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Article

Sustainable Green Educational Paths in the Italian Higher Education Institutions: A Text Mining Approach

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Abstract: In response to the global imperative of environmental sustainability, higher education institutions play a pivotal role in shaping a green-conscious society. This study delves into the landscape of Italian university education, analyzing the green educational offer and examining the degree programs with a dedicated focus on environmental sustainability promoted during the academic year 2021–2022. For this purpose, we employed statistical-textual analyses techniques to examine the texts describing the educational objectives and the expected professional outcomes after the completion of the study paths for 179 Italian green degree courses (BA and MS), analyzing a corpus resulting in 144,709 occurrences. In particular, the multifaceted nature of the green educational approach, including its multidisciplinary and interdisciplinary orientation, attention to territorial dynamics, intersectoral collaboration, and the balance between theoretical and applied training, are studied. The results reveal an integration of these crucial elements within the Italian university educational offer. This research addresses the growing importance of environmental sustainability in higher education and provides insights into how Italian universities contribute to this global discourse. The findings contribute to ongoing discussions on refining educational strategies, aligning with global sustainability goals, and fostering a generation of environmentally conscious and skilled professionals.

Keywords: environmental sustainability; higher education institutions; green educational approach; Italian university; green degree courses

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1. Introduction

Sustainability and sustainable development have by now become keywords in the contemporary world. The increased awareness of the climate emergency has brought the need to act for a more sustainable future to a large audience of key actors committed in both civil society and political institutions. Despite this new consciousness, declared intentions do not always translate into concrete actions. Hence, it is necessary to develop a wide-ranging reflection that involves various areas of intervention capable of fostering the development of specific skills in support of sustainability. This need has inevitably opened a reflection on education for sustainability, launched during the 1992 United Nations Conference in Rio de Janeiro. On that occasion, the need for an educational focus on sustainable development, for an increase in public awareness of environmental issues, and for specific environmental training aimed at educators were underlined (For further insights on the contents of the Rio de Janeiro conference, see [1]). Furthermore, given the importance attributed to culture about sustainability, education for sustainable development has been expressly mentioned among the 17 Sustainable Development Goals (SDGs) described in the 2023 UN Agenda, and set as a specific target of the fourth goal ‘Quality education’: “By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, thorough education for

sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (target 4.7).

It is evident, as underlined in various documents produced by the European Union and the United Nations [2–8], the central role played by training agencies at different levels (schools, universities, etc.) in the context of sustainable development and green transition, another key concept of contemporary society.

On that basis, it is our interest to investigate the way in which higher education institutions (HEI) face the challenge of environmental sustainability and which implemented strategies and actions contribute to defining the 'green university'.

There are three main aspects on which the academic institution can work to facilitate the ecological transition and sustainable development: 1. 'teach to do things for the environment', that is, design study programs for environmental sustainability; 2. 'do things for the environment', that is, implement environmental sustainability practices; 3. 'building network for the environment', that is, cooperate to define new content and new shared operational strategies.

Regarding the role that the university should assume for a future in the name of sustainability, the literature first recalls the essential contribution it can provide through educational planning. In fact, it is essential to increase courses of study on sustainability, aimed at boosting young people's awareness, their knowledge of the conceptual tools for understanding sustainability processes, and the skills to adequately face a global transition towards a more sustainable world [9].

Secondly, a sustainable university reduces its impact on the environment: it has eco-sustainable buildings, is committed to appropriate land use planning, reduces energy consumption, and makes efficient use of resources (ibidem).

Lastly, it is a shared opinion that the processes that guide sustainable development are more efficient when they involve different actors, both within the same context and from different fields/sectors [10]. Regarding the higher education context, cooperation should take place at several levels:

- a. Intra-institute cooperation, which intends the collaboration between all the actors of the university world (professors, students, administrative staff, people who hold institutional roles) to ensure long-term stability of the internal actions undertaken in favor of environmental sustainability [11,12].
- b. *Inter-institute cooperation*, which intends the coordination among various universities to harmonize institutional activities aimed at disseminating environmental culture and good sustainability practices.
- c. Inter-sector cooperation that increases the synergy within the so-called "knowledge triangle", that is, between scientific world, educational world and business world. As underlined by the EU, HEIs should act with the aim of becoming "civic-minded learning communities connected to their communities" [13] (p. 7).

In relation to the three main fields of intervention characterizing university action in favor of sustainable development, this work will focus on the aspect related to the design of study courses for environmental sustainability. It is considered particularly important to dwell on this aspect, since the education for sustainable development is not yet fully disseminated, even though universities have acquired awareness of the role of higher education in the processes that facilitate a sustainable future and are committed to implementing practices in favor of the green transition [14]. For this reason, while acknowledging the progress made by many Member States in this sense, the European Union insists in the recent recommendations of 2022 on the need to step up efforts to further develop policies and practices in favor of sustainable development learning, paying particular attention to environmental topics.

Sharing these considerations and recalling again the recommendations of the European Union regarding the need to develop a "green skills set for the labour market with a

view to creating a generation of environment-conscious professionals and green economic operators, integrating environmental and climate considerations into general education, higher education, vocational education and training as well as research" [7] (p. 2), in this study, the Italian context is observed in particular.

2. Literature Review

As already mentioned, education plays an essential role in facing issues related to climate change. With ever increasing attention, universities are responding to the request to design educational paths aimed at promoting environmental sustainability and at facilitating the achievement of the SDGs [14], also providing for the involvement of different social actors (political, entrepreneurial, social) in an intersectoral perspective [15]. The objectives of the UN, in fact, have produced an intensification of the planning and launch of study courses, research activities, and interventions focused on strategies for implementing the green transition [12]. In this direction, an ever clearer image of sustainable university has emerged in recent years, which — taking up the words of Velazquez et al. — could be defined as "a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles" [16] (p. 812).

Promoting sustainability in the university world implies the adoption of 'whole-university approaches', i.e., multidisciplinary, interdisciplinary and transdisciplinary approaches in the definition of study programs and the contents of university curricula, in research initiatives, in institutional policy actions, and in awareness-raising activities on sustainable development [14]. However, the integration of sustainability in the practices of HEIs is still often fragmented (*ibidem*) because there is not a widespread agreement about which competences should be included in sustainability training programs [17]. Moreover, as reported in a recent document of the European Commission [18], the inclusion and integration of competences for sustainability in learning programs is at the discretion of the training institutes (schools, universities, etc.).

The difficulty that can be encountered with respect to the integration of sustainability in teaching proposals is well highlighted in a study by Reid and Petrocz published in 2006 [19]. In their research, the two authors investigate the relationship, which in the professors' perspective is defined or can be defined between specific teaching and sustainability issues. The results of the research reveal three different conceptions of this relationship:

1. According to the "disparate" conception, teaching and sustainability are two unrelated ideas, and are seen as two separate entities: "teaching focuses on the content of a subject and 'covering' a syllabus, sustainability is seen as keeping something going or the 'green' approach" (p. 113).
2. According to the "overlapping" conception, the teaching activity focuses on the reference discipline and on the topics that define the study program, albeit with some 'strategic' reference to the concept of sustainability (e.g., using concepts/data/materials concerning environmental sustainability when possible as explanatory examples of topics of the teaching subject). As the authors explain, "the notion of sustainability overlaps to an extent with the activity of teaching; teaching is seen as ensuring that students understand the substantive content of the course; teachers see that specific ideas such as environmental or cultural sustainability could be incorporated in their teaching (as examples, etc.) but only to the extent that the situation allows" (p. 114).
3. According to the "integrated" conception, the concept and theme of sustainability are specific to the teaching and are 'naturally' integrated. As the authors explain, "in this conception, sustainability in all its guises is an essential component teaching; teaching is seen as encouraging the students to make a personal commitment to the area represented by course content, including sustainability as part of that" (p. 114).

Although some progress has certainly been made in integrating the issue of sustainability into educational programs since the publication of the study, approaches to sustainability education may still be affected today by the problems highlighted by Reid and Petrocz. In this regard, Tassone et al. [20] propose an operational definition of Responsible Research and Innovation (RRI — Term used by the EU to describe processes of scientific research and of technological development that concerns and potential impacts on the environment and society) in higher education and discuss some elements for the (re-)design of study programs. Investigating the educational fields of technical sciences and engineering, social sciences and humanities, and the interactions between them, they propose three educational design principles: 1. Education for society; 2. Education with society; 3. Educating whole persons.

The first principle, *Education for society*, concerns an ‘applied knowledge’ that allows students to deal with real problems and respond to society’s problems, benefiting from transversal and interdisciplinary training.

The second principle, *Education with society*, taking up the invitation of the European Commission to all stakeholders “to work together for inclusive and sustainable solutions to our societal challenges”, concerns “collaborative, social, and trans-disciplinary learning”. In particular, it refers to a training action that prepares and educates students for dialogue and interaction between the various actors (academic, social, entrepreneurial and institutional), promoting knowledge of multiple perspectives.

The last principle, *Educating whole persons*, refers to the complementarity of three different learning domains: cognitive learning, or ‘learning to know’, through which critical thinking is developed; affective learning, or ‘learning to be’, which develops affective skills and relational skills useful for collaborating with others; and psycho-motor learning, which is, ‘learning to do’, which concerns the behavior and the tangible expression of individual abilities (for example the development of multi-perspective communication strategies).

According to the authors, “in practice those three learning domains need to be interwoven and challenged simultaneously (e.g., Barnett 2007), for example through experiential or praxis-oriented learning processes that support students to learn while ‘walking the change’ as proposed by Wals et al. 2016” (p. 345).

Sharing the principles proposed by the authors, it is possible to define some elements that should recur in the educational offer aimed at enhancing green issues and developing skills related to green jobs: 1. the adoption of a multidisciplinary and transdisciplinary training orientation; 2. attention to the territory, that is, the definition of educational programs that are in synergy with the territory in which they are provided; 3. an intersectoral approach, which favors dialogue and collaboration with other stakeholders in the public and private spheres (politicians, public administrators, entrepreneurs, social players, etc.); and 4. the balance between theoretical training and applied and professionalizing training, to facilitate entry into the world of work. These elements are to be considered closely connected to each other and, in some ways, inseparable.

Refer to the first element, as Sekamatte [15] recalls, taking up Nussbaum et al. [21], some authors argue that universities should address issues related to climate change and strategies to combat its negative effects—as well as the various issues related to sustainability broadly considered—across all disciplines and take this broadly into account when designing curricula, developing global approaches to sustainability education (see also [22]).

Furthermore, the design of an educational offer oriented towards green issues should evaluate the peculiarities of the territory in which it is provided to optimize the training action considering the recommendations expressed by international institutions. In fact, as Cerutti and colleagues underline, in the processes of sustainable development and in the implementation of the UN 2030 Agenda, territorial awareness on the part of local communities takes on great importance: “the ‘awareness of place’ [23], intended precisely as awareness of the existence of values, symbols and norms that insist on it, manifests

positive and lasting effects, stimulating forms of collaboration, favoring the rediscovery of the local heritage, facilitating the promotion of initiatives and the enhancement of the specific features of the territory, which constitute element of differentiation” [24] (p. 54). In fact, the authors continue, saying that an international level particular importance is given to the ‘territorialization’ of the SDGs and, taking this into account, local administrations must provide a cooperation infrastructure that favors shared decision-making processes, make economic resources and skills available, and incentivize forms of collaboration. This is an infrastructure which the university world must be a part of, assuming the role of activator of the local development processes (see also: [25,26]).

Therefore, multi-actor cooperation becomes central, favored by an inter-sectoral approach where the university must be the promoter and spokesperson. The need for a synergistic intervention by the government, institutions, and social parties in various strategic sectors (including research and training) emerges with ever greater evidence, in order to generate ‘green skills’ and professionalism that facilitate the ecological transition and sustainable development processes [24]. In fact, the need for a ‘new contract between science and society’ is evident, which creates a ‘bridge’ between science and society, aimed at strengthening the synergy between the academic community and the rest of society, and to help young people navigate the contemporary ‘super-complex’ world [20]. An aid that the University can provide is by engaging in the design of educational paths capable of adequately balancing theoretical and applied training, favoring the development of professionalizing skills useful for satisfying the renewed needs of companies.

3. Cognitive Objective, Methodology, and Description of the Case Study

Keeping in mind the observations expressed in the literature about the role of the university in the green transition and on the definition of a green educational offer, as anticipated, the proposal of degree courses (DC) in Italy will be studied in this work. In particular, through the use of statistical analysis techniques of textual data, the educational offer promoted by Italian universities in a.y. 2021–2022 is analyzed, pursuing three main objectives: 1. investigate the training orientation of the Italian university related to green issues; 2. detect the main fields of interest and intervention strategies about environmental sustainability; 3. trace the presence or absence of the defining elements discussed above (multidisciplinary and interdisciplinary approaches, territorialization of the study courses, intersectoral approach, balance between theoretical and applied training).

Overall, 5432 degree courses were provided in the reference period, 47.61% were bachelor’s degrees and 52.39% master’s degrees. Researching the presence of certain keywords within the denomination of the DC, 182 (3.4%) degree courses which provided an educational offer on green topics were identified. Looking at the distribution of green degree courses (GDC), it is possible to note, first of all, that there are more master’s degrees focused on environmental sustainability than bachelor’s degrees (63% green master’s degrees vs 37% green bachelor’s degrees).

These data highlight these topics are considered more specialized, although the presence of 37% of bachelor’s degrees also indicates a tendency to create professional profiles that give access to job positions which can be accessed with a three-year degree. There are significant differences, however, in regards to the attention dedicated to green issues in the various scientific-disciplinary areas: GDCs are mainly activated in the scientific-technological disciplinary area (they are around 80%) and, to a much lesser extent, in the humanistic-social disciplinary area (they are around 20%); they are completely absent, however, in the medical and health areas.

As mentioned, once the GDCs were identified, a statistical-textual analysis was conducted of the content of the educational offers proposed by the Italian universities on the topics of interest to the research, which will be discussed in the next paragraph. For our purposes, the texts of the paragraphs relating to the description of the educational objectives of the degree course and the professional opportunities foreseen at the end of the study course, published on the university websites, were manually collected. To allow the

partitioning of the text on the basis of determinate attributes and, therefore, to carry out specific analyses on groupings of text segments (e.g., the analysis of the specific language), the following variables have been associated with the single texts:

- DC identification code;
- Size of the university (n. of students)—up to 29,000, from 30,000 to 59,999, 60,000 and beyond;
- Disciplinary area—scientific-technological, humanistic-social, medical, health (The disciplinary area variable provides for four modalities, but as can be seen from the descriptive analyses carried out on the database of all the Italian degree courses presented above, there are no GDC pertaining to the medical and health disciplinary areas.);
- Degree course level—bachelor’s degree or master’s degree;
- Geographical area—north-east, north-west, centre, islands, south;
- Course delivery language—Italian, English, bilingual, trilingual.

Before proceeding by illustrating the data that emerged from the statistical-textual analysis, it is useful to make some clarifications on the necessary operations of the preparation and pre-treatment of the corpus. Preliminary explorations of the text guided the pre-processing phase of the corpus, during which the following cleaning operations were carried out:

- Correction of some typos present in the collected texts;
- Elimination of numerical characters deemed irrelevant following an initial exploratory analysis;
- Treatment of alpha-numeric strings relating to acronyms of scientific disciplinary sectors and degree classes (e.g., ‘ICAR 01’ recoded into ‘icar_01’, ‘LM 30’ recoded into ‘lm_30’, etc.), recoded as multi-words because they were considered relevant for the specific discursive context;
- Elimination of dates;
- Elimination of hyperlinks;
- Identification and treatment of recurring acronyms and denominations to make them homogeneous in the corpus (extended denominations brought back to their acronym/reduced denomination—e.g., ‘National Institute of Statistics’ recoded into ‘Istat’, ‘disciplinary scientific sector’ recoded into ‘ssd’, etc.).

Furthermore, as often happens when dealing with specialized corpuses, for a more precise statistical-textual analysis, an extraction of the repeated segments characteristic of the discursive context was made. Subsequently, the n-grams with a number of occurrences equal to or greater than 10 were recoded as multi-words in order to allow their recognition within the corpus vocabulary.

4. Exploring the Corpus: Key-Themes and Strategic Axes of the Italian Green Educational Offer

The corpus, pre-processed and subjected to parsing and normalization processes, is of medium size. It has a total of 144,709 occurrences (tokens), 7988 forms (types), and 2922 hapax.

The calculation of the main lexicometric measures (Table 1) confirms the adequacy of the corpus for an automatic treatment of the text, except for the Giraud index, which, however, is just below the threshold of 22.

In this first analysis, the corpus is not lemmatized to allow for a better disambiguation of the terms (The *Lemmatization* converts the inflected form of words into the corresponding lemma. Normally, in the Italian language, nouns and adjectives are transformed into the masculine singular form and verbs into the infinitive.).

Table 1. Corpus lexicometric measures.

Lexicometric Measures	Values
N. of text	179
N. of occurrences (N or else tokens)	144,709
N. of forms (V or else types)	7988
N. of hapax ¹	2922—20.2% of occurrences; 36.58% of forms
N. of average occurrences per text	808.43
Type/Token Ratio (TTR) ²	5.52
Zipf's law ³	1.3
Giraud Index ⁴	20.99

¹ Hapax are forms that appear only once in the text and should be less than 50% of all forms in the corpus. ² The TTR index is the ratio between the forms (V) and the occurrences (N) of the corpus, according to the formula $V/N \times 100$. A corpus is considered adequate for lexicometric analysis if its value is less than 20%. ³ Zipf's law considers the relationship between rank and frequency of words; in fact, the frequency is inversely proportional to the rank according to a constant increase coefficient. This law is expressed with the following equation $c = f^r$, where f = occurrences, r = rank, and the coefficient a is well approximated by the ratio $\log N / \log V$ [27]. Values equal to or less than 1.3 indicate a good lexical richness of the text. ⁴ The Giraud index measures the lexical richness of a corpus. Calculated according to the formula, VN is less affected by the size of the corpus than the TTR, since it puts the square root of the occurrences in the denominator. Values above the threshold of 22 indicate greater lexical richness [28].

An initial exploration of the corpus brings out the use of theme-words (Figure 1)—those which record the medium frequencies and which, therefore, specifically characterize the corpus—relating to the green theme (*ambiente, territorio, ambientale, ambientali, sostenibilità*; eng. trans.: environment, territory, environmental, sustainability), to the main actions and main objectives (*gestione, attività, analisi, sistemi, processi, progettazione, sviluppo*; eng. trans.: management, activity/activities, analysis, systems, processes, design, development), and to both the university training and working context (*competenze, ambito, capacità, conoscenze, ingegneria, laureato, tecnologie, settore*; eng. trans.: competences, scope, skills, knowledges, engineering, graduate, technologies, sector).

In particular, the frequent use of these words highlights the contact with the territory and the need to create and consolidate a synergy between the university world and the working world, promoting 'strategic' actions and activities linked, on the one hand, to development and to innovation, on the other hand, to the resolution of existing problems and situations.

The full words (or meaningful words) that record the highest occurrence in the text, the word *gestione* (eng. trans.: management) and the word *ambiente* (This word is present in its inflected forms, as a noun and as an adjective both singular and plural, *ambiente/ambientale/ambientali* – eng. trans.: environment/environmental), represent the key concepts around which the entire corpus is defined. In particular, what emerges from the analysis of the concordances is interesting, which allows us to explore the different contexts of use of the words. The word *gestione*, especially, is declined in three main ways, which coincide with different training objectives aimed at defining specific professional profiles:

1. First strategic axis: Environmental protection—the purpose of creating professional roles specialized in the management of various territorial contexts is highlighted, which is developed with respect to three main aspects: (a) management of environmental risk and control of environmental impacts; (b) management of emergencies and natural events; (c) economic and ecological management of environmental resources and infrastructures.
2. Second strategic axis: Planning and consulting—the purpose of creating professional roles capable of developing and coordinating projects to provide business advice to companies with respect to the management of projects and activities, of services, of

production processes, of collaboration networks, and of advertising campaigns and communications is highlighted.

3. Third strategic axis: Technological interventions—the purpose of creating professional roles specialized in the design of structures and systems, environmental technologies/instruments, and in the management of technological interventions is highlighted.

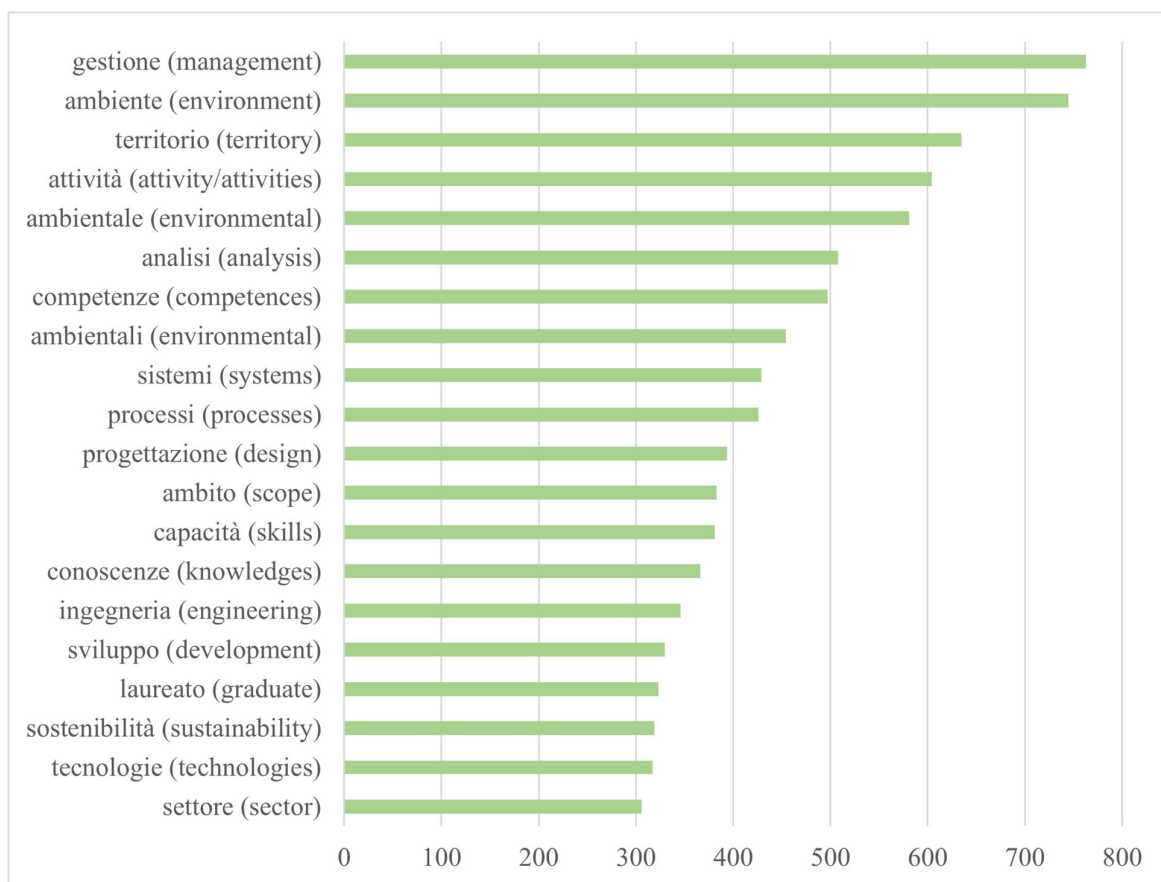


Figure 1. Top 20 keywords of corpus.

Territorial Awareness and Degree-Level Differentiation: The Analysis of Specificities on the Corpus

Continuing with the lexical analysis, the calculation of specificities, i.e., the extraction of the characteristic language of a part of the corpus defined according to a classification variable, was elaborated.

Considering the geographical area variable, the study of the specific language brings particular attention to specific thematic aspects or different fields of action according to the geographical area in which the degree courses are offered.

The universities of the north-east area of Italy focus their green educational program in the sector of agriculture and livestock, with particular attention to animal and plant production, to development of low-carbon technologies, and to the management of soil in agriculture.

The educational program proposed by the GDCs provided in the north-west area of the country is more oriented to the industrial, technological, and engineering sector, with specific focus on the mountain environment. This datum reflects the characteristics of the territory, in which the most active industrial hubs of the country are concentrated.

Concerning the area of Central Italy, the analysis highlights a clear reference to the socio-humanities and communication disciplines. This confirms what emerges from a further statistical-descriptive analysis of the Italian DCs. In fact, almost half of the GDCs that pertain to the humanistic-social area are gathered in Central Italy (45%).

The green training offer proposed in the islands focuses more on the protection, defense, and management of the territory, with particular reference to the marine and coastal areas. Furthermore, an in-depth study conducted through the analysis of the concordances and the reading of the specific denominations of the DCs has revealed, on the one hand, attention dedicated by the courses provided in Sardinia to the development of sustainable tourism, and on the other hand, a specialization in field of energy and nuclear engineering offered by the courses provided in Sicily.

Finally, the texts of the educational program proposed in southern universities are characterized by the prevalence of terms that refer to the energy sector and civil and environmental engineering, with particular attention to the issue of safety and protection of the territory. Furthermore, a precise openness to multidisciplinary emerges. In this regard, it should be noted that Southern Italy in recent years has experienced particular events connected to environmental disasters and the mismanagement of plants with repercussions on environmental well-being and on the population, circumstances that explain the need to invest in training activities focused on environmental safety.

These data confirm that Italian universities possess that ‘awareness of place’ cited by Magnaghi [23], which allows the ‘territorialization’ of the teaching proposal, an essential element in the definition of the green educational offer. In fact, the Italian GDCs seem strongly focused on the characteristics of the reference area, confirming the deep bond with it and the shared willpower to enhance and protect the resources of each area to foster local development and innovation.

The corpus was also analyzed considering the degree level variable, observing the specificities of the educational program of the bachelor’s degrees and those of the master’s degrees separately.

As for the bachelor’s degree programs, in addition to the more obvious introductory aspects related to learning basic knowledges in the various disciplines — evident from the occurrence of terms such as *fisica, chimica, matematica, base, scienze* (eng. trans.: physics, chemistry, mathematics, basics, sciences) — the specificities analysis highlights a particular attention to the territory and to the agro-food sector. Among the most characterizing terms, in fact, we also find *agrario, forestale, montano, agroforestale, cibo, scienza del territorio, riserve, and consorzi* (eng. trans.: agrarian, forestry, mountain, agroforestry, food, land science, reserves, consortia). Moreover, the use of words such as *junior, mondo del lavoro, proseguire, pianificare, and scopo* (eng. trans.: junior, working world, to continue, to plan, purpose) defines a projection towards the future, both in relation to the university career and in the working world.

In a complementary way, the proposal of the master’s degree courses underlines more specialized aspects linked to the learning of advanced knowledge and skills in the various disciplines; however also emphasizing an openness both towards international dimension and towards multidisciplinary and the intersectoriality.

5. Analysis of the Educational Objectives Sub-Corpus and Professional Opportunities Sub-Corpus

According to the methodological choices that guided the textual data collection, distinguishing the sub-corpus made of texts that describe the educational objectives of GDC from that which is made of texts concerning professional opportunities was subsequently studied.

The calculation of the main lexicometric measures (Tables 2 and 3) confirmed the suitability of the sub-corpus for an automatic analysis of the text. For the reasons explained above, it was also decided in this case to treat the not lemmatized text.

Table 2. Lexicometric measures of the sub-corpus of educational objectives.

Lexicometric Measures	Values
N. of text	179
N. of occurrences (N or else tokens)	75,098
N. of forms (V or else types)	6167
N. of hapax	2495—3.32% of occurrences; 40.46% of forms
N. of average occurrences per text	419.54
Type/Token Ratio (TTR)	8.21
Zipf's law	1.28
Giraud Index	22.50

Table 3. Lexicometric measures of the sub-corpus of professional opportunities.

Lexicometric Measures	Values
N. of text	176
N. of occurrences (N or else tokens)	69,611
N. of forms (V or else types)	5285
N. of hapax	2061—2.96% of occurrences; 39% of forms
N. of average occurrences per text	396.52
Type/Token Ratio (TTR)	7.59
Zipf's law	1.3
Giraud Index	20.03

As can be seen by studying the vocabulary of the sub-corpus of the educational objectives (Figure 2), the training provided by Italian universities develops according to two main descriptive axes: The first recalls the theme of environmental sustainability with the occurrence of words such as *territorio*, *sostenibilità*, *sviluppo*, and *ambientale* (eng. trans.: territory, sustainability, development, environmental); The second refers to both theoretical education — through the occurrence of words such as *conoscenza*, *ambito*, and *formazione* (eng. trans.: knowledge/s, field, education) — and applied training, through the occurrence of words such as *attività*, *competenze*, *analisi*, *processi*, *ingegneria*, *capacità*, and *tecniche* (eng. trans.: activities, skills, analyses, processes, engineering, ability, techniques).

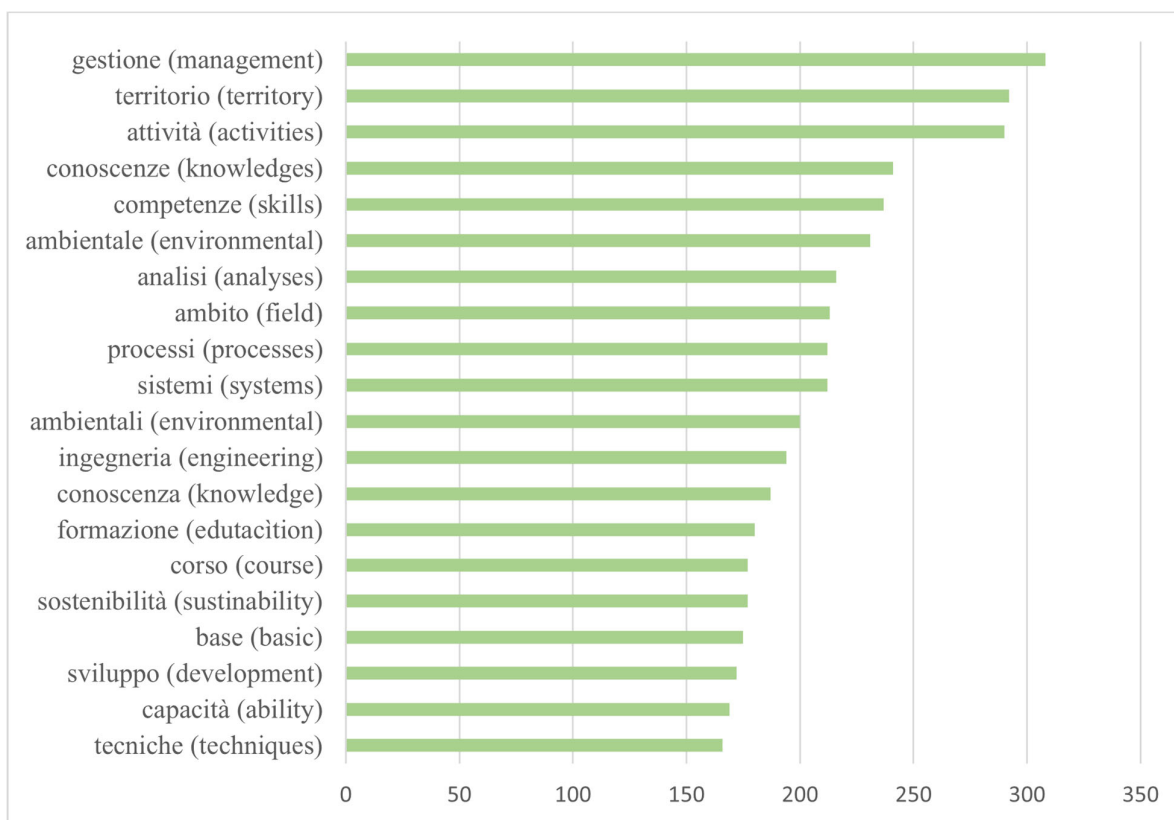


Figure 2. Top 20 keywords of the sub-corpus of the educational objectives.

Further analysis of the concordances reveals an interesting aspect. Exploring the contexts of the term *processi* (eng. trans: processes), an attention to change and evolution emerges. In fact, this word is often accompanied in the same sentence by terms such as *sviluppo*, *innovazione*, *promozione*, *valorizzazione*, and *trasformazione* (eng. trans: development, innovation, promotion, enhancement, transformation).

From the analysis of the keywords of the sub-corpus of professional opportunities, the pivot term *attività* stands out, used both in the singular and in the plural (eng. trans.: activity/activities), which records the highest number of occurrences. The greater frequency of this noun indicates a focus on the professionalizing and practical aspects of training.

By jointly reading the analysis of the concordances of the term activity and the analysis of the other key words (Figure 3), a tripartition of the discourse emerges:

- (1) Reference to training activities in the strict sense, linked to the university context — *competenze*, *capacità*, *laureato*, and *ambito* (eng. trans.: skills, abilities, graduate, field).
- (2) Reference to professional activities, which highlights the orientation of training to the working world, both in the public and private spheres — *aziende*, *servizi*, *settore*, and *imprese* (eng. trans.: companies, services, sector, enterprises).
- (3) Reference to general environmental issues — *ambientali*, *sistemi*, *processi*, *produzione*, and *impianti* (eng. tras.: environmental, systems, processes, production, plants) — and to activities, actions, and objectives characterizing the contexts of application in the environmental field — *analisi*, *progettazione*, *valutazione*, and *ricerca* (eng. trans.: analysis, planning, evaluation, research).

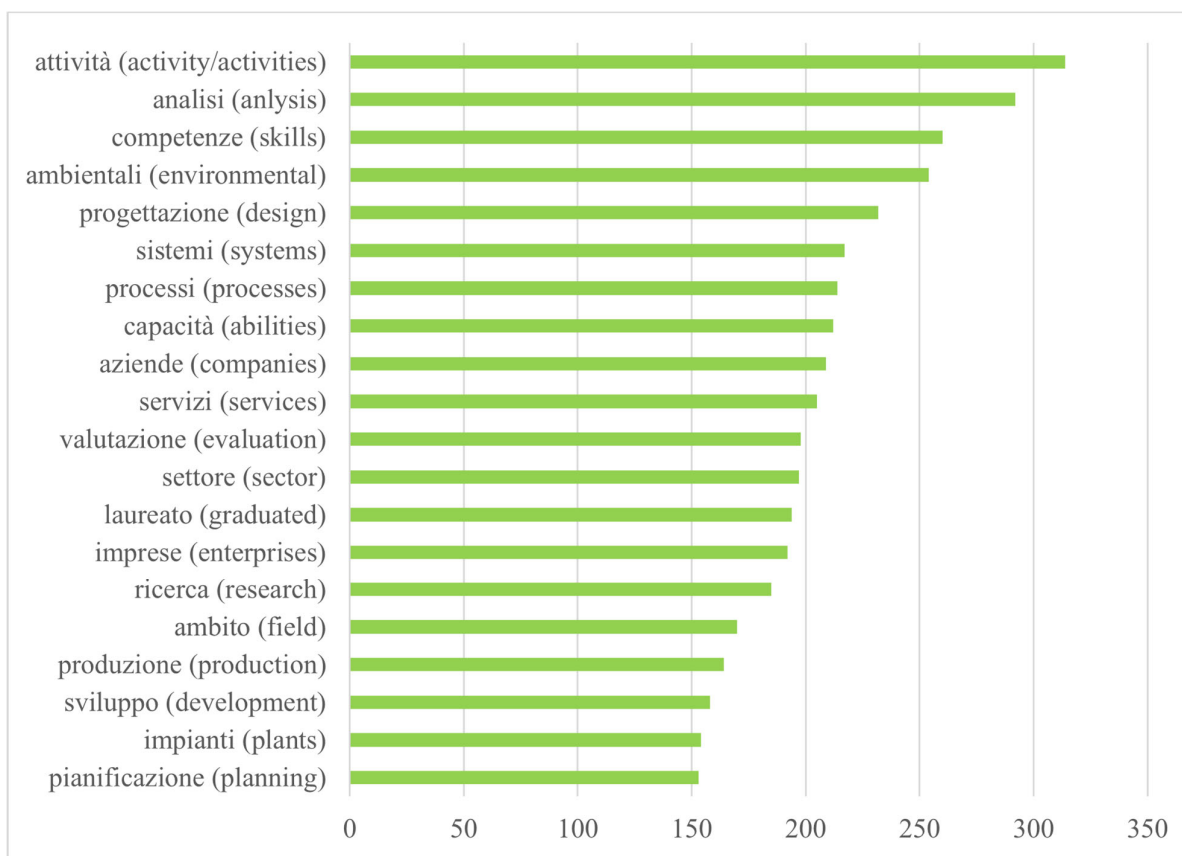


Figure 3. Top 20 keywords of the sub-corpus of the professional opportunities.

6. Unveiling Latent Dimensions of the Italian Green Educational Offer: An Application of Cluster Analysis on the Two Sub-Corpus

To study the latent lexical worlds of text content, the classification method of Reinert [29,30] (The Reinert method used by Iramuteq is a multidimensional technique of descending hierarchical classification (CHD). The method identifies the most significant terms of vocabulary in each class based on the Chi-square statistic. Furthermore, the algorithm determines which text segments are associated with each class or group of words and classifies them according to their chi-square value.) was adopted, aimed at topic extraction. In particular, this technique was adopted to analyze both the two sub-corpora already explored. It should be noted that to optimize the classification, the analysis was conducted on lemmatized text segments.

Observing the sub-corpus of the educational objectives, it can be seen from the classification validation measures (Table 4) that 94.6% of the segments have been classified. There are six identified clusters, and the characteristic segments are divided fairly equally between the groups (Figure 4 – the translation of the most significant words of the various clusters is reported in note 12).

Table 4. Classification validation measures of the sub-corpus of the educational objectives with Reinert method.

Measures	Valori
N. of texts	179
N. of text segments	824
N. of forms	6167
N. of occurrences	75,098

N. of lexemes	4230
N. of active forms	3935
N. of supplementary forms	256
N. di active forms with frequency ≥ 3	1848
Average of forms per segment	91.13
N. of clusters	6
N. of segments classified	780 on 824 (94.66% of the segments)

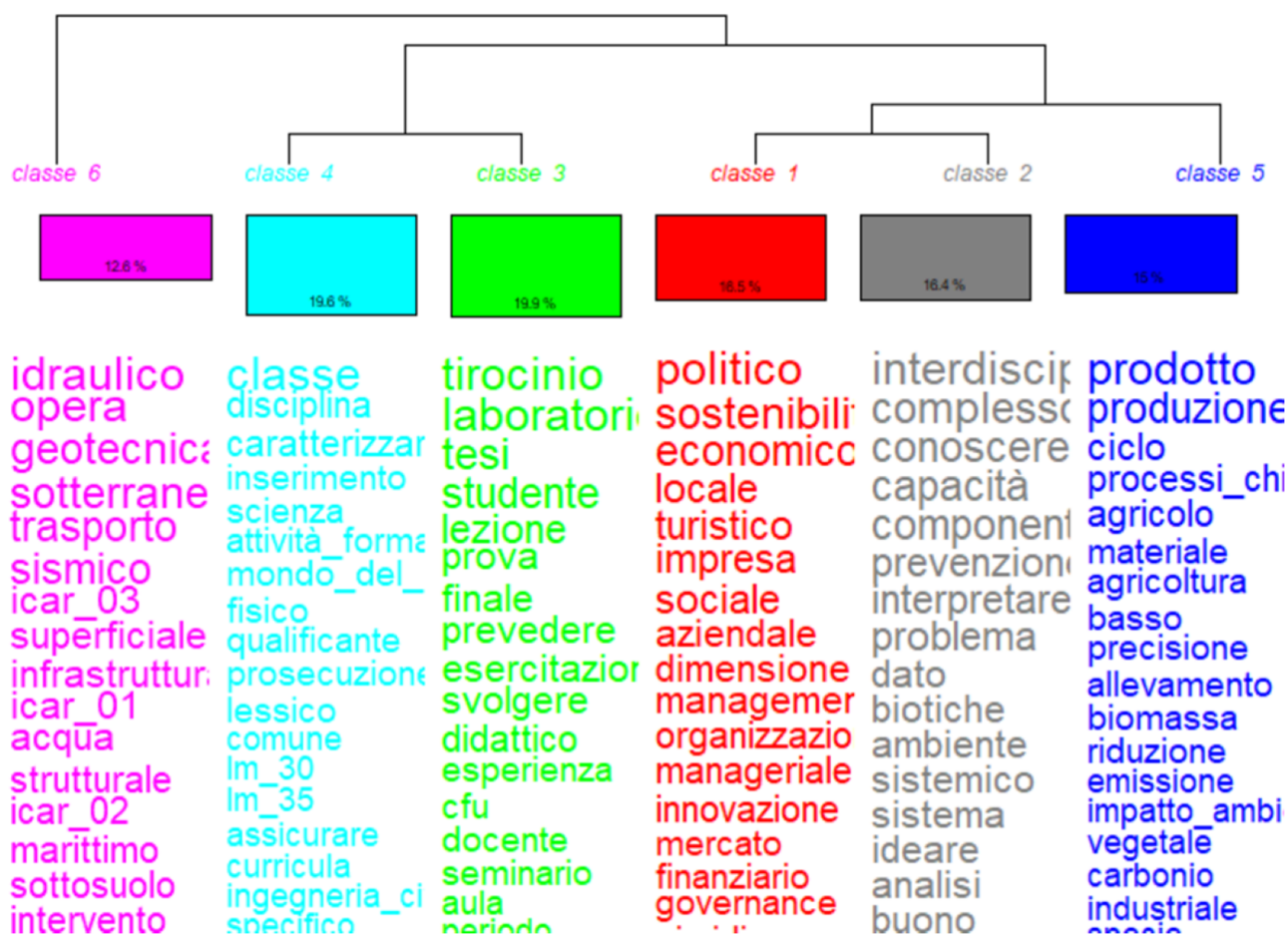


Figure 4. Classification dendrogram of the six clusters extracted from the sub-corpus of the educational objectives (Below is the translation of some most significant words for each cluster: cluster 1—policies, sustainability, economic, local, touristic, enterprise, social, business (adj), dimension, management, organization, managerial, innovation, market, financial, governance; cluster 2—interdisciplinary, complex, to know, capability, component, prevention, to interpret, problem, data, biotic, environment, systemic, system, devise, analysis, good; cluster 3—internship, laboratory, thesis, student, lesson, exam, final, predict, exercises, carry out, experience, ECTS credits, lecturer, seminar, classroom; cluster 4—class, discipline, characterized, integration, science, training activities, job market, physical, qualifying, continuation, lexicon, common, LM 30 (Master’s degree in Energetic and Nuclear Engineering), LM 35 (Master’s degree in Environmental and Territorial Engineering), ensure, curricula, civil engineering; cluster 5—product, production, cycle, chemical processes, agricultural, material, agriculture, low, precision, livestock, biomass, reduction, emission, environmental impact, vegetal, carbon, industrial; cluster 6—hydraulic, work, geotechnics, subterranean, transport, seismic, icar_03 (code indicating the Sanitary and environmental engineering discipline), surface, infrastructure, icar_01 (code indicating the Hydraulics discipline), water, structural, icar_02 (code indicating the Hydraulic and Maritime Engineering and Hydrology discipline), maritime, subsurface, intervention.).

The first extracted cluster (red) summarizes the content of the educational offer proposed in the socio-humanistic disciplines, in which the local and territorial dimension linked to three main aspects emerges: 1. the social and economic policies that favor the ecological transition and sustainability; 2. the relationship with local enterprises; 3. sustainable local tourism.

The second cluster (grey) consists of keywords that evoke the essential element of interdisciplinarity in the study and analysis of the complexity of environmental issues. In particular, they reflect the need to address sustainability-related topics by promoting a global and systemic approach.

The third and fourth clusters synthesize elements of practical education in two different facets. The third cluster (green) emphasizes the more applied aspects of education, underlining the importance of hands-on learning (internships and lab activities, the production of final projects, international experiences), as well as interaction and engagement with lecturers. Meanwhile, the fourth cluster (light blue) underscores the professional perspective of education, bridging the gap between the academic and professional worlds, with particular reference to the fields of engineering and applied sciences.

The fifth cluster (blue), along with the previously discussed cluster 1, refers to the 'thematic' aspects of education, specifically within the technical-scientific disciplinary field. The cluster's words are associated with educational offerings related to the sustainability of production processes, sustainable agriculture and livestock practices, and the optimization of chemical processes with the aim of reducing environmental impact.

The sixth cluster (pink) reflects the conceptual dimension of technical education, with a specific emphasis on aspects related to the management of territory, infrastructure, and natural resources. The cluster's keywords encompass disciplines such as hydraulic engineering, seismic engineering, maritime engineering, and sanitary-environmental engineering, all oriented towards the sustainable management of territory and natural resources.

From the analysis of the clusters just described, it emerges that Italian universities, in defining the educational offer on environmental sustainability, tend to enhance the various facets of university education: theoretical education, which focuses on the acquisition of basic concepts and theories; applied education, which emphasizes the practical application of such knowledge in real contexts; and technical education, aimed at the development of specialized skills and the use of innovative technologies. This variety of educational approaches is valuable in best preparing students in the field of green jobs, new and now essential professions for successfully addressing the challenges related to environmental sustainability.

This versatile educational strategy becomes even clearer when observing the distribution of the six clusters on the factorial plane (Figure 5).

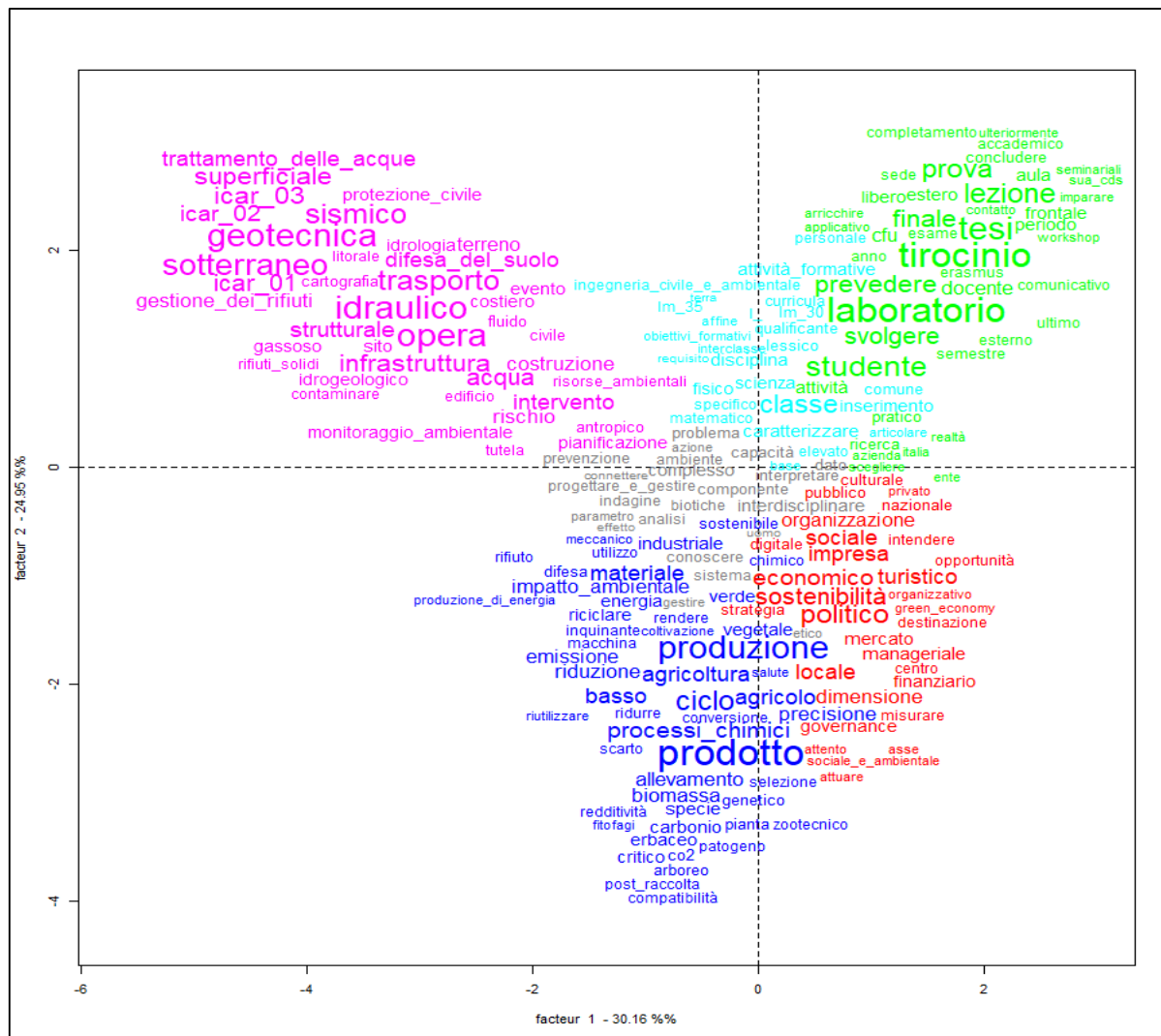


Figure 5. Distribution of the word clouds of the six clusters on the factorial axes.

Regarding the first factor on the x-axis, on one side (positive semi-axis), we observe the presence of clusters characterized by words describing the university pathway and the academic context; on the other side (negative semi-axis), we see the presence of clusters conceptually related to the practical application of knowledge in real-world contexts, particularly in the field of land management and natural resources. The conceptual dimension on the second factor on the y-axis, on the other hand, represents different types of education: clusters located on the negative semi-axis evoke the thematic aspects of theoretical education offered in the two distinct disciplinary areas; clusters positioned on the positive semi-axis, on the other hand, evoke applied and technical education.

In regard to the sub-corpus of professional opportunities, the cluster analysis with the Reinert method classified 84.8% of the segments (Table 5). Four clusters emerge from the analysis and, also in this case, the characteristic segments are divided equally among the groups (Figure 6 — the translation of the most significant words of the various clusters is reported in note 13).

Table 5. Classification validation measures of the sub-corpus of the professional opportunities with the Reinert method.

Measures	Valori
N. of texts	176
N. of text segments	780
N. of forms	5285
N. of occurrences	69,611
N. of lexemes	3750
N. of active forms	3498
N. of supplementary forms	211
N. di active forms with frequency ≥ 3	1691
Average of forms per segment	89.24
N. of clusters	4
N. of segments classified	662 on 780 (84.87% of the segments)

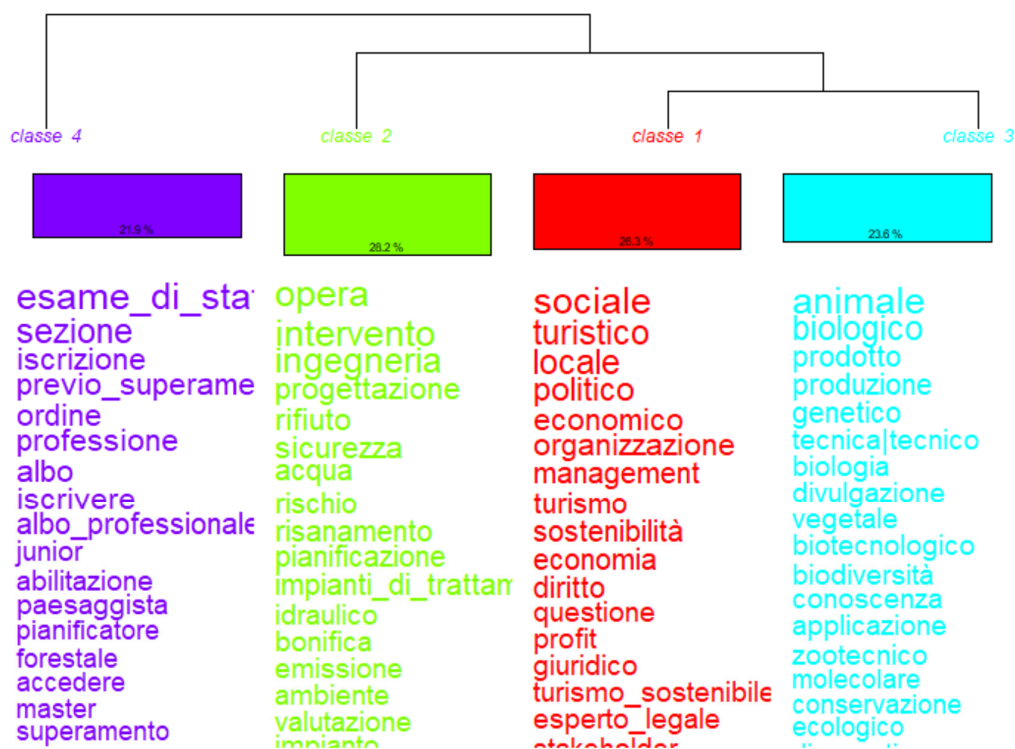


Figure 6. Classification dendrogram of the six clusters extracted from the sub-corpus of the professional opportunities (Below is the translation of some most significant words for each cluster: cluster 1—social, touristic, local, policies, economic, organization, management, tourism, sustainability, economy, law; cluster 2—works, intervention, engineering, design, waste, safety, water, risk, remediation, planning, treatment plants, hydraulic, reclamation, emission, assessment; cluster 3—animal, biological, product, production, genetic, technique, technical, biology, dissemination, plant, biotechnological, biodiversity, knowledge, application, zootechnical, molecular, conservation, ecological; cluster 4—state certification exam, section, enrollment, after passing, board (of professional categories), profession, register (of professional categories), to register, professional board, junior, license, landscape, planning, forestry, access, master’s degree, passing).

The first extracted cluster (red) is composed of words that refer to degree programs focusing on economic, social, and legal aspects of sustainability, with a particular emphasis on themes such as sustainable tourism and social policies. Additionally, there is a clear reference to the local dimension of sustainability.

The second cluster (green) is focused on aspects related to environmental engineering, specifically concerning the design of interventions, waste management, safety, and environmental risk management.

The third cluster (light blue) refers to educational paths related to biological sciences, with a particular focus on biotechnology, eco-sustainable production processes, and biodiversity enhancement.

The fourth and final cluster (purple) refers to degree programs that prepare students for so-called 'regulated professions', which require membership in professional associations or orders, sometimes following the successful completion of a state examination. In particular, the analysis of the concordances of the terms *paesaggista* (landscape architect) and *forestale* (forestry) found in the cluster has highlighted references to professional figures such as architects, agricultural engineers, and forest technicians.

Observing the distribution of clusters on the factorial plane (Figure 7), the first factor, placed on the x-axis, represents the conceptual dimension of modes of access to the job market, contrasting, on one hand, 'enabling' degree courses oriented towards regulated professions, and on the other hand, degree courses oriented towards professions that allow 'direct' access to the job market.

The second factor, situated on the y-axis, reflects the territorial dimension of sustainability. On one hand, it recalls degree programs focused on territory protection and environmental risk management (clusters 2 and 4 on the positive semi-axis). On the other hand, it relates to degree programs centered on the valorization of the territory and production processes (clusters 1 and 3 on the negative semi-axis). Furthermore, the proximity of clusters 1 and 3, with terms almost merging into a single cloud of words, suggests a reference to the element of interdisciplinary studies, both in the humanities and social sciences and in the technical and scientific fields.

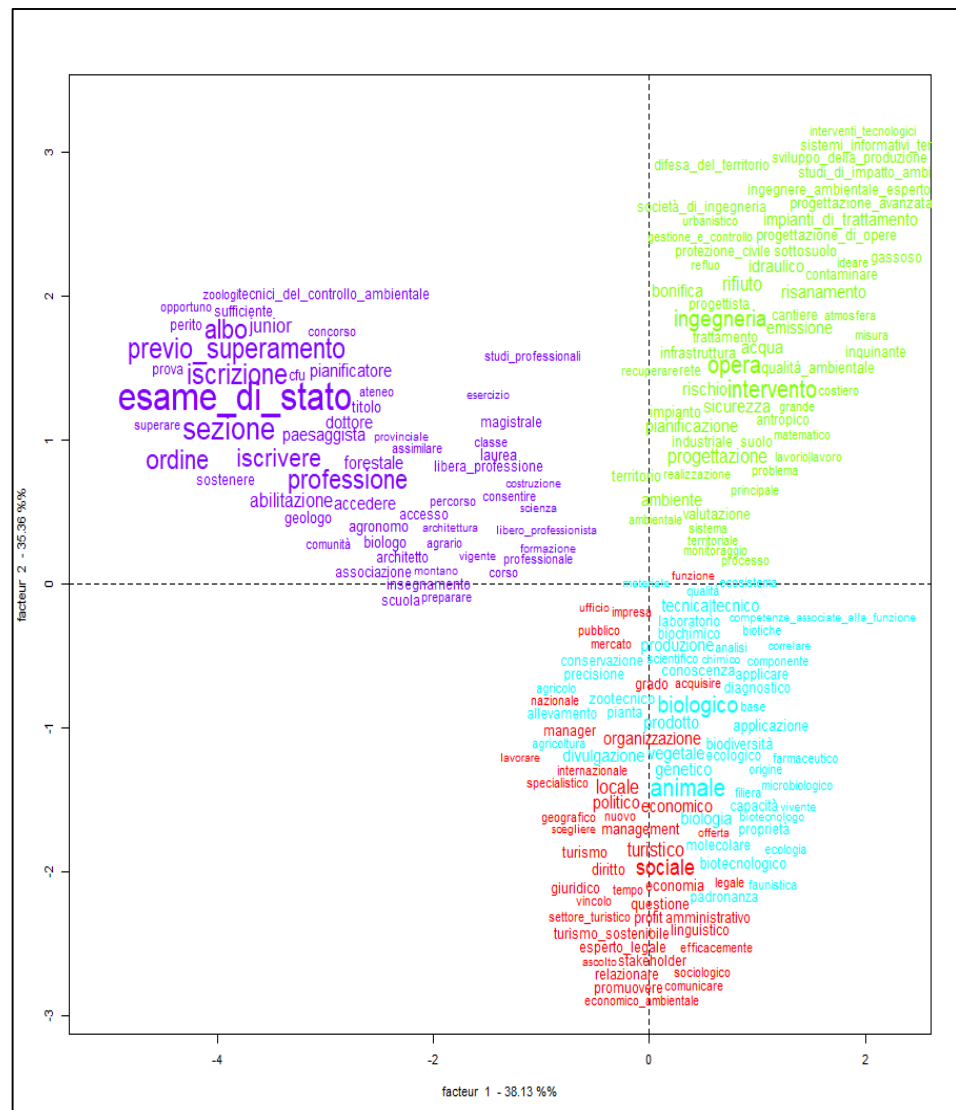


Figure 7. Distribution of the word clouds of the four clusters on the factorial axes.

7. Conclusions

Scientific literature argues that in order to prepare individuals for green jobs, university educational systems should embody four critical elements: 1. the adoption of a multidisciplinary and interdisciplinary approach; 2. the attention to the territory in synergy with the local dimension; 3. the adoption of an intersectoral approach with a variety of local actors; and 4. the balance between theoretical, applied, and professionalizing education to promote access into the labor market. The analysis discussed in this paper shows that in the Italian university system, the educational offer concerning green topics encompasses, more or less explicitly, all these essential aspects. In fact, it aligns with the European community's guidelines for promoting eco-sustainable development and fostering knowledge and skills essential for the green transition.

The adoption of a multidisciplinary and interdisciplinary approach emerges not only from the analysis of the vocabulary, but also from both the analysis of the specificities of the master's degree programs and overall from the word's clusters identified in the corpus.

The concept of territorialization is also encountered in the corpus with the following meanings: on the one hand, territorialization clearly recalls the harmonization of the higher

educational training offer with the characteristics of specific territories; on the other hand, territorialization is also meant to foster dialogue with economic and social stakeholders, encompassing both institutional and private entities. This collaborative perspective aims at integrating activities within the specific local dimension. This aspect also emerges from the cluster analysis carried out on the educational objectives of the green degree courses, belonging to the humanistic-social area, showing the will to establish synergies with local players.

An intersectoral approach is imperative when we talk about sustainability. In fact, the challenges posed by the ecological transition for a more sustainable future needs the engagement of local actors crosscutting different economic sectors. This engagement emerges in both the sub-corpus concerning the educational objectives, and the professional opportunities of the green degrees analyzed.

Furthermore, achieving a balance between theoretical, applied, and professionalizing education is crucial for preparing individuals to enter the labor market. The analysis of vocabulary in the sub-corpora highlights a tendency to give value to both theoretical and applied training, a finding reinforced once again by cluster analysis on the sub-corpus of educational objectives.

Despite the presence of these essential elements, in the Italian educational landscape, green degree programs remain relatively underrepresented, comprising only 3.4% of the total. Moreover, they are often considered specialized, with over 60% being master's degree courses, and predominantly focused on technical-scientific disciplines (80%) and to a lesser extent, socio-humanistic fields (20%). It is worth noting that they are completely absent in the health and medical fields.

Considering these factors, the current scenario seems to be the initial stage of a developmental path for Italian green higher education degree courses. This process should be fostered and expanded by creating autonomous training pathways addressing specific thematic strands from foundational concepts to specialization. Furthermore, there is a need to enhance interdisciplinary approaches in order to include the disciplinary areas still absent in teaching programs. In our opinion, by following this direction, comprehensive courses can be developed to train green professionals capable of addressing, both socially and professionally, the increasingly urgent and complex challenges posed by environmental sustainability.

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