Sustainable and Responsible Management

The Journal of Sustainable Business

ISSN *2724-4466*

Volume No. 5, Issue No. 2 - 2024

Abruzzese Salute ETS

sustainable-and-responsible-management.org

Journal Information

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ISSN
2724-4466

Online since 18th November, 2020
With authorization from the Court of Pescara no. 1 year 2020

Classification by Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR)
Scientific Journal
Governing Board Resolution nr. 184 of 27th July, 2023

DOI Prefix by Multilingual European DOI Registration Agency (mEDRA)
10.61013

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Table of Contents

Academic Research Papers

Academic Research Papers

Problems of social sustainability: economic poverty and children's rights

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Abstract

The issue of poverty is important not only in developing societies, but also in those that are more economically and technologically developed. In the international context, Italy maintains critical situations with significant manifestations, on a quantitative and qualitative level, of absolute and relative poverty. The data confirms a growing and never-surpassed trend of dualisms between North and South, with critical issues that involve families and individuals. Interventions necessary to rebalance the situation require reflections on the level of fair reciprocity and redistribution of economic, social, health and cultural resources. Social policies called upon to design contrast strategies are inevitably involved. The issue of poverty opens up to more general problems relating to rights and their enforceability, especially for minors, who are often more exposed to the risks associated with the various forms of economic deprivation. The rights of minors are expressed, in the different dimensions of life, in terms of the necessary sustainability of protection and safeguard of social systems in which the phenomenon of poverty presents itself with significant criticality at the macro and micro-social level. In this regard, no less exempt from the duties of protection and safeguarding of minors is the social subsystem of large-scale communications.

Keywords – Poverty; Families; Food; Minors; Sustainability; Communication.

Paper type – Academic Research Paper

Sommario

Problemi di sostenibilità sociale: povertà economica e diritti dei bambini. – Il tema della povertà è rilevante non solo nelle società in via di sviluppo, ma anche in quelle economicamente e

tecnologicamente più sviluppate. Nel contesto internazionale, l'Italia mantiene situazioni critiche con significative manifestazioni, a livello quantitativo e qualitativo, di povertà assoluta e relativa. I dati confermano una tendenza crescente e mai superata di dualismi tra Nord e Sud, con criticità che coinvolgono famiglie e singoli individui. Gli interventi necessari a riequilibrare la situazione richiedono riflessioni sul livello di equa reciprocità e redistribuzione delle risorse economiche, sociali, sanitarie e culturali. Sono inevitabilmente coinvolte le politiche sociali chiamate a progettare strategie di contrasto. Il tema della povertà apre a problematiche più generali relative ai diritti e alla loro esigibilità, soprattutto per i minori, spesso più esposti ai rischi connessi alle diverse forme di deprivazione economica. I diritti dei minori si esprimono, nelle diverse dimensioni della vita, in termini di necessaria sostenibilità di tutela e salvaguardia dei sistemi sociali in cui il fenomeno della povertà si presenta con significative criticità a livello macro e micro-sociale. In questo senso, non meno esente dagli obblighi di tutela e salvaguardia dei minori è il sottosistema sociale delle comunicazioni su larga scala.

Article history:
Received 28 September 2024
Received in revised form 24 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.14-30

1 Poverty, absolute poverty and relative poverty[1]

Studying poverty on a macro-sociological level means building indicators and indices based on measurement tools and empirical data collection. ISTAT (Istituto Nazionale di Statistica) detects the degree of incidence of poverty in a given population by calculating the ratio between the number of families with a monthly expenditure for consumption equal to or below the poverty threshold and the total number of resident families; the measurement is carried out with reference to a specific historical period and a specific geographical area. The study of the phenomenon is carried out not only at the family level, but also with respect to individuals. The value obtained is given by the ratio between the number of people living in poor families and the total number of people resident in a given territorial reality. On a micro-sociological level, the analysis shifts to subjective experiences, motivational aspects, interactions and social and communicative relations, which contribute to defining the poverty paths of individuals and families. ISTAT distinguishes between an absolute poverty threshold and a relative poverty threshold, defined in relation to the different severity of the phenomenon. The absolute poverty threshold refers to the minimum expenditure necessary to purchase goods and services included in the absolute poverty basket and considered essential to people's daily life; this hamper varies according to the size of the family, the age composition of its members, and the territorial context of reference. The hamper of goods relating to the detection of the incidence of absolute poverty is made up of goods and services that, in the Italian context and for a typical family, are considered essential for a minimally acceptable standard of living. The relative poverty threshold is determined by referring to the average expenditure per person, we speak of pro-capite expenditure; this value is obtained by dividing the total expenditure for consumption sustained by the family by the total of its members. From this methodological clarification derive the concepts of absolute poverty and relative poverty, the related measurement tools and the data suitable for describing the situation in the Italian context.

Absolute poverty represents the most serious situation of poverty; absolutely poor are families whose monthly expenditure is equal to or lower than the absolute poverty threshold. Relative poverty defines the less serious condition: those families whose consumption expenditure is equal to or lower than the relative poverty threshold (poverty line) are considered poor. The Carbonaro equivalence scale provides a set of correction coefficients that are used to determine the poverty threshold for families with a number of members other than two. Families whose monthly expenditure is equal to or lower than the poverty line are classified as poor.

[1] By Vincenzo Corsi.

> For families of different sizes, the value of the line is obtained by applying an appropriate equivalence scale, which takes into account the economies of scale that can be achieved by increasing the number of members (ISTAT, 2023, p. 9).

ISTAT has released poverty estimates based on data relating to the survey on consumption expenditure of italian families, taking into account the main social, economic and territorial characteristics of families resident in our country. The measurement is carried out for families, understood as a reference unit for the detection of the phenomenon, in relation to the characteristics of the nucleus and the specific needs of the members. In identifying essential needs, ISTAT places the following goods and services: adequate nutrition, the availability of a home suitable for the family in terms of size and dimensions of the nucleus (a home heated and equipped with the main services, durable goods and related accessories), the availability of the minimum necessary for dressing, communicating, informing oneself, moving around the territory, educating oneself and maintaining one's health by its members. In building the poverty threshold, it is necessary to consider, writes ISTAT (2023, p. 11), that:

> it is not a single threshold, but as many thresholds of absolute poverty as there are combinations between family typology (obtained as a combination of number and age of the members), region and type of municipality of residence (distinguishing between municipalities in the centre of the metropolitan area, periphery of the metropolitan area and municipalities with 50,001 inhabitants or more and other municipalities with up to 50,000 inhabitants other than municipalities in the periphery of the metropolitan area).

The analysis proposed by ISTAT allows us to detect different forms of poverty in the Italian population. Economic poverty, an aspect that unites and from which, for different aspects and causes, the forms of poverty (relational, educational, food) derive, can be defined as a state of indigence that is expressed and clarified, in the existential determinants, as a function of an income level that is too low to be able to satisfy the basic needs of life. The lack of economic resources sufficient to satisfy the essential needs of the person, also measured with regard to the society and the historical and cultural period of reference, determines the formation of situations that are also serious of deprivation in vulnerable groups of the population starting from the youngest age groups and minors. The level of income determines the basket of goods and services that families and individuals can access during their existence, starting with food products, which represent one of the critical points of the system. These goods and services are of primary importance since their lack of availability and adequate access derives from other situations of marginalization and social exclusion. Poverty is a growing phenomenon

both globally and in individual national realities, including Italy. The effects are manifested, with different consequences in terms of incidence and territorial articulation, in the socioeconomic and sociocultural expressions of inequalities and opportunities for growth and social mobility. The sociological analysis allows, on a comparative level, to define the countries and regional areas at greatest risk of poverty, the families and social groups involved, the structural variables that are the cause; the effects are determined at the micro level, for individuals and groups, and at the macro level for the social system as a whole, for its stability in terms of integration and for the forms of social solidarity of welfare policies.

Poverty is a phenomenon of great importance for contemporary societies; it determines strong impacts for the economic, social and demographic development of individual countries. In the context of the definition of poverty, the World Bank has developed measurement indicators and has identified the causes and consequences for the people involved such as inadequate or insufficient school education for the development of the person and the cultural capital of a country, difficulty in accessing social, health and health care services. These are forms of vulnerability and social exclusion that determine significant inequalities in guaranteeing equal access to consumption and services by the populations involved. Data on economic poverty in the world highlight how a considerable number of individuals must also face the problem of hunger on a daily basis. This is a critical aspect especially on an ethical and social justice level. The lack of shelter, the difficulties in accessing education, health care, equally represent forms of deprivation of people of essential goods for existence, in a circular relationship of cause and effect: the difficulty in accessing such goods and services is a consequence and cause of poverty. The World Bank has defined the monetary value of poverty as the threshold or minimum level of income below which a person or family struggles for survival. People who find themselves in this situation are unable to provide for their basic needs, such as having adequate housing, access to health care, food (FAO, IFAD, UNICEF, WFP, & WHO, 2020). Families living below this international poverty line, equal to $2.15 per person per day, have significant limitations in their daily lives. At a global level, the World Bank, in measuring poverty, has found:

> the international poverty line is set at $2.15 per person per day using 2017 prices. This means that anyone living on less than $2.15 a day is in extreme poverty. About 648 million people globally were in this situation in 2019. The COVID-19 pandemic dealt the biggest setback to global poverty-reduction efforts since 1990, increasing the number of people in extreme poverty from about 70 million, to 719 million people. Rising energy and food crises, caused in part by the war in Ukraine, and the effects of climate change contribute to an uneven recovery[2].

[2] https://www.worldbank.org/en/topic/measuringpoverty

According to the FAO (Food and Agriculture Organization of the United Nations)[3], 828 million people in the world suffer from hunger[4]. For them, access to food resources is limited. The relationship between economic poverty and food poverty, a critical aspect of the system, especially for minors, presents a strong correlation, with effects on the dimensions of a person's life: priorities change and opportunities for individual and social development are reduced. The issue of food leads to focusing the attention of social policies on the forms and consequences of economic inequalities for the population; the phenomenon concerns not only societies that are backward in terms of economic and technological development, but also Western ones, which are richer and more industrialized, including Italy. The issue of access to adequate food for all is an urgent topic, for which solutions must be found at global and local levels (Atkinson, 1998).

2 Poverty as a permanent phenomenon in Italian society[5]

The sociological analysis of poverty focuses on the plurality and multidimensionality of the phenomenon. A central theme is represented by the concept of capability deprivation (Sen, 1999), which includes, Morlicchio points out, "the possibility of eating adequately and in accordance with one's values, the availability of housing, basic education, as well as being able to participate in community life and be able to appear in public without shame" (Morlicchio, 2020).

Poverty in Italy, in the forms of absolute and relative poverty, involves a significant number of families and individuals. It is an economic condition characterized by difficulty in accessing goods and services that are necessary and adequate for daily life: a greater number of members and the presence of minors in the family unit are conditions that increase the risk of the family finding itself in situations of poverty.

ISTAT (2024) detects significant forms of absolute poverty for Italy:

> according to preliminary estimates, in 2023, families in absolute poverty stood at 8.5% of the total resident families (they were 8.3% in 2022), corresponding to approximately 5.7 million individuals (9.8%; a share almost stable compared to 9.7% in 2022). The intensity of absolute poverty at a national level is also unchanged (18.2%).

[3] https://www.fao.org/home/en/
[4] https://www.compassion.com/poverty/poverty-and-hunger.htm
[5] By Vincenzo Corsi.

The historical perspective (Baldini & Bosi, 2007) shows that territorial differences have never been definitively overcome (Brandolini & Saraceno, 2007; Brandolini & Torrini, 2010; Commissione di indagine sulla povertà e sull'emarginazione, 1998); the economic disadvantage is found above all in the Southern regions. Taking absolute poverty as a reference, a greater incidence of families in this condition emerges in the South, with a growing value, from 10.1% in 2022 to 10.7% in 2023. In Italy, poverty is the consequence of structural characteristics of the country, on which cyclical situations of a multidimensional phenomenon insist: work and its lack are relevant aspects of the condition of poverty, to which are added the increase in forms of job insecurity, the involvement of people in poor and low-income jobs, the limited female participation in the labor market, the fragmentation and heterogeneity of the social protection system, the poor and unequal territorial availability of services for the conciliation between family activities and external work, the differences in the distribution of wealth (Saraceno, Benassi, & Morlicchio, 2022). The relationship between economic poverty and food poverty is confirmed in the empirical analysis (Campiglio & Rovati, 2009) by highlighting the need for change in welfare systems and social policies (Maroncelli, 2017). The sociological perspective highlights static and dynamic analyses of the phenomenon (Biolcati-Rinaldi & Ciampaglia, 2011), which open up to different interpretations, forms of intervention and possible social policies. The dynamic perspective highlights that in life one is not poor forever: there may be moments in which one is poor; the condition of poverty can change even several times in the life cycle of a family or a person, and manifests itself in different forms and levels of severity. The condition of being poor, in the dynamic perspective, has the character of being temporary (Siza, 2009), it can also last a short time and reappear at several moments in the life cycle. The static perspective describes a permanent condition of poverty for specific social groups, identifiable on the basis of structural variables that affect the economic well-being of families and people (Bosco & Negri, 2003). In Italy the phenomenon is growing. In 2005, families in absolute poverty were 819 thousand, with an incidence of 3.6%. In 2022, ISTAT detected just over 2.28 million families in absolute poverty, equal to 8.3% of the total (1.9 million in 2021). The data describes a situation that has been increasing over the years; those most affected by poverty are families residing in the municipalities of Southern Italy (ISTAT, 2023). The trend of poverty in the different areas of the country defines a plurality of forms and expressions of social inequalities. In Southern Italy, the incidence of individual poverty was higher than in other geographical areas of the peninsula, with a value of 12.1% in 2023. In the same year, the North worsened its situation: it went from an incidence of 8.5% in 2022 to 9.0% in 2023, with 2.4 million people affected by the phenomenon (ISTAT, 2024). The data confirms that the families in greatest difficulty remain the largest ones: in 2022, poverty affects 22.5% of families with five or more members and 11.0% of those with four. Families with three members are also worsening: they are 8.2%

compared to 6.9% the previous year (ISTAT, 2023). The risk of poverty increases among families with minor children. ISTAT (2024, p. 5) writes:

> the presence of minor children continues to be a factor that exposes families to hardship and poverty phenomena; the incidence of absolute poverty is confirmed to be more marked for families with at least one minor child (12.0%), while for those with elderly members it stands at 6.4%.

Poverty affects families with foreign members more than families with only Italians. ISTAT (2023, p. 5) writes:

> there are over one million and 700 thousand foreigners in absolute poverty, with an incidence of 34.0%, over four and a half times higher than that of Italians (7.4%). However, for the latter there is an increase in absolute poverty at a national level (7.4% from 6.9% in 2021), but also in the North and in the South (respectively 5.4% and 11.4%, from 4.9% and 10.6% in the previous year) […]. Families with at least one foreigner in which there are minors show an incidence of poverty equal to 30.7% (322 thousand families); the subset of families of only foreigners with minors shows greater signs of hardship (36.1%), over four and a half times higher than that of families of only Italians with minors (7.8%). In the South and the North, the incidence in families with foreigners where there are minors exceeds 30%, 37.6% and 30.8% respectively, compared to 12.6% and 4.5% of families of only Italians with minors.

The condition of poverty of families in which there are minors has effects that involve aspects and dimensions of their daily life: poverty determines limitations in access to goods and services that are fundamental for the growth of the minor (Agostini, 2023). The effects that economic poverty has on them prove difficult to interrupt (Caritas Italiana, 2022) and are such as to affect different dimensions of life, from health conditions to the development of the person as a whole (Saraceno, Benassi, & Morlicchio, 2022), determining other forms of poverty (food, educational, cultural) attributable to the difficulties of families in adequately coping with the needs of the daily life of its members.

3 The right of minors to the sustainability of at least "one healthy meal a day"[6]

"The families suffering the most are especially those with three or more minor children". The Convention on the Rights of the Child and the Adolescent is certainly the essential and dutifully most recalled reference when dealing with minors: it is the world charter for their protection and safeguarding and for the protection and safeguarding of their rights. It marked the beginning of an international institutional attention, of a culture of intent rich in declarations which were and are followed by concrete action. It is not only the document that proclaims the rights of minors, it is testimony. The Convention, in defining what is due to them, testifies to what has been, is, and can still be inflicted on them: discriminated (art. 2), forgotten (art. 3), killed (art. 6), torn away (art. 9), ignored (art. 12), abandoned, violated, exploited, mistreated, abused (arts. 17, 19, 33, 34), malnourished (art. 24), deprived (arts. 28, 29, 30, 31), sold (art. 35), tortured (art. 37), recruited (art. 38), deviated (art. 40). With the ratification of the document, for the States Parties, the best interests of the minor must definitively be a permanent consideration in all decisions that concern them, within the competence of public or private social welfare institutions, courts, administrative authorities and legislative bodies (art. 3).

In particular, the right not only to life (art. 6), but to a standard of living necessary for physical, mental, spiritual, moral and social development (art. 27) commits to ensuring "the right to enjoy the highest attainable standard of health" (art. 24) and therefore also to "combat disease and malnutrition […] through […] the provision of nutritious food and safe drinking water" (art. 24, c); to "ensure that all groups in society […] receive information on child health and nutrition, the advantages of breastfeeding, hygiene and a healthy environment and the prevention of accidents and receive assistance to enable them to put this information into practice" (art. 24, e); to assist materially and through support programmes parents or persons responsible for them in difficulty with regard to food, clothing and housing (art. 27, 3).

According to the documents of the V and VI Report to the UN Committee – a commitment that Italy fulfills every five years to update on its state of application of the Convention – there are essentially three areas of planning and social intervention that involve nutrition: support for poverty, behavioral disorders and the promotion of healthy lifestyles. These are areas that have required, and consolidated, inter-institutional collaboration with the School.

The measures undertaken to support poverty are:

[6] By Sabrina Speranza.

- the adoption of the National Plan for the fight against poverty and social exclusion and the forecast of the Support for Active Inclusion (SIA) to be guaranteed as a priority to families with minors;
- the Operative Program I relating to the Fund for European Aid to the Most Deprived (FEAD), approved by the European Commission to the Ministry of Labor and Social Policies (MLPS), consisting mainly in the financing of the purchase and distribution of food products for the period 2014-2020;
- at local level, school canteen services as an element of combating food poverty and the Canteen Commissions, in collaboration with the municipal administration and stakeholders, for the control of the quality and quantity of food administered to pupils in reference to the current dietary tables[7].

In 2013, the National Action Plan for Mental Health (PANSM) recommended early and timely interventions for mental disorders in adolescents and young people (age group 15-21 years), including in the area of eating disorders, for which the Ministry of Health developed in 2017 the National Guidelines for nutritional rehabilitation in eating disorders and monitored and updated the National Map of Services for the treatment of Eating Disorders.

Strategic planning for the promotion of healthy lifestyles has included programs (e.g. the Prime Ministerial Decree of 4 May 2007 – Earning Health: making healthy choices easy where poor nutrition is indicated as one of the risk factors for chronic-degenerative diseases) and surveillance systems for data collection (for example Okkio alla salute carried out five data collections, in all Italian regions and in the school system from 2008/09 to 2015/2016, on overweight and obesity in childhood, as well as on children's lifestyle; for example the HBSC project, Health Behaviour in School-aged Children, carried out two national surveys, in 2010 and 2014, on overweight in all age groups).

The National Prevention Plans of the last ten years are aimed at increasing the consumption of fruit and vegetables, promoting breastfeeding, improving and controlling the nutritional quality of school canteen menus (for example the national strategy of the EU Fruit, Vegetables and Milk in Schools Programme for the period 2017-2023).

[7] The National Plan for the Fight against Poverty and Social Exclusion is a gradual progression plan, from 2016 onwards, for the achievement of essential levels of welfare benefits to be guaranteed throughout the national territory to combat poverty. The FEAD reaches approximately half of the minor population in conditions of absolute poverty and approximately a quarter of those in relative poverty. Central coordination takes place between the MLPS, the Ministry of Agricultural, Food and Forestry Policies (MIPAAF) and the Agency for Agricultural Payments (AGEA). The national coordination structures of the lead partner organizations are Associazione Banco Alimentare of Rome, Banco delle Opere di Carità, Caritas Italiana, Comunità di S. Egidio, Croce Rossa Italiana, Fondazione Banco Alimentare. https://www.minori.gov.it/it/minori/v-e-vi-rapporto-allonu-su-infanzia-e-adolescenza-italia

In the projects promoted by the Ministry of Health in the field of physical activity, nutrition is one of the vectors of psychophysical well-being (for example the project Movement in 3S: promotion of Health in Schools through Sport and the project SBAM! Sport, Well-being, Nutrition, Mobility, School, activated respectively by the Regions of Friuli Venezia Giulia and Puglia, in relation to the National Plan for the Promotion of Sporting Activity).

Currently, a point of reference for national initiatives is the European Child Guarantee (EU, 2021), the European Guarantee System for vulnerable children, especially due to the economic and social impact of the pandemic. It is the document that urges to allow minors in need to have free and effective access to at least one healthy meal per school day:

> access to healthy and sustainable food is especially challenging for low-income families. Programmes promoting healthy food and diet can help address issues such as unhealthy eating habits, lack of physical activity, obesity or alcohol and tobacco consumption, thereby reducing malnutrition and poor nutrition, which are more prevalent among children from disadvantaged backgrounds. Experience with the COVID-19 pandemic has shown the importance of school feeding programmes for some children, who were suddenly deprived of a reliable source of nutrition during the lockdown. It is therefore crucial that children in need have access to at least one healthy meal per day at school, which could be achieved by providing such meals or by ensuring that parents, guardians or children are able to provide them, taking into account specific local circumstances and needs (EU, 2021).

In Italy, the implementation of the Child Guarantee is represented by the 5th National Action Plan and Interventions for the Protection of Rights and the Development of Subjects in Developmental Age 2022-2023. Education, Equity, Empowerment and above all by the National Action Plan for the Implementation of the Child Guarantee (Piano di Azione Nazionale della Garanzia Infanzia-PANGI). These Plans also experiment with mechanisms for the active participation of minors in order to guide the target actions in the most appropriate way. The YAB (Youth Advisory Board) was established for the PANGI, whose recommendations are an integral part of it. As regards nutrition, one of the priority themes of the Child Guarantee, the YAB's reflections have been consolidated into three orders of perceived and/or experienced difficulties:

> a) we need more information about eating disorders and how to prevent them;
> b) we need regulations to protect girls and adolescents from the spread of harmful images, perfect bodies and stereotyped beauty standards, which make adolescents tend towards unattainable and unrealistic models;

c) we should make quality food more accessible and less expensive, educate about healthy eating and provide support for families or at least the guarantee of a balanced lunch every day at school […] (Ministero del Lavoro e delle Politiche Sociali, 2022).

4 The duties of commercial communication[8]

The YAB recommendations to the PANGI Working Group reported above question communication: more information, i.e. more content to understand and non-deceptive commercial communication, i.e. honest in the objectives it aims for and the meanings it intends. Minors have the right to question communication: they are, must be, free to go through it ("freedom to seek, receive and disseminate information", art. 13 of the UN Convention[9]) and to be able to rely on it because on the other hand the media must perform the function of disseminating information and materials of "social and cultural utility" for "their social, spiritual and moral well-being as well as their physical and mental health" (art. 17, UN Convention).

The Advertising Self-Discipline Institute (Istituto dell'Autodisciplina Pubblicitaria-IAP) has been thinking about the protection and safeguarding of minors in commercial communications since 1966. The Institute was founded in Milan with the aim of promoting "honest, truthful and correct" commercial communication, which "must avoid anything that could discredit it" through the application of the Self-Discipline Code of Commercial Communication/Codice di autodisciplina della comunicazione commerciale (art. 1 Fairness of Commercial Communication). Periodically updated (the last time in 2024), the Code dictates a series of procedural and substantive rules, which require compliance with fundamental principles to protect the consumer public, fair competition between operators, human dignity and minors.

The Code dedicates three specific rules to minors in particular: art. 11, Children and adolescents; art. 22, Alcoholic beverages; art. 23 bis, Food supplements and dietary products.

According to art. 11, both messages addressed to minors and those received by them "must not contain anything that could harm them psychologically, morally or physically and must not abuse their natural credulity or lack of experience, or their sense of loyalty". In particular, commercial communication aimed at the sale of food and drink products must not induce "belittling the role of parents and other educators in providing sound dietary advice" and "adopt the habit of unbalanced eating habits, or neglect the need to follow a healthy lifestyles" (IAP, 2024a).

[8] By Sabrina Speranza.
[9] Signed by 196 countries (as of 12 July 2022).

Article 22 on alcoholic beverages recommends

> not to oppose […] consumption models inspired by moderation, correctness and responsibility. This is to protect the primary interest of people, and in particular children and adolescents, in a family, social and working life protected from the consequences connected to the abuse of alcoholic beverages. […] not to address or refer, even indirectly, to minors, and represent the latter or subjects who clearly appear to be such as to be intent on consuming alcohol; […] not to use signs, drawings, characters and people, directly and primarily linked to minors, which may generate a direct interest in them (IAP, 2024a).

Commercial communication of food supplements and dietary products (art. 23 bis)

> must not boast properties that do not conform to the particular characteristics of the products, or properties that are not actually possessed […] and must be made in such a way as not to lead consumers into nutritional errors and must avoid references to medical recommendations or attestations. These rules also apply to dietary foods for early childhood, to those that replace breastfeeding in whole or in part and to those that serve for weaning or for the nutritional integration of children (IAP, 2024a).

Integral parts of the Code are the Regulation for commercial communication relating to food products and beverages, to protect children and their correct nutrition (Regolamento per la comunicazione commerciale relativa ai prodotti alimentari e alle bevande, a tutela dei bambini e della loro corretta alimentazione: IAP, 2024b) and the Regulation on commercial communication of food supplements (Regolamento sulla comunicazione commerciale degli integratori alimentari: IAP, 2024c).

The limits imposed by the first Regulation highlight everything that a commercial communication, of which advertising is one of the forms, can imply/generate/contain. The presentation of food products and beverages must avoid any misleading statement or representation, even "through omissions, ambiguities or exaggerations […], especially with regard to the nutritional characteristics and effects of the product, the price, the fact that it is free, the conditions of sale, the distribution, the identity of the people represented, the prizes or awards"; it shouldn't "lead to believe that the failure to consume the product which is the object of the commercial communication means inferiority, or failure of parents or other educators to fulfill their duties" (IAP, 2024b, point 4).

Audiovisual commercial communication must not "accentuate the positive qualities of the nutritional aspects of food products or drinks dependent on fats, trans fatty acids, sugars, sodium or salt, whose excessive intake in the general diet is not recommended" (IAP, 2024b, point 5).

"Performance claims must be reflected in an adequate scientific basis and must reflect the characteristics and boastable properties of a product" (IAP, 2024b, point 7.1); they must not "use approvals, recalls and recommendations or medical certifications that result in attributing health characteristics outside of the cases in which this is permitted by current legislation" (point 7.2). Furthermore, commercial communications must not: "show situations that suggest excessive or unbalanced consumption, in contrast with correct eating habits" (point 7.3); "represent behavior by adults that endorses incorrect eating habits" (point 7.4); "ridicule correct eating habits, inducing people to break them, or inciting them to adopt incorrect eating habits" (point 7.5); "represent situations that lead to the belief that failure to consume the product will lead to rejection by friends or exclusion from the peer group or community" (point 7.6); "[…] belittle the importance of an active life" (point 7.7); "show scenes of children who, alone, consume food in front of a screen so as to encourage a particularly inactive lifestyle" (point 7.10).

The Regulation on commercial communication of food supplements does not refer to minors, but it is important for everything that, reaching them, can influence them, especially if they are pre-adolescents and adolescents. Consider, for example, the induced confusion of the concept of health with that of weight loss: "it is not admissible to present the products in question as 'slimming'. The role of supplements aimed at controlling or reducing weight is that of 'adjuvants of low-calorie diets'. Furthermore, the concept of weight loss as a synonym of health must not be emphasized" (IAP, 2024c, point 1).

Then there are green claims. These are advertisements that present a brand image characterized by environmental commitment and that can induce the purchase of products considered more suitable for an eco-friendly lifestyle, even for children and teenagers. The environmental benefits of a product boasted and promised by an advertisement must however correspond to a concrete commitment by companies to protecting the environment. Ecological, organic, compostable, biodegradable, recyclable, eco-sustainable are potentially misleading claims. Article 12 of the Code, Protection of the natural environment, imposes precise standards of correctness, so that ecological slogans do not become phrases of mere common use, watered down with promises (green washing) devoid of concrete meaning for the purposes of characterizing and differentiating products and companies[10].

[10] The requirements for correct environmental advertising are: clear and comprehensible information (without ambiguity); indications on the scope to which they refer (product, process, packaging, entire life cycle or part of it); evidence to support what is stated (relevant, significant data, verifiable according to updated standards of the recognized scientific methodology); no vague and generic statements (consistency between the promised environmental benefit and the function of use); no peremptory claims (Zero emissions, Zero impact, 100% green, 100% natural, Sustainable project). See IAP, 2023.

The Institute is also remembered for: the signing with the Ministry of Health and other associations in the food sector of the Guidelines for commercial communication relating to food products and beverages, to protect children and their correct diet on the risk of overweight and obesity; the Memorandum of Understanding with the Authority for Children and Adolescents (AGIA) to jointly monitor compliance by advertising operators with the UN Convention; the Framework Agreement with the Authority for Communications (AGCOM) to coordinate their respective competences (exchange of data and information, guidance and prevention activities aimed at consumers and businesses and aimed at promoting correct commercial communication, verification of regulatory conditions – obligations, prohibitions – in the field of advertising and protection of consumers and users, organization of seminars, study groups and training activities in matters of common interest); the recent development of a Digital Chart that provides a picture of the most widespread forms of commercial communication on the Internet, in the digital world in general and that details the theme of the recognizability of digital commercial communication.

The last decades have certainly been full of intentions and exercises of responsibility even if the behavior of communication operators is certainly not resolved "with legal or para-legal regulations and with punitive interventions". Violations in the media field always pose a "problem of custom, mentality, culture, civil and not only civil ethics". Communication remains "an area of freedom and conscientious choices", and with human-social costs of a non-accountable nature (Rossi, 2004).

5 Conclusions

The work, in examining the relationship between poverty and nutrition, focuses on the issues related to the spread of poverty in Italy and highlights the correlation between economic and social determinants, and the recognition of minors' rights. There is an increase in the spread and incidence of the phenomenon of poverty, in the aspects of absolute poverty and relative poverty, in all Italian geographical contexts. In particular, the essay highlights the growing involvement of minors with respect to whom it is necessary to rethink the actions of contrast starting from the identification of rights and their enforceability in the different territories and relational contexts. The analysis, in detecting the poverty of families and minors, investigates the consequences that this condition has on the level of cultural, educational and lifestyle sustainability, as recommended and become areas of special protection in international conventions and in the commitments undertaken by Italy.

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Exploring the Intersection of Workplace Spirituality, Innovative Work Behavior, and Engagement in Public Administration: A Bibliometric Study

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Abstract

This study presents a comprehensive and systematic synthesis of the rapidly evolving literature on workplace spirituality (WPS) and its influence on innovative work behavior (IWB) and employee engagement (EE) within public administration. As interest in these themes continues to grow, there remains a notable lack of thorough, cohesive analysis in the field. To fill this gap, we conducted a bibliometric analysis of 195 peer-reviewed articles published between 2015 and 2024, sourced from the Scopus database. Utilizing citation, co-citation, and cluster analysis, we identified the most impactful publications, leading scholars, and key journals, mapping the intellectual structure of the research domain. An in-depth review of 89 articles from the main clusters provided valuable insights into the emerging themes and trends. Our findings revealed four major research clusters, shedding light on the dominant theoretical frameworks, contextual applications, and methodological approaches driving the discourse. Furthermore, this study highlights critical research gaps and offers directions for future investigation, making a start for new contributions. By clarifying the role of workplace spirituality in enhancing innovation and employee engagement in the public sector, this research delivers essential insights for scholars and policymakers aiming to optimize organizational performance and cultivate a more engaged, innovative workforce in public organisations.

Keywords – Workplace Spirituality; Innovative Work Behavior; Engagement; Public Organizations; Bibliometric Analysis.

Paper type – Bibliometric Analysis

Sommario

L'intersezione tra spiritualità sul posto di lavoro, comportamenti lavorativi innovativi e impegno nella pubblica amministrazione: uno studio bibliometrico. – Questo studio presenta una sintesi completa e sistematica della letteratura, in rapida evoluzione, relativa alla spiritualità sul posto di lavoro, alla sua influenza sul comportamento lavorativo innovativo e sul coinvolgimento dei dipendenti all'interno della pubblica amministrazione. Mentre l'interesse per questi temi continua a crescere, permane la carenza di analisi approfondite e coerenti nel settore. Per colmare questa lacuna, è stata condotta un'analisi bibliometrica di 195 articoli sottoposti a *peer review* pubblicati tra il 2015 e il 2024, provenienti dal database Scopus. Utilizzando citazioni, co-citazioni e analisi di cluster, abbiamo identificato le pubblicazioni di maggiore impatto, i principali studiosi e le riviste chiave, mappando la struttura intellettuale del dominio di ricerca. Una revisione approfondita di 89 articoli dei principali cluster ha fornito preziosi spunti sui temi e sulle tendenze emergenti. I risultati hanno rivelato quattro principali cluster di ricerca, facendo luce sui quadri teorici dominanti, sulle applicazioni contestuali e sugli approcci metodologici che guidano il discorso. Inoltre, questo studio evidenzia le lacune critiche della ricerca e offre indicazioni per indagini future, dando il via a nuovi contributi. Chiarendo il ruolo della spiritualità sul posto di lavoro nel migliorare l'innovazione e il coinvolgimento dei dipendenti nel settore pubblico, questa ricerca fornisce spunti essenziali per studiosi e politici che mirano a ottimizzare le prestazioni organizzative e coltivare una forza lavoro più impegnata e innovativa nelle organizzazioni pubbliche.

Article history:
Received 23 September 2024
Received in revised form 21 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.31-55

1 Introduction

In the evolving world of administration, the concept of workplace spirituality (WPS) has emerged as a crucial factor that can greatly impact how employees behave and the overall outcomes of organizations (Baber, Baber, & Di Virgilio, 2023). As public sector entities aim to encourage innovation and boost employee involvement, grasping the connection between WPS, innovative work behaviour (IWB) and employee engagement (EE) becomes increasingly vital. Despite the growing interest in this subject, there remains a lack of synthesis in existing literature, leaving gaps in our understanding of these concepts and their interactions within public administration.

This study sets out to explore how to bridge this knowledge gap by conducting a bibliometric analysis of the literature on WPS and its influence on IWB and EE within public administrations. From 2015 to 2024, our research dives into 195 peer-reviewed journal articles from the Scopus database. By utilizing citation, cluster and co-citation analyses, we meticulously pinpoint the works that outline the intellectual landscape of this field and highlight areas that require further investigation.

Using analysis forms the foundation of our research, allowing us to identify articles, journals, authors, and countries involved in research output as well as significant keywords. This thorough evaluation offers an overview of the evolving subject matter and sets the stage for future research initiatives. Our discoveries highlight four areas of interest, each representing an aspect of workplace spirituality and its implications for individual well-being and employee engagement. By identifying research areas and utilizing a theoretical framework, specific settings, characteristics and methodologies, our study creates opportunities for future researchers to explore new aspects of workplace spirituality in public administration. The insights gained from this analysis aim to improve the understanding of regulators and scholars by providing insights into workplace spirituality, individual well-being, and employee engagement. Additionally, it identifies areas for enhancement that can guide policymakers and practitioners in cultivating an innovative and involved workforce within the public sector.

As we navigate the intersection of spirituality and public administration, this research aims to illuminate the impact that workplace spirituality can have on fostering an environment of innovation and engagement among public servants. We aspire that the outcomes of this study will not only enrich discussions but also translate into practical strategies that enhance the efficiency and welfare of public organizations globally.

Research Objectives for the study are as follows:

- Which trends in WPS, IWB, and EE in public organizations, including keywords, journals, authors, and nations, have a significant impact?
- What is the conceptual structure of the WPS, IWB, and EE in the public sector?

- What are the research's gaps and future directions?

The research aims to study public organizations' most influential WPS, IWB, and EE trends, including keywords, journals, authors, articles, and affiliated countries. It will also determine the intellectual structure of WPS, IWB, and EE in public administrations and identify gaps for future research.

2 Literature Review

2.1 The emergence of Workplace Spirituality

Workplace spirituality has gained traction over the past few decades as organisations seek to understand the deeper human drives that fuel workplace motivation and satisfaction. The seminal works of Giacalone and Jurkiewicz (2010) and Grant (2005) laid the foundation for WPS, conceptualising it as a framework where employees seek a sense of purpose and meaning in their work that aligns with their inner lives. The literature suggests that WPS encompasses a sense of interconnectedness among employees, alignment with organisational values, and a feeling of completeness and joy in one's work (Baber, Baber, & Di Virgilio, 2023; Petchsawang & McLean, 2017; Garcia‐Zamor, 2003).

2.2 Workplace Spirituality and Innovative Work Behaviour

One of the key outcomes of workplace spirituality is its influence on innovative work behavior. IWB is characterised by employees introducing and applying new ideas, products, processes, and procedures within a work role, group, or organization. Research by Ranasinghe and Samarasinghe (2019) and Khan, Mubarik, Ahmed, Islam, and Rehman (2024) have explored the relationship between WPS and IWB, suggesting that employees are more likely to engage in creative and innovative endeavours when they find their work spiritually fulfilling. The intrinsic motivation provided by WPS is believed to be a catalyst for innovation, as employees are driven by a sense of purpose beyond mere financial gain.

2.3 Workplace Spirituality and Employee Engagement

Another crucial aspect of workplace spirituality is its impact on employee engagement. EE is a construct that reflects the level of an employee's emotional and cognitive commitment to their

organization. The work of Fachrunnisa and Adhiatma (2014) and subsequent studies by Milliman, Gatling, and Kim (2018) have established a link between WPS and higher levels of EE. They propose that when employees perceive their work as meaningful and aligned with their personal values, they are more likely to invest themselves fully in their job roles. Saks (2011) further argues that WPS could foster a sense of belonging and engagement, leading to improved job performance and reduced turnover.

2.4 Bibliometric Analysis in Public Administration Research

The application of bibliometric analysis in public administration research is relatively novel (Di Virgilio, Borgia, La Torre, & de Lisio, 2022). This methodological approach, as utilised in the current study, allows for the quantitative analysis of written publications to map out the intellectual landscape of a research domain. The works of Zupic and Čater (2015) and Sezgili (2022) have provided comprehensive guidelines on how bibliometric methods can be used to analyse large sets of academic literature, which is instrumental in understanding the evolution of WPS, IWB, and EE in public administration.

2.5 Synthesis of the Literature and Identification of Gaps

Despite the growing body of literature, there remains a scarcity of studies synthesising the findings on WPS, IWB, and EE, particularly within the context of public administration. The current study addresses this gap by systematically reviewing and analysing 195 peer-reviewed journal papers. The bibliometric analysis reveals four key clusters that represent the core themes within the literature: (1) theoretical underpinnings of WPS, (2) empirical relationships between WPS and IWB, (3) WPS and its influence on EE, and (4) methodological approaches in studying WPS in public administration.

The literature review highlights the importance of WPS in fostering IWB and EE within public administration. The findings from the bibliometric analysis underscore the need for further empirical research to validate and extend the theoretical frameworks. The identified gaps and emerging clusters from the analysis provide a roadmap for future research, suggesting that a deeper exploration into the nuances of WPS could yield valuable insights into enhancing innovation and engagement in the public sector. This study serves as a stepping stone for scholars and practitioners alike, offering a clearer understanding of the impact of WPS on public administration outcomes.

3 Methodology

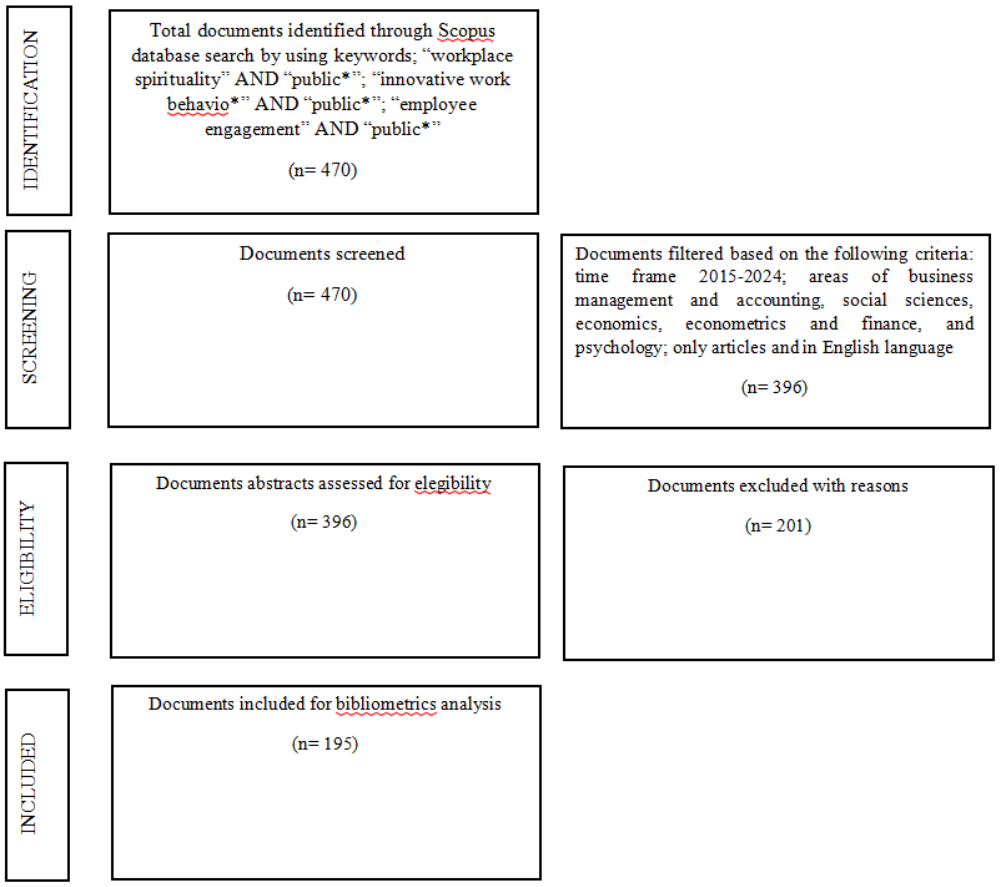
The research methodology applied to the present study incorporates bibliometric analysis. Bibliometrics, a statistical methodology, examines critical document data such as authors, keywords, nations, and references to reveal insights into the topic's evolution (Nicolaisen, 2010; Van Raan, 2005). The Bibliometrics methodology combines various approaches, including citation analysis, bibliographic coupling analysis, co-word analysis, and co-citation evaluation (Leung, Sun, & Bai, 2017; Nicolaisen, 2010). In the current research, we conducted a citation analysis to identify prominent keywords, journals, authors, and nations in the fields of workplace spirituality, innovative work behavior, and employee engagement in the public sector. We followed up with co-citation analysis to determine the conceptual structure of WPS, IWB, and EE studies within public organizations. Co-citation analysis, as proposed by Small (1973), elucidates the conceptual structure of arguments by examining the frequency with which two documents are jointly cited (Marshakova, 1973; Small, 1973). Small (1973) highlights that the number of comparable citing elements between two referenced research studies influences co-citation, with author, document, and journal co-citations serving as fundamental units of analysis. To facilitate the construction and examination of bibliometric maps, we employed Vosviewer, a software application that integrates the VOS mapping approach with a user-friendly interface (Van Eck & Waltman, 2009). This software application enables the seamless visualization of the co-citation network, providing a comprehensive and intuitive representation of the intellectual structure and relationships within the research field.

3.1 Data Collection

Creating bibliometric data involves identifying and evaluating databases and enhancing bibliographic records. Selecting software and deciding on data visualization are necessary steps. We utilized the Scopus database in our research, which aided in identifying minor research fields that were previously underrepresented (Zupic & Cater, 2015). Before selecting papers for the study, the authors needed to determine the methodologies for information synthesis.

The term PRISMA stands for “Preferred Reporting Items for Systematic Reviews and Meta-Analysis”; it is a meticulously designed methodology. It involves the careful selection and critical evaluation of relevant literature, as well as the precise extraction and analysis of data through systematic techniques (Moher, Liberati, Tetzlaff, & Altman, 2010; Paul & Dhiman, 2021).

Figure 1 – Stages for Data Collection Using PRISMA Instructions



Source: Authors' elaboration

Identification: The identification phase was conducted with utmost thoroughness, encompassing a comprehensive study of a desktop search. First, a computer/desktop search of the world's broadest database of published research and publications, "Scopus", was performed. We meticulously planned the search phase to last from 2015 to 2024. The second step was to find keywords and topics in public organizations, such as WPS, IWB, and EE, that could help achieve the study's proposed objectives. The initial papers found by the research are 470.

Screening: During the screening process, we opted to incorporate articles following these criteria: range of time 2015-2024; areas of research limited to business management and accounting, economics, social sciences, econometrics and finance, and psychology; consider only articles in the English

language. Following applying the pre-determined criteria, we eliminated 74 documents in this phase and identified 396 eligible papers or studies.

Eligibility: We read the full-text versions of the 396 articles/papers selected in the previous step during this phase. Although full-text versions of several studies were unavailable, the authors said they would review the abstracts and decide whether to incorporate the study for further analysis. The analysis excluded 201 papers and articles considered irrelevant, leading to the utilization of a total database of 195 studies.

Included: This analysis employed a total database of 195 studies. The investigations analyzed citations to identify prominent authors, sources, organizations, and nations on the subject. We considered conducting citation analysis to identify prominent authors, sources, organizations, and nations.

4 Bibliometric Analysis

4.1 Publication Trends

From 2015 to 2024, there was an increase in WPS, IWB, and EE research in public organizations, with varying phases of publication, as shown in Figure 2. Between 2015 and 2018, publications were infrequent and represented a nearly static trend. The number of publications has increased significantly since 2018, although there has been a minimal reduction in 2021, and an acceleration has followed in 2022. The current trend indicates that the public sector's WPS, IWB, and EE are receiving crucial interest from academics in this management area.

4.2 Highly Prominent Articles

This research determines the citations of the papers that are the highest-ranking in the WPS, IWB, and EE domains. The paper *Competing through employee engagement: a proposed framework* (Al Mehrzi & Singh, 2016) received the most citations in the Journal International Journal of Productivity and Performance Management, with over 156. The second most mentioned document in the collection was the article *Transformational Leadership, Creative Self-Efficacy, Trust in Supervisor, Uncertainty Avoidance, and Innovative Work Behavior of Nurses* (Afsar &Masood, 2017) with a count of 114

citations followed by *Public service sector: The compassionate workplace - The effect of compassion and stress on employee engagement, burnout, and performance* (Eldor, 2018) with 78 citations count in *Journal of Public Administration Research and Theory*.

Figure 2 – Number of Publications per Year

Source: Authors' elaboration

4.3 Highly Prominent Authors

This analysis discovered 498 authors. We identified highly prominent authors based on the criterion of having published at least two texts. Table 2 ranks significant authors based on the number of citations for their published work on WPS, IWB, and EE in the public sector, with or without numerous co-authors. Alfes and Bailey obtained the most citations (2 documents and 190), followed by Asfar (3 documents and 161 citations). In contrast, Hameduddini has published the most documents in this sector, with a total of four, but their work has received less attention than others.

4.4 Highly Prominent Journal

We identified sources with at least three documents and three citation sources to create a comprehensive citation map. It was discovered that only 20 out of 121 sources matched the criterion. Table 3 lists the most cited journals. The *Public Relations Review* published by Elsevier Ltd received the highest citation of 237, totaling seven documents. The second leading journal was *International Human Resources Management*, published by Routledge, which received 182 citations for three documents. The *European Journal of Innovation Management*, published by Emerald Group Holdings Ltd, is ranked with 140 citations and five documents.

Table 1 – Highly Prominent Articles

Most Cited Papers	Type of Study	Journal	Citations Count
Competing through employee engagement: a proposed framework (Al Mehrzi & Singh, 2016)	Qualitative	*International Journal of Productivity and Performance Management*	156
Transformational Leadership, Creative Self-Efficacy, Trust in Supervisor, Uncertainty Avoidance, and Innovative Work Behavior of Nurses (Afsar & Masood, 2018)	Quantitative	*Journal of Applied Behavioral Science*	114
Public service sector: The compassionate workplace – The effect of compassion and stress on employee engagement, burnout, and performance (Eldor, 2018)	Qualitative	*Journal of Public Administration Research and Theory*	78
Servant leadership and followership creativity: The influence of workplace spirituality and political skill (Williams et al., 2017)	Qualitative	*Leadership and Organization Development Journal*	74
Employee workplace spirituality and pro-environmental behavior in the hotel industry (Rezapouraghdam et al., 2018)	Qualitative	*Journal of Sustainable Tourism*	73
The nature of employee engagement: rethinking the employee–organization relationship (Eldor & Vigoda-Gadot, 2017)	Qualitative	*International Journal of Human Resource Management*	72
Innovative work behaviour in knowledge-intensive public sector organizations: the case of supervisors in the Netherlands fire services (Bos-Nehles et al., 2017)	Qualitative	*International Journal of Human Resource Management*	69
Understanding Employee Engagement in the Public Sector: The Role of Immediate Supervisor, Perceived Organizational Support, and Learning Opportunities (Jin & McDonald, 2017)	Quantitative	*American Review of Public Administration*	69
Sense of community, sense of community responsibility, organizational commitment and identification, and public service motivation: a simultaneous test of affective states on employee well-being and engagement in a public service work context (Boyd & Nowell, 2020)	Quantitative	*Public Management Review*	56
Sense of Community, Sense of Community Responsibility, and Public Service Motivation as Predictors of Employee Well-Being and Engagement in Public Service Organizations (Boyd et al., 2018)	Quantitative	*American Review of Public Administration*	56

Source: Authors' elaboration

Table 2 – Highly Prominent Authors

Authors	Affiliation	Total Documents	Total Citations	Country	Total Link Strength
Alfes, Kerstin (2017)	ESCP Business School Berlin	2	190	Germany	5
Bailey, Catherine (2017)	King's College London	2	190	United Kingdom	5
Afsar, Bilal (2018)	Asian Institute of Technology	3	160	Thailand	3
Eldor, Liat (2018)	The Wharton School, University of Pennsylvania, Coller Business School	2	150	United States	2
Vigoda-Gadot, Eran (2017)	University of Haifa	2	94	Israel	2
Hameduddin, Taha (2020)	Lee Kuan Yew School of Public Policy, National University of Singapore	4	58	Singapore	7
Yasir, Muhammad (2019)	Hazara University	2	44	Pakistan	2
Jabeen, Fauzia (2021)	Abu Dhabi University	2	29	Abu Dhabi	1
Al Wali, Joether (2020)	American University of Iraq	2	26	Iraq	1

Source: Authors' elaboration

4.5 Highly Prominent Nations

Figure 3 illustrates a visual representation of citations based on nations with a minimum limit of 5 documents and ten citations in which fewer than 14 countries satisfied the requirement, showing that only 14 of the 65 countries met the condition. Table 4 lists the ten leading and referenced countries in the world. The United States was ranked first in papers (36) and citations (790), with 13 overall link strength. Pakistan was second with 21 documents, 371 citations, and 11 total links, followed by the United Arab Emirates, Malaysia, and others.

Table 3 – Outlook of Highly Prominent Journal

Journal	Publisher	Documents	Citations
Public Relations Review	Elsevier Ltd	7	237
International Human Resources Management	Routledge	3	182
European Journal of Innovation Management	Emerald Group Holdings Ltd	5	140
American Review of Public Administration	SAGE Publications Inc.	4	140
Leadership and Organizational Development Journal	Emerald Group Holdings Ltd	4	101
Public Management Review	Taylor and Francis Ltd	4	77
International Journal of Public Administration	Taylor and Francis Ltd	6	74
Public Personnel Management	SAGE Publications Inc.	5	60

Source: Authors' elaboration

Table 4 – Highly Prominent Nations

Nation	Documents	Citations	Total Link Strength
United States	36	790	13
Pakistan	21	371	11
United Arab Emirates	7	281	8
Malaysia	17	142	10
Ghana	11	110	7
South Korea	7	109	9
China	8	106	6
Australia	6	72	6
India	11	71	1
South Africa	8	69	3

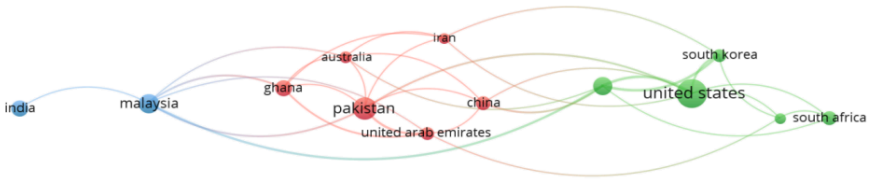
Source: Authors' elaboration

4.6 Highly Prominent Author's Keywords

The study created a keyword co-occurrence map using keywords provided by the authors. It reveals keywords that appear within four occurrences of each other and their corresponding thresholds, and only 27 of the 564 total keywords fit the criteria. Table 5 includes the most prominent authors based on

the frequency with which their published work on WPS, IWB, and EE appears in public organizations, with either a single or multiple co-authors. The term "employee engagement" appears the most frequently. The research found that EE occurred 56 times in the publications, with a connection strength 33. Workplace spirituality was identified as the second most common keyword, with 27 occurrences, followed by innovative work behavior and innovative work behavior, which had 22 occurrences. Similarly, additional terms such as "public sector", "work engagement", "transformational leadership", "public service motivation", "affective commitment", and "leadership" were discovered in the top ten keywords for this study.

Figure 3 – Result of Country Citation



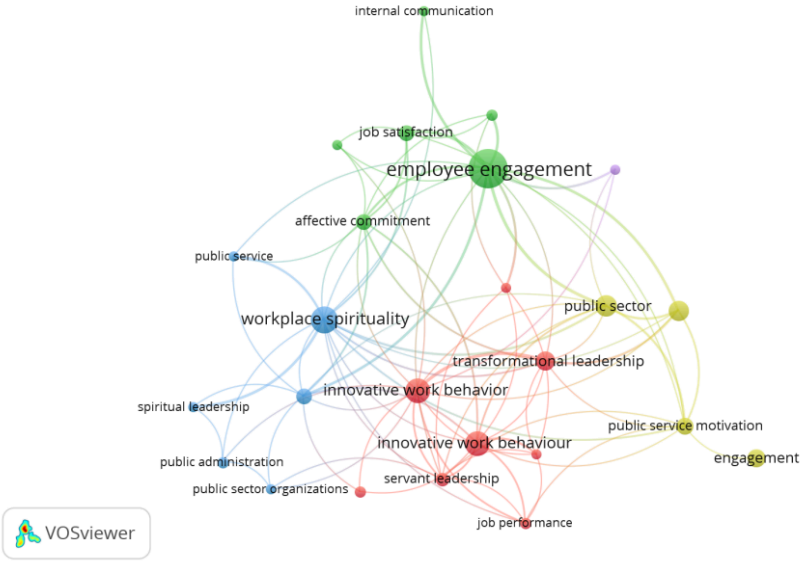
Source: Authors' elaboration

Table 5 – Outlook of Highly Author's Keywords

N.	Keywords	Occurrence	Total Link Strength
1	Employee Engagement	56	33
2	Workplace Spirituality	27	18
3	Innovative Work Behavior	22	16
4	Innovative Work Behaviour	22	14
5	Public Sector	17	20
6	Work Engagement	16	14
7	Transformational Leadership	14	17
8	Public Service Motivation	11	14
9	Affective Commitment	9	14
10	Leadership	10	17

Source: Authors' elaboration

Figure 4 – Result of Author's Keywords



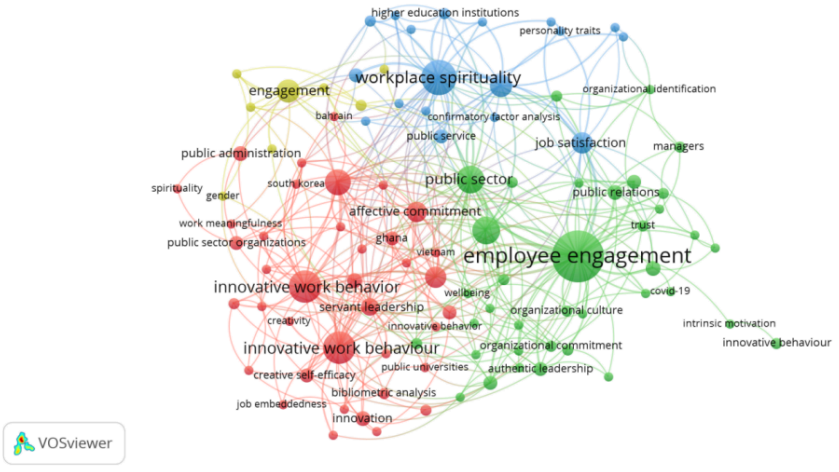
Source: Authors' elaboration

5 Cluster Analysis

The authors utilized VOSviewer software to conduct a term cluster analysis to identify significant research flows. Figure 5 illustrates the visualization of terms based on at least two occurrences. Researchers identified four significant clusters based on repeated terms: red, green, yellow, and blue. The first identified cluster is red and is renamed "innovative work behavior". It contained keywords such as innovative work behavior, transformational leadership, affective commitment, public sector organizations, and many more. The cluster highlights innovative work behavior in the public sector and all the variables connected. The prominent studies were *Innovative Work Behavior in Knowledge-intensive Public Sector Organizations: The Case of Supervisors in the Netherlands Fire Services* (Bos-Nehles, Bondarouk, & Nijenhuis, 2017), *Innovative Work Behavior in the Public Sector: The Roles of task characteristics, social support, and proactivity* (Suseno, Standing, Gengatharen, & Nguyen, 2020), *Transformational Leadership, Creative Self-Efficacy, Trust in Supervisor, Uncertainty Avoidance, and Innovative Work Behaviour of Nurses* (Afsar & Masood, 2018). The green cluster "employee engagement" is the second major cluster in this research. The association between the public

sector and employee engagement is clear in the literature. Many studies have found that public sector and employee engagement are linked, such as *Competing through employee engagement: a proposed framework* (Al Mehrzi & Singh, 2016), *Demands or Resources? The Relationship Between HR Practices, Employee Engagement, and Emotional Exhaustion Within a Hybrid Model of Employment Relations* (Conway, Fu, Monks, Alfes, & Bailey, 2016) and *Do HR Practices Influence Job Satisfaction? Examining the Mediating Role of Employee Engagement in Indian Public Sector Undertakings* (Pradhan, Dash, & Jena, 2019). Other crucial keywords such as employee engagement, job satisfaction, turnover intention, engagement, internal communication, and many more were also a part of this cluster. The third cluster is a blue color called "workplace spirituality". The most representative keywords are workplace spirituality, job satisfaction, spiritual leadership, employee well-being, sense of community, public service motivation, and many more. The cluster illustrates the variables used to analyze the relationship among them. The most influential studies were *Employee Workplace Spirituality and Pro-environmental Behavior in the Hotel Industry* (Rezapouraghdam, Alipour, & Darvishmotevali, 2018); *Sense of Community, Sense of Community Responsibility, Organizational Commitment and Identification, and public service motivation: a simultaneous test of affective states on employee well-being and engagement in a public service work context* (Boyd & Nowell, 2020) and *Towards Examining the Link Between Workplace Spirituality and Workforce Agility: Exploring Higher Educational Institutions* (Saeed, Khan, Zada, Ullah, Vega-Muñoz, & Contreras-Barraza, 2022). The last cluster is the smallest and includes only eight items, including keywords such as engagement, communication, performance, and satisfaction.

Figure 5 – Cluster Analysis



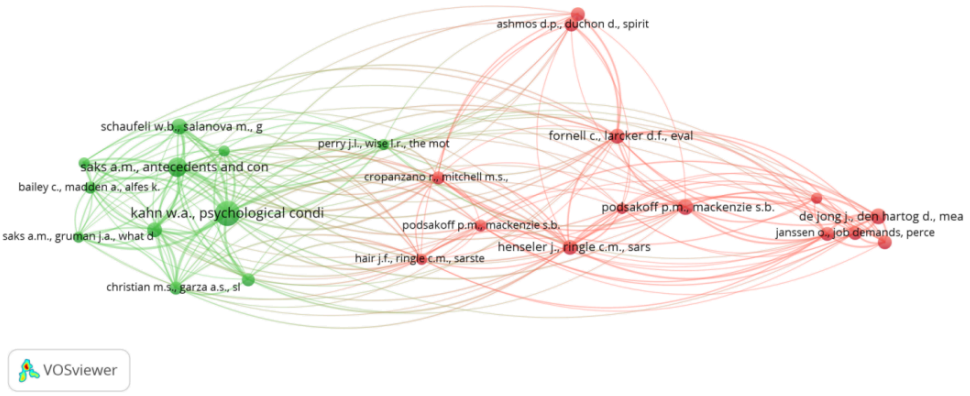
Source: Authors' elaboration

6 Co-Citation Analysis

6.1 Document Co-Citation Analysis

Document co-citation analysis identifies the intellectual structure of related works in a specific area. This investigation will identify which documents reflect the intellectual structure of WPS, IWB, and EE in public organizations. In the present study, we identified 13,034 citations, of which 25 met the minimum 10 citations per work threshold. We specified the number of citations per document in each node and its size. The relationship was a co-citation. The nodes with identical colors were in the same cluster. Figure 6 powerfully illustrates that the process used by the VOS viewer resulted in two major clusters (red and green). The red cluster is the major and counts 14 items with 185 citations. The red cluster emphasizes evaluations of employee innovative behavior, the factors that influence it (such as views of fairness), and the methodological difficulties encountered in a study in this area. Also, the documents underline the importance of taking employees' emotional and spiritual well-being into account as a significant factor in increasing workplace performance and satisfaction. The crucial studies that formed part of the red cluster were *Measuring innovative work behavior, creativity, and innovation management* (De Jong & Den Hartog, 2010), *Job demands, perception of efforts reward fairness and innovative work behavior* (Janssen, 2000) and *Common methods bias in behavioral research: a critical review of the literature and recommended remedies* (Podsakoff, 2003). Other influential documents that create this cluster are: *Spirituality at Work: A Conceptualization and Measure* (Ashmos & Duchon, 2000), followed by *Evaluating structural equation models with unobservable variables and measurement error* (Fornell & Larcker, 1981) and *Workplace spirituality and employee work attitudes: An exploratory empirical assessment* (Milliman, Czaplewski, & Ferguson, 2003). The green cluster reflected the influential publications on employee engagement in the public sector, with 185 citations and 11 items. In general, the materials included in this cluster address employee engagement, namely the significance of creating an engaging and stimulating work environment to maximize human potential and create long-term success. For example, Khan (1990), titled *Psychological Conditions of Personal Engagement and Disengagement*, describes three psychological conditions that lead to personal engagement at work and how these affect employees physically, cognitively, and emotionally in their work roles. Another study, *Antecedents and consequences of employee engagement* (Saks, 2006), explores the causes and repercussions of employee engagement. Similarly, more studies such as *The measurement of engagement and burnout: a two sample confirmatory factor analytic approach* (Schaufeli, Salanova, González-Romá, & Bakker, 2002) and *The meaning of employee engagement* (Macey & Sneider, 2008) formed the central part of the second cluster.

Figure 6 – Co-Citation Network of Documents

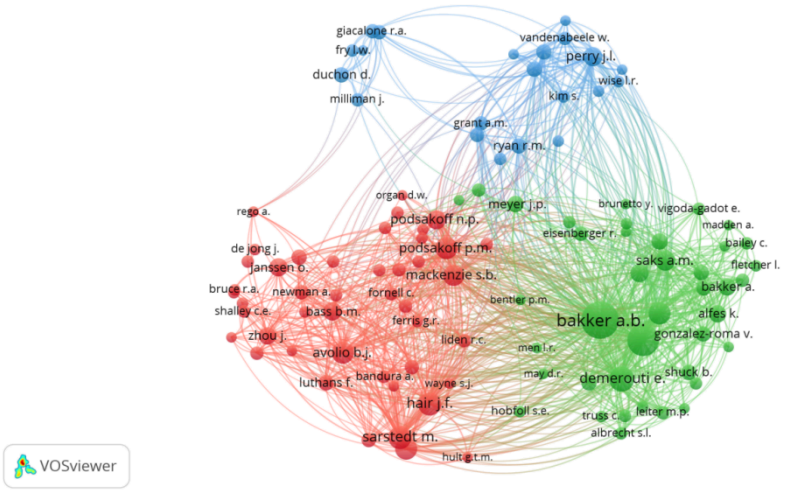


Source: Authors' elaboration

6.2 Author's Co-Citation Analysis

The second study analyzed the author's co-citation network on WPS, IWB, and EE in public organizations. We considered only authors with at least 25 citations, totaling 106 authors. In the present study, we applied co-citation analysis to the 106 contributions. The resulting network, including the formation of specific clusters, can be observed in Figure 7. Co-citation analysis was performed to identify a total of three clusters. The first significant cluster, the red cluster, reveals 45 authors who have worked and contributed towards understanding and developing innovative work behavior (e.g., Janssen, 2000; De Jong & Den Hortag, 2010; Yuan & Woodman, 2010). For instance, Janssen investigates crucial organizational elements such as job demands and perceived fairness, which can substantially impact employee innovation. Each node of the same color represents how individuals' labor in a given cluster connects. The green cluster shows various authors who have contributed to the said domain to explore employee engagement. For instance, authors such as Saks (2006), Bakker and Demerouti (2008), and Bailey, Madden, Alfes, and Fletcher (2017) in their studies emphasize the role of leadership, organizational support, work satisfaction, and communication in boosting employee engagement and well-being, which has significant consequences for companies and their outcomes. The blue cluster includes all the works on workplace spirituality, particularly authors such as Duchon, Fry, Giacalone, and others. They have contributed to expanding knowledge on the subject.

Figure 7 – Co-Citation Network of Authors



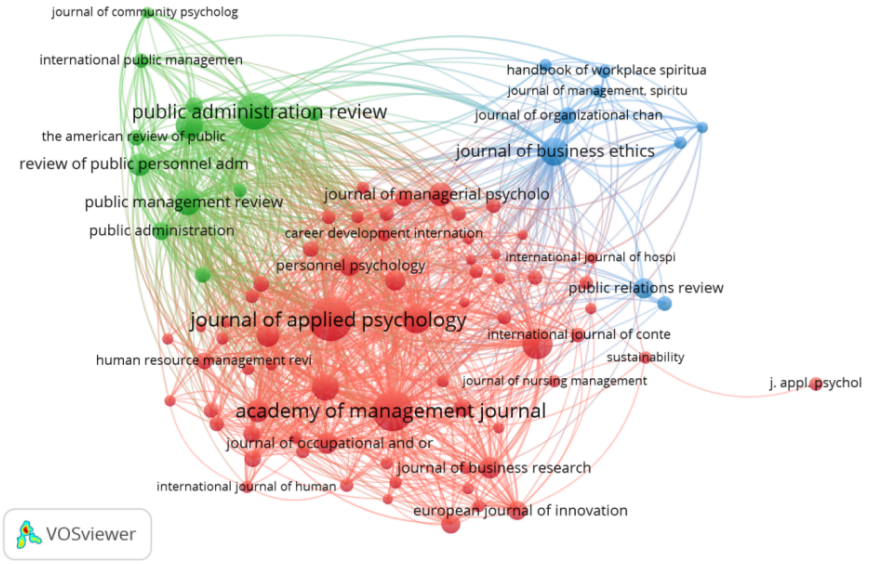
Source: Authors' elaboration

6.3 Journal Co-Citation Analysis

In the study, the authors analyzed the journal co-citation network for workplace spirituality, innovative work behavior, and employee engagement in public administrations, identifying a total of 4,934 sources with a minimum of 25 sources. Of the 4,934 sources, 87 match the criteria. Each node indicated a source, and its size corresponded to the amount of citations. A connection between two elements implies a co-citation relationship. In the VOSviewer visualization, we sorted the nodes according to their similarity. The sources in a similar cluster (color) were positioned closer together than those in a dissimilar cluster (color). The VOSviewer software grouped journal co-citations into three clusters (Figure 8). The red cluster contained 66 sources primarily focused on organizational behavior, human resources management, leadership, management, and organizational psychology (namely *Journal of Applied Psychology*, *Academy of Management Journal*, *Journal of Management*, *Journal of Organizational Behavior*, and many more). The *Journal of Applied Psychology* ranked first, with 403 citations and a total link strength of 117,418, followed by the *Academy of Management Journal*, with 351 citations and 12,677 total link strength. The second cluster was green and comprised 12 items, including the journals mainly related to public management (*Public Administration Review*, *Public Management Review*, *Public Personnel Administration*, *Journal of Public Administration Research and Theory*, and many more). Of these, the *Public Administration Review* received the most citations, with a count of 288 and a total link strength of 12,502, followed by the *Public Management Review* that received a citation of 151 and a total link strength of 7,013. The last cluster is blue and consists of 9

sources based on business ethics, workplace spirituality, religion, and organizational performance (*Journal of Business Ethics*, *Handbook of Workplace Spirituality and Organizational Performance*, *Journal of Management*, *Spirituality and Religion*). The most prominent journal in this cluster is the *Journal of Business Ethics*, with 174 citations and 6,108 total link strength.

Figure 8 – Co-Citation Network of Journals



Source: Authors' elaboration

7 Discussion and Conclusions

This exhaustive analysis offers valuable insights into the research landscape on workplace spirituality, innovative work behavior, and employee engagement in the public sector context. The citation analysis reveals the most impactful publications in this domain, with the paper by Al Mehrzi and Singh (2016) on "Competing through employee engagement" receiving the highest number of citations. This underscores the significance of employee engagement as a strategic lever for organizational performance, particularly in the public sector. The prominence of the work by Afsar and Masood (2018) on the role of transformational leadership and other factors in driving innovative work behavior further highlights the importance of leadership and individual-level factors in fostering innovation among public sector employees. The analysis of prolific authors identifies Alfes, Bailey, and Afsar as the most cited researchers in this area, indicating their influential contributions to the theoretical and empirical understanding of these constructs in public organizations. Interestingly,

Hameduddini has published the most documents but received fewer citations, suggesting the need to evaluate the quality and impact of research outputs critically. The journal-level analysis demonstrates the dominance of outlets such as the *Public Relations Review*, *International Human Resource Management*, and the *European Journal of Innovation Management* in disseminating high-impact research on WPS, IWB, and EE in the public sector. This information can guide researchers in identifying appropriate publication channels for their work. The country-level analysis reveals the United States, Pakistan, and the United Arab Emirates as the leading contributors to the research in this domain, underscoring the need for more global representation and cross-cultural comparisons to enhance the generalizability of findings. The keyword co-occurrence analysis provides a useful map of the conceptual linkages between the key constructs, with "employee engagement", "workplace spirituality", and "innovative work behavior" emerging as the most prominent themes. This suggests that these areas are closely intertwined and warrant further exploration to understand their synergistic effects on public sector performance and employee well-being. The co-citation analysis has shed light on the intellectual structure underlying research on workplace spirituality, innovative work behavior, and employee engagement in public organizations. Three distinct clusters emerged from this analysis. The prominent red cluster emphasizes evaluating employee innovative behavior and the factors that shape it. Key studies in this cluster explore the role of fairness perceptions and methodological considerations in studying innovative work practices. Importantly, this cluster underscores the need to account for employees' emotional and spiritual well-being as a significant driver of workplace performance and satisfaction. In contrast, the green cluster reflects the influential publications on employee engagement in public sector contexts. These works highlight the importance of cultivating an engaging and stimulating work environment to unlock human potential and drive long-term organizational success. Seminal studies in this cluster examine the antecedents and consequences of employee engagement, providing a solid foundation for understanding this critical aspect of public sector management. The blue cluster, on the other hand, centers around the literature on workplace spirituality. This cluster features key contributors, such as Duchon, Fry, and Giacalone, who have significantly advanced the theoretical and empirical understanding of Spirituality in the workplace and its organizational implications. The co-citation analysis has revealed the intellectual landscape shaping research on workplace spirituality, innovative work behavior, and employee engagement within public organizations. The red cluster highlights the importance of measuring and comprehending innovative work behavior, including the influential role of fairness perceptions and employee well-being in driving organizational performance. The green cluster emphasizes the criticality of employee engagement in public sector settings, underscoring the need for leadership, organizational support, and work satisfaction to enhance employee well-being and productivity. Finally, the blue cluster showcases the

growing body of literature on workplace spirituality, reflecting the contributions of prominent scholars in expanding our understanding of this emerging concept and its organizational implications. This study provides a complete overview of the current state of research on WPS, IWB, and EE in the public sector, highlighting the most influential publications, authors, journals, and countries contributing to this field. The findings can inform future research directions, guide scholars in identifying impactful research streams, and assist practitioners in designing evidence-based interventions to foster employee engagement, innovative behaviors, and a spiritually enriched work environment in public organizations. This extensive examination offers significant insights into the theoretical foundations and key works shaping research on these domains within the public sector context.

8 Research Gaps and Future Directions

According to the search results, there needs to be more literature about workplace spirituality, innovative work behavior, and employee engagement in public organizations. Firstly, researchers should conduct more studies investigating the relationship between workplace spirituality, innovative work behavior, and employee engagement within public organizations. The search results reveal a growing pattern in study in this field, but more research is needed to understand the relationship between these variables completely. Secondly, there is a need for more research on the factors that influence WPS, IWB, and EE in public organizations. The search results highlight the importance of leadership, transformational leadership, public service motivation, job satisfaction, and trust in supervisors in promoting WPS, IWB, and EE. However, there is a need for more research to understand the role of these factors in promoting WPS, IWB, and EE in public organizations. Thirdly, there is a lack of research on the impact of WPS, IWB, and EE on organizational performance in public organizations. The search results show that further study is needed to understand better the influence of WPS, IWB, and EE on organizational performance in public organizations. Lastly, there is a need for more research on the role of technology in promoting WPS, IWB, and EE in public organizations. The search results indicate a need for more research to understand the role of technology in promoting WPS, IWB, and EE in public organizations.

In summary, the literature on WPS, IWB, and EE in public organizations has several gaps. Future research should focus on understanding the relationship between these variables, the factors that influence them, the impact of WPS, IWB, and EE on organizational performance, and the role of technology in promoting them.

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TF-based approach in the Metaverse foresight for cultural heritage

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Abstract

Forced stop of cultural institutions, due to the COVID-19 pandemic, led to the acceleration of a digitalization process already begun within cultural sites. In this framework, more experimental practices emerged related to the digitalized tourist-cultural experience, such as the development of cultural space within the Metaverse, a three-dimensional place that extends beyond the physical into the digital. This research developed an analysis based on TF-Technology Foresight approach, identifying a series of key elements characterizing the current dynamics, in order to formulate some progressive scenario hypotheses. The results, albeit with some constraints and risks, show a growing functional relationship between cultural heritage and the Metaverse.

Keywords – Metaverse; Tourism; Cultural Heritage; Technology Foresight.

Paper type – Academic Research Paper

Sommario

Patrimonio culturale e Metaverso: analisi di scenario basate sul metodo TF. – La forzata interruzione di attività delle istituzioni preposte, a causa della pandemia di COVID-19, ha comportato l'accelerazione del processo di digitalizzazione già avviato all'interno dei siti culturali. In questo quadro, sono emerse pratiche più sperimentali legate all'esperienza turistico-culturale digitalizzata, come lo sviluppo dello spazio culturale all'interno del Metaverso, un luogo tridimensionale che si estende oltre il fisico nel digitale. Questa ricerca ha sviluppato un'analisi basata sull'approccio *TF-Technology Foresight*, identificando una serie di elementi chiave che caratterizzano le dinamiche attuali al fine di formulare ipotesi progressive di scenario. I risultati, pur con alcuni vincoli e rischi, mostrano una crescente relazione funzionale tra il patrimonio culturale e il Metaverso.

Article history:
Received 17 September 2024
Received in revised form 3 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.56-80

1 Introduction: Dynamics of the Metaverse in cultural heritage

The first time that the term "metaverse" appaired was in the fiction novel *Snow Crash*, written by Neal Stephenson (see Duan et al., 2021). Being the possibility of expanding spaces beyond (meta) the universe (towards) of material reality, cultural sites seem to acquire a ubiquitous position that extends them beyond the confines: inserted into panoramas and digitalized realities a cultural-site, when virtual, becomes accessible from any position, outside of the "institutional walls". This virtual place offers the possibility of having an interactive dynamic, with its great interoperability and the ability of users to create, use, develop, buy and sell intangible assets (see Ball, 2020).

Generation Z is completely immersed in digital, while Generation Y, preceding it, is more inclined to combine physical experiences with digital ones. Generation Y, more commonly described as Millennials, was born between the early 1980s and the mid-1990s-early 2000s, after Generation X. For this target of users, in particular, the new digital technologies and the Metaverse are arising as interesting tools for co-creation of value in transformative processes of experiential tourism. And it is precisely the co-creation of value that characterizes the Metaverse, defined in fact as a parallel virtual universe that uses environmental intelligence to enhance physical spaces, products and services. In this way Metaverse is emerging as a shared collective and virtual space of co-creation of value (see Xiang, Tussyadiah, & Buhalis, 2015). The Metaverse can also be defined as a real-time 3D virtual space that exists and evolves independently of interaction with the user (see Ivanova & Watson, 2021), in which actors interact in the form of avatars and which develops through experiential and structural that can respond to commercial logics, linked to blockchain or video game dynamics (see Duan et al., 2021; Catlow, 2017).

In the tourism sector, the Metaverse is based on a hybrid reality (MR, Mixer Reality) which combines physical reality with digital reality in the forms of augmented reality (AR) and virtual reality (VR), generating a 3D virtual space in which users can conduct experiential tours. In MR, tourists develop a holistic approach in which real and virtual are not distinguishable (Rauschnabel, 2021) in which experiences are not static but animated and dynamic (Kaplan & Shiff, 2016), as the multiple repetition of experiential cultural fruition mediated by Metaverse provides new elements and new emotional stimuli for the user every time. Even if the common sense tendency is to separate physical space from virtual space, even within the same virtual space strong differences emerge depending on the platform used. For instance, in VR the dynamic of virtual-cultural use is totally immersive without overlapping with physical reality, whereas AR users instead adopt an additional approach that sees physical and digital reality as overlapping layers. VR is preferred more by Gen Z while AR by Gen Y.

The externalities offered by the use of the Metaverse in the tourism field are different, but a first and evident characteristic concerns the possibility of preserving the existing physical cultural heritage over

time. Physical cultural heritage consists of tangible entities transmitted from generation to generation, such as popular music, paintings, sculptures, works, and these physical entities may be partially or completely damaged or destroyed over time. Compared to classical geography, which uses Euclidean geometry as the reference metric, in the geography of digital tourism mediated by the Metaverse it is necessary to redefine the appropriate metrics.

This is a topic that is rapidly becoming central to the scientific debate in the geographical sector, offering a series of critical ideas that generate new epistemological elements with which researchers must deal with. In this sense, a non-Euclidean categorization that can characterize the Metaverse in relation to cultural heritage, identifies appropriate forms of representation: for example, folk music can be considered as a type of cultural heritage in sequential or in a 1-dimensional form (1D); paintings (oil, watercolor) constitute a form of two-dimensional (2D) cultural heritage; finally, sculptures are a three-dimensional (3D) form of cultural heritage. Added to these forms of the 4D and 5D Metaverse could be recognized. In the 4D form the time variable is present: cultural heritage stories convey messages or values rooted in certain cultures, sciences or religions. The 5D shapes refer to cultural heritages characterized by specific applications of context connotation that can improve the user experience and the appreciation of contexts and contents classified by history, culture, science, etc., through storytelling with use of digital videos, animations, audio, tactile perceptions and other sensitive interface meta-systems (see Zhang et al., 2022). Such applied forms of the Metaverse generate a hyper-presence of cultural heritage with its elements (see Chang, Cai, & Thwaites, 2017).

Next section shows the main structural feature of Technology Foresight approach.

2 TF – Structural features

The terms technology foresight and foresight are used interchangeably. Two definitions of technology foresight are provided by UK researchers. The most cited definition belongs to Ben Martin (1996), who describes foresight as the process involved in systematic attempts to look, in the long term, at the future of science, technology, economics and society with the objective of identifying strategic research areas and generic emerging technologies, capable of producing maximum economic and social benefit. Similarly, Luke Georghiou (1996) describes technological foresight as a systematic means of evaluating scientific and technological developments that could have a strong impact on industrial competitiveness, wealth creation and quality of life.

Some important aspects can be seen in these definitions:

- Attempts to look into the future must be systematic to be able to speak of foresight. This distinguishes foresight from endogenous scenario construction, in which everyone is busy planning their daily lives.
- Foresight must concern medium/long-term dynamics. Time horizons for foresight are typically between five and thirty years.
- Scientific/technological drive must be balanced with market demand. This means that the technological perspective must not be dominated only by science and technology, but attention must also be paid to socio-economic factors.
- Attention must be given to social impacts, not just those involved in wealth creation. This has led to the application of foresight exercises for topics such as crime prevention, education and skills, aging society, etc.

According to FOREN – Practical guide to regional forecasts – (2011) foresight involves five essential elements:

- Structured anticipation and long-term projections of social, economic and technological developments and needs.
- Interactive and participatory methods of exploratory discussion, analysis and study, involving a wide variety of stakeholders.
- Engaging interactive approaches that forge new social networks. Emphasis on networking role that varies according to foresight programs.
- Formal foresight products go beyond presenting scenarios and preparing plans. The key thing is the development of a guide for the strategic vision, towards which there must be a common sense of commitment (achieved, in part, through networking processes).
- Concrete and non-utopian shared vision of the evolutionary scenario.

Foresight is often confused with other future-oriented activities, such as forecasting, futures studies, and strategic planning. Forecasting tends to be more focused on the assumptions about how the future will develop. In contrast, foresight does not seek to predict: it is a process that seeks to create shared visions of the future, which stakeholders are willing to endorse with the actions they choose to take at the present moment. In this way, foresight is not interested in predicting the future, but rather is concerned with factors and milestones could generate a possible future scenario. In this perspective, foresight is not a substitute for forecasting, future studies, or strategic planning. Each activity has its role, and in many cases it can happen that they support each other.

Technological foresight first came to prominence in the late 1950s in the United States, in the defense industry and in work for consultancies such as the RAND Corporation. The latter were responsible for the development of some of the main technological forecasting tools, such as the Delphi

questionnaire survey and scenario analysis. Large-scale forecasting exercises were performed during the 1960s by the United States Navy and the United States Air Force. Technological foresight has also been used by private companies, for example in the energy sector. However, subsequent developments, and the emergence of foresight activities, took place in Japan.

The prediction has evolved over three generations (Georghiou, 1996). First-generation foresight deals with expert technology forecasting, second-generation foresight introduces industry and market, and third-generation foresight adds a social and user-oriented perspective.

Japan has engaged in several foresight exercises since 1970. However, prior to 1990, there was relatively little technology foresight in the rest of the world. Around 1990, the situation changed: major foresight exercises were launched in countries such as Australia, France, Germany, the Netherlands, the United Kingdom and the United States.

The growing number of foresight programs suggests that it can be a useful policy tool in different national innovation systems. Emerging economies face a number of challenges as they attempt to both find a new role in changing international environments and derive significant benefits from a foresight agenda. Foresight has now reached a point where different approaches can be compared to highlight "good practices": what has worked in certain circumstances (the level of development, the challenges and therefore the objectives). In other words, foresight must be used in a context of adequate needs, as in this case regarding cultural-touristic needs. It can also contribute to identifying/reframing such needs. Its focus (e.g. purely technological, techno-economic or socio-economic orientation) is therefore largely determined by perceived socio-economic and development needs.

Deciding on what you want to achieve from the TF, who should be involved, the areas that should be covered, the methods to be used, etc., are matters of debate and negotiation within a process called "scoping".

The term "scoping" refers to those processes of research and deliberation that contribute to the form and timing of a TF activity. In particular, through the scoping process, the structural characteristics of the TF applied to the phenomenon being forecast are identified. The analysis of these characteristics, as shown in the following paragraph, allows us to formulate progressive scenario hypotheses regarding the evolutionary track of the technology analyzed.

3 TF-based approach in the Metaverse foresight of cultural heritage

3.1 Characteristics of the TF approach in the cultural-tourism field

In the proposed TF-approach, the first step has been to identify seven categories of parameters for the possible development of Metaverse technology in the cultural-tourism sector: demand, general constraints, necessary resources, competing technologies, synergistic initiatives and technologies, regulatory factors.

Each category includes several aspects as shown in Table 1.

Table 1 – Characteristics of the TF approach in the cultural-tourism field

Elements	Description
DEMAND	The COVID-19 pandemic has highlighted some vulnerabilities of the tourism industry. According to Le Chatelier's universal principle, this produced, and continues to produce, reactions aimed at finding new balances which have favored and facilitated the development of virtual methods of the various phases of the tourism chain: supply, use, management and promotion. In particular, if in an initial phase digital presented itself as an alternative to physical interaction with cultural heritage, it subsequently took the form of an additional dynamic which did not replace the physical interaction between tourist and cultural heritage, but rather as a form of valorization, amplification and differentiation. A crucial change that the development of digital technologies, and in particular of the Metaverse, can promote with an exponentially growing intensity and pervasiveness.
GENERAL CONSTRAINTS	Return of Investments (ROI) critical reflections impact on enabling technologies that require infrastructure. The adoption of Metaverse technology requires safe and protected products. Possible privacy policies regulations and liability could be a disincentive for organizations to implement such technology without specific training of specially trained personnel. Cultural tourism sites with high value assets will be able to support additional costs related to Metaverse technology based on the expected ROI. Sites characterized by low value and high intensity require a large number of digital implementations which represents proportionally high product costs that limit the ROI.
NECESSARY RESOURCES	Different devices can be used to facilitate Metaverse tourism experiences. One of the keys to offering Metaverse tourism is having a device with enough processing power to access inside it. Fortunately, such devices are those recognizable in everyday use such as modern smartphones and tablets or desktop and laptop computers. Smartphones are useful for augmented reality because the cameras and screens of modern smartphones can combine to overlay information onto real-world environments. However, a reasonably powerful computer is one of the best options because these devices can be used with a wide range of external devices, such as virtual reality (VR) headsets. Virtual reality headsets allow users to be placed in a digital environment that is different from their real-world. By wearing a VR headset and using the right accessories,

	tourists can move around a virtual space and interact with its elements. When entering the Metaverse, VR headsets offer a high level of immersion. Augmented reality (AR) is somewhat similar to virtual reality, but involves overlaying data on a real-world environment rather than replacing the real-world environment with a fully digital one. AR can be achieved just by using a simple smartphone with a camera, and Pokemon Go is one of the best-known examples. Regarding its role in the Metaverse combined with the goals of the tourism industry, augmented reality glasses can help provide additional valuable information. Mixed reality is another Metaverse tourism technology that is broadly similar to augmented reality because it uses digital overlays and does not completely replace the real-world environment. However, unlike AR, it always requires a headset and takes the basic AR concept to the next level by allowing for much greater interaction. In particular, mixed reality allows users to interact with the digital objects they see, and these digital objects can often interact with each other as well. This makes it a more immersive experience than AR. It should also be noted that mixed reality is not yet at the same level as VR and AR when it comes to being tried and tested.
COMPETING TECHNOLOGIES	Metaverse and virtual reality are two similar but different technologies and not yet always used collaboratively. Foresight on virtual tourism opportunities is currently very focused on virtual reality. However, it is still not clear whether the two technologies will take a divergent Y-shaped path or whether they will evolve in full convergence.
SYNERGISTIC INITIATIVES	The diffusion of the Metaverse in specific sectoral areas, such as the cultural heritage, depends on the level of relations exchanged between the cultural institutions that adopt this technology. The evaluation of network metrics between cultural node-sites can constitute a good proxy index of the phenomenon.
SYNERGISTIC TECHNOLOGIES	Metaverse and artificial intelligence (AI) are known as the Digital Twins. AI and the Metaverse are becoming more and more ready to play a key role in the transition from Industry 4.0 to Industry 5.0. This 5.0 paradigm is already involving cultural heritage. This scenario sees the rise of digital twins, virtual replicas of physical systems that can be monitored and modified in real time. Digital twins, generated and powered by AI, can replicate entire processes of interaction with cultural heritage within the Metaverse, enabling remote management and control in real time. Furthermore, the tourist becomes a prosumer, influencing the object he visits! This is where the possible synergy between AI and Metaverse lies.
REGULATORY FACTORS	As any phase of technological transition, the integration of digital technologies with the dynamics of cultural heritage raises a series of ethical and governance issues. Aspects such as data privacy, cybersecurity and the social responsibility of cultural sites are gaining increasing importance.

Source: Author's elaboration on data available in https://www.revfine.com/metaverse-tourism/

With particular reference to the last point of the Table 1, from a TF perspective, it is necessary to highlight some important elements that will have an influence on the future development of the Metaverse in relation to cultural heritage.

It will be essential to create a regulatory framework that safeguards the rights of individuals and promotes responsible innovation. If, on one hand, the "technology neutral" approach of the European Regulation on the Protection of Personal Data (GDPR), allows to the data universe of the Metaverse to be framed as already subject to some legal limits, on the other, the European Union is also thinking of regulating the new frontiers of technology and data use, such as the Metaverse, introducing new rules to protect the fundamental right to the protection of the personal sphere. Subjects approach the Metaverse right away will be able to enjoy a competitive advantage ("first to market advantage"), but they will also have to face some choices to operate legally in a terrain that is still largely unexplored, also in terms of legal themes. Given the large number of personal data involved in the activities carried out in the Metaverse, touristic companies and cultural touristic institutions, that intend to operate in this context, will have to process the data (collect them, examine them, process them, communicate them to third parties, store them, delete them, etc.) in compliance with the obligations and legal constrains deriving from the GDPR. Further, the adoption of measures and processes to be able to implement the key principles applicable in this area, the identification of adequate legal bases for processing, the preparation of information (as "smart" as possible, e.g. multilayer and graphics) that can satisfy the necessary transparency requirements, the collection and management of consensus, the carrying out of accurate impact assessments (given in particular the use of new technologies), the preparation of procedures to be able to avoid and possibly manage effectively possible data breaches, carrying out assessments regarding the transfer of data to third countries and adopting measures to ensure that, even in such cases, a level of data protection substantially equivalent to the European one is ensured.

The Spanish supervisory authority – AEPD – also recently intervened in reiterating these obligations with a statement dated 14 June 2022 regarding the relationship between Privacy and Metaverse.

Some of the most relevant aspects that privacy legislation requires to be considered, from this perspective, are:

- Careful and documented self-regulation, in light of the principle of accountability, which takes into account in particular the principle of necessity and minimization.
- The adoption of Data Protection Engineering measures (such as, for example, the use of Privacy Enhancing Technologies to strengthen data protection) aimed at giving concrete implementation to the principles of privacy.

- The evaluation, from a privacy perspective, of artificial intelligence systems (which strongly characterize the Metaverse, given the amount of data to be processed), considering the impact on the interested parties also from an ethical and social equity perspective.
- The implementation and updating of adequate technical and organizational measures with respect to the new risks connected to the reality in question and the initiatives that are intended to be undertaken, in light of the so-called risk based approach.

3.2 Foresight analysis

The Metaverse is still in the early stages of development (Duan et al., 2021). Based on the methodological elements of the Table 2, these progressive development foresight scenarios have been drawn up.

Foresight (a) – Decrease of costs of Metaverse technology

Building a Metaverse requires a robust and versatile technology stack to manage the complexity of the virtual environment, user interactions, and data management. The specific technology stack may vary based on project requirements and goals, but some essential components typically involved in building a Metaverse are standard:

- 3D Engine: A powerful 3D engine is essential for rendering virtual environments, objects, and avatars in the Metaverse. The most popular engines include Unity3D, Unreal Engine and Godot.
- Virtual Reality (VR) and Augmented Reality (AR) Support: To create a virtual reality Metaverse environment, you need to incorporate technology that supports these immersive experiences. This includes compatibility with various VR headsets and AR devices.
- User Interface (UI) and User Experience (UX) Design: Creating an intuitive and easy-to-use interface for navigating the Metaverse is critical.
- Networking and Real-Time Communication: To facilitate interactions between users in the Metaverse, a reliable real-time communication system is needed. WebSocket or WebRTC protocols are commonly used for networking in real-time applications.
- Backend and server infrastructure: Metaverse requires a scalable, high-performance server infrastructure to manage user data, interactions, and synchronization. Cloud platforms like AWS, Azure or Google Cloud are commonly used for backend services.
- Database Management: Storing and managing user data, virtual resources, and other information requires a database. Depending on your specific needs, you can use SQL or NoSQL databases such as MongoDB or PostgreSQL.

The high cumulative and recurring costs inhibit the implementation of projects based on the Metaverse for cultural tourist sites that are not well structured or are part of the nodes of the atlas of minor cultural heritage assets. To prevent this from happening, a new low-cost production process is needed. So advanced manufacturing technologies and alternative materials will have a greater impact on the future adoption of Metaverse technology. Over time, the cost of the total implementation system will lower and the adoption of Metaverse technology will spread and the industry will gain experience.

Foresight (b) – Integration of the Metaverse with other technologies

IoT and Metaverse are certainly the two most common terms that describe the current digital era. These technologies allow the convergence between virtual reality, coding, computational logic and the Internet of Things (IoT). The Internet of Things (IoT) is a network of devices connected to each other that interact by sharing and exchanging information without human intervention. These devices may include, for example, sensors, portable devices, GPS-equipped vehicles, industrial machines, home systems, environmental monitoring systems, and any other device supported by a network connection. The union between these worlds opens the door to a new era in the field of advanced technologies: the possibilities and impact on everyday life offered by IoT in the Metaverse are in fact very great. Thanks to the integrated application of networked sensors, immersive 3D simulations and other digitalized tools, it will be possible to create an even more interactive virtual environment, usable in all current fields, bringing enormous benefits from both an economic and social point of view. When the two worlds of IoT and the Metaverse come together, users can create unique experiences that combine the interactivity of virtual reality with the convenience and connectivity of IoT, with the ability to create real-time applications. For example, users could use IoT to provide instructions to a robot in a metaverse environment. Users could use IoT to customize the appearance of the virtual environment in real time by controlling the quality of light or atmospheric visibility. Additionally, sensors can be used to acquire additional information about elements present in physical space, providing more contextual information to the Metaverse. Finally, a scenario that can be realized in the short term sees a strong convergence between Metaverse and gamification based on serious games (see Cai et al., 2013; see Cai, Indhumathi, Chen, & Zheng, 2008) for the promotion of cultural heritage, especially towards younger age groups of users, sometimes less inclined towards cultural heritage.

Foresight (c) – Improvement of reliability and safety

The particular area of cultural heritage presents risks of damage and degradation of assets in the physical space, but also in relation to interaction with hybridization activities with the Metaverse, these risks are present. The evolutionary scenario will include increasingly greater and more specific best

practices and policies for ensuring the integrity of cultural heritage in relation to the type of cultural heritage with which the Metaverse interfaces.

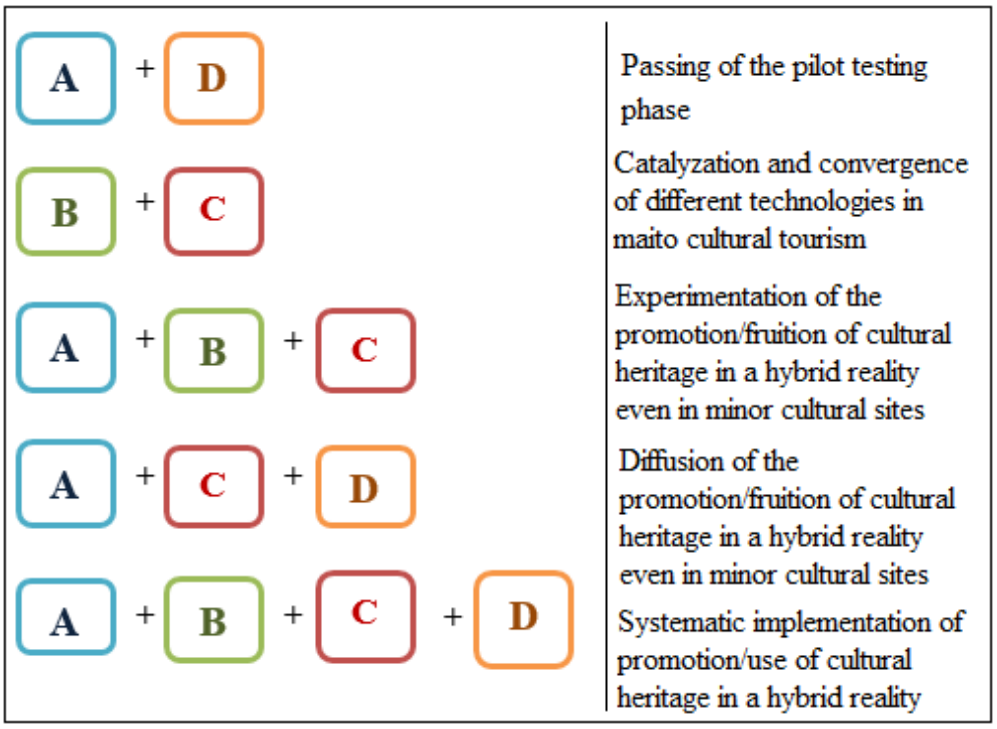
Foresight (d) – Infrastructure

When an adequate infrastructure is developed, the number of entities that can use Metaverse technology increases. The advantages of tourist promotion/fruition through Metaverse emerge only if the majority of actors throughout the sector's supply chain adapt with a systematic infrastructure. Otherwise only isolated applications linked to the resourcefulness of the individual tourist service provider and that of the advanced tourist, could be recognized. This dynamic is typical of infrastructure-user systems (as in the case of electric mobility).

Progressive foresight hypotheses

By combining the four main implications in different ways, different "consequences of change" are obtained, as shown in Figure 1.

Figure 1 – Progressive foresight-scenario hypotheses



Source: *Author's elaboration*

Each foresight-scenario involves decreasing costs. Currently, even if the costs of Metaverse viewers are decreasing, the prices of global implementation remain high, i.e. hardware, software, personnel, technology management, etc.

After this descriptive framework of the TF approach, applied to cultural heritage, the next section presents a survey of real cases of Metaverse applications in different parts of the world. The last section focuses on Italian dynamics and shows the results of a survey conducted on some different Italian museum sites. Furthermore, in the last section, a network analysis is proposed between the Italian surveyed structures to verify the degree of involvement of the various cultural actors.

4 Geography of Metaverse and Agenda 2030

The effects of the pandemic on tourism have been, as in other sectors, very significant. In 2021, according to the World Tourism Organization estimates (UNWTO, 2022), there was a decline in international tourist arrivals of approximately 72%. This dynamic has generated a strong development of digital tourism promotion/fruition technologies. At a global level, tourist sites adopted a method based on the Metaverse are already becoming significant (Figure 2). Some cases of application of the Metaverse are reported in Table 2a and others specifically applied to cultural heritage are reported in Table 2b.

Figure 2 – Distribution of touristic sites adopting Metaverse

Source: Author's elaboration on on-line data research

Table 2a – Examples of tourism initiatives based on the Metaverse

Tourist initiative based on the Metaverse	Description
Great Tapestry of Scotland	It is one of Scotland's most unique and impressive tourist attractions. It is a community art project hosted in the town of Galashiels, where a digital tapestry tells the story of Scotland. To achieve this, NFTs[1] were created for different tapestry themes, such as battles, traditions, and kings and queens. NFTs were designed to be easily resized and there are plans to add interactive games in the future.
EmirateS	Emirates experimented tourism solutions based on the Metaverse for several years, and virtual reality experiences are now at the heart of the company's offerings. For example, Emirates' website allows users to explore a 360-degree virtual tour of the cabin of an Emirates aircraft. Furthermore, Emirates has developed its own VR app, which allows users to explore the interiors of Airbus A380 and Boeing 777 aircraft. Finally, an interactive 3D seat map allows customers to better understand what their seat will be like and can even book their favorite seat from within that virtual environment.
Coachella	The Coachella music festival has engaged in Metaverse-based tourism activities by creating the Coachellaverse digital experience. The main goal of the Coachellaverse is to allow people who cannot attend the event in person to interact with elements of the event or participate in their own way from home. For example, users can experience live performances by musical artists enhanced through augmented reality technology. Additionally, there are ways to interact with other users, play games, purchase music-related NFTs, and view exclusive content from musicians performing at the event.
Vueling	The Spanish low-cost airline Vueling has become one of the first airlines to sell services within the Metaverse through the use of a specific Next Earth platform and through a partnership with blockchain technology operators.
Metaverse Seoul	One of the Metaverse's most ambitious tourism projects comes from the Seoul Metropolitan Government, which launched Metaverse Seoul, a Metaverse replica of a real city. Creation of the virtual world itself is expected to wrap up in 2026, but the initial launch allows users to create avatars and interact in several vital ways. For example, users can use their avatars to visit youth centers for counseling or tax offices to receive financial advice.

[1] An NFT (Not fungible Token) is a special type of "token", which represents the title deed and the certificate of authenticity, written on Blockchain, of a unique asset (digital or physical). Non-fungible tokens are therefore not mutually interchangeable. A non-fungible good, unlike a fungible good such as a banknote, cannot be exchanged one for one with other goods of the same type indiscriminately. NFTs are a type of non-fungible asset that holds unique data and can be used to record and verify ownership via blockchain technology.

Rendezverse	Rendezverse is a tourism and hospitality platform based on the Metaverse, which aims to reproduce the experience of events and conferences taking place in hotels, but within a virtual space. Essentially, the platform allows hotels and event companies to create a digital version of a property, which users can then populate or explore. Users can encourage participants to create their own avatars, which will be featured within the virtual world. Meetings can also be recorded for future reuse or analysis so you can learn lessons and improve future meetings. Recreated properties could be sell event spaces online without in-person visits.
Decentraland	The Government of Barbados begun to explore Metaverse-based tourism by participating in the virtual world Decentraland. The government has established a Metaverse embassy on this platform, the first of its kind. This means that anyone using a computer and/or virtual reality headset can access an official embassy. Millennium Hotels used the Decentraland platform for tourism purposes in the Metaverse, becoming the first company to open and operate a hotel within the Metaverse. The hotel was introduced to help create awareness of virtual socializing and the virtual property has been carefully modeled to resemble real buildings.
Qatar Airways	Qatar Airways tested tourism options in the Metaverse with excellent results. The QVerse solution, a virtual reality experience where website visitors can log in and get a virtual tour, highlighting the look and feel of Business Class and Economy Class cabins. However, Qatar Airways has taken this concept to the next level by creating a fully narrated and digital cabin crew-led experience. A 3D human model walks users through their virtual experience, explaining key features on board and offering a level of interaction and immersion not seen in other VR airline experiences.

Source: Author's elaboration on on-line data research

Table 2b – Examples of tourism initiatives based on the Metaverse in the culture heritage

Cultural heritage tourist initiative based on the Metaverse	Description
South Korean Museum	The South Korean Podo Museum was founded in 2021 with the aim of promoting an inclusive attitude in respect of diversity through art. In the same year, the museum opened a digital headquarters within the South Korean Zepeto Metaverse, a virtual world released in 2018 that is based on avatar customization. Here the museum offers a digital copy of its physical environments and installations with the aim of gaining visibility and reaching potential stakeholders at an international level. Users can walk through the museum and enjoy the works on display.

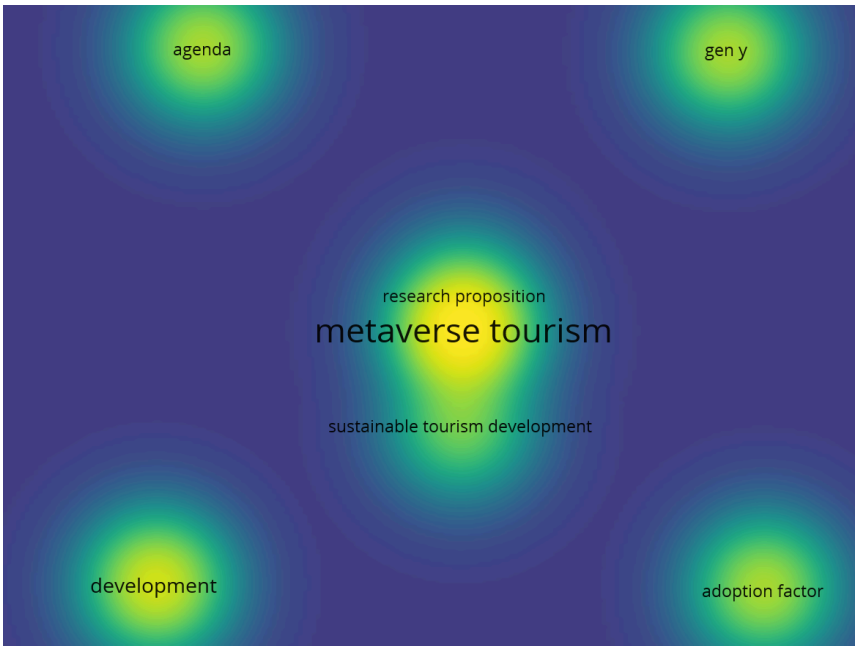
Museum of Contemporary Digital Art	This museum promotes digital art through research and dissemination activities and in 2021 opens its first branch on Decentraland, a browser-based Metaverse where users can create, experiment and monetize contents and applications. Since the museum does not yet have a physical location, the digital building does not simulate any precise real environment but proposes a plausible museum structure. The institution exploits the spatiality and always connected social dimension of Decentraland to introduce some traditionally "physical" museum practices, unlike the experience of the Podo Museum.

Source: Author's elaboration on on-line data research

To verify which sectors are highly involved in the data mining assessment, a first literature review on Web of Science was conducted and exported in VOSviewer. The VOSviewer software has been used to analyze the topic cluster regarding the main keywords – "Metaverse" and "cultural heritage" – and their network fluxes within scientific debate. This software allows researchers to visualize data maps of bibliometric networks based on Visualization of Similarities (VOS) and it is generally used to perform preliminary research literature review. The distance between the nodes is proportional to the divergence that occurs between the topics (see Van Eck & Waltman, 2018). Through this logic, our two-dimensional map represents the existing network between topics in which have been published papers and studies between 2015 and 2023 that include the keywords mentioned above. In addition, the size of the nodes is weighted by the number of articles published in the journal based on the selected query.

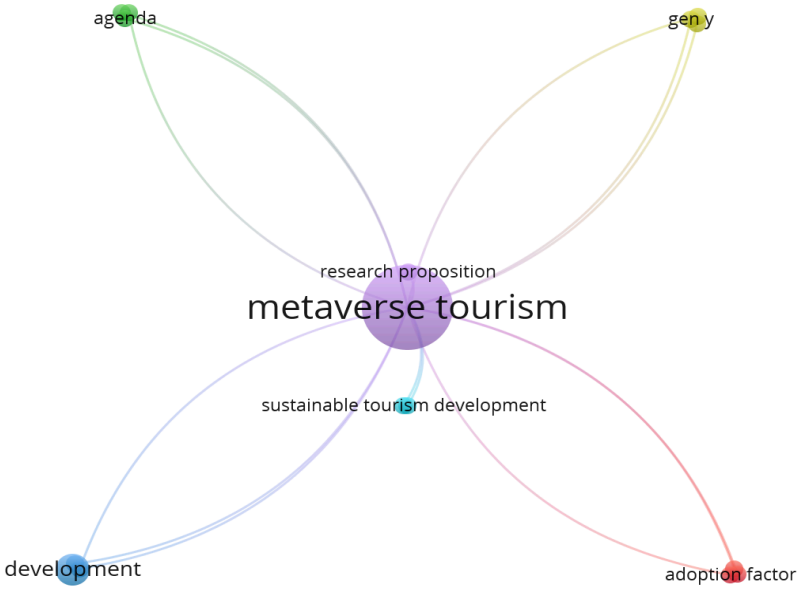
The representation of the thematic distribution is shown in Figure 3a, with evidence of concentrations of the thematic nodes, and in Figure 3b, reporting the relationships between the nodes. The topics of the clusters are: "genY", which was discussed at the beginning of the paragraph; "agenda" with reference to the 2030 Agenda; "development" and "adoption factors" on which the proposed Technology Foresight approach is based.

Figure 3a – Topics clustering topic-hot map visualization including keywords used in this research



Source: Authors' elaboration using VOSviewer in Web of Science

Figure 3b – Topics visualization 2-D map including keywords used in this research



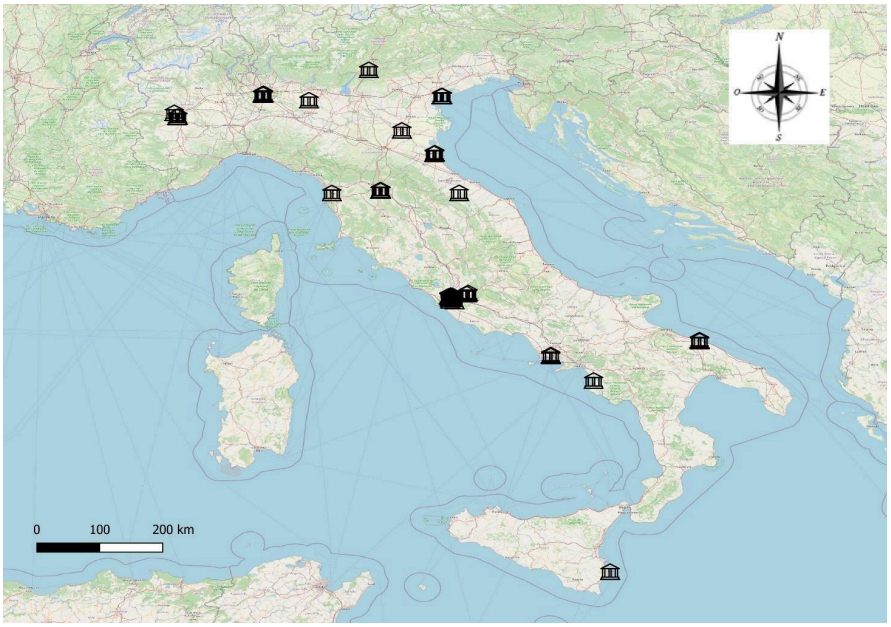
Source: Author's elaboration using VOSviewer in Web of Science

The research network well highlights the strength of the relationship between the Metaverse and the 2030 Agenda SDG (Sustainable Development Goals), as also well highlighted in the work of Go and Kang (2023). According to these researches, in fact, Metaverse tourism and other relevant research subjects are studied in accordance with the goals of creating jobs and income sources to reduce poverty (SDG 1), giving opportunities for quality education in sustainable learning environments (SDG 4), preserving tourism resources through the efficient use of water, pollution control and technology efficiency (SDG 6), accelerating the shift to clean energy usage (SDG 7), providing industry innovation and infrastructure (SDG 9), supporting sustainable cities and communities (SDG 11) and conserving and preserving biodiversity, but also in generating revenue as an alternative livelihood to local communities (SDG 15).

5 Italian dynamics

In Italy, the dynamics of the Metaverse is still in its early stage, but a transition phase is already significant with several cultural sites, particularly museum cases, characterized by hybrid visiting methods between physical and virtual reality (Fig. 4).

Figure 4 – Distribution of Italian cultural sites adopting virtual technologies



Source: Author's elaboration on on-line data

In the frame of Italian museums it is possible to conduct virtual tours across the various rooms of the buildings where is possible to carry out, using a 360° motion camera, a tridimensional visit as evident from the comparison between Figures 5a and 5b and also between 6a and 6b, reporting two examples of virtual museums.

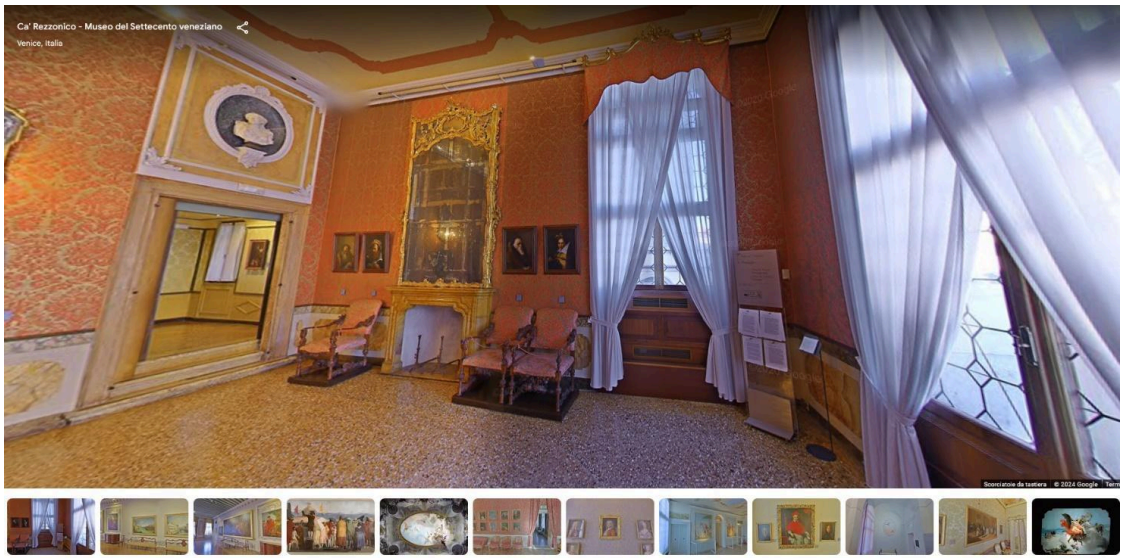
Figure 5a – Capodimonte Museum, Naples Italy, virtual cultural site

Source: https://artsandculture.google.com/streetview/stanza-31-salone-della-culla-primo-piano-del-museo/yAHY7 thHxWQcnA

Figure 5b – Capodimonte Museum, Naples Italy, virtual cultural site

Source: https://artsandculture.google.com/streetview/stanza-31-salone-della-culla-primo-piano-del-museo/yAHY7thHxWQcnA

Figure 6a – Ca' Rezzonico, Venice Italy, virtual cultural site



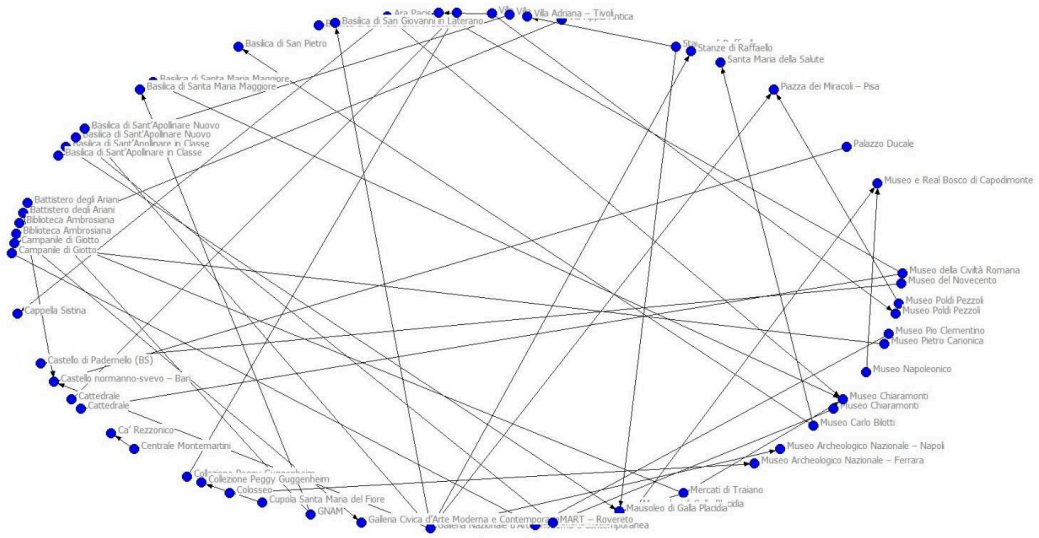
Source: https://artsandculture.google.com/streetview/ca-rezzonico-museo-del-settecento-veneziano

Figure 6b – Ca' Rezzonico, Venice Italy, virtual cultural site

Source: https://artsandculture.google.com/streetview/ca-rezzonico-museo-del-settecento-veneziano

In order to verify characteristic #5 of Table 1 of the TF, "synergistic initiatives", a network analysis was conducted in the context of the virtual museums surveyed (list in Appendix). Possible synergies[2] with respect to the implementation of the virtual dynamics between the various cultural sites were reconstructed through an on-field investigation[3]. To this end, the data have been processed using the Ucinet networking software and the various network metrics have been calculated. The results, graphically reported in Figure 7, confirmed a good network dynamic with respect to the adoption of virtual technologies.

Figure 7 – Networking between cultural sites adopting virtual technology



Source: Author's elaboration with Ucinet® software on cultural sites (list in appendix)

The output log file (Table 3) shows the density value as 0.5473, which means that 55% of all possible bonds are present. It is a medium value, given that the index varies from 0 to 1, which allows us to observe how already a sufficient level of cohesion is present in the class. The density value is confirmed by the standard deviation value[4] of 0.5703, which indicates the presence of a fairly high amount of variability in the bonds.

[2] The coding of "synergy" was understood in a broad sense: collaboration; information sharing; presentations of activities in joint events, etc.
[3] By mail contacts.
[4] Standard deviation measures how much variation exists between values in the matrix. If all the elements were "1" (maximum density) or "0" (network completely disconnected) the standard deviation would be zero, therefore there would be no variation. With binary data the maximum variability is obtained with a density of 0.5. As the density approaches 0 or 1 the standard deviation decreases.

Table 3 – Networks metrics

Metric	Value
Density / average value within blocks	1/0.5473
Standard Deviations within blocks	1/0.5703

Source: Author's elaboration with Ucinet® software

Conclusions

The tourism industry is an information-intensive sector (Fotis, Buhalis, & Rossides, 2011). The valorization of cultural heritage sites with immersive hybrid reality experiences adds value to the entire user engagement, especially in combination with personalization according to each tourist's preferences (see Partarakis, 2016). The Metaverse encourages users to experience and interact with historical objects while in the real world, integrating engaging ways of storytelling to engage visitors. It supports the integration of physical and digital displays by projecting digital information into real environments and even displaying items without material availability.

The cultural sites in the Metaverse have opened a perspective of investigation towards the rethinking of the processes of interaction, fruition and cultural production towards the more contemporary ones of the virtual world (see Khundam, 2020). The visitor of a cultural site now also finds himself dealing with "metaversic" environments, in which the distinction between real and digital seems to be linked more to the experience of the spectator himself than to a formal classification: what distinguishes a material experience from a virtual one, will be the different types of experience available to the user and no longer its location, first of all that of the avatar (see Girvan, 2018).

In this framework, this research has developed an analysis conducted according to a technology foresight approach, identifying a series of key elements characterizing the current dynamics, in order to formulate some progressive scenario hypotheses. The results found, albeit with some constraints and risks, show a growing functional relationship between cultural heritage and the Metaverse. In addition to improving the visitor experience, the Metaverse can offer a new avenue for cultural heritage protection, site maintenance, conservation of heritage objects and monitoring. It will contribute to the promotion, dissemination and legacy of traditional cultural heritages. Furthermore, the Metaverse of cultural heritage opens up the scientific debate of the geographical discipline with new critical epistemological ideas that will have to ask ourselves about new non-Euclidean metrics to be defined in a new virtual space.

Future works

The development of this research will regard the use of the scenario analysis grid, realized in this work, in application of the Delphi methodology, envisaged as part of the TF approach, to carry out a survey among groups of stakeholders and sector experts. The objective of the research development is to build a predictive time-diagram related to the scenario hypotheses formulated.

Appendix – List of surveyed virtual museums

Colosseo	Cappella Arcivescovile o di Sant'Andrea	Santa Maria della Salute
Ara Pacis	Galleria degli Uffizi	La Venaria Reale
Mercati di Traiano	Basilica di Santa Maria Novella	Galleria Civica d'Arte Moderna e Contemporanea
Via Appia Antica	Basilica di Santa Croce	Palazzo Madama
Basilica di San Paolo fuori le mura	Cupola Santa Maria del Fiore	MART – Rovereto
Basilica di San Giovanni in Laterano	Basilica Santa Maria del Fiore	Museo Archeologico Nazionale – Ferrara
Basilica di Santa Maria Maggiore	Campanile di Giotto	Piazza dei Miracoli – Pisa
Basilica di San Pietro	Cappella Brancacci	Necropoli etrusche
Cappella Sistina	Cappelle Medicee	Basilica di San Nicola – Bari
Stanze di Raffaello	Pinacoteca di Brera	Cattedrale di San Sabino – Bari
Museo Pio Clementino	Museo Poldi Pezzoli	Castello normanno-svevo – Bari
Museo Chiaramonti	Museo Diocesano	Bastione di Sant'Antonio – Bari
Villa d'Este – Tivoli	Biblioteca Ambrosiana	Chiostro del Monastero di Santa Chiara – Urbino
Villa Adriana – Tivoli	Museo del Novecento	Tempio di Nettuno – Paestum
Basilica di San Vitale	Galleria d'arte moderna	Museo Archeologico Nazionale – Napoli
Basilica di Sant'Apollinare in Classe	Cattedrale	Museo e Real Bosco di Capodimonte
Basilica di Sant'Apollinare Nuovo	Basilica di Sant'Ambrogio	Castello Maniace – Siracusa
Mausoleo di Galla Placidia	Palazzo Ducale	Castello di Padernello (BS)
Mausoleo di Teodorico	Collezione Peggy Guggenheim	Battistero degli Ariani
Ca' Rezzonico	Palazzo Grassi	Battistero Neoniano

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Exploring the impact of livestock farming on air quality in Lombardy

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Abstract

Pollution has become a major concern in recent years, since all its facets have a significant impact on ecosystems and human health. Air pollution is one of the most critical issues, with particulate matter (PM) being a key indicator of air quality. In particular, the formation of atmospheric PM_{10} (i.e., particles with an aerodynamic diameter of 10 μm or less) depends on various factors, that is precursor gases, weather conditions, and human activities. Exploring the relationship between PM_{10} and these factors is essential for understanding the dynamics of air pollution and developing effective mitigation strategies. Hence, this study investigates the spatial distribution of PM_{10} and the other factors in Lombardy, Italy, and aims to identify spatial clusters of these variables. Specifically, the relation between PM_{10} and ammonia (NH_3) is of primary importance, as a large portion of Lombardy is characterized by intensive livestock farming activities, which are a major source of NH_3 emissions in the region. The analysis is referred to the year 2020, and is based on data from the AgrImOnIA dataset, which includes information on air quality, meteorology, emissions, livestock, and land use. The investigation of the spatial distributions is conducted using spatial interpolation techniques, specifically Kriging, while the local Getis-Ord index is applied to recognize hot spots, that is clusters of municipalities with high pollution levels that require targeted interventions. The results show a positive correlation between PM_{10} levels and NH_3 emissions, with hot spots identified in areas with high animal density. The findings

provide valuable insights into the dynamics of air pollution in Lombardy and highlight the need for sustainable agricultural practices to improve air quality in the region.

Keywords – Air quality; Livestock sector; Lombardy; Po Valley; PM_{10}; NH_3.

Paper type – Academic Research Paper

Sommario

L'impatto dell'allevamento sulla qualità dell'aria in Lombardia. – Negli anni recenti, l'inquinamento è diventato una delle principali preoccupazioni, poiché tutti i suoi aspetti hanno un impatto significativo sugli ecosistemi e sulla salute umana. L'inquinamento atmosferico è uno dei problemi più critici, poiché il particolato (PM) è un indicatore chiave della qualità dell'aria. In particolare, la formazione di PM_{10} atmosferico (ovvero particelle con diametro aerodinamico pari o inferiore a 10 μm) dipende da vari fattori, ovvero gas precursori, condizioni meteorologiche e attività umane. Esplorare la relazione tra il PM_{10} e questi fattori è essenziale per comprendere le dinamiche dell'inquinamento atmosferico e sviluppare strategie di mitigazione efficaci. Pertanto, questo studio indaga la distribuzione spaziale del PM_{10} e degli altri fattori in Lombardia, Italia, e mira a identificare cluster spaziali di queste variabili. Nello specifico, il rapporto tra PM_{10} e ammoniaca (NH_3) è di primaria importanza, poiché gran parte della Lombardia è caratterizzata da attività di allevamento intensivo, che rappresentano una delle principali fonti di emissioni di NH_3 nella regione. L'analisi si riferisce all'anno 2020 e si basa su dati tratti dal dataset AgrImOnIA, che include informazioni su qualità dell'aria, meteorologia, emissioni, bestiame e uso del territorio. L'indagine delle distribuzioni spaziali viene condotta utilizzando tecniche di interpolazione spaziale, nello specifico Kriging, mentre l'indice locale Getis-Ord viene applicato per riconoscere gli hot spot, ovvero cluster di comuni con elevati livelli di inquinamento che richiedono interventi mirati. I risultati mostrano una correlazione positiva tra i livelli di PM_{10} e le emissioni di NH_3, con punti caldi identificati in aree ad alta densità di animali. I risultati forniscono preziose informazioni sulle dinamiche dell'inquinamento atmosferico in Lombardia ed evidenziano la necessità di pratiche agricole sostenibili per migliorare la qualità dell'aria nella regione.

Article history:
Received 29 August 2024
Received in revised form 23 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.81-100

1 Introduction

Air pollution poses a growing threat to the environment and human health, with profound implications for quality of life and ecosystem (European Environment Agency, 2021). A thorough understanding of the various pollutants involved is critical to develop effective mitigation strategies. Air pollutants are mainly divided into two categories: primary pollutants, which are emitted directly into the atmosphere, and secondary pollutants, which are formed by chemical reactions and micro-physical processes involving various precursor gases (Nenes, Pandis, Weber, & Russell, 2020).

Air quality analysis focuses primarily on the role of atmospheric particulate matter (PM), i.e. particles classified according to their aerodynamic diameter and considered key indicators in the presence of pollutants in the air. These fine dusts not only reflect the chemical composition of pollutants but also have direct implications for the health of the population. The study of their diffusion and concentration in the air is therefore crucial to understand the overall impact of this phenomenon.

According to Thunis et al. (2021), ammonia (NH_3) plays a crucial role among the most relevant precursor gases in the formation of atmospheric particulate matter.

The analysis proposed by Giannakis, Kushta, Bruggeman, and Lelieveld (2019) utilized annual simulations based on advanced meteorological models and global emission data to assess the impact of ammonia productions on fine particulate pollution in Europe. The research employed the Weather Research and Forecasting model coupled to Chemistry (WRF-Chem) to demonstrate whether ammonia reductions, in line with emission commitments starting from 2020, lead to an effective decrease in $PM_{2.5}$ (i.e., particulate matter with a diameter of 2.5 micrometers or less) concentrations in the air. The simulation reveals that such reduction in NH_3 productions showed relatively large contractions in $PM_{2.5}$ levels in Central-Western Europe and the United Kingdom. Furthermore, a peculiar aspect that emerged is that the economic benefit resulting from the avoided premature deaths in Europe amounts to 14.837 million Euros per year, an interesting element given the existing correlation between reductions in $PM_{2.5}$ and the decrease in premature mortality rates due to diseases linked to air pollution (Giannakis, Kushta, Bruggeman, & Lelieveld, 2019).

In Italy, the Lombardy region, along with other areas of the Po Valley, is of significant interest due to its intense agricultural activity, which substantially contributes to NH_3 emissions. These emissions play a critical role in the formation of PM_{10} (i.e., particulate matter with a diameter of 10 micrometers or less) and $PM_{2.5}$, as evidenced by ARPA Lombardia (ARPA Lombardia, n.d.) and the AgrImOnIA project (Agriculture Impact On Italian Air Quality; Fassò et al., 2023), both of which underscore the considerable impact of agricultural practices on air quality in northern Italy.

Further research has highlighted the significant role of intensive livestock farms in the production of ammonia and, consequently, in contributing to air pollution. In Italy, for example, intensive livestock

farms are identified as a major source of ammonia, which leads to the formation of particulate matter, surpassing even the transportation and industrial sectors in this regard. As shown in a recent 2022 Greenpeace map (Greenpeace, 2022), these farms are mainly concentrated in the Po Valley, with Lombardy leading the way. This study also revealed that nearly 90% of these farms received public funds, underscoring the complexity of the problem and the need for more sustainable policies.

An imperative approach involves exploring sustainable solutions to mitigate poor air quality and promote eco-friendly agricultural and industrial practices in areas that require greater attention. To this purpose, our research aims to propose an approach to analyse whether the diffusive behaviour of atmospheric particulate matter correlates with the dynamics of agricultural ammonia emissions, in order to explore the possible interaction between these two phenomena. Unlike previous investigations, which focused more on $PM_{2.5}$, our study focuses on PM_{10}. This choice is motivated by the significant presence of sensors for monitoring PM_{10}, as opposed to $PM_{2.5}$, which is monitored by a smaller number of stations. The larger PM_{10} database allows us to investigate air quality dynamics in greater detail, broadening our understanding of environmental implications. We will analyze whether significant variations in PM_{10} measurements can be attributed to intensive use of NH_3 in specific areas of Lombardy, especially in contexts of massive pig and bovine farming. The identification of similar spatial patterns or characteristic clusters among these variables could unveil new insights into the dynamics affecting air quality in the Po Valley.

Through the use of spatial data analysis and geostatistical techniques, we aim to gain a deeper understanding of the factors affecting air quality. Our approach not only offers new insights into the impact of agricultural livestock farming on air quality in this geographic area but also paves the way for more effective strategies to promote sustainable agricultural practices.

The paper is organized as follows: Section 2 presents an initial exploratory analysis of the data, while Section 3 offers a brief introduction to spatial interpolation using Kriging. Section 4 presents the results of spatial clustering through the *local G index*, and Section 5 concludes with a discussion.

2 The data

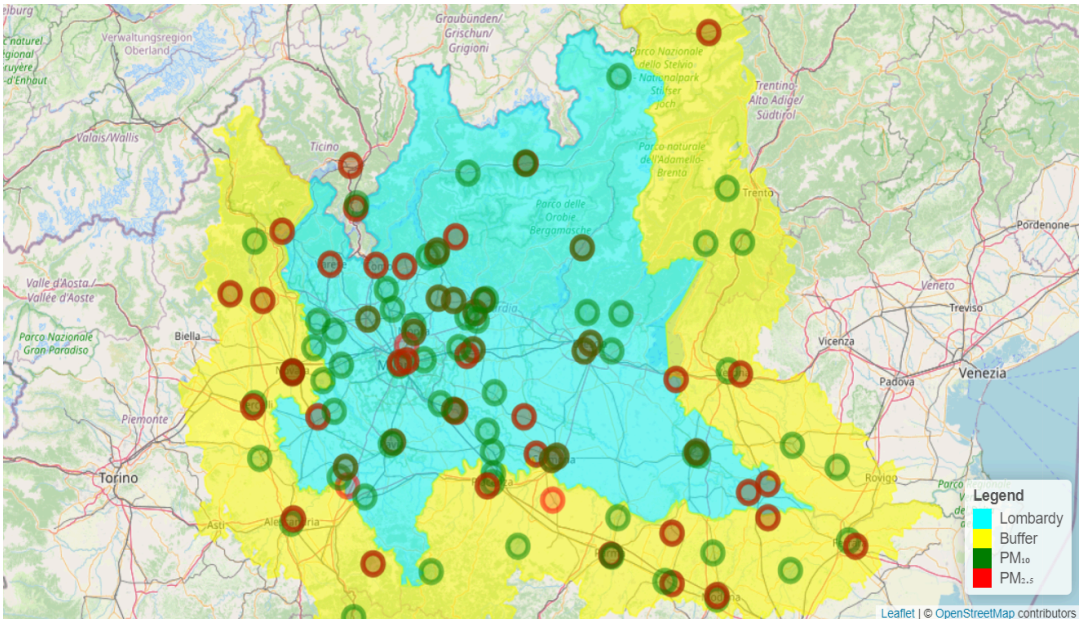
The data used in our study are from the open access dataset AgrImOnIA2 version 2.0.2, available on Zenodo (Fassò et al., 2022). This dataset was crucial for conducting our analysis and understanding the interaction between ammonia emissions and pollutant levels. In a preliminary step, researchers affiliated with this project processed and harmonized the data, aligning them to the same temporal and spatial

resolution to ensure consistency and reliability in the information collected. For specific details about the data harmonization, the reader is referred to the project documentation (Fassò et al., 2022).

The AgrImOnIA2 dataset includes daily surveys collected from 2016 to 2021 from five distinct fields of study that are essential for analyzing different aspects of the surrounding environment. These fields are: air quality (AQ, Air Quality), which monitors particles and noxious gases; meteorology (WE, Weather), which records data such as temperature, humidity and precipitation; air and sectoral emissions (EM, Emissions), which track pollution from various industries; livestock (LI, Livestock), which is important for studies on the impact of intensive livestock farming; and land use and land cover (LA, Land Use), which helps to understand changes in land use. The collection of these data provides a detailed picture of the natural and man-made environment.

The AQ data refer to measurements from 141 monitoring stations scattered throughout Lombardy, along with an area of 30.000 km^2 surrounding it. This additional area serves as a 0.3° buffer, included to improve the accuracy of estimates along the borders. Of these stations, 93 are located within Lombardy and 48 in the extended area. The location of the stations is shown in Figure 1.

Figure 1 – Map of Lombardy and buffer with stations equipped with PM_{10} and $PM_{2.5}$ sensors



Source: Authors' elaboration

Table 1 – Description of variables used in the analysis

Variable name	Variable description	Field of study	Source
Latitude	Latitude of the monitoring stations expressed in degrees		
Longitude	Longitude of the monitoring stations expressed in degrees		
Time	Daily observation timestamps, covering the period from 2016 to 2021		
AQ_PM10	Concentration of particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}), measured in micrograms per cubic meter ($\mu g/m^3$)	Air Quality	(ARPA Lombardia 2023), (EEA, 2023)
WE_tot_precipitation	Total precipitation, including accumulated liquid and frozen water (such as rain, snow, and sleet) reaching the Earth's surface, measured in meters (m)	Weather	(Copernicus Climate Change Service, 2023)
EM_nh3_livestock_mm	Emissions of ammonia (NH_3) from livestock activities, measured in milligrams per square meter (mg/m^2). Data collected to assess agricultural emission sources	Emission	(ECCAD, 2022)
EM_nh3_sum	Total emissions of ammonia (NH_3), covering sources such as livestock, soil, and burning, measured in milligrams per square meter (mg/m^2). Data used for comprehensive emission monitoring	Emission	(ECCAD, 2022)
EM_nox_traffic	Emissions of nitrogen oxides (NO_x) from road traffic, measured in milligrams per square meter (mg/m^2). Data obtained to evaluate transportation-related pollution on road	Emission	(ECCAD, 2022)
LI_pigs	Density of pigs within the municipality that has the closest centroid to the monitoring station, measured in square kilometers (km^2). The data help to understand the influence of pigs on emissions impacting air quality in the region	Livestock	(Italian Ministry of Health, 2021)
LI_bovine	Density of bovines within the municipality that has the closest centroid to the monitoring station, measured in square kilometers (km^2). The data help to understand the influence of bovines on emissions impacting air quality in the region	Livestock	(Italian Ministry of Health, 2021)
LA_hvi	High Vegetation Index in m^2/m^2. This index is a key parameter for the study of land use and vegetation cover, reflecting the environmental conditions of the analyzed region	Land Use	(Muñoz, 2019)

Source: AgrImOnIA2 dataset

As part of our research, we decided to focus on a specific subset of variables among those available in the dataset, which we believe are particularly relevant for analyzing the interaction between NH_3 emissions and PM_{10} levels. In fact, this interaction is influenced by other variables related to human activities (such as agriculture and urban traffic) and natural factors (such as precipitation and vegetation). A detailed list with related descriptions of these selected variables is given in Table 1. By focusing on these features we are able to perform a more detailed and meaningful analysis, which we expect will contribute to accurate and informative results.

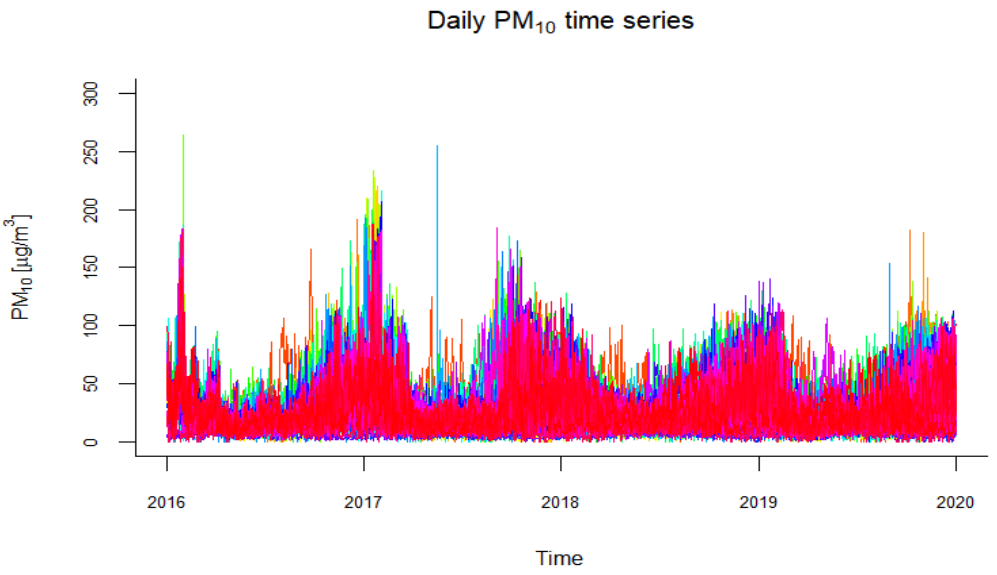
The dynamics the daily time series of PM_{10} and NH_3 are shown for all the monitoring sites in Figure 2 and Figure 3, respectively, from 2016 to 2020.

Both variables exhibit a clear periodicity, with PM_{10} levels increasing during the winter months and decreasing in the summer. In contrast, ammonia shows an opposite trend, with levels rising in the summer and declining during the winter period. However, since our focus is primarily on spatial analysis, we chose to aggregate the data annually (i.e., marginalizing time) to concentrate on the spatial distribution of PM_{10} and NH_3.

As a result, Figure 4 illustrates the annual average of PM_{10} concentrations for three years (2016, 2018 and 2020) and for all stations in the study region. The points vary in size and color intensity to reflect the magnitude of the phenomenon. These plots offer an immediate and intuitive representation of the geographic distribution and severity of PM_{10} pollution, highlighting the most affected areas. However, because the data are only available at specific monitoring stations, spatial interpolation is necessary to gain a comprehensive understanding of the pollutant distribution across the entire region. Interpolation allows us to estimate pollutant levels at locations between these stations, providing a surface of PM_{10} concentrations. This process is also crucial for comparing the spatial distribution of PM_{10} with that of NH_3. By interpolating PM_{10} data, we can better analyze and visualize how its distribution aligns or contrasts with the distribution of NH_3, thereby enhancing our overall understanding of air quality patterns in the region.

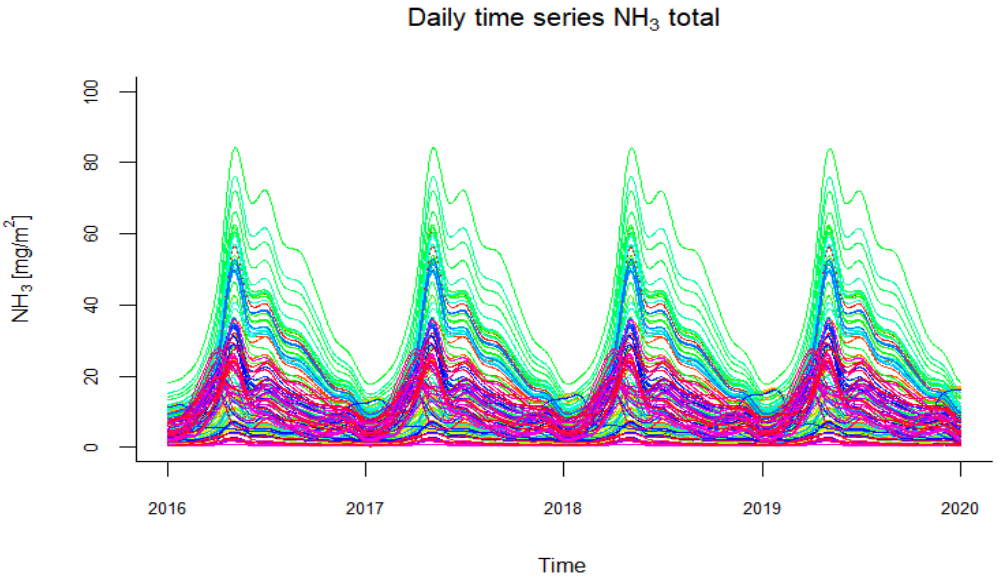
Our spatial analysis centers on data from the year 2020, chosen for its representativeness and the availability of comprehensive information on PM_{10} and NH_3 concentrations. This year reflects the environmental trends observed from 2016 to 2020, which were marked by relative stability. The analysis was also limited to 2020 due to the absence of ammonia data for 2021, which prevents a fair comparison with prior years.

Figure 2 – Daily time series of PM_{10} levels for all monitoring stations in Lombardy



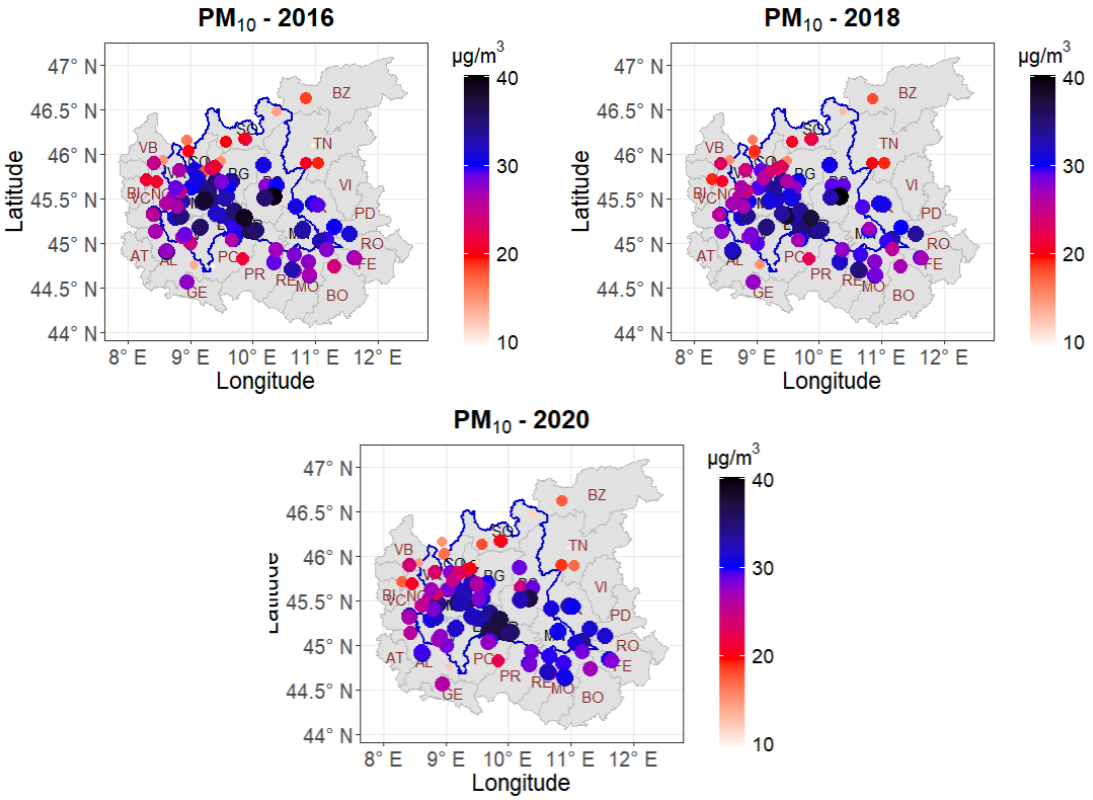
Source: Authors' elaboration

Figure 3 – Daily time series of total NH_3 levels for all monitoring stations in Lombardy



Source: Authors' elaboration

Figure 4 – Maps of average PM_{10} concentration levels for each site in the years 2016, 2018, 2020



Note: Darker color and bigger point size indicate higher concentrations.

Source: Authors' elaboration

3 Spatial interpolation by Kriging

This section provides a brief introduction on Kriging for using this method to interpolate the values of continuous variables, such as PM_{10} concentrations. This choice promotes an extension of the representation of the environmental variables under study, beyond the boundaries of the directly monitored sites.

If $z = \left(z\left(s_1\right), \ldots, z\left(s_n\right)\right)'$ are measurements observed at n spatial locations, $s_1, \ldots, s_n$, from a real-valued spatial process $\{Y(s),\ s \in D\}$, with $D \subset R^d$, a widely used representation of the random process is:

$$Z(s) = Y(s) + \epsilon(s)$$

where $\epsilon(s)$ is a sequence of uncorrelated Gaussian random variables, each with mean 0 and variance σ_{ε}^{2}. The process $Y(s)$ corresponds to the true (latent) spatial process vector of interest for which we further assume the following decomposition:

$$Y(s) = \mu(s) + \eta(s)$$

where $\mu(s)$, represents a spatial mean component and, $\eta(s)$, is a zero mean spatially-dependent random process with covariance matrix Σ_{η}. Usually, the mean, $\mu(s)$, is a parametrized function of spatial covariates, $X_j(s), j = 1, ..., p$.

Predicting or interpolating the variable of interest, Y, at some unobserved location s_0, it is of particular interest in spatial analysis. In practice, many different methods exist for spatial prediction, and the choice of a given method will depend on the specific characteristics of the data being analysed. Gaussian processes and Kriging (Cressie, 1993) are powerful tools for spatial interpolation and can be used to capture complex spatial structures and dependencies.

The application of Kriging, based on accurate spatial correlation between the sampling points, not only facilitates estimation, but also allows for detailed and uniform mapping of the distribution of environmental phenomena over the entire Lombardy region. This gives an extended and comprehensive view of the analyzed environmental impact, while also integrating the uncertainty estimates associated with each interpolation.

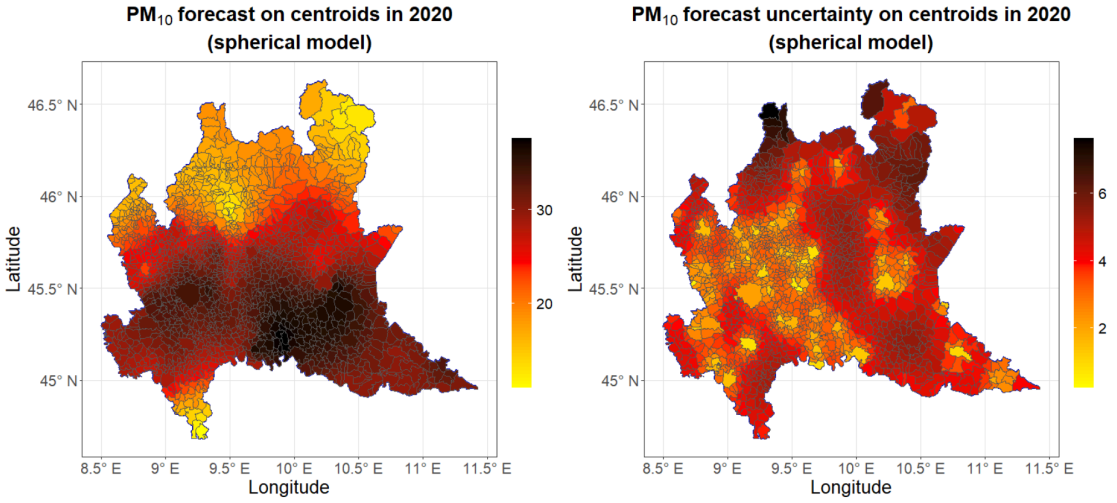
Mathematically, the Kriging prediction at the new site s_0 results in a linear combination of data,

$$\hat{Y}(s_0) = \sum_{i=1}^{n} \lambda_i z(s_i)$$

where λ_i, $i = 1,...,n$, are weighting coefficients which, under the choice of Universal Kriging (Cressie, 1993), depend on some trend coefficients, the covariance function used to represent the spatial dependence and the measurement noise.

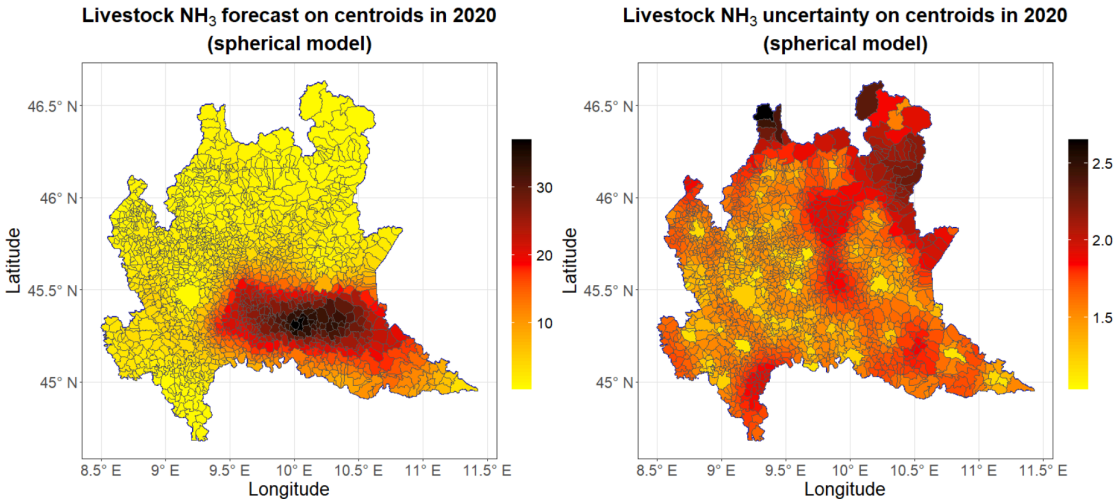
Figures 5 and 6 display the predictions at the 1503 centroids of the municipalities, along with the corresponding measures of uncertainty, for PM_{10} and livestock NH_3 for the year 2020. Predictions provided at the municipality level allow for the spatial alignment of PM_{10} data with NH_3 and facilitate a comparison between the two variables. These predictions were obtained by fitting a linear trend and a spherical covariance function with an included nugget effect. The critical parameters of the spherical model — namely *sill, range, and nugget* — were estimated using the maximum likelihood method (Cressie, 1993). All estimates were computed using the "geoR" package in R (Ribeiro & Diggle, 2001).

Figure 5 – Spatial distribution of PM_{10} in 2020 at the 1503 centroids of the municipalities of Lombardy



Source: Authors' elaboration

Figure 6 – Spatial distribution of NH_3 from livestock farming in 2020 at the 1503 centroids of the municipalities of Lombardy



Source: Authors' elaboration

As observed, the highest levels for both variables are found in the southeast part of the region. Additionally, the uncertainty in the predictions tends to be higher in areas with fewer monitoring sites.

4 Spatial clusters: the local G_i index

The examination of statistical dependence between observations assumes fundamental importance not only for interpolation purposes. A central principle is the notion of spatial autocorrelation, defined as the propensity of geographically contiguous observations to exhibit similar attributes. This phenomenon is crucial to the analysis of the spatial structure of datasets and finds its foundation in the First Law of Geography formulated by Tobler, which postulates that "everything is related to everything else, but the nearest elements exhibit a higher degree of correlation than those that are more distant" (Tobler, 1970). Spatial autocorrelation can manifest itself in the form of positive autocorrelation, characterized by the aggregation of similar observations, or negative autocorrelation, where observations close to each other have a high degree of dissimilarity.

To address these features in the data at the municipality level, distance metrics and weight matrices must be specifically calibrated to quantify the spatial relationships between observations. Within this analytical framework, the local spatial index of Getis and Ord assumes critical importance, as it facilitates the identification of spatial clusters of similar or dissimilar observations, contributing significantly to the exploration of the spatial structure of the data for the benefit of statistical modeling (Getis & Ord, 1996). The Getis-Ord G index is computed as a function of a distance or threshold predefined by the analyst and allows for a distinction between global-level analysis and local-level analysis. The global-level analysis is carried out through global G index, which provides a single value for the entire study domain. The local-level analysis is carried out through the local G_i index, which captures the presence of spatial autocorrelation at the local scale for each geographic unit or municipality.

There are two main variants of the local G_i index that tend to generate comparable results, despite their methodological differences. The first variant, denoted as G_i, excludes the autocorrelation of an observation with itself, thus precluding the value of the *i-th* variable from the autocorrelation computation and focusing only on the values of *j-th* adjacent features. In contrast, the second variant, identified as G_i^*, integrates the value of the *i-th* feature with those of neighboring observations, allowing the autocorrelation of a unit to be assessed by taking into account the interactions with its spatial neighbors.

For the development of the present study, a methodological choice aimed toward the use of the local index G_i was adopted. The formulation of the index G_i, employed in our investigation, is broken down as follows:

$$G_i = \frac{\sum_{j \neq i} w_{ij}(d) y_j}{\sum_{j \neq i} y_j}$$

where G_i is the Getis-Ord index for the spatial unit *i-th*, w_{ij} is the weight assigned to the pair of spatial units *i* and *j* based on their distance *d* or neighborhood relationship, and y_j is the value of the variable of interest for all neighbouring spatial units *j* other than *i*.

The formula under analysis highlights the mechanism by which the cross product between the *y* values at positions *i* and *j* is weighted by a distance coefficient w_{ij}. This coefficient is defined in such a way that it takes on the value of unity if the two positions are identical or are within a distance less than a given threshold limit *d*, and zero otherwise.

The investigation of the statistical significance of local autocorrelation is conducted through statistical inference, which makes it possible to perform homogeneous comparisons between different spatial units. In addition, the evaluative approach toward clustering patterns related to spatial concentration and their statistical significance provides a quantitative basis for interpreting the statistical significance of the identified spatial configurations.

Hence, the application of the local G_i index proves crucial in examining the spatial distribution of values within specific geographic areas, allowing one to distinguish between random distributional configurations and the marked presence of hot spots and cold spots. A hot spot is defined as an area where a significantly high concentration of high values is observed, indicative of an agglomeration of positive or high intensity events or attributes in the specific region. In contrast, a cold spot is identified as a prevalent area of low values, which denotes an accumulation of negative or low intensity events or attributes. The analysis made possible by the G_i index facilitates the identification of clusters of homogeneous (hot spots) or heterogeneous (cold spots) values, providing a detailed representation of spatial variations that contributes to the interpretation of complex phenomena.

The adoption of a *Z test* to assess the presence of hot spots and cold spots is justified through its ability to quantify the distance of local G_i index values from their expected value, assuming the null hypothesis of random distribution. In practical terms, the *z-score* transforms the local G_i index into a value that reflects the number of standard deviations of difference between the local observation and the expected mean under the null hypothesis. This transformation facilitates hypothesis testing, allowing us

to determine whether the observed spatial concentrations (hot spots or cold spots) are statistically significant or the result of chance. The null hypothesis (H_0) assumes that there is no spatial autocorrelation, implying that the spatial distribution of observed values is the result of chance. The alternative hypothesis (H_1), in contrast, suggests the existence of spatial autocorrelation, thus indicating the presence of spatial clusters of high values (hot spots) or low values (cold spots) (Abdulhafedh, 2017). The *Z test* takes the following form and distribution:

$$Z_i = \frac{G_i - E(G_i)}{\sigma_{G_i}} \sim N(0,1)$$

where $E(G_i)$ is the expected value of the G_i index under the null hypothesis of no spatial autocorrelation, representing the mean expected in a random distribution, while σ_{G_i} is the standard deviation of the G_i index under the null hypothesis, indicating the expected variability of G_i in a context of random distribution.

The classification of clusters into hot spots, cold spots and insignificant areas is evaluated based on the following criteria:

- **Hot Spots**: An area is classified as a hot spot if it has a positive *z-value* and a *p-value* below the predefined significance threshold ($\alpha = 0.05$). This indicates a significant concentration of high values, higher than expected under the randomness assumption.
- **Cold Spots**: An area is identified as a cold spot if it has a negative *z-value* accompanied by a *p-value* below the significance threshold. This suggests a significant concentration of low values, implying a clustering of lower values than expected by chance.
- **Insignificant Areas**: Areas are considered insignificant if their *p-values* exceed the established significance threshold, indicating that the spatial concentration could result from random variations.

Applying this statistical framework for local G_i index analysis allows for accurate classification of areas in terms of spatial significance, providing a solid basis for interpreting the distribution of the phenomena studied. Identifying hot spots and cold spots provides valuable insights into areas requiring priority attention or specific interventions, while distinguishing insignificant areas helps avoid false interpretations of random patterns as significant phenomena. This methodology not only enriches spatial analysis in the context of air quality in Lombardy but also offers a replicable model for similar studies in other disciplines and geographic settings.

4.1 Spatial clusters

For a clearer and spatially contextualized understanding of the results, we provide a visual analysis using "cluster maps", thus based on the application of the local spatial index G_i. This mapping will highlight classified areas, allowing us to quickly identify critical areas and thus assess the spatial organization of clusters.

The variables considered in the analysis are *PM_{10}*, *total and livestock NH_3 emissions*, *pig and bovine density*, *NO_x traffic emissions*, *high vegetation index* (*HVI*), and *total precipitation*. Each of these is relevant to study the spatial distribution of phenomena that contribute negatively or positively to air quality in Lombardy. Therefore, our analysis was conducted by calculating the G_i for the above variables, filtered according to the reference period (2020).

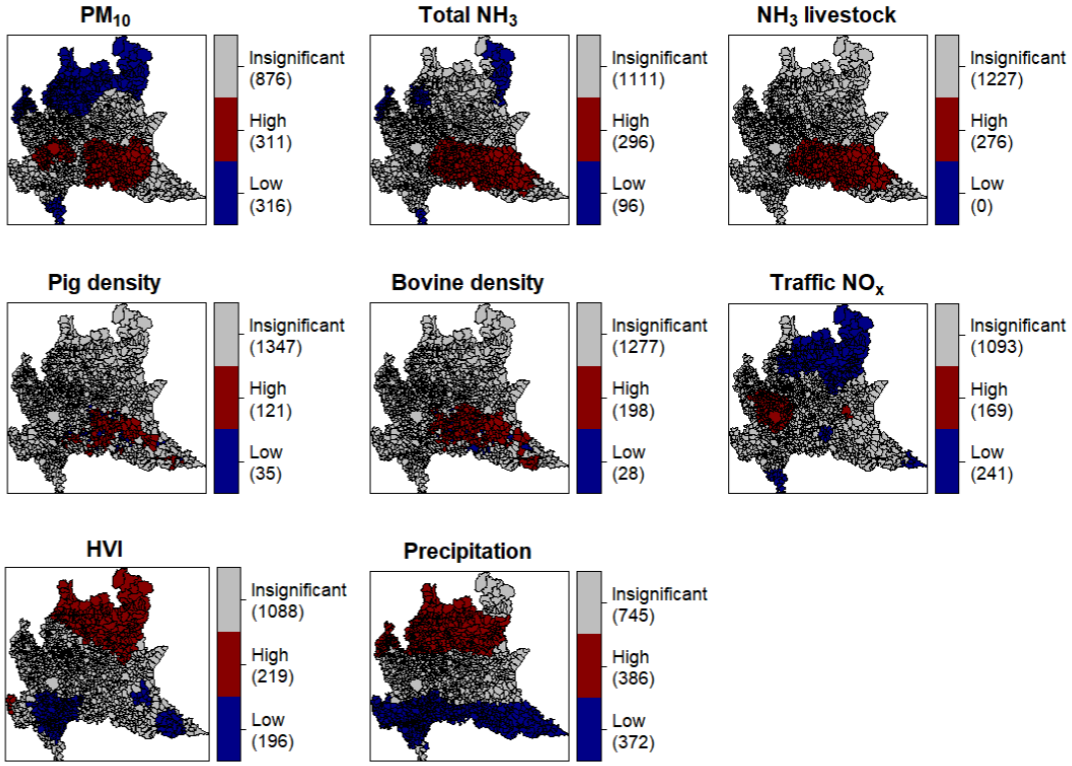
In order to apply this measure, we define a neighborhood structure by considering the matrix of spatial weights based on the "*k-nearest neighbors*" criterion: given the varied landscape of municipal areas in Lombardy, we adopt this matrix configuration in order to ensure that each unit has a uniform number of neighbors. This aims to prevent overestimation of units characterized by a larger number of neighboring localities. Considering some exploratory surveys conducted on the number of connections between municipalities, we decided to adopt a value of $k = 5$ and standardize the contiguity matrix by row.

Using the "localG()" function of R's "spdep" library (Bivand, 2022), the software provides the local G_i measures for each area, including also the relative *expected value*, *z-scores* and associated *p-values*. In Figure 7, we report the results obtained from the "spplot()" function applied to the considered local index (Bivand, Pebesma, & Gomez-Rubio, 2013).

In general, the maps illustrate a notable spatial correspondence in the concentration levels of various environmental and agricultural variables. Specifically, high or low concentrations of PM_{10}, NH_3 emissions from the livestock sector, total NH_3 levels, animal species density (including pigs and bovine animals), and traffic emissions of nitrogen oxides (NO_x) tend to occur at the same geographic locations. This alignment suggests that these variables are closely linked spatially, possibly due to common influencing factors such as regional agricultural practices, traffic patterns, or environmental conditions. On the other hand, an opposite distribution is observed for the variables High Vegetation Index and total precipitation. Areas with high HVI typically indicate regions with dense vegetation, which could absorb pollutants and potentially lower the concentrations of PM_{10} and NH_3 emissions. Similarly, high total precipitation often results in the removal or dilution of pollutants, leading to lower observed concentrations. Thus, regions with high vegetation and high precipitation might show reduced levels of

pollutants compared to areas with less vegetation and lower precipitation. This contrast highlights the different influences these factors have on environmental and air quality conditions.

Figure 7 – Cluster map of air quality in Lombardy (2020) based on the local G_i index



Note: "High" denotes hot spots, "Low" denotes cold spots.

Source: Authors' elaboration

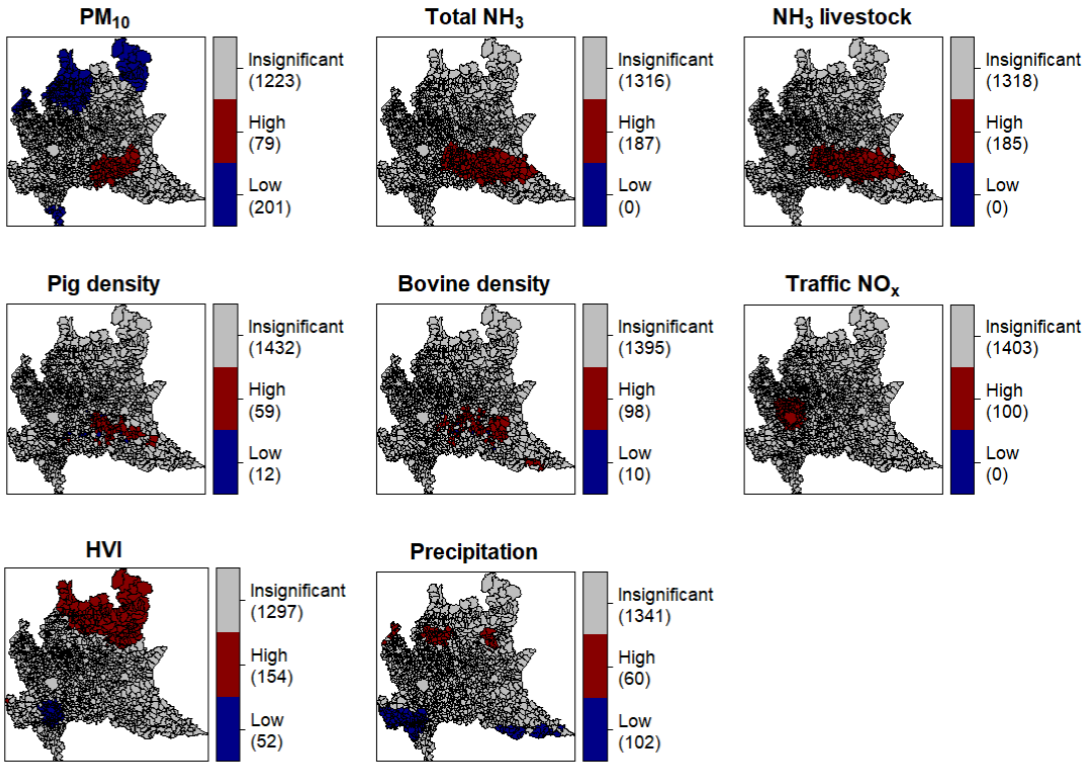
From the analysis conducted, a significant framework emerges that draws attention to the areas identified as hot spots, clearly highlighted in red in the maps. The relevant intensity in these specific areas underscores the importance of adopting targeted approaches to monitor high pollutant measurements in the area.

An important methodological challenge in local spatial autocorrelation statistics is selecting an appropriate p-value cut-off to effectively control the Type I error rate. To enhance the robustness of our findings and minimize the risk of Type I errors (false positives), we applied the False Discovery Rate

(FDR) adjustment (Benjamini & Hochberg, 1995) to the p-values. This adjustment was necessary to address the issue of multiple comparisons, which is common in spatial analysis using the local G index.

The FDR procedure offers a more flexible approach than the Bonferroni correction, as it controls the expected proportion of false positives among the rejected hypotheses. This less stringent method strikes a better balance between detecting true clusters and reducing false positives. Using this procedure, we recalculated the local G index for the same variables and extracted the associated p-values. The FDR correction was then applied following the Benjamini-Hochberg (1995) method, which limits the proportion of false positives among the significant results. Significant clusters were identified using a consistent α threshold of 0.01 across all variables, ensuring the detection of interesting spatial patterns while maintaining strict control over false positives.

Figure 8 – Cluster map of air quality in Lombardy (2020) based on the local G_i index corrected using False Discovery Rate (FDR)



Note: "High" denotes hot spots, "Low" denotes cold spots.

Source: Authors' elaboration

The resulting map in Figure 8 reveals differences compared to the uncorrected map (Figure 7) for the local G_i index, particularly in the identification of new, refined spatial clusters. This highlights the importance of applying appropriate correction methods to enhance the reliability of hot spot and cold spot analysis in spatial studies.

5 Conclusions

This work aimed to investigate the spatial relationship between PM_{10} concentration levels and several variables representing meteorological conditions, vegetation, and emission levels of air pollutants related to human activities such as farming and traffic (i.e., NH_3 and NO_x, respectively). In particular, the study domain was the Lombardy region, and the territories located in its southeastern part (i.e., those belonging to the Po Valley and corresponding to the provinces of Mantova, Cremona, and Brescia) are characterized by intensive agricultural and livestock activities, a significant source of NH_3 emissions, which in turn contribute to the formation of atmospheric PM_{10}. Hence, ammonia emissions are a crucial factor to consider when analyzing air quality in this region. The first step in the analysis involved the alignment of the spatial scales of PM_{10} levels and NH_3 emissions. Universal Kriging was used to predict the values of these variables at the municipality level, and Figures 5 and 6 depicted that the highest levels of PM_{10} and livestock NH_3 emissions were concentrated in the southeastern part of Lombardy, corroborating the potential relationship between the two variables.

The second stage of the analysis focused on the spatial clustering, using the local G_i index, of eight variables, namely PM_{10}, total and livestock NH_3 emissions, pig and bovine density, NO_x traffic emissions, HVI, and total precipitation (see Figure 7). Furthermore, to minimize the risk of Type I errors (false positives), the FDR correction was applied (see Figure 8). Overall, these analyses revealed the presence of hot spots and cold spots in the region. Areas identified as hot spots, characterized by high levels of PM_{10} and NH_3 emissions, were found in the Central-South belt (within the Po Valley), where intensive agricultural and livestock activities are prevalent, and there is low vegetation and total precipitation. Another hot spot area was identified in the vicinity of Milan and adjacent municipalities, where NO_x emissions from traffic are more pronounced. This area is much smaller than the previous one, indicating that reducing ammonia emissions from farming activities could have a more significant impact on the air quality of the region than reducing NO_x emissions from traffic.

It is important to mention that there are alternative indices for the identification of spatial clusters, such as the local Moran I_i index (Anselin, 1995). In this study, the "localmoran()" function from the "spdep" package in R was also applied (Bivand, 2022), producing results similar to those obtained with the local G_i index, as shown in Figures 7 and 8. This consistency suggests that the spatial patterns identified are robust to the choice of index, reinforcing the validity of the conclusions drawn.

In summary, the analysis carried out in this work suggests that the spatial distribution of PM_{10} concentrations in Lombardy is influenced by farming activities, as well as road traffic and environmental factors such as vegetation and precipitation. A limitation of this study is that the complexity of spatial interdependencies in spatial autocorrelation was underscored. Further research is needed to carry out an integrated approach to sustainability that addresses both air quality issues and the social impacts resulting from these environmental conditions. On the other hand, the results of this study can be used to inform policy decisions and interventions aimed at improving air quality and public health in Lombardy. In fact, this work highlights that strategies aimed at reducing ammonia emissions in the atmosphere are compelling in the areas identified as hot spots.

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Towards social inclusion through a second language. Evidence from an unstructured interview

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Abstract

The aim of this article is to present the results of an unstructured interview with the didactic coordinator of a school teaching Italian to foreigners. Through the description of the interviewee's experiences, the social value of teaching a second language for the implementation of social inclusion is highlighted. Therefore, this paper intends to shed light on the importance of second language learning for social inclusion.

Keywords – Second Language; Social Inclusion; Unstructured Interview.

Paper type – Academic Research Paper

Sommario

Verso l'inclusione sociale attraverso una seconda lingua. Evidenze da un'intervista non strutturata. – Lo scopo di questo articolo è presentare i risultati di un colloquio non strutturato con il coordinatore didattico di una scuola che insegna la lingua italiana a stranieri. Attraverso la descrizione delle esperienze dell'intervistato viene evidenziato il valore sociale dell'insegnamento di una seconda lingua per l'attuazione dell'inclusione sociale.

Article history:
Received 15 September 2024
Received in revised form 13 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.101-110

1 Introduction

Globalization, migration processes and new forms of mobility have led to a significant and progressive increase in linguistic diversity and multilingualism (Adamo & Marácz, 2017). Thus, in order to overcome the objective difficulties caused by a lack of proficiency in the national language, learning a second language becomes crucial for those living in a foreign country (Odrowaz-Coates, 2018). A possible link between second language learning and social inclusion emerges, as well as the importance of the presence of organisations providing second language training for foreigners.

The aim of this article is to present the content of an unstructured interview with the didactic coordinator of an organisation offering Italian language courses to foreigners, located in Rome, Italy, to highlight the link between this activity and the possibility of increasing the likelihood of students achieving a satisfactory level of integration and social inclusion through the understanding and use of the national language. The analysis of the content of the interview demonstrated the link between second language learning and social inclusion. The interviewee's assertions confirm what various scholars have shown in their contributions to the relevant literature: The interviewee's assertions confirm what various scholars have shown in their contributions to the relevant literature: the teaching of a second language and the involvement of students in socialisation activities that are complementary to language courses are to be considered fundamental in supporting the process of integration and inclusion of participants in the society of the country of their choice.

2 Literature review

Over the years, several scholars have explored the relationship between second language learning and social inclusion, looking at the issue from both the learner's and the teacher's perspective.

Dunn's (2011) study, for example, highlighted the "social turn" in applied linguistics towards overcoming the formal view of language and the growing interest in the socio-cultural aspect of second language teacher education. In McColl's (2005) contribution, the relationship between learning a foreign language and inclusion is addressed in the context of children's special educational needs in foreign language classes. The author argued for the importance of considering that learning a foreign language only makes sense if contextualized in the social community that uses that language and suggested some measures to implement language courses so that they meet the aforementioned educational needs. Yates (2011), on the other hand, examined the role of social networks as a practical support for the early integration of immigrants. The author showed the importance of this channel both

for the acquisition of foreign language skills and for the creation and development of a socially inclusive community. Using data from a previous study, the author then analysed the opportunities and criticalities of foreign language learning and the implications for social inclusion.

Ortiz and Finardi (2015) proposed a case study referring to the experience of social inclusion of immigrants and refugees in Switzerland. The methodologies employed by the La Roseraie structure for learning French were examined, and highlighted how these methodologies are connected to the social inclusion of the participants. In a further research, a framework was proposed for the collaborative use of the community's linguistic resources to improve second language learning. The framework presented the character of multidimensionality, from learning, to the development of empathy, to the integration of the learner in the reference community, with the ultimate goal of social inclusion (Huang, Cordella, Browning & Baumgartner, 2016).

According to Bacquet (2020), identity, empowerment and investment are the key to successful social inclusion for second language learners. The author linked these dimensions to language learning and provides suggestions for investing in students who intend to improve their sense of empowerment and inclusion. Mirici (2020) considered learning the language of the host country an indispensable requirement for integration and inclusion in the new social community. The author, through the administration of a questionnaire and analyzing the reference literature, demonstrated that learning the national language at a basic level is not sufficient for inclusion in the host society, but advanced teaching programs are necessary, consisting of a mix of classroom lessons and direct experiences of daily life.

St John (2023), on the other hand, analysed the Swedish programme "Swedish for Immigrants", to investigate the role of adult immigrants' first languages by multilingual assistants in the learning of additional languages for the social inclusion of students.

Another study involved a sample of 561 schools and analysed the impact of various group, family and individual characteristics, as well as proficiency in the national language, on inclusion and acceptance among classmates. The results of the analysis showed the positive influence of the density of immigrants in the class on social inclusion; gender seems to have a negative influence on inclusion, while proficiency in the national language seems to be a much stronger determinant of inclusion than other variables related to individual and family characteristics. The analysis also found that this factor holds true for second-generation immigrants (Cavicchiolo et al., 2023).

Rodríguez-Izquierdo and colleagues (2020) conducted a study on a sample of multicultural schools in Andalusia to examine teachers' beliefs about linguistic diversity and their approaches to teaching Spanish as a second language in the inclusion of immigrant students. The study demonstrated the importance of promoting multilingualism as a fundamental resource for inclusion.

The study by AbuJarour and Krasnova (2017), using information obtained by interviewing a sample of Syrian refugees in Germany, explored the effects of technologies on social inclusion processes. The results of the investigation showed the positive relationship between the use of technologies and social inclusion, especially with reference to the support they can offer in learning a new language. Azimova and Solidjonov (2023) also analysed the role of technology, in particular the use of augmented reality (AR), in teaching English as a second language. Their study showed that the use of augmented reality, by improving pronunciation, grammar, reading and writing in the native language, can improve teaching strategies and provide non-native speakers with an enjoyable and productive learning experience.

Grosso (2015) considered the possible benefits of artistic activities of various kinds (photography, painting, etc.) for the learning of the national language by young immigrants. The contribution by Clyne and colleagues (2013), on the other hand, reports on the results of a pilot project carried out in Australia linking second language learning and social inclusion of older people with a migrant background.

3 Methodology

The aim of this paper was to present the results of an unstructured interview with the teaching coordinator of a school of Italian to foreigners, in order to highlight the social value of second language learning for integration.

The unstructured interview method was used for data collection. The choice of this technique was based on the fact that unstructured interviews allow the positive and negative aspects of the phenomenon under study to be captured in greater depth than semi-structured interviews; moreover, interviewees value unstructured interviews as they are better suited to providing a more accurate description of experiences related to the topic under analysis (Gibson, 1998). In addition, unstructured interviews offer a high degree of flexibility, as there are no guidelines that might limit the boundaries of the topics under study (Mueller & Segal, 2014).

In the present study, the method of reporting the content of unstructured interviews by Burnard (1991) was applied, which not only proposes a method, but also points out the possible criticalities associated with the whole analysis process. One of the educational managers of the *Koinè - ETS Association* in Rome, Italy, was interviewed in June 2024. The interview took place in a single meeting, but prior to the interview the interviewees were contacted to explain the purpose of this paper. A total of 10 open-ended questions were asked with the aim of gathering information about the activity of teaching a second foreign language (Italian) and the purposes assigned to this activity (link with the social inclusion of learners).

The method proposed by Burnard (1991) involves a number of stages:

- preparation of post-interview notes regarding the interview transcript;
- reading the transcripts in order to identify the general themes contained in them;
- open coding stage, in which the transcripts are read a second time and headings are placed to describe various aspects of the interview content;
- analysis of the categories and reduction of their number by grouping those that are similar to each other;
- production of the final list of categories and sub-categories;
- generation of category systems;
- joint reading of transcripts and list of categories and subtitles to confirm consistency;
- coding of transcripts according to categories;
- enucleation of the coded parts from the transcripts;
- cut sections pasted on sheets with titles and subtitles;
- verification of the appropriateness of the category system by selected interviewees;
- filing of all sections to facilitate the writing and results;
- beginning of the writing process;
- linking the data to the literature (at the researcher's discretion).

Therefore, although unstructured interviews are not particularly predictive, they allow us to obtain information based on solid data. The fact that unstructured interviews generate highly contextual responses makes them useful for both qualitative and quantitative research (Bihu, 2020): "[...] Specifically, interviewees' oral voices can be more meaningful to describe values, feelings and beliefs than meanings in descriptions generated by quantitative measures such as Likert scale and semantic differentials trying to set up best and worst options for respondents to evaluate and discriminate plausible cases from probable distractors through highly structured instruments" (p. 719).

4 Interview contents presentation

This section reports the contents of the unstructured interview with one of the head teachers of a school teaching second language to foreigners, following the methodology proposed by Burnard (1991).

Firstly, the contents of the interview were transcribed. Subsequently, some notes in the margins of the transcription were elaborated. A second reading of the transcript made possible to identify the following general themes:

- characteristics of the organisation;
- type of activity carried out, services offered and recipients of the activity;
- objectives of the organisation;
- link between activities carried out by the organisation and social inclusion.

Table 1 below shows the results of the open coding stage (Burnard, 1991).

Table 1 – Open coding stage

Interview transcript	Open coding
The organisation provides L2 Italian language courses, official examinations to certify knowledge of the Italian language, and cultural and educational activities to promote the integration of learners into the national social context. The organisation operates in the field of vocational education and training with the aim of promoting social inclusion and the knowledge of the Italian language among foreign communities in the national territory. The provision of Italian L2 courses and activities to promote knowledge of Italian culture promotes the social inclusion of all those who have long-term life plans in the national territory. The strengths are the small size of the organisation – which allows all those involved in the training activities (teachers and learners) to get to know each other and establish a relationship of trust – and the careful selection of staff, who must have certain professional qualifications to work in the organisation. The main critical point is undoubtedly the constant difficulty of finding a balance between the economic sustainability of the organisation and the cost of the proposed activities, which must nevertheless remain accessible to as many learners as possible. We are convinced that in order to guarantee real and lasting social inclusion for all, it is necessary to work on linguistic inclusion; only in this way it will be possible to reduce inequalities and problems at the level of employment, to guarantee more equitable relations and thus to favour the achievement of effective social cohesion.	The organisation provides Italian language courses for foreigners alongside other educational and training activities to promote the integration of learners ... the main objective is to promote social inclusion ... the small size of the organisation allows for a more direct relationship between teachers and course participants ... the most critical issue is finding a balance between the economic sustainability of the organisation and the cost of the activities proposed. The main critical issue is to find a balance between the economic sustainability of the organisation and the cost of the proposed activities ... linguistic inclusion is key to achieving social inclusion ...

Source: Author's elaboration from Burnard, 1991

At the end of the open coding phase, the categories with their subtitles were formed and the transcript of the interview was coded (Table 2).

Table 2 – Transcription coding stage

Interview transcript	Categories
Interviewer: *What is the name of the organisation?*	Name of the organization
Interviewee: *Koinè Association - ETS*	
Interviewer: *What type of organisation is it?*	Type of organization
Interviewee: *Third sector organisation*	
Interviewer: *How many members are there in the organisation?*	Members of the organization
Interviewee: *The organisation has between 7 and 10 employees, depending on seasonal needs.*	
Interviewer: *What is your role in the organisation?*	Role of respondent in the organization
Interviewee: *Didactics coordinator*	
Interviewer: *Which services does the organisation offer?*	Services provided by the organisation
Interviewee: *Italian L2 courses; official examinations certifying knowledge of the Italian language; cultural and educational activities to foster the integration of learners into the national social context.*	
Interviewer: *How does the organisation provide services?*	The way in which the organisation provides its services
Interviewee: *Group courses; individual lessons; preparation courses for certification exams; organisation of extracurricular activities aimed at getting to know Italian culture (e.g. guided historical-archaeological tours, tastings, cooking lessons, etc.).*	
Interviewer: *What are the organisation's objectives?*	Objectives of the organization
Interviewee: *The organisation operates in the field of vocational education and training with the aim of fostering social inclusion and promoting knowledge of the Italian language among foreign communities in the country.*	
Interviewer: *Do you think that the organisation's activities have a social sustainability purpose? If yes, please specify in what way.*	Linkage between the organisation's objectives and social inclusion objectives
Interviewee: *Yes, because the provision of Italian L2 courses and activities that promote knowledge of Italian culture favours the social inclusion of all those who have long-term life plans in Italy.*	
Interviewer: *What are the strengths of the organisation, what are the main weaknesses?*	Organisational strengths and shortcomings
Interviewee: *The strengths are the small size of the organisation – which allows all those involved in the training activities (teachers and learners) to get to know each other and establish a relationship of trust – and the careful selection of staff, who must have certain professional qualifications to work in the organisation. The main critical point is undoubtedly the constant difficulty of finding a balance between the*	

economic sustainability of the organisation and the cost of the proposed activities, which must nevertheless remain accessible to as many learners as possible.	
Interviewer: *Do you think that the organisation's objectives include following the principles of social sustainability? If so, please explain how.*	Linkage between organisational and social sustainability objectives
Interviewee: *Yes, because we are convinced that in order to guarantee real and lasting social inclusion for all, it is necessary to work on linguistic inclusion; only in this way it will be possible to reduce inequalities and problems at the level of employment, guarantee more equitable relations and thus favour the realisation of effective social cohesion.*	

Source: Author's elaboration from Burnard, 1991

The verification of the consistency of the categories was carried out independently by the author of this article, as were the other activities in stages 7-13 of Burnard's (1991) method. With regard to the relationship between the data obtained from the unstructured interview and the literature, it should be noted that the results of the present paper are consistent with the findings of previous studies linking second language learning and teaching with social inclusion (see Section 2 of this paper).

5 Conclusions

This paper presented the content of an unstructured interview with the teaching director of an organisation providing Italian language courses for foreigners. The aim of the interview was to highlight the link between second language learning and social inclusion, which has already been demonstrated by many contributions in the reference literature. The interviewee explained that the social integration of the course participants is the ultimate objective of the activity carried out by the provider organisation and in fact the language classes are accompanied by numerous socialisation activities (guided tours of the city, social experiments in pubs, cinemas, theatres, etc.).

This work seeks to contribute to the dissemination of the importance of supporting people in a foreign country, first and foremost by teaching them the national language, in order to increase their chances of integration and social inclusion, as this link is now recognised both by the academic world and by the organisations that provide this important service on a daily basis.

The implications of this work are both theoretical and practical. On one hand, it contributes to the field of research on the relationship between second language learning and social inclusion; on the other, by reporting on the direct experience of an operational reality active in the world of teaching

languages to foreigners, it aims to draw attention to the importance of learning the language of the host country, both through lectures and through activities based on real situations in a foreign country.

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Enhancing Sustainability and Cost Efficiency in Albania's Water Supply Sector: A Path Toward Responsible Water Resource Management

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Abstract

The Albanian water supply sector is facing important challenges despite the country's abundant natural water resources. In terms of coverage, only 71% of the population has access to safe drinking water. There are significant interruptions in supply, and many Water Utilities (WUs) underperform financially and technically.
This study aims to explore the cost structure of Albania's WUs, assess their operational sustainability (exploring their cost structure), and identify cost-saving opportunities.
Individual data for each WU (57 in total) for the period from 2008 to 2015 is used and a translog cost function to estimate economies of output, customer density, and economies of scale is applied. By employing a hedonic approach, the analysis incorporates technical variables such as network length, number of customers, water losses, and load factors along with output and input prices.
The results highlight the presence of diseconomies of output density, customer density, and scale, indicating that increasing water production or the customer base disproportionately raises operational costs. These findings reflect Albania's water supply inefficient infrastructure, a consequence of major network losses, poor network conditions, and limited capacity to manage increasing demand efficiently.
Several policy implications derive from this study. There is an urgent call for investment in infrastructure upgrades, and a strong sectorial reform to improve the financial and operational sustainability of WUs. Policymakers should also consider strategic tariff adjustments and potential regionalisation of services to mitigate rising costs along with regulators and national authorities to guide interventions in enhancing water service delivery, ensuring equitable access, and promoting long-term sustainability.

Keywords – Water utilities; Water supply management; Cost efficiency; Economies of Scale.

Paper type – Academic Research Paper

Sommario

Migliorare la sostenibilità e l'efficienza dei costi nel settore dell'approvvigionamento idrico in Albania: un percorso verso la gestione responsabile delle risorse idriche. – Il settore dell'approvvigionamento

idrico albanese si trova ad affrontare sfide importanti nonostante le abbondanti risorse naturali del paese. In termini di copertura, solo il 71% della popolazione ha accesso ad acqua potabile sicura. Si verificano interruzioni significative nella fornitura e molte aziende idriche hanno prestazioni scadenti dal punto di vista finanziario e tecnico. Questo studio mira a esplorare la struttura dei costi delle aziende idriche albanesi, valutare la loro sostenibilità operativa (esplorando la struttura dei costi) e identificare opportunità di risparmio. Vengono utilizzati dati individuali per ciascuna azienda idrica (57 in totale) per il periodo dal 2008 al 2015 e viene applicata una funzione di costo translogaritmica per stimare le economie di produzione, la densità dei clienti e le economie di scala. Utilizzando un approccio edonico, l'analisi incorpora variabili tecniche come la lunghezza della rete, il numero di clienti, le perdite idriche e i fattori di carico insieme ai prezzi di produzione e di input. I risultati evidenziano la presenza di diseconomie tra densità di produzione, densità di clienti e scala, indicando che l'aumento della produzione di acqua o della base di clienti fa aumentare in modo sproporzionato i costi operativi. Questi risultati riflettono l'inefficienza delle infrastrutture di approvvigionamento idrico dell'Albania, come conseguenza delle gravi perdite di rete, delle cattive condizioni della stessa e della scarsa capacità di gestire in modo efficiente la domanda crescente. Da questo studio derivano diverse implicazioni politiche. Urgono investimenti nel potenziamento delle infrastrutture e una decisa riforma settoriale per migliorare la sostenibilità finanziaria e operativa delle aziende idriche. I politici dovrebbero anche considerare gli aggiustamenti tariffari strategici e la potenziale regionalizzazione dei servizi per mitigare l'aumento dei costi insieme a organismi regolatori e autorità nazionali per guidare gli interventi volti a migliorare la fornitura dei servizi idrici, garantire un accesso equo e promuovere la sostenibilità a lungo termine.

Article history:
Received 12 September 2024
Received in revised form 22 October 2024
Accepted 1 November 2024
Available online
DOI 10.61013/2724-4466/5.2.111-134

1 Introduction

Albania has abundant water resources, one of the highest see river discharge in Europe, around 40km^3/year. Groundwater resources consist of 23% of the total renewable resources, the main source of drinking water, and the major source of irrigation (Water Action Hub. *Albania*). They are estimated to be around 288 cubic meters per second (m³/s), with exploitable resources making up about 140 m³/s, or roughly 50% of the total natural groundwater resources in most aquifers. Currently, urban and industrial water supply from groundwater in Albania is approximately 12 m³/s, while rural water supply utilizes about 2.0 m³/s, bringing the total water usage to around 14 m³/s. (Eftimi, Shehu, & Sara, 2023).

Renewable water resources are one of the major assets of the Albanian economy, crucial for electricity production (Drin, Mati, and Bistrice rivers' hydroelectric plants produce 97% of Albania's energy in 2011, according to Osservatorio Balcani e Caucaso Transeuropa – OBCT), irrigation in agriculture (the biggest consumer of fresh water, around 60% of the total water use, according to Diku, 2011), industry, fishing, tourism, and drinking water sector. The paradox is that only 71% of the population in Albania has access to a safely managed drinking water service (UN Water, 2022) with discontinued water supply services (continuity of water supply for 2022 was 16.3 hours per day according to Water Regulatory Authority of Albania – WRA, 2022).

The water and sanitation sector (WSS) mainly operates through operators organised as a joint stock company owned by the local government. There are 57 operators, 53 of them operating under a WRA license and 48 operators that apply tariffs approved by WRA. Sewerage services are offered by 32 operators, five of which also do wastewater treatment, covering 12 counties and 61 municipalities (World Bank, 2022).

In recent decades, Albania has developed a strong regulatory and legal framework for water services delivery and introduced changes in institutional arrangements to improve service delivery. Moreover, the legislation for Integrated Water Resources Management in Albania will improve compliance with the Water Framework Directive – WFD (Alla, 2019). The integrated management of water resources is based on six principles (Article 6 Law No. 111/2012 "On the Integrated Management of Water Resources", amended):

- sustainable development: respecting the integrity of water basins and balancing water use to meet the current needs, and simultaneously guarantee the water resources quality and quantity, without compromising the ability of future generations to meet their own needs;
- efficiency: using water resources efficiently, respecting the principle of recovering the costs of water services, including the costs of environment, under the "polluter pays" principle[1];

[1] The Polluter Pays Principle (PPP) in the water sector states that those who cause water pollution should bear the costs of managing and mitigating the pollution, aiming to incentivize polluters to reduce their environmental impact

- environmental protection: preserving water ecosystems, biodiversity, and natural habitats through responsible water management practices and all principles of environmental protection[2];
- equity and social justice: ensuring balanced and equitable water use and fair access to clean water for all;
- precaution: applying the precautionary principle to manage risks associated with water resources and prioritising actions to prevent harm;
- transparency: maintaining openness and accountability in decision-making processes related to water management to build trust and confidence among stakeholders.

Albania does not lack adequate water resources and therefore should be able to provide its entire population with safe and fresh drinking water. Nevertheless, most of the water utilities in Albania continue to perform poorly, both technically and financially. An important indicator of their performance is "non-revenue water", consisting of the lost volume of produced water due to non-metered connections in the network and technical losses due to amortisation of the distribution infrastructure. For the year 2022, according to WRA, this indicator was about 63.7% on average among operators (WRA, 2022). This results in low levels of service to the population and to businesses, and an inability to extend services to those without them, especially the most vulnerable in the peri-urban and rural areas of the country. Around 20 % of the rural population has no piped access at home. Most utilities are chronically dependent on central government funding; 37 out of the 58 municipal water companies continued to rely on budget support (World Bank, 2022).

The situation in Albania is a product of the low performance of operators in the sector of drinking water in the context of largely renewable natural water resources. Exploring the cost structure of the water supply operators will give us valuable hints in terms of their operational sustainability. The individual cost structure explored in time will provide information about the presence of economies of customer density and scale. The objective of this work is to assess the cost structure of WUs in Albania, identifying the most significant drivers that influence the operational costs and providing some practical policy implications to improve the situation of the water and sanitation sector performance.

The article is organized as follows: Section 2 will revise critically the related literature and Section 3 will describe the data and the variables of the analysis in detail. Section 4 will focus on the model specification, stating the theoretical function model, the econometric techniques used, and the calculation of the cost economies. Section 5 will present the results from the translog cost approach,

by making them financially responsible for the damage they cause (practically imposing fines, fees, or charges on industries and individuals that discharge pollutants into water bodies).

[2] It is defined in Law No. 10 431, dated 9.6.2011, "For Environment Protection". https://albcold.gov.al/wp-content /uploads/2021/05/Law-No.-111-2012-On-Integrated-Management-of-Water-Sources.pdf.

along with the cost economies results and robustness check to validate the results. The Section 6 will provide the conclusions and policy implications of the article.

2 Related literature

There is a wide literature on the water supply and utilities sector, specifically focusing on cost efficiency, regulatory frameworks, and the relationships between operational and environmental factors. Several key studies have contributed to the understanding of how utility companies manage their costs, and efficiency levels, and respond to external pressures like regulation and environmental changes. However, these works are focused more on developed realities, and the unique context of developing countries, where infrastructure challenges and evolving regulatory environments play a major role, remains partially or less explored. This section reviews the main contributions of pioneer and recent studies to the field and highlights how this work fits into and contributes to the existing literature.

2.1 Operational and environmental factors and utility efficiency

Kim (1987) investigates the presence of economies of scale in firms producing multiple products. Using a translog cost function to model the cost structure of multi-product firms, the study examines whether increasing output across different product lines leads to cost advantages. The analysis uses firm-level data to estimate the economies of scope and scale. Traces of economies of scale were found in certain industries. Additionally, related to economies of scope, it was found that producing multiple products jointly is more cost-efficient than separately.

Mizutani and Urakami (2001) conducted a detailed analysis of Japanese water supply utilities, focusing on how cost efficiency is affected by the network density and the scale of operations. They applied a translog cost function approach to data from numerous water utilities across Japan, and they were able to quantify the presence of economies of scale and their relationship with operational size. Their findings demonstrated that smaller-sized water utilities (specifically those serving densely populated areas) benefit from economies of scale (i.e., as their output and service areas increase, their average costs decrease). However, the study also found a turning point beyond which the expansion of utilities (particularly larger ones) leads to diseconomies of scale. Due to higher infrastructure costs, and logistical challenges in larger service areas, increasing the size of operations results in higher average costs, suggesting that while small to medium-sized utilities can achieve cost savings through expansion, larger utilities may face inefficiencies that counteract these benefits. The study's findings highlight the

need to carefully consider the optimal size of utilities and the role of network density in maintaining operational efficiency, particularly in densely populated regions.

The article by Fabbri and Fraquelli (2000) analyses the cost structure and technological efficiency in the Italian water industry, focusing on the relationships between scale, scope, and output density. The authors use a translog cost function to estimate the cost structure of water utilities, utilising data from 53 Italian water companies. The objective is to assess whether economies of scale and scope exist in the industry and to identify the impact of customer and output density on costs. The results indicate economies of scale for smaller firms but diseconomies of scale for larger companies, suggesting inefficiencies in large-scale operations. Additionally, the study finds evidence of economies of scope when combining water production and distribution, recommending better resource integration to reduce costs.

Garcia and Thomas (2001) explored similar issues in the French water industry, conducting a detailed analysis of the cost structures of local water utilities, focusing on the relationship between economies of scale and operational efficiency. Their research found there is a significant cost savings scenario that could be achieved by larger utilities (particularly those that managed both water distribution and wastewater treatment services, called multiple output utilities). This finding supports the argument that where utilities combine multiple water-related functions (integrated service provision) can lead to decreased average costs and improved financial and operational sustainability. It was highlighted that economies of scale were strong in areas where utilities were able to expand their service areas and customer base, suggesting that larger utilities benefit from spreading fixed costs over a greater volume of water supplied. Moreover, it was found utilities that combine water and wastewater services were able to achieve additional cost efficiencies and further reduce operational expenses (through shared infrastructure and administrative systems).

2.2 Efficiency in water utilities: ownership structure, privatisation, and regulation role

Bhattacharyya, Harris, Narayanan, and Raffiee (1995) investigate the impact of ownership structure on the economic efficiency of water utilities in the United States. Using a translog cost function and panel data, they estimate the cost structures of publicly and privately owned water utilities to assess differences in efficiency. The study finds that publicly owned utilities tend to operate less efficiently compared to their private counterparts, primarily due to less stringent cost controls and managerial practices. The authors highlight that private utilities face stronger incentives to minimize costs, leading to better performance. The results suggest that ownership type plays a significant role in influencing the

economic efficiency of water utilities, with policy implications for the privatization and management of such services.

Saal and Parker (2000) explored the effects of privatisation and regulation on cost efficiency focused on the water and sewerage industry in England and Wales. Privatisation has been found to have a limited direct impact on cost efficiency, while effective regulation played a more important role in reducing costs and ensuring that savings were passed on to consumers. This study offers a relevant perspective for understanding how cost structures in utilities evolve in response to both market changes and regulatory interventions. It emphasises the variation in regulatory practices, which is critical in understanding how water utilities in different countries perform under varying market conditions. The findings underline the importance of robust regulatory practices in ensuring utility efficiency, a theme that echoes in many studies focused on developed countries but is less addressed in developing economies like Albania, where regulatory reforms are still in progress.

Pazzi, Tortosa-Ausina, Duygun, and Zambelli (2016) investigate the cost efficiency of water utilities with a particular focus on the impact of public ownership. Using a panel dataset from Italian water utilities, the study employs stochastic frontier analysis to assess whether public ownership influences operational efficiency. The findings suggest that public ownership, by itself, does not necessarily lead to inefficiency, but the governance structure and management practices associated with public entities can significantly affect performance. The authors highlight that publicly owned utilities tend to perform worse in environments where governance oversight is weaker, suggesting that the quality of management and regulatory frameworks play a crucial role in driving efficiency, rather than ownership per se. This work contributes to the debate on privatisation versus public ownership in the utilities sector by showing that ownership effects are context-dependent and that improving governance is key to enhancing cost efficiency in publicly owned utilities.

2.3 Cost structure of water utilities in developing countries

The literature is notably sparse when it comes to water management in developing countries, especially concerning cost structures in highly fragmented and inefficient utility networks like those found in Albania. A few consulted papers are described as follows.

Nauges and van den Berg (2008) conducted an important study on the economies of scale, scope, and density in the water supply and sewerage sectors across four developing and transition economies: Brazil, Moldova, Romania, and Vietnam. Using a translog cost function in a panel data context, from their research emerged that economies of scale were present in most countries, except for Brazil. This result has a great impact since indicates that larger utilities could reduce average costs by expanding

operations, particularly in Moldova, Romania, and Vietnam. Additionally, the study found evidence of economies of density (i.e., including new water connections, in densely populated areas, can lower average costs). Economies of scope were also identified, in the scenario of combining water supply and sewerage services under the same utility, rather than operating them separately. From the study, it was emphasised the important role of utility size and service integration in improving operational efficiency in the water sectors of these countries. However, Nauges and van den Berg (2008) identified the significant challenges that utilities face in realising these efficiencies, such as the limited infrastructure and fragmented utilities. In developing economies, outdated infrastructure, high levels of non-revenue water (water loss), and fragmented service delivery networks can affect negatively the potential cost savings from economies of scale and scope. For instance, utilities often struggle to maintain and expand services due to financial limitations, dependence on central government funding, and the need to service dispersed populations.

Similarly, Tsegai, Linz, and Kloos (2009) examined the cost structure of water utilities in the Middle Olifants sub-basin of South Africa, estimating the marginal cost of water supply and tracing the presence of economies of scale. Their study used the same methodology (a translog cost function) and data from the South African National Treasury to estimate the marginal cost of water supply and evaluate the financial sustainability of Water Service Authorities (WSAs). Authors found evidence of economies of scale, suggesting an important implication: merging smaller WSAs into larger utilities could reduce costs and improve efficiency. The study underscores the importance of setting appropriate water tariffs that reflect the true cost of service provision and the potential benefits of consolidating smaller utilities to achieve greater operational efficiency. Both under-pricing and fragmented networks create financial strain on utilities, limiting their ability to invest in necessary infrastructure upgrades, which in turn exacerbates issues of water loss and service inefficiencies.

Zhao (2020) conducts an in-depth analysis of productivity change in China's privatised water sector between 1999 and 2006, using and applying a translog stochastic frontier production function and the Malmquist productivity index (MPI) to assess efficiency and productivity dynamics over time. By examining panel data from 38 water utilities across various Chinese cities, Zhao investigates how privatisation and regulatory reforms impacted the sector's productivity. The methodology makes an explicit distinction between operational improvements efficiency and technology advancements, providing valuable insights into whether productivity gains were driven by better resource management or technological innovation. The study's results stated that privatisation alone did not uniformly enhance operational performance across the sector.

Lajqi, Đurin, Vataj, and Nakic (2023) work represents one of the few works for the region (Kosovo, a country neighbour of Albania). They utilised data from water utilities across the country to evaluate

key efficiency metrics, including water loss rates, energy consumption, and cost management, and to evaluate the level of financial and operational efficiency. The authors applied benchmarking techniques and several performance indicators, and it merged a significant level of inefficiencies in the water distribution system due to the outdated infrastructure, high degree of non-revenue water, and inadequate resource allocation. They suggested targeted interventions for the case water sector in Kosovo, starting from prioritising the infrastructure upgrading, improving metering systems, and enhancing staff training.

Nyathikala, Jamasb, Llorca, and Kulshrestha (2023) conducted a detailed study examining the governance structures, incentive mechanisms, and performance outcomes in India's urban water sector. The researchers employed a panel data methodology, utilising data from 24 urban water utilities across India over five years. By applying a stochastic frontier analysis (SFA) model, the study aimed to measure the technical efficiency of water utilities while accounting for variations in governance and incentive structures. Moreover, they applied a two-stage analysis to isolate the impact of governance and incentives on utility efficiency, finding that utilities with more decentralised governance and stronger performance-based incentives tended to operate more efficiently than those with centralised or less flexible governance structures.

2.4 Contributions to the literature

Most existing research has focused on utilities operating within well-established regulatory frameworks and with stable infrastructures, leaving a significant gap in understanding the dynamics of water utilities in more volatile and infrastructure-constrained environments. The contribution of the work is multiple: providing (in our best knowledge) probably one of the first) empirical analysis at the level of the operators-structure cost for the case of Albania as a developing country contributing also to the sparse literature about the cost structure of operators in the water industry of developing countries, (ii) offering a consolidated methodology to provide reliable and robust findings using through the estimation of the translog cost function and the measurement of economies of customer density and scale (important indicators for water policies related to planning or water tariffs), (iii) offering a valuable document to the policymakers, regulators and national authorities to better formulate the needed interventions in the sector.

3 Data

Data is collected from WRA Performance Reports for the period 2008-2015, for 57 utilities for a total of 390 observations. The choice of the period of study was driven by the interest in examining the situation before the 2018 reform under the National Strategy on Integrated Water Resources Management (2018-2027). This allows for an evaluation of the sector's dynamics before the reform, providing a baseline against which future developments and policy impacts can be assessed.

Several indicators (performance, economic, financial) are extracted from the reports. The Water Utilities (WUs) included in the dataset have differences in size, water resources, geological distribution area's characteristics, production technology (gravitational system or electrical pumps system for extracting the underground water resources), and customer demand and are located across Albania, in a national level. Table 1 summarizes the descriptive statistics.

Table 1 – Sample descriptive statistics

Variable	Unit	Mean	SD	Min	Max
Variable costs	1000 ALL	62201.58	160967.634	0	1640971
Output	1000 m3 /year	4833.165	14081.691	0	109052.268
Labor price	1000 ALL/ worker/year	248.451	162.345	0.575	700.097
Energy price	ALL/1000 m3/year	2.366	6.372	0	39.063
Material price	ALL/1000 m3/year	15.151	38.393	0	429.914
Network length	km	117.017	239.403	3.1	2267.783
Customers	1000	46503.741	117844.948	866.252	911916.738
Network losses	%	0.461	0.736	0.083	1
Load	%	0.538	0.736	0	9.323
System type	-	0.394	0.489	0	1

Source: Author's elaboration

Our variable of interest is the Water[3] Variable Cost of each utility (*WVC*), which is expressed in thousands of Albanian Lek (ALL). It is used the cost function versus the production function for the analysis of the WUs technology following Shephard (1953). The analysis will be based on one output y_{prod} (the total water volume produced expressed in thousands of cubic meters per year. Input prices w_L, w_{MA}, *and* w_E are respectively the unit price of labour, materials, and electricity; w_L is derived as labour

[3] Sewerage and water treatment processes are not included since only 32 out of 57 offer sewerage services and only 5 do wastewater treatment.

costs divided by the number of staff for each utility (expressed in thousands ALL per worker annually). Electricity price w_E and material price w_{MA} are expressed in ALL per thousands of cubic meters annually and derived respectively as the ratio of energy costs and material costs divided by the output produced.

To consider some technical variables, three variables are included: the number of customers (*cust*) expressed in thousands, the network losses (y_{loss}) derived as the differences between the total water volume produced and total volume sold (expressed in thousands of cubic meters per year) and served as a proxy for the quality of the network infrastructure, and the load factor (*load*) a proxy of the percentage of the water volume sold over the total volume produced. As a control variable, a proxy for the existing capital was considered the network length (*length*) expressed in kilometres (km).

As a proxy for the type of system technology (gravitational or pumping system) a dummy variable (*systype)* was included with value 1 if the volume of water produced from the gravitational system is higher than the one produced with the pumping system, and 0 otherwise. Moreover, to capture any effect of public regulation changes, the intention was to include a second dummy for the effect of the National Strategy on Integrated Water Resources Management 2018-2027, but data stopped 3 years before its implementation.

4 Model specification

4.1 Theoretical model

There was a choice made between variable and total costs and it was oriented by the assumption that using total costs implies that the utilities are at their long-term equilibrium (their production factors minimize the total costs). For the case of the water utilities, this is a strong assumption (their capital stock probably is not at its optimal level since it is relatively costly to modify it and water utilities are demand-specific (their activity depends on the seasonal and unexpected demand variations), so the capital stock is assumed to be fixed in the short-run and it can adjust partially to the long-run equilibrium (Baranzini and Faust, 2009). So, the variable costs include labour, electricity, materials, and other costs.

The traditional costs functional form usually includes as determinants only output and price of inputs without considering the characteristics of the served areas of each utility, technical variables (such as network performance measures), or unexpected events in terms of public regulation. This limited framework does not consider other environmental variables, very important for their impact on costs, especially for water sectors with a higher degree of heterogeneity. For the reasons mentioned

previously, a hedonic approach was preferred to use in this context; operator-specific indicators will be included to capture any operator specificity.

Translog functional form for the cost function was chosen versus the Cobb-Douglas one since is a flexible form that provides a second-order approximation for every cost function to be estimated. The translog specification of the model (all the variables except for the dummy one are expressed in natural logs) is presented as follows:

$$WVC_{it} = \alpha_0 + \sum_t \alpha_t + \beta_{y_{prod}} y_{prod\,i,t} + \sum_{i=1}^{3} \beta_{w_i} w_{i,it} + \sum_{k=1}^{4} \beta_{z_k} z_{k,it} + + 1/2\beta_{y_{prod}y_{prod}} \left(y_{prod\,i,t}\right)^2 + 1/2 \sum_{i=1}^{3}\sum_{j=1}^{3} \beta_{ij} w_{i,it} w_{j,it} + 1/2 \sum_{k=1}^{4}\sum_{m=1}^{4} \beta_{km} z_{k,it} z_{m,it} + \sum_{i=1}^{3} \beta_{iy_{prod}} w_{i,it} y_{prod\,i,t} + \sum_{i=1}^{3}\sum_{k=1}^{4} \beta_{ik} w_{i,it} z_{k,it} + \sum_{k=1}^{4} \beta_{ky_{prod}} z_{k,it} y_{prod\,i,t} + \beta_{systype} systype_{it} + u_{it}\,, \quad (1)$$

where: α_0 is the constant term, α_t the time effect, $\beta_{y_{prod}} y_{prod\,i,t}$ is the linear term for the output, $\sum_{i=1}^{3} \beta_{w_i} w_{i,it}$ is the linear terms for input prices (i=1, 2, 3) such as labor, electricity, and material prices, $\sum_{k=1}^{4} \beta_{z_k} z_{k,it}$ is the linear terms for the hedonic variables included (k=1,2,3,4) such as network length (*length*), number of customers served (*cust*), water losses *(yloss)* and load factor (*load*), and $\beta_{systype}$ for the technology. Each $\sum_{i=1}^{3}$, $\sum_{i=1}^{3}\sum_{j=1}^{3}$, and $\sum_{i=1}^{3}\sum_{k=1}^{4}$ are the coefficients of interaction terms, and ε_{it} the error term.

4.2 Econometric issues and estimation techniques

Costs and input prices were normalized by the price of materials to guarantee homogeneity in input prices and the symmetry is achieved from the condition $\beta_{ij} = \beta_{ji}\ \forall i \neq j$, and $\beta_{km} = \beta_{mk}\ \forall k \neq m$. The homogeneity restriction ensures that the cost function is homogeneous of degree one in input prices $\sum_{j=1}^{3} \beta_{ij} = 0$, $\sum_{i=1}^{3} \beta_{iy_{prod}} = 0$, for each input price i, and $\sum_{i=1}^{3} \beta_{w_i} = 1$. By applying the symmetry and

homogeneity restrictions to the translog cost function, it is ensured that it behaves in line with economic theory[4], making it suitable for modelling cost functions in applied econometric analysis.

To profit from the econometric point of view, a joint estimation of equation 1 and the cost-share equations 2.1 and 2.2 will be performed. This dual approach increases the number of degrees of freedom, producing more precise estimators and controlling for possible correlations among disturbances' equations (Bottaso & Conti, 2009). According to Shephard's Lemma[5], taking the partial derivative of the translog cost function concerning w_i will produce the cost-share equation for each input i as follows:

$$S_{i,it} = \frac{\partial WVC_{it}}{\partial w_{i,it}} \tag{2}$$

There will be two equations, only for electricity and labour cost share. The cost-share equation for material is not included due to singularity issues.

$$S_{L,it} = \alpha_L + \beta_L w_{L,it} + \beta_L w_{E,it} + \beta_{Ly_{prod}} y_{prod,it} + \sum_{k=1}^{4} \beta_{Lz_k} z_{k,it} + \beta_{Lsystype} systype_{it} + u_{Lit}\,, \tag{2.1}$$

$$S_{E,it} = \alpha_E + \beta_E w_{E,it} + \beta_E w_{L,it} + \beta_{Ey_{prod}} y_{prod,it} + \sum_{k=1}^{4} \beta_{Ez_k} z_{k,it} + \beta_{Esystype} systype_{it} + u_{Eit}. \tag{2.2}$$

Zellner's (1962) Seemingly Unrelated Regression (SUR) method will be applied. This method will estimate the systems of equations 1, 2.1, and 2.2 jointly, providing more efficient estimates than OLS (residuals of the equations are correlated). The output and input prices are considered exogenous as is common in the study of public utility (Fabbri & Fraquelli, 2000).

Generalised Least Square (GLS) estimators will be produced as a robustness test, corrected for heteroscedasticity and autocorrelation of first order among ν_{it} (Greene, 2018). Moreover, a hedonic Cobb-Douglas cost function functional form will be performed along.

[4] The monotony and concavity are tested after the estimation of costs, controlling that the Hessian matrix is a negative semi-definite matrix and marginal costs are positive.

[5] It states that the cost-minimizing share of any input in total costs is the partial derivative of the cost function concerning the input price producing the respective input demand function.

4.3 Cost economies

After the estimation of equations 1, 2.1, and 2.2, the economies of output density, customer density, and economies of scale are evaluated. Economies of output density *(EOD)* measure the variance of costs with the increasing of output, keeping fixed the rest of the variables (input prices, load factor, the number of served customers, and the network length):

$$EOD = \frac{1}{\frac{\partial WVC}{\partial Y_{prod}}} = \frac{1}{\varepsilon_{WVC, Y_{prod}}}, \quad (3)$$

where EOD is for the economies of production density, WVC is the water variable cost, Y_{prod} is the volume of water produced, and $\varepsilon_{WVC, Y_{prod}}$ is the cost elasticity of the output. There are economies of output density if EOD is greater than 1, otherwise, there are EOD diseconomies. In terms of WUs, EOD exists if the operational average cost decreases as the volume of water produced increases, while the number of served customers and the served size area remain fixed. As an indicator is relevant for the decision of whether local monopoly or competition is the most efficient form in the water production and distribution sector.

When considering also the customers along with the increasing output (keeping fixed the rest of the variables such as input prices, load factor, and the network length), the economies of customer density *(ECD)* can be quantified as follows:

$$ECD = \frac{1}{\frac{\partial WVC}{\partial Y_{prod}} + \frac{\partial WVC}{\partial cust}} = \frac{1}{\varepsilon_{WVC, Y_{prod}, cust}}, \quad (4)$$

where ECD is for economies of customer density, WVC is the water variable cost, Y_{prod} is the volume of water produced, $cust$ is the number of served customers, and $\varepsilon_{WVC, Y_{prod}, cust}$ is the cost elasticity of the output and customers served. There are economies of consumer density if ECD is greater than 1, otherwise, there are not. This indicator is important when analyzing the service cost for an area of service that becomes more densely populated.

Lastly, economies to scale *(ES)* measures the variability of the costs after a simultaneous increase in output, customers, and network length (holding fixed the rest of the variables such as input prices and load factor) as follows:

$$ES = \frac{1}{\frac{\partial WVC}{\partial Y_{prod}} + \frac{\partial WVC}{\partial cust} + \frac{\partial WVC}{\partial length}} = \frac{1}{\varepsilon_{WVC, Y_{prod}, cust, length}}, \quad (5)$$

where ES is the return to scale, WVC is the water variable cost, Y_{prod} is the volume of water produced, $cust$ is the number of served customers, $length$ is the network length of the WUs, $\varepsilon_{WVC,\,length}$ is the cost elasticity of the network length, and $\varepsilon_{WVC,\,Y_{prod},\,cust}$ is the cost elasticity of the output, customers served, and network length. There are economies of scale if ES is greater than 1, otherwise there are diseconomies of scale. ES gives very important information about the market structure of the water sector in terms of the concentration level of WUs or for analysing the impact on costs of merging two near WUs.

5 Results

5.1 Empirical results

Table 2 reports only the first-order coefficients. Since expressed in natural logs, can be interpreted as cost elasticities for each variable.

The high value of R^2 shows a good fit for estimating the translog model. The coefficient of the output, labour and energy price, and the number of customers served are statistically significant respectively for 1%, 1%, 5%, and 10% and have the expected sign. The capital stock, proxied by the network length, as suggested by the theory, has a negative impact on variable costs, even though the coefficient resulted statistically not significant. Also, the load factor resulted in the expected sign, although not significant. The higher the losses, the higher the variable costs (statistically significant at 1%). This means that WUs can invest in increasing the infrastructure quality, minimising the network losses, and benefiting in terms of variable costs from the increased quality of the distribution infrastructure. The time trend coefficient resulted in a negative sign, meaning that there is a decreasing tendency of the WUs variable costs in time, even though not statistically significant. Finally, as expected, the system type variable coefficient is negative and significant at 1%, confirming that the WUs whose activity is based on the gravitational water production and distribution system, are profiting in terms of variable costs since they are using less electricity input in the process (around 40% less compared to WUs that are using pumping water production and distribution system).

Table 2 – Parameter estimates of the translog variable cost function

Variable	Parameter	SUR -Coefficient	Robust SD Error
Constant	α_0	5.814	50.614
Output	$\beta_{y_{prod}}$	4.796 (***)	1.278
Labor price	β_{w_L}	1.402 (***)	0.233
Energy price	β_{w_E}	0.479 (**)	0.222
Material price	β_{w_M}	-	-
Network length	β_{length}	-0.877	0.648
Customers	β_{cust}	2.063 (*)	1.213
Network losses	$\beta_{y_{loss}}$	0.390 (***)	24.307
Load	β_{load}	8.217	23.2
System type	$\beta_{systype}$	-0.405 (***)	0.049
Time trend	α_t	-0.004	0.009
R^2		0.955	
Observations		321	

Note: ***p<0.01, **p<0.05, *p<0.l.

Source: Author's elaboration

5.2 Robustness tests

The first robustness check is the evaluation of the same system of equations (1, 2.1, 2.2) using the Random Effects (Generalised Least Squares – GLS) procedure. The results are summarized in Table 3.

They are relatively consistent with the ones in Table 2 and the signs of the coefficient are as expected (except for the customers and load factor coefficients that resulted surprisingly negative). Moreover, as expected, the network length coefficient, used as a proxy for the fixed capital of WUs, resulted significantly at 10%.

Table 4 summarizes the results for the Cobb-Douglas costs functional form.

The signs of the estimated coefficient are as expected, while fewer variables resulted significantly compared to the scenario of the translog cost function (Table 2). Moreover, for comparability of the results, it was used a hedonic Cobb-Douglas version, including also the environmental and technical variables as in the translog cost function, confirming that the latter was the appropriate choice to model the variable cost function for the Albanian WUs.

Table 3 – Parameter estimates of the translog variable cost function with the GLS method

Variable	Parameter	SUR -Coefficient	Robust SD Error
Constant	α_0	-18.709	41.076
Output	$\beta_{y_{prod}}$	6.509 (***)	1.225
Labor price	β_{w_L}	1.243 (***)	0.168
Energy price	β_{w_E}	0.444 (**)	0.212
Material price	β_{w_M}	-	-
Network length	β_{length}	-1.019 (*)	0.568
Customers	β_{cust}	-3.820 (***)	1.239
Network losses	$\beta_{y_{loss}}$	-13.879	19.404
Load	β_{load}	-4.884	18.839
System type	$\beta_{systype}$	-0.475 (***)	0.056
Time trend	α_t	0.008	0.008
Observations		320	

Note: ***p<0.01, **p<0.05, *p<0.l.

Source: Author's elaboration

Table 4 – Parameter estimates of the Cobb-Douglas variable cost function with the RE method

Variable	Parameter	SUR -Coefficient	Robust SD Error
Constant	α_0	-0.793	0.653
Output	$\beta_{y_{prod}}$	0.534 (***)	0.130
Labor price	β_{w_L}	0.946 (***)	0.038
Energy price	β_{w_E}	0.033	0.037
Material price	β_{w_M}	-	-
Network length	β_{length}	0.104	0.071
Customers	β_{cust}	0.248 (**)	0.108
Network losses	$\beta_{y_{loss}}$	0.095	0.174
Load	β_{load}	0.199	0.215
System type	$\beta_{systype}$	-0.419 (***)	0.119
Time trend	α_t	-0.015	0.009

Note: ***p<0.01, **p<0.05, *p<0.l.

Source: Author's elaboration

5.3 Cost economies results

Table 5 presents the results for cost elasticities to output, output, and customers and output, customers, and network length simultaneously, the respectively EOD, EOC, ES, and marginal costs. What emerged is that there is the presence of diseconomies of output density, diseconomies of customer density, and diseconomies of scale (the respective indicators are less than 1) when cost elasticities are estimated at the sample mean.

Diseconomies of output density occur when an increase in the volume of water produced leads to a more than proportional increase in costs (the WU produces more water and becomes less efficient). The presence of diseconomies of output density Albanian water sector suggests that expanding water production leads to rising costs rather than cost savings. This could be due to limitations in infrastructure (e.g., water treatment plants or pipelines), inefficiencies in resource management, or the use of more expensive sources of water as output increases. WUs might struggle to meet higher demand without driving up costs, which could result in higher prices for consumers or financial strain on the WUs.

Table 5 – Cost elasticities and economies, and marginal costs for translog variable cost function

$\varepsilon_{WVC,Y_{prod}}$	**EOD**	$\varepsilon_{WVC,Y_{prod},cust}$	**EOC**	$\varepsilon_{WVC,Y_{prod},cust,length}$	**ES**	**MC**
4.787 (***)	0.209	2.358 (***)	0.424	1.368 (***)	0.731	61.619 (***)
(1.277)		(0.667)		(0.525)		(16.442)

Note: ***p<0.01, **p<0.05, *p<0.l.
The Delta method was used to calculate the standard errors (in parenthesis).
They are calculated at the sample mean.

Source: Author's Elaboration

Diseconomies of customer density occur when increasing the number of customers served leads to a disproportionate rise in costs. This means that serving additional customers, particularly in low-density rural areas or challenging terrain, raises costs per customer rather than reducing them. This can happen: (i) in geographically dispersed or challenging-to-serve areas, and (ii) in rural ones: serving rural areas often comes with higher costs due to lower population densities, meaning that fixed costs (e.g., building and maintaining water lines) are spread over fewer customers, raising the average cost per customer; and due to (iii) the network strain: the existing network infrastructure might be insufficient to handle the increasing number of customers, leading to higher maintenance costs, network bottlenecks, and water losses. This is an indicator that the infrastructure of the Albanian water sector is not well-suited to

handling additional connections efficiently, possibly leading to increased operational and maintenance expenses. This could be a sign that expanding service areas without upgrading infrastructure or improving operational efficiency may be unsustainable.

Diseconomies of scale occur when an increase in the scale of the water utility (i.e., expanding the service area or increasing output and customer base) increases the average cost of providing services. This means that as the utility increases in size (in terms of both output and customer base), its cost per unit of service rises rather than falls. For the Albanian water sector, this suggests that WUs are becoming less efficient as they scale up. Larger water utilities might face higher management and coordination costs, more complex logistical challenges, or increased infrastructure strain, all of which contribute to rising costs. This could indicate a need for decentralisation, operational improvements, or targeted investments in infrastructure to achieve better cost-efficiency.

6 Conclusions

Albania is a Southern European country, situated in the Western part of the Balkan peninsula, favoured by rich natural water resources per capita. Speaking in terms of water supply coverage and duration, operating WUs do not cover with service all the population and the duration of service is not 24 hours per day. These facts tell about a very challenged water sector in Albania, with 57 operators struggling to survive financially.

The focus of this study is to explore the situation of the water sector in Albania. For all the operating WUs financial and economic data was collected for the period from 2008 to 2015 and elaborated in terms of modelling the cost structure of them, using it to trace the presence of economies of output density, consumer density, and scale. The approach used was a hedonic one, including also technical and environmental variables along with output and input price variables.

The analysis of Albania's water supply sector reveals significant inefficiencies in operational performance, most notably reflected in the presence of diseconomies of output density, customer density, and scale. These inefficiencies point to critical structural and operational challenges within Albania's Water Utilities (WUs). Despite an increase in the customer base and the volume of water produced, the expected cost reductions have not materialised. In contrast, expanding operations often lead to higher operational costs, suggesting that the current infrastructure is incapable of efficiently handling a rise in water demand. This limitation is particularly concerning given the projected increases in water demand driven by population growth, urbanisation, and industrial activities.

Addressing diseconomies of scale and density. The diseconomies of output density indicate that as water production increases, WUs incur disproportionately higher costs, leading to inefficiency. Several factors influence these dynamics: aging infrastructure (i.e., it cannot support the increased output due to the increased demand), and the customer base geographical distribution (especially in rural areas). Trying to reach low densely populated or remote areas requires major infrastructure investments, not expected to scale efficiently (serving a small number of customers). This scenario will probably increase the cost per unit of service, putting another challenge on the financial viability of WUs. These findings highlight the need for policymakers to focus and prioritise firstly the improving of the existing infrastructure efficiency and then to plan about expanding capacity. A potential, worth-to-be-considered solution is to encourage urban densification. By promoting higher population densities in urban areas, WUs can benefit from more concentrated service areas, where the cost of infrastructure can be spread over a larger customer base. This would reduce the per capita cost of service provision, helping to mitigate the diseconomies of scale and density. Rural areas from the other side, can be the object of targeted water conservation initiatives and local water management solutions such as promoting rainwater harvesting or decentralized water treatment systems. These activities could reduce the investments for infrastructure expansion while helping rural communities meet their water needs more efficiently.

Existing infrastructure modernisation and new investments. The traced inefficiency in Albania's water sector is further worsened by the outdated infrastructure. With an average water loss rate of 63.7% across operators (high levels of non-revenue water), a considerable proportion of the produced output is lost due to leaks, illegal connections, and other forms of wastage. This represents a substantial financial burden, as these losses increase operational costs without generating corresponding revenue. To address this, infrastructure modernization should be a top priority for both policymakers and WUs. Investments should focus on the following areas:

- *Improving distribution networks*. The aging and poorly maintained distribution networks are the main source of water losses. Investments oriented towards leak detection technologies, inefficient (energy-intensive) pipe replacement programs, and qualitative maintenance practices can be some needed interventions. The results are an improved short-run operational efficiency (less non-revenue water that is a burden to the WUs' budget) but also more improved quality of water services, contributing significantly to the long-term financial sustainability.
- *Increasing the degree of the sector formalising*. The phenomenon of illegal connections and unmetered water connections (they are recognised in the network, but do not have a meter, paying in this way not based on the consumption, but a flat tariff) contribute significantly to non-revenue water levels. The installation of water meters for all connections can reduce illegal

water consumption. Policymakers should be supportive of this by creating incentives for households to legalize their connections (subsidies or payment plans for low-income and marginalised households).

- *Adopting leak detection technologies*. To improve system efficiency and to minimise water losses, modern leak detection technologies can be implemented identifying leaks in the distribution network more quickly, lowering the time of response and improving the overall system efficiency. To consider that these technologies are suggested to be an organic part of the maintenance practices to detect leaks, interventions need to take place, before they lead to significant water loss.

Considering and prioritising the infrastructure challenges, it can be feasible for Albania's WUs to reduce operational costs, improve service delivery, and at the same time enhance financial sustainability. Note that this is translated into some important investment, from government authorities or potentially from private sector partnerships. Exploring several financing options, such as international development grants, public-private partnerships (PPPs), or concessional loans should be considered by policymakers to fund these critical infrastructure projects.

Labour costs and workforce efficiency. Another critical finding from the analysis is the impact of labour costs on operational efficiency. In the Albanian water sector, labour costs have a higher impact on total costs compared to energy prices, which is somewhat expected given the sector's overstaffing issues. WUs often employ more staff than necessary, which drives up operational costs without corresponding increases in efficiency. This overstaffing issue is compounded by the fact that many processes within the WUs are manual or require significant human intervention, further inflating labour costs. To address this important problem, policymakers should encourage the adoption of operational automation and digitalization from WUs. Routine tasks, (e.g., meter reading, billing, and maintenance scheduling) could be perfectly automated and in turn, reduce the excessive staff, improving also the accuracy and efficiency. Moreover, training of the workforce and capacity-building are tools to be considered in the transition to more technical and specialised roles of the staff. In cost terms, by improving staff efficiency indicators through automation, each WUs can reduce manual labour reliance, achieving more sustainable operational models.

Regionalisation and decentralisation of water services. From the findings of this work, it emerged the presence of diseconomies of scale in larger water utilities suggests that these utilities face operational challenges related to resource management and coordination. Aiming to expand their service areas and customer bases, WUs face increased complexity in infrastructure and human resources management, and operational financial aspects administration, leading to inefficiencies (as the customer base increases, the operational costs increase also). One form to address this issue policymakers could

be water services regionalisation (smaller, more manageable utilities are created to serve specific areas) leading to the reduction of the operational complexity faced by larger utilities while meeting the unique needs of each region. This fact, in terms of governance, would require localised governance of water services, so the response to local challenges would be faster providing more tailored solutions to be implemented. Decentralisation should be seen also in the decision-making process of local authorities (or smaller utility entities), leading to greater accountability (local managers can be more directly accountable to the communities they serve). There is an issue that should be considered, the careful planning of regionalisation and decentralisation, meaning that WUs should preserve their financial and operational capacity to meet their obligations. regional water management boards or cooperatives can be created by the policymakers to ensure the technical support and financial resources for all WUs to operate efficiently.

Summarising, several policy recommendations for sustainable water services can be formulated:

- incentivising urban densification (i.e., it can be achieved a reduced per capita cost of water service provision in highly dense urban areas, mitigating the presence of diseconomies of scale and density);
- promoting water conservation practices in rural areas (e.g., rainwater harvesting and decentralised water treatment systems initiatives can reduce the need for costly investments in low dense and difficult to be reached rural areas);
- infrastructure investments (distribution networks should be prioritised to be upgraded with the installation of leak detection technologies in order to reduce non-revenue water level and improve WUs financial and operational stability and sustainability;
- the implementation of processes automatisation and digitalisation to reduce labour costs and improve operational efficiency along with labour force training;
- regionalisation and decentralisation (the creation of smaller, more manageable WUs with decentralised decision-making for higher responsiveness and accountability;
- alternative financing mechanisms (public-private partnerships (PPPs), international development grants, or concessional loans could support several costly infrastructure investments).

By implementing these recommendations, Albania can create a more sustainable, efficient, and resilient water supply sector. Policymakers should act accordingly to address the critical inefficiencies identified in this study, ensuring that the country's water utilities are prepared to meet the growing demand for water services in the face of population growth, urbanization, and climate change. In the end, water is a human right and should be managed as a common god, not as a commodity, and the government authorities have the responsibility to explore additional ways to enhance the sustainability of water supply services in Albania.

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