OVERLAPPING OF ONSHORE OIL ACTIVITIES AND BIODIVERSITY IN ITALY: SPATIALIZING THE GUIDELINES FOR THE ENVIRONMENTAL IMPACT ASSESSMENT IN "VAL D'AGRI" CONCESSION, BASILICATA, SOUTH OF ITALY

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ABSTRACT
Among the human activities characterized by higher negative effects on biodiversity conservation, there is the hydrocarbons extraction, with all the connected phases. The production of hydrocarbons, in fact, can lead to a wide range of effects on ecosystems including contamination of soil, water and air pollution, deforestation and habitat fragmentation. In Italy there are few analysis about the relationship between oil extraction and environment and biodiversity, so this research provides an evaluation of the main Italian onshore oil activities ("Val d'Agri" Concession, in Basilicata, South of Italy) through two steps: development of Environmental Impact Assessment guidelines and the spatialization of oil operation and biodiversity through the analysis of oil operation in relation to Natura 2000 network. The research presents the development of new guidelines providing a significant contribution to identification and management of adverse impacts in continental areas characterized by high biodiversity. The guidelines focus on the life cycle project of oil activities, the impacts and the possible mitigations, in the framework of Environmental Impact Assessment. Tuned guidelines are then tested and spatialized in the case study showing the level of pressure on biodiversity due to oil operation.

Keywords: Onshore oil activities, Biodiversity, EIA performance, Guidelines, GIS analysis

1 - INTRODUCTION

Many areas in the world, characterized by high biodiversity, are affected by oil activities. Studies on tropical rain forests of Western Amazon (Colombia, Ecuador, Peru, Bolivia and Brazil), one of the key areas for biodiversity, showed that these activities have caused significant environmental impacts, determined by deforestation carried out for the building of access roads and locations of extraction and for the laying of pipelines, and pollution of water resources caused by oil spills and waste water, with serious threats to biodiversity [1]. Emblematic is the case of Ecuador, where in over thirty years of oil resources exploitation more than 30 serious cases of oil spills from pipelines have been recognized, with a total spill of 63,300 m^3 of crude oil [2]. The oil concessions in Ecuador currently affect also protected areas, such as the Yasuní National Park, located in the north-east of the country, one of the major areas of biological and cultural diversity [3].
Focusing on Mediterranean ecosystems (another hot spot for biodiversity), there are many cases of oil extraction in continental contexts with high biological diversity. The most significant case is represented by the extraction of hydrocarbons from the "Val d'Agri" Concession, in Basilicata (Italy), which affects protected areas such as a national Park and Natura 2000 network sites.
In many jurisdictions oil operations should be submitted to EIA process to receive environmental licenses, in this context many guidelines for the identification of environmental impacts by oil extraction and the relative mitigations have been developed by the governments of the major oil producing countries and some associations of oil companies.
In the Italian scientific literature and in the production of nationwide administrative documents, similar guidelines have not been processed yet, so the guidelines described in this paper represents the first case in Italy. Moreover, the guidelines developed, called IMOG (Impact Mitigations Oil

Guidelines), also represent a unique example at the international level, as arisen in the context of a university research and not of public administration or oil association of producers.

1.1 Oil operations: impacts and mitigations

For every phase of oil production cycle many impacts with the related mitigation measures have been identified and reported in literature. After wide analysis of literature [4, 5, 6, 7, 8, 9], in this research oil operations has been summarized in four phases:

- oil exploration, whose purpose is to check the presence of hydrocarbons reservoirs using geophysical surveys and seismic reflection [10, 11, 12];
- well drilling, in which many rock formations and aquifers are being crossed to arrive to the oil field and the well structures are being built [13];
- production phase, in which crude oil is being extracted from the reservoir rocks and then its three phases, oil, production water and gas are being separated [14];
- decomissioning, in which all the structures used during the production phase have to be reclaimed and the area have to be restored [15, 16].

Oil-environment related literature recognizes many environmental components, on which the various phases can act [4, 5, 6, 7, 8, 9]. In this research focus has been devoted to five components: “atmosphere”, ”acoustic climate”, “soil and subsoil”, “aquatic environment” and “vegetation, fauna, ecosystems”.

On the “atmosphere" the major impacts are related to the gas flaring and gas venting operations, during the production phase, with the emission of gases like Volatile Organic Compounds (VOCs), nitrogen oxides (NO_x), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), CO and CO_2. Some of these gases may be very toxic and in some cases fatal, for human beings and other animals [17, 18]. The measures identified to reduce gaseous emissions of gas flaring and gas venting relate to the ongoing maintenance of the burning system and the recovery of as much gas as possible [7, 19, 20].

For what concerns the “acoustic climate”, important sources of impacts are represented by the noises and vibrations determined by seismic surveys that use explosive charges [4]. To reduce impacts on “acoustic climate” due to seismic surveys, the most effective measure is the decrease in the number of prospecting, using data from surveys undertaken previously [1].

About the component "soil and subsoil" and “aquatic environment” the major impacts are determined by possible oil spills from pipelines or well facilities [4] and the disposal of formation water and drilling muds [4, 9, 21]. To avoid possible oil spills it’s advised to make a constant maintenance of the facilities potentially affected by spills and to equip the well facilities and the pipelines of appropriate safety valves [1, 7, 8, 19, 22].

The major impacts on component "vegetation, fauna, ecosystems" are in particular caused by ecosystems fragmentation, due to road pipeline and other infrastructures, and pollutants dispersion into the aquatic environment, showing various problems such as alterations in the development of organisms, like congenital birth defects [17, 23]. Another impact is the disturbance of fauna caused by noise and vibration produced by the movement of equipment and vehicles [4]. The adoption of measures that minimize ecosystems fragmentation and soil, subsoil and water reserves contamination, and decrease toxic gases emission and noise and vibration, reduces the impact on the component concerned [1, 7, 8, 9, 19, 22].

1.2 Oil extraction in Italy

1.2.1 National oil production

Data about hydrocarbons production in Italy in the period 1994-2014, has been fared rather discontinuous [24]. After a gradual increase in the period 1994-1997, the oil production continued to fall until 2001 and then, has increased during the last decade, albeit with some downturns, in particular in 2009. Overall, in 2014 there is a production of 5,75 million tons, an increase of 29% compared to

the production of the year 2001 (4,07 million tons). Most of the production, for 2014, comes from onshore concessions (4,99 million tons equal to 87% of national production) [24].
On the contrary the production of gas is still decreasing from the 1994. The production of 2014, 7,28 billions of Sm^3, shows a decrease of 65% comparing to the 20,64 billion of Sm^3 produced in the year 1994 [24].
In 2014, Italy results in fourth place among the major European hydrocarbons producers with an average of 114 thousand oil barrels daily produced (crude and non-conventional oil, natural gas liquids), behind Norway (1.892 thousand barrels per day), the UK (872 thousand barrels per day) and Denmark (165 thousand barrels per day) [25].
About the estimated oil reserves, on 31 December 2014, Italy is the in the third place in Europe, with 619 barrels of proved reserves, after Norway (5.497 million barrels) and the UK (3.033 million barrels), before Denmark (611 million barrels) and Romania (600 million barrels) [25]. Focusing on the location of proved reserves, 89,7% of oil reserves comes from onshore fields, almost entirely in southern Italy (81,5%), mainly in Basilicata [24], where it is located the most important reservoir of continental Europe, in correspondence with the "Val d'Agri" Concession [26], from which, relating to the year 2015, the 68,8% of the national oil production comes [27].
Finally, on 31 July 2016, in Italy there are 102 research permits (of which 80 are onshore, and 22 offshore) and 188 production concessions (of which 119 onshore and 69 offshore) [27].

1.2.2 The "Val d'Agri" Concession

The "Val d'Agri" Concession, 660.15 km^2 wide, about 20 km South-Est of Potenza city, affects the upper valley of the river Agri and part of the surrounding mountains (Fig.1) [28]. The current owners of the Concession are Eni SpA, with the role of operator and main representative (with a share of 60.77%), and Italy SHELL E&P SpA (with a share of 39.23%) [28]. At present the wells in the Concession "Val d'Agri" are 40, of which 22 are in production phase, 15 not productive yet [27] and 3 closed, one of which converted to reinjection well [28]. There are wells organized into "clusters", i.e. groups of two or three wells in the same location, and "single" wells, i.e. only one well for each location. In total the clusters are 10, including 24 wells. The single wells are instead 16 [28]. The Val d'Agri is an high biodiversity area, with endemic and rare species [29], evidenced by the presence of a National Park and 11 Natura 2000 Network sites, directly affected by the "Val d'Agri" Concession.

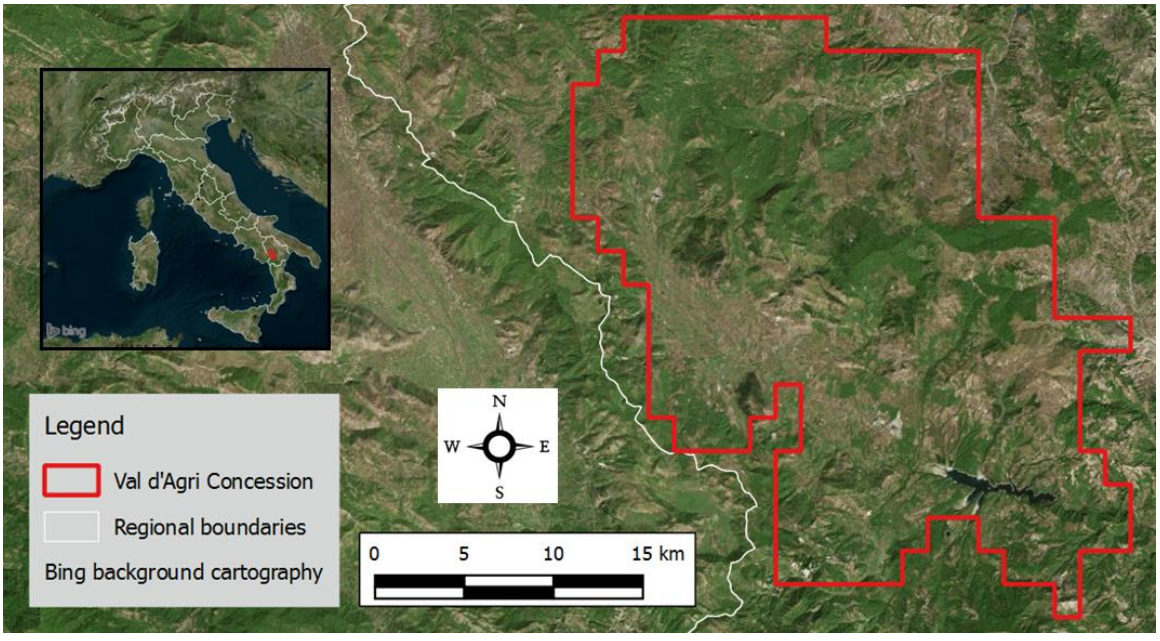

Fig.1. The "Val d'Agri" Concession. GIS Data processing using QGIS

Another factor of extreme environmental criticality is the fact that the oil activities in the "Val d'Agri Concession" affect the catchment of the river Agri, barred just downstream of these activities to create the "Pietra del Pertusillo" Lake, very important as an essential source of drinking water for the Basilicata and Puglia regions [30]. The possible hydrocarbon contamination of the lake water would have important effects on the environment and human health [30].

1.2.3 Oil activities and Environmental Impact Assessment

In Italy, the national legislation for Environmental Impact Assessment (EIA) is represented by Lgs.D. 152/2006, Part II, Title III, laying down rules for the Environmental Impact Assessment and subsequent amendments made by the Lgs D. 4/2008, by the Lgs D. 128/2010 and D.L. 5/2012 [31].
The oil extraction industry, is part of the "Onshore Activities of cultivation of liquid and gaseous hydrocarbons and geothermal resources" (Annex III to Part II of D.Lgs. 152/2006 and subsequent amendments) and is therefore subject to EIA procedure of regional competence (D.Lgs no. 3 April 2006, n. 152, and subsequent amendments) [31].
The first legislation to establish an EIA procedure for oil extraction in Italy was the RPD 526/1994, which stated that the formal procedures were to be followed by the Ministry of Environment [32]. Later in the implementation of the Presidential Decree 12/04/1996 "Act guidance and coordination for the implementation of Article 40, paragraph 1 of Law 146/1994" [33], it is delegated to the regions the enactment of a law to define the regional responsibilities for the management of procedures EIA of certain projects, including the prospection, exploration and production of hydrocarbons. The various regions have therefore implemented the decree enacting a specific law [33].

2 - MATERIAL AND METHODS

2.1 Construction of guidelines

The development of the IMOG guidelines was based on the bibliographic analysis of scientific and technical literature, examining scientific articles and international guidelines of oil and gas industry sector. Taking international guidelines as a model, the information obtained was summarized in tables for quick reference, in which the impacts of oil extraction on different environmental components and their mitigation measures are specified.
From this information a checklist of questions was prepared to facilitate the analysis of oil activities through both the examination of documents and the direct observation of the production facilities.
The method of the checklist is one of the most used because it represents a simple tool, easily adaptable to different types of project. This method allows to quickly identify aspects of the project that may be very significant for their impact on the environment, providing a critical reading key for the whole of the project cycle [34].
Specifically, the checklist, is configured as a "questionnaire checklist", since it consists of a series of questions by which investigating different aspects of the project cycle, with the possibility to provide a detailed analysis of direct and indirect impacts and to identify possible mitigation measures [34].
For the development of the IMOG checklist, the checklist introduced by the European Commission in 2001 [35] was used as a reference model of analysis. This checklist allows to evaluate, critically and in-depth, the various aspects of the Environmental Impact Statement, the features of the project, the alternatives and the environmental components potentially affected by the project [35].

2.2 Testing guidelines applicability: the analysis of oil activities in the "Val d'Agri" Concession

To test the concrete applicability, IMOG guidelines have been employed in the analysis of some EIS related to the activities of the "Val d'Agri" Concession and some extraction facilities of the same concession. To get the SIA, the main oil company, i.e. Eni Spa, the Regional Office of Environmental Compatibility and the municipalities involved by oil activities were contacted.

For a more complete analysis of oil activities in Val d'Agri, some interviews were carried out with regional officials for the investigation about the Environmental Impact Assessments, the official for the Regional Agency for Environmental Protection (ARPAB) designed to monitor the environmental components potentially affected by oil extraction, some officials of the municipalities interested by wells, some local citizens to know their point of view and with representatives of some environmental groups.
The observation of the extraction facilities has been accomplished through the use of GPS technology for the collection of geotagged photos and items of interest.

2.3 GIS Analysis of the relationship between wells areas and sensible elements in "Val d'Agri" Concession

The analysis of the relationship between the well areas and sensitive elements of the territory of the Val d'Agri was accomplished using GIS software and defining five types of elements towards which the presence of an extraction well may be an impact factor. These elements are:
- Buildings (regardless of their use, both residential and not);
- Park ("Appennino Lucano Val d'Agri Lagonegrese" National Park);
- SCI/SACs;
- SPAs;
- Water system (rivers and lakes).

The GIS analysis, made by QGIS software, allowed to define distances from the well areas to the five categories of sensitive elements. The distance was calculated from the precise location of the well head in the case of individual wells or by a barycentric point between the heads of the wells in the case of cluster.
Starting from the measurements carried out, matrices were made to highlight spatial relationships between the well-areas and the sensitive elements of the five identified categories. For each location, a value from 0 to 1 has been given, calculated proportionally to the well or cluster area which is located respectively at minimum distance (0 meters) and maximum distance from its sensitive element of the category. In addition, for each category of sensitive element, based on the value obtained, for each location it was assigned a category of relative distance from sensitive elements according to the following scheme: minimum distance (red color) (from 0 to 0.25); lower-middle distance (orange color) (0.26 to 0.50); upper-middle distance (yellow color) (from 0.51 to 0.75); maximum distance (green color) (from 0.76 to 1).

3 – RESULTS AND DISCUSSIONS

3.1 The guidelines

The processed guidelines are divided into three parts: environmental impacts; mitigations; checklist. The part relating to the impacts consists of nine tables in which the impacts are divided according to the different phases and operations of the project cycle. Then in each table the impacts are divided into the five environmental components described in the 1.1 paragraph. The references are specified into the right column of each table.
The same structure made of tables is for the part relating to mitigations.
The checklist has been built starting from the mitigation measures identified in the second part of the guidelines. The questions of the checklist, have been defined as if the analysis were to be accomplished only on EIS documents, and it can be easily adapted for the field observations by changing the formulation of the questions.

3.1 The analysis of the Environmental Impact Statements

Overall, the EISs analyzed by the IMOG guidelines were only two, namely the only ones that could be retrieved during the documentation search phase. The two EISs are:
- *Progetto di "Sviluppo Caldarosa"* [15];
- *Area cluster "S. Elia 1 - Cerro falcone 7*" [26].

Both the documents refer to the drilling of a cluster made of two wells, the pipeline laying and the decommissioning phase.
The critical analysis of the two EISs shows that the characterization of the environmental components of the project area is rather rough and the impacts on many of these components affected by the implementation of the projects have not been defined in detail. Overall the influence area of the project has not been identified. The influence area of the project, although it is not considered enough by the international literature, should be always defined in order to determine a detailed characterization of the various environmental aspects of the territory affected by oil activities, with the aim of outlining a precise landscape which is comprehensive of the possible impacts on the environmental components and related mitigations.
Analyzing the EISs, e.g., there is no sufficiently detailed description of surface water and groundwater which could be affected by oil operations and there is no definition of the risk of any contamination of water bodies, with treats for biodiversity and for drinking and irrigation purposes.
Of particular importance it is the inadequate description of the aspects related to the seismicity of the area and the strength of the project structures to seismic events, despite of the high seismic risk of the examination area.
In addition to this, the relationship between the facilities of the project and the protected areas is unclear because the distances between the protected areas and the project facilities are not always specified.
Overall, the EISs assert, using a terminology often ambiguous and misleading, that the adoption of mitigative measures will delete the impacts. This is not possible because, while taking all possible precautions, there is always the risk of human errors, as in the operations of the fuels, or even accidents, such as breakage of the safety valves and pipelines.
It also seems clear that during the definition of the project there weren't sufficient contacts with the authorities and local experts, aspect that is very relevant to a comprehensive definition of environmental impacts and related mitigations, but also to identify appropriate meeting points with stakeholders, avoiding any conflicts of social nature that may occur during the project realization and later.

3.2 The analysis of the wells directly on the field

To verify the concrete applicability of the IMOG guidelines, 16 of the 40 wells of the "Val d'Agri" Concession, grouped into 13 sites (10 single wells and 6 wells in clusters made by 2 wells each one), were visited and examined. They were chosen to analyze both productive, closed, reinjection and in drilling phase wells. It was not possible to access well areas because the oil company, Eni, after many requests answered to be not interested in this research. The evaluation of the wells was based, therefore, on the photographs and the observations taken outside the fences of the well areas. Some critical factors observed for several wells are the great proximity to some sensitive elements such as houses and farms (in some cases the distance between well sites and other buildings was found to be less than 100 m) and the fact that the ground level surrounding the wells is placed at a lower level of the ground surface of the well (Fig.2).

Fig.2. Cattle farm (in the foreground) bordering a cluster of wells, Monte Alpi Pozzo West 1 / Monte Enoc 4 (in the background, red circled), Viggiano (PZ). Author: A. Diantini, 12/10/2013

In the event of uncontrolled release of crude oil from the well facilities, the surrounding area could therefore be easily contaminated. In the event of uncontrolled release of crude oil from the well facilities, the surrounding area could therefore be easily contaminated.
The lack of access to the well sites and the inability to analyze the EIAs of most of the wells have stopped to check out other very important aspects of oil extraction as the adoption of mitigation and prevention against possible hydrocarbons and other chemicals leakages from the wells.
All in all, the use of the IMOG guidelines examining the case study of the "Val d'Agri" Concession didn't allow to produce a comprehensive analysis of the impacts of the production activities in the concession. This result is not attributable to mistakes made in the definition of the guidelines but to the non-availability of the EIAs related to most of the extraction plants present and the denied access to the well sites for more detailed observations.
It should be noted also the substantial deny by many municipalities contacted for the research in supplying requested environmental data, violating in this way the commitments of Aarhus Convention.

3.3 GIS Analysis of the relationship between wells and sensible elements

The examination of the relationship between well sites and protected areas (Fig.3, Tab. 1) shows the following results:
- 7 sites, for a total of 14 wells, are located inside the boundaries of the "Appennino Lucano Val d'Agri Lagonegrese" National Park;
- 1 sites, corresponding to 1 well, is located inside the boundaries of a SCI;
- 7 sites, for a total of 13 wells, are located inside the boundaries of SPAs;

Overall, the analysis shows that for the three categories of protected areas, there is always the 50% or more of well sites inside the "minimum distance" category.
For "buildings" and "rivers and lakes" categories, more the 75% of well sites is inside the "minimum distance" and "lower-middle distance" categories.
From the analysis of the summary matrix of the values of all the categories examined, for each well site considering the presence of at least a "minimum distance" value from a sensitive element, it is possible to observe that only two well sites, do not fall in "minimum distance" category.

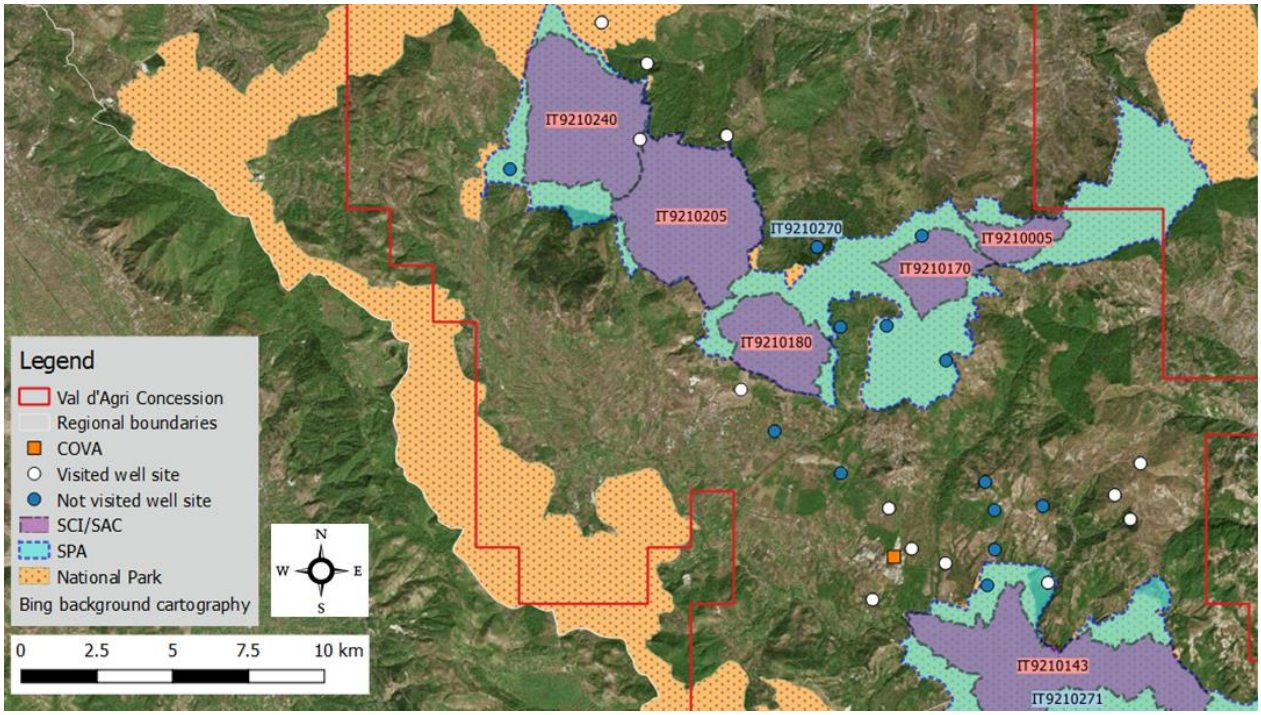

Fig. 3. Distribution of the well sites of "Val d'Agri" Concession in relation to the boundaries of the National Park, SCI/SACs and SPAs

Table 1. Overall analysis of the spatial relationship between well sites and sensitive elements in "Val d'Agri" Concession

Indicators	Buildings	SCIs	SPAs	PARK	RIVERS AND LAKES
Minimum distance (m)	130 m	0 m	0 m	0 m	200 m
Maximum distance (m)	2.100 m	7.200 m	4.860 m	3.460 m	2.470 m
Number of wells in "minimum distance" category (from 0 to 0.25)	22	23	24	24	12
Number of wells in "lower-middle distance" category (0.26 to 0.50)	12	10	7	8	19
Number of wells in "upper-middle distance" category (from 0.51 to 0.75)	4	5	5	4	5
Number of wells in "maximum distance" category (from 0.76 to 1)	2	2	4	4	4

4 - CONCLUSION

Overall in Basilicata and in general in Italy there is a large number of protected areas affected by oil and gas concessions, exposing them to possible adverse effects with strong potential impacts on biodiversity. Therefore it is necessary to make a regulation of oil and gas extraction in particular in onshore protected contexts, like Natura 2000 sites, both nationally and internationally. In fact, for offshore oil and gas activities there is an European Directive, the Directive 2013/30/EU of the European Parliament and of the Council, which provide suggestions in preserving, protecting and improving the quality of the environment involved in the using offshore hydrocarbons resources [36]. The directive focuses the attention on the adopting best practice in relation to the control of the major hazards throughout the design and operational lifecycle of offshore oil and gas operations, showing transparency in environmental information managing, the public participation relating to the effects of planned offshore oil and gas exploration operations on the environment and the cooperation

between each Member State in exchanging knowledge, information and experience in offshore oil and gas sector [36].
A similar European Directive or a national law for onshore oil and gas extraction would certainly improve the management of these activities in contexts of high biodiversity, reducing the possible damages to the environment.
Europe and Italy should also provide regulations defining the distance for the oil activities from protected areas such as parks or SCIs and SPAs, an issue debated at the international level but rather lacking under the legislative profile. From the reviewed literature, only the document produced by the Government of India [19] defines the limit distances: the construction of oil wells should not take place at distances below 5 km from areas of scientific importance for the point of view of the vegetation and animal species [19].
Relatively to the experience gained in the analysis of the oil activities of "Val d'Agri" Concession it is possible to state that it is right to improve the management and dissemination of environmental data, making available the EIAs in online platforms and providing more information about the relationship between oil and gas assets and protected areas. The organism with the task to reach this goal should be the "Osservatorio Ambientale Val d'Agri", founded as a measure of environmental compensation in connection with the oil exploitation of the "Val d'Agri" Concession. The observatory should work in order to give stakeholders a complete landscape of environmental information of what happens in the areas affected by oil activities.
Focusing on the examination of the two EIAs processed using the IMOG guidelines, it appears that these documents would require appropriate revisions to fill the gaps identified, in particular regarding the definition of an adequate influence area of the project for a detailed characterization of various environmental aspects of the area affected by the extraction activities.
From the point of view of the IMOG guidelines processing, if it hasn't been possible to produce a comprehensive analysis of provided and present impacts and mitigations for the oil activities in the Concession "Val d'Agri", the research, however, has allowed to define a clearer picture of the activities inside the concession, specifying the legal aspects and the authorization processes, the starting point for further research programs about oil activities and environmental impacts.

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