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Footpaths to Sustainability: A Case Study from Maribor's High School

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Abstract

In response to societal and climatic changes, we present a unique approach at our high school (SGŠG Maribor), Slovenia. We recognize the need for adaptive knowledge and skills to navigate a sustainable future. As part of the national initiative 'Climate Goals and Contents in Education', our contribution elucidates the role of advanced technologies, digitalization, and sustainability principles in vocational education. The study highlights the experiences and skills gained through project-based learning with students, specifically through the Climate Goals and Content in Education (PCVIZ) project. We further illustrate the real-world application of these concepts through a current practical case: revitalizing the school atrium and applying green infrastructure principles. The revitalized atrium serves as a space for socialization, outdoor learning, and enhanced connection with nature for students and teachers. The value of this contribution lies in its demonstration of the practical application of theoretical concepts, innovative solutions to modern educational challenges, its focus on sustainability, and its interdisciplinary approach. This study catalyzes further discourse on the role of sustainability in education.

Keywords: sustainability in education; climate change; green transition; project-based learning; green infrastructure

1. Introduction

In an era of rapid technological progress and growing awareness of sustainable development, education is key to successfully facing future challenges. Our paper focuses on the PCVIZ(Podnebni Cilji in Vsebine v Vzgoji in IZobraževanju - Climate goals and content in education) project implemented by the Secondary Construction School and Gymnasium (SGŠG), and how this educational institution adapts to the needs of the modern world.

PCVIZ is an innovative project that combines advanced technology and sustainable development in construction education. This approach, which includes sports and cultural activities, interdisciplinarity and a green transition, has proven to be effective in preparing students for the challenges of the future.

As part of the PCVIZ project, a large-scale revitalization of the school atrium is also being carried out. Its redesigned design will include greening of horizontal and vertical surfaces, the installation of eco-friendly outdoor furniture and the inclusion of a water feature, creating a space for socializing, learning and relaxing for everyone in the school. This design emphasizes the necessity of connecting sustainable development with the educational process.

With an emphasis on practical training for a circular economy and by showing the active role of schools in solving environmental problems, our contribution represents a valuable insight into the possibilities and potential brought by the intertwining of people, technology and environmental awareness in education.

Figure 1 Poster promoting project on our school (own source: TPN)

2. PCVIZ project

As a pilot school, our institution, Secondary Construction School and Gymnasium Maribor (SGŠG Maribor), participates in the PCVIZ project (Climate Goals and Content in Education). We recognize that the world around us is changing rapidly. We are facing environmental and climate challenges, and everyone is learning how to live more sustainably. Each step taken by each individual contributes towards a better collective life in a sustainable community. Let's preserve our environment today for a better tomorrow. Let's collaborate!

The beginning of the school year brought events that encourage us to walk the path of sustainability towards the future: Erasmus: Bridges Connect Us, Sustainable Mobility, the visit of Prof. Dr. Ana Vovk, expert excursions, the use of renewable resources, waste separation, and the election of class ambassadors.

Our participation in the PCVIZ project emphasizes the imperative of addressing climate and environmental issues in the context of education. The project, integrating Climate Goals and Content into Education, is a pathbreaking venture that involves multiple schools, such as ours, as key participants. This initiative has helped us pivot our educational and organizational approach to one that actively acknowledges the urgency of climate change and sustainability.

Figure 2 One of the first more visible measures - separate collection of waste (own source: TPN)

We firmly believe that education is the gateway to instigate meaningful changes in our societal behaviors and attitudes towards our environment. Therefore, the PCVIZ project's focus lies not only in including the climate goals and sustainability concepts in our curriculum but also in creating a school environment that emulates these principles.

At the onset of this academic year, we organized a series of events, each carefully curated to reflect the ethos of sustainability and our commitment to the PCVIZ project. One such event was "Erasmus: Bridges Connect Us," fostering international collaboration and shared learning. "Sustainable Mobility," another event, demonstrated the potential of greener and more sustainable transportation alternatives, inculcating the practicality of sustainable choices in our students.

We were also delighted to host Prof. Dr. Ana Vovk, whose insightful discourse further enriched our students' understanding of environmental challenges and potential solutions. Expert excursions provided hands-on exposure to the real-world application of

sustainable practices. Our school has also initiated measures like the use of renewable resources and waste separation, further instilling the principles of sustainability among the students.

A crucial part of our journey towards sustainability has been empowering students to take on leadership roles. This year, we have been electing class ambassadors, whose primary role is to spearhead sustainable practices within their respective classes. This approach fosters a sense of ownership and responsibility towards our shared environment, thereby making sustainability a collective endeavor.

In conclusion, our active involvement in the PCVIZ project symbolizes our commitment to sustainability and our dedication to instilling these principles in the future generations. It is a journey of collective learning and adaptation, taking one step at a time towards a more sustainable future.

Figure 3 Prof. ddr. Ana Vovk lecture about sustainable life (own source: TPN)

3. Revitalization of our school atrium

In the context of the PCVIZ project, a significant undertaking has been the extensive revitalization of our school atrium. Initially, the school atrium was a harsh concrete space with little respite from the heat. With the intention to transform it into a pleasant and inviting green space conducive to the socializing of students, we embarked on an ambitious project to reimagine the atrium.

Figure 4 Student competition poster for the school atrium (own source: TPN)

In line with our objective of instilling the principles of sustainable development into our education process, we initiated an open call for designs. The aim was to invite students to propose ideas to convert this concrete expanse into a sustainable and comfortable space for socialization, learning, and relaxation. The invitation was extended to all students, nurturing an environment of inclusivity and creativity. This student-led initiative created a platform for them to explore their imagination and ideas, applying theoretical knowledge in a real-life situation.

To further enrich the students' ideas, we organized lectures by external specialists. These experts in the field of sustainable architecture and design provided insightful guidance to the students, broadening their understanding of green design principles, ecological considerations, and practical feasibility. These interactions offered students a more in-depth understanding of the challenges and opportunities of sustainable design, empowering them to propose innovative, practical, and sustainable solutions.

Figure 5 Lecture of M.Sc. Niko Stare, a leading landscape architect in Maribor (own source: TPN)

Once all the proposals were submitted, the designs were evaluated based on their creativity, sustainability, and practicality. The winning design was selected, combining the best of innovative thinking, practicality, and above all, sustainability. It proposed a complete transformation of the atrium, integrating greenery in horizontal and vertical spaces, adding ecological outdoor furniture, and including a water feature. The implementation of these elements would create a harmonious balance between nature and the built environment, fostering a calm and nurturing space for all within the school.

Figure 6 Workshop after the lecture (own source: TPN)

Implementing the winning design was a significant endeavor, and we encouraged the active participation of students in bringing the design to life. This project saw a massive mobilization of students, working collectively in implementing the design. This active involvement allowed students to witness first-hand the transformation of their idea into reality, providing them with an invaluable learning experience. It fostered a sense of ownership and achievement among the students, nurturing their interest and commitment towards sustainable practices.

Figure 7 A lecture on green infrastructure by dr. Nataša Atansova from University of Ljubljana (own source: TPN)

The project's progress has been remarkable, and the transformations are evident. The concrete has given way to green landscapes, the ecological outdoor furniture has started taking shape, and the water feature is in the making. As each component comes together, the vision of a green, inviting, and sustainable atrium is gradually taking form.

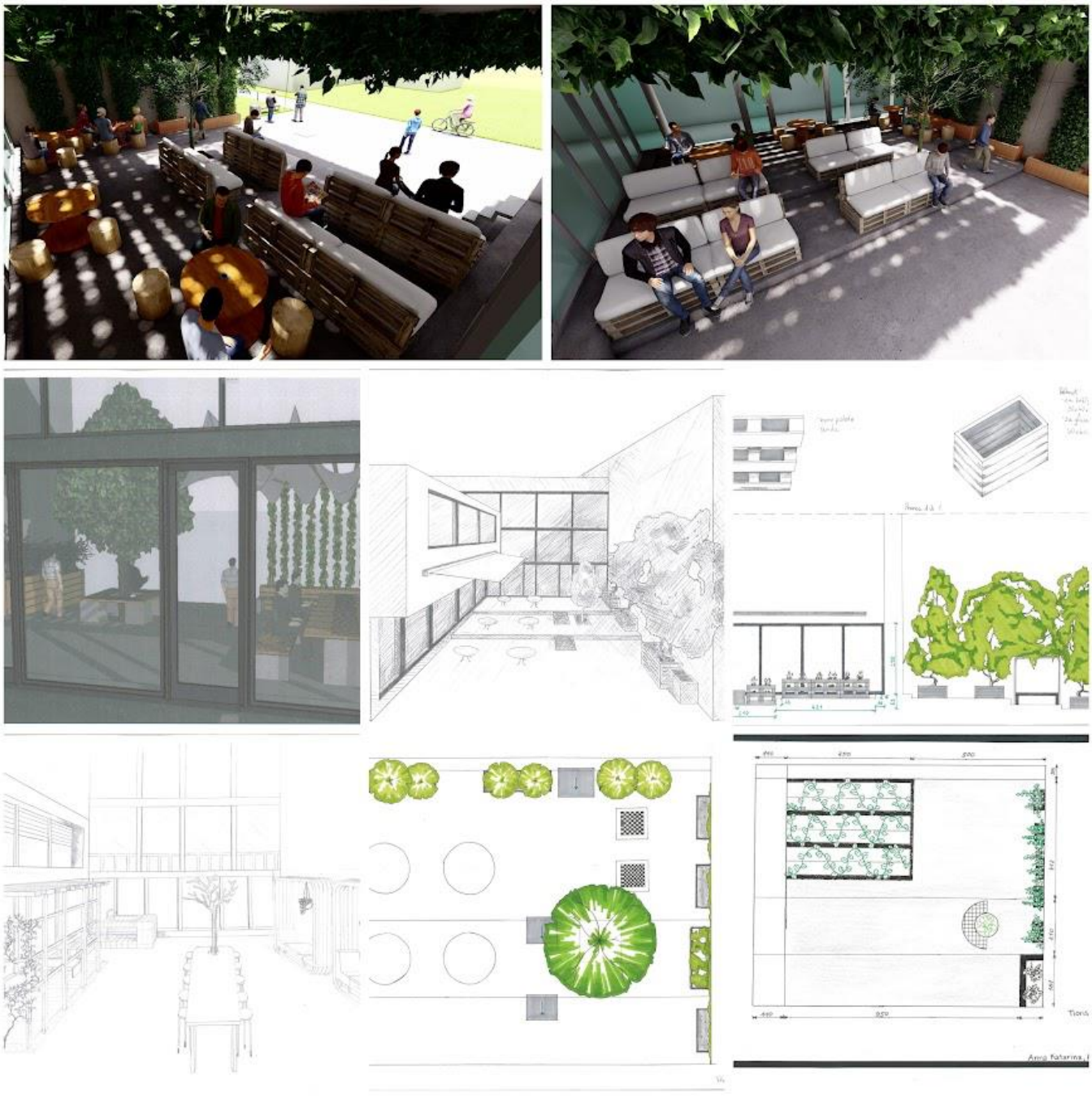

Figure 8 Exhibition of the *Students solutions (own source: TPN)*

This project has been more than just a transformation of a physical space; it has been a transformation in the way we think, learn, and act towards our environment. It has created an experiential learning opportunity for our students, giving them practical exposure to the concepts of sustainability. It has encouraged a sense of responsibility towards the environment, demonstrating that sustainable practices are not just theoretical concepts, but actionable steps that can be incorporated into our daily lives.

Figure 9 Work in progress – realization of the project *(own source: TPN)*

4. Conclusions

The revitalization of the school atrium has been a transformative journey, one that has been a testament to the spirit of collaboration, creativity, and most importantly, our unwavering commitment towards sustainability. The PCVIZ project has been a keystone in this journey, providing the necessary impetus and a framework that has guided our efforts. The results have been rewarding, but we understand that this is merely the beginning. We are excited about the future and look forward to continuing to take steps towards fostering an increasingly sustainable school environment, and ultimately, contributing to a sustainable future.

In conclusion, the transformation of our school atrium is a practical demonstration of how the principles of sustainable development can be seamlessly integrated into educational environments. This endeavor goes beyond creating aesthetically pleasing spaces. It exemplifies the potential for learning environments to become experiential spaces where concepts such as sustainability are not merely theoretical constructs discussed within the four walls of a classroom, but can be experienced, practiced, and appreciated by students in their everyday school life.

This project is not an end in itself but a strong embodiment of our commitment to shaping the educational process in a way that is conscious of the environmental challenges that we face today. Our aim is to create a learning environment that goes beyond just

imparting knowledge. Instead, we seek to shape future citizens who not only value sustainability but who actively practice and promote sustainable behaviors.

Through this project, and others like it, we aim to demonstrate the significant role that educational institutions can play as agents of change. Schools can lead the way in promoting sustainable practices and lifestyles, creating ripple effects that can reach far beyond the confines of the school environment. By embedding sustainability in the educational experience, we can ensure that the future generations are well equipped to take on the mantle of environmental stewardship, making a positive impact in their communities and in the world.

In essence, the revitalization of our school atrium is a reflection of our larger goal: to intertwine education and sustainability, creating a learning environment that motivates and prepares our students to contribute positively to a sustainable future.

Analysis of the accounting law of non-profit organizations in Republic of North Macedonia-Challenges and Recommendations

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Abstract

Non-profit organizations are obliged to keep accounts, compile and submit accounting statements in accordance with the law and accepted accounting principles, accounting practices and accounting standards. The main aim is to create accurate, reliable and up-to-date statements of balance positions, both the assets and liabilities, sources of funds, income and expenses and the results of operations. The law on accounting of non-profit organizations regulates the keeping of accounts, business books, accounting documents and data processing, recognition of income and expenses, assessment of balance sheet positions, submission of financial statements and other issues related to accounting. Additionally, non-profit organizations are obliged to keep accounting according to the system of double-entry accounting and according to the schedule of accounts from the accounting plan for non-profit organizations. The law on accounting of non-profit organizations prescribes the accounting principles and rules, as well as the content of the basic financial information that is disclosed by civil organizations to interested parties. The purpose of this paper is the analysis of the law on accounting of non-profit organizations. In addition to the legal framework, this analysis also includes research through the form of a survey questionnaire as well as direct interviews with relevant representatives regarding the application of the law. The analysis provides a detailed overview of the current legal regulations, as well as recommendations for their revision. The subject of the paper is the management of accounting, business books, accounting documents and data processing, financial statements, as well as other issues related to the accounting of non-profit organizations.

Keywords: accounting, law, non-profit, principles, financial information.

1. Introduction

Nonprofit organizations (NPO) are very important part of any country. They help with the development of societies and are also very beneficial for the governments. In this context, nonprofit organizations can be defined as organizations that provide assistance to individuals or groups, rather than focusing on obtaining financial gains for them. In addition, the main difference with commercial organizations is the fact that commercial organizations are aiming their work towards achieving business profits, while NPOs strive towards providing public benefits (Jin, 2010). Moreover, when it comes to accounting procedures that NPOs use, there are also some differences with the commercial organizations. The law on accounting of non-profit organizations prescribes the accounting principles and rules, as well as the content of the basic financial information that is disclosed by civil organizations to interested parties. The law regulates the legal framework on the basis of which it is reported to the competent state authorities. Considering that the law has been in operation for 15 years, there is a need to analyze whether the existing legal solutions are the most appropriate according to the functions and development of the non-profit sector to date. In addition, in the previous period since the application of the law, various criticisms could often be heard, primarily from the people themselves, regarding whether the law fulfills its function, but somehow it could not be materialized into concrete points, which are the points that should be addressed for improvement. In this context, Non-profit organizations are obliged to keep accounts and compile and submit accounting statements in accordance to the law. The aim is to provide accurate, comprehensive and up-to-date statements of their balance sheet positions, their sources of funds and their income and expenses. However, designing a system of comprehensive financial reporting is a challenge precisely because of the specifics of the non-profit sector. A basic characteristic in the operation of non-profit organizations is the achievement of goals of wider social interest. The activities of the non-profit sector complement or are related to the operations of the business community, public institutions, and state authorities. Hence, the legal framework, and in particular the Law on Accounting of nonprofit organizations, should enable the correct addressing of these issues to the greatest extent possible, i.e. the standard forms of financial reporting and an accounting system based on the principles of the Law, should together provide quality financial information for the presentation to financiers. On the other hand, it is necessary to complement the financial reporting with a narrative part precisely because the results of the operation of non-profit organizations often cannot be quantitatively measured. However, it is also worth mentioning that non-profit organizations are very important for creating sustainable society. In addition, thanks to the public initiative, in most of the developed countries, the importance of non-profit organizations has increased. Hence, in order to understand the origins of the non-profit organizations, seeral theories have to be understood, such as: *Theory of*

public goods, contract failure theory, welfare state theory, interdependence theory and social origins theory (Bartosova and Podhorska, 2021). Undoubtedly, NPOs are very important part for every society, but, their accounting procedures are very important part in their further development. In this context, the aim of this paper is to analyze the accounting of NPOs in N. Macedonia.

2. Defining the permanent legal framework

Legal framework refers to the set of legal documents that define the rules, rights, obligations and responsibilities of companies, government and citizens in one country (NSGI, 2015). Therefore, the law on the accounting of non-profit organizations together with the by-laws is part of the legal framework that regulates the non-profit sector in the broadest sense, here the most significant include:
1) Law on associations and foundations;
2) Law on the Red Cross of the Republic of Macedonia;
3) Law on political parties;
4) Law on financing of political parties; and
5) Law on the legal status of a church, religious community and religious group.
The Law on Accounting of Non-Profit Organizations (hereinafter referred to as the Law) was adopted in 2003, which introduced a legal framework and minimum requirements for accounting, financial reporting and administration of documentation by non-profit organizations. In accordance with the Law, by-laws have also been adopted. Later, with the changes to the Law in 2011 and 2015, only the section on fines, misdemeanor provisions and the threshold for recognition of fixed assets was added, while the essential definitions and provisions that regulate the accounting operations remain unchanged to this day. The basic legal framework defines the types of entities that are subject to accounting and financial reporting based on the Law. Furthermore, the Law prescribes provisions for keeping accounting, business books, accounting documents and data processing, recognition of income and expenses, assessment of balance sheet positions, revaluation, mandatory financial reports and deadlines for submission to competent institutions (Law on accounting for non-profit organizations published in the Official Gazette of the Republic of North Macedonia, no. 24/2003; 154/2015)

3. Application of the accounting law to non-profit organizations

Legal entities of a non-profit nature that are established to carry out wider economic, social, cultural, scientific, humanitarian, educational, sports and other purposes, are obliged to keep accounts according to the Law. This includes the following forms of organization:
• Economic interest community;
• Associations of citizens, foundations and other forms of association;
• Political parties;
• Religious communities;
• Religious and other groups;
• The Red Cross of the Republic of Macedonia;
• Associations of foreigners;
• Foreign and international non-governmental organizations;
• Humanitarian organizations and associations
• Trade unions, and
• Other legal entities established by special regulations from which it follows that they are non-profit organizations.
The provisions of the Law on financial reporting, administration of documentation and way of keeping accounting are uniformly applied to all entities, regardless of the nature of their activities and the volume of financing. Also, there is no division in terms of the mission and the goals for which the organizations were formed. It can be said that the Law on the Accounting of Non-Profit Organizations represents a basic law in the legal framework that regulates the non-profit sector. The law regulates matter that should enable documentation, accuracy and quality of financial information. The financial information obtained on the basis of the accounting entries is further used for the purposes of additional reporting based on special laws and control by state institutions and regulatory bodies. However, the Law on Accounting of Non-Profit Organizations is part of the wider legal framework, that is, a set of Laws that complement each other and together regulate the operation of the non-profit sector. So there are certain issues that are related to accounting work, and are defined by laws that govern certain types of organizations, that is, entities (Law on accounting for non-profit organizations published in the Official Gazette of the Republic of North Macedonia, no. 24/2003; 154/2015).

The broader legal framework prescribes additional reports and disclosure of data by certain types of non-profit organizations under a separate law. In addition, a special law regulates the tax incentives for donations and sponsorships in public activities, the criteria for using them and the inspection control and supervision. For example, the Law on financing of political parties provides for a separate annual report of the political party as a supplement to the standard package of financial reports prescribed by the Law on the accounting of non-profit organizations. The special annual financial report enables a more detailed and analytical presentation of income and expenses by type, with the aim of enabling more transparency and accountability. Furthermore, for political parties, an additional notification is prescribed, which includes a specification of the income and expenses of a transaction account from an election campaign, as well as a notification of the costs of renting advertising space in an election campaign. Also, associations and

foundations that have acquired the status of public interest, according to the Law on Associations and Foundations, have special obligations for financial reporting. The organization with the status of public interest is obliged to submit a business and financial report on its work to the Government of the Republic of N.Macedonia once a year. The special notification of the Associations and foundations of public interest includes a section on the Business operations of the year, where information regarding the activity, the level of activity, the organizational structure, human resources, the mission and activities of the organization, the available budget, transparency and accountability are disclosed in a narrative manner.
The second part refers to financial operations, where, similarly to the case of political parties, associations and foundations of public interest require a detailed and analytical presentation of expenses and income by type. In the area of controls, special powers are given to the Public Revenue Administration (PRA) in case of using tax incentives from a given donation or sponsorship in accordance with the Law on Donations and Sponsorships in Public Activities. Here the IRS and other competent authorities control the giving, receiving and use of the donation and sponsorship in cases of application of tax incentives. If the IRS or another competent authority determines irregularities and abuses in the use of the donation and sponsorship, it may file a misdemeanor or criminal report.
Of essential importance for tax controls is the accounting record of all events that cause a financial effect on the non-profit organization, the documentation of transactions and the confidentiality of the accounting information system. All these aspects are regulated by the Law on the accounting of non-profit organizations, which is the basis for the implementation of the provisions of other laws. All non-profit organizations are obliged to keep accounts according to the system of double-entry accounting in the manner prescribed by the law on the accounting of non-profit organizations and are obliged to compile basic financial statements, a balance sheet, a balance sheet of income and expenses and notes to the financial statements for the reporting period , i.e. calendar year. The only exception applies to "micro" non-profit organizations that have property or realize an annual income lower than EUR 2,500, these organizations are exempt from the obligation to keep the accounts according to the double-entry bookkeeping system and to prepare and submit financial reports for the year in question. Non-profit organizations that have an obligation for additional financial reporting pursuant to another Law (Political parties, associations and foundations with public interest status) report additionally based on that Law. There is equal application of the law for domestic and foreign non-profit organizations, whereby for the activities carried out on the territory of the Republic of Macedonia, foreign organizations register a legal entity or subsidiary (Law on accounting for non-profit organizations published in the Official Gazette of the Republic of North Macedonia, no. 24/2003; 154/2015).

In this part, the Law on the Accounting of Non-Profit Organizations is harmonized with the Law on Associations and Foundations, which also provides for equal rights during the registration and registration in the Central Register of the Republic of N. Macedonia of an association or foundation founded by domestic and foreign persons, without the existence of any restriction regarding of the nationality or geographical region they come from. Also, there is a specificity regarding the economic interest community which is regulated by the Law on Commercial Companies, whereby the Economic Interest Community (SIZ) can be formed by two or more natural and legal persons in order to facilitate and improve the performance of the commercial activities that constitute the subject of their operation and to increase or improve their result. The subject of the operation of the economic interest community can only be in relation to the commercial activities carried out by the members and can only be an aid to those activities. The SIZ does not make a profit for itself, but if a profit is made as a result of the operation, it is considered a profit of the members of the SIZ and is distributed among them according to the founding agreement or, if there is no agreement, it is divided into equal parts.
Furthermore, the Law on Commercial Companies provides provisions for keeping accounting, commercial books and administration of documentation for traders to whom the Law on Commercial Companies applies. According to the definition given in this Law, a merchant is any person who independently and permanently as an occupation carries out commercial activity for the purpose of making a profit through production, trade and providing services on the market. Since SIZ is primarily a foundation and works with a non-profit character, we believe that the Law on keeping the accounting of non-profit organizations would be applied here instead of the provisions that refer to the accounting operations of commercial companies (Law on accounting for non-profit organizations published in the Official Gazette of the Republic of North Macedonia, no. 24/2003; 154/2015).
In order not to create confusion in the practice resulting from the interaction between the two Laws, the law on commercial companies should be supplemented with a provision that stipulates that "The economic interest community keeps accounting and business books based on the Law on Accounting of Non-Profit Organizations". Although the economic community of interest among the wide group of non-profit organizations has the most pronounced profit component, provided for by the Law on Commercial Companies, the primary goal of establishment and operation should be taken into account, which is the promotion and affirmation of the activity of its members. This is a broader goal, which does not include the market performance of the economic interest community itself. While at the secondary level, the possibility of SIZ making a profit from certain activities is not excluded. What distinguishes the economic interest community from other associations and foundations is the possibility of distributing the realized profit between the members. The possibility of making a certain profit also exists with the rest of the associations and foundations, while the associations and foundations are also not established with the primary purpose of making a profit, but they can perform activities that will make them a certain profit, which must derive from the objectives of the operation determined by the statute of the organization and the profit to be used to achieve the goals determined by the statute of the organization. The profit achieved cannot be distributed among the founders, members, directors, employees or any other person related to them (Law on accounting for non-profit organizations published in the Official Gazette of the Republic of North Macedonia, no. 24/2003; 154/2015).

3.1 Administrative requirements prescribed by law for accounting of non-profit organizations

The administrative function in non-profit organizations largely depends on the nature of the activity as well as on the form of establishment. Unlike the business sector, in the non-profit sector the priority is usually the social component as well as the realization of the mission and the planned activities, so the results of the operation cannot be fully measured through financial indicators. Finance, administration, and accounting are often considered a secondary function, but nonprofit organizations certainly direct some of their resources to perform these functions. The accounting function should be at the level of the minimum requirements prescribed by the Law. Organizations may establish additional accounting and administrative procedures in order to ensure greater transparency and quality of financial information. This especially applies to non-profit organizations that are regulated by special laws and that are subject to additional financial reports (political parties and associations and foundations with public interest status). Undoubtedly, the accounting system of these organizations should enable additional analytics for the preparation of annual financial reports prescribed by a special law. The decision on how to organize and run the financial operation, including the administration and the accounting part, depends on the requirements of the interested parties, the main donors, the management, the scope of activities as well as the nature of the activity. The law establishes a unified framework in terms of keeping business books, documentation and data processing. Here, to a large extent, precise directions are given, but there are also parts that allow for some flexibility.

3.2 Accounting

The basic concept of double-entry accounting is also applied in the non-profit sector, which is a requirement that every transaction be recorded on at least two different accounts with an equal and opposite effect, that is, every accounting event is recorded on at least two accounts from the Chart of Accounts. For example, the payment of overhead expenses is reflected in the financial statements by decreasing the cash account (100) and increasing the expense account (401), inflows from membership fees cause an increase in the cash account (100) and a simultaneous increase in dues income on account (730) etc. Furthermore, it is prescribed that non-profit organizations keep accounting, compile and submit accounting statements in accordance with the Law on the accounting of non-profit organizations and with the accepted accounting principles, practice and accounting standards if they do not contradict the Law or another regulation, with the aim of accurate , a true, reliable, comprehensive, timely, up-to-date and individual statement of the balance sheet positions, the balance of assets, liabilities, sources of funds, income and expenses and results of operations. This broad definition makes it possible to additionally rely on the IFRS framework if accounting events arise in practice that are not specifically covered by the Law on Accounting of Non-Profit Organizations, especially IFRS for Small and Medium Enterprises, as long as a certain accounting treatment resulting from a reading of IFRS standards do not contradict the provisions of the Law on Accounting of Non-Profit Organizations and its by-laws Rulebook on accounting for non-profit organizations published in the Official Gazette of the Republic of Macedonia no. 42/2003....175/2011).

3.3 Business books, accounting documents and data processing

Non-profit organizations are obliged to keep business books in accordance with the provisions of this law, the accepted standard accounting practice and accounting standards. Uniform records and other forms of records are provided through the business books, which provide insights into the state and movements of assets, liabilities, sources of assets, income, expenses and the result of operations. Non-profit organizations keep records of income and expenses, prepare plans, reports and analyses. The data from the business books should enable the competent authorities to plan and execute the income, prepare and adopt the financial plans and for other purposes.

Non-profit organizations keep business books in the Macedonian language, with Arabic numerals and values expressed in Denars. If abbreviations, codes, signs or symbols are used, their meaning must be clearly explained. All data registered in business books and other reports must be complete and complete, timely, updated and presented chronologically, that is, accurately reflect the time sequence of their occurrence. Registered data in the business books must not be changed or supplemented in a way that will later make it impossible to determine the originally registered content.

Business books of non-profit organizations are: journal, general ledger and auxiliary books (analytical records). Mandatory auxiliary books are: book for the treasury, book for purchases, book (inventory) of capital assets-fixed assets, book of incoming accounts and book of outgoing accounts. In addition to business books, non-profit organizations can keep other auxiliary books (analytical records). The way of keeping business books of non-profit organizations depends on the technique of entering business changes, ie transactions. The technique of data entry and processing of business changes, i.e. transactions of non-profit organizations can be with the help of an electronic calculator, semi-automated data processing and manual data processing, observing the principles of proper accounting. Non-profit organizations are obliged, regardless of the way of keeping and keeping the books, to ensure their availability at all times, to keep and protect them within the period established for this, and must guarantee that they can be presented at any time . The Minister of Finance prescribes the form and manner of keeping the business books of non-profit organizations. Data entry in the business books of non-profit organizations must be based on reliable, true and orderly accounting documents. An accounting document is a written proof of the business change, that is, a transaction (Rulebook on the content of separate accounts in the accounting plan of non-profit organizations published in the Official Gazette of the Republic of Moldova no. 117/2005).

Furthermore, the recognition of income and expenses of non-profit organizations is carried out according to the accounting principle of modified occurrence of business changes, ie transactions. Revenues should be recognized in the accounting period in which they occurred according to the criterion of measurability and availability. Income is measurable when it can be expressed in value. Revenues are available when they are realized in the accounting period or within 30 days after the end of the accounting period, provided that the revenues refer to the accounting period and serve to cover the obligations of that accounting period. Expenses should be recognized in the accounting period in which they occurred or within 30 days after the end of the accounting period, provided that the obligation to pay arose in that accounting period. Materials inventory items are expensed at cost. The purchase price consists of the purchase price, increased by import duties, value added tax, transportation expenses and all other expenses that can be directly added to the purchase price, i.e. to the purchase costs, reduced by discounts and rebates.

3.4 Assessment of balance sheet positions, revaluation and inventory

Under the assessment of balance positions, in the sense of this law, it is understood the determination of the value of separate balance positions. Non-profit organizations are obliged to carry out the assessment of balance positions contained in the general ledger according to the accounting principle of modified occurrence of business changes, ie transactions. Long-term and short-term assets are stated at cost. The purchase value of long-term and short-term assets consists of the purchase price increased by import duties, value added tax, transportation expenses and all other expenses that can be directly added to the purchase value, that is, to the purchase costs. The cash in the treasury and in the accounts in domestic currency are entered in the general ledger in a nominal amount, and in foreign currency according to the rate of the National Bank of the Republic of Macedonia on the day of the balance. The balance sheet positions of receivables and payables are recognized according to the agreed amounts in the contract. Non-profit organizations are obliged to revalue long-term assets, in a manner prescribed by the Minister of Finance. Non-profit organizations are obliged at least once a year to reconcile the state of assets and their sources stated in the accounting with the actual state determined by an inventory on December 31, in a manner prescribed by the Minister of Finance.
Non-profit organizations are obliged to compile basic financial reports, namely: balance sheet, income and expenditure balance and notes to the financial statements. The balance sheet shows the balance of assets, liabilities and sources of funds as of a certain date. The income and expenditure balance sheet shows the income and expenditure, i.e. the surplus or deficit realized in the business year or in some other period during the business year. The notes to the financial statements represent a detailed elaboration and addition of the data from the balance sheet and from the income and expenditure balance sheet. Basic financial statements must provide an accurate, true, and complete overview of assets, liabilities, sources of funds, and income and expenses. Non-profit organizations whose total property value or annual income is less than 2,500 euros in Denar equivalents are not obliged to compile financial reports and submit them in accordance with the provisions of this law. Non-profit organizations are obliged to submit their annual accounts to the Public Revenue Administration and to the Register of Annual Accounts at the Central Registry by the end of February of the following year, that is, within 60 days from the date of the status change (Rulebook on the accounting plan and balance sheets of non-profit organizations published in the Official Gazette of the Republic of Moldova no. 08/09; 11/2006; 117/2005).

4. Empirical analysis

As part of the analysis, a sample of representatives of the non-profit sector was surveyed. Respondents expressed their views by answering a questionnaire. Respondents from 70 different organizations gave their comments on questions related to the practical application of the Law on Accounting of Non-Profit Organizations, identifying potential shortcomings. The structure of the sample is shown in the graphs below.
In Figure 1 are presented the answers from the first question in the survey: ‘Apart from the basic sources of financing (donations, grants, and sponsorships) do you earn income from economic activity?’ Therefore, it can be concluded that according to the funding sources, 53 organizations realize financial inflows exclusively from donations, grants, aid or other forms of unilateral transfers. While 17 of them earn additional income from providing goods and services. Additional income usually comes from activities related to renting space, conducting courses, workshops, consulting services, selling products made by members of the organization, etc. In the non-profit sector, most of the income is received based on donations, sponsorships and aid (unilateral transfers), by their economic essence, these inflows do not represent income from performing activities. Therefore, the income from donations, sponsorships, grants, membership fees, as well as funds received from the Budget of the Republic of Macedonia, the budgets of the municipalities, given for realizing certain programs and goals determined in accordance with the statute and the program, are not subject to taxation with a tax on gain. The Law on Donations and Sponsorships in Public Activities also prescribes additional tax incentives. In addition, the organizations that realize incomes from performing activities should be able to prove that these incomes are used for the performance of the basic goal and mission. Hence, the expenditure side is also significant, i.e. accounting records of expenses by types, from which it will be possible to determine their expediency. Cost analysis is also important for financial/tax control, in order to determine whether the organization is using the additional income for the purposes of achieving its mission or if possible hidden profit payments have occurred. Bearing in mind that citizens' associations and foundations do not have the possibility of paying profits to their founders.
Additionally, in Figure 2 are presented the answers from the second question: ‘Have you submitted financial statements for inspection at the request of state institutions (except, if applicable, the regular submission of final accounts), donors and other interested parties?’ Hence, the high percentage (50%) of non-use of mandatory financial statements indicates that organizations spend additional resources on financial analysis and auditing, which in certain cases could be avoided if there was a comprehensive

financial reporting framework. This leads to the conclusion that the current forms for submitting the annual account are not sufficiently clear and precise and do not allow interested parties to obtain adequate and sufficient information if they were to analyze them. Most often, donors or other interested parties hire auditors or other professionals to rely on the data in the financial statements.Taking into account the specifics of the non-profit sector, whose results often do not have quantitative content, the need for a narrative presentation of the achieved goals for the year is imposed. Adding this information to financial reporting increases the level of quality, relevance and transparency of financial reporting. The high percentage (50%) of non-use of mandatory financial statements indicates that organizations spend additional resources on financial analysis and auditing, which in certain cases could be avoided if there was a comprehensive financial reporting framework.

Figure 1. Responses from the first question

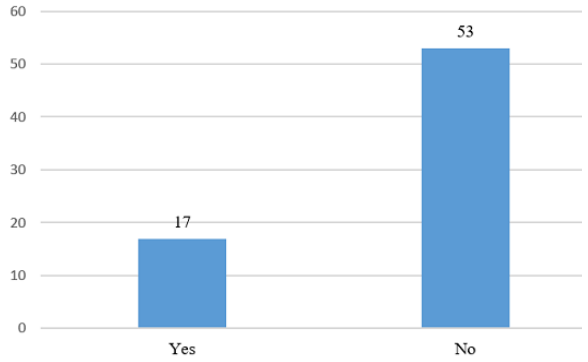
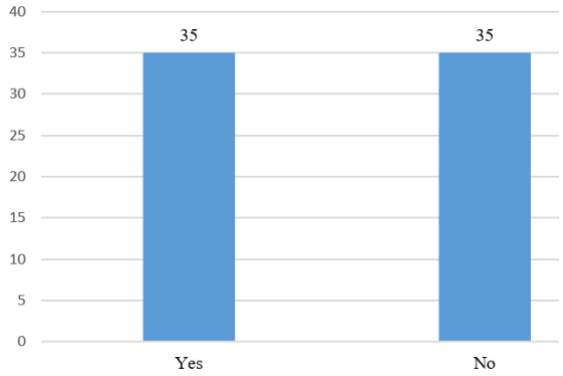


Figure 2. Responses from the second question



Source: Author's calculations

In Figure 3 are presented the answers from the third question: 'Are the minimum requirements for accounting and financial reporting prescribed by the Law on Accounting of Non-Profit Organizations and by-laws sufficiently clear?' Hence, regarding the general evaluation of the Law on Accounting of Non-Profit Organizations, 11 organizations responded that they have no objections to the existing legal solutions, 49 stated that the existing legal solutions are sufficiently clear, and 10 of the organizations responded that they are not satisfied with the legal solution. Organizations are sufficiently familiar with the legal framework, but these results show that there are issues that cause hesitation and uncertainty. Many of these questions are already covered in the text of this study. Also, the study should provide a basis for further discussion between organizations, stakeholders and competent institutions for the improvement of the legal framework and the implementation of laws and by-laws.

Furthermore, In Figure 4 are presented the answers from the fourth question: 'Does the application of the provisions of the Law enable transparent financial reporting?' When asked whether the provisions of the Law on Accounting of Non-Profit Organizations enable transparent financial reporting, 18 organizations answered that they have no objections to the existing legal solutions, 49 of the organizations, as in the previous question, stated that the existing legal solutions sufficiently enable transparent financial reporting and yet only 3 of the organizations that responded to the questionnaire do not consider that the existing law enables transparent financial reporting.

According to the given answers to this question, it can be concluded that, just as in the previous question, the existing legal requirements should undergo certain changes in order to adjust them in order to contribute to more transparent financial reporting. The issue of transparency is of crucial importance in attracting new funds and sources of financing as well as in the efficiency of financial and tax controls. By increasing transparency, confidence in the mission and the achieved results is raised, and thus the organization increases its capacity to absorb new financial resources.

Although 70% of the respondents answered that applying the provisions of the Law sufficiently enables transparent financial reporting, raising the degree of transparency and disclosure of financial information goes in favor of strengthening the capacities of the non-profit sector. Especially considering that in this sector there are no elements of market competition, so the disclosure of financial information on a wider scale will not adversely affect the results of the operation.

Figure 3. Responses from the third question

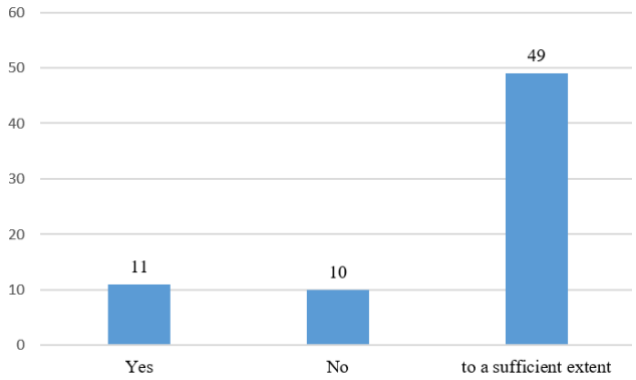
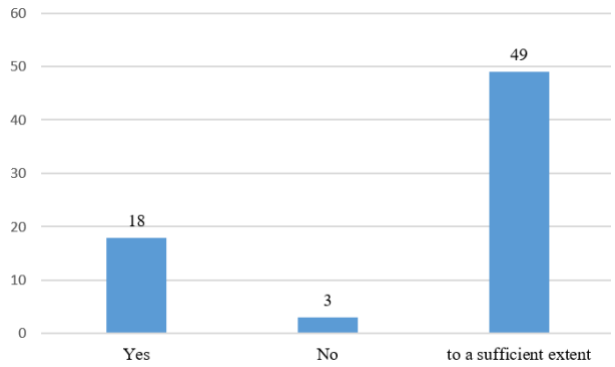


Figure 4. Responses from the fourth question



Source: Author's calculations

In Figure 5 are presented the answers from the fifth question: 'Are you obligated to a final account, according to Article 18, paragraph 1 of the law?' Thus, 61 organizations answered that they are obliged to submit a final account, and the remaining 9 that they do not have such an obligation. These 9 organizations that answered that they are not obliged to submit a final account meet the condition stated in Article 18, paragraph 1 and have revenues less than 2,500 euros. This can be seen from the review earlier where the data on the structure of the respondents is listed.

In the following Figure 6, are presented the answers from the sixth question: 'Do you use external accounting?' When asked whether the organization uses external accounting or has an organized accounting service within the organization itself, 53 of the organizations answered that they use the services of an external accounting company that keeps their accounting records and prepares the annual account, 10 answered that they have an organized accounting service in the organization itself, and 7 did not provide data.

Figure 5. Responses from the fifth question

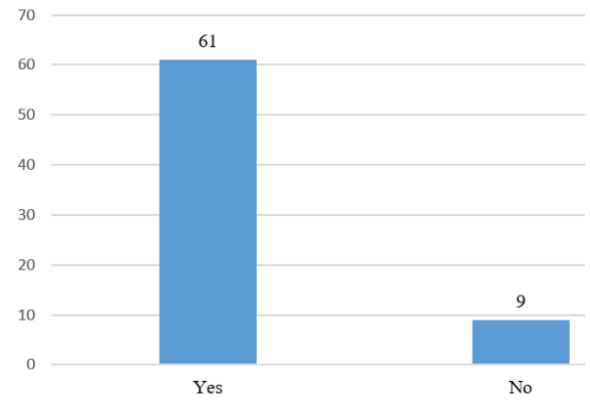
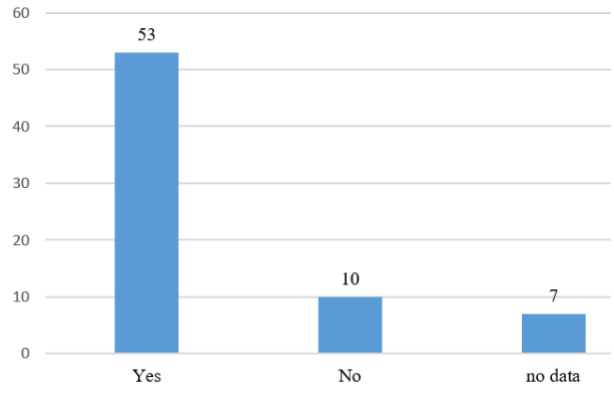


Figure 6. Responses from the sixth question



Source: Author's calculations

The seventh question 'Are there certain parts of the Law on Accounting of Non-Profit Organizations and by-laws that create confusion in application?' and its answers are presented in Figure 7. When asked whether certain parts of the Law on Accounting of Non-Profit Organizations and other by-laws create confusion in their application, 31 of the organizations answered affirmatively. That suggests that during their work they faced confusing parts of the Law and by-laws, 32 of the organizations believe that the existing legal regulations are in order and that there is no confusion during their application, and seven of them did not submit data. According to the above, we would conclude that it is necessary to conduct additional training for accountants in order to resolve the dilemmas surrounding the principle of modified occurrence of business changes, i.e. transactions, in order to resolve the dilemmas and misunderstandings that arise from its application.

In Figure 8 are presented the answers from the eight question: 'Are there certain requirements in the legal framework, which in your opinion unnecessarily complicate accounting and the preparation/submission of financial statements?' When asked whether there are sections in the existing legal regulations that unnecessarily complicate the keeping of business books and the preparation of financial statements, 25 of the organizations answered affirmatively. That is that during their operations they were faced with sections of the Law and by-laws that they consider problematic when conducting accounting and preparation of financial reports, 38 of the organizations consider that the existing legal regulations are in order and that there are no provisions that they consider inexpedient, while seven of them did not submit data. Most often, the following are the parts of the existing legal regulations that organizations consider unnecessary and make it difficult to manage accounting and the preparation of financial statements.

The volume and inaccuracy in the items of the existing forms for submitting the final account, the preparation of additional forms for statistics, the method of records and calculation of revaluation of long-term assets and the need that arises from the calculation of revaluation of long-term assets. Additionally, the provision for keeping accounting according to the principle of modified occurrence of business changes, i.e. transactions, the absence of a special form for a tax balance, which creates confusion during its filling.

Figure 7. Responses from the seventh question

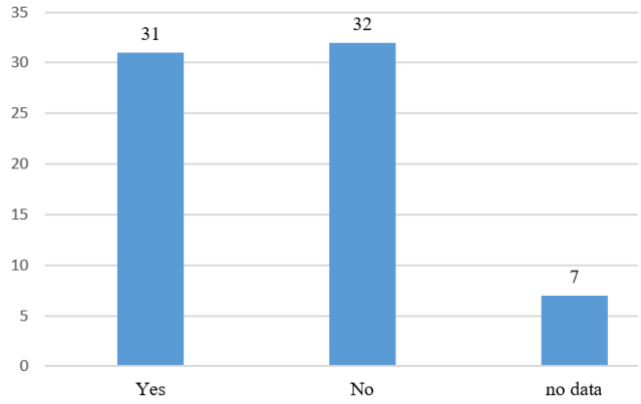
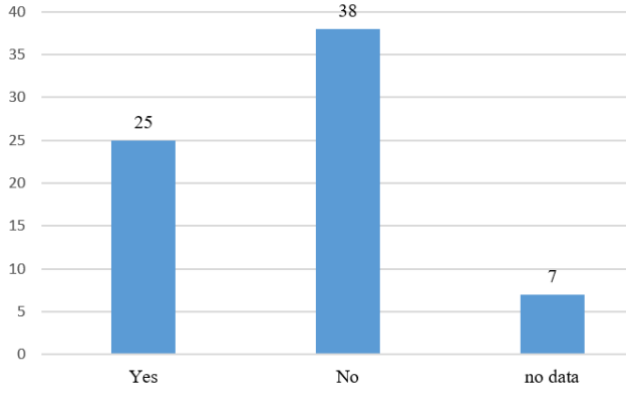


Figure 8. Responses from the eight question



Source: Author's calculations

4.1 Recommendations

The legal framework that governs the matter of accounting and accounting operations of non-profit entities in the Republic of N. Macedonia has already been established. Hence, through the analysis of the legal provisions, we can formulate the main conclusions and recommendations for further improvements and revision of certain provisions, with the aim of adapting the legal framework to the real conditions and needs in the non-profit sector. Therefore, the recommendations can be summed up in the following way:

-Formulating additional guidelines for improving administrative requirements and the way of keeping accounting;
-Adoption of a new by-law on the content and form of the Accounting Plan;
-Abolition of the obligation for annual revaluation of long-term assets;
-Narrative section and explanatory notes as a supplement to the financial statements;
-Recognition of fixed assets according to management's expectations for the future use of a particular asset and the anticipated future uses;
-Precise definition of criteria for determining "micro" non-profit organizations, which are not obliged to submit a final account;
-Prescribing criteria for determining large non-profit organizations, as well as the obligation to audit financial statements for large organizations;

5. Conclusion

The non-profit sector in N.Macedonia is of exceptional importance for the overall development of society. Therefore, the creation of an enabling environment in which some kind of sustainability of civil society organizations will be realized will depend primarily on the capacity to attract funds, especially fundings from abroad. Hence, the administrative function is of great importance in terms of presenting the financial picture of the organization as well as enabling transparency in reporting. The role of the Law on the Accounting of Non-Profit Organizations and its by-laws is to set a framework for financial reporting and processing of accounting documents to ensure efficient, accurate and timely financial information, and this undoubtedly serves the development of the sector. In the analysis of the Law on the Accounting of Non-Profit Organizations, the entities subject to the obligation to keep accounting and financial reporting, the administrative requirements and principles for the way of keeping accounting, the prescribed rules for recognition of assets, liabilities, sources of funds, income, etc. Financial reporting and the accounting procedures are also integral; part of the non-profit organizations, although their primary focus ate not the finances. Therefore, establishing an enabling environment for NPOs to adhere to legal requirements and thrive will undoubtedly foster the growth of organizations that operate in such a manner. As a result, the impact will be advantageous for society as a whole.

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Estimating the progress of Albania toward the green growth

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Abstract

The concepts of green economy and green growth are the main focus of various international organizations. The interest for green economy and green growth is increasing rapidly. Green growth is an approach for fostering the economic growth and development while meeting the environmental protection objectives and social equity. OECD has developed the Green Growth Strategy, which provide a framework for the achievement of economic growth and development. The Global Green Growth Institute (GGGI) is advising countries for the implementation of Green Growth Strategy. The Balkan region has endorsed the Green Agenda for the Western Balkan (GAWB) and as well as the GAWB Action Plan. This paper will be focused to Albania, but we have analyze it on the context of 8(eight) Countries of South East Europe, geographically close, three of them member of the EU (Greece, Croatia, Bulgaria) and 5(five) of them non EU countries (Albania, Serbia, Montenegro, North Macedonia, Bosnia and Hercegovina). We have selected 16 indicators from the OECD Green Growth database in order to analyses and monitor the progress towards green growth. Albania has the Law on Protection of Environment that defines the key principles for supporting Green Growth. Albania is performing well in terms of the supply of renewable energy and renewable electricity, but has the lowest stock of forest of a value 54.93 and is displaying a decreasing trend compared to previous periods. Also the production based CO_2 productivity, displays an increasing trend with a value of 9.85 for 2021. The results can be used by the policy makers for developing a policy for the improvement of these indicators.

Keywords: OECD Green Growth database, green growth indicators, environment .

1. Introduction

The concept of green growth has gained significant attention from international organizations such as the OECD, UNEP, and the World Bank. The term "green economy" was first used in 1989 in a report called "Blueprint for a Green Economy," prepared for the UK Government. The United Nations Conference on Environment and Development (UNCED), also known as the Rio Conference or Earth Summit, held in 1992, focused on the integration of environment and development. The outcomes of the Rio Conference included Agenda 21, the Climate Change Convention, and the Convention on Biological Diversity.

In 2002, the Earth Summit 2002 (Rio+10) took place in Johannesburg, South Africa, where sustainable development was recognized as an overarching goal. The United Nations Conference on Sustainable Development (UNCSD), also known as Rio 2012 (Rio+20 or Earth Summit 2012), was held in Rio de Janeiro, Brazil, in June 2012. The main outcome of this conference was the document "The Future We Want," where the participating governments promoted a sustainable future and an inclusive green economy.

The concept of green growth was coined during the Fifth Ministerial Conference on Environment and Development (MCED) in Seoul in 2005, where stakeholders agreed to move towards green growth. The OECD prepared the main principles and strategies of green growth, including the Green Growth Strategy and OECD Indicators.

In October 2020, the Sofia Declaration on the Green Agenda for the Western Balkans (GAWB) and the GAWB Action Plan were signed during the Brdo Summit in 2021. The Western Balkan countries have defined their regulatory frameworks, policies, initiatives, projects, and programs for the implementation of the green economy (Matlievska & Matlievska 2022). However, the implementation of specific activities in these countries is still at a low level (Knez et al. 2022). Albania has also approved several laws aimed at integrating the principles of sustainable development and filling gaps in the environmental sector (Ongari 2016).

In this study, the focus is on analyzing and monitoring the progress towards green growth specifically in Albania. To achieve this, 16 indicators from the OECD Green Growth Database are selected. In addition to Albania, the study includes eight Southern European countries. Among these countries, three are members of the European Union (Greece, Croatia, Bulgaria), while the remaining five are non-EU countries (Albania, Serbia, Montenegro, North Macedonia, Bosnia and Herzegovina).

The study aims to assess the country's performance in terms of efficient use of natural capital, environmental and resource productivity, and the extent to which economic growth is becoming greener.

2. Literature review

Green growth, as a component of sustainable development, encompasses the protection of the environment while enabling economic growth (OECD 2015, Capasso et al. 2019, Sowah & Kirikkaleli 2022). It involves transitioning to a low-carbon and resource-efficient society (Lyytimäki et al. 2018), which require active involvement in public policy and implementation at the territorial level (Dogaru 2021). Sustainable development represents a new approach to the economic, environmental, social and institutional aspects of development (Golusin et al. 2011). The concept of the green economy is broad and encompasses various aspects of growth, well-being, efficiency, and the reduction of risks associated with the use of natural resources (Loiseau et al. 2016). Governments worldwide have prioritized economic growth and environmental sustainability as important policy objectives (Hao et al. 2021). The green economy has been a significant element of initiatives such as the Europe 2020 strategy (Kasztelan 2021), aiming to achieve sustainable development and address challenges related to pollution, waste management, resource efficiency, and climate change (Dogaru 2021). Green growth is considered one of the most effective solutions to combat environmental degradation. By promoting sustainable practices and policies, green growth seeks to decouple economic growth from environmental harm. It emphasizes the importance of investing in clean technologies, renewable energy, energy efficiency, sustainable agriculture, waste management, and other measures that contribute to environmental protection.

There are many studies that provide valuable insights into the relationship between renewable energy, economic growth, and CO_2 emissions in different contexts. Awosusi et al. (2023) investigated energy transition economies and found a bidirectional causality between renewable energy and CO_2 emissions. This implies that as renewable energy increases, CO_2 emissions decrease, and vice versa. They also identified a unidirectional causal relationship between economic growth and CO_2 emissions, suggesting that economic growth leads to higher emissions. Saqib et al. (2023) were focused on the G-10 countries and examined the impact of various factors on CO_2 emissions. They found that increasing the use of environmentally based technologies, economic complexity, and renewable power generation had a strong positive impact on reducing carbon emissions. This suggests that adopting environmentally friendly technologies and promoting renewable energy can contribute to CO_2 emission reductions. Nataly Echevarria Huaman & Xiu Jun (2014) suggest two approaches to reduce CO_2 emissions: firstly, by reducing the demand for energy through energy efficiency measures, conservation, and behavioral changes and secondly, by altering the methods of energy production and delivery, such as transitioning to renewable energy sources. These strategies can help mitigate carbon emissions. Mitic & Cvetanovic (2018) in their analysis were focused on nine South East European countries and found a positive bidirectional causality between CO_2 emissions and GDP per capita. This implies that economic growth and CO_2 emissions are interdependent, with each influencing the other. Higher GDP per capita is associated with increased emissions, and vice versa.

The renewable energy system plays a crucial role in achieving energy sustainability and sustainable supply chain management. Sun et al. (2023) emphasize the importance of renewable energy in supporting sustainable practices throughout the supply chain. Renewable energy is defined by Wee et al. (2012) as a free and sustainable energy source that does not harm the environment. It serves as an alternative to traditional energy sources, which are often associated with negative environmental impacts and limited availability. By utilizing renewable energy sources, societies can reduce their reliance on fossil fuels and mitigate the environmental and social consequences of conventional energy production.

One important source of renewable energy is biomass. Biomass resources encompass a wide range of organic materials, including wood, agricultural residues, energy crops, and industrial waste (Wee et al. 2012). The utilization of biomass for energy purposes offers multiple benefits, including reduced greenhouse gas emissions, waste management, and the potential for local resource development.

The forestry sector can contribute to the enhancement of renewable energy and the reduction of greenhouse gas emissions. Forests can serve as a sustainable biomass resource through the utilization of wood and other plant-derived materials. Proper forest management practices, including reforestation and sustainable harvesting, can ensure the long-term availability of biomass resources. By utilizing forestry residues and sustainably managed wood resources, the forestry sector can play a significant role in promoting renewable energy and reducing carbon emissions.

3. Methodology

The OECD Green Growth database was used to assess the progress towards green growth in Albania and seven other selected countries. A total of 16 indicators were chosen (Table 1) based on well-specified criteria and a conceptual framework provided by the OECD (2017). These indicators are designed to capture the key aspects of green growth, focusing on environmental and resource productivity.

Table 1. Green Growth Indicators (OECD) used in the study

Variable			Unit	Legend	Effect
Environmental and resource productivity	CO_2 Productivity	Production-based CO2 productivity, GDP per unit of energy-related CO2 emissions	US dollars per kilogram, 2015	X_1	Positive
	Energy productivity	Energy intensity, TPES per capita	Tonnes of oil equivalent (toe)	X_2	Negative

		Renewable energy supply, % total energy supply	Percentage	X_3	Positive
		Renewable electricity, % total electricity generation	Percentage	X_4	Positive
	Non-energy material productivity	Non-energy material productivity, GDP per unit of DMC	US dollars per kilogram, 2015	X_5	Positive
		Biomass, % of DMC	Percentage	X_6	Positive
		Non-metallic minerals, % of DMC	Percentage	X_7	Negative
		Metals, % of DMC	Percentage	X_8	Negative
	Forest resources	Forest resource stocks	Cubic metres, Millions	X_9	Positive
Environmental dimension of quality of life	Exposure to environmental risks	Mean population exposure to PM2.5	Micrograms per cubic metre	X_{10}	Negative
		Mortality from exposure to ambient PM2.5	Per 1 000 000 inhabitants	X_{11}	Negative
		Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent	Percentage	X_{12}	Negative
Economic opportunities and policy responses	Technology and innovation: Patents	Development of environment-related technologies, % all technologies	Percentage	X_{13}	Positive
		Development of environment-related technologies, inventions per capita	Number	X_{14}	Pozitive
Socio-economic context	Economic context	Real GDP, Index 2000=100	Index, 2000=100	X_{15}	Positive
		Real GDP per capita	US Dollar, 2015	X_{16}	Positive
Source: Data extracted on 27 May 2023 16:26 UTC (GMT) from OECD.Stat					

The study uses the index method, which make possible the comparison of each of 8 countries. For this reason we have use the method proposed by Prendi & Murrja (2023) for the calculation of index of performance. The authors (Prendi & Murrja 2023) use the following formulas:

The average of the variables over years for each country

$$Average\ of\ variables\ (country)_k = \frac{sum\ of\ all\ observation\ for\ each\ variable}{Total\ number\ of\ observations\ for\ each\ variable}$$

Percentage of the contribution per variable for each country:

$$\rho = \frac{Average\ (country)_k}{\sum_{k=1}^{n} Average\ (country)_k} x100$$

Index of performance is calculated as following:

$$\varphi = \sum_{k=1}^{n} k_i$$

k_i = points for each variable

The same authors (Prendi & Murrja 2023) explain that the calculation of points for each variable (ki) can be done as shown in table 2.

Table 2. Calculation of points for each variable (ki)

Variable with positive effect	0	1	2	3	4
	0-10%	11-20%	21-30%	31-40%	41-50%
Variable with negative effect	4	3	2	1	0

Methodology according to Prendi & Murrja (2023)

To calculate the index using the selected indicators positive or negative effects are assigned based on the values of ρ (percentage contribution) for each variable. The suggested approach is shown in table 2. It is assigned a positive effect for variables where larger values of ρ indicate a positive impact on green growth or sustainable development and as a negative effect for variables where larger values of ρ indicate a negative impact on green growth or sustainable development.

The points are assigned based on the magnitude of the positive or negative effect of each variable, with larger positive effects or smaller negative effects receiving higher points.

This approach allows to calculate an index of performance that considers the contribution of each variable and its positive or negative impact on green growth or sustainable development.

Our study has been extended including not only the West Balkan countries but also three other countries in Southeast Europe. By including a broader range of countries, can be obtained a more comprehensive understanding of green growth and sustainability in the region. Using 16 indicators instead of the eight used by Prendi & Murrja (2023) allows for a more detailed analysis of various aspects of green growth. Furthermore, the inclusion of a larger number of indicators and of additional Southeast European countries will contribute to a more comprehensive regional analysis, allowing for the identification of common challenges, best practices, and potential areas for collaboration in promoting green growth and sustainable development in the region.

4. Results and discussions

According to OECD (OECD 2017), production-based CO_2 productivity measures the economic value generated per unit of CO_2 emitted. It is calculated based on gross direct CO_2 emissions from fossil fuel combustion within a country's national territory, excluding bunkers, sinks, and indirect effects. Fossil fuel combustion has contributed to significant human health and welfare issues (Midilli et al. 2006). It is mentioned that global economic growth conflicts with the increasing CO_2 emissions. Sowah & Kirikkaleli (2022) suggest that rising CO_2 emissions are driven by GDP per capita, indicating a correlation between economic growth and CO_2emissions.

A study by Santra (2017) found that technological innovation has a positive impact on CO_2 emission productivity in BRICS countries (Brazil, Russia, India, China, and South Africa).

When comparing data from the OECD database, it is found that Albania has the highest level of production-based CO_2 productivity (Figure 1), followed by Croatia. On the other hand, Bosnia and Herzegovina have the lowest values. The trend for Albania, Croatia, Greece, and Bulgaria shows an increasing pattern, while for other countries, it remains constant.

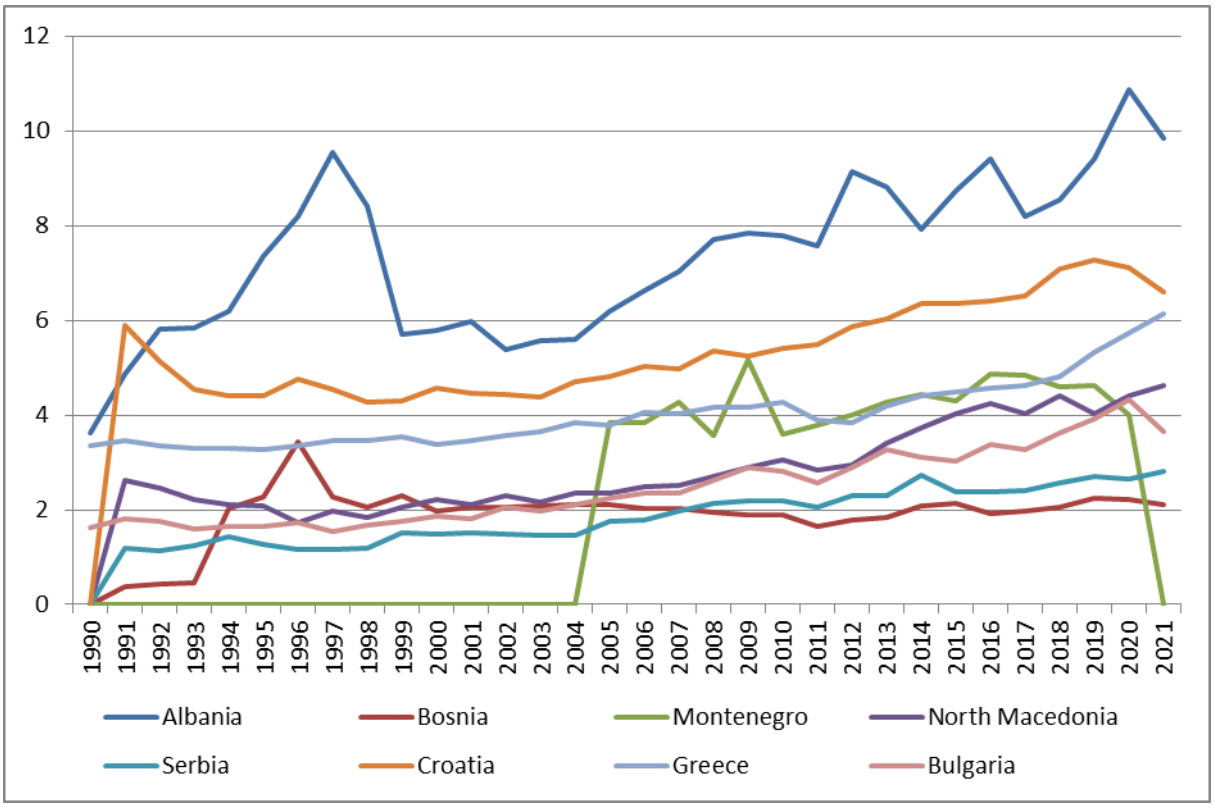


Figure 1. Production-based CO_2 productivity: GDP per unit of energy-related CO_2 emissions.
Source: author calculations based on OECD.stat

Indeed, environmental sustainability has been a prominent focus in studies concerning energy. In the current study, the emphasis is on energy and non-energy productivity parameters. Energy plays a vital role as an input in all economic activities. Energy productivity is defined as the output generated (measured in terms of real GDP) per unit of Total Primary Energy Supply (TPES) and signifies efforts to improve energy efficiency and reduce carbon and other atmospheric emissions (OECD 2017). Energy productivity represents energy consumption and the efforts made to enhance energy efficiency while simultaneously reducing carbon and other emissions into the atmosphere (Petković 2023). It also provides insights into the relative performance of countries concerning the interconnected economic, energy, and environmental issues they face (Atalla & Bean 2017). Energy intensity, another metric discussed in literature, holds potential as a variable in energy and climate policies (Atalla & Bean 2017). It indicates the amount of energy required to produce a unit of economic output. Lower energy intensity values denote greater energy efficiency within an economy. Policies aimed at reducing energy intensity can contribute to improved energy efficiency, decreased carbon emissions, and the establishment of a more sustainable energy framework. The concepts of energy productivity and intensity are influenced by a range of factors, including both structural and climatic elements (Gavurová et al. 2021; Petković 2023).

The work by Midilli et al. (2006) highlights the pressing need to develop green energy strategies for a sustainable future. According to the authors, green energy can be defined as an energy source with minimal or zero environmental impact, characterized by its environmentally friendly nature and long-term sustainability. Green energy is typically generated from renewable sources such as solar, hydro, biomass, wind, geothermal, among others. The primary objective of green energy is to reduce the negative effects associated with fossil fuel resources, decrease overall emissions from electricity generation, mitigate greenhouse gas emissions, and actively contribute to environmental improvement. Furthermore, green energy aims to meet the growing demand for clean energy in both industrial and non-industrial sectors.

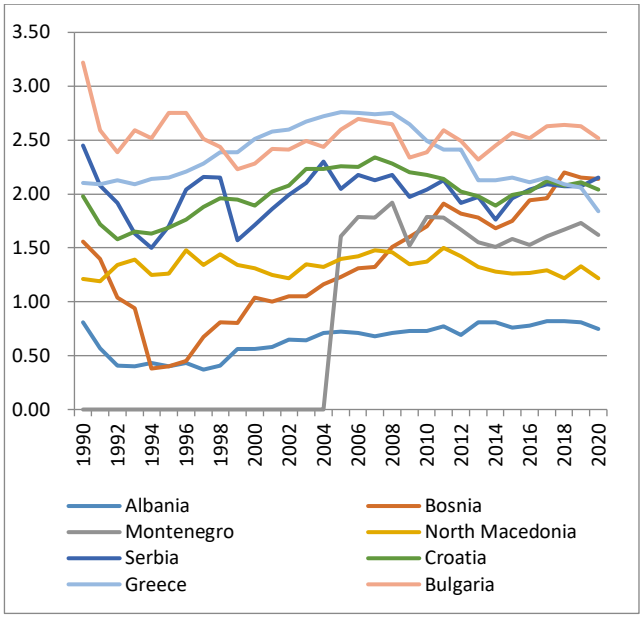
Energy consumption and economic growth are widely recognized as key drivers of CO_2 emissions, which in turn play a crucial role in climate change. Given the adverse consequences associated with increasing atmospheric CO_2 levels, concerted efforts are necessary to mitigate these emissions. Renewable energy consumption and innovation have been identified as factors that can help reduce emissions (Godil et al. 2021). The authors highlight the negative impact of renewable energy consumption and innovation on emissions. By transitioning from fossil fuels to renewable energy sources, countries can effectively lower their greenhouse gas (GHG) emissions and mitigate the environmental impact of energy generation.

Climate change and global warming are considered urgent and contentious environmental issues confronting the world (Kirikkaleli et al. 2023b). In this context (Mitić et al. 2020) propose that renewable energy sources have the potential to significantly reduce GHG emissions compared to fossil fuels. The utilization of renewable energy is seen as an alternative that can replace non-renewable energy sources and contribute to improving environmental quality (Kirikkaleli et al. 2023a). The consumption of renewable energy has the added benefit of mitigating the negative effects of carbon footprints (Sowah & Kirikkaleli 2022). By reducing reliance on carbon-intensive energy sources, societies can limit their carbon footprints and contribute to a more sustainable and environmentally friendly energy system.

Previous studies have indicated that an increase in energy productivity and energy prices promotes renewable energy consumption, particularly in BRICS countries between 1990 and 2018 (Majeed et al. 2022). This suggests that improving energy efficiency and implementing policies that increase energy prices can incentivize the adoption of renewable energy sources, thus further reducing emissions.

In figure 2 are shown the indicators related to energy productivity. Albania has the lowest values for the indicator "Energy intensity, TPES per capita", indicating that it has relatively lower energy consumption per capita compared to the other countries examined in the study. On the other hand, Bulgaria, Greece, and Croatia exhibit the highest values for this indicator, implying that they have higher energy consumption per capita. This suggests that Albania is more efficient in utilizing energy resources compared to these countries. Additionally, Albania has the highest values for the indicators "Renewable energy supply, % total energy supply" and "Renewable electricity, % total electricity generation". This implies that a significant portion of Albania's energy supply comes from renewable sources, such as solar, wind, hydro, or biomass, in relation to the total energy supply.

The values for the "Renewable electricity, % total electricity generation" indicator appear to be constant for Albania, while the values for the same indicator show fluctuations for the other countries under study. This suggests that Albania has consistently maintained the proportion of renewable electricity generation over time, while the other countries may have experienced fluctuations in their renewable electricity generation shares.



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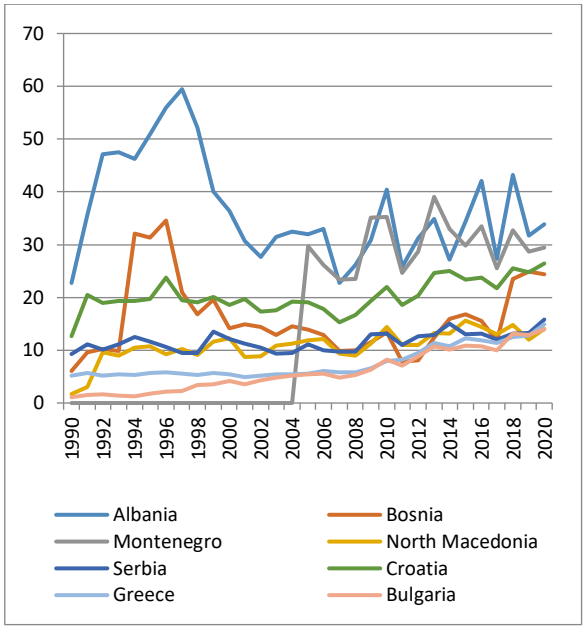

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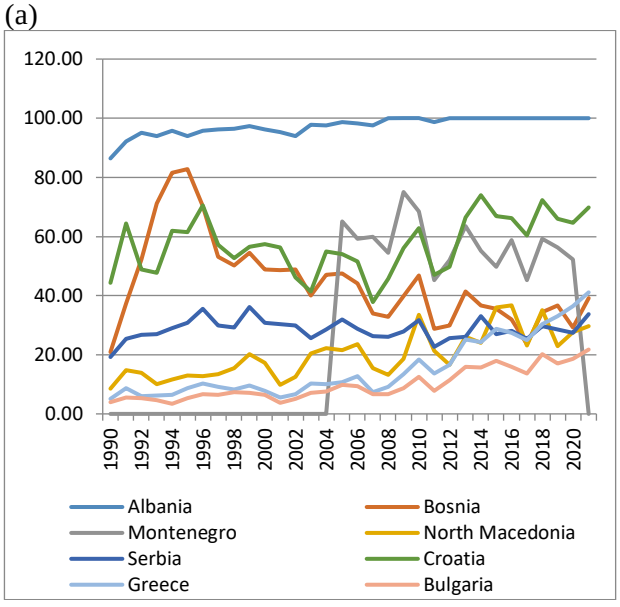


(c)

Figure 2. Energy productivity. (a) Energy intensity, TPES per capita; (b) Renewable energy supply, % total energy supply; (c) Renewable electricity, % total electricity generation
Source: author calculations based on OECD.stat

The non-energy material productivity parameters related to waste materials and recycling are analysed in the current study. Understanding and improving these parameters can have significant implications for sustainability and the circular economy. Biomass, plays a crucial role in the bioeconomy and serves as an alternative to fossil resources. Biomass refers to organic materials

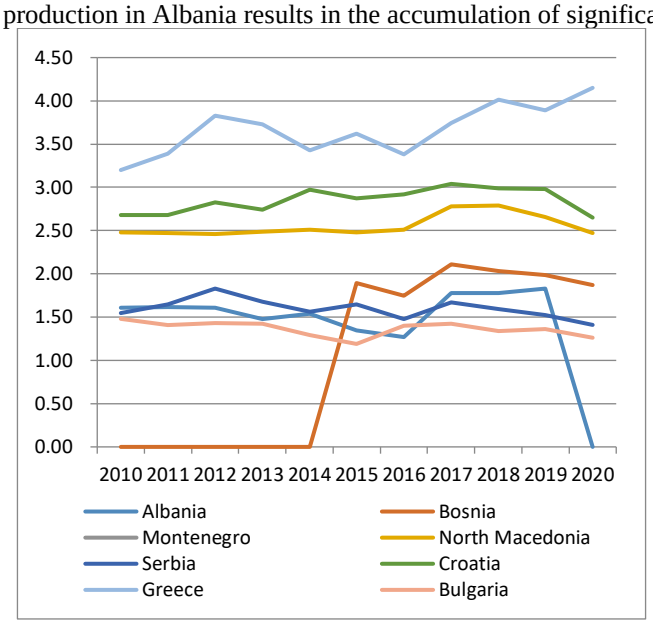
derived from plants, animals, and other organic sources. It can be used for various purposes, including energy production, biofuels, and the manufacturing of bio-based products.

In the context of the transition toward a low-carbon economy, biomass becomes particularly important. As societies aim to reduce their reliance on fossil fuels and decrease greenhouse gas emissions, biomass offers a renewable and potentially carbon-neutral energy source. Biomass energy systems can utilize organic waste, agricultural residues, dedicated energy crops, and sustainably managed forests to produce heat, electricity, and biofuels.

The findings regarding "Non-energy material productivity, GDP per unit of DMC" are shown in figure 3. The highest values are found for Greece, Croatia, and North Macedonia, while other countries have lower and similar values. Montenegro data is missing for all indicators in this category. "Biomass" Bulgaria has the lowest values and other countries have similar values that remain constant throughout the period. Regarding "Non-metallic minerals" Bulgaria's data is available for a limited period (2014-2019); Albania's data is missing for the year 2020. Two groups can be observed: First group (higher values): Croatia, Greece, Bulgaria, Albania, and Bosnia. The second group (lower values): Serbia and North Macedonia. "Metals (% of DMC)" Two clear groups can be observed: First group (higher values): Bulgaria, Serbia, and North Macedonia and all the other countries comprise the second group. Values for this indicator appear to be constant.

The review conducted by Golušin et al. (2013) sheds light on the state of energy systems in the Western Balkans countries, emphasizing several key characteristics and the importance of prioritizing the development and intensification of renewable energy sources, particularly wind energy, in the Western Balkans. By diversifying the energy mix and reducing reliance on fossil fuels, the region can address environmental challenges, promote sustainable development, and enhance energy security

In the review of Đurašković et al. (2021) it is highlighted that the Western Balkans region possesses considerable potential for developing sustainable and resilient energy systems through the utilization of renewable energy sources (RES). The analysis conducted by the authors concludes that many countries in the Western Balkans have already set renewable energy targets within their energy policies. These targets serve as guidelines for the adoption and implementation of renewable energy technologies, as well as establishing a framework for policy implementation. By incorporating renewable energy targets into their energy policies, the countries in the Western Balkans are demonstrating their commitment to transitioning towards more sustainable and environmentally friendly energy systems. The study of Brahushi et al. (2020) focuses on assessing the potential of biomass derived from fruit trees and grapes for bio-energy production in Albania. The researchers calculated predictive agricultural biomass production in the short and long term for Albania up to 2025 and found satisfactory biomass production. The increasing agricultural production in Albania results in the accumulation of significant residues, which can be utilized for energy production.



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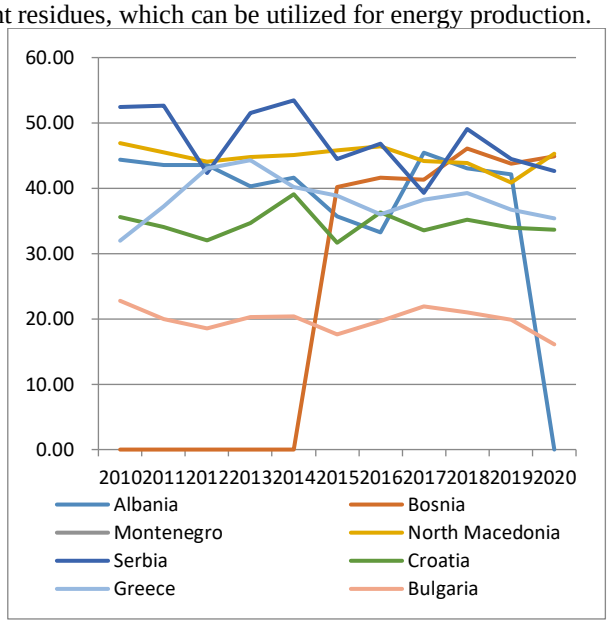

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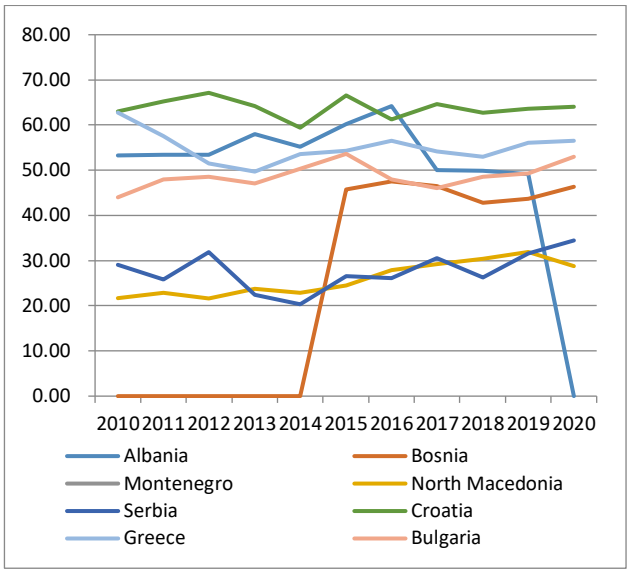

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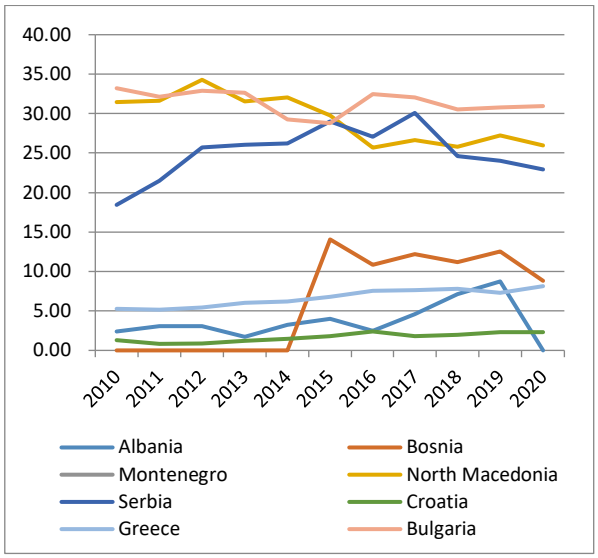


(d)

Figure 3. Non-energy productivity. (a) Non-energy material productivity, GDP per unit of DMC; (b) Biomass, % of DMC; (c) Non-metallic minerals, % of DMC; (d) Metals, % of DMC
Source: author calculations based on OECD.stat

According to (OECD 2017) forest resource stocks measured as the growing stock of standing trees. It is defined as the volume over bark of all living trees with a minimum diameter of 10 cm at breast height and including the stem from ground level up to a top diameter of 0 cm excluding branches. Figure 4 illustrates the forest stock in different countries. Bulgaria has the largest stock of forests among the mentioned countries. It implies that Bulgaria has a significant amount of forested areas compared to the others. Croatia and Bosnia and Herzegovina have relatively similar forest stocks. This suggests that both countries possess a comparable amount of forested areas. Starting from 2010, Serbia also shows a similar forest stock to Croatia and Bosnia and Herzegovina, which indicates that Serbia has experienced a notable increase in its forested areas during that period. North Macedonia and Albania have the lowest forest stocks among the mentioned countries. It implies that these countries have comparatively fewer forested areas in their territories.

Between 1990 and 2000, Albania experienced significant changes in greenhouse gas emissions. Emissions associated with changes in land use and forestry notably decreased during this period, while emissions from other sectors increased (Knez et al. 2022). Merko et al. (2019) emphasized the critical issue of deforestation in Albania and the need for effective forest resource management. The authors indicate that over the past 30 years, Albania has experienced a concerning trend of forest degradation. Forest development policies and programs have highlighted this negative trend and the urgent need to address degradation and redirect development efforts towards sustainable practices. The authors report that tragic figures from the past two decades reveal a significant reduction about 40% in the national forest fund. Wood cutting for firewood exceeds the annual growth of forests by 2-2.5 times, and a substantial portion of the cut forests are inefficiently burned for fuel, further contributing to degradation.

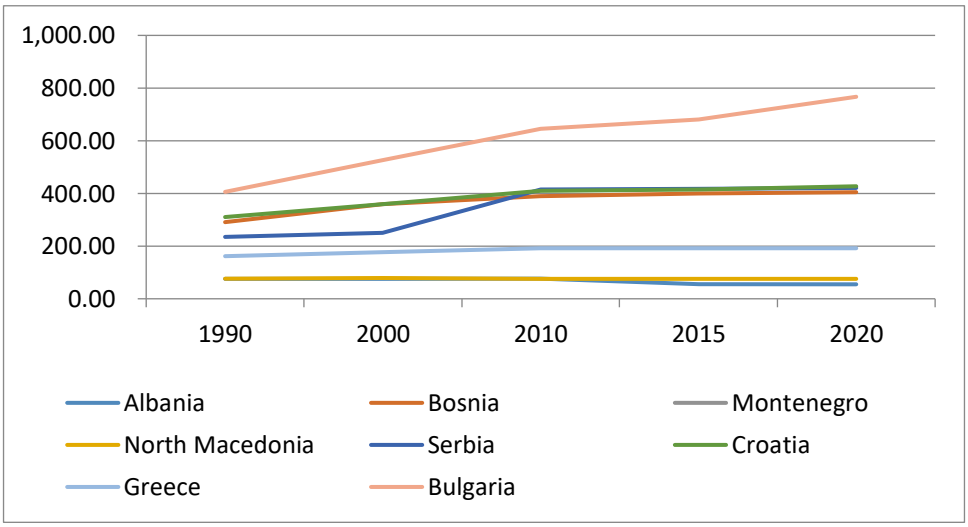


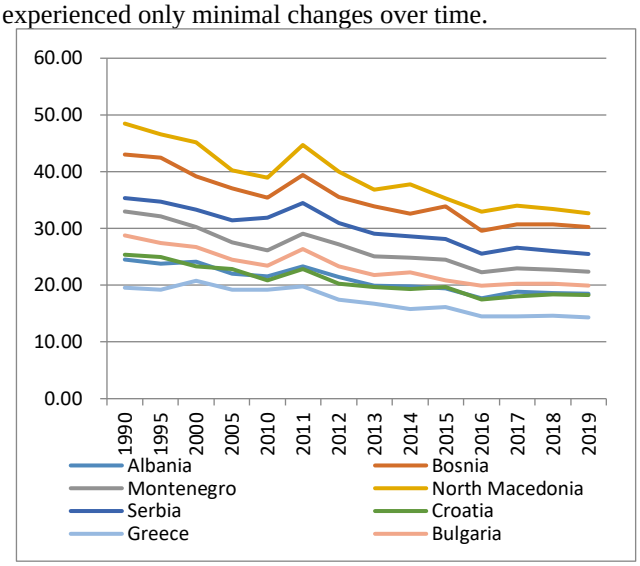
Figure 4. Forest resource stocks.
Source: author calculations based on OECD.stat

In figure 5 are indicated the indicators of group Environmental dimensions and quality of life. Figure 5a is represents the energy intensity (measured in tonnes of oil equivalent per unit of GDP) for each country in the Western Balkans region over the specified years. Energy intensity provides an indication of the amount of energy consumed per unit of economic output.

North Macedonia has consistently had the highest energy intensity values among the Western Balkans countries, indicating a relatively higher energy consumption per unit of GDP. On the other hand, Greece has consistently had the lowest energy intensity values, implying a lower energy consumption per unit of GDP. Additionally, the trend of the data shows a decreasing pattern from 1990 to 2019 for all countries. This suggests that over time, the energy intensity, or the amount of energy required to produce a unit of GDP, has generally decreased in the SEE region. This might be attribute of factors such as improvements in energy efficiency, increased use of renewable energy sources, and advancements in technology and production processes.

It appears that Bulgaria experienced an increasing trend in mortality from exposure to PM2.5 until 1998, followed by a decreasing trend (Figure 5b). This suggests that efforts to address air pollution and improve air quality may have been implemented after 1998, leading to a reduction in mortality related to PM2.5 exposure. On the other hand, the other countries in the region show a slight increase in mortality from ambient PM2.5 over the observed period. This indicates that these countries may still be facing challenges in controlling and reducing air pollution levels, resulting in negative health impacts. Albania has the lowest values, suggesting a relatively lower impact of ambient PM2.5 pollution on mortality.

Figure 5c displays the indicator "Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent." This indicator represents the economic costs associated with premature deaths caused by exposure to fine particulate matter (PM2.5) in ambient air pollution. Bulgaria has the highest values for this indicator, indicating that the country experiences significant economic costs due to premature deaths associated with PM2.5 exposure. On the other hand, Albania has the lowest values, suggesting lower economic costs related to premature mortalities from ambient PM2.5 exposure. In the case of Bulgaria, the values for this indicator initially show an increase until 1997, followed by a subsequent decrease up to the present time. This indicates that the economic costs associated with premature deaths from PM2.5 exposure peaked in 1997 and have since decreased. It's important to note that without the actual figures or further context, the reasons for this trend cannot be determined. For the other countries under study, the trend for the indicator is described as either constant or showing a very slight increase. This suggests that the economic costs related to premature mortalities from exposure to ambient PM2.5 in these countries have remained relatively stable or have experienced only minimal changes over time.



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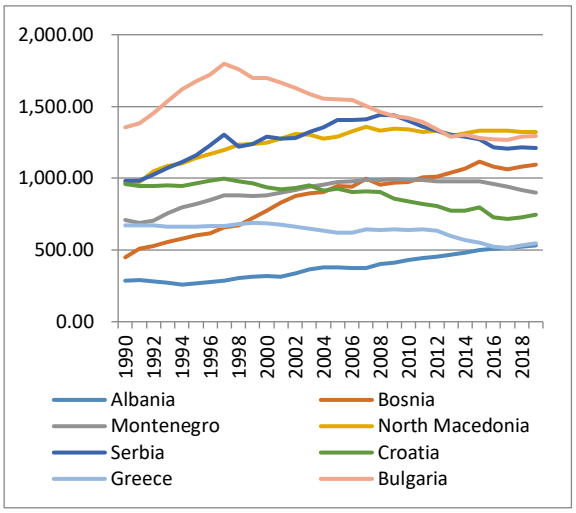

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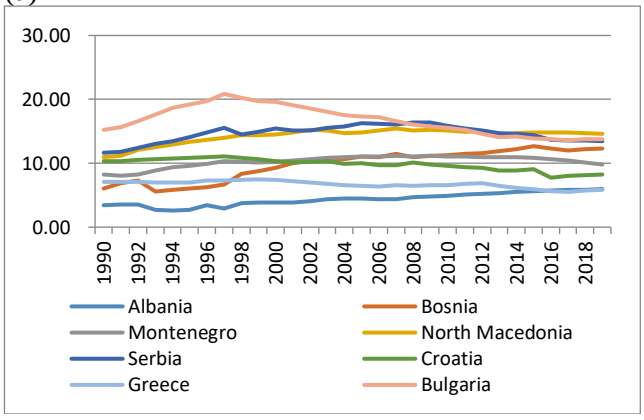
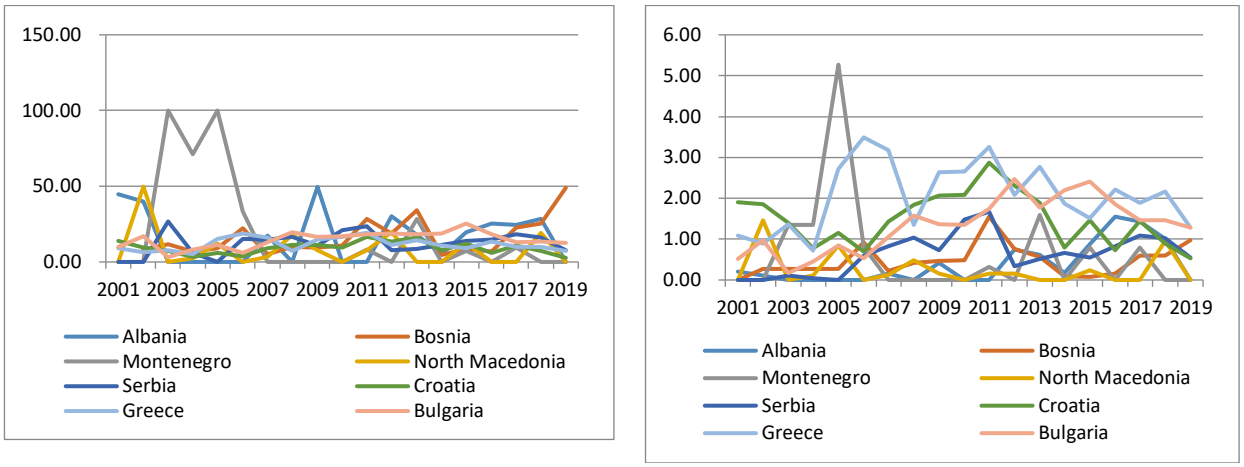


(c)

Figure 5. Exposure to environmental risks. (a) Mean population exposure to PM2.5; (b) Mortality from exposure to ambient PM2.5; (d) Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent
Source: author calculations based on OECD.stat

Figure 6a shows the results for the indicator "Development of environment-related technologies, % all technologies." It is observed that Montenegro has the highest values until 2006, indicating a relatively higher proportion of environment-related technologies compared to other technologies. After 2006, all countries under study have similar values, suggesting a relatively balanced development of environment-related technologies compared to other technological areas. In Figure 6b, the results for the indicator "Development of environment-related technologies, inventions per capita" are shown. In 2005, Montenegro has the highest values, indicating a relatively higher number of inventions related to the environment per capita compared to other countries. However, after 2005, Greece displays the highest values, suggesting a higher rate of environmental technology inventions per capita. On the other hand, Montenegro has the lowest values in this indicator. It is important to note that the values for all countries in both figures show slight fluctuations over the observed period. These fluctuations may be influenced by various factors such as research and development investments, innovation policies, and technological advancements in the environmental sector.

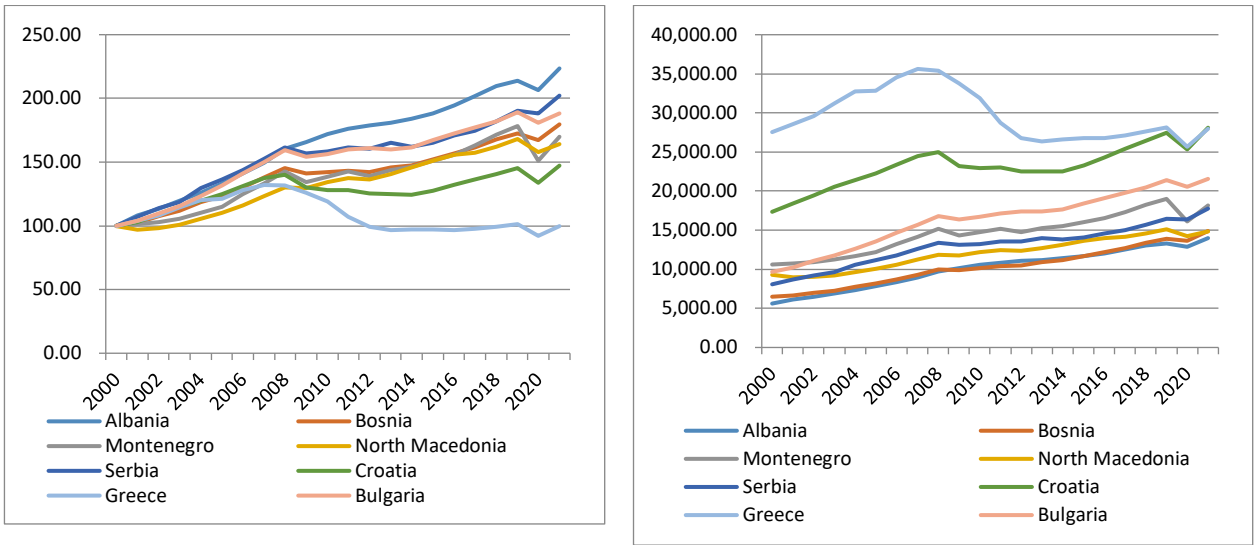


(a) (b)

Figure 6: Technology and innovation: Patents (a) Development of environment-related technologies, % all technologies; (b) Development of environment-related technologies, inventions per capita

Source: author calculations based on OECD.stat

Figure 7a displays the results of the indicator "Real GDP, Index 2000=100." From 2000 to 2008, the values for each country are quite close, indicating a relatively similar level of economic growth during that period. However, after 2008, there is higher variability in the values, suggesting diverging economic trends among the countries under study. Albania has the highest values, indicating a relatively stronger economic growth compared to the other countries, while Greece has the lowest values, indicating a relatively weaker economic performance during this period. In Figure 7b, the results for the indicator "Real GDP per capita" are shown. Greece has the highest values, indicating a relatively higher economic output per person in comparison to other countries. Croatia and Bulgaria follow with relatively high values as well. On the other hand, Bosnia displays the lowest values, suggesting a lower level of economic output per capita compared to the other countries in the study. These indicators provide insights into the economic context of the countries under study, showcasing differences in GDP growth and GDP per capita levels. The variations in these indicators can be influenced by factors such as economic policies, investments, productivity, and overall economic performance



(a) (b)

Figure 7. Economic context (a) Real GDP, Index 2000=100; (b) Real GDP per capita
Source: author calculations based on OECD.stat

Table 3. Percentage of contribution for each country

Variable	Effect	Albania		Bosnia		Montenegro		North Macedonia		Serbia		Croatia		Greece		Bulgaria	
		ρ	k	ρ	k	ρ	k	ρ	k	ρ	k	ρ	k	ρ	k	ρ	k
X_1	Positive	24.43	2	6.41	0	14.11	1	9.56	0	6.24	0	17.89	1	13.31	1	8.2	0
X_2	Negative	4.66	4	9.71	4	12.01	3	9.6	4	14.38	3	14.45	3	16.89	3	18.3	3
X_3	Positive	26.29	2	11.49	1	21.5	2	7.82	0	8.36	0	14.6	1	5.65	0	4.33	0
X_4	Positive	29.49	2	13.43	1	17.4	1	6.07	0	8.65	0	17.34	1	4.66	0	2.99	0
X_5	Positive	10.2	0	12.47	1			16.42	1	10.28	0	18.32	1	23.59	2	8.77	0
X_6	Positive	15.32	1	15.8	1			16.59	1	17.67	1	12.84	1	14.31	1	7.49	0
X_7	Negative	17.1	3	14.16	3			8.03	4	8.48	4	19.96	3	17.18	3	15.13	3
X_8	Negative	3.7	4	10.58	3			26.68	3	22.84	3	1.53	4	6.07	4	28.63	3
X_9	Positive	3.33	0	18.13	1			3.79	0	17.12	1	18.91	1	8.99	0	29.77	2
X_{10}	Negative	9.84	4	16.55	3	12.41	3	18.33	3	14.13	3	9.76	4	8.11	4	10.91	3
X_{11}	Negative	4.95	4	11.13	3	11.81	3	16.34	3	16.46	3	11.56	3	8.25	4	19.53	3
X_{12}	Negative	5.05	4	11.34	3	11.89	3	16.47	3	16.9	3	11.33	3	7.74	4	19.33	3
X_{13}	Positive	14.96	1	14.38	1	19.91	1	7.99	0	10.98	1	8.37	0	10.43	1	13.03	1
X_{14}	Pozitive	5.49	0	6.39	0	9.8	0	3.74	0	8.57	0	20.02	1	27.89	2	18.17	1
X_{15}	Positive	14.82	1	12.58	1	12.27	1	11.87	1	13.81	1	11.39	1	9.71	0	13.59	1
X_{16}	Positive	7.81	0	7.98	0	11.3	1	9.33	0	10.08	0	17.92	1	22.95	2	12.67	1
Total			32		27		19		23		23		29		31		24

In table 3 are shown the results regarding each index and each country. Albania is performing better in the following indicators:

- Energy intensity, indicating that Albania has relatively lower energy consumption per capita compared to other countries in the study.
- Metals % of DMC: Albania has a lower share of non-renewable and environmentally intensive metal resources in its domestic material consumption.
- Mortality from exposure to ambient PM2.5: Albania has lower mortality rates associated with PM2.5 exposure.
- Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent: Albania has lower economic costs associated with premature mortality from PM2.5 exposure.

On the other hand, Albania is performing worse in the following indicators:

- Non-energy material productivity, GDP per unit of DMC: This suggests that Albania has lower productivity and efficiency in using non-energy materials for economic output.
- Forest resource stock: Albania has relatively lower levels of forest resource stocks, indicating potential challenges in forest conservation and sustainable management.
- Development of environment-related technologies, inventions per capita: Albania has lower technological innovation and advancement in environmentally related areas.
- Real GDP per capita: Albania has lower economic well-being and living standards compared to other countries in the study

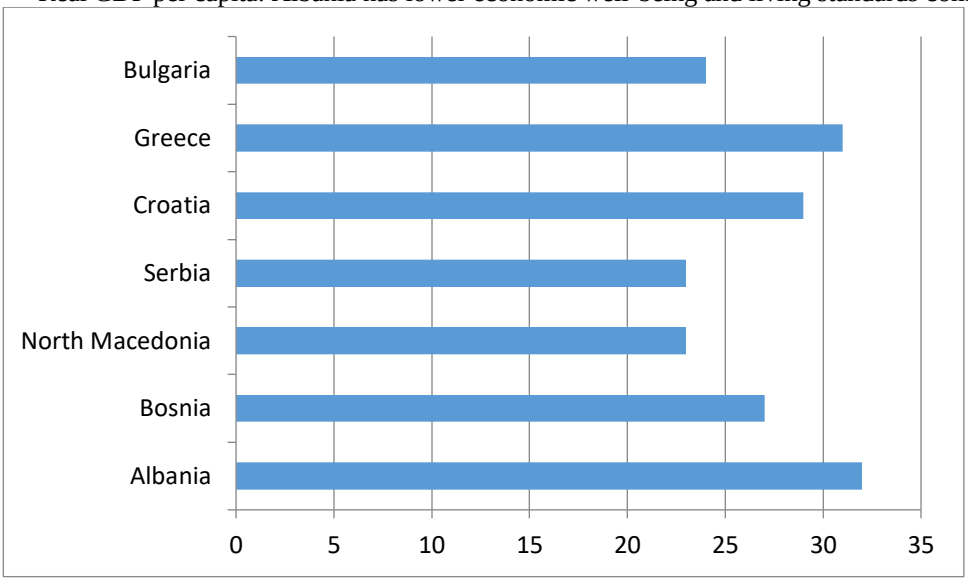


Figure 8 Coefficient of performance.
Source: author calculations based on OECD.stat

Figure 8 illustrates the coefficient of performance for each country, excluding Montenegro, because the data for 5 indicators are lacking. From both Table 3 and Figure 8, it can be observed that Albania has the best performance. Albania demonstrates a higher coefficient of performance compared to other countries, indicating a relatively better overall performance across the selected indicators. Greece follows Albania in terms of performance, displaying a relatively high coefficient of performance (31). North Macedonia and Serbia exhibit lower coefficients of performance compared to other countries, suggesting weaker performance across the selected indicators

5. Conclusions

The selected indicators from the OECD Green Growth database provide quantitative data and measurements that can be used to assess the effectiveness of policies, identify areas for improvement, and track progress over time. This approach enables researchers and policymakers to monitor the transition towards sustainable and resource-efficient economies, fostering environmentally friendly practices and promoting sustainable development.

By analyzing energy productivity and intensity, are provided insights into the relationship between economic activities, energy utilization, and environmental considerations. This comprehensive assessment can aid in understanding a country's performance in terms of energy efficiency, carbon emissions reduction, and overall sustainability. By embracing green energy strategies, countries can promote a transition towards cleaner and more sustainable energy systems while fulfilling their energy requirements.

The adoption of renewable energy sources, coupled with enhanced energy productivity and pricing, represents a promising pathway to reduce CO_2 emissions and address the pressing challenges of climate change and global warming.

Biomass is indeed a key component of the bioeconomy and offers an alternative to fossil resources. Its increasing demand stems from the transition toward a low-carbon economy, where renewable and sustainable sources of energy and materials are crucial for achieving long-term environmental and economic goals. Biomass, which is a natural renewable material obtained from agricultural, forestry, and household residues, offers the advantage of generating low or no-cost renewable energy while contributing to sustainable development and environmental protection.

The recognition of renewable energy is a significant component in the energy policies of Western Balkan countries. These targets are expected to drive the deployment of renewable energy technologies, promote sustainable energy development, and contribute to the overall resilience of energy systems in the region.

Utilizing forest resources in a steady and sustainable manner is crucial for long-term environmental and socio-economic benefits. By aligning the use of forest resources with the country's development goals, it becomes possible to optimize their value while ensuring the preservation and health of forest ecosystems for future generations.

Implementing measures such as stricter emission controls, promoting renewable energy sources, and enhancing air quality monitoring and management can contribute to reducing the health risks associated with ambient PM2.5 pollution. It's worth noting that the indicator "Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent" reflects the economic impact of premature deaths caused by PM2.5 pollution, and it serves as an important measure of the health and environmental consequences associated with air pollution.

The economic contexts can be influenced by various factors, including national economic policies, investment levels, market conditions, and global economic trends. These factors can contribute to the variations in economic performance and GDP indicators among the countries studied.

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Alterations affecting LRRK2 gene signaling in Parkinson disease

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Abstract

Parkinson disease (PD) is a chronic neurodegenerative pathology affecting both motor and nonmotor body functions. The prevalence of this disease is around 1% of the elderly over 60 years old, and up to 5% in people over 85 years old. It is characterized by difficulty in movement and constant shaking. Even though the majority of cases of PD are attributed to idiopathic or sporadic factors, 10% are of inherited genetic causes. Other afflicting factors depend on the age of the individual or environmental factors. One of the most common genetic mutations leading to late onset familial PD, are alterations of the LRRK2 gene responsible of coding leucine-rich repeat kinase 2 (LRRK2). Whilst the mutations in LRRK2 lead to increased activity in the brain and can induce neuron damages in the patients, the underlying mechanism is still unknown. Our study focuses on identifying possible mutations of non-synonymous nucleotide polymorphisms (nSNPs) in the LRRK2 gene and assessing their effects in the downstream signaling pathway. We analyzed 30 different variant mutations affecting LRRK2 with 3 mutation prediction tools to evaluate their effects on the encoded protein. This was coupled with several in silico software to analyze and predict the protein structure, its solvent and surface accessibility, changes in either structure or function of the corresponding amino acid and gene conservation. We elucidate the role of these mutations and their effects on the LRRK2 gene, and by extension the corresponding signaling pathway in PD.

Keywords: Parkinson disease, LRRK2, mutation, protein, signaling

1. Introduction

Neurodegenerative diseases are characterized by dysfunctional nerve cells that prematurely lose their function and die (Murphy et al, 2021). One of the most common neurodegenerative disorders is Parkinson's disease (PD) occurring in adults over the age of 40. In individuals younger than 40 years old the onset of this disease is much less common but not impossible. Studies have shown that males are at higher risk to develop Parkinson's disease either through inherited genetic mutation or exposure to stress factors and toxins. The key feature of PD is the abnormal accumulation of alpha-synuclein protein in the so-called Lewy bodies. The early symptoms are weakness, slower movements, muscle rigidity and continuous shaking (Dauer W et al, 2003).

The part of the brain that is more affected by neuronal degeneration is the pars compacta region of the substantia nigra where dopamine, one of the neurotransmitters, is produced. In healthy presynaptic neurons, dopamine is secreted to interact with its specific receptors expressed in the postsynaptic neuron. As a result, the postsynaptic neuron is activated and the signal is transmitted to the next cell. In case of Parkinson's disease, there is a lack of dopamine release form the presynaptic neuron leading to a block of the transmission of the signal (Rivero-Rios et al, 2020). This can be caused from several factors including a higher generation of reactive species, abnormal functioning of the mitochondria, mutations occurring mainly in Leucine-Rich Repeat Kinase 2 (LRRK2), alpha-synuclein, Parkin, Pink1 and DJ-1 (Joshi N. et al 2020).

Over the years, an extensive number of studies have been published in attempt to completely characterize the causative agent/s that led to the development of the Parkinson's disease. Hence, a definitive diagnosis is still not available. Investigations performed at the molecular level have emphasized the high occurrence of mutations in the LRRK2 gene in both familial and sporadic cases of PD. LRRK2 gene encodes for a large and complex protein with many domains including a GTPase domain and a serine-threonine kinase domain (Guaitol et al, 2016), making it susceptible to mutations. LRRK2 mutations are found in up to 40% of the cases with PD (Zhao Y. et al.2023) and induced an increase activity of the protein (Tolosa et al, 2020). Due to the protein complexity, it has been and still is difficult to specify all possible interactions with other up- and/or downstream proteins.

In this paper, we have focused on the assessment of 30 non-synonymous nucleotide polymorphisms (nsSNPs) by analyzing sequence homology of the LRRK2 gene, to identify the point mutations that affect the gene, the changes in its protein function, structure and phylogenetic conservation.

2. Material and Methods

The database of the NCBI (National Center for Biotechnology Information) (https://www.ncbi.nlm.nih.gov/gene) was utilized to gain access to the information about the LRRK2 gene, responsible for PD. The pathogenic SNPs mutations affecting LRRK2 gene were obtained from the NCBI Variation Viewer (https://www.ncbi.nlm.nih.gov/variation/view/). The protein sequences of the LRRK2 gene were acquired in FASTA format from the UniProt databases, which serve to support biomedical research by giving comprehensive overview of all known protein sequences and their function (Coudert et al., 2023). Analysis of the deleterious nature of the SNPs affecting the LRRK2 gene was achieved via computational algorithms:

1) SNAP2- is a trained classifier based on neural networks which predicts effects of the function of mutations. This algorithm differentiates between SNPs that have an effect and/or are neutral. It is also based on the evolutionary traits obtained from multiple alignments of the sequence (Hect M et al, 2015).
2) PolyPhen-2 (Polymorphism Phenotyping v2)- uses comparative and physical criteria to anticipate the effects on the structure and function of proteins when amino acids are substituted (Adzhubei et al, 2013).
3) SNP&Go- a predictive tool to analyze mutations which result in substitutions of amino acids residues in proteins (Calabrese et al., 2010).

Deleterious effects of mutations on protein function also affect other characteristics of the protein. One key issue, resulting in normal protein function, is structural stability. To assess this effect, iStable was used. iStable is an integrating predictor based on sequential and structural changes affecting protein stability, which provides a series of new designs for the novel protein (Chi-Wei Chen et al., 2013). The LRRK2 gene downstream signaling is responsible for a series of functions affecting the brain, ranging from neuronal development and function, synaptic function and responses, homeostasis and several immune responses. Changes in this signal leads to aberrant communications between other interacting proteins connected to LLK2. In order to analyse these interactions between LRRK2 and other proteins to assess their importance, STRING (Search Tool for the Retrieval of Interacting Genes) databases tool was used (Szklarczyk et al, 2019). NetSurfP-2 was used to assess a variety of characteristics necessary to consider a protein as normal. This instrument is used to generate accurate predictions regarding structural disorders, changes in dihedral angles, secondary structure of the protein and lastly, solvent accessibility for every single amino acid residue in the sequence (Michael Schantz Klausen et al., 2019). Structural and/or stability adjustments comprise one key aspect of the normal function of proteins. The level of conservation of the gene is regarded as another major factor of normal protein function. Residues, part of the protein sequence, when substituted by other amino acids, result in one of two situations:

A) Loss/malfunction of function of the protein
B) Loss of structure

Either one of these changes lead to damage to normal metabolic and biological activity. The algorithm used for this assay was ConSurf, used to predict profiles of conservation of the evolution of proteins (Ben Chorin A et al., 2020).

3. Results and Discussion

The LRRK2 gene plays an important role in the human brain. It is important for the synthesis of the dardarin protein and it also helps to control and repair the damage of the macrophages'endomembranes. In order to assess the interactions of the LRRK2 protein with other proteins inside the cell, STRING was used. Figure 1 shows the relation between these proteins, creating a network responsible for the normal function and structure of the cell. Some of the major connections are between LRRK2 and DVL1, responsible for the activation of the Wnt signal leading to development and proliferation of the brain. Another major connection is with the ARHGEF7 and RAB29 protein, in control for the activation and regulator of the LRRK2 gene respectively. This network of proteins shows a clear picture of the important role of the LRRK2 gene and the damage mutations affecting this protein and it's signaling pathways can create. In order to evaluate the damage of these mutations computational algorithms were used and data is shown on table 1:

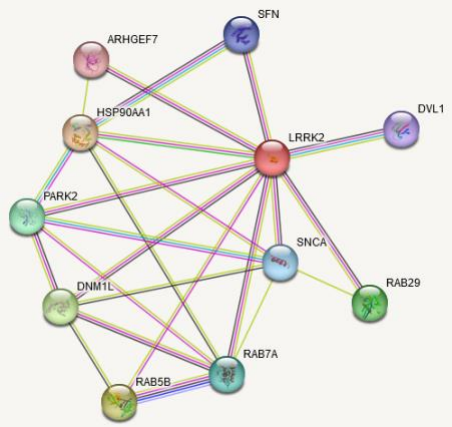

Figure 1: Protein-protein interaction of the LRRK2 protein in the brain

Table 1: Deleterious/neutral effects of mutations affecting LRRK2

	SNAP2		PolyPhen		SNP&Go	
Mutation	Effect	Score	Effect	Score	Effect	Score
V21R	effect	46	damaging	1	disease	6
A211V	neutral	-71	benign	0.01	neutral	1
H230R	effect	34	damaging	0.95	disease	5
A397T	neutral	-40	damaging	0.7	disease	1
G472R	effect	82	damaging	0.99	disease	7
Q501W	effect	77	damaging	1	disease	5
L550W	effect	76	damaging	0.99	disease	8
N551K	neutral	-50	damaging	1	disease	9
T1343V	neutral	-25	damaging	0.88	neutral	6
K1347A	effect	60	damaging	1	neutral	7
T1348N	effect	26	damaging	1	neutral	7
R1398H	neutral	-10	damaging	1	neutral	4
R1398L	effect	7	damaging	0.99	neutral	1
K1423K	neutral	-96	benign	0.01	neutral	
N1437H	effect	54	damaging	1	neutral	7

	SNAP2		PolyPhen		SNP&Go	
Mutation	Effect	Score	Effect	Score	Effect	Score
A1440P	effect	75	damaging	1	neutral	7
R1441C	effect	8	damaging	1	neutral	3
R1441G	effect	32	damaging	1	neutral	3
R1441H	effect	8	damaging	1	neutral	4
R1628P	effect	43	damaging	1	neutral	4
Y1699C	effect	71	damaging	1	neutral	2
S1761R	effect	31	damaging	1	neutral	7
K1906M	effect	83	damaging	1	neutral	7
D1994A	effect	90	damaging	1	neutral	2
D1994N	effect	88	damaging	1	neutral	5
D1994S	effect	89	damaging	1	neutral	3
G2019S	effect	85	damaging	1	neutral	2
I2020T	effect	36	damaging	0.98	disease	0
Y2064K	effect	83	damaging	0.9	neutral	0
G2385R	neutral	-44	benign	0.057	neutral	4

Thirty mutations were taken into account and analyzed by three algorithms. SNAP2 results showed that 23 mutations (77%) are predicted to have an effect on the gene and only 23% were tolerated. SNAP2 prediction score is linked to the severity of the effect shown. This is numerically scored: high scores, Score >50 is predicted to have sever effects on the protein. Intermediate effects are found in the interval between -40<score <50, whereas neutral substitutions considered as low scores are found score <-40. Out of the 23 mutations that show an effect, only 7 of them are not considered severe in nature. The rest are predicted to show substantial changes affecting the role or structure of LRRK2. The next software used was PolyPhen. This algorithm found and predicted that out of the 7 neutral sites, another 2 (N551K and T1343V) were considered damaging as well. The remaining five are considered to benign (B) even if they were to exhibit any particular effect. This predictor toll analyses with a very high sensitivity (98-99%) and specificity (99%). The data showed that apart from the A397T mutation, which has a score of 0.7, all the rest of the damaging mutations have an extremely high score value, ranging form 0.95- 1. The last tool used to predict these effects was SNP&Go. This tool is based on support vector machines, with a scoring accuracy of 82% and Matthews correlation coefficient of 0.63. another factor to be taken into account is the Reliability index (RI) with a score from 0 (unreliable) to 10 (reliable). Most of our mutations, which were predicted as having an effect or being damaging, were shown to not have an effect on the protein. Even though they are predicted as neutral, it must be mentioned that they also have a low RI score, making them questionable regarding their position and effect on the protein. 5 mutations (V21R, H230R, G472R, Q501W, L550W) were considered as having an effect leading to protein damage or disease by all three predicting tools with a high RI and score. Only three (A211V, K1234K, G2385R) were considered neutral by all three software with high scoring values, and the rest were considered deleterious or neutral by two predicting tools. It must also be mentioned that even though the G2385R mutation is considered as neutral and/or benign, several studies have shown that it is responsible for the onset of PD in Asian populations (Carrion MDP et al., 2017, Di W et al., Zhang Jinru et al., 2021, Tezuka Y et al., 2022). Since this mutation affects the brain over a long period of time and

has a slow progression, it is usually considered as non-deleterious, because it is not directly linked with PD progression, but rather it aggravates the brain environment and further progresses aging (Toshiki T et al 2022).
In order for a protein to function normally, proper folding is a must to achieve the third dimensional structure to make it specific (Joshi N et al., 2020). If this folding is incorrect, it leads to the formation of protein clumping. According to Snyder and Wolozin., 2004, the aggregation of alpha-synuclein proteins bind and inhibit the activity of the proteasome. This dysfunctional proteasome is thought to contribute to the severity of PD pathology. To elucidate the homeostasis levels of the mutated proteins we used iStable to analyze whether they retain their normal structure and function or they suffer losses:

Table 2: Protein stability and conservation

Mutation	Stability	Score	Protein residues		Conservation
V21R	decrease	0.86	exposed	function	conserved
A211V	increase	0.8	buried	structure	neutral
H230R	increase	0.63	buried	structure	neutral
A397T	decrease	0.84	buried	structure	variable
G472R	decrease	0.75	exposed	function	slightly conserved
Q501W	increase	0.8	buried	structure	conserved
L550W	decrease	0.8	buried	structure	slightly conserved
N551K	decrease	0.76	exposed	function	conserved
T1343V	increase	0.7	exposed	function	variable
K1347A	increase	0.74	buried	structure	conserved
T1348N	decrease	0.64	exposed	function	conserved
R1398H	decrease	0.67	exposed	function	slightly conserved
R1398L	increase	0.69	exposed	function	slightly conserved
K1423K	increase	0.7	exposed	function	slightly conserved
N1437H	decrease	0.82	exposed	function	conserved

Mutation	Stability	Score	Protein residues		Conservation
A1440P	decrease	0.66	exposed	function	slightly conserved
R1441C	decrease	0.71	exposed	function	conserved
R1441G	decrease	0.77	exposed	function	conserved
R1441H	decrease	0.74	exposed	function	conserved
R1628P	decrease	0.73	exposed	function	slightly conserved
Y1699C	decrease	0.72			slightly conserved
S1761R	increase	0.8	buried	structure	slightly conserved
K1906M	increase	0.61	buried	structure	conserved
D1994A	decrease	0.87	buried	structure	conserved
D1994N	decrease	0.85	buried	structure	conserved
D1994S	decrease	0.87	buried	structure	conserved
G2019S	decrease	0.79	buried	structure	conserved
I2020T	decrease	0.84	buried	structure	slightly conserved
Y2064K	decrease	0.74	buried	structure	conserved
G2385R	decrease	0.83	buried	structure	variable

The ten most known mutations as causative for onset of PD or aggravation of the pathology (N1437H, R1441C/G/H, R1628P, Y1699C, S1761R, G2019S, I2020T and G2385R) all show a decrease in protein stability. All the results are scored very high with a confidence score of more than 0.7. Our data shows that these mutations are negatively impacting the afflicted patient and increasing the severity of the pathology. Studies have shown that the increase in protein stability, meaning lower degradation and lesser aggregation is modulated by molecular chaperones that help the proteins to refold when they are misfolded or unfolded (Kim Y.E et al 2013, Joshi N et al., 2020). In the cases where an increase in protein stability is observed, the mutated protein may not have a deleterious effect on the gene, or it may indirectly impact the disease and the destabilization of the protein may not be very high.
Another component we took issue with was the conservation of the gene, it having a key role in normal biological and metabolic functions. Any substitution of the amino acids position in the protein could create a dysfunctional protein with abnormal structure. The higher the level of conservation, the higher the risk of aberrant protein function/structure is. Our analysis showed that 15 mutations showed high levels of protein conservation, and the changes affecting it have shown increased levels of PD severity. Ten were showed to be slightly conserved, 3 were neutral and only 2 were considered variable. This protein is presented as conserved and small changes in its structure have led to aberrant signal and function. Consurf, in tandem with NetSurfP 2, predicted a model which elucidates the role of these amino acid residues. If the residue is predicted in the buried position, this signifies that the changes affecting the protein are of structural importance. If the residues are predicted as exposed, they are considered as having a functional role. 15 out of 30 mutations showed they play a structural role, 14 have a functional role and 1 is still uncharacterized.

Figure 2: Amino acids conservation analysis with ConSurf

Figure 2 shows clearly the position of the mutations we analyzed and the level of conservation each of them has. As previously mentioned, this protein is quite conserved and relatively large (2527 amino acids). This is of particular interest because being such a large protein with a high level of conservation and variability the probability for error is quite significant. The number of studies regarding this protein are numerous, especially for its role in late onset PD. Nonetheless the number of known mutations that affect this protein is still low. Our approach tried to implement a higher number of SNP mutations to ascertain the effects they might have on the LRRK2 protein. One of the issues sometimes presented with in silico approaches is the presence of differences between the results with different tools for the same point mutation. Event though the accuracy and specificity of these tools is relatively high, there is still the necessity for a more complex and extensive assessment for these diseases.

4. Conclusions

Our study focuses on assessing and elucidating the effects, role and function of SNPs affecting the LRRK2 protein, responsible for Parkinson's disease. Until now the number of known deleterious point mutations affecting this protein is still low, and our approach found a higher number of mutations that affect the protein, leading to possible harmful effects, destabilization of the whole protein and changes in its structure. Even though our study showed these possible effects affecting the LRRK2 gene and its impact on Parkinson's disease, laboratory experiments are necessary to provide conclusive evidence for

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