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Cultural Identity Distance Computation through Artificial Intelligence as an Analysis Tool of the Amazon Indigenous People. A Case Study in the Waorani Community

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Received: 1 October 2020; Accepted: 13 November 2020; Published: 15 November 2020

Abstract: Cultural identity is a complex concept that includes subjective factors such as ideology, family knowledge, customs, language, and acquired skills, among others. Measuring culture involves a significant level of difficulty, since its study and scope differ from the point of view, the time and the place where the studies are carried out. In the Amazon, indigenous communities are in an accelerated process of acculturation that results in a loss of cultural identity that is not easy to quantify. This paper presents a method to measure the cultural distance between individuals or between groups of people using Artificial Intelligence techniques. The distance between individuals is calculated as the distance of the minimum path in the self-organizing map using Dijkstra's algorithm. The experiments have been carried out to measure the cultural identity of indigenous people in the Waorani Amazon community and compares them with people living in cities who have a modern identity. The results showed that the communities are still distant in terms of identity from the westernised cities around them, although there are already factors where the distances are minimal concerning these cities. In any case, the method makes it possible to quantify the state of acculturation. This quantification can help the authorities to monitor these communities and take political decisions that will enable them to preserve their cultural identity.

Keywords: cultural identity; indigenous identity; Amazon communities; artificial intelligence; cultural distance

1. Introduction

The migratory movements of indigenous people in Latin America are slightly lower than the movements of non-indigenous individuals; however, beyond quantitative values, theoretical social models attempt to differentiate their cause and provide explanations as to their consequences and implications on peoples. According to Valdés [1], indigenous migration shows no explanatory difference from non-indigenous migration, but he attributes this to the fact that existing instruments are not capable of detecting differences, especially since these populations integrate cultural and ethnic variables rooted in historical memory.

Indigenous migration, mainly for employment reasons, increased from the 1960s onwards. This migration introduced significant amounts of income remittances into their villages, which led to a

social and cultural reordering, altering their traditional agricultural production, changing consumption patterns, and ways of living together [2]. In the case of certain indigenous communities in the Amazon, which were not subject to the conquest by the Europe west during the 16th century, their colonization began in the mid-20th century. These peoples are currently undergoing a strong process of migration and immigration as a result of such colonization and globalization, the main consequence of which is an affectation of their own identity [3]. In this sense, there is concern that their communities will disappear or lose their identity. This concern is coupled with the risk of loss of the Amazon ecosystem. In Amazonian societies, the link between individuals and the ecosystem is indispensable, an ecosystem that is currently in serious danger [4].

In the case of the Amazon, since the end of the 1950s, it has been experiencing a deep process of change. The Ecuadorian anthropologist Fernando Santos points out that the region is undergoing changes associated with the processes of globalization, understanding this as processes of expansion of capitalism [5]. Chirif et al. [6] also point out that the Amazon Basin and its indigenous inhabitants have undergone profound changes due to massive migration, investment in economic development, colonization, and political influence.

Protectionist policies in the Amazon initially perceived the natural resources of the Amazon as a world ecological heritage and promoted the creation of ecological zones to be managed by foreign environmental agents. These policies not only failed to take into account the territorial rights of indigenous peoples but also, in some cases, served as an incentive for states to expropriate indigenous territories and to criminalize certain ancestral practices that they considered an attack on nature [7]. For indigenous people, their worldview combines the environment with their habitat and life itself in a balanced, harmonious, and coherent way [8]. In this regard, the Constitution of Ecuador emphasizes the responsibility to protect and preserve historical memory, collective rights, values, and manifestations of cultural identity, including nature as a subject of law [9].

The migratory phenomenon is affecting each people differently, since their populations come from different origins and territories, leading to different degrees of fusion in their identities with respect to other populations. In this regard, Quijano [10] points out that, as a result of colonialism and immigration by dominant groups from Europe west, indigenous communities and nationalities in Latin America have experienced accelerated ethnic-cultural mergers and changes. Taking into account this point of view and as mentioned by Moltedo [11], an indicator of social affectation, cultural identity, and acculturation of indigenous populations would be migration.

A cultural fusion between two or more cultures can occur when one culture dominates the other or simply when two communities are united for various reasons: wars, conquests, colonization, migration, climate change, economic interests, globalization, and telecommunications [12]. For Berry, [13] acculturation in some indigenous peoples occurs by imposition, receiving another culture in their territory, without them having the will to accept it, while in the case of migrants, they voluntarily chose new territories out of influence or necessity. However, the vast majority of American indigenous peoples have resisted the adoption of another language, wage labor instead of community work, and the admission of religions, but the process of acculturation is breaking this resistance, and this process of acculturation has not succeeded in improving the quality of life; on the contrary, new problems have emerged that are alien to their cultures [14]. For Bello [15], some of these migratory phenomena of indigenous peoples follow their own cultural rules that are not explained by traditional definitions and Western concepts.

All of these social phenomena, as Carrasco mentions [12], produce territorial heterogeneity and different cultural expressions that make it difficult to have a system of measurement and analysis that fully encompasses cultural identity. In this sense, Visvizi et al. [16,17] propose the use of technological tools to address the challenge of refugee and migrant crises and mention that the implementation of migration policies also implies moral obligations.

In this context, the use of artificial intelligence tools could provide a method for quantifying the cultural distances of indigenous peoples from other peoples to which they are subject to migration.

The main objective of this research is to determine and quantitatively measure the degree of ethnic identity that an indigenous person or an entire community has and to compare it with identities of westernised cities in their environment. This will provide a method to know about an indigenous person or a whole community, how close or distant their identity is from another individual in the same community, or from another population with a different culture.

This article has the following structure: Section 2 presents a review of the literature on migration and its influence on peoples' cultural identity, and also studies that have used methods with artificial intelligence tools, related to ethnic identification and migration. Section 3 describes the indigenous territory, which is the object of the research and the identity data collection tool that was previously developed by the authors. Section 4 shows the AI-based method for determining ethno-cultural identity distances between indigenous individuals and distances to urban individuals. The distances to the individual who has the greatest value in terms of indigenous identity, and the ethnic distances for each identity factor, are also analyzed. Finally, Section 5 presents the main conclusions of the study.

2. Literature Review

The ethnic identity, culture, and migration of peoples, considered to be of social interest, is the cause of several dialogues and debates between academia and social decision-makers [18]. Beck [19] states that identity is a protagonist because of the threat felt by all peoples and cultures from a very intense rival called globalization, which penetrates their borders in various ways, one of them being migration.

Migration is capable of influencing several aspects of cultural identity. In one state of Mexico, Velasco et al. [20] studied qualitatively, in a group of indigenous people, the impact that migration causes on a set of cultural aspects such as language, skin color, and ancestral origin. In addition to the fact that the indigenous people devalued their culture, it became clear that discrimination contributes to a distancing from their own ethnic identity. Authors such as Cross Jr. [21] and Helms [22] developed theoretical models of ethnic identity from the racial identity of blacks. The model of Cross, mentioned by Phinney [23], contemplates three states: (1) negative valuation and preference towards another race (the whites); (2) knowledge and interest in oneself; and (3) international acceptance of the group.

The ethnic background of the individuals was also studied. Schneider and Heath [24] analyzed the attitudes that individuals have towards immigration and ethnic groups with a migration background. While Carley [25] studied the adaptability of migrants, based on a thesis of shared knowledge, she concluded that some groups endure longer when faced with the incorporation of new individuals, while others have a greater capacity for admission.

In response to the accelerated process of acculturation, Moreno [26] in Costa Rica conducted a study of the ethnic identity of the Huetares de Quitirrisí de Mora regarding indigenous people who, in the face of migration and globalization, are reluctant to maintain their customs and traditions. The results showed that the Indians placed little value on elements such as dress, language, and customs, yet they continued to be proud of belonging to their people.

Measuring cultural distances between various peoples was proposed by Farias Nazel [27]. Farias made a comparative analysis, in two time periods, between the measures of cultural distances of 7 countries from several continents. The analysis included four cultural dimensions proposed by Hofstede [28].

Concerning the identity of indigenous Amazonian migrants, Frigola [29] studied the labor activities carried out by indigenous Amazonian people in the city. He determined that in the area of labor, indigenous people's work depended on their ancestral knowledge and that, in various cultural areas, they prioritize their cultural identity.

The problems of migration and ethnic identification are also addressed by new technologies and artificial intelligence [30]. Gutta et al. [31] proposed a hybrid classifier based on sets of Radial Basis Functions (RBF), inductive Decision Trees (DT), and Support Vector Machines (SVM) for the classification of gender and ethnicity. They achieved results with an accuracy value of 92% in the

ethnic classification. Lu et al. [32], for the recognition of Asian ethnicity, proposed a method based on Linear Discriminant Analysis (LDA).

Other studies proposed classifying urban identity and identifying certain characteristics and attributes of identity from public space. Chang et al. [33] used the Principal Component Analysis (PCA) technique and the K-means approach to perform feature extraction, as it can help the urban designer identify which features are more important than others. In this sense, Tang et al. [34] suggested other techniques, such as dimensional reduction to eliminate noisy and redundant attributes.

In a study of migration in urban areas in terms of employment, transport, and human mobility problems, Behnisch and Ultsch [35] proposed the use of AI as a data mining tool for data classification and used self-organized maps (SOM) as an unsupervised classifier. Meanwhile, Abarca-Alvarez et al. [36], in a province of Spain, studied the housing occupation of permanent residents and short and long-term migrants. They used a combination of Geographic Information Systems (GIS) with AI.

AI and biometric recognition are generally associated with the control and surveillance of individuals at borders and in migratory areas. However, Pereyra and Estefanía [37] questioned their use, since migration control using biometrics gives privileges to some and deepens others, promoting segmented mobility that undermines ethnic equality.

On the other hand, there are also studies on intelligent cities concerning the expression of their individuals with diverse identities. Visvizi et al. [38], Alkhammash et al. [39] studied citizen expression expressed on websites and social networks for the development of smart cities and education. Smart cities must be people-centred and demand-driven in urban and rural areas, and the classification model makes a connection between the well-being of individuals, their participation, and sustainability [40].

In the literature review, there was no evidence of migration studies on indigenous peoples using AI-based tools. However, a recent study by the authors [41] classified and quantified the identity of the Waorani Amazon indigenous people and two western-cultured towns with the help of AI. Different classifiers were used such as k-Nearest Neighbor (Knn), Linear Discriminant Analysis (LDA), Self-Organized Map (SOM), Neural GAS Variant (NGAS), and Support Vector Machines (SVM), as well as a Multiclassifier (MC). The results showed that, in all performance criteria, they exceeded 90%, with SVM obtaining the best results with 95%. In that work, no methods were proposed to quantify distances between villages or communities.

3. Materials and Methods

The study was conducted with cultural identity information obtained from Waorani indigenous people. For indigenous people who live in the Amazon, their colonization occurred only in the 50s of the twentieth century and that, having some contact or influence of city cultures as a result of migration flows, may be affected in their cultural identity.

3.1. Description of the Indigenous Territory

The indigenous Waorani Amazon communities are distributed over a territory of about 790,000 hectares between the countries of Ecuador and Peru (South America). Their population is approximately 13,000 inhabitants, distributed in 22 communities, (see Figure 1). Its territory, to the east, is surrounded by Yasuní National Park—a park that conserves exuberant biodiversity—and by an area called intangible, an area inhabited by the Tagaeri and Taromenane Indians, peoples who live with their original culture without any contact, while, to the west, it borders provinces with cities with globalized culture.

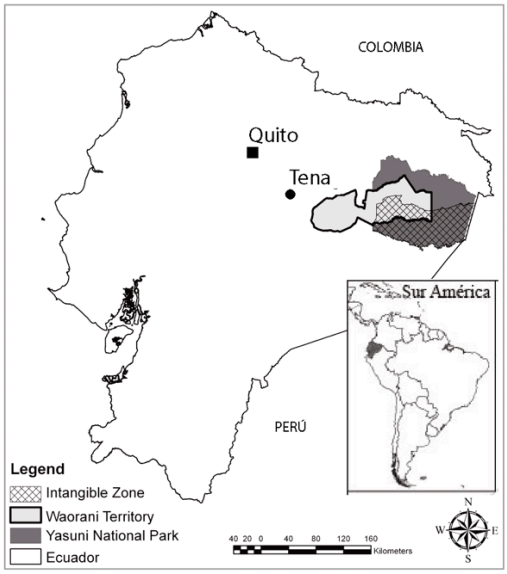


Figure 1. The geographical location of the Waorani territory.

3.2. Description of the Tool Used to Quantify Identity from an Indigenous Perspective

The instrument used as a data source for this study [42] was developed after a process of validation and measurement of its reliability. The instrument was designed so that its items could be obtained from the individual and community perspectives. As Smith states [43], the methodology and methods built upon the Indigenous actors become important acts that also need to be decolonized. In the same work, Smith affirms that some scientific research in colonized societies has been complicit in and has left a mark on Western imperialism. However, this is not a rejection of all Western production, but rather a critique so that his works are carefully directed and applied to defend the cultural interests of indigenous populations. The study was carried out after contacting these communities through an agreement between the Central University of Ecuador and the Waorani Indigenous Nationality, where teachers and students carry out research and social practice. After obtaining authorization from community leaders and chiefs, the study was carried out in the field over relatively long periods (stays of six months to one year). These stays allowed us to get closer to the communities, generating confidence and interest so that the indigenous people would not only be a source of information but would also participate in the generation of items.

The qualitative study was carried out based on interviews with inhabitants of three communities. The interviews, conducted with the respective protocols and with individual informed consent, were carried out in two phases. The first phase, called the unstructured phase, consisted of free expression interviews, in which the indigenous people expressed, from their point of view and in a spontaneous manner, diverse themes and content that they considered being of interest, and the second phase, called semi-structured, with interviews in which the themes were in some way oriented towards identity and cultural content.

To obtain the items and identity factors, a qualitative analysis of the interviews was carried out using the Atlas.ti tool [44]. As a result of the study, 99 items were obtained, which were grouped into 30 sub-dimensions—factors—and these, in turn, were grouped into five dimensions, which are shown in Table 1.

Table 1. Dimensions and subdimensions of the Waorani Identity Instrument [42].

Dimensions		Subdimensions (Factors)	Items
1. Economic (E)	9	Handicrafts (E1), Exchange of products (E2), Cultivation (E3), Tourism (E4), Work (E5), Mingas (E6) *, Trade (E7), Hunting and fishing (E8), Breeding of animals (E9)	22
2. Family and reproduction (F)	6	Education (F1), Care and upbringing of children (F2), Medicine (F3), Marriage (F4), Coexistence (F5), Reproduction (F6)	21
3. Ideological (I)	4	Religion (I1), Beliefs (I2), Spirituality (I3), Rites (I4)	13
4. Organization (O)	3	Community (O1), Justice (O2), Government (O3)	6
5. Social (S)	8	Music, dance, and songs (S1), Art (S2), Food (S3), Dress (S4), Housing (S5), Culture, ethnicity, and identity (S6), Language (S7), Sports and recreation (S8)	37
Total Subdimensions	30	Total Items	99

Note: * Mingas or nopos, indigenous words that mean community work without payment.

The same authors, using artificial intelligence techniques, classified individuals from the three populations using the ethnic identity information provided by the instrument [41]. The study also determined the identity factors that most and least influence the classification, with factors related to beliefs (I2) (Ideological Dimension) having the greatest influence on the population classification.

3.3. Description of the Individuals of the Study

In order to establish the distances between the identities of the Waorani Indians and those of the inhabitants of city towns, the instrument mentioned in the previous subsection (99 items) was applied employing surveys to 299 people: 88 Waorani Indians, 100 inhabitants of the city of Quito, and 111 inhabitants of the city of Tena. These three populations represent 3 types of cultures in Ecuador: Amazon Waorani Indians, who are the subjects of the study, the data was collected in 3 of the 22 communities (Konipare, Menipare, and Gareno). Quito (the capital of Ecuador) was selected because it is a city with western culture. The city of Tena, selected because it is an Amazonian tourist city, situated geographically between the city of Quito and the Waorani territory. The city of Tena has a western culture; however, it receives a migratory flow from the indigenous communities, so it is of special interest to see how much distance there is between its inhabitants and the indigenous people.

3.4. Method to Determine Identity Distances

The method to calculate the distances between identity cultures is based on the tool for quantifying identity from an indigenous perspective described in Section 3.2 and self-organized maps (SOM). The qualitative data collected by the instrument in 99 items (see Table 1) are quantified and normalized (between 0 and 1) forming a multidimensional vector. This vector is used as the input patterns of an SOM. Therefore, first of all, we proceed to train a self-organized map (SOM) using the 299 individuals of the three populations. Each individual corresponds to an input pattern composed of the 99 items of the instrument. The training process is capable of configuring the two-dimensional space of the map, whose topology is fixed, by grouping the neurons that are most similar to each other (in terms of Euclidean distance at the 99-dimensional space of the neuron called codebook). This implies that close neurons in its neighborhood (two-dimensional) are in the 99-dimensional input space. Once the training was completed (in an unsupervised mannerin this paper), the resulting map was labeled with the type of population that each input pattern represents. Figure 2 shows the unified distance matrix (U-matrix) of the trained and labelled SOM. The U-matrix makes it possible to visualize the Euclidean distance between adjacent neurons. The large distances between neurons correspond to the red color and indicate a gap between the codebooks of the neurons in the input space. In the same way, the blue colors between neurons indicate that the codebooks are close, and therefore in the input space.

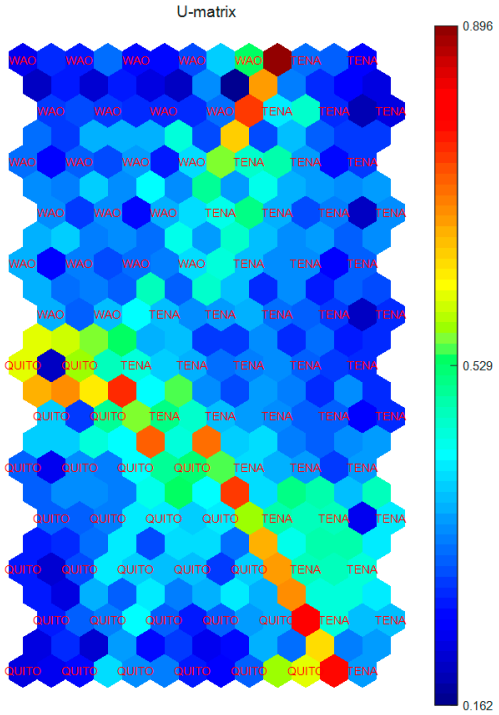


Figure 2. Self-organized map (SOM) map for the three populations.

Therefore, in Figure 2, it can be seen that there are three clearly differentiated clusters corresponding to each of the population types marked by their borders with greater distances in the U-matrix (colors different from blue). Also, it can be observed than a greater distance (mostly the red color separation) separates the indigenous Waorani people (Wao in the Figure) from the inhabitants of the city of Quito and between the inhabitants of the city of Tena and the inhabitants of the city of Quito, while the separation distances decrease (red and blue color separation) between the inhabitants of the city of Tena and the indigenous Waorani people. In addition, in the cluster corresponding to the patterns of the inhabitants of the Tena, there are greater distances inside the cluster than in the rest of the others.

In order to determine ethnic identity distance values between inhabitants of the same towns (Waoranis, Tena, and Quito) and between individuals belonging to towns, the resulting SOM has been used to calculate what we have called the SOM topographic distance. This distance is calculated by finding the minimum path between two neurons by the algorithm proposed by Dijkstra [45]. The algorithm explores the distances between the vertices that connect nodes in a network of nodes to determine the shortest distance between pairs of nodes. The neurons correspond to those that are activated in response to the two input patterns corresponding to the individuals from whom we want to determine their ethnic distance. After calculating the minimum path, the resulting distance is the sum of the Euclidean distances of the neurons visited during the route.

Identity distances were determined for each individual from the three populations in comparison with each of the other individuals from the same three populations (299 × 299 distances), firstly by taking into account only the identity factors belonging to the belief sub-dimension (I2) (this is the one that most influences the classification), and then by taking into account all the instrument's factors (30 sub-dimensions). The distances between each individual and the indigenous Waorani with the highest identity score were also determined. We will call this individual from now on the indigenous "WM." The distances of identity between each indigenous person and his or her population, as well as between each indigenous person and the westernized cities (Tena or Quito), were also determined (see Figure 3).

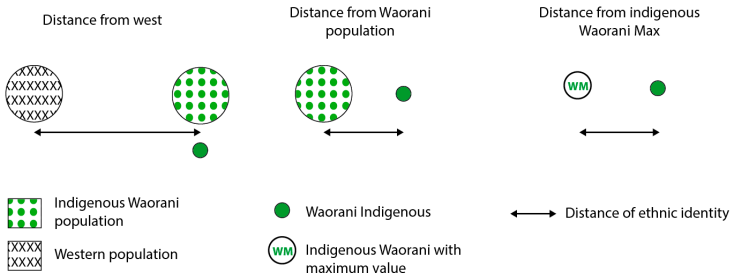


Figure 3. General diagram of identity distances.

4. Experiments

This section shows the experiments carried out to validate the cultural identity distance as an analysis tool of the Amazon indigenous people. Specifically, the identity distance has been calculated to study the Waorani community compared with the identity of the inhabitants of Tena and Quito.

4.1. Population Distances

The identity factor related to beliefs (I2 sub-dimension) belonging to the ideological dimension (I) is the sub-dimension that contributes most to the classification of individuals in the three populations [41]. For this reason, sub-dimension I2 was used to determine the topographical distance of ethnic identity between individuals in the same populations. Figure 4 shows the results according to the topographical distance of the beliefs dimension (I2) from each indivual to the rest of them, conforming a 299 × 299 matrix of distances. It is important to note that the individuals have been organized to show them graphically. The Waorainis individuals correspond to rows and columns 1 to 88, the inhabitants of Tena from row and column 89 to 199, and finally the inhabitants of Quito from 200 to 299. The diagonal corresponds, of course, to the comparison of an individual with him or herself and that the matrix is symmetrical. In consequence, in Figure 4 (greater red distance, less blue distance) it can be seen that, with only this sub-dimension (1 of 30), there is already a pattern of ethnic distances between populations. That is, with the first glance, it is possible to observe 9 regions: those corresponding to the distances between the same population (diagonal) and those between the different populations that are symmetrical. The greatest ethnic distance exists between the Waorani Indians and the inhabitants of the city of Quito (yellow color), while the smallest distances are not found between the inhabitants of their towns, but between the Waorani Indians and the inhabitants of the city of Tena (greater blue color). Table 2 shows the average topographic distance between populations (distances from 0 to 1).

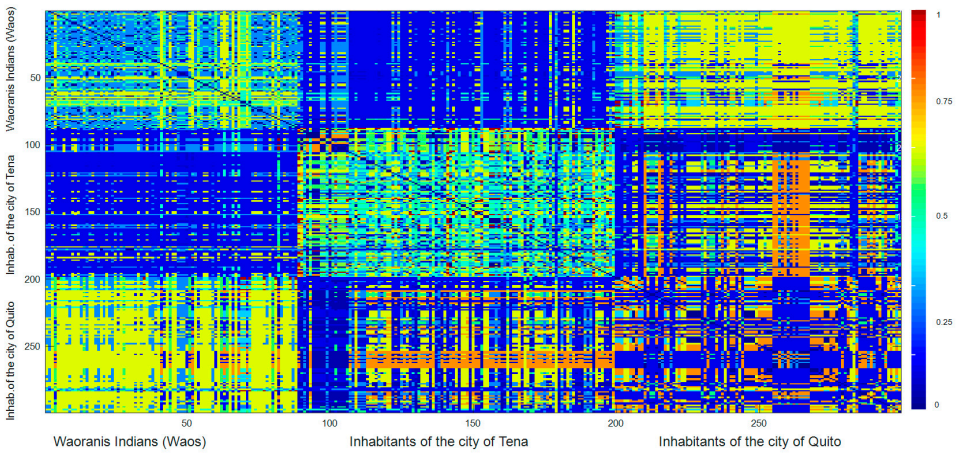


Figure 4. The topographical distance of the beliefs dimension (I2) of the ideology dimension (I) for the three populations.

Table 2. Identity distance between populations for the belief sub-dimension (I2).

Populations	Colour Predominance	Dist. Average (0–1)
Waoranis-Waoranis	Green	0.4039
Waoranis-City of Tena	Blue	0.1994
Waoranis-City of Quito	Yellow	0.5585
City of Tena-City of Tena	Green	0.4463
City of Tena-City of Quito	Blue-orange	0.3452
City of Quito-City of Quito	Blue-orange	0.3328

However, when all 30 sub-dimensions are applied, the topographical distance of ethnic identity between populations is more pronounced. Figure 5 uses a range of distances between 0 and 4.5. In this figure, it can be observed that in the populations of the Waorani Indians and the inhabitants of Quito (in the Figure the areas: Waorani-Waorani and Quito-Quito) there is a greater homogeneity and proximity between their inhabitants (mostly blue). However, for the inhabitants of the city of Tena (in Figure 5, the Tena-Tena area), these distances are greater and heterogeneous (a mixture of blue and green colors). On the other hand, the distance separating the Waorani Indians from the inhabitants of the city of Quito is notoriously greater (Waorani-Quito area, mostly red with an average of 3.43) than the distance separating them from the inhabitants of the city of Tena (Waorani-Tena area mostly green, with an average of 2.42). Table 3 shows the average distance of the inhabitants from town to town and its standard deviation.

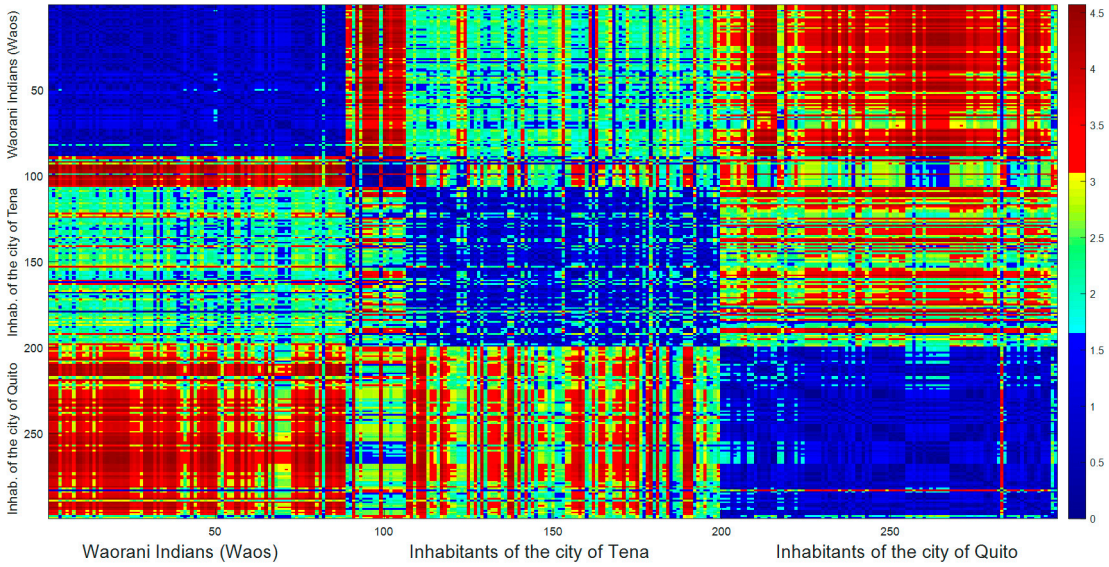


Figure 5. Topographical distance: Waorani Indians, city of Tena, and city of Quito.

Table 3. Statistics on the population identity distances of each population.

Population	Colour Predominance	Mean	Typical Deviation
Waoranis-Waoranis	Blue	0.7823	0.4537
City of Tena-City of Tena	Blue-Green	1.4553	0.9342
City of Quito-City of Quito	Blue	0.9450	0.6170
Waoranis-City of Tena	Green	2.4221	0.8223
Waoranis-City of Quito	Red	3.4349	0.7841
City of Tena-City of Quito	Red-Green	2.9325	0.9527

4.2. Distances from the WM Indigenous

In order to identify the Waorani indigenous person with the highest identity value, we proceeded to explore the values obtained by the instrument in the surveys. Each of the 99 items in the instrument

has a value of 4 to 0, with 396 being the maximum score that a Waorani inhabitant with an ideal identity would obtain at 100%. After the application of the instrument, the results showed that the 37th native obtained the highest value with 354/396 (89.4% of the ideal). This indigenous person corresponds to a woman who is 36 years old, we will call her "WM" indigenous.

Once the indigenous person with the highest Waorani (WM) identity had been identified, the ethnic topographical distances from the rest of the inhabitants of the three towns (88 Waoranis, 111 from Tena and 100 from Quito) were determined. Figure 6 specifically focuses in row 37 of the matrix corresponding to Figure 5 to show that the ethnic identity distances of each indigenous person in the Waorani communities are closer to their own WM member (greater blue color), while the inhabitants of Tena (greater green color) and Quito are further away (greater red color). Figure 6 actually matches the spectrum of cultures [46] where societies are positioned within a continuum from "cold" to "hot," whereby archaic culture represents the cold, and the elaborated, "progressive" culture the hot aggregate state. Table 4 shows the descriptive values of the distances of the three populations with respect to the WM individual, evidencing notably that the average population identity distance to the WM individual is greater from the inhabitants of the city of Tena and much more from the inhabitants of the city of Quito.

Figure 6. The topographical distance of the Waorani Indians, inhabitants of the city of Tena, and the city of Quito from the WM Indian.

Table 4. Statistics on population distances from the indigenous WM.

Population	Mean	Medium	Typical Deviation
Waorani Communities	0.7054	0.6053	0.4787
City of Tena	2.5031	2.2072	0.8378
City of Quito	3.9219	3.9035	0.6152

Considering WM as the one with the greatest indigenous identity, 8 indigenous people had a topographic distance of 0.0 with respect to that indigenous person. In Figure 7 they are located, like WM, right in the middle. Consequently, 10.22% (9 of 88 indigenous people) would be considered the indigenous people with the most Waorani identity compared to the ideal (396 points). Table 5 shows the scores of these Indians when applying the instrument (the 9 Waorani Indians are among the 16 best scores out of 299 individuals); however, all are women, and none are under 18 years of age.

On the other hand, the study of the distances for each identity factor (30 sub-dimensions) was carried out. Figure 8 shows the average distance of all individuals in each population in relation to the WM indigenous. It was determined that, in the case of the Waoranis, the factors related to the breeding of animals (E9) are the most distant from their maximum identity (represented by the WM), in the case of the Tena inhabitants the tourism factors (E4) and, for the Quito inhabitants, the community factors (O1). While the trade-related factors (E7) are the least distant from all populations. These values can be seen in Table 6.

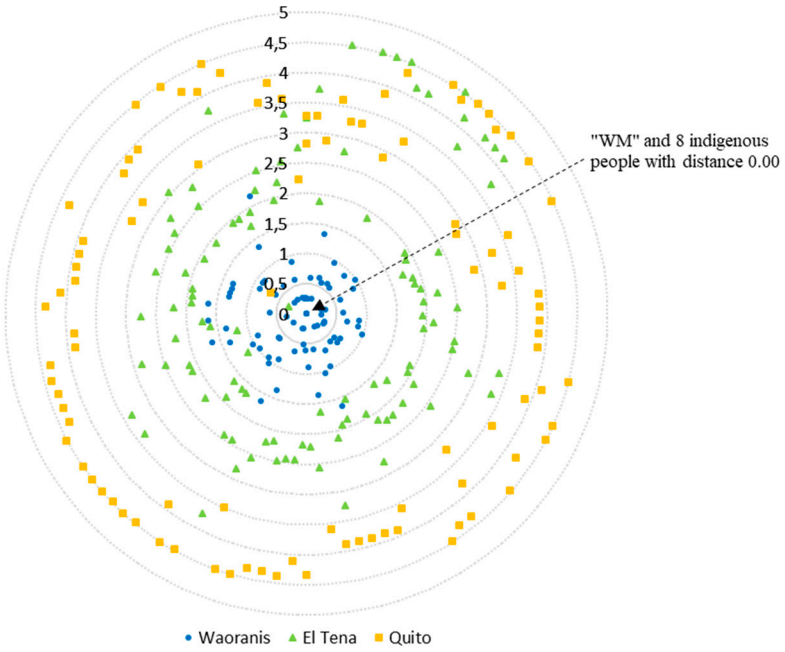


Figure 7. Distribution of the 299 individuals' topographical distance from the Waorani (WM) Indian.

Table 5. Description of the indigenous people with the greatest Waorani identity.

N. Inst	Age Type	Gender	Dist. to "WM"	Score	%
1	Young Adult	Woman	0.000	342.0	86.364
9	Young Adult	Woman	0.000	342.0	86.364
13	Young Adult	Woman	0.000	351.0	88.636
18	Adult	Woman	0.000	344.0	86.869
21	Adult	Woman	0.000	330.0	83.333
23	Young Adult	Woman	0.000	342.0	86.364
37 *	Adult	Woman	0.000	354.0	89.390
78	Young Adult	Woman	0.000	328.0	82.828
83	Adult	Woman	0.000	325.0	82.071

Note: * WM indigenous.

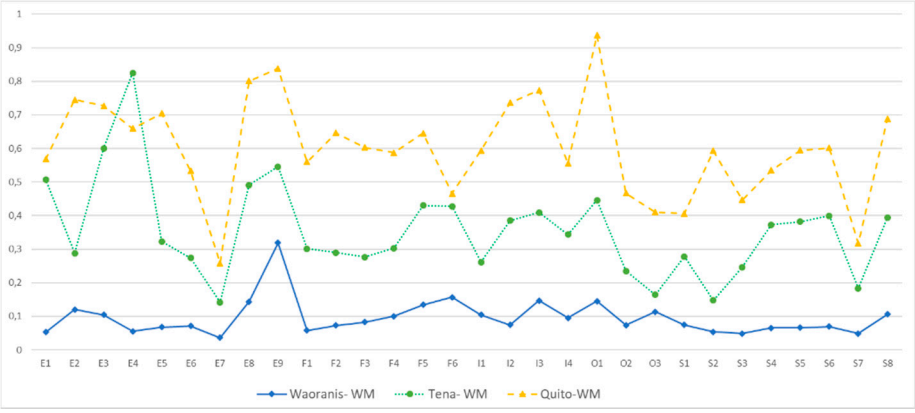


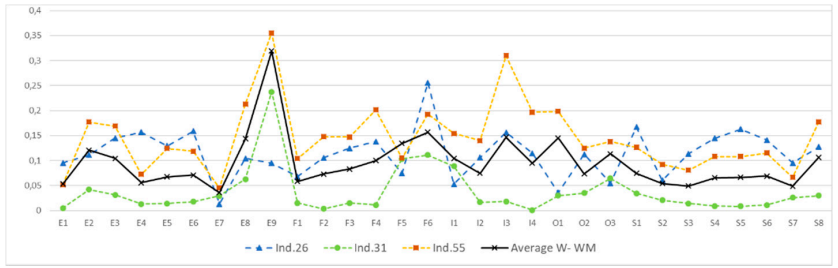
Figure 8. The average distance of each population by the identity factor.

Table 6. Identity factors: Major and minor distances to the WM indigenous.

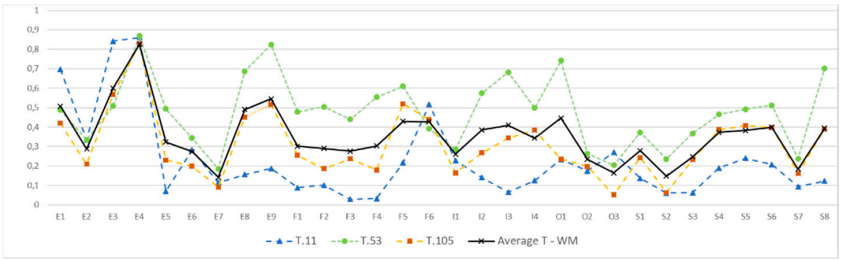
	Larger Distances		Minor Distances	
From: Town	**Factors**	**Value**	**Factors**	**Value**
Waorani Indians	E9-breeding of animals	0.3190	E7-Trade	0.0359
Population of Tena	E4-Tourism	0.8250	E7-Trade	0.1419
Inhabitants of the city of Quito	O1-Community	0.9368	E7-Trade	0.2579

For the Waorani inhabitants, the factors of greater distance (E9) from their individuals to WM would be affecting their identities, as would the factors closer to them from the inhabitants of Tena and Quito (E7). On the other hand, the factors of lesser distance (E7) from their individuals would be helping to maintain or protect their identity, as would the factors of greater distance (E4 and O1) from the inhabitants of Tena and Quito.

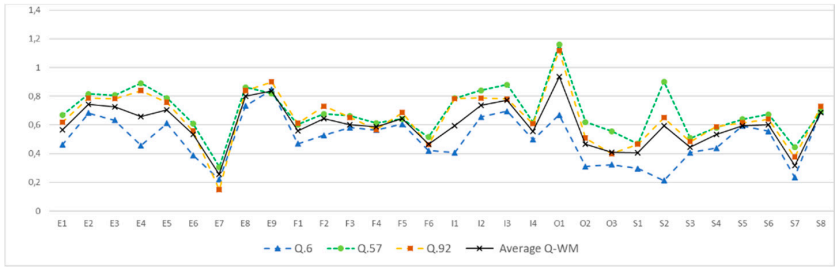
For each of the 298 individuals (87 Waorani Indians, 111 inhabitants of Tena, and 100 inhabitants of Quito), the ethnic distances for each identity factor were obtained from the Waorani WM and the average distance of its population from the same WM. Figure 9 shows the distances of nine individuals—three Waorani Indians (a), three individuals from the city of Tena (b), and three individuals from the city of Quito (c)—and their distances from each identity factor to the Waorani WM (abscissa axis) and the average distance from their population (black line).



(**a**)



(**b**)



(**c**)

Figure 9. Identity distance by identity factor of several individuals from each population to WM. (**a**) distances of three Waorani Indians. (**b**) distances of three individuals from the city of Tena. (**c**) distances of three individuals from the city of Quito. For the 3 graphs the average distance from their population is showed in the black line.

Figure 9a shows how the identity values of Waorani Indian #55 (Ind.55) are above average for all identity factors, except for F5 (Coexistence). A similar case, but with all distances below the mean, has the indigenous #31 (Ind.31). However, the indigenous #26 (Ind.26) presents a more heterogeneous variation. Similarly, Figure 9b,c show individuals from the cities of Tena and Quito whose distances from their identity factors, for the same individual, are in some cases above the mean, and in other cases below the mean (individual from the city of Tena T.105). On the other hand, other individuals maintain almost all their factors above average (individual from the city of Tena T.53) or below average (individual from the city of Quito Q.6). This variability of results allows us to confirm the usefulness of this technique, since it would make it possible to identify, in the social-cultural sphere of the indigenous Amazon territory, the possible causes of the impact or lack thereof that each individual indigenous person would have on his or her cultural identity.

5. Discusion and Conclusions

Cultural identity is a topic that involves the whole society. Its study is complex since it includes variables of subjective nature and specific of each people. The cultural identity of the indigenous Waorani Amazon people will be subject to acculturation processes that affect their own identity, due to the constant migratory flows as a consequence of the colonization of their territories by populations that mostly come from cities with western culture and globalization.

From the review of the literature, it can be deduced that there are specific studies on indigenous identity. However, these studies are focused exclusively on qualitative analysis. No studies have been found that quantify cultural identity using AI-based tools from the data obtained by an instrument. Nor were any studies found that determine ethnic topographical distances between indigenous people, between communities, or distances from indigenous villages to cities. The absence of these studies did not allow comparisons to be made on an equal basis with the results of this research.

In this research, through the application of an instrument and its subsequent analysis using AI techniques, the identity of the indigenous Waorani people is measured and compared with the identity of the inhabitants of two cities (Tena and Quito). The results made it possible to distinguish marked differences in identity between individuals in the three populations. In the authors' opinion, this is good news since the indigenous peoples still retain a marked cultural differentiation.

In the grouping of individuals using self-organized SOM maps, the results showed that the greatest identity distances of the Waorani Indians were found when compared to the inhabitants of the city of Quito. However, these distances decreased when the comparison was made with the inhabitants of the city of Tena. On the other hand, it was found that while the identity distances between the indigenous people themselves and between the inhabitants of Quito are homogeneous and closer to each other, the distances between the inhabitants of Tena are greater and heterogeneous.

By establishing distances from the indigenous person with the highest value of identity (WM with 89.4% of ideal value identity), it was possible to identify those Waoranis with a cultural identity who were either closer or more distant from their own identity as a community. It was also possible to quantify the community's distance from other populations that have city identity. Furthermore, it was possible to see that adult women were the most representative of Waorani culture. This higher score in women would be due to the fact that, while when the indigenous men carry out economic activities such as selling handicrafts, exchanging products and trade, travel to the city of Tena, the women stay in their territory to take care of the children, avoiding the influence of an external culture and maintaining, at the same time, their own identity.

The topographical distances for each identity factor made it possible to determine those characteristics of the indigenous people that are most valuable or least valuable within the distances of each indigenous person from the maximum identity of the Waorani people. It was determined that the factors related to trade are the closest regarding the inhabitants of Tena and Quito in relation to the indigenous people, which would indicate that activities related to the buying and selling of external products would influence the Waorani identity by the city inhabitants. While the factors most distant

from the inhabitants of Tena and Quito are related to tourism and community, these activities should be monitored so that their cultural distance does not diminish.

This study has some limitations. The most important are related to access to territory and communication. In the indigenous Amazonian cultures, their study becomes even more complex, the access to their territory is limited due to the necessity of authorizations of community leaders, embarrassing geography, and the difficulty of interpreting words or own expressions and of their language (Wao-terero), as in many of the cases a semantic translation to languages like the Spanish or English does not exist. Moreover, it should be noted that the identity values offered by this tool are based on the scores of the instrument designed specifically for the Waorani community. Therefore, variations in the instrument and/or its application to other communities could affect the identity-distance results for those communities. However, the proposed method for measuring distance is generic and could be used to measure cultural distance between other populations and cultures. Moreover, the proposal could be generalised to measure, in a quantitative way, qualitative and categorical data for other problems of similar characteristics.

The main contribution of this study is that AI-based tools have been used to quantitatively measure the cultural identity of an individual or a group of individuals who share the same cultural heritage. The tools presented in this work could serve as a thermometer to measure the state of the cultural identity of an indigenous community. Therefore, the authors believe that its social implications can be very useful in the future. Determining the state of cultural identity of an indigenous people through each factor of identity—cultural dimensions and sub-dimensions—will allow to evaluate if any political measure or decision has impacted on those factors and, therefore, if it has favored or damaged their cultural identity. This "cultural thermometer" would help modulate such decisions in the sense of preserving the identity of indigenous peoples. However, these political decisions would not apply to communities that have their governance and laws, or that live in voluntary isolation, such as the Tagaeri and Taromenane indigenous communities, which, belonging to the Waorani people, have not been contacted by Western culture and live with their original culture.

Author Contributions: Conceptualization, formal analysis, A.E.-L., M.L.P.-F.; investigation, A.E.-L., M.L.P.-F., methodology, A.J.-M., J.A.-L.; supervision, M.L.P.-F., A.J.-M.; writing—original draft, A.E.-L., A.J.-M.; writing—review and editing, A.J.-M., J.A.-L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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