Application of the Paraconsistent Annotated logic in the comparative analysis of the artisanal fisheries diet from Ilhabela/SP, Brazil

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Abstract: - This work presents an application of the Paraconsistent Logic in an analytical and comparative study related to the consumed alimentary item in the diet of the artisanal fisheries families that inhabit the coast north of the state of São Paulo in Brazil. In this boarding the main objective was to demonstrate the possibility to apply techniques of Artificial Intelligence where algorithms structuralized in non-classic logics, as the Paraconsistent Logics, promote the analysis of taken quantitative values through research and for subjective concepts with aggregation of uncertainties. For these analyses extracted algorithms of the Paraconsistent Logic had been used. The Paraconsistent Logic has as main characteristic the acceptance of the contradiction in its theoretical bases. From information taken through recalls 24-hours questionnaires with the fisheries families and organized in tables of values. First the evidence degrees are extracted of the propositions and, through the treatment of these signals of information by configurations of composed networks of paraconsistent algorithms the resultant Evidence Degrees are gotten. The results calculated through the method that was originated in the concepts of the consistent Logic, are compared with other values obtained for statistical ways. This new form of boarding indicates that the Paraconsistent Logic applied to the analysis of on proposals the partner-economic behaviors, as the studied case that deals with the diet of artisanal fishermen communities, presents conditions to serve as parameter for support in the elaboration of conclusions that aim at the applications of directed politics to the welfare of these populations and sustainable use of the fishery resources. The techniques of computational treatment of data that are the representatives of uncertain information, offer excellent characteristics as; the easy agreement of the analysis process, the low computational cost, the possibilities of storage of data for future comparisons and the efficiency in the presentation of the results. All these advantages in relation to the method purely mathematician come of the use of networks of algorithms based on Paraconsistent Logic, proving as soon as this type of non-classic logic are fully capable to present essential information for the support in the opinion formation on the diet of the fishermen of the studied communities. The results of this work show conditions so that techniques of Artificial Intelligence that treat uncertainties based on Paraconsistent Logic come to serve as efficient tool of support the decision to study this subject.

Key-Words: - Algorithm, Paraconsistent Logic, Human Ecology, Artisanal Fishermen, Diet, Artificial Intelligence.

1 Introduction

In this study of application of techniques of Artificial Intelligence using the Paraconsistent Logic in the treatment of uncertainties for comparative analysis in fisheries diets the data handling is made collected in two artisanal fishermen communities of Ilhabela, located in the north coast of the São Paulo State, Brazil. The objectives are to search and to analyze definitive food items consumed for fishermen of different communities. This is part of studies wider than they aim in set with other information to understand the ambient and cultural aspects of the interaction fish-fishing-fishermen. As RAMIRES 2008 [1] is verified that the relative aspects to the diet, how much to the fished consumption of, and the fishing activity is part of the body of knowledge of the fishermen and constitutes a rich quantity of knowledge that added the biological information is useful for the conservation of the fishery resources. It is excellent that research improves the analyses and increases the efficiency of the results using new computational techniques, and thus direct politics that they aim at, among others things, one better quality of life for these people.

1.1 The used Study-standard as reference

For the comparative verification and analyses between the results taken for statistical methods and the presented one in this work, that deals with the use
of techniques of Artificial Intelligence using as it has supported the algorithms of the Paraconsistent Logic, it was chosen as reference the data taken in [1] [2] [3]. In this work of reference the information will be extracted that will be represented in the form of Degrees of Evidence, as the methodology that will be used. The collection of the data on the diet of the fishermen was carried through in two artisanal fisheries communities located in Ilhabela in the north coast of São Paulo State. Recalls 24 hours were carried out checking consumed food items of the 15 families in Serraria Beach and 4 families of the Jabaquara Beach, totaling 489 showed meals this research.

1.1.1 Results of the research of the used Study-standard as reference

The diet data had been analyzed through indices of diversity, amplitude of niche, rarefaction curves and test . These analyses that include the application of methods of ecology to the ethnoecology have been applied wide in studies on the diversity of use of natural resources [2] [3]. As [1] through the analyses of the statistical data was verified that the diet of the fishermen revealed diversified in relation to the total of consumed food item and some differences had been identified in the comparison between the communities. Of this form, the frequency of consumption of the fishes one can be influenced by the seasonality of the fishing activity, by the availability of the local resources, by the access of the fishermen the food item acquired in the urban centers, as for example, the bovine meat, the chicken and also for the value of sales of determined species of fish.

1.1.2 Tables of values searched in the used Study-standard as reference

Several tables [1] [2] [3] in show the results obtained in this research with respect to the consumed food item in at least 1% of the total of meals showed in the two studied communities. These data will be considered as a source of generating information of Degrees of Evidence for the analysis through the Paraconsistent Logic. A table of values obtained in some studies was published that had left well registered the percentages of fishes consumption of in detriment to other foods of animal origin in other more distant populations of urban centers. These values, which include of the proper research, are represented in table 1 that also it will be used as source of generating information of Degrees of Evidence.

In RAMIRES 2008 [1] the data had been analyzed in seasonal form and at two times (winter and summer) because, according to fishermen of Ilhabela and [2] [3], in the summer the fishing productivity is bigger and more steady, in contrast of the winter, where the production is relatively lower and unstable. The results of these researches are presented in table 2 that it will serve as the third source of information for generation of the evidence degrees in the application of the paraconsistent logic[4] [5].

<table>
<thead>
<tr>
<th>Place</th>
<th>Consumption of Fish</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island Buzios</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puruba Beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point of Almada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boqueir (Ilhabela)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Island Ilha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puruba Beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serraria (Ilhabela)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>São Paulo Ribeiro</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puruba Beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedrinhas (Ilha)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Percentage of fishes consumption in fisheries communities of the Brazilian coast.

In the process of application of the paraconsistent logic the tables with the results of the research are the sources of information of where the degrees of evidence will be extracted to form the corresponding annotation to the proposition that will be analyzed.
We present to follow a summary of the basic concepts of the Paraconsistent Logic and the algorithms used in this study.

2 The Annotated Paraconsistent Logic

The paraconsistent logics are considered logical non-classic and possess as characteristic main the acceptance of the contradiction in its theoretical structure. Amongst the Paraconsistent Logics exist the class Paraconsistent Logics that possess associated lattice and had been introduced for the first time in logical programming by Subrahmanian in [4]. The methods of treatment of uncertainty presented here use the beddings of an extension of the paraconsistent annotated logic called of the paraconsistent annotated logic with annotation of two values (PAL2v) [5] [6][7].

2.1 The Lattice Associated to the Paraconsistent Annotated Logic with Annotation of two values

In the Paraconsistent Annotated Logic the propositional formulas come accompanied of annotations. Each annotation, belonging to a Lattice finite, attributes values to his correspondent propositional formula [4][5]. To obtain a larger representation it is used a Lattice formed by pairs orderly, such that: \( \tau = \{(\mu, \lambda) \mid \mu, \lambda \in [0, 1] \subset \mathbb{R} \} \). An operator is considered \( \neg \) : \( [\tau] \rightarrow [\tau] \), where the operator \( \neg \) it constitutes the "meaning" of the logical symbol of negation \( \neg \) of the system that will be considered.

If \( P \) is a basic formula [4] [5][6][8], then the operator \( \neg \) : \( [\tau] \rightarrow [\tau] \) is considering as: \( \neg \) \( (\mu, \lambda) = (\lambda, \mu) \), where, \( \mu, \lambda \in [0, 1] \subset \mathbb{R} \). In that way:

\[ (\mu, \lambda) : \text{An Annotation of } P. \]

\( P_{(\mu, \lambda)} \): The Paraconsistent logic signal, where the Evidence favorable degree \( \mu \) and Evidence unfavorable degree \( \lambda \) compose an Annotation that attributes a logical connotation to the Proposition \( P [5][6][7] \). This way, the association of an annotation \( (\mu, \lambda) \) to a proposition \( P \) means that the Evidence favorable Degree of in \( P \) is \( \mu \), while the Evidence unfavorable Degree, or contrary, is \( \lambda \). Intuitively, in such Lattice we have:

\( P_{(\mu, \lambda)} \)\( = P_{(0, 0)} \) : indicating 'existence of total favorable evidence and null unfavorable evidence', attributing a connotation of Inconsistency to the proposition.

\( P_{(\mu, \lambda)} \)\( = P_{(0, 1)} \) : indicating 'existence of null favorable evidence and total unfavorable evidence', attributing a connotation of Indetermination to the proposition.

\( P_{(\mu, \lambda)} \)\( = P_{(1, 0)} \) : indicating 'existence of total favorable evidence and null unfavorable evidence', attributing a connotation of Indetermination to the proposition.

\( P_{(\mu, \lambda)} \)\( = P_{(1, 1)} \) : indicating 'existence of total favorable evidence and total unfavorable evidence', attributing a connotation of Inconsistency to the proposition.

Through lineal transformations in an unitary square in the Cartesian plan [6] and the representative Lattice of the LPA can be arrived the transformation:

\[ T(x, y) = (x-\nu, x+y-1). \]

Relating the components of the transformation \( T(x, y) \) according to the usual nomenclature of PAL2v, where \( x = \mu \) (Evidence favorable Degree) and \( y = \lambda \) (Evidence unfavorable Degree). From the first term obtained in the orderly pair of the transformation equation, comes that:

\[ x = \nu = \mu - \lambda \]

which denominated of certainty Degree \( D_c \). Therefore, in the PAL2v the certainty Degree is obtained by:

\[ D_c \mu = \mu - \lambda \quad (1) \]

And their values, that belong to the real number set \( \mathbb{R} \), they vary in the interval closed +1 and -1, and they are in the horizontal axis of the Lattice, which is called of "Axis of the Degrees of Certainty". When \( D_c \) results in +1 it means the logical state resulting from the Paraconsistent analysis is True \( t \), and when \( D_c \) results in -1 it means that the logical state resulting from the analysis is False \( F \). From the second term obtained in the orderly pair of the equation of the transformation is:

\[ x+y-1 = \mu + \lambda -1, \]

which denominated of Contradiction Degree \( D_\perp \). Therefore, the Contradiction Degree is obtained for:

\[ D_\perp = (\mu + \lambda) - 1 \quad (2) \]

And their values, that belong to the real number set \( \mathbb{R} \), they vary in the interval closed +1 and -1, and they are in the vertical axis of the Lattice, which is called of "Axis of the Degrees of Contradiction". When \( D_\perp \) results in +1 it means the logical state resulting from the Paraconsistent analysis is Inconsistent \( T \), and when \( D_\perp \) results in -1 it means that the logical state resulting from the analysis is Indeterminate \( \perp \).
It is possible the obtaining of the Degree of Real Certainty $D_{CR}$ as a value projected in the axis of the degrees of certainty of Lattice through the equations [5] [6]:

$$D_{CR} = 1 - \sqrt{(1 - |D_c|)^2 + D_c^2}, \quad \text{if } D_c > 0 \quad (3)$$

$$D_{CR} = \sqrt{(1 - |D_c|)^2 + D_c^2} - 1, \quad \text{if } D_c < 0 \quad (4)$$

And starting from $D_{CR}$ it is possible to calculate his value normalized, that is denominated of Resulting Evidence Degree $\mu_{ER}$. Therefore:

$$\mu_{ER} = \frac{D_{CR} + 1}{2} \quad (5)$$

2.2 Algorithms used in the Paraconsistent analysis

All of the procedures related to the paraconsistent treatment logical, so much in the signals captured through the tables as in the treatment of information in the form of resulting Evidence Degrees will be related to the analysis made by an extracted algorithm of Paraconsistent Logic's theoretical foundations PAL2v, denominated of PAN (Paraconsistent Analysis Node) [5] [6].

2.2.1 The Paraconsistent Analysis Node

The descriptive and the symbol of a typical PAN that it will be used in the comparative analysis of the diet of artisanal fishermen of Ilhabela (Brazil) it will be presented to proceed.

![Symbol of a typical PAN](image)

A lattice description uses the values obtained by the equation results in the Paraconsistent Analyzer Node Algorithm [6] that can be written in a reduced form, as follows:

1. Enter with the input values
   $\mu$ */ favorable evidence Degree $0 \leq \mu \leq 1$
   $\lambda$ */ unfavorable evidence Degree $0 \leq \lambda \leq 1$

2. Calculate the Contradiction Degree
   $D_a = (\mu + \lambda) - 1$

3. Calculate the Interval of Certainty
   $\varphi = 1 - |D_a|$

4. Calculate the Certainty Degree
   $D_c = \mu - \lambda$

5. Calculate the distance $d$ into Lattice
   $d = \sqrt{(1 - |D_c|)^2 + D_c^2}$

6. Compute the output signal

   If $\varphi \leq 0.25$ or $d \geq 1$ Then do $S1 = 0.5$:
   Indefinite logical state and go to the steep 9
   Or else go to the next step

7. Calculate the real Certainty Degree
   If $D_c > 0$ $D_{CR} = (1 - d)$
   If $D_c < 0$ $D_{CR} = (d - 1)$

8. Calculate the real Evidence Degree
   $\mu_{ER} = \frac{D_{CR} + 1}{2}$

9. Present the outputs
   Do $S1 = \mu_{ER}$

10. End

2.2.2 The Algorithm Extractor of Contradiction effects

The Extractor of effects of the Contradiction receives signals and, independently of other external information it has the function to do a paraconsistent analysis in their values and to present in the output a Degree of Evidence resulting Real from where were extracted the effects caused by the contradiction. The algorithm used in the process is described to proceed:

1. Present the values of Evidence Degrees of the groups in studies:
   $G_{ER1} = (\mu_A, \mu_B, \mu_C, ..., \mu_n)$ */ $0 \leq \mu \leq 1.0 */

2. Select the largest value among the Evidence Degrees of the group in study.
   $\mu_{max} = \max (\mu_A, \mu_B, \mu_C, ..., \mu_n)$

3. Select the smallest value among the Evidence Degrees of the group in study.
   $\mu_{min} = \min (\mu_A, \mu_B, \mu_C, ..., \mu_n)$

4. Do make the Paraconsistent analysis among the selected values:
   $\mu_{R1} = \mu_{min} \cap \mu_{max}$ */ Utilization of a PAN */

5. Increase the obtained value $\mu_{R1}$ in the group in study, excluding of this the two values selected previously.
   $G_{ER1} = (\mu_A, \mu_B, \mu_C, ..., \mu_{R1}, \mu_{max}, \mu_{min})$

6. Return to the item 2 until that the Group in study has a single element that is considered the value resulting from the analyses.
   $G_{ER1} = \mu_{ER}$

3 Application of the Paraconsistent Logic for Diet Analyses

Paraconsistent analysis for treats on the inhabitants' diet in communities of artisanal fishermen the information presented in the tables 1 and 2 were used as sources of information from where are extracted the Evidence Degrees. These degrees will were analyzed in blocks Extractors of effects of Contradiction built by PANs - Paraconsistent Analyses Nodes. In that work it was used a configuration of networks of Paraconsistent
algorithms that more it approximates the results of the analyses of the propositions used in the reference work.

### 3.1 Description of the method of analysis of the Paraconsistent Network proposed

The paraconsistent analysis will have the purpose of investigating in the form of treatment of evidences those communities' behavior related to the consumption of his fishing product. In that way the first proposition analyzed by the network will be related to the consumption of the fish in detriment to identified meat as animal protein. With base in the conclusions obtained in the reference study [1] [2] is considered the object of the research the proposition: \( P_0: \) “The community \( x \) consumes fish”. In the Network of Paraconsistent Analyses to find the Evidence Degree regarding the proposition object \( P_0 \) are necessary the Paraconsistent analyses in primary propositions \( P_p \) and secondary propositions \( P_s \). The primary propositions \( P_p \) are analyzed through values of the extracted Degrees of Evidence of sources of primary information, as the tables of the study presented in [1] used in that work. The secondary propositions are analyzed through the linking of located PANs inside the Network of Paraconsistent Analysis [6]. As the characteristics of interconnections of PANs allow several configurations of networks for the action of the analysis, the formation of the structure will be made by the following stages: acquisition of data, extraction of the Evidence Degrees and configuration of network.

#### 3.1.1 The acquisition of data

The first steps of the process of development of the network of paraconsistent analyses refer the collection of relative data to the analyzed proposition, that it will be extracted of the table 2. In that way the tables 1 and 2 will be used as primary sources of information. In that way the table 2 will be used as reference pattern for the proposition object \( P_0 \) and it will supply the Degree of resulting Evidence through the following primary proposition: \( P_{p_0}: \) "The communities of Brazilian fishermen consumes fish"

#### 3.1.2 Extraction of the of Evidence Pattern's Degrees

The capture of the degrees of evidence pattern is made through normalization where the values of probabilities of the table 2 are transformed in Evidence Degrees valued between 0 and 1. This way, the equations used for the obtaining of the Evidence Degrees related to the primary propositions are:

\[
\mu = \frac{N_{meals}}{sp} \quad \text{and} \quad \lambda = \frac{N_{meals}}{PA}
\]

The table 3 will be used as reference sample for the proposition object \( P_0 \) and following the reference study will supply the Resulting Evidence Degree of through the following primary propositions:

\( P_{p_01}: \) “The community \( x \) consumes fish species in the summer"

\( P_{p_02}: \) “The community \( x \) consumes fish species in the winter"

\( P_{p_03}: \) “The community \( x \) consumes fish species the summer/winter"

The acquisition of the degrees of evidence of the sample is made through mathematical equations of normalization that transform the exposed values in the table 2 in Evidence Degrees valued between 0 and 1. This way, the equations used for the obtaining of the Evidence Degrees are equations shown in equation (6) and the favorable Evidence Degrees \( \mu \) were obtained by the equation (7) it presents that process.

#### 3.1.3 Configuration of Network

Based on the way of you analyze of the diets of the fishermen presented in [1] the configuration of the network was built. The results are presented in the form of Resulting Evidence Degrees easily visualized in each point considered relevant of the network.

### Table 2: Percent of fish consumption in communities of artisanal fishermen of the Brazilian coast

<table>
<thead>
<tr>
<th>Location</th>
<th>( \mu )</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blumenau (Sao Paulo)</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Sao Paulo)</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Porto Alegre (Uberaba SP)</td>
<td>0.23</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 4 Diagram of extraction of Degrees of Evidence starting from the table 2 that shows diversity values and seasonality fish consumption in communities of artisanal fishermen of Ilhabela (Brazil).

The table 3 display the results obtained starting from the values of the reference study where the two communities' of fishermen of Ilhabela data are analyzed.

Table3: Results obtained through the paraconsistent analyses

<table>
<thead>
<tr>
<th></th>
<th>Global Resulting Evidence Degree Sample Jakupagura</th>
<th>Global Resulting Evidence Degree Sample Serrura</th>
<th>Resulting Evidence Degree of the Serrura community</th>
<th>Global Resulting Evidence Degree of the study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P=0.411</td>
<td>P=0.591</td>
<td>P=0.342</td>
<td>P=0.325</td>
</tr>
</tbody>
</table>

4 Conclusion

In that work we presented an application of the Paraconsistent Annotated Logic as a new method used to take advantage information subjective, uncertain, and same the contradictory ones. The configuration of the Network used in that work will easily be able to be modified for improvement of the you analyze with studies more deepened through comparisons among the methods of presentation of results of that research type, getting like this a better quantitative comparison of the precision. The easy visualization of the results demonstrates a larger efficiency of the analysis with conditions of joining the network a convenient interface where computational forms of acquisition of data are used through electronic spreadsheets and interfaces with processing units of signals or standardized files. Due to the dynamism in the application of those new computation tools can be guided with the demanded speed the way as those resources will be used and like this to supply important political actions to seek to those fisheries communities sustainability.

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References: