INTERDISCIPLINARITY IN ENVIRONMENTAL RESEARCH: AN ANALYSIS BASED ON SCIENTIFIC PUBLICATIONS

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EXTENDED ABSTRACT

The environment is a complex scientific concept; it is difficult to define and classify the various environmental fields. Although traditional sectoral scientific approaches are necessary, they are not enough to deal with modern challenges. During last decades, new, more integrated research methods contribute to understanding complicated environmental problems. This paper explores some multidisciplinary, interdisciplinary or transdisciplinary aspects of modern environmental research based on the study of relevant publications in scientific journals.

In the first phase of the work, a limited list of environmental journals was defined. Through a random selection of not too specialized environmental articles from the Science Direct database, a list of 20 authors has been produced. In a next stage, the Google Scholar database has been used to identify 230 environmental publications of the above authors; one criterion for the authors’ selection was that they should have published at least four articles in three different environmental journals; in the final stage, the selected papers were studied and classified into categories based on their content, aim and methodology. For the classification of the publications into categories we used three approaches. The objective of each approach is to examine the percentage of authors whose publications belong not only to one category. In the first approach the number of different categories had been fixed to 16; in the second approach we have tried to correspond all the publications in 6 wider categories; in the third approach we have defined 8 new categories corresponding to the main environmental receiving systems.

The results showed that the selected authors publish papers that do not belong only to their scientific specialties. Evidently, the way specialties are separated results in different estimations of interdisciplinarity. The influences of scientific journals, through their publishing policy as well as limitations to the adoption of integrated approaches by researchers specialized in narrow environmental fields are important issues that may contribute negatively or positively to the development of interdisciplinarity. Of course, it is worth noting that scientists’ preoccupation with different specialties is only one aspect of interdisciplinarity; whether or not studies of complex issues follow interdisciplinary procedures may be another question that requires a special study.

Keywords: Integrated approach, multidisciplinarity, interdisciplinarity, transdisciplinarity, scientific articles, categories of publications.

1. INTRODUCTION

The concept of system is analyzed in General Systems Theory (Bertalanffy, 1950). “In systems, science is used to analyze complexity, to bring a greater amount of transparency into the interaction of parts” (Sydow, 2009). Environment is a complex system with a variety
of interactions (Hadjibiros, 2007). The difficulty of analyzing the environment consists in the fact that man is part of the complex system/ecosystem (Sydow, 2009) and he interacts with it. The meaning of the environment does not only include the natural one but also the socioeconomic environment. According to Weingart and Stehr (2000) “the most socioeconomic problems are interdisciplinary in nature”. Although traditional disciplinary approaches have had greatly contributed to understanding environmental problems, they are not enough for the management of the modern environmental challenges. So, for the last past decades, new, more integrated scientific methods of research and solution of environmental problems have appeared, which “outcome from disciplinary research, thus breaking down the methodological, epistemological and ontological boundaries that prevent shared understandings of complex issues” (Jacobs and Amos, 2010) and create a new more integrated knowledge. Under the umbrella of “integrative approaches” terms like multidisciplinarity, interdisciplinarity and transdisciplinarity have appeared. These terms “are used to express forms of research cooperation crossing disciplinary boundaries” (Tress et al, 2006) and create new methods, theories and knowledge. While these terms are not antagonistic, as they “share the common goal of understanding the reality” (Zaman and Goschin, 2010), “there are often subtle, but significant differences between the terms which mean they cannot (or should not) be used interchangeably” (Stock and Burton, 2011). Tress et al (2006) suggest that “the lack of common understanding of integrative research concepts is a key barrier to integration”. Multidisciplinary research involves the participation of two or more different disciplines but “with each of them working primarily on its own framings and methods” (Cronin, 2008) and “collaboratively create a more complex image of reality” (Zaman and Goschin, 2010). In multidisciplinary approach researchers have different goals and they work together “without integration but usually with the aim to compare results” (Tress et al, 2006). Multidisciplinary research “does not involve any integration of new knowledge” (Stavridou and Ferreira, 2010). As Klein (1990) suggests “It is essentially additive, not interactive”. An example of multidisciplinary research is Environmental Impact Study; each of the scientists works on his own discipline in order to assess the environmental, social and economic possible (positive or negative) impact that a proposed project may have on the environment; there is no integration of new knowledge as they work independently and they simply add their results.

Interdisciplinarity differs from multidisciplinarity in the level of integration as “seeks to bridge disciplinary viewpoints and potentially enable the examination of existing accumulated knowledge from the perspective of a neighboring discipline” (Stock and Burton, 2011). The US National Academy of Sciences (2004) defines interdisciplinarity as “a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice”. Tress et al (2006) suggest that the term ‘integration’ means that different knowledge cultures (disciplines that have different concepts of data and validation), like natural sciences, social sciences and humanities are bridged and this requires that researchers must be ‘competent’, each one in the scientific sector of the other (Perper, 1989). The term ‘competent’ implies the need for an advanced degree of knowledge beyond that of specialty of each scientist. Jakobsen et al (2004) divide interdisciplinarity into ‘unidirectional interdisciplinarity’ when a single discipline dominates and controls the integration and ‘goal-oriented interdisciplinarity’ when the interaction is guided by the nature of the issue.

“Transdisciplinarity is a new field of research emerging in the ‘knowledge society’, which links science and policy to address issues such as environmental degradation, new technologies, public health and social change” (Cronin, 2008). The main difference from
interdisciplinarity is that in transdisciplinarity research integrates both academic and non-academic participants with final objective their connection with politics. “Transdisciplinarity combines interdisciplinarity with a participatory approach” (Tress et al, 2006b). “Academic participants are researchers and non academic participants are societal actors such as policy makers, representatives of administration or interest groups, locals or the broader public” (Tress et al, 2006). Klein (1990) suggests Structuralism, Political Sciences, Marxism and General Systems Theory as transdisciplinary examples. “Transdisciplinarity defines a research focused on problems that cross the boundaries of two or more disciplines, aiming at a holistic approach” (Zaman and Goschin, 2010). However Hadjibiros (2012) criticizes the concept of holism as it is “strongly related to metaphysical views and lies in the opposite of an integrated systemic approach”. Transdisciplinarity is a new term and “it is not yet clear what sort of creature this really is, or how it is deliberately created” (Lynch, 2006). Interdisciplinarity may be considered as “the attainable” and transdisciplinarity may be considered as “the ideal” but both are integrated approaches.

2. METHODOLOGY
We try to contribute to the study of integrated scientific approaches through the study of publications in environmental journals and proceedings of international environmental conferences. Our objective is to study if each author’s publications belong to more than one scientific fields; and therefore if the authors themselves have an advanced degree of knowledge beyond that of their specialty.

This study was carried out in two phases (Makrogianni, 2012). In the first phase we selected a limited list of environmental journals; afterwards, we made a random selection of not too specialized articles via the Science Direct data base which led to a first random selection of authors; then via the Google Scholar data base, we looked for their publications. The prerequisite was that the authors should have at least four publications in at least three different environmental journals; this prerequisite was set because most journals are specialized and publish articles only in a narrow sector or sub-sector of environmental sciences. A second prerequisite was that we could have access to at least the title and the summary of the publication. Finally we selected 20 authors with a total number of 230 publications. In the second phase we studied and classified their publications into categories. For the classification we used three approaches. The objective of each approach is to examine the percentage of authors whose publications belong to more than one category; we defined this method as a way to estimate the degree of interdisciplinarity.

1st approach: the categories resulted from the study of the publications in relation to their content, aim and methodology. The categories initially were 20; however there have been categories to which only one publication corresponded; so, the final number of categories has been reduced to 16. The categories represent scientific (environmental) specialties. (Table 1).

2nd approach: we grouped all the 16 categories of the first approach into 6 broader categories that could be considered (scientifically) relevant. Our aim was to examine the degree of interdisciplinarity when the categories were more general (Table 1).

3rd approach: we grouped all the 16 categories of the first approach into 8 new categories according to the environmental receptors (Water, Soil, Forest, Atmosphere).

Finally, 4 categories remained the same both in the second and the third approach (Table 1).
Table 1: The 16 categories which belong to the first approach have been grouped in the 2nd and the 3rd approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>Name of category</th>
<th>Grouping of the 16 categories which belong to the first approach</th>
</tr>
</thead>
</table>
| 2nd and 3rd approach| Society – Economy - Policy                | • Sustainable Development  
                          • Environmental Legislation  
                          • Environmental Policy  
                          • Social Participation  
                          • Environmental Economy (Emissions, Resources, Ecosystems) |
| 2nd and 3rd approach| Tools – Environmental Assessment          | • Environmental Impact Assessment  
                          • Tools of Environmental Analysis, Assessment and Management |
| 2nd and 3rd approach| Environmental Social Philosophy           | • Environmental Social Philosophy |
| 2nd and 3rd approach| Ecology                                   | • Ecology |
| 2nd approach        | Pollution - Degradation                   | • Soil Pollution  
                          • Atmospheric Pollution  
                          • Degradation of Water Resources  
                          • Pollution – Degradation of Forest Ecosystem |
| 2nd approach        | Environmental Management                  | • Management of Water Ecosystem  
                          • Management of Water Resources  
                          • Management of Forest Ecosystem |
| 3rd approach        | Water                                     | • Management of Water Resources  
                          • Degradation of Water Resources  
                          • Management of Water Ecosystem |
| 3rd approach        | Forest                                    | • Management of Forest Ecosystem  
                          • Pollution-Degradation of Forest Ecosystem |
| 3rd approach        | Soil                                      | • Soil Pollution |
| 3rd approach        | Atmosphere                                | • Atmospheric Pollution |

3. RESULTS

The maximum number of an author’s publications (Table 2) is 36 and the minimum is 4, with an average of 11.5 publications/author. Also there are authors whose publications belong to many categories compared to the number of their publications as well as authors whose publications correspond to a small number of categories compared to the number of their publications (Table 2).
Table 2: Number of publications and categories corresponding to each author

<table>
<thead>
<tr>
<th>Authors</th>
<th>Number of publications</th>
<th>1st Approach</th>
<th>2nd Approach</th>
<th>3rd Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I. G.</td>
<td>36</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2. K. K.</td>
<td>14</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>3. K. H.</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4. D. N.</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5. S. H.</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>2</td>
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<tr>
<td>6. D. R.</td>
<td>13</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7. N. P.</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>3</td>
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<tr>
<td>8. P. R.</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>3</td>
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<tr>
<td>9. R. K.</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>3</td>
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<tr>
<td>10. A. H.</td>
<td>15</td>
<td>2</td>
<td>1</td>
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<tr>
<td>11. H. S.</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>4</td>
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<tr>
<td>12. N. R.</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>13. J. T.</td>
<td>4</td>
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<tr>
<td>14. M. E.</td>
<td>6</td>
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<td>15. J. C.</td>
<td>10</td>
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<td>4</td>
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<tr>
<td>16. A. M.</td>
<td>5</td>
<td>3</td>
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<tr>
<td>17. C. R.</td>
<td>15</td>
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<td>3</td>
<td>3</td>
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<tr>
<td>18. B. V.</td>
<td>23</td>
<td>2</td>
<td>2</td>
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<tr>
<td>19. M. S.</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>20. J. O.</td>
<td>9</td>
<td>1</td>
<td>1</td>
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</table>

Moreover, in order to estimate the degree of interdisciplinarity, we compare the results between the three approaches:

In the first approach, an author’s publications correspond to minimum 1 and maximum 7 categories, with an average of 3.75 categories/author (Table 2). There is a 5% of the authors whose publications belong to 1 category only; while 95% of them correspond to a number of categories between 2 and 7 (Table 2). These results show that the specific authors study scientific subjects beyond the limits of their specialty. So, an increased degree of interdisciplinarity is noticed.

In the second approach, an author’s publications correspond to minimum 1 and maximum 5 categories with an average of 2.75 categories/author (Table 2). There is a 20% of the authors whose publications belong to 1 category only; while 80% of them correspond to a number of categories between 2 and 5 (Table 2). In comparison with the first approach, we observe (Table 2) that the publications of 65% of the authors fall in less categories. Specifically, the publications of 30% and 35% of the authors fall in 2 and 1 less categories respectively. So, comparatively with the first approach, in the second approach we find, as expected, a smaller degree of interdisciplinarity.

In the third approach, there is a 10% of the authors whose publications belong to 1 category only; while 90% of them correspond to a number of categories between 2 and 4 (Table 2), with an average of 2.8 categories/author. In comparison with the first approach, we observe (Table 2) that the publications of 60% of the authors fall in less categories. Specifically, the publications of 5%, 20% and 35% of the
authors fall in 3, 2 and 1 less categories respectively. So, we observe a smaller degree of interdisciplinarity compared to the first approach.

In comparison with the second approach, 75% of the authors' publications correspond to the same number of categories (Table 2). Also we observe (Table 2) that the publications of 10% of the authors fall in less categories. This happens because in the second approach their publications correspond to different categories, but concern one environmental receptor. For the rest 15% of the authors an increase (by 1 category) in the number of categories where their publications belong is observed (Table 2). This may be explained by the fact that their publications concern two different environmental receptors, but in the second approach they correspond to 1 category. So, we observe a higher degree of interdisciplinarity compared to the second approach.

Table 3: Degree of interdisciplinarity in each approach

<table>
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<tr>
<th></th>
<th>1st Approach</th>
<th>2nd Approach</th>
<th>3rd Approach</th>
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<tbody>
<tr>
<td>Number of categories</td>
<td>16</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Average of categories</td>
<td>3,7</td>
<td>2,75</td>
<td>2,8</td>
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<tr>
<td>corresponding to each</td>
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<tr>
<td>author</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Percentage of authors</td>
<td>5%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>whose publications</td>
<td></td>
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<tr>
<td>correspond to 1 category</td>
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<td></td>
<td></td>
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<tr>
<td>Degree of interdisciplinarity</td>
<td>95%</td>
<td>80%</td>
<td>90%</td>
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<td>categories)</td>
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4. DISCUSSION

Environmental problems are interdisciplinary in nature but “not all interdisciplinarity research is integrated across disciplines to the same level” (Stock and Burton, 2011). Rinia (2007) divides two levels of interdisciplinarity; ‘big’ and ‘small’ interdisciplinarity. ‘Big’ interdisciplinarity occurs between different disciplines (e.g. chemistry and physics), while ‘small’ interdisciplinarity occurs between different specialties (e.g. organic chemistry and applied chemistry) (Larivière and Gingras, 2009). Kutílek and Nielsen (2007) suggest that this division refers to the nature of the issue, that is whether the problem is likely to require big interdisciplinarity or not. In this paper we recognize this division and we try to contribute to the measuring of ‘small’ interdisciplinarity by estimating the degree of interdisciplinarity through publications in environmental journals or environmental conferences. The outcome showed that the way specialties are separated results in different estimations of interdisciplinarity. Also, the percentage of authors whose publications do not belong only in one category was high (in all the approaches), which led to a higher degree of interdisciplinarity. So, as we observed, the specific researchers have published papers beyond their specialty. This ‘competence’, according to Perper (1989), is a prerequisite for the integrated approaches. We also add that this ‘competence’ does not include only the need for an integrative knowledge but also the need for the integration of the researchers themselves, a fact which affects the success of interdisciplinary research. The character, the abilities, the culture, the existence of virtues - such as respect, patience, communication and support - are values that a scientist needs to develop in order to be able to collaborate into a multidisciplinary team. In addition, the personal and professional aspirations of each scientist, such as his level of scientific training and the need for higher specialisation in his scientific field, may constitute boundaries that affect the implementation of interdisciplinary research. Also, the big number of publications a scientist needs to study so as to be aware in his specialty (Pellmar and Eisenberg, 2000) and which increases by 3% each year (Ware,
may have a negative impact on the development of a researcher as it requires time. This, in turn, withholds the scientist from a further specialisation in his own scientific sector and also influences the number of his publications. This fact may explain why authors, who have published papers that belonged to different categories, did not have a bigger number of publications. Moreover, the lack of structures and motives from the Universities, so that the integrated approaches would constitute a piece of scientific research (Rhoten, 2004), are also considered as barriers. Also, the ambiguity that exists around integrated approaches creates a confusion of what the integrated researches really are (Jacobs and Amos, 2010). According to Stock and Burton (2011) “researchers have suggested three fundamental reasons for the failure of integrated research projects; lack of researchers trained in integrated research; lack of quality journals to publish in; lack of ‘college of peers’”. The interdisciplinary journals should have peer-reviewers specialised in interdisciplinary researches (Lee, 2006), who could know the scientific “language” and the methodological characteristics of various sciences (Perper, 1989). The existence of such peer-reviewers, who are specialised in many disciplines, is difficult and as a result, a lot of interdisciplinary researches do not see the light of publicity. Also, according to Kueffer et all (2007) “the lack of practice-oriented journals strongly suggests that there are few options for pushing the boundaries of transdisciplinary research practice, either through sharing lessons learned or proposing and debating new methodological developments. This also makes it harder for transdisciplinary researchers to find each other and to establish a “college” of peers who build on and critique each other’s work, in the process raising the quality and applicability of transdisciplinary methodologies”. Last but not least, language and terminology have been cited as most important barriers to interdisciplinary research (Donaldson et all, 2010). Disciplines “share a common framework of thought” (Lattuca, 2002), a common “language” which enables the members of the discipline to clearly understand each other. However, in integrated approaches, where this framework is merged, “the lack of clear structures and rules for conducting research may prove a barrier to effective research” (Jacobs and Amos, 2010). Communicative and methodological differences between disciplines should create a special discussion. For the successful implementation of integrated approaches, these barriers should be overcome or minimized.

5. CONCLUSION

This paper discusses multi-, inter- and transdisciplinarity and the barriers that they need to overcome in order to achieve a successful implementation. One of our objectives of preparing this paper is to help finding ways to estimate interdisciplinarity in environmental studies. The results showed that the selected authors have published papers that belong not only to their narrow scientific specialities. This means that they are ‘competent’ to more than one scientific specialties; that is an important prerequisite for the successful implementation of integrated research projects. Also, we notice the influence of scientific journals through their publishing policy, in the adoption of integrated approaches. Of course, it is worth noting that scientists’ preoccupation with different specialities is only one aspect of interdisciplinarity; whether or not studies of complex issues follow interdisciplinary procedures may be another question that requires a special study.

REFERENCES


Follows an Appendix with the titles of 230 publications.
APPENDIX: LIST OF PUBLICATIONS


CEST2013_0681


CEST2013_0681