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# MODEL OF ECONOMIC VALUE FOR THE DESSERTIFICATION PROCESS OF THE "TATACOA DESSERT"

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## ABSTRACT

A tool for collecting information for the economic value of the soil erosion growing in the Tatacoa dessert was design and validated. The internal consistency analysis calculated with the alpha coefficient of Cronbach was used for validation purposes which is a very trustable instrument. For the economic value of the desertification process was used a basic aggregate model which allows observing the desertification effects on such variables as "economic capital and work" expressed in the model as "gross value of agriculture production" (VBP). The model variables affect in a whole the "gross value of agriculture production" finding, furthermore, that economic capital, terrain, desertification and terrain-desertification interaction are variables that, individually, explain the gross value and agriculture production.

**Keywords:** desertification, Tatacoa dessert, gross value, agriculture production, economic value.

## INTRODUCTION

Desertification and soil damage threaten to finish the strategic ecosystems and endangered economic activities of the eco-region people which leads to reduce their life quality.

According to Ortiz (2013), desertification is the degradation of arid soils, semi-arid and dry sub-humid zones caused mainly by climatic variations and such human activities as crop and excessive grazing, deforestation and scarcity of water. According to UN through the program for the environment (PNUMA) (1994), desertification threatens one fourth of the planet's life, affects directly more than 250 million people and endangers the living resources of people from more than 100 countries since soil productivity for agriculture and cattle rising is reduced.

In Huila State (Colombia) this type of inconvenient is presented in arid and semi-arid zones belonging to the Tatacoa desert eco-region in the mayorship of Villavieja. It is located in the north part of the Huila state and according to Espinal (1990), is has two zones with bio-temperature in °C and rain precipitation en mm corresponding to: very dry tropical woodland (bms-T) with +- 24°C, rain 500-1000 mm; dry tropical woodland (bs-T) +- 24°C, rain 1000-2000 mm.

Olaya, Sanchez and Acebedo (2001) affirm that in the Tatacoa desert predominate surface soils, eroded with rock outcrops and many natural drainage channels and dry-sterile edaphic association with shorter availability of water periods and longer humidity deficit periods. Soils of these zones present sedimentary accumulation materials very sensitive to erosion. Cattle, sheep and goats belonging to the zone are fed with native grass and bushes which leads to create erosion process and to impede the vegetable cover development. Furthermore, certain amount of water rain falls as intensive heavy rain, then, water precipitation and surface rain-off are very erosive. These two factors plus the anthropic effect have generated the formation of furrows and the activation of collapse and caving in the terrains with low vegetation. Besides, it is important to perform researches highly contributing to direct efforts towards improving economic and social by adequate soil and water use according to the desert potential.

This study has a result a model for the economic value of the desertification effects and soil degradation in the Tatacoa desert.

## METHODOLOGY

### Preparation and validation of the research instrument

A bibliographic search was performed for the elaboration of the diagnostic tool. Several sets of questions related to general information, surveyed economic conditions, terrains, economic capital and hand labor were established. Table-1 shows the consulted references related to the economic value of natural resources that provided valuable information for the elaboration of the diagnostic tool.

The design questions for the diagnostic tool were subjected to approbation according to the opinion of several experts on the topic by using Delphi sessions following the methodology used by Castro y Ramírez (2009). Internal consistency analysis was used for the instrument's validation by calculating the Cronbach's alpha coefficient. This reliability measurement method has been used in researches conducted by Álvarez *et al*. (2006), Meliá *et al*. (1990), Ledesma *et al* (2002) and Oviedo y Campo (2005), to provide trustworthiness to the measurement instrument used in the collection of the information.

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**Table-1.** Main consulted references for elaborating the diagnostic instrument.

| Author | Title |
|---|---|
| Castellanos *et al*. (2007) | Aplicaciones sobre Prospectiva y Valoración Económico Ambiental |
| Colombo *et al*. (2003) | Análisis económico de la erosión del suelo: valoración de los efectos externos en la cuenca del Alto Genil |
| Cristeche y Penna (2008) | Métodos de Valoración Económica de los Servicios Ambientales |
| Henao *et al.* (1999) | Valoración económica aproximada de los costos ambientales de la cuenca del Río Las Ceibas |
| Minambiente (2003) | Metodologías para la valoración económica de Bienes, Servicios Ambientales y Recursos Naturales |
| Muñoz (2004) | La evaluación del paisaje: una herramienta de gestión ambiental |
| Ortiz (2013) | Identificación y descripción del avance del proceso de desertificación en el ecosistema estratégico desierto de la Tatacoa |
| Serna (2009) | Valoración contingente de la erosión de los suelos de la zona cafetera central de Colombia |
| Tarazona (2010) | Evaluación económica de recursos naturales del Cerro La Judía mediante Valoración Contingente |
| Vargas (2007) | Caracterización de los factores Socioeconómicos de la desertificación en México |

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The calculation of the Cronbach's alpha coefficient ($\alpha$) is given by Equation (1).

$$\alpha = \left[\frac{k}{k-1}\right]\cdot\left[1-\frac{\sum s_i^2}{\sum s_t^2}\right] \qquad (1)$$

where

$s_i^2$ = Variance sum in each item

$s_t^2$ = Total row variance (total judges score)

$k$ = Number of questions/item

**Diagnostic instrument application an simple size**

A representative simple size was determined by the use of Equation 2 which was used by Saavedra (2005), for simple random sampling. Several rural properties in the influence area of the Tatacoa desert were selected by this way, completely random.

$$n = \frac{z^{2\alpha}/2\cdot(p\cdot q)^2}{e^2+\dfrac{z^{2\alpha}/2\cdot(p\cdot q)^2}{N}} \qquad (2)$$

where

$n$ Optimum simple size

$z^{2\alpha}/2$ corresponds to 1.96 for a confidence level of 95%

$p$ Proportion of the population with interest features

$q$ 1-$p$

$e^2$ Standard deviation of the estimation or tolerance error for the measurement (4.5%)

$N$ Population size

**Economic value of the erosion growing process**

For this aspect, an aggregate basic model used by Morales (2012) was utilized. This allows observing the desertification effects on such variables as economic capital and work and expressed as "net value of agriculture productivity" (VBP)

Several regression analyses of these linearized variables were run with the ordinary minimum squares (MCO) utilizing a portable informatics application EViews 5.0, in which "net value of agriculture productivity" (VBP) was taken as the dependent variable and variables explaining the basic productive factors were taken: terrain (ti), economic capital (ki) and work (li). In order to represent the desertification phenomenon, a dummy variable (DES) with binary character was introduced. Another variable to account for interaction between terrain and desertification factors (DES*ti) was

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also used to explain the desertification effects on elasticity VBP-terrain, (Equation 3).

$$VBP = \beta_0 + \beta_1 * \text{ti} + \beta_2 * \text{ki} + \beta_3 * \text{li} + \beta_4 * \text{DES} * \text{ti} + \beta_5 * \text{DES} + \varepsilon i \quad (3)$$

Where

$VBP$ = Natural log of "net value of agriculture productivity"
$\beta$ = Coefficients of yi, ti, ki and li, (natural logs of productive factors)
DES = Dummy desertification variable where DES=1 when the territorial unit in which the rural property is located is severely affected by desertification and DES=0 for the contrary case.
$\varepsilon$i = Error term

The same procedure was applied assigning to the variable DES the zero value in all observations affected by desertification, with the objective of estimating the model variation in the hypothetical case that the rural properties do not suffer such problem.

## RESULTS

### Diagnostic tool application and validation and information analysis

An instrument formed by 39 items was designed. They were organized in five thematic axes: "identification of the interviewed personal", "general information and family outcome", "terrains", "economic capital" and "hand labor". By applying Equation (1) to estimate the confidence index and the alpha Cronbach internal consistency, a value of 0.84 was found. According to the study by Cristopher (2007), summarized in Table-2, it fit in the interval corresponding to "high confidence" which indicates that the diagnostic tool is trustable and provides excellent internal consistency. A correlation of the items with the collected information by the diagnostic tool was determined.

77% of interviewed were men and the remaining 23% were women. All of them are head of house. The average age was 50 years old and the schooling level was: 57% elementary school, el 37% high school and el 3% had a bachelor degree. 3% had no school.

**Table-2.** Confidence criterion value.

| Criterion | Value |
|---|---|
| Untrustable | -1 to 0 |
| Low confidence | 0.01 a 0. 49 |
| Moderate confidence | 0.5 a 0.75 |
| Strong confidence | 0.76 a 0.89 |
| High confidence | 0.9 a 1 |

Fuente: Cristopher, 2007

The simple size was found by applying Equation 2. The resulting value was 30 rural properties which were ramdomly selected. They were located in seven zones of the Tatacoa desert as follows: Doche, San Alfonso, Potosí, La Manguita, Cuzco, San Nicolás and Polonia. The participation percentage is given in Figure-1.

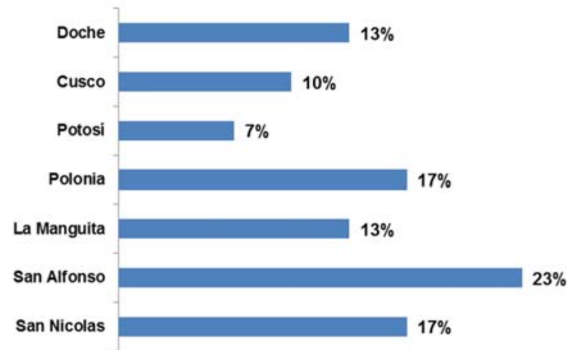


**Figure-1.** Studied zones in the Tatacoa desert.

As far as the terrain features is concerned, 43% of the interviewed affirmed to be ignorant about the type of soil in his/her rural properties. 57% affirmed that according to the studies on soils conducted in their farms by associative aggrupation or irrigation districts the soil types in their zones corresponded to: Sandy, clayey, free from sand and free from clay; these type of soils are fairly fertile with reduction of their fertility tending to be more notorious in the past 10 years, caused by climate change.

Figure-2 shows the main economic activities performed by people of the surveyed rural properties. As reported in Figure-2, in the studied zones at the Tatacoa desert 54% of the economic activity corresponds to agriculture, 33 % to both agriculture and cattle rising, 3 % to cattle rising and 10 % to tourism. The animal species raised in the mentioned zones are cattle, sheep and goats which are intended to self-consume, milk selling, meat selling and gastronomic food preparation according to the tradition of people in the eco-region.

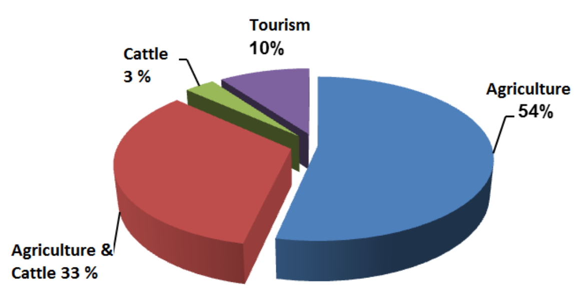


**Figure-2.** Economic activities of the people in the studied rural properties.

In the agriculture field several crops are grown depending on the ago-system conditions of the zone. The

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implemented crops in the studied zone are shown in Figure-3.

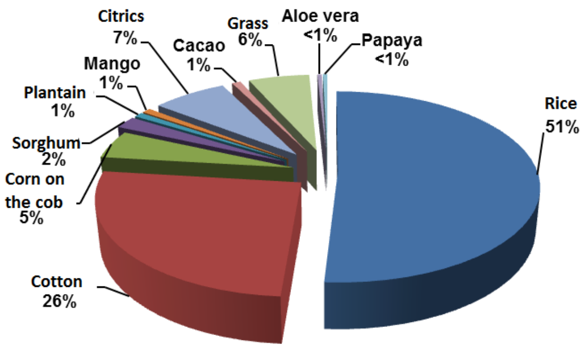


**Figure-3.** Crops implemented in the studied zone.

In the studied zones, rural properties intended to agriculture activities cover a total area of 240 Ha, 51% of which -equivalent to 122.5 Ha- are used in rice crops. Farmers are involved in associations and/or the San Alfonso irrigation district, and the implemented irrigation system is supported by gravity with supplying from pumping activities from the the Villavieja and Magdalena rivers. Other important implemented crops in the zone are: Cotton with 62 Ha, cítrics with 17 Ha, grass 14 Ha, corn in the cob 11.5 Ha, sorghum5 Ha and other on small cultivation areas with plantain, mango and cacao, 2 Ha of each one, and papaya and aloe vera with 1 Ha cultivated. The capacity in $Ton.Ha^{-1}$ has decreased in the last five years due to either drought, bad seed implementation inappropriate to the soil and lack of plague control.

The average monthly income goes from one to three minimum lawful wages and 70% of the owners currently have a mortgage for agriculture investment with any bank office. Regarding agricultural machinery availability, 27% of the farmers own some kind of machinary: tractors, combine harvesters, harvesters and engine pumps.

In average, farmers are willing to pay a monthly economic value of ten thousand seventy seven Colombian pesos ($10.767) or USD$ 5 during a year for performing projects tending to improve the environmental quality in the Tatacoa desert eco-region. 100% of the interviewed accepted to provide an economic support.

**Economic value of the erosion in the Tatacoa desert soils**

Table-3 presents the β coefficient values of the variables: $\beta_0$ = 3.151525, $\beta_1$=0.189188, $\beta_2$=0.083862, $\beta_3$=0.176339, $\beta_4$=0.029553 and $\beta_5$=-0.031986. Replacing the coefficients into Equation 3, the estimation model of the "net value of agriculture productivity" is generated as given below;

$$\begin{aligned} VBP = & 3.15 + 0.189 * ti + 0.083 * ki + 0.176 * li + \\ & 0.029 * DES * ti - 0.031 * DES + \varepsilon i \end{aligned} \quad (4)$$

In the above model, the coefficient of variable DES is observed. It has a significant reduction effect on the production of the Tatacoa soils; coefficient DES*ti is not significant, then, there will not be any incidence on the elasticity VBP/terrain caused by desertification.

By analyzing the R-squared behavior is observed that its highest value is greater than 0.06 indicating that, as a whole, the variables affect the "net value of agriculture productivity". The probability value for the *ti* variable is 0.0127 which lower tnan 0.05 meaning that this variable, individually, does not explain the behavior of the "net value of agriculture productivity". Variables *ki*, *li*, *DES*ti* and *DES* present probability values greater than 0.05, in other words, individually, these variables explain the behavior of the "net value of agriculture productivity".

Table-4 presents the results for the model of "net value of agriculture productivity" without considering both desertification (DES) interaction between terrain and the desertification (DES*ti) variables. When analyzing the R-squared behavior we can observe that its highest value is 0.06 indicating that, as a whole, the variables affect the value of the net production. The probability value for variables *ti*, *ki* and *li* are less than 0.05, which means that under these new model conditions, these variables, individually, do not explain the behavior of the "net value of agriculture productivity".

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**Table-3.** Results obtained for the economic value using the ordinary minimum square method.

| Variable | Coefficient β | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X0 | 3.151525 | 0.408175 | 7.721015 | 0.0000 |
| Ti | 0.189188 | 0.070249 | 2.693091 | 0.0127 |
| Ki | 0.083862 | 0.044572 | 1.881515 | 0.0721 |
| Li | 0.176339 | 0.133605 | 1.319847 | 0.1993 |
| DES*ti | 0.029553 | 0.161958 | 0.182475 | 0.8567 |
| DES | -0.031986 | 0.213871 | -0.149558 | 0.8824 |
| R-squared | 0.514702 | Mean dependent var | | 4.510637 |
| Adjusted R-squared | 0.413598 | S.D. dependent var | | 0.293750 |
| S.E. of regression | 0.224945 | Akaike info criterion | | 0.030935 |
| Sum squared resid | 1.214406 | Schwarz criterion | | 0.311174 |
| Log likelihood | 5.535981 | Durbin-Watson stat | | 1.727817 |

**Table-4.** Obtained results for the economic value model using the ordinary minimum square without the desertification variable.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X0 | 3.158621 | 0.382843 | 8.250438 | 0.0000 |
| Ti | 0.186787 | 0.061666 | 3.029011 | 0.0055 |
| Ki | 0.081027 | 0.039414 | 2.055811 | 0.0500 |
| Li | 0.195373 | 0.072581 | 2.691779 | 0.0123 |
| R-squared | 0.514010 | Mean dependent var | | 4.510637 |
| Adjusted R-squared | 0.457934 | S.D. dependent var | | 0.293750 |
| S.E. of regression | 0.216274 | Akaike info criterion | | -0.100975 |
| Sum squared resid | 1.216136 | Schwarz criterion | | 0.085851 |
| Log likelihood | 5.514624 | Durbin-Watson stat | | 1.708841 |

Comparing the found probability for each case, it can be affirmed that including variables DES and DES*ti in the model of "net value of agriculture productivity", the probability values for *ti*, *ki* and *li* have a different behavior: variable *ti* varies in a 43.30%, *ki* has a variation of 69.34%, and variable *li* has a small variation of 6.17%. This indicates that variables *ti* and *ki* added to DES and DES*ti permit explaining the behavior of "net value of agriculture productivity".

In studies performed by Morales (2012) in Chile, similar results are shown in the aggregate analysis were coefficients DES and DES*ti were found for four desert zones which negatively affect productivity of the rural properties located in the zones under desertification. They show significant differences with those without suffering this phenomenon. Additionally, calculated R-squared values between 0.50 and 0.57, validating, as in this research, that desertification has a negative impact on the net value of agriculture productivity.

## CONCLUSIONS

a) The confidence estimated by the Alpha Cronbach coefficient has a value of 0,84 meaning that the design diagnostic tool for economic value has an excellent internal consistency; it also measures satisfactorily what is expected and compiles good information of the obtained sample from the population in a steady and trustable way.
b) There exists an inverse behavior between the variables DES - corresponding to desertification- and the variable "net value of agriculture productivity". The coefficient of variable DES has an important reduction effect on agriculture productivity in the soils of the Tatacoa desert. Interaction between terrain and desertification factors has no incidence on the elasticity VBP/terrain caused by desertification.
c) As a whole, the model variables affect the "net value of agriculture productivity". Economic capital, terrain, desertification and interaction between terrain and desertification factors are variables that, individually, explain net value of agriculture productivity.

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## REFERENCES

Álvarez M., Estrada A., Montoya E y Melgar H. 2006. Validación de escala de la seguridad alimentaria doméstica en Antioquia, Colombia. Consultado el 30 de octubre de 2014.
http://www.scielosp.org/pdf/spm/v48n6/a05v48n6.pdf

Castellanos C, M., Montauban, J. G., Rodríguez A. 2007. Aplicaciones sobre Prospectiva y Valoración Económico Ambiental. Editorial Academia, La Habana, Cuba.

Castro J. K. and Ramírez V.E. 2009. Diagnóstico de los Niveles de Gestión de la Higiene y de la Calidad en Empresas del Sector Agroalimentario del Departamento del Huila. Trabajo de Grado para optar al Título de Ingeniero Agrícola. Universidad Surcolombiana. Neiva. p. 117.

Colombo S., y Calatrava R.J. 2003. Análisis económico de la erosión del suelo: valoración de los efectos externos en la cuenca del Alto Genil. Economía Agraria y Recursos Naturales. ISSN: 1578-0732. 3, 8: 21-40.

Cristeche E., Penna J.A. 2008. Métodos de Valoración Económica de los Servicios Ambientales. Instituto Nacional de Tecnología Agropecuaria (INTA). Estudios Socioeconómicos de la Sustentabilidad de los Sistemas de Producción y Recursos Naturales No. 3. ISSN 1851 - 6955. Enero. Argentina.

Espinal L.S. 1990. Notas ecológicas sobre el Huila. Universidad Nacional de Colombia sede Medellín. p. 91.

Henao S.G., Salazar C.M., y Solano R.S. 1999. Valoración económica aproximada de los costos ambientales de la cuenca del Río Las Ceibas en el Municipio de Neiva Huila. Tesis para optar al título de Especialista en Ingeniería Ambiental. Universidad Surcolombiana. Neiva. p. 197.

Ledesma R., Molina G., y Valero P. 2002. Análisis de consistencia interna mediante Alfa de Cronbach: un programa basado en gráficos dinámicos. Consultado el 30 de octubre de 2014. http://pepsic.bvs-psi.org.br/pdf/psicousf/v7n2/v7n2a03.pdf.

Meliá J.L., Pradilla J. F., Martí N., Sancerni M.D, Oliver A., y Tomás J. M. 1990. Estructura factorial, fiabilidad y validez del cuestionario de satisfacción s21/26: un instrumento con formato dicotómico orientado al trabajo profesional. Consultado el 30 de octubre. http://www.uv.es/meliajl/Research/Art_Satisf/ArtS21_26.PDF.

Minambiente (Ministerio de Ambiente, Vivienda y Desarrollo Territorial), 2003. Metodologías para la valoración económica de Bienes, Servicios Ambientales y Recursos Naturales. Bogotá D.C. Colombia.

Morales C. 2012. Los costos de la inacción ante la desertificación y degradación de las tierras en escenarios alternativos de cambio climático. Comisión Económica para América Latina y el Caribe (CEPAL). Santiago de Chile. p. 96.

Muñoz P.A. 2004. La evaluación del paisaje: una herramienta de gestión ambiental. Revista Chilena de Historia Natural. 77: 139-156.

Olaya A., Sánchez M., y Acebedo J. 2001. La Tatacoa Ecosistema estratégico de Colombia. Editorial Universidad Surcolombiana, Neiva. p. 158.

UN. Organización de las Naciones Unidas. 1994. Programa de las Naciones Unidas para el Medio Ambiente. Consultado el 31 de octubre de 2014: http://www.cinu.org.mx/temas/des_sost/desert.htm.

Ortiz N.H. 2013. Identificación y descripción del avance del proceso de desertificación en el ecosistema estratégico desierto de la Tatacoa. Trabajo de grado para optar al Título de Magíster en Ecología y Gestión de Ecosistemas Estratégicos. Universidad Surcolombiana, Neiva. p. 81.

Oviedo H.C., y Campo A. 2005. Aproximación al uso del coeficiente alfa de Cronbach. Consultado el 30 de octubre de 2014. http://www.scielo.org.co/scielo.php?pid=S003474502005000400009&script=sci_arttext.

Saavedra J. 2005. El modelo EFQM como herramienta de mejora continua para el sistema cooperativista vitivinícola de la D.O. Valencia España. Tesis Doctoral, Departamento de Tecnología de alimentos - Universidad Politécnica de Valencia-España. pp. 111-168.

Serna C.A. 2009. Valoración contingente de la erosión de los suelos de la zona cafetera central de Colombia. Cenicafé 60 (1): 86-104.

Tarazona V.R. 2010. Evaluación económica de recursos naturales del Cerro La Judía mediante Valoración Contingente. Trabajo de grado para optar al Título de Economista. Universidad Industrial de Santander. Bucaramanga. p. 73.

Vargas V.S. 2007. Caracterización de los factores Socioeconómicos de la desertificación en México. Proyecto realizado entre el Instituto Mexicano de tecnología del agua y la Secretaría del medio ambiente y recursos naturales. México. p. 102.