

**WHAT ECOLOGICAL APTITUDE FOR WHAT  
INDIVIDUAL CLIMAT PERFORMANCE?**

*"A CORRELATION EXPLAINED BY THE TABLE OF  
EXPECTATIONS"*

**QUELLE APTITUDE ECOLOGIQUE POUR  
QUELLE PERFORMANCE CLIMATIQUE ?**

*« UNE CORRELATION EXPLIQUEE PAR LE TABLEAU DES  
ATTENTES »*

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**Abstract**

This work is in line with work that opts for an "ecological rationalism" combined with an Ethics of climate change encouraging cognitive progress. We want to highlight a particular dimension related to cognition (orientation). By rehabilitating statistical tools such as "correlation, both the concept and the coefficient", and using one of the most user-friendly and easily understood ways of presenting correlation for non-statisticians (expectations table), can we project ourselves into the future? End if so, what should be the quality of the candidates who will manage the actions that will be taken against the climate change ? A priori, it suffices to submit our future managers of climate change to an Ecological Aptitude test knowing their Climatic Performance to be sure that we are on the right track of a long path leading us towards sustainable development.

**Key words:** Ecological Aptitude, Climatic Performance, Correlation, Sustainable Development, Ecological Rationalism, Cognitive Progress, Expectations Table.

## Résumé

Ce travail s'inscrit dans la lignée d'un travail qui opte pour un « rationalisme écologique » allié à une éthique du changement climatique favorisant le progrès cognitif. Nous voulons mettre en évidence une dimension particulière liée à la cognition (l'orientation). En réhabilitant des outils statistiques tels que « la corrélation, à la fois le concept et le coefficient », et en utilisant une des manières les plus conviviales et compréhensibles de présenter la corrélation pour les non-statisticiens (tableau des attentes), peut-on se projeter dans le futur ? Et si oui, quelle doit être la qualité des candidats qui sauront gérer les actions qui seront menées contre le changement climatique ? A priori, il suffit de soumettre nos futurs gestionnaires du changement climatique à un test d'Aptitude Ecologique connaissant leur Performance Climatique pour être sûr que nous sommes sur la bonne voie d'un long chemin nous menant vers le développement durable.

**Mots clés :** Aptitude écologique, Performance climatique, Corrélation, Développement durable, Rationalisme écologique, Progrès cognitif, Tableau des attentes.

## Introduction

Almost all international bodies, scientists, public decision-makers, industrialists and financiers, companies and individuals recognize the veracity of the harmful effects of climate change in order to mobilize. This does not prevent gaps in perception from remaining, which distorts the choices regarding decision-makers, strategies, timing, actions... Who better than scientific research could raise this confusion to limit actions and thus the business of change? climate change will become everyone's business. This work is in line with work that opts for an "ecological rationalism" combined with an Ethics of climate change encouraging cognitive progress.

The modeling of the multi-actor relationship allowed us, in an article previously published in 2017 in the interdisciplinary journal (REMSES)<sup>1</sup>, to understand the structure of the strategies of the actors of sustainable development. In this work, we get to the heart of the matter: within the framework of a sustainable development strategy and more precisely within the framework

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<sup>1</sup> REMSES like Review of Multidisciplinary Studies in Economic And Social Sciences

of the axis of the fight against climate change, how to choose the heads of ecological groups hired by the actors of sustainable development (the State, citizens and businesses), following an Ecological Aptitude<sup>2</sup> Test and information on the Climatic Performance<sup>3</sup> of the candidates who will be the subject of our study. We want to highlight a particular dimension related to cognition, adaptation through learning.

By distinguishing declarations of intent from effective practices, the problem is as follows: is the Ecological Aptitude (X) (having a high score in the Ecological Aptitude test) sufficient to explain a possible Climatic Performance (Y) (generate a maximum of pro-environmental action within the framework of an ecological group). We demonstrate this by passing, on the one hand, through the table of expectations: a tool that serves to reproduce, in terms that are easier to understand and put into practice, the information already established by the correlation: more the greater the Ecological Aptitude of a person, the higher will be his Climatic Performance?

A second time the demonstration will be supplemented by the test  $\chi^2$  (Chi square) to see if the difference in size of the three groups of Ecological Aptitude would be due to chance or it is a "real" difference which means that one does not cannot trust the climate aptitude test to choose candidates for the fight against the adverse effects of climate change.

Methodologically, we will go through the inductive method and a static inference for categorical variable. Thus, we begin to recall the concept of correlation which will be part of the tools confirming or invalidating the hypotheses of our model.

## **I. REMINDER OF THE « CORRELATION CONCEPT » AND ITS METHODOLOGICAL USEFULNESS?**

Linear correlation is a concept imported from the work of English biometrics in the early years of the 20th century...especially thanks to Galton's eugenics and biometric program which introduced first reversion, then regression and finally linear correlation. The linear correlation

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<sup>2</sup> We define Ecological Aptitude or environmental fitness as the acquisition of skills and qualities that will serve to defend the environmental cause. Among these skills and qualities, we can cite an inquisitive mind, a desire to protect the environment (with a balanced approach to issues), being patient in gathering, precise, methodical in carrying out experiments, communication skills in informing the public on wildlife, conservation areas, actions to be taken to limit the effects of climate change or other danger having an impact on ecosystems.

<sup>3</sup> We define Individual Climate Performance by the behaviors (to perform), actions, exploits, records that each individual undertakes or intends to undertake with a view to preserving the environment in general and the atmospheric climate in a specific way. We quote the most important actions which indicate to us according to a scale that individuals perform ecologically: we take the example of French Association for Standardization AFNOR (Association française de normalisation) and say that it is "the fight against climate change and the protection of the atmosphere; the preservation of biodiversity, environments and resources as well as the promotion of responsible production and consumption methods"

coefficient is an elementary tool of mathematical statistics, a common thread in econometrics. This is a statistical indicator, standard<sup>4</sup> « gross » relative, which is not always easily understood by non-statisticians but is the object of reconstruction efforts. It is a matter of determining, characterizing and measuring (quantifying) the degree of relationship existing between two series of observations (the correlation coefficient), but it is just as important to be able to decide whether a connection observed in a sample indicates or not that the variables studied are probably associated in the population from which the sample was drawn. In some situations, it is important to present the results of a linear correlation analysis in a simpler way. The table of expectations is the ideal tool to do this.

### **1.1. Correlation: a question of position and / or causality?**

#### **1.1.1. Causality!**

One of the fundamental bases of our reasoning in this article is that the existence of even a high correlation between two series of observations does not necessarily imply the existence of a cause-and-effect relationship (causality) between the two considered variables. Indeed, the observed correlations may be due to the fact that the variables studied are both subject to common influences, simultaneously modifying the values, either in the same direction (positive correlation), or in opposite directions (negative correlation).

It is not enough to increase the number of workers in a factory to improve its profitability even if there is a positive correlation between the income per unit of labor and the importance of the workforce. The explanation is simple: the size of the factory is linked to the two variables at the same time, which gives an observed correlation explained by the fact that on the one hand, large factories are economically more profitable and therefore require even a large number of workers.

We will see later, and this is the cornerstone of this work, that Ecological Aptitude (EA) is insufficient to explain a possible Climatic Performance (CP) (generating a maximum of pro-environmental action within the framework of an environmental group).

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<sup>4</sup> In the sense that one can use the linear correlation coefficient to compare, for the same phenomenon, two elements belonging to two different populations: for example, the comparison of the degree of linear correlation between unemployment and inflation of the two Moroccan and French economies would be possible without go through the standardization of this coefficient according to national statistics (Gros Domestique Product or General Price Level). if our variable is standardized (centered and reduced), we must use the regression coefficient [ $a = \text{COV}(x,y) / V(X)$ ].

### 1.1.2 The position of the variables

If we base the calculation of the correlation on the simple numerical difference obtained between two measurements, the conclusion will be erroneous, unless the two measurements are on the same measurement scale (having the same mean and the same variance). Since we often want to calculate the correlation between two variables that are not measured on the same scale, we need to find a more general approach.

The most general and satisfactory method for describing the similarity between two variables is that chosen by « Pearson ». The correlation between two variables is defined as the degree to which the relative position of the observations is the same on two variables. The position of an observation on a measurement is defined as the standardized deviation which exists between the value obtained on a variable by an observation and the mean of this variable.

## II. THE MODEL: ASSUMPTIONS, CONTROL VARIABLES AND RESULTS

For each subject of our population, we have two measures, Ecological Aptitude (EA) and Climatic Performance (CP) and we are interested in the relationship between these two variables (possible link, its characterization, its measurement). The correlation coefficient is therefore a measure that evaluates the conformity of the observations with a general model of relations between the two measures. This general model is most often a linear model and the associated correlation coefficient is the « r » of Bravais-Pearson for the scales of intervals or ratios. In our case, since we intend to group the candidates into categories, according to « Weak », « Medium » and « Strong » aptitude, this implies a type I scale, in this case categorical. Thus, and since it does  $[r = \sum(\frac{COV(x,y)}{\sigma_x \sigma_y})]$

### 2.1. Climate Ethics literature and assumptions

#### 2.1.1. A « certain » Climate Ethics Literature!

This work is in line with the work that opts for an « ecological rationalism »<sup>5</sup> combined with a certain Climate Change Ethics (Jamieson, D., (1996) <sup>6</sup>, Gardiner, SM, (2011))<sup>7</sup> encouraging

<sup>5</sup>"A rationalism that would have succeeded in freeing itself from belief in myth progress" According the expression of Jean-Matthias Fleury in "For an ecological rationality", an Interview with Jacques Bouveresse, Interview by Jean-Matthias Fleury, and Jean-Jacques Rosat, Agone 2017/1 n° 61 | pages 53 to 83.

<sup>6</sup>Jamieson, D., (1996). *Ethics and intentional climate change*. Climatic Change, 33, 323-336.

<sup>7</sup>Gardiner, SM, (2011). *A Perfect Moral Storm: The Ethical Tragedy of Climate Change*. Oxford University Press, Oxford and New York, 495 p.

cognitive progress. According to (Hansen. J et al., (2004)<sup>8</sup>; Grothmann and Patt, (2005)<sup>9</sup>; Weber, (2010)<sup>10</sup>), in their “Observations and perceptions of climate change: comparative analysis in three West African countries » published in 2015, the cognitive factors, *via* respective perceptions of changes, risks and adaptive capacities, play a role in the adaptation process. Normative information on climate is clearly provided by scientific expertise. However, learning about climate change from personal experience is a widely shared process, and the resulting perceptions are often a precondition for action (mitigation and adaptation), whether or not there is access to scientific information »<sup>11</sup>.

When we have easy access to the latter, Smithson, M., Budescu, DV, Broomell, SB, & Por, HH (2012)<sup>12</sup>, argue that the public can misinterpret these terms which distort the understanding of the phenomena of climate change.

According to Osman, M. (2010)<sup>13</sup>, man, in order to adapt to climate and climate change, must progressively develop specific reasoning and problem-solving capacities to understand and respond to complex conditions.

We want to highlight a particular dimension related to the cognition and orientation of the individuals / groups involved in the ecological affair. By rehabilitating statistical tools such as "correlation, both the concept and the coefficient", can we project ourselves into the future and if so, what would be the quality of the candidates who will manage the actions to be taken against the change? climate?

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<sup>8</sup>Hansen et al., (2004) *The Role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida*. IRI Technical Report 04-01. International Research Institute for Climate Prediction, Palisades, NY.

<sup>9</sup>Grothmann and Patt, (2005), *Adaptive capacity and human cognition: the process of individual adaptation to climate change*, Global Environmental Change, Part A 15, 199-213.

<sup>10</sup>Weber, (2010) *What shapes perceptions of climate change?* Wiley Interdisciplinary Reviews: *Climate Change*, 1(3):332-342.

<sup>11</sup>Kosmowski Frédéric, Lalou Richard, Sultan Benjamin, Ndiaye O., Muller B., Galle Sylvie, Séguis Luc. *Observations and perceptions of climate change: comparative analysis in three West African countries*. 2015, p. 89-110. (Syntheses). ISBN 978-2-7099-2146-6

<sup>12</sup>Smithson, M., Budescu, DV, Broomell, SB, & Por, HH (2012). *Never say « not »: Impact of negative wording in probability sentences on imprecise probability judgments*. *International journal of approximate reasoning*, 53(8), 1262-1270.

<sup>13</sup>Osman, M. (2010). *Controlling uncertainty: a review of human behavior in complex dynamic environments*. *Psychological Bulletin*, 136(1), 65



Annamaria Lammel<sup>14</sup>, in his article "Climate change: from perception to action", published in 2015 in the newsletter N°5 of the Fondation de l'Ecologie Politique<sup>15</sup>, emphasizes the importance of the study of cognition and cultural context in the ability of individuals to respond to climate change. She adds that it is necessary to be able to put the individual and his specific characteristics back at the center of a theoretical model of dynamic adaptation to change. Also, in the framework of the ACOCLI project<sup>16</sup>, the general hypothesis is that human cognition enables adaptation to environmental changes. However, rapid climate change creates cognitive conflicts that lead to impaired cognition and increase vulnerability.

Within the framework of a large national project for the prevention of climate change, a national administration would like to test the hypothesis according to which, "the Climatic Performance of citizens is determined by the number of actions taken to limit greenhouse gas emissions (Eco-Responsible Consumer, etc.) ". The idea is to form groups of people coordinated by an agent capable of successfully passing the test of Ecological Aptitude. Would the Ecological Aptitude (EA) be sufficient to explain a possible Climatic Performance (CP) (to generate a maximum of pro-environmental action within the framework of a group).

The purpose of the study is to improve the selective system (the Ecological Aptitude (EA) test) for the choice of group leaders carrying out the most eco-responsible actions. We begin by hypothesizing that the people who will obtain the highest values in the Ecological Aptitude test (EA) will prove to be the most efficient in terms of climate (CP) (likely to generate a maximum of pro-environmental action within the framework of a group). We intend to check it by calculating the linear correlation existing between the measurement of Ecological Aptitude (EA) and Climatic Performance (CP).

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<sup>14</sup>PhD lecturer in intercultural psychology (Paris 8 University) and researcher at the Paragraphe laboratory. Annamaria Lammel is an anthropologist and doctor in cognitive psychology. She is one of the authors of the 5th report of the IPCC (Intergovernmental Panel on Climate Change), in French, GIEC (Groupe d'experts intergouvernemental sur l'évolution du climat).

<sup>15</sup>The Political Ecology Foundation (Fondation de l'Ecologie Politique) is recognized as being of public utility. Its purpose is to promote the gathering of ideas around the project of ecological transformation of society, to contribute to the development of the theoretical and practical corpus corresponding to this new model of society and to the values of political ecology.

<sup>16</sup>The ACOCLI project ACOCLI (Adaptation Cognitive aux Changements Climatiques), funded by the National Research Agency and coordinated by Annamaria Lammel and Frank Jamet within the Paragraphe laboratory of the University of Paris 8. The general problem of the ACOCLI project questions the relationship between environment and society and more specifically the relationship between society and climate.

### **2.2.2. Ecological Aptitude and Climatic Performance**

To verify this hypothesis - the Ecological Aptitude (EA) is sufficient to explain a possible Climatic Performance (CP) -, we randomly choose 180 people among 500, disregarding any social criterion of gender, socio-professional or psycho-graphic categories.<sup>17</sup>... having applied to be team leader for environmental actions. An environmental performance test is administered online. This is a questionnaire that lists the environmental actions carried out by the candidates during the last 2 years between 2019 and 2021. This will give us the average monthly number of environmental actions that each candidate has carried out. These figures would be the basis for calculating Climatic Performance (CP). The Ecological Aptitude (EA) test is administered to these 180 candidates. We therefore obtain, for each, two pieces of information: its Climatic Performance (CP) and its performance in the Ecological Aptitude test (EA).

#### **i. Climatic Performance**

A Potential Ecological Group leader is undoubtedly an eco-responsible consumer. We make the assumption that the candidates to be selected as a leader of an ecological group must above all have an exemplary behavior on a daily basis towards the environment in which they live: the three components of sustainable development, (3V) Livable (benefit for society and the environment), Viable ((benefit for purchasing power and the environment) and Vitality or equitable (social and economic benefit), with an intergenerational balance as an option, is pushing him today to rethink his relationship with the products and services he consumes. In addition to including the use made of the product or service until its end of life, according to ADEME<sup>18</sup>, responsible consumption corresponds to the fact of « choosing consumer goods according to one's needs and their impact on the environment ». In his multi-agent model of sustainable development based on the prisoner's dilemma, M. Tounsi (2017) presents a table describing roughly the actions of the actors of sustainable development<sup>19</sup>.

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<sup>17</sup>A psychographic criterion is a segmentation or targeting criterion based on consumer lifestyles, beliefs, values and personalities.

<sup>18</sup>Environment and Energy Management Agency, a French public establishment created in 1991, of an industrial and commercial nature which participates in the implementation of public policies in the field of the environment, energy and sustainable development.

<sup>19</sup>M. Tounsi, (2017), *A strategic cooperation between actors for a local sustainable development*, REMSES Review of Multidisciplinary Studies in Economic And Social Sciences, 4 January.



**Table (1): summary of the commitment actions of the various SDS actors<sup>20</sup>.**

Engagements	Score
1. Social and economic dimensions	10 POINTS
2. Resource conservation and management	10 POINTS
3. Strengthening the role of major groups	10 POINTS
4. Means of execution	10 POINTS
5. Respect for the laws that govern community life	7 POINTS
6. The discovery of institutions and public life.	7 POINTS
7. Engage in the democratic process through participation in community life	8 POINTS
8. Make responsible purchases	8 POINTS
9. The trend books	7 POINTS
10. Incentive to change	7 POINTS
11. Animation of human resources	8 POINTS
12. Corporate Social Responsibility and prevention	8 POINTS

## ii. Ecological Aptitude

The Ecological Aptitude test is based on questions presented along 4 axes:

- Science and life axis: it concerns general questions such as (Which of these gases produced by human activity is not a greenhouse gas?  
O<sub>2</sub>                      H<sub>2</sub>O                      NO<sub>2</sub>                      CO<sub>2</sub>?
- Ecological history axis where the questions look like: Over the past 35 years, the sea ice surf has  
decreased by 50%                      decreased by 30%                      increased by 10%?
- Environment and economy axis: In terms of transport, what action would have the greatest impact? (i) Launch a major plan to promote bicycle taxis / (ii) Improve aircraft efficiency / (iii) Build a global network of high-speed trains / (iv) Develop teleworking.
- Environment and humanity axis: What percentage of the world's population lives near the coast?  
i. 10%                      ii. 25%                      iii. 40%                      iv. 70%

The results of the test made it possible to divide the candidates into 3 groups of Ecological Aptitude (Low (score < 40, Medium (score between 40 and 59), High (score greater than 80). The inventory of the real pro-environment actions of the candidates made it possible to classify

<sup>20</sup>Sustainable development strategy.

the candidates by level of performance in three Climatic Performance categories (Low, Medium, High).

## **2.2. Control variables**

The regulation in our model is the variable that includes the maximum information on the characteristics of the candidates, on their behavior as well as on their respective intentions and which will have an impact on the representativeness of our sample. This variable is the size of the categories whether for Ecological Aptitude or Climatic Performance. Moreover, this variable will play a very important role in the process of (not) determining a possible link between Ecological Aptitude and Climatic Performance through the correlation coefficient. Also, it would be essential thereafter that the size of the categories be put to the test of the famous test of « Khi-square ».

### **2.2.1. The coefficient of correlation / of (non)determination**

We verify the hypothesis by calculating the correlation (EA / CP) and find that it is positive and substantial:  $r_{xy} = + 0.58$ . There is 58% similarity between the relative position of observations on Ecological Aptitude and the relative position of these same observations on Climatic Performance. We now have evidence that performance on the Ecological Aptitude test is positively related to Climatic Performance without confirming that there is a causal relationship. Thus, those who demonstrate the greatest aptitude (as measured by the test) tend to be more engaged in environmental actions. It can also be argued that knowing the Ecological Aptitude (EA) reduces the uncertainty about the eventual Climatic Performance (CP). From a technical point of view, in order not to be too demanding,

- Since the correlation coefficient is non-zero, the candidates' success in the test (Ecological Aptitude) is more or less able to reduce the degree of uncertainty about Climatic Performance.
- Since this correlation is imperfect, we can use an indicator that allows us to refine our conclusions about the relationship between Ecological Aptitude (EA) and Climatic Performance (CP).

By calculating the coefficient of determination  $R^2 = (0.58)^2 = 0.33$ , it can be said, in a linear case, knowing the Ecological Aptitude (EA) of the candidates would reduce the uncertainty as to the possible Climatic Performance (CP) by 33%. Thus, the 67% fluctuation in Climatic Performance is explained by a phenomenon other than Ecological Aptitude which is not part of

the model. This would encourage us to seek to identify the catalytic element which makes (EA) and (CP) linked up to 33%.

### **2.2.2. The correlation coefficient in practice: « *the table of expectations* »**

One of the most user-friendly and easily understood ways of presenting correlation for non-statisticians is that of the expectations table (see Table 2). This is a double-entry matrix that is constructed as follows: three groups of 60 people each are formed. In group 1, which is labeled (LCP) « Low Climatic Performance », we place the people who are in the lower third of the Climatic Performance distribution. We place in group 3, HCP « High Climatic Performance », people who are in the upper third of Climatic Performance. All the others, the third of his sample that falls in the middle of the Climatic Performance distribution, are placed in group 2, MCP « Medium Climatic Performance ».

The scores obtained in the Ecological Aptitude Test (TAE) vary between 20 and 80. The performance of the test (Ecological Aptitude) is then divided into three groups: group 1, "Low Ecological Aptitude", includes candidates who have obtained 39 or less, in the test. Those who obtain 60 or more form group 3: « High Ecological Aptitude ». The others, those who obtained between 40 and 59, form group 2: « Medium Ecological Aptitude ». Table 1 shows the observed data. Note that, in this table, 60 candidates are classified in the « Low Ecological Aptitude » group, 56 and 64 candidates, respectively, in the « Medium Ecological Aptitude » and « High Ecological Aptitude » groups.

Then, for each group of performance in the Ecological Aptitude test (EA), the number of people who have a low, medium or high Climatic Performance is identified. We note in Table 1 that, of the 60 people who scored low on the Ecological Aptitude test, 45, 14, and 1 fall into the low, medium, and high-performance groups, respectively (row 1 of the table). We can now express these results in percentages (shown in probabilistic form in parentheses in the table). Thus, we see that 75% of people who scored low on the Ecological Aptitude test demonstrate low Climatic Performance, and only 2% of people who demonstrate low Ecological Aptitude show high Climatic Performance. About a quarter (23%) of applicants who scored low on the test provide average Climatic Performance. Interpreting these percentages in probabilistic terms, we can conclude that those who scored low on the test have a very low probability ( $p=0.02$ ) of providing strong Climatic Performance, an intermediate probability ( $p=0.23$ ) to be moderately efficient and a very high probability of providing poor Climatic Performance ( $p = 0.75$ ).

Thus, clearly the greater the Ecological Aptitude of a person, the higher will be his Climatic Performance! The table of expectations reproduces, in terms that are easier to understand and put into practice, the information already established by the correlation.

A question might now come to mind: if the expectation chart is a convenient and simple way to show the correlation between two variables, why did we calculate the correlation? The answer brings us back to the discussion of measurement scales. The measure of Ecological Aptitude and that of Climatic Performance in Table 2 on a categorical scale. Categorization results in a significant loss of information. This is because converting an interval scale to an ordinal scale reduces the precision of the data. Thus, the category "Low Ecological Aptitude" includes both the person who obtained 20 on the test and the one who obtained 39, and considers that the latter provided a performance very different from another person who would have obtained 40. , only one more point. This does not prevent categorization from allowing us to make a summary analysis to go further in the analysis by practicing, for example, simple regression, which allows us to make the same kind of prediction without converting the data into nominal variables. But, for that, you will have to learn and understand other statistical techniques!

We can push the analysis further by using a test  $\chi^2$  to check if the distribution in terms of proportion between the three categories of Ecological Aptitude (low, medium or high) gives the same proportion in Climatic Performance?

*Table (2): Climatic Performance versus Ecological Aptitude*

		Climatic Performance (CP)			
		G <sub>1</sub> : LCP	G <sub>2</sub> : MCP	G <sub>3</sub> : HCP	TOTAL
Ecological Aptitude (EA)	LEA (20.39)	45 (0.75)	14 (0.23)	1 (0.02)	60
	MEA (40.59)	13 (0.23)	29 (0.52)	14 (0.25)	56
	HEA (60.80)	2 (0.03)	17 (0.27)	45 (0.70)	64
	TOTAL	60	60	60	180

## 2.3. The results: tests and analyzes

### 2.3.1. Analysis of the expectations table

Let us recall the question we are seeking to answer: Does the distribution in terms of proportion between the three categories of Ecological Aptitude give the same proportion in terms of Climatic Performance? We perform these analyzes for each row of the expectations table. This gives us three results to analyze.

**i. Low Ecological Aptitude (LEA)**

It corresponds to the first row of data in the Table. Of the 60 people who showed poor performance on the test, 75% (45/60) are low productive, 23% (14/60) are moderately productive and 2% (1/60) are very productive. Expressing these percentages in probabilistic terms, we can conclude that people who do not pass the test (low Ecological Aptitude; with a score of less than 40) have a very low probability ( $p = 0.02$ ) of being very good candidates. performance (group 3) and a very high probability ( $p = 0.75$ ) of providing poor Climatic Performance.

**ii. Medium Ecological Aptitude (MES)**

It corresponds to the second row of data in the Table. Of the 56 people who demonstrated strong performance on the test, 23% (13/56) are low productive, 52% (29/56) are moderately productive, and 25% (14/56) are highly productive. Expressing these percentages in probabilistic terms, we can conclude that people who pass the test moderately (Medium Ecological Aptitude; having a score between 40 and 60) have a probability ( $p = 0.23$ ) of being very good candidates. performers (group 3) and a probability ( $p = 0.23$ ) of providing poor Climatic Performance.

**iii. High Ecological Aptitude (HEA)**

It corresponds to the third row of data in the Table, for example: of the 64 people who demonstrated strong performance on the test, 3% (2/64) are low productive, 27% (17/64) are moderately productive and 70% (45/64) are very productive. Expressing these percentages in probabilistic terms, we can conclude that people who perform very well on the test (high Ecological Aptitude; 60 and above) have a very high probability ( $p = 0.70$ ) of being high performers (group 3) and a very low probability ( $p = 0.03$ ) of providing poor Climatic Performance.

These results make it possible to make a decision as to the categories of candidates to be hired. After administering the Ecological Aptitude test to future candidates, we see, by consulting the table of expectations, that it would be preferable not to hire the candidate who will obtain a low score ( $< 40$ ) (low aptitude) in the test because he will have a low probability of providing exceptional Climatic Performance ( $p=0.02$ ) and a very high probability ( $p=0.75$ ) of not performing well. But if he obtained more than 59, his probability of becoming a very productive employee would be very strong ( $p = 70$ ) and it would then be relevant to hire him.

### 2.3.2. The test of the representativeness of the sample (the chi-square test)

The independent variable is Ecological Aptitude (EA) and the dependent variable is Climatic Performance (CP), which is measured on a nominal scale: the size of the workforce for each of the three categories of the independent variable. The statistical question to be answered becomes: « Is the size of the workforce the same or different for the three categories (at the start and at the finish?) ». By referring to the results recorded on this sample, can we generalize to the entire population from which it comes?

As with any statistical inference, a hypothesis ( $H_1$ ) and a null hypothesis ( $H_0$ ) must be established. In this case, the hypothesis ( $H_1$ ) would be that there is no difference between the distribution of the workforce (between the departure and arrival categories) while the null hypothesis should be that there is a size difference. If the null hypothesis is not false, we should observe a different size for the three categories: each category must contain more or less 60 people. The second row of Table (3) shows the expected results if the null hypothesis is true.

	Performance		
	Low	Medium	High
Observed performance ( $f_o$ )	60	60	60
Expected performance ( $f_e$ ) under $H_0$	60	56	64

**Table (3): observed and expected performances**

The first row of Table (3) shows the effective size of the groups of candidates who passed the Ecological Aptitude test, ranked by results (from low to high to medium). We call it the *observed frequency* ( $f_o$ ). At first glance, the size of the groups seems equal, which encourages us to reject the null hypothesis. But, as with all statistical tests, the size difference ( $f_o$ ) could be the result of chance. We must therefore determine the probability of obtaining the observed difference if, in reality, there was a difference in the size of the categories (ie the null hypothesis). This second frequency called the *expected frequency* ( $f_e$ ). Let's recap,  $f_o$  is the observed frequency and  $f_e$  is the expected frequency (under  $H_0$ ).

$$\text{Formula 1} \quad \chi^2 = \sum \left[ \frac{(f_o - f_e)^2}{f_o} \right]$$

The difference between the two frequencies allows us to calculate the Chi Square or « Chi Square » statistic, symbolized by the Greek letter  $\chi^2$  and will be the basis for the required statistical analysis. Statistic  $\chi^2$  produces a mathematical index that compares the size of the



difference between the observed frequency and that predicted by the null hypothesis. If the difference is large, the conclusion will be the rejection of the null hypothesis. Otherwise, it will be necessary to conclude that the observed difference is attributable to the hazard and therefore, it will not be possible to reject  $H_0$ .

The numerator calculates the difference (squared) that exists between the observed values( $f_o$ ) and expected( $f_e$ ) for each category of the nominal variable and we establish the ratio of this difference with the expected frequency. When the observed and expected frequencies are the same for one or more categories, the ratio established between these frequencies will be zero. But, as the difference increases, the ratio takes on larger and larger positive values, and in doing so, the final summation will produce a larger and larger  $\chi^2$ .

Calculate the  $\chi^2$  statistic from Table (4) and (3). We calculate the difference between the observed frequency( $f_o$ ) and the expected frequency ( $f_e$ ) (if  $H_0$  is true) which we square and we divide this squared difference by the expected frequency. We do this for each cell and then add all of these results together to get the  $\chi^2$  statistic.

		Climatic Performance (Y)			TOTAL
		<i>observed frequencies</i>			
		Low	Medium	High	
Ecological	Low	45	14	1	60
	Medium	13	29	14	56
	High	2	17	45	64
	TOTAL	60	60	60	

Table (4): observed frequencies (number of candidates)

		Climatic Performance (Y)			
		The expected frequencies under $H_0$			
		Low	Medium	High	
Ecological Aptitude	Low	$(60*60)/180$ 20	$(60*60)/180$ 20	$(60*60)/180$ 20	60
	Medium	$(56*60)/180$ 18.66666667	$(56*60)/180$ 18.66666667	$(56*60)/180$ 18.66666667	56
	High	$(64*60)/180$ 21.33333333	$(64*60)/180$ 21.33333333	$(64*60)/180$ 21.33333333	64

	<b>TOTAL</b>	<b>60</b>	<b>60</b>	<b>60</b>
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**Climatic Performance (Y)**

*The expected frequencies under H<sub>0</sub>*

		<b>Low</b>	<b>Medium</b>	<b>High</b>	
<b>Ecological</b>	<b>Low</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>60</b>
	<b>Medium</b>	<b>18.66</b>	<b>18.66</b>	<b>18.66</b>	<b>56</b>
	<b>High</b>	<b>21.33</b>	<b>21.33</b>	<b>21.33</b>	<b>64</b>
	<b>TOTAL</b>	<b>60</b>	<b>60</b>	<b>60</b>	

**Table (5): expected frequencies (under H<sub>0</sub>)**

$$\chi^2 = \sum \left[ \frac{(f_o - f_1)^2}{f_o} \right] = \left[ \left( \frac{(45-20)^2}{20} + \frac{(45-20)^2}{20} + \frac{(45-20)^2}{20} \right) + \left( \frac{(13-18.66)^2}{18.66} + \frac{(29-18.66)^2}{18.66} + \frac{(14-18.66)^2}{18.66} \right) + \left( \frac{(2-21.33)^2}{21.33} + \frac{(17-21.33)^2}{21.33} + \frac{(45-21.33)^2}{21.33} \right) \right]$$

$$\chi^2 = 104,37$$

### 2.3.3. Interpreting the chi-square ( $\chi^2$ ) statistic

H<sub>1</sub>: there is no difference between the distribution of the workforce (between the departure and arrival categories). Any apparent difference is due to chance.

H<sub>0</sub>: there is a (real) difference in the distribution of numbers between the different categories of Ecological Aptitude

To make a valid interpretation of the Chi-square statistic, we must compare the result obtained (calculated value for the model) (for example  $\chi^2 = 104.37$ ) with a table of critical values (read values) of the distribution of the  $\chi^2$  statistic depending on the degrees of freedom determined from the number of categories in the study. With three categories (k=3) under consideration, the degree of freedom (k-1) is (3-1 = 2). With a sample size of 180 candidates, and let us know that the subject of climate change is a very sensitive subject, which requires very minimal risk taking: it corresponds to an alpha threshold of ( $\alpha < 1\%$ ). The critical value for  $\alpha < 1\%$  is 21.666.

The  $\chi^2$  value calculated for the model is  $\chi^2 = 104.37$  is compared to the critical value (values read on the  $\chi^2$  table of the distribution of the  $\chi^2$  statistic according to the degrees of freedom (ddl = 2) and the risk threshold ( $\alpha < 1\%$ ), which is 21.66. the value obtained by the model is much higher than the critical value, it is logical to reject H<sub>0</sub>: statistically, we cannot conclude

that there really is a difference in size between the categories of candidates. It would be wise to conclude that if there is an apparent difference between the sizes of the categories, it is due to chance. Thus, we can say that the structure of the categories does not in any way influence the link between the degree of Ecological Aptitude and the degree of Climatic Performance or the results resulting from this link. In other words, there is a very strong chance that the candidates initially belonging to a category of low Ecological Aptitude will find themselves in a category of low Climatic Performance on arrival.

### **Conclusion**

This work is in line with work that opts for an "ecological rationalism" combined with an "Ethics of climate change" encouraging cognitive progress. We have highlighted a particular dimension linked to the cognition and orientation of the individuals (groups) concerned by the ecological affair. By rehabilitating statistical tools such as "correlation, both the concept and the coefficient", can we project ourselves into the future and if so, what would be the quality of the candidates who will manage the actions that will be taken against the climate change? *A priori*, it suffices to subject our future managers of climate change to an Ecological Aptitude test knowing their Climatic Performance to be sure that we are on the right track of a long path leading us towards sustainable development.

Our model tells us that, in our experience, Ecological Aptitude (EA) (having a high score on the Ecological Aptitude Test) is sufficient to explain possible Climatic Performance (Y) (generating maximum pro-environmental action within the framework of an ecological group) registered for three categories of candidates (future group leaders). The latter will have the mission of establishing an epistemic democracy allowing the popularization of the discourse on climate change in order to fill the gap between thoughts and actions relating to the problem of the fight against the effects of climate change. The independent variable is Ecological Aptitude and the dependent variable is Climatic Performance, both measured on a categorical scale (three categories for each variable): certainly, the categorization of data causes a significant loss of information. But it allows us to do a summary analysis to go further in the analysis by practicing simple regression, for example, which would allow us to make the same kind of prediction without converting the data into nominal variables.

In our model, the regulating variable is the size of the workforce for each of the three categories. The statistical question to be answered was: "Is the size of the workforce the same or different for the three categories (at departure and at arrival) of Climatic Performance and Ecological Aptitude, two variables, supposed to be linked?" ". We have demonstrated, first, the existence of a link between the two variables, passing through the table of expectations, a tool that serves to reproduce, in terms that are easier to understand and put in practice, the information already established by the correlation. The result is clear: the greater a person's Ecological Aptitude, the higher their Climatic Performance. By calculating the coefficient of determination  $R^2$ , it was concluded that knowing the Ecological Aptitude (EA) of the candidates would reduce the uncertainty as to the possible Climatic Performance (CP) by 33%. Thus, the 67% fluctuation in Climatic Performance is explained by a phenomenon other than Ecological Aptitude which is not part of the model. This encourages us to seek to identify the catalytic element that makes (EA) and (CP) linked up to 33%.

The demonstration was completed by the  $\chi^2$  (chi-square) test from which it was concluded that the apparent difference in size of the three Ecological Aptitude groups would be due to chance and thus the Climatic Aptitude test can be trusted to choose candidates for the fight against the harmful effects of climate change. Statistically, we cannot conclude that there really is a size difference between the candidate categories. Thus, it can be said that the structure of the categories in no way influences the link between the degree of Ecological Aptitude and the degree of Climatic Performance, nor the results that follow from this link. There is a very strong chance that candidates who initially belong to a category of strong Ecological Aptitude, Can we still deny the complexity of the problem of climate change and especially the urgent nature of the actions to be taken for at least prevention or for the reduction of its harmful effects on the most fragile populations? Even putting cognition, ecological rationality, justice and epistemic democracy or the risks of a perception gap, we are far from the mark. It's true that we give ourselves « good conscience » but it would be difficult to believe in the exhaustiveness of our analyzes to take the best actions when and where necessary. We could have fallen back on the legal side to preserve the rights of the planet and the beings living on it. Unfortunately, the law remains silent on subjects that involve the gains of interest groups and lobbies. For the ecological matter, using the argument "no one is supposed to ignore the law..." remains in the domain of the "virtual".

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