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Title of paper: Sustainable rural development index

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Abstract

The Sustainable Rural Development Index (IDRS) was elaborated with the purpose of characterizing, in the rural space (predominantly occupied by agriculture and livestock), the economical (IDE), social (IDS) and environmental (IDA) development through three primary indexes, seven secondary indexes and seven parameters. The secondary indexes were computed using the mean values of different parameters, by county, trough normalized variables (range from 0 to 1). The economical index used the following normalized variables: Gross Income Product ($R\$.county^{-1}.year^{-1}$) (first parameter), per capita income ($R\$.person^{-1}.year^{-1}$) (second parameter) (in relation to their maximum values for a specific county). The social index used relative values of scholarity (number of years) (third parameter), life expectance (years) (fourth parameter) and employment level (%) (fifth parameter) (also in relation to their maximum values for a specific county). The environmental index used relative values of Legal Reserve area (ha) (sixth parameter), as well as the Permanent Preservation Area (ha) (seventh parameter), actually used by farmers and the correspondent minimum areas required by the Brazilian law 12.651 (published at DOU in 25 May 2012). The universal model, that typically presents exponential growth, was proposed for computing the secondary index (dependent variable) using a normalized variable as independent variable. This methodology was applied for characterizing the CODEMAU (Association for Developing the 'Médio Alto Uruguai' region) area (23 counties), located at North region of 'Rio Grande do Sul' State. It was verified that: (i) 'Rodeio Bonito' and 'Dois Irmãos das Missões', 'Alpestre' and 'Frederico Westphalen', and 'Vicente Dutra' and 'Taquaruçu do Sul' were the counties that presented, respectively, the lowest and highest values of IDE, IDS and IDA; but, (ii) 'Vicente Dutra' and 'Dois Irmãos das Missões' were the counties that presented, respectively, the lowest and highest values of IDRS. The sustainable rural development index presents as an excellent tool for comparing regions (rural properties, counties, states and countries, for example).

Keywords: Economic development; Social development; Environmental development; Rural space

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1 INTRODUCTION

With the exponential growth of humanity ever more agriculture has a key role in the survival of people, which requires from farmers responsibility to exploit natural resources without exhausting them and also make them more productive. How to consolidate and expand the process of exploitation of natural resources, with increased production of food and other agricultural goods without compromising environmental sustainability? How to insert the entire production activity to economic development and the development of people who participate in these processes?

The traditional agriculture that was being practiced by the majority of farmers for many years, has been influenced by urbanization also in the farthest areas of large cities. This promotes in portion of family farmers, the incursion into new areas such as agroindustry supply of commodities, fruit, services, crafts and other news and / or innovations (KAGEYAMA, 1987, 2008; MÜLLER, 1989; DELPEUCH, 1990; PLOEG, 2008; PELEGRINI; CADONÁ; GAZOLLA, 2009; WANDERLEY, 2009; SCHNEIDER; GAZOLLA, 2011).

There are serious obstacles in measuring the changes occurring in rural areas over time, changes in occupation of rural areas, in manner to develop agriculture, income and the market mainly. This is due to the numerous concepts, situation and levels of development, especially on the gradient of the concrete realities of the rural environment (KAGEYAMA, 1987, 2008; MÜLLER, 1989; DELPEUCH, 1990; PAULILO, 1990; WANDERLEY, 2009).

In southern Brazil, Rio Grande do Sul, it is situated the region's ‘Médio Alto Uruguai’, where around 95% of farmers can be classified as agriculture family (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS – IBGE, 2012). In this region there is a predominance of family units with land areas in the range of 3 to 25 hectares (IBGE, 2012).

This region is represented by the Development Council of ‘Médio Alto Uruguai’ (CODEMAU). It is seen that this region also is characterized by the greater presence of people living in rural areas, which represent 54.75% of the total population (IBGE, 2012).

The topography of the region is the prevalence of hilly areas, making it difficult and even prevents certain agricultural practices.

This creates a gradient of farmers with different areas of land, family units structures; diversity of crops and livestock, technology levels, incomes, various stages of training and perception, with different implications for the development and quality of life.

Farmers to engage in realizing their livelihood, reproduction and family relocation must be connected and integrated into the global context. This process is intrinsically linked to education in the family, school, community and access to information and knowledge, to crops, creations and market to their culture and can not be seen as single and / or isolated from all this process context. The focus now turns on a new look to the countryside, which is the response that the share of agriculture is drafting for the different impacts these changes have caused.

The new forms, practices and processes by which farmers are used to solve their various problems of life, relationships and production are different. Whether they are specifically market, productive, technological, social, work, social organization, services, among others, and that lead to new and challenging strategies of social reproduction.

When we focus on a particular index to evaluate the development we are not suggesting that there is any single development criterion, but a more comprehensive analysis in order to meet this complexity and this diversity of family farming. When building a rural development index strives to understand that the various issues of rural development can be seized through simplifications, without this makes the results devoid of theoretical support (CONTERATO; FILLIPI, 2009).

The construction of a Sustainable Rural Development Index (IDRS) it is a complex and challenging process before constantly renewed scenario (MCLUHAN, 1969). This brings theoretical and practical implications for the various agents that analysis object or agriculture action or rural areas. For farmers, the changes in the form and production conditions imply the adaptation or conversion of their production systems.

Meanwhile, institutions and professionals who work with technical assistance and rural development need to redefine their conceptions strategies and working methods. This is necessary to account for the new issue of agriculture and the consequent demands which they are made and for all that this index can be an alternative. Also relate to land use social function of land.

This work established an index with possibilities to measure and classify the sustainable rural development, not only in their eminently agricultural concepts, but inserted in various aspects of rural areas.

2. MATERIALS AND METHODS

From this study it is established Sustainable Rural Development Index (IDRS), with normalized values ($0 \leq x \leq 1$) and using an empirical model parameter determined by nonlinear regression analysis.

To calculate the Sustainable Rural Development Index (IDRS), the following parameters were used: (i) economic development index (IDE), (ii) social development index (IDS), and (iii) environmental development index (IDA).

For this work, set up the data collection of the 'Médio Alto Uruguai' region (CODEMAU - RS) in order to establish the agricultural conditions and carry out the application of the index.

It should be noted that the Sustainable Rural Development Index is designed to make comparisons at different scales and can insert or remove variables depending on data availability.

In this particular case, the model was used in rural areas of the region CODEMAU, focusing on family farming, which is the audience of more than 90% of the region occupying the countryside. To do so, the following parameters were used for the calculation of (i) economic development index: agricultural gross domestic product and per capita income, (ii) social development index: life expectancy, education, employment, (iii) environmental development index: legal reserve area and permanent preservation area.

1.1 Sustainable Rural Development Index

The social and economic rural development index (*IDES*) can be determined by the following equation:

$$IDES = \frac{IDE + IDS}{2} \quad \textbf{(1)}$$

The social and economic rural development index restricted (*IDESr*) can be determined by the following equation:

$$IDESr = \sqrt{IDE.IDS} \quad \textbf{(2)}$$

The economic, social and environmental rural development index (*IDESA*) can be determined by the following equation:

$$IDESA = \frac{IDE. + IDS + IDA}{3} \quad \textbf{(3)}$$

The Sustainable Rural Development Index relativo (*IDRSr*) can be determined by the following equation:

$$IDRSr = \sqrt[3]{IDE.IDS.IDAr} \quad (4)$$

The Sustainable Rural Development Index (*IDRS*) can be determined by the following equation:

$$IDRS = \sqrt[3]{IDE.IDS.IDA} \quad \textbf{(5)}$$

Where *IDE* refers to the economic development index, *IDS* the Social Development Index, and *IDA* environmental development index.

1.2 Economic development index

Economic development index (*IDE*) is calculated using the following expression:

$$IDE = \sqrt{IPIBR.IRPCMR} \quad \textbf{(6)}$$

where *IPIBR* refers to rural gross domestic product index and *IRPCMR* the per capita income rate in rural areas.

1.2.1 Rural gross domestic product index

The rural gross domestic product index (*IPIBR*) can be calculated by the following expression:

$$Z_2 = \frac{Z_0}{Z_1} \quad \textbf{(7)}$$

$$x = X_1 = \frac{Z_2}{Z_{2_{max}}} \quad \textbf{(8)}$$

$$IPIBR(x) = 1 - \frac{2.\left(\frac{n_0 - x}{n_0 - m_0}\right)}{1 + \left(\frac{n_0 - x}{n_0 - m_0}\right)^{a_0}} \quad \textbf{(9)}$$

Where n_0 e m_0 refer to the relative maximum number (1) and minimum (0) of *IPIBR*, Z_0 gross domestic product agricultural (rural) (PIB, R$.counties^{-1}), Z_1 the number of farms by counties (farms.counties^{-1}), Z_2 the farm average gross domestic product of (R$.farm^{-1}), Z_{2max} the maximum farm average gross domestic product (R$.farm^{-1}), and X_1 the auxiliary variable (x – independent variable) referring to the relative farm average gross domestic product (In this case, it is considered 1 – equivalent to 100% - the PIB the best agricultural counties, to be the largest PIB of CODEMAU) ($0 \leq x \leq 1$), and a_0 the empirical model parameter determined by nonlinear regression analysis (Table 1).

Table 1 – Rural Gross Domestic Product Index (PIB) rural (*IPIBR*) based on the proportion (%) of PIB rural in relation to PIB total the best counties in absolute values (z) and relative values (x)

Z	*x*	*IPIBR*	Class
0,0	0,000	0	Very low
25,0	0,250	0,09	Low
50,0	0,500	0,30	Medium
75,0	0,750	0,56	Very good
100,0	1,000	1,00	Excelent

1.2.2 Per capita income level of rural environment

Per capita income level of rural environment (*IRPCMR*) can be calculated by the following expression:

$$Q_2 = \frac{Q_1}{12.S_{\min}} \quad \textbf{(10)}$$

$$x = X_2 = \frac{Q_2}{Q_{2_{\max}}} \quad \textbf{(11)}$$

$$\text{IRPCMR}(x) = 1 - \frac{2.\left(\frac{n_1 - x}{n_1 - m_1}\right)}{1 + \left(\frac{n_1 - x}{n_1 - m_1}\right)^{a_1}} \quad \textbf{(12)}$$

Where n_1 e m_1 refer to the relative maximum (1) and minimum (0) per capita income rate of rural environment, Q_2 the number of minimum salaries per family member per month (salaries.person^{-1}.month^{-1}) in absolute values, Q_1 the annual income per capita (R$.person^{-1}.year^{-1}), S_{min} the minimum salarie (R$678,00) X_2 the number (x – independent variable) minimum salaries per family member per month in relative values ($0 \leq x \leq 1$), and a_1 the empirical model parameter determined by nonlinear regression analysis (Table 2).

Table 2 - Per capita income level in rural areas (IRPCMR) on the basis of per capita income, in number of minimum salaries per family member per month in absolute values (q) and relative values (x)

q	x	*IRPCMR*	Class
0,5	0,0143	0,00	Very low
3,0	0,0857	0,02	Low
7,5	0,2143	0,10	Medium
15,0	0,4286	0,25	Very good
35,0	1,0000	1,00	Excelent

1.3 Social development index

The social development index (IDS):

$$IDS = \sqrt[3]{IEV.IE.INE} \quad \textbf{(13)}$$

Where *IEV* refers to life expectancy index, *IE* the education index; and *INE* employment level index.

1.3.1 Life expectancy index

The life expectancy index (*IEV*) can be determined by the following equation:

$$x = X_3 = \frac{EV}{EV_{\max}} \quad \textbf{(14)}$$

$$IEV(x) = 1 - \frac{2.\left(\frac{n_2 - x}{n_2 - m_2}\right)}{1 + \left(\frac{n - x}{n_2 - m_2}\right)^{a_2}} \quad \textbf{(15)}$$

Where n_2 e m_2 refer to the relative maximum number (1) and minimum (0) Life expectancy index, *EV* of life expectancy (Age, years of life) in absolute values, EV_{max} the maximum life expectancy (age, years of life) in absolute values, X_3 to life expectancy (x – independent variable) in relative values ($0 \leq x \leq 1$) and a_2 the empirical model parameter determined by nonlinear regression analysis (Table 3).

Table 3 - Life expectancy index (*IEV*) depending on age (years of life) in absolute values (i) and relative values (x)

i	x	*IEV*	Class
35	0,389	0,100	Very low
49	0,544	0,250	Low
63	0,700	0,460	Medium
76	0,844	0,710	Very good
90	1,000	1,000	Excelent

1.3.2 Education Index

The education Index (*IE*) can be determined by the following equation:

$$x = \frac{f}{f_{\max}} \tag{16}$$

$$IE(x) = 1 - \frac{2.\left(\frac{n_3 - x}{n_3 - m_3}\right)}{1 + \left(\frac{n_3 - x}{n_3 - m_3}\right)^{a_3}} \tag{17}$$

Where n_3 and m_3 refer to the relative maximum number (1) and minimum (0) the education index, f the number of years of school enrollment in absolute values, x the number of years of school enrollment in relative values ($0 \leq x \leq 1$), and a_3 the empirical model parameter determined by nonlinear regression analysis (Table 4).

Table 4 - Education index (*IE*) depending on the number of years of school enrollment in absolute values (*f*, anos) and relative values (x)

F	*x*	*IE*	Description	Class
0	0,00	0,00	Illiterate	Very low
3	0,17	0,06	Education to the first grade of elementary school	Low
10	0,56	0,34	Complete primary education	Medium
13	0,72	0,53	Completed high school	Very good
18	1,00	1,00	Complete higher education	Excelent

1.3.3 Employment level index

The employment level index (*INE*) can be determined by the following equation:

$$e = 100 - d \tag{18}$$

$$x = X_5 = \frac{e}{e_{\max}} \tag{19}$$

$$INE(x) = 1 - \frac{2.\left(\frac{n_4 - x}{n_4 - m_4}\right)}{1 + \left(\frac{n_4 - x}{n_4 - m_4}\right)^{a_4}} \tag{20}$$

Where n_4 and m_4 refer to the relative maximum number (1) and minimum (0) employment level index, *d* the proportion (%) of the population unemployed, *e* the proportion (%)employed people, e_{max} the proportion (%) maximum of people employed, X_5 the variable (x – independent variable) auxiliary ($0 \leq x \leq 1$), and a_4 the empirical model parameter determined by nonlinear regression analysis (Table 5).

Table 5 - Employment level index (*INE*) depending on the absolute proportion (d, %) and relative proportion (D) of the population unemployed

d	$D=d/d_{max}$	*x*	*INE*	Class
60	1,00	0	0,01	Very low
45	0,75	0,25	0,05	Low
30	0,50	0,50	0,25	Medium
15	0,25	0,75	0,55	Very good
0	0,00	1,00	1,00	Excelent

1.4 Environmental Development Index

The Environmental Development Index (*IDA*):

$$IDA = \sqrt{IARL.IAPP} \quad \textbf{(21)}$$

Where *IARL* refers to the Legal reserve area index and *IAPP* the permanent preservation area index.

The relative Environmental Development Index (*IDAr*):

$$IDAr = \sqrt{IARLr.IAP\,\mathrm{Pr}} \quad \textbf{(22)}$$

Where *IARLr* refers to the relative Legal reserve area index and *IAPPr* the relative permanent preservation area index.

1.4.1 Legal reserve Index

The Legal reserve Index (*IARL*) can be determined by the following equation:

$$x = X_6 = \frac{S_1}{S_L} \ (\text{Se } s \leq S_L) \quad \textbf{(23)}$$

$$x = X_6 = 1 \ (\text{Se } s > S_L) \quad \textbf{(24)}$$

$$IARL(x) = 1 - \frac{2.\left(\frac{n_5 - x}{n_5 - m_5}\right)}{1 + \left(\frac{n - x}{n_5 - m_5}\right)^{a_5}} \quad \textbf{(25)}$$

The relative Legal reserve Index (*IARLr*) can be determined by the following equation:

$$x = \frac{X_6}{X_{6_{max}}} \quad \textbf{(26)}$$

$$IARLr(x) = 1 - \frac{2.\left(\frac{n_5 - x}{n_5 - m_5}\right)}{1 + \left(\frac{n_5 - x}{n_5 - m_5}\right)^{a_5}} \quad (27)$$

Where n_5 and m_5 refer to the relative maximum number (1) and minimum (0) to the legal reserve index, S_1 the percentage (%) of the average of the legal reserve, S_L of the minimum percentage (%) required by law, x relative value ($0 \leq x \leq 1$) between the average value and the minimum required by law (in decimal), a_5 the empirical model parameter determined by nonlinear regression analysis and X_{6MAX} refers to the maximum value of X_6 (Table 6).

Table 6 - The legal reserve Index (*IARL*) according to the percentage (%) required by law in absolute values (S_1) and relative values (x)

S_1	X	*IARL*	Class
0	0,00	0,000	Very low
25	0,25	0,025	Low
50	0,50	0,215	Medium
75	0,75	0,516	Very good
100	1,00	1,000	Excelent

1.4.2 Permanent preservation area Index

The permanent preservation area Index (*IAPP*) can be calculated by the following expressions:

$$x = X_7 = \frac{G_1}{G_L} \text{ (Se } G_1 \leq G_L) \quad \textbf{(28)}$$

$$x = X_7 = 1 \text{ (Se } G_1 > G_L) \quad \textbf{(29)}$$

$$IAPP(x) = 1 - \frac{\frac{n_6 - x}{n_6 - m_6}}{1 + \left(\frac{n - x}{n_6 - m_6}\right)^{a_6}} \quad \textbf{(30)}$$

The relative permanent preservation area Index (*IAPPr*) can be calculated by the following expressions:

$$x = \frac{X_7}{X_{7_{\max}}} \tag{31}$$

$$IAP\,\Pr(x) = 1 - \frac{\dfrac{n_6 - x}{n_6 - m_6}}{1 + \left(\dfrac{n_6 - x}{n_6 - m_6}\right)^{a_6}} \tag{32}$$

Where n_6 e m_6 refers to the relative maximum value (1) and minimum (0) the legal reserve index, G_1 the average percentage (%) of permanent preservation area (*APP*) current of county, G_L the minimum average percentage (%) required by law of the county, X_7 the value (x – independent variable) relative ($0 \leq x \leq 1$) of permanent preservation area (*APP*) required by law per county, a_6 the empirical model parameter determined by nonlinear regression analysis and X_{7MAX} refers to the maximum value of X_7 (Table 7).

Table 7 - Permanent preservation area index (IAPP) according to the percentage (%) of permanent preservation area (APP) required by law in absolute values (GL) and relative values (X7)

G_L	X_7	*IAPP*	Class
0	0,0	0,00	Very low
70	0,7	0,50	Low
80	0,8	0,65	Medium
90	0,9	0,80	Very good
100	1,0	1,00	Excelent

3. RESULTS AND DISCUSSIONS

With the result of the calculation of sustainable rural development index for the region CODEMAU confirms that it is necessary to expand the range of perspectives on the rural areas, especially those related to agricultural production, market, income and environmental preservation.

The rural sustainable development index is up an initial work from the perspective of using sociological concepts with the use of models. In this model, to calculate the levels of economic, social and environmental development, the standard variable displays Typically used exponential growth.

It was used as a case study, the values of the counties of CODEMAU. For purposes of calculating the environmental development index, the legal parameters were used, according to Brazilian law,

regarding the Forest Code legal reserve area of 20% to the calculation of the legal reserve ratio, and the restrictions were observed legal to calculate the permanent preservation area index.

It was verified that: (i) 'Rodeio Bonito' and 'Dois Irmãos das Missões', 'Alpestre' and 'Frederico Westphalen', and 'Vicente Dutra' and 'Taquaruçu do Sul' were the counties that presented, respectively, the lowest and highest values of IDE, IDS and IDA; but, (ii) 'Vicente Dutra' and 'Dois Irmãos das Missões' were the counties that presented, respectively, the lowest and highest values of IDRS. The sustainable rural development index presents as an excellent tool for comparing regions (rural properties, counties, states and countries, for example).

The Sustainable Rural Development Index is presented as an excellent tool for comparing regions (properties, cities, states and countries, for example).

The data collection allows you to analyze the situation in the region under study, understand the conditions of the rural areas of the region, family farming and development. The index also considers the assessment of the issues of human development, rural and human development index.

Table 8 – Economic development index (*IDE*), Social development index(*IDS*), environmental development index (*IDA*) and sustainable rural development index (*IDRS*). Council of Regional Development 'Médio Alto Uruguai' (CODEMAU), Rio Grande do Sul, Brazil. 2009, 2010 e 2011

Id	County	*IDE*	*IDS*	*IDA*	*IDRS*
1	Alpestre	0,187	0,852	0,0027	0,076
2	Ametista do Sul	0,140	0,899	0,0933	0,227
3	Caiçara	0,340	0,957	0,0228	0,195
4	Cristal do Sul	0,189	0,853	0,0139	0,131
5	Dois Irmãos das Missões	1,000	0,887	0,1032	0,451
6	Erval Seco	0,229	0,916	0,0635	0,237
7	Frederico Westphalen	0,459	0,986	0,0373	0,257
8	Gramado dos Loureiros	0,206	0,875	0,0208	0,155
9	Iraí	0,249	0,931	0,0096	0,131
10	Jaboticaba	0,244	0,889	0,0123	0,139
11	Nonoai	0,523	0,890	0,0298	0,240
12	Novo Tiradentes	0,239	0,925	0,0079	0,121
13	Palmitinho	0,262	0,915	0,0256	0,183
14	Pinhal	0,425	0,915	0,0181	0,192
15	Pinheirinho do Vale	0,294	0,903	0,0097	0,137
16	Planalto	0,177	0,886	0,0543	0,204
17	Rio dos Índios	0,185	0,860	0,0107	0,119
18	Rodeio Bonito	0,175	0,936	0,0080	0,109
19	Seberi	0,313	0,905	0,0553	0,250
20	Taquaruçu do Sul	0,359	0,960	0,0550	0,267
21	Trindade do Sul	0,240	0,917	0,0229	0,171
22	Vicente Dutra	0,260	0,887	0,0006	0,051
23	Vista Alegre	0,401	0,891	0,0223	0,200

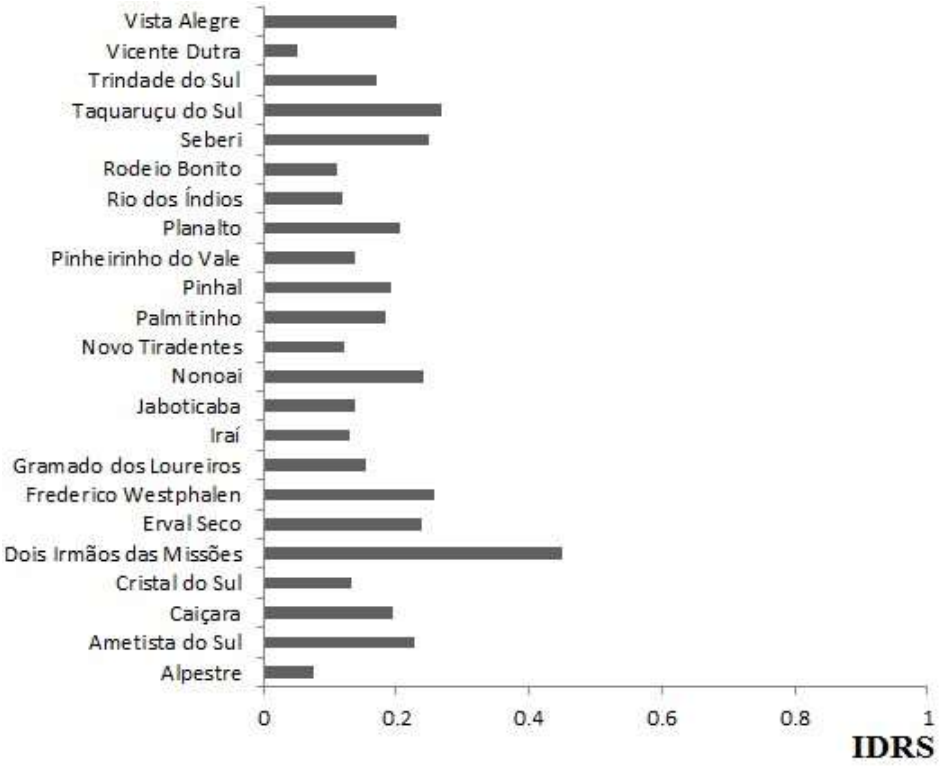

Figure 1- Sustainable rural development index (*IDRS*) for the counties of the Regional Development Councilo Médio Alto Uruguai (CODEMAU), Rio Grande do Sul, Brazil. 2009, 2010 e 2011

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