selling of a quantity of drinking water (cubic meters) by 38% less than the chlorine option, to become profitable (Table 7).

Table 4. Performance level for each criterion and policy option assigned by the representatives of stakeholders.

Policy option	Stakeholder	Environment Protection	Equity	Technical performance	Economic Efficiency	Political Feasibility
Conventional (Chlorine)	Local administration	8 7 6	7 7 8	10 10 10	7 8 6	5 5 4
	Water companies	7 6 7	10 10 10	10 10 10	8 8 8	9 9 10
	Water potabilization technologies providers	7 9 5	10 10 10	8 8 10	4 4 7	10 10 10
	NGOs	4 4 6	10 10 10	8 9 8	3 3 3	10 10 10
Average score of conventional (Chlorine) policy option for each criterion		*(8 + 7 + 6 + . . . + 6)/12 = 6*	*(7 + 7 + 8 + . . . + 10)/12 = 9*	*(10 + 10 + 10 + . . . + 8)/12 = 9*	*(7 + 8 + 6 + . . . + 3)/12 = 6*	*(5 + 5 + 4 + . . . + 10)/12 = 9*
General average score of conventional (Chlorine) policy for all criteria				*(6 + 9 + 9 + 6 + 9)/5 = 7.8*		
O3BioFilter	Local administration	8 7 7	7 7 8	9 10 8	8 9 10	4 5 5
	Water companies	5 5 7	8 9 9	8 8 9	8 8 8	9 9 10
	Water potabilization technologies providers	8 8 7	9 10 9	10 10 8	10 10 9	10 10 10
	NGOs	10 10 10	10 10 10	10 10 10	10 10 10	10 10 10
Average score of O3BioFilter policy option for each criterion		*(8 + 7 + 7 + . . . + 10)/12 = 8*	*(7 + 7 + 8 + . . . + 10)/12 = 9*	*(9 + 10 + 8 + . . . + 10)/12 = 9*	*(8 + 9 + 10 + . . . + 10)/12 = 9*	*(4 + 5 + 5 + . . . + 10)/12 = 9*
General average score of O3BioFilter policy for all criteria				*(8 + 9 + 9 + 9 + 9)/5 = 8.8*		

Table 4. *Cont.*

Policy option	Stakeholder	Environment Protection	Equity	Technical performance	Economic Efficiency	Political Feasibility
"Do nothing"	Local administration	4 4 4	6 6 5	2 2 2	2 2 2	5 5 5
	Water companies	4 3 4	2 2 3	1 1 1	1 1 1	2 3 2
	Water potabilization technologies providers	4 3 3	1 3 2	1 1 1	1 1 1	2 2 3
	NGOs	3 2 2	2 1 1	1 1 1	1 1 1	1 2 2
Average score of "do nothing" policy option for each criterion		*(4 + 4 + 4 + . . . + 2)/12 = 3*	*(6 + 6 + 5 + . . . + 1)/12 = 3*	*(2 + 2 + 2 + . . . + 1)/12 = 1*	*(2 + 2 + 2 + 2 . . . + 1)/12 = 1*	*(5 + 5 + 5 + . . . + 2)/12 = 3*
General average score of "do nothing" policy for all criteria				*(3 + 3 + 1 + 1 + 3)/5 = 2.2*		

Table 5. Importance of criteria (as assigned by stakeholders).

Stakeholders/Criteria	Environment Protection	Equity	Technical Performance	Economic Efficiency	Political Feasibility
Local administration	7 6 7	6 8 6	10 10 10	10 10 10	10 10 10
Water companies	8 8 8	6 8 7	10 10 10	10 10 10	8 9 7
Water potabilization technologies providers	10 10 9	8 7 8	10 10 10	10 10 10	7 6 7
NGOs	10 10 10	10 10 10	10 10 10	10 10 10	10 10 10
Average importance	(7 + 6 + 7 + . . . + 10)/12 = 8.6	(6 + 8 + 6 + . . . + 10)/12 = 7.8	(10 + 10 + 10 + . . . + 10)/12 = 10	(10 + 10 + 10 + . . . + 10)/12 = 10	(10 + 10 + 10 + . . . + 10)/12 = 8.8

Table 6. Weighted average scores and cost-effectiveness of policy options.

Average Importance and Average score	Environment Protection	Equity	Technical Performance	Economic Efficiency	Political Feasibility	Weighted Average Score	Cost-Effectiveness Using the Acquisition Price	Cost-effectiveness Using Annual Costs
Average importance of criterion (from Table 5)	**8.6**	**7.8**	**10**	**10**	**8.8**	-	-	-
Average score of conventional (Chlorine) policy option for each criterion (from Table 4)	6	9	9	6	9	$(8.6 \times 6 + \ldots + 8.8 \times 9)/5 = 70$	112,000/70 = 1600	67,000/70 = 957
Average score of O3BioFilter policy option for each criterion (from Table 4)	8	9	9	9	9	$(8.6 \times 8 + \ldots + 8.8 \times 9)/5 = 79$	90,000/79 = 1139	39,920/79 = 505
Average score of "do nothing" policy option for each criterion (from Table 4)	3	3	1	1	3	$(8.6 \times 3 + \ldots + 8.8 \times 3)/5 = 20$	0	0

Table 7. Economic characteristics of chlorine and O3BioFilter technologies and their break-even point

Costs, Selling Price, and Break-even Point	Based on Chlorine (20 m^3/h)	O3BioFilter (20 m^3/h)
Fix costs:	47,800 Euro/year	31700 Euro/year
-Maintenance	15,000	9300
-Amortization (linear; 5 years)	22,400 (selling price: 112,000 Euro)	18000 (selling price: 90,000 Euro)
-Administrative taxes	400	400
-Service	1000	1000
-Personnel	9000 (3000 Euro/year × 3 persons)	3000 (3000 Euro/year × 3 pers.)
Variable costs (maximum capacity: continuous flow, high charges of contaminants)	**0.11 Euro/ m3**	**0.04 Euro/ m3**
-Materials	0.06 Euro/ m^3 - Aluminum sulfate: 3000 Euro/year - Sodium hypoclorite: 5000 Euro/year - Sodium chloride for ionic exchange: 1000 Euro/year - Flocculant for mud: 1000 Euro/year - pH correction lime: 200 Euro/year	0.01 Euro/ m^3 - Sodium chloride: 100 Euro/year - Nitrification bacteria: 120 Euro/year - Sodium hypochlorite: 2000 Euro/year
-Energy	0.05 Euro/ m^3	0.03 Euro/ m^3
Selling price / m^3 of drinking water	1.1 Euro/ m^3	1.1 Euro/ m^3
Break-even point	48283 m^3/ year	29906 m^3/ year

The evaluations performed in the study can be extended to include other quantitative and qualitative methods, each bringing their advantages and disadvantages, which will be judged in the context of the environmental and health public policy specificity. In addition, additional evaluation criteria or a different calculation of the indicators used here can be adopted. Thus, the weighted cost-effectiveness method may also include the monetary evaluations of the social and environmental costs and benefits. The herein evaluations are not representative for all selected stakeholder categories in the region, due to the small size and non-probabilistic nature of the sample (convenience sample). Only two technological alternatives were analyzed, as consequence of lack of transparency regarding the costs. In the context of a high diversity of the drinking water making technologies available on the market, a future research will provide a more accurate image of the public policy options if more of them will be included in the analysis.

5.5. Selection of the Preferred Public Policy Alternative

The authors want to clearly underline that the present study offers an evaluation of different options of public policy on providing drinking water in peripheral, polluted or disaster rural areas, not a direct indication of "the best choice". It is a representation of a possible scenario in the evaluation process of policy alternatives and it does not provide a ready-made solution valid in any case, because each selection depends on multiple variables such as time, available resources, relative importance of criteria (economic, social, environmental or political) and we have to be aware that there is no such thing as an absolutely correct, rational, and complete analysis [12].

The whole process of policy definition and the ex-ante evaluation were encapsulated in the sustainable development thinking—equal concern for economic efficiency, social fairness and environmental protection. Although controversy still persists about the appropriateness of acting as a framework for environmental public policies worldwide, sustainable development became the support for high level decision making [61]. The authors engaged in this reasoning (accountable to nature, society, and economy) because of the need to generate fundamental changes in the way economic activities are designed and implemented, so that the welfare of contemporary society is not achieved at the cost of destroying the chances of a better life for future generations.

6. Conclusions

The present study offers policy makers a perspective on how to assess the consequences of future actions or the effectiveness of measures they have already adopted in the field of providing access to drinking water in peripheral, disaster and polluted rural areas. The inertia of public authorities in maintaining the *status-quo* or their path-dependency on the conventional technology to provide drinking water must be counterbalanced by methods that lead to long-term viable options for the benefit of society and environment. The technical and economic evaluation of the chlorine and of the advanced oxidation process with bio-filter treatment solutions reveals higher performances of the latter, raising awareness on the existence of technologies that are, at the same time, economically efficient, technically performant, and environmentally friendly. From the perspective of a decision maker dedicated to connecting Romania, including its very extended PDP rural areas, to the philosophy of sustainable development, the alternative O3BioFilter should be chosen. The adoption of green solutions can be backed up at political level by massive lobby from NGOs, pressure from citizens, and, also, by public financial support coming from national or EU funds.

The ex-ante analysis performed in the present study can be transposed in PDP rural areas of other countries too, provided that they have similar economic, social, political, and environmental needs. Consequently, it becomes a decision tool in the adoption and implementation of sustainable water public policies, and furthermore, it can generate one or more pieces of legislation, making the transition from simple political statements to enforceable legal norms, from soft to hard law instruments.

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