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Exploring Relationship between Perception Indicators and Mitigation Behaviors of Soil Erosion in Undergraduate Students in Sonora, Mexico

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Abstract: Soil erosion represents a critical socio-economic and environmental hazard for Mexico and the world. Given that soil erosion is a phenomenon influenced by human activities, it is essential to know the level of cultural perspectives on this matter. An instrument with eight scales was applied to 275 university students from a northwestern Mexican city, which measured the knowledge about soil erosion, self-efficacy in solving the problem, future perspectives, perceived consequences, obstacles to addressing soil erosion, and mitigation intentions and behaviors. To analyze the relationship between the scales and the intentions and behaviors of soil erosion mitigation, a model of structural equations was tested. In summary, the participants know the problem of soil erosion, its impacts, and recognize risks to human and environmental health. They also know their important role within soil conservation; however, they identified significant obstacles to action. This study determined that each indicator has a correlation with soil erosion mitigation intentions except for the obstacles. The indicators that had the greatest positive relationship in mitigation intentions were knowledge, self-efficacy, and the perspective of the future. The implications of these results open the landscape to the creation of efficient strategies to mitigate soil erosion in this region and Mexico.

Keywords: soil degradation; environmental psychology; agricultural practices; soil conservation; knowledge; pro-environmental behavior

1. Introduction

The rapid growth of the world population, the increase of consumption rates, especially in the developed countries, and the rapid industrialization, have caused the increase in the global demand and competition for resources such as water, land, and energy [1]. However, this has led to the overexploitation of ecosystems, which has contributed to increased problems and serious challenges, such as deforestation, desertification, biodiversity loss, deterioration of natural resources, climate change, and soil degradation [2]. In fact, soil erosion is one of the most severe environmental and public health problems worldwide, as it threatens food security, environmental conservation, and life on Earth [3,4].

Soil erosion is the loss of fertile soil due to dynamic agents such as wind and water [5]. Soil, organic matter, nutrients, and beneficial microorganisms are redistributed through these processes, resulting in lower soil productivity and a higher demand for synthetic fertilizers [6]. However, despite being a natural process, soil erosion is intensified by human activities. In particular, deforestation, poorly planned construction of roads, the lack of appropriate drainage systems, agriculture intensification, and urban sprawl are some of the activities that most contribute to soil erosion [7–9]. However, the main cause of soil erosion is the use of non-sustainable agricultural practices (e.g., monoculture, excessive application of agrochemicals, and crop residue burning), making this a serious problem [10,11]. Thus, soil erosion causes negative impacts both on the sites where the erosion originates (in situ) and on the places where this soil is deposited (ex-situ). The in-situ consequences of soil erosion are (i) the loss of the fertile soil layer, (ii) decrease in infiltration rate and lower water holding capacity, (iii) decrease in organic matter, nutrients, and biota, and (iv) increase in desertification. Among the ex-situ consequences are (i) the eutrophication of water bodies modifying these habitats, (ii) deposition of polluting compounds at deposit sites, (iii) reduction of the storage capacity of rivers, lagoons, and dams, and the modification of the natural watercourse [8,10,12,13].

Currently, soil erosion affects about two-thirds of the world's land surface, resulting in a loss of 75 billion tons of fertile soil per year [14], with an annual economic cost of approximately 400,000 million dollars [15]. Therefore, due to the economic, political, and social importance of soil degradation, Mexico, like other countries, has carried out different studies to estimate soil erosion and to evaluate its impacts [8,13,16,17]. The most recent official soil degradation study in Mexico is the project "Evolution of soil degradation caused by humans in the Mexican Republic, at a scale of 1:250,000". This study reported that 44.9% of the country's soils are degraded, where agricultural activities cause 77% of soil deterioration nationwide [11]. In contrast, Bolaños-González et al. (2016) developed a 1:50,000 scale national erosion map using satellite image photo-interpretation techniques, specialized cartography, and field information, which showed that 76% of the national surface is affected to some degree by water erosion, while 72% of the territorial surface of the state of Sonora is affected by water erosion [18].

Sonora, Mexico, is one of the most agriculturally important areas in the country; and the Yaqui Valley located on the northwest coast of mainland Mexico is the birthplace of the green revolution. The green revolution consisted of the adoption of a series of practices and technologies, including the sowing of cereal varieties more resistant to extreme climates and pests, new cultivation methods (including mechanization), innovation in irrigation systems, and the use of agrochemicals on a large scale [19]. These intensive agricultural practices led to an increase in crop yields between 1960 and 2000 worldwide [20]. However, intensive agricultural practices in combination with the semi-arid climatic conditions have negatively impacted the sustainability of food production in the Yaqui Valley, i.e., soil fertility loss, salinization, microbial degradation, low use of agricultural inputs, among others [19,21].

Because of the serious environmental, social, and economic consequences of soil erosion in Sonora and the rest of the world, it is necessary to obtain precise information on the magnitude of soil erosion that affects our lands, study the perception that society has of the problem, and develop new strategies and enhance the existing environmental management strategies. Despite its importance, the negative implications of soil erosion have not been sufficiently assessed, and the problem has not been efficiently addressed [22–24]. At present, soil erosion management strategies have focused on the technical, but it is essential to include a cultural transformation approach. Different factors may explain this paradigm: (a) erosion is in some cases slow and "invisible"; not perceptible to society, (b) the problem is not considered and is accepted as a completely natural process that it is not necessary to address, or (c) erosion is highly complex, and society does not know how to deal with this problem [24].

Given that soil erosion is a phenomenon influenced by human activities, it is essential to know the level of sociocultural knowledge and cultural perspectives on soil erosion and degradation in Sonora, i.e., knowledge about soil erosion, self-efficacy in solving the problem, their perspectives on the future, perceived environmental impacts and health risks, obstacles to acting against soil erosion, as well as their behavioral intentions and mitigation behaviors [25,26]. The study of this sociocultural perspective can help in identifying and understanding the factors that facilitate and inhibit mitigation behaviors and the adoption of sustainable practices, both of which are essential to improve the efficiency and effectiveness of soil management and, in particular, soil conservation strategies. Most studies on environmental perception and behavior focus on other environmental issues [25,27–30], with only a few focusing on soil erosion. Besides, studies on the perception of soil erosion have been carried out on farmers and leave out the other social groups [31–33]. Furthermore, there is a paucity of studies that simultaneously include the prediction of soil erosion mitigation responses in the region.

Undergraduate students are key to this understanding since they are the major stakeholders in higher education institutions; they will become the workforce in the short term and they have the potential to become agents for future changes [27,34–36]. Janmaimool and Khajohnmanee (2018) stated that students who understand their surroundings can act as a pioneering group that practices pro-environmental behaviors and can influence society to contribute to sustainable improvement [34]. This work aims to analyze the relationship between perception indicators (knowledge, self-efficacy, future perspective, risk perception, and obstacles) in undergraduate students to understand their perception of the problem of soil erosion and determine the factors that promote the intentions and behaviors of its mitigation. This research is framed within environmental psychology and takes up variables that have been studied and whose predictive power has been proven [30,37,38].

2. Materials and Methods

2.1. Participants

The sample for this study was selected using the non-probabilistic convenience sampling method. A total of 275 undergraduate students from Ciudad Obregon, Sonora—a northwestern Mexican city—answered an instrument (see Section 2.3); 106 were men and 169 women. Their ages ranged from 18 to 32 years (M = 20.5 years, SD = 2.09). Regarding the courses studied by the participants: 65 (23.6%) were studying a bachelor of accountancy, 54 (19.6%) environmental sciences, 32 (11.6%) psychology, 31 (11.3%) chemical engineering, 21 (7.6%) educational sciences, 20 (7.3%) industrial and systems engineering, 15 (5.5%) engineering in biosystems, 9 (3.3%) civil engineering, 9 (3.3%) geosciences engineering, 5 (1.8%) electromechanical engineering, 3 (1.1%) environmental engineering, 3 (1.1%) mechatronics engineering, 3 (1.1%) engineering in biotechnology, 2 (0.7%) business administration, 1 (0.4%) natural resource sciences, 1 (0.4%) veterinary medicine, and 1 (0.4%) software engineering.

2.2. Instruments

An instrument with eight scales in a Likert-type response format was applied (Appendix A).

The psychometric properties of the scales were verified. For content validity, the scales used were subject to a panel of experts in soil erosion and environmental psychology. For construct validity, the scales were subjected to confirmatory factor analysis (CFA) to verify the fit of the measurement model to the data. Finally, reliability was obtained using Cronbach's Alpha.

The first scale measured knowledge about soil erosion consisted of 13 items with five response options (1 = totally disagree to 5 = totally agree). Through a confirmatory factor analysis, the fit to the data measurement model was verified (Goodness of fit: X^2 = 104.59 (63 df), p = 0.000, BBNFI = 0.90, BBNNFI = 0.94, CFI = 0.96; RMSEA = 0.05). Its reliability measured with Cronbach's alpha (α) was 0.86.

The self-efficacy scale measured the belief that participants have of themselves to take actions to mitigate soil erosion. This scale was integrated by three items with five response options (1 = totally disagree to 5 = totally agree). The results of the confirmatory factor analysis showed the fit of the measurement model to the data (Goodness of fit: X^2 = 0.114 (2 df), p = 0.944, BBNFI = 0.99, BBNNFI = 1.00, CFI = 1.00; RMSEA = 0.00). The reliability of the scale was acceptable (α = 0.68).

For the future time perspective subscale, the Zimbardo Temporal Perspective Inventory [39] adapted by Corral-Verdugo, Fraijo-Sing, and Pinheiro (2006) was used [37]. It measures situations and beliefs characteristic of people with a future orientation, such as planning days, setting goals, meeting obligations on time, among others. It consisted of 11 items with five response options ranging from 1 = very uncharacteristic to 5 = very characteristic. The fit of the measurement model to the data was verified with a confirmatory factor analysis (Goodness of fit: X^2 = 97.87 (42 df), p = 0.0000, BBNNFI = 0.90, CFI = 0.93; RMSEA = 0.07). The value of α = 0.84, indicated an adequate reliability of the scale.

The perceived environmental impact was measured through 15 items that rated the degree of agreement regarding the impacts on the environment caused by soil erosion, such as loss of air quality, soil contamination, increase in food costs, among others. The scale was a Likert type, with five response options (1 = totally disagree to 5 = totally agree). Through a confirmatory factor analysis, the fit to the data measurement model was verified (Goodness of fit: X^2 = 161.80 (63 df), p = 0.0000, BBNFI = 0.90, BBNNFI = 0.92, CFI = 0.94; RMSEA = 0.07). Its reliability was measured at α = 0.91.

The perceived health risks were evaluated through 8 items, where the degree of agreement regarding the health risks caused by soil erosion is rated, such as waterborne diseases, respiratory problems, anemia, and cancer. The scale was a Likert type, with five response options (1 = totally disagree to 5 = totally agree). The results of the confirmatory factor analysis showed the fit of the measurement model to the data (Goodness of fit: X^2 = 63.50 (18 df), p = 0.0000, BBNFI = 0.93, BBNNFI = 0.92, CFI = 0.95; RMSEA = 0.09). The value of α = 0.85, indicated adequate reliability of the scale.

Obstacles to conducting behaviors to mitigate erosion were measured through 9 items [40] with five response options (1 = totally disagree to 5 = totally agree), which describe possible obstacles such as not knowing what to do, lack of motivation, lack of help, lack of money, among others. The fit of the measurement model to the data was verified with a confirmatory factor analysis (Goodness of fit: X^2 = 55.27 (19 df), p = 0.0000, BBNFI = 0.92, BBNNFI = 0.92, CFI = 0.95; RMSEA = 0.08). The reliability of the scale was acceptable (α = 0.82).

Finally, the behavioral intention to act against soil erosion and mitigating behaviors of soil erosion was measured through 9 items on the Likert scale. The intention scale evaluated the probability of carrying out soil erosion mitigation activities with five response options (1 = not at all probable to 5 = very probable). The results of the confirmatory factor analysis showed the fit of the measurement model to the data (Goodness of fit: X^2 = 43.12 (12 df), p = 0.0000, BBNFI = 0.96, BBNNFI = 0.95, CFI = 0.97; RMSEA = 0.09). The value of α = 0.89, indicated adequate reliability of the scale.

In the case of the scale of mitigation behaviors, the frequency they perform these activities was measured with four response options (1 = never to 4 = always). The fit of the measurement model to the data was verified with a confirmatory factor analysis (Goodness of fit: X^2 = 141.21 (27 df), p = 0.0000, BBNFI = 0.91, BBNNFI = 0.90, CFI = 0.93; RMSEA = 0.09). Its reliability was measured as α = 0.93.

2.3. Procedure

The instrument was administrated in the participants' classrooms. They were informed about the aim of the study and the confidentiality of the data collected. Students were also given a space in which they indicated their agreement to participate, thus providing their informed consent. The administration of the instruments took about 15–20 min.

2.4. Data Analysis

This research was quantitative, cross-sectional, correlational, and had a non-experimental design. Univariate descriptive statistics [frequencies, means (*M*), standard deviations (*SD*), maximum (*Max*), and minimum values (*Min*)] were calculated, as well as an internal consistency indicator for the scales (Cronbach's alpha). A correlation matrix was also obtained from Pearson's correlation coefficients between the analyzed variables: knowledge, self-efficacy, the perspective of the future, perceived environmental impacts, perceived health risks, obstacles, mitigation intentions, and mitigation behaviors. To analyze the direct and indirect relationships between these variables, structural equation models (SEM) were specified [41] using parcels for the studied constructs in the EQS statistical package.

Eight first-order factors were pre-specified: (1) knowledge of soil erosion, (2) self-efficacy, (3) perspective of the future, (4) perception of environmental impact, (5) perception of health risk, (6) perception of obstacles to act against soil erosion, (7) intention of mitigating behavior, and (8) behavior of mitigating soil erosion. In the first model, factors 1–6 were used to form a second-order construct that was called "perception indicators", in the second model only factors 1, 2, and 3 were used as perception indicators in the construct, and in the third model the factors 4 and 5 were used to form a second order called "perceived consequences of soil erosion". The specified models hypothesized that the perception indicators would have a positive influence on the mitigation intentions, and these, in turn, would positively and significantly influence the soil erosion mitigation behaviors.

3. Results

The univariate descriptive statistics of the scales, as well as their internal consistency, are shown in Table 1. Given that the range of responses to the KNW, EFF, FUT, IMP, RSK, OBS, and INT scales varied from 1 to 5 (Low: 1–2.3; Moderate: 2.4–3.7; High: 3.8–5), and the range of responses to the MIT scale varied from 1 to 4 (Low: 1–2; Moderate: 2.1–3; High: 3.1–4), we can conclude that the participants reported high levels of perception for different environmental impacts caused by soil erosion (*M* = 4.19, *SD* = 0.560), high future perspective (*M* = 4.10, *SD* = 0.551), high perception of obstacles to perform soil erosion mitigation actions (*M* = 4.02, *SD* = 0.659), and knowledge about soil erosion (*M* = 3.94, *SD* = 0.56). On the other hand, their perception of health risks (*M* = 3.68, *SD* = 0.749), their self-efficacy to face soil erosion (*M* = 3.35, *SD* = 0.761), and behavioral intentions (*M* = 3.35, *SD* = 0.865) had moderate mean values. The lowest score was soil erosion mitigation behaviors (*M* = 2.25, *SD* = 0.788). Reliability tests were conducted on each scale with satisfactory results, Cronbach alphas varied from 0.68 to 0.93, indicating an adequate level of internal consistency.

Table 1. Descriptive statistics of the scales.

	Min	*Max*	*M*	*SD*	*Alpha*
Knowledge (KNW)	1.00	5.00	3.94	0.560	0.86
Self-efficacy (EFF)	1.25	5.00	3.35	0.761	0.68
Future perspective (FUT)	1.09	5.00	4.10	0.551	0.84
Environmental impact (IMP)	1.15	5.00	4.19	0.560	0.91
Health risk (RSK)	1.13	5.00	3.68	0.749	0.85
Obstacles (OBS)	1.25	5.00	4.02	0.659	0.82
Behavioral intention (INT)	1.00	5.00	3.35	0.865	0.89
Mitigation behaviors (MIT)	1.00	4.00	2.25	0.788	0.93

Min = Minimum, *Max* = Maximum, *M* = mean, *SD* = Standard deviation, *Alpha* = Cronbach's alpha.

Regarding the knowledge about soil erosion among the participants, the items with the highest mean values were that: soil erosion is reducing soil productivity (*M* = 4.29, *SD* = 0.865), humans have a great contribution to soil erosion (*M* = 4.21, *SD* = 0.887), and seeking alternatives to reduce erosion rates is important for the agricultural, social, and economic sector (*M* = 4.33, *SD* = 0.883); while the lowest two items were that soil erosion is one of the most important problems in today's society (M = 3.50, SD = 0.953) and the soils of the region have deteriorated (M = 3.71, SD = 0.940) (Table 2). Nevertheless, that the students know the problem of soil erosion and its negative impacts, they do not all visualize the problem in the region. Consequently, it is not given the necessary importance.

Table 2. Descriptive statistics of knowledge on soil erosion.

	Min	*Max*	*M*	*SD*
1. Erosion represents one of the greatest threats to the sustainability of ecosystems	1	5	4.09	0.925
2. Humans have a great contribution to soil erosion	1	5	4.21	0.887
3. One of the main causes of soil erosion is poor agricultural practices	1	5	3.94	0.925
4. Erosion is a serious economic problem	1	5	3.80	0.956
5. Soil erosion is reducing soil productivity	1	5	4.29	0.865
6. Soil erosion is a problem in Sonora	1	5	3.86	0.957
7. Soil erosion is a problem in Mexico	1	5	3.97	0.845
8. Soil erosion is one of the most important problems in today's society	1	5	3.50	0.953
9. The soils of Sonora (the Yaqui Valley) are deteriorated	1	5	3.71	0.940
10. Erosion is the main cause of soil degradation	1	5	3.73	0.933
11. The direct effect of erosion is the loss of agricultural productivity	1	5	3.82	0.917
12. Erosion carries contaminants such as: fertilizers, pesticides, heavy metals, organic waste	1	5	4.03	0.951
13. Find alternatives to reduce erosion rates important for the agricultural and social and economic sector	1	5	4.33	0.883

Cronbach's alpha = 0.86; *Min* = Minimum, *Max* = Maximum, *M* = mean, *SD* = Standard deviation.

Furthermore, the students presented moderate levels of self-efficacy to face the problem of soil erosion (Table 3). The highest statement was that the participants consider that they can improve their activities to prevent soil erosion (M = 3.74, SD = 0.946). The students' future time perspective scale showed high levels (M = 4.10, SD = 0.551). The items with the highest level of agreement were to propose goals and evaluate the resources that are available to achieve objectives (M = 4.33, SD = 0.781), as well as the inconvenience of being late for commitments (M = 4.32, SD = 0.846); while the least represented actions within those mentioned in the instrument were to make pending lists (M = 3.79, SD = 1.150) and have constant progress in activities to finish projects on time (M = 3.90, SD = 0.890), however, their means remained high (Table 3).

Table 3. Descriptive statistics of self-efficacy against the problem of soil erosion and their perspective of the future.

	Min	*Max*	*M*	*SD*	*Alpha*
Self-efficacy					
1. I am confident that I could effectively manage soil erosion	1	5	3.27	0.958	
2. I can improve my activities to prevent erosion	1	5	3.74	0.946	0.68
3. Thanks to my experience and resources, I can reduce soil erosion	1	5	3.04	1.021	
Future perspective					
1. I worry if things are not done on time	1	5	4.23	0.835	
2. When I want to achieve some things, I set goals and evaluate the resources I have, to achieve those goals	1	5	4.33	0.781	
3. Meeting deadlines and doing the necessary things are things that come before fun	1	5	4.23	0.834	
4. I'm uncomfortable being late for my commitments	1	5	4.32	0.846	
5. I fulfill my obligations to my friends and authorities on time	1	5	4.21	0.746	0.84
6. Before making a decision, you evaluated the costs and benefits of that decision	1	5	4.16	0.842	
7. I finish my projects on time because I keep constant progress of activities of that project	1	5	3.90	0.890	
8. I make lists of the things I have to do	1	5	3.79	1.150	
9. I can resist temptations when I know there is work to be done.	1	5	3.93	0.985	
10. I keep working on difficult and not interesting tasks if they are going to help me move forward	1	5	3.98	0.883	
11. There will always be time to update my work	1	5	4.09	0.906	

Min = Minimum, *Max* = Maximum, *M* = mean, *SD* = Standard deviation, *Alpha* = Cronbach's alpha.

All the environmental impacts indicated in the instrument were considered to be of a high level by the participants (*M* = 4.19, *SD* = 0.560). The deterioration of the soil structure (*M* = 4.56, *SD* = 0.645), loss of soil fertility (*M* = 4.48, *SD* = 0.738), loss of flora and fauna (*M* = 4.32, *SD* = 0.783), and land abandonment (*M* = 4.30, *SD* = 0.863) were the impacts that participants agreed the most that were consequences of soil erosion. The lowest perceived impact was the risk in the energy supply (*M* = 3.56, *SD* =1.026) (Table 4). In the case of the perceived risks to human health, poisoning from eating contaminated food (*M* = 4.13, *SD* = 1.011), waterborne illness (*M* = 3.99, *SD* = 0.959), and respiratory illness (*M* = 3.97, *SD* = 0.964) were the items that achieved the highest scores, while the least perceived health risk by the participants was anxiety (*M* = 3.19, *SD* = 1.166) (Table 4). Regarding the obstacles to carrying out actions to mitigate erosion, lack of knowledge was the obstacle in which participants achieved the highest level of agreement, either due to ignorance of the problem (*M* = 4.45, *SD* = 0.765) or ignorance of technological advances in soil management (*M* = 4.21, *SD* = 0.916), followed by the lack of support from the government (*M* = 4.19, *SD* = 0.977). The obstacle with the lowest mean value was the lack of time (*M* = 3.29, *SD* = 1.276) (Table 4).

Table 4. Descriptive statistics of environmental impact, health risk, and obstacles perceived.

	Min	*Max*	*M*	*SD*	*Alpha*
Environmental impacts perception					
1. Soil contamination	1	5	4.28	0.885	
2. Decrease in water quality	1	5	4.07	0.891	
3. Deterioration of the soil structure	1	5	4.56	0.645	
4. Reduction of the catchment capacity of the dams due to sedimentation	1	5	4.07	0.853	
5. Increase in food production costs	1	5	4.24	0.836	
6. Loss of soil fertility	1	5	4.48	0.738	
7. Formation of sandbanks and gravel pits (accumulations of soil in unwanted places)	1	5	4.19	0.824	
8. Increased desertification	1	5	4.25	0.807	0.91
9. Loss of wildlife (flora and fauna)	1	5	4.32	0.783	
10. Migration caused by the impoverishment of the affected rural areas	1	5	4.04	0.878	
11. Sliding and landslides	1	5	4.26	0.786	
12. Shortage of food products	1	5	4.04	0.919	
13. Risk in energy supply (hydroelectric, hydrothermal and solar)	1	5	3.56	1.026	
14. High demand for fertilizers (due to high loss of fertility)	1	5	4.26	0.832	
15. Abandonment of land due to not being feasible for cultivation	1	5	4.30	0.863	
Health risks perception					
1. Waterborne diseases	1	5	3.99	0.959	
2. Infectious diseases	1	5	3.83	1.053	
3. Respiratory problems	1	5	3.97	0.964	
4. Anemia or malnutrition	1	5	3.48	1.107	
5. Cancer	1	5	3.60	1.132	0.85
6. Stress	1	5	3.26	1.171	
7. Anxiety	1	5	3.19	1.166	
8. Poisoning from eating contaminated food	1	5	4.13	1.011	
Obstacles					
1. Ignorance of the problem of soil erosion	1	5	4.45	0.765	
2. Ignorance of management technologies	1	5	4.21	0.916	
3. Lack of time	1	5	3.29	1.276	
4. Lack of economic resources	1	5	3.78	1.147	
5. Lack of laws and policies for soil conservation and sustainable use	1	5	4.14	1.000	0.82
6. Lack of government support	1	5	4.19	0.977	
7. Lack of support from agricultural institutions	1	5	4.13	0.919	
8. Lack of interest in the problem by the scientific community	1	5	3.96	1.117	
9. Lack of motivation	1	5	4.08	1.027	

Min = Minimum, *Max* = Maximum, *M* = mean, *SD* = Standard deviation, *Alpha* = Cronbach's alpha.

Regarding behavioral intentions towards erosion mitigation, the actions represented in the scale had moderate mean values; the actions reported as being most likely by the participants were to use non-polluting products or products with low environmental impact (M = 3.82, SD = 1.086), read about the problem (M = 3.62, SD = 1.216), and disseminate information about problems related to erosion (M = 3.48, SD = 1.209), while the action with the lowest value was to attend meetings or training on topics related to soil conservation (M = 2.87, SD = 1.203) (Table 5). In the case of the mitigation behaviors, which are activities that the participants frequently carry out concerning the mitigation of soil erosion, the items showed low and moderate mean values (between 1.91 to 2.72). The most frequently self-reported mitigation behavior was also to use non-polluting or low-impact products (M = 2.72, SD = 0.970), and the action with the lowest score was attending meetings or training on soil conservation (M = 1.91, SD = 0.922) (Table 5).

Table 5. Descriptive statistics of soil erosion mitigation intentions and behaviors.

	Min	*Max*	*M*	*SD*	*Alpha*
Mitigation intentions					
1. Reforest and give new use to abandoned areas (parks, sports fields)	1	5	3.28	1.055	
2. Attend regular meetings and trainings on soil conservation	1	5	2.87	1.203	
3. Apply organic matter to soils at risk	1	5	3.07	1.179	
4. Read about soil erosion	1	5	3.62	1.216	
5. Disclose information about problems related to erosion	1	5	3.48	1.209	0.89
6. Investigate the physical, chemical and biological characteristics of the soil	1	5	3.43	1.196	
7. Use non-polluting or low-impact products to the environment	1	5	3.82	1.086	
8. Apply the use of new technologies that reduce erosion	1	5	3.26	1.212	
9. Identify sources of erosion and try to reduce them	1	5	3.36	1.166	
Mitigation behaviors					
1. Reforest and give new use to abandoned areas (parks, sports fields)	1	4	2.35	0.947	
2. Attend regular meetings and trainings on soil conservation	1	4	1.91	0.922	
3. Apply organic matter into the soil	1	4	2.17	1.013	
4. Read about soil erosion	1	4	2.29	1.002	
5. Disseminate information about erosion-related problems	1	4	2.19	0.987	0.93
6. Investigate the physical, chemical and biological characteristics of the soil	1	4	2.30	0.991	
7. Use non-polluting or low-impact products to the environment	1	4	2.72	0.970	
8. Apply new technologies that reduce erosion	1	4	2.15	1.032	
9. Identify sources of erosion and try to reduce them	1	4	2.20	1.037	

Min = Minimum, *Max* = Maximum, *M* = mean, *SD* = Standard deviation, *Alpha* = Cronbach's alpha.

Significant statistical correlations between knowledge and all studied factors (EFF, FUT, IMP, RSK, OBS, and INT) were found, having a higher correlation with the perception of environmental impacts (r = 0.531, p < 0.01). Furthermore, there was a high correlation between self-efficacy and mitigation intentions (r = 0.310, p < 0.01). The perspective of the future had a high correlation with the perception of environmental impacts (r = 0.324, p < 0.01), and also, with the obstacles to acting against erosion (r = 0.335, p < 0.01). The perception of environmental impacts had a high correlation with the perceived health risks (r = 0.543, p < 0.01), and with the obstacles to act against erosion (r = 0.433, p < 0.01). Mitigation intentions are highly correlated with mitigation behaviors (r = 0.520, p < 0.01). However, there was no correlation between knowledge and mitigation behavior (Table 6).

The results of the structural model evaluating the relationship between physiological indicators, mitigation intentions, and mitigation behaviors are showed in Figure 1. The factor loadings that connected the first-order factors with their corresponding items were high and significant (λ < 0.50, p < 0.05), revealing convergent construct validity for the specified factors. Furthermore, the first-order factors (KNW, EFF, FUT, IMP, RSK, and OBS) correlated significantly with their corresponding second-order factor (perception indicators), as revealed by the value and statistical significance of their factorial loadings (λ < 0.40, p < 0.05). The perception indicators in this model had a positive correlation with the mitigation intentions (structural coefficient = 0.27, p < 0.05), which, in turn, as expected, positively influenced mitigation behaviors (structural coefficient = 0.55, $p < 0.05$). The goodness of fit indicators for this first SEM are presented at the bottom of Figure 1. Although the chi-square value associated with this model was significant and did not report statistical goodness of fit, the values of the practical indices Bentler Bonett Normed Fit Index (*BBNFI*), Bentler Bonnet Non-Normed Fit Index (*BBNNFI*), Comparative Fit Index (*CFI*), as well as the Root Mean Square Error Approximation (*RMSEA*) support the pertinence of this interrelations model [41]. The structural model explains 7% of the intention to act and 32% of the erosion mitigation behaviors.

Table 6. Pearson's correlation matrix.

	KNW	EFF	FUT	IMP	RSK	OBS	INT	MIT
Knowledge	1							
Self-efficacy	0.261 **	1						
Future perspective	0.306 **	0.247 **	1					
Environmental impact	0.531 **	0.193 **	0.324 **	1				
Health risk	0.324 **	0.213 **	0.165 **	0.543 **	1			
Obstacles	0.310 **	0.146 *	0.335 **	0.433 **	0.246 **	1		
Intention	0.140 *	0.310 **	0.147 *	0.187 **	0.217 **	0.044	1	
Mitigation	0.099	0.248 **	0.139 *	0.063	0.164 **	0.061	0.520 **	1

KNW = Knowledge, EFF = Self-efficacy, FUT= Future perspective, IMP= Environmental impact, RSK = Health risk, OBS = Obstacles, INT = Intention, MIT = Mitigation behaviors. ** The correlation is significant at the 0.01 level. * The correlation is significant at the 0.05 level.

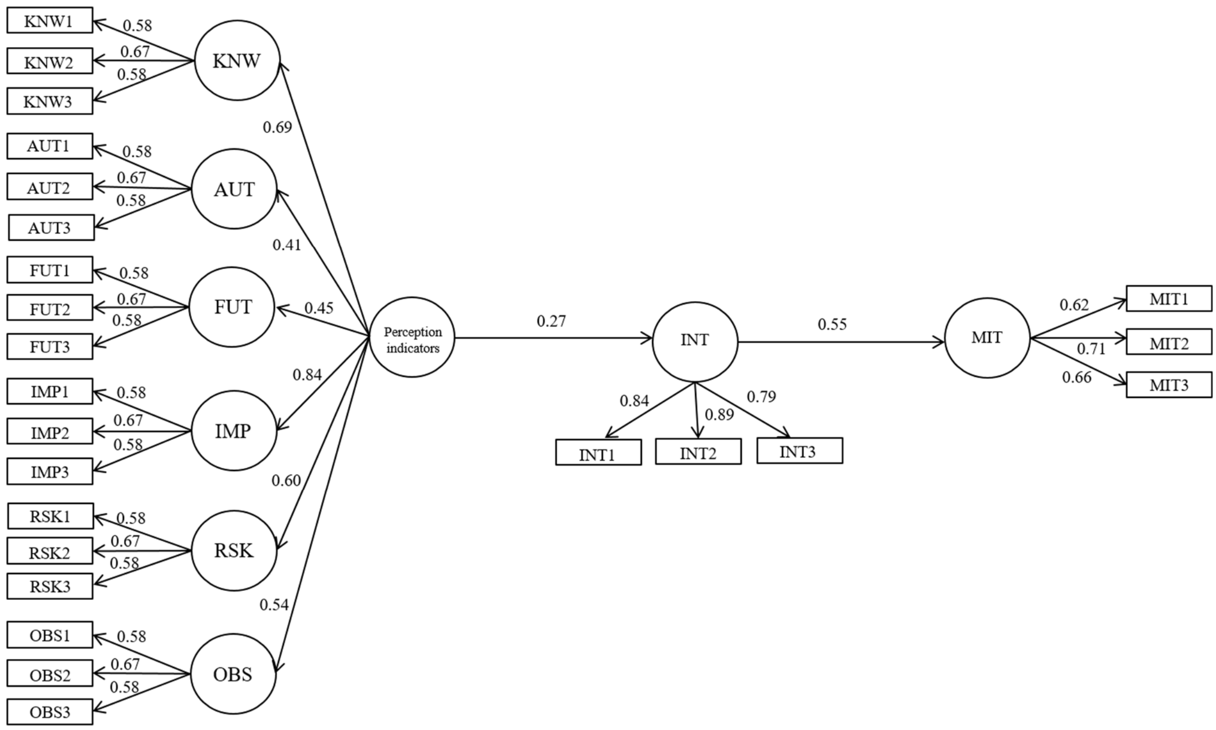

Figure 1. Structural model of mitigation intentions and behaviors, predicted by perception indicators. KNW1, 2, 3, EFF1, 2, 3, FUT1, 2, 3, etc., represent the items corresponding to their respective first-order factors. Goodness of fit: X^2 = 368.63, 192 df, p = 0.000; *BBNFI* = 0.92, *BBNNFI* = 0.95, *CFI* = 0.95, *RMSEA* = 0.05; R^2 Intentions = 0.07; R^2 Mitigation behaviors = 0.32.

Due to the low explanation of the model for behavioral intentions, the model was simplified leaving the perception indicators with three factors: knowledge, self-efficacy, and future perspective (Figure 2). In this model, the relationship between perception indicators and intentions to act increased (structural coefficient = 0.42, $p < 0.05$), explaining this variable by 18%, while their correlation with mitigating behaviors remained. The model still did not report statistical goodness of fit, however, the practical indicators reveal a slight increase in the goodness of fit in this second model, as compared with the first one.

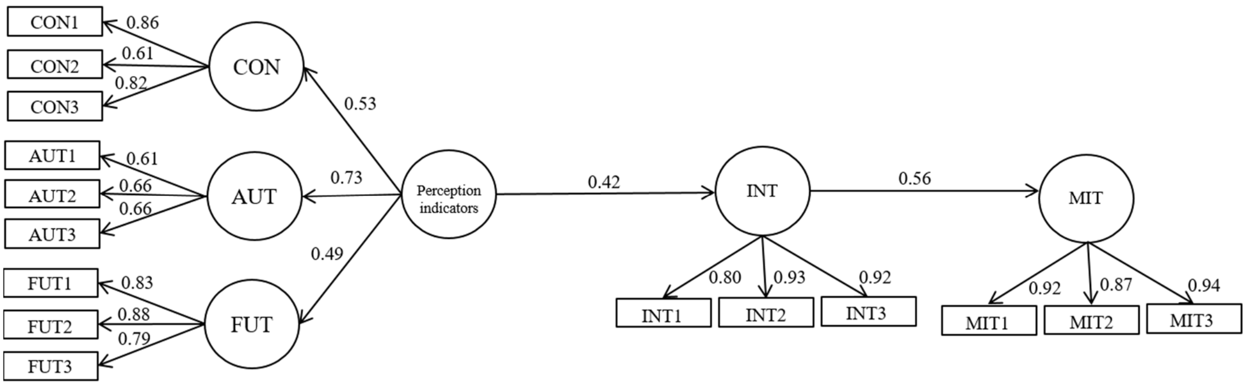

Figure 2. Structural model of mitigation intentions and behavior, predicted by perception indicators (using only knowledge, self-efficacy and perspective of the future). KNW1, 2, 3, EFF1, 2, 3, FUT1, 2, 3, etc., represent the items corresponding to their respective first-order factors. Goodness of fit: $X^2 = 129.88$, 85 df, $p = 0.001$; *BBNFI* = 0.94, *BBNNFI* = 0.97, *CFI* = 0.98, *RMSEA* = 0.04; R^2 Intentions = 0.18; R^2 Mitigation behaviors = 0.32.

Besides, a third structural model that evaluates the relationship of knowledge, obstacles, and perceived environmental impacts and health risks with behavioral intentions and mitigation behaviors was established (Figure 3). This model showed a high positive relationship between knowledge and obstacles (structural coefficient = 0.90, $p < 0.05$). The more knowledge they have on the soil erosion problem, the more obstacles they perceive, however, the obstacles did not influence behavioral intentions or mitigation behaviors. Likewise, the more knowledge they have on the problem, the more the participants perceive the consequences of soil erosion (structural coefficient = 0.64, $p < 0.05$). The latter had a positive influence on behavioral intentions (structural coefficient = 0.24, $p < 0.05$). The model explains only 6% of the intentions to act, while the relationship between intentions and mitigating behaviors remained.

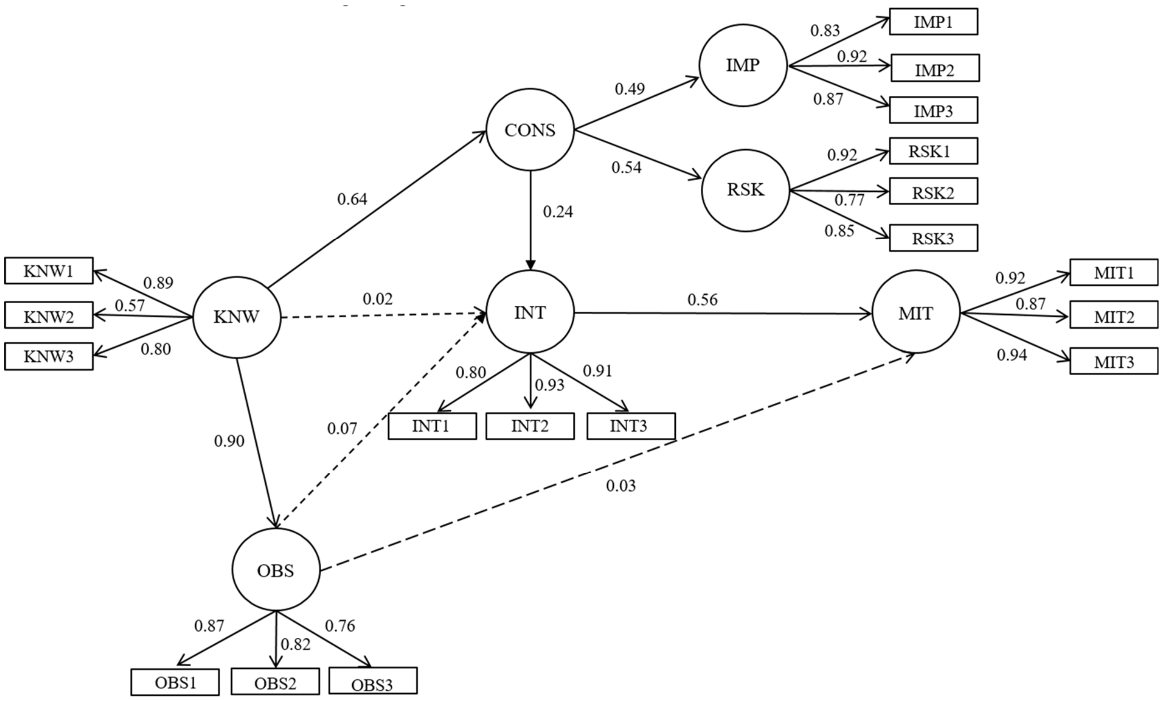

Figure 3. Structural model of mitigation intentions and behavior, predicted by knowledge, obstacles and perceived consequences of soil erosion (perceived environmental impacts and health risks). KNW1, 2, 3, EFF1, 2, 3, FUT1, 2, 3, etc., represent the items corresponding to their respective first-order factors. Goodness of fit: $X^2 = 368.63$, 192 df, $p = 0.000$; *BBNFI* = 0.92, *BBNNFI* = 0.95, *CFI* = 0.95, *RMSEA* = 0.05; R^2 Intentions = 0.06; R^2 Obstacles = 0.02; R^2 Consequences = 0.24; R^2 Mitigation behaviors = 0.32.

4. Discussion

This study explored some elements of the university students' knowledge on the impacts of soil erosion, showing that participants are aware of the severe environmental, economic, and human health impacts that soil erosion causes (Tables 1, 2 and 4). The foregoing may be related to prior knowledge about this problem, either associated with or outside of their university studies. This study also evaluated the perception and knowledge of this problem and its positive relationship to behavioral intentions and mitigation behaviors (Figure 2). Currently, some studies have focused on the analysis of the understanding of soil erosion by society, including students and farmers, which have shown that most participants confused the concept of soil erosion with other definitions [42,43].

Since soil erosion is a major problem around the world, understanding and conceptualizing the problem, as well as raising awareness and taking action, are essential for the development of future mitigation behaviors [44]. Although, it has been found that when it comes to complex environmental problems, e.g., climate change, learning about mitigation can be difficult because some studies indicated that after the theoretical courses there are still important errors and misunderstandings in its conceptualization [45]. As a result, better strategies for teaching pro-environmental behaviors in schools are required to promote awareness and social action [44]. In this regard, Vicente-Molina et al. (2013) show that knowledge, both objective and subjective, influences pro-environmental behavior, however, subjective knowledge is the most relevant of all the factors analyzed in their study. From what they mention, it is convenient for students to become familiar with current environmental problems, instead of developing technical environmental knowledge [35].

Some studies have found a gap between knowledge and behavior [35,46,47], as shown in this study by the low and non-existent correlation between the knowledge scale and the mitigation intentions, and the knowledge and the mitigation behaviors, respectively (Table 6). This is because behavior, in turn, is influenced by other factors, such as positive attitudes, self-efficacy in solving problems or changing behaviors, a sense of responsibility, social pressures, and the perception of risk to oneself and the environment, among others [2,27,36,48,49]. This is demonstrated with the structural models presented in Figures 1 and 2, where the factors that form the perception indicators (including knowledge) explained 7% and 18% of the behavioral intentions, respectively, while knowledge alone did not have a direct relationship with the behavioral intentions as shown in the model in Figure 3; this result is consistent with the findings of previous research [50].

Knowledge was highly correlated to the perception of environmental impacts and health risks as shown in Table 6; similar results were found by Barrera-Hernandez et al. (2020), ratifying that beliefs and knowledge about environmental problems are related to the perception of risk, therefore these factors can partly explain the behavioral intentions and can be used as a strategy in the development of mitigation behaviors [30]. For example, Semenza et al. (2011) indicated that the participants in their study may be more receptive to behavior change and be motivated to adopt mitigation measures when climate change is framed in terms of public health [40]. As shown in Figure 3, knowledge is positively correlated to the perceived consequences of soil erosion, and this, in turn, to behavioral intentions; however, the explanation of intentions in this model decreased to 6%.

Some studies have reported that connection with nature is an important predictor of ecological behavior [51,52]. Thus, Ball et al. (2018) state that raising awareness of the importance of sustainable soil management can be facilitated by improving the actors' connections with the soil, either through direct (theoretical-practical training, field walks, community gardens), indirect (school curricula, social media groups), or temporary (environmental monitoring initiatives, scientific dissemination programming) connections [53]. Wilson et al. (2020) assert that work-integrated learning is an excellent option for students to gain a deeper understanding of the environment. In this type of learning, students go on excursions and get involved in projects related to sustainability, which encourages their decision-making on corrective actions and conservation management, for example, the implementation of soil erosion control measures [54].

Various authors have shown that people with a higher perception of self-efficacy participate more in pro-environmental behaviors [36,49,50,55]. However, although the scale of mitigation behaviors was the lowest (Tables 1 and 5), the participants answered that they felt self-effective in solving this problem and have mitigation intentions; besides, there was a high correlation between self-efficacy with mitigation intentions and behaviors (Table 6). According to Yusliza et al. (2020), a strategy to increase the adoption of sustainable practices is to promote the motivation of individuals, once individuals have strong self-efficacy, they would exert considerable commitments and efforts to protect the nature [36]. On the other hand, the future time perspective influences individual pro-environmental attitudes and behaviors [56]. For example, Corral-Verdugo et al. (2006) identified that future-oriented people are more involved in water conservation practices [37]; however, in this study, there was no correlation between the future scale perspective and the intentions of mitigation behaviors (Table 6). The structural model in Figure 2, however, was the one that best explained the behavioral intentions, in which the perception indicators were reduced leaving only knowledge, self-efficacy, and the perspective of the future, the model explained the intentions to act by 18%.

The scale of obstacles was greater than the self-efficacy scale (Table 1) and they presented a low correlation between them (Table 6). Some studies have identified that the commitment to mitigate environmental problems is still limited, since young students attribute the responsibilities to other people, especially the government [45,46]. In this study, all the obstacles described in the instrument were strongly perceived by the participants (Table 4). Likewise, in some studies the influence of the perceived barriers is also high, indicating that without their elimination, despite having the necessary information and the action measures, they will not result in the desired behavior change [40]. This highlights the need for due attention to promotion and education programs focused on soil conservation to reduce limitations to act [33,38]. However, when the obstacles were included in the model, it showed no relationship with the behavioral intentions or mitigation behaviors (Figure 3), concluding that the obstacles are not a limitation when it comes to acting by the students of Sonora. Similar results were found by Barrera-Hernandez et al. (2021), where the perception of obstacles did not significantly impact the intentions to act on their model [30].

As shown in this study, we can expect that the participants know about the problem of soil erosion, and this makes them aware of the environmental impacts and the risks to human health that are occurring. This can be reflected in the high intentions that students must get involved in the mitigation of the problem, and in the considerations of self-efficacy of themselves to participate in the mitigation process, however, despite thia, the results on the scale of the current mitigation behaviors had the lowest mean values, so it is necessary to investigate how to encourage applicable practices and strategies to mitigate soil erosion.

The internet has an impact on the behavior and social participation of people concerning the protection of the environment [57], therefore another important point to highlight is the dissemination of environmental information and problems at a local and global level. For example, Huang (2016) found that news coverage of global warming and self-efficacy positively influenced pro-environmental intentions and proactive environmental behavior, but the efficiency of coverage content is also a point to consider [50]. Unfortunately, soil erosion does not receive the same coverage diffusion as other environmental problems such as climate change and deforestation. Therefore, it is necessary to develop efficient dissemination mechanisms in these types of environmental problems in which strategies and action measures are disclosed and their implementation encouraged, for example, soil conservation forums (for all levels), practical courses, informative capsules in the media, podcast, among others.

Since the last two decades, there has been a proliferation of citizen science initiatives in Mexico, focused on integrating the participation of the non-specialized public in research. Citizen science offers great potential to address data gaps, which provide decision-makers with complete and accurate information on where more resources are needed and where policy improvements are needed [58]. Most of the initiatives have focused on environmental monitoring and biodiversity conservation, however, initiatives regarding the monitoring of soil properties and their conservation are still scarce. It is essential to increase efforts to promote more citizen science projects, as these will allow participants to express their concerns, become familiar with scientific approaches, and improve the availability of knowledge, which increases the possibilities to facilitate collective action [59,60].

In conclusion, this study evaluated the relationship of different perception indicators in behavioral intentions and mitigation behaviors of soil erosion, determining that each indicator has some influence on the intentions to mitigate soil erosion, except for the obstacles. The indicators that had the greatest positive relationship in mitigation intentions were the knowledge of this problem, self-efficacy to mitigate soil erosion, and the future perspective, the latter related to personal responsibility. Behavioral intentions, in turn, influenced mitigating behaviors, and this relationship was not affected by any of the other factors. Although most of the mitigation behaviors described in this study are not carried out regularly by the participants, this study reduced the knowledge gap about the perception of the problem in the region and opens the landscape to the creation of efficient, understandable, and practical strategies to mitigate soil erosion. Therefore, these types of studies should be applied to a larger population including stakeholders, agricultural producers, rural and urban communities, students from other universities, and society in general to obtain a complete overview of the perception of soil erosion and its influence on the mitigation behaviors in the population of Sonora.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. This study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to confidentiality that was guaranteed to research participants in the informed consent letter.

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Appendix A

Table A1. Items of the scales in the original language.

Scale	Items
Conocimientos acerca de erosión de suelo	La erosión representa una de las mayores amenazas para la sostenibilidad de los ecosistemas
	Los humanos tenemos gran aportación a la erosión de suelo
	Una de las principales causas de la erosión del suelo son las malas prácticas agrícolas
	La erosión constituye un grave problema económico
	La erosión del suelo está reduciendo la productividad de los suelos
	La erosión del suelo es una problemática en Sonora
	La erosión del suelo es una problemática en México
	La erosión del suelo es uno de los problemas más importantes de la sociedad actual
	Los suelos del valle del yaqui se encuentran deteriorados
	La erosión es la principal causa de degradación del suelo
	El efecto directo de la erosión, es la pérdida de productividad agrícola
	La erosión arrastra contaminantes como: fertilizantes, pesticidas, metales pesados, desechos orgánicos
	Buscar alternativas para reducir las tasas de erosión es importante para el sector agrícola y social y económico
Autoeficacia para mitigar erosión de suelo	Tengo confianza en que podría manejar eficazmente la erosión del suelo
	Tengo la capacidad de mejorar mis actividades para evitar la erosión
	Gracias a mi experiencia y recursos puedo reducir la erosión del suelo
Perspectiva del futuro	Me preocupo si las cosas no se hacen a tiempo.
	Cuando quiero conseguir algunas cosas, me propongo metas y evalúo los recursos con que cuento, para alcanzar esos objetivos.
	Cumplir con los plazos que están por vencerse y hacer las cosas necesarias son cosas que vienen primero que la diversión.
	Me incomoda llegar tarde a mis compromisos
	Cumplo a tiempo mis obligaciones con mis amigos y autoridades.
	Antes de tomar una decisión, evalúo costos y beneficios de esa decisión.
	Termino mis proyectos a tiempo porque mantengo un constante avance de actividades de ese proyecto.
	Hago listas de las cosas que tengo que hacer.
	Soy capaz de resistir las tentaciones cuando sé que hay trabajo por hacer.
	Sigo trabajando en tareas difíciles y no interesantes, si ellas me van a ayudar a avanzar.
	Siempre va a haber tiempo para poner al día mi trabajo.
Impactos ambientales erosión de suelo	**¿Diría usted que la erosión del suelo causa los siguientes tipos de impactos ambientales?**
	Contaminación de suelo
	Disminución en la calidad del agua
	Deterioro de la estructura del suelo
	Reducción de la capacidad de captación de las presas debido a sedimentación
	Incremento en los costos de producción de alimentos
	Pérdida de la fertilidad de los suelos
	Formación de arenales y graveras (acumulaciones de suelo en lugares no deseados)
	Aumento de desertificación
	Pérdida de vida silvestre (flora y fauna)
	Migración provocada por el empobrecimiento de las zonas rurales afectadas
	Deslizamiento y desprendimientos de suelo
	Desabasto de productos alimentarios
	Riesgo en abastecimiento de energía (hidroeléctrica, hidrotérmica y solar)
	Alta demanda de fertilizantes (por alta pérdida de fertilidad)
	Abandono de tierras debido a no ser factibles para el cultivo

Table A1. *Cont.*

Riesgos a la salud por erosión de suelo	**¿Cree que la erosión plantea un riesgo para la salud de alguna de las siguientes maneras?**
	Enfermedades de transmisión por agua
	Enfermedades infecciosas
	Problemas respiratorios
	Anemia o desnutrición
	Cáncer
	Estrés
	Ansiedad
	Intoxicaciones por ingerir alimentos contaminados
Obstáculos para realizar acciones de mitigación de erosión de suelo	**¿Cuáles son los obstáculos o barreras que tiene para realizar acciones para mitigar (reducir) la erosión?**
	Desconocimiento de la problemática de la erosión del suelo
	Desconocimiento de las tecnologías de gestión (avances tecnológicos)
	Falta de tiempo
	Falta de recursos económicos
	Falta de leyes y políticas para la conservación de los suelos y su uso sustentable
	Falta de apoyo por parte del gobierno
	Falta de apoyo por parte de instituciones agrícolas
	Falta de interés en la problemática por parte de la comunidad científica
	Falta de motivación
Intenciones de mitigación de erosión de suelo	**¿Qué tan probable es que realice las siguientes actividades en los próximos 12 meses?**
	Reforestar y dar nuevo uso a zonas abandonadas (parques, campos deportivos)
	Asistir a reuniones y capacitaciones periódicamente sobre conservación del suelo
	Aplicar materia orgánica a suelos en riesgo
	Leer acerca de la erosión del suelo
	Divulgar información acerca de problemas relacionados con la erosión
	Investigar sobre las características físico, químicas y biológicas del suelo
	Utilizar productos no contaminantes o de bajo impacto al medio ambiente
	Aplicar el uso de nuevas tecnologías que reduzcan la erosión
	Identificar fuentes de erosión y tratar de reducirlas
Comportamientos de mitigación de erosión de suelo	**¿Qué tan frecuentemente lleva a cabo las siguientes acciones?**
	Reforestar y dar nuevo uso a zonas abandonadas (parques, campos deportivos)
	Asistir a reuniones y capacitaciones periódicamente sobre conservación del suelo
	Aplicar materia orgánica a suelos en riesgo
	Leer acerca de la erosión del suelo
	Divulgar información acerca de problemas relacionados con la erosión
	Investigar sobre las características físico, químicas y biológicas del suelo
	Utilizar productos no contaminantes o de bajo impacto al medio ambiente
	Aplicar el uso de nuevas tecnologías que reduzcan la erosión
	Identificar fuentes de erosión y tratar de reducirlas

References

1. FAO. *The Future of Food and Agriculture—Trends and Challenges*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2017.
2. Bijani, M.; Ghazani, E.; Valizadeh, N.; Haghighi, N.F. Pro-environmental analysis of farmers′ concerns and behaviors towards soil conservation in central district of Sari County, Iran. *Int. Soil Water Conserv. Res.* **2017**, *5*, 43–49. [CrossRef]
3. Gomiero, T. Soil Degradation, Land Scarcity and Food Security: Reviewing a Complex Challenge. *Sustainability* **2016**, *8*, 281. [CrossRef]
4. Lal, R. Soil degradation as a reason for inadequate human nutrition. *Food Secur.* **2009**, *1*, 45–57. [CrossRef]
5. de los Santos-Villalobos, S.; Ayala-Zepeda, M.; Bórquez-Holguín, R. Estrategia Para La Conservación Del Suelo. *CyD* **2016**, *1*, 26–31.
6. Vega, R.D.C.C.; Teloxa, L.C.L.; Flores, J.V.T.; Fleites, G.L.; Montalvo, A.C. Erosión y pérdida de nutrientes en diferentes sistemas agrícolas de una microcuenca en la zona periurbana de la ciudad de Puebla, México. *Rev. Terra Latinoam.* **2017**, *35*, 229. [CrossRef]

7. Ercoli, R.F.; Matias, V.R.D.S.; Zago, V.C.P. Urban Expansion and Erosion Processes in an Area of Environmental Protection in Nova Lima, Minas Gerais State, Brazil. *Front. Environ. Sci.* **2020**, *8*, 52. [CrossRef]
8. Bravo-Linares, C.; Schuller, P.; Castillo, A.; Ovando-Fuentealba, L.; Muñoz-Arcos, E.; Alarcón, O.; Villalobos, S.D.L.S.; Cardoso, R.; Muniz, M.; dos Anjos, R.M.; et al. First use of a compound-specific stable isotope (CSSI) technique to trace sediment transport in upland forest catchments of Chile. *Sci. Total Environ.* **2018**, *618*, 1114–1124. [CrossRef]
9. Karamage, F.; Shao, H.; Chen, X.; Ndayisaba, F.; Nahayo, L.; Kayiranga, A.; Omifolaji, J.; Liu, T.; Zhang, C. Deforestation Effects on Soil Erosion in the Lake Kivu Basin, D.R. Congo-Rwanda. *Forests* **2016**, *7*, 281. [CrossRef]
10. Zepeda, M.A.; Rodríguez, A.M.D.; Cardoso, R.; Muniz, M.C.; Astorga, R.T.; Linares, C.B.; Dos Anjos, R.M.; Velasco, H.; Vega, S.T.; Santos-Villalobos, S.D.L. Isótopos estables de compuestos específicos para estimar la redistribución del suelo por eventos erosivos. *Agrociencia* **2020**, *54*, 601–618. [CrossRef]
11. SEMARNAT-CP. *Memoria Nacional 2001–2002. Evaluación de la Degradación Del Suelo Causada por El Hombre en la República Mexicana, Escala 1:250,000*; Publicaciones Diamante: Estado de México, Mexico, 2003.
12. Telles, T.S.; Guimarães, M.D.F.; Dechen, S.C.F. The costs of soil erosion. *Rev. Bras. Ciência Solo* **2011**, *35*, 287–298. [CrossRef]
13. Astorga, R.T.; Villalobos, S.D.L.S.; Velasco, H.; Domínguez-Quintero, O.; Cardoso, R.P.; Dos Anjos, R.M.; Diawara, Y.; Dercon, G.; Mabit, L. Exploring innovative techniques for identifying geochemical elements as fingerprints of sediment sources in an agricultural catchment of Argentina affected by soil erosion. *Environ. Sci. Pollut. Res.* **2018**, *25*, 20868–20879. [CrossRef]
14. Gaspar, M. Un Terreno Estable: Técnicas Nucleares Para Frenar La Erosión Del Suelo En Viet Nam. In *Átomos Para la Paz y El Desarrollo. Edición Especial del Boletín del OIEA Sobre los Usos Pacíficos de la Tecnología Nuclear*; Gaspar, M., Ed.; Organismo Internacional de Energía Atómica: Viena, Austria, 2015; pp. 14–15.
15. ELD Initiative. *Report for Policy and Decision Makers: Reaping Economic and Environmental Benefits from Sustainable Land Management*; The Economics of Land Degradation: Bonn, Germany, 2015.
16. SEMARNAT. SUELOS. In *Informe de la Situación del Medio Ambiente en México. Compendio de Estadísticas Ambientales. Indicadores Clave y de Desempeño Ambiental*; SEMARNAT: Zapopan, Mexico, 2013; Volume 23, pp. 119–154.
17. García-Ruiz, J.M.; Beguería, S.; Nadal-Romero, E.; Hidalgo, J.C.G.; Lana-Renault, N.; Sanjuán, Y. A meta-analysis of soil erosion rates across the world. *Geomorphology* **2015**, *239*, 160–173. [CrossRef]
18. Bolaños-González, M.A.; Paz-Pellat, F.; Cruz-Gaistardo, C.O.; Argumedo-Espinoza, J.A.; Romero-Benitez, V.M.; de la Cruz-Cabrera, J.C. Mapa de Erosión de Los Suelos de México y Posibles Implicaciones En El Almacenamiento de Carbono Orgánico Del Suelo. *Terra Latinoam.* **2016**, *34*, 271–288.
19. Matson, P.A. *Seeds of Sustainability*, 1st ed.; Matson, P.A., Ed.; Island Press: Washington, DC, USA, 2012.
20. FAO. *The State of Food and Agriculture 2003–2004*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2004.
21. Sasmal, J.; Weikard, H.P. Soil Degradation, Policy Intervention and Sustainable Agricultural Growth. *Q. J. Int. Agric.* **2013**, *52*, 309–328. [CrossRef]
22. López-Reyes, M. Degradación de Suelos En Sonora: El Problema de La Erosión En Los Suelos de Uso Ganadero. *Región Soc.* **2001**, *XIII*, 73–97.
23. Cotler, H.; López, C.A.; Martínez-Trinidad, S. ¿Cuánto Nos Cuesta La Erosión de Suelos? Aproximación a Una Valoración Económica de La Pérdida de Suelos Agrícolas En México. *Investig. Ambient.* **2011**, *3*, 31–43.
24. Blaikie, P. *The Political Economy of Soil Erosion in Developing Countries*; Routledge: London, UK, 2016. [CrossRef]
25. Whitmarsh, L. Behavioural responses to climate change: Asymmetry of intentions and impacts. *J. Environ. Psychol.* **2009**, *29*, 13–23. [CrossRef]
26. Valle, A.; Blake, W.; Kelly, C.; Bravo, C.; Izquierdo, A.; Carvajal, F. Reversing Soil Erosion Trends at the River Basin Scale: A Participatory Model of Intervention for Building Resilience in Developing Countries. In *Global Symposium on Soil Erosion*; FAO: Rome, Italy, 2019.
27. Hansmann, R.; Laurenti, R.; Mehdi, T.; Binder, C.R. Determinants of pro-environmental behavior: A comparison of university students and staff from diverse faculties at a Swiss University. *J. Clean. Prod.* **2020**, *268*, 121864. [CrossRef]
28. Shafiei, A.; Maleksaeidi, H. Pro-environmental behavior of university students: Application of protection motivation theory. *Glob. Ecol. Conserv.* **2020**, *22*, e00908. [CrossRef]
29. Karimi, S. Pro-Environmental Behaviours among Agricultural Students: An Examination of the Value-Belief-Norm Theory. *J. Agric. Sci. Technol.* **2019**, *21*, 249–263. [CrossRef]
30. Barrera-Hernández, L.-F.; Corral-Verdugo, V.; Echeverría-Castro, S.-B.; Sotelo-Castillo, M.-A.; Ocaña-Zúñiga, J. Beliefs, perceived risk, obstacles and intention to act. An explanatory model for mitigation and coping behaviours regarding climate change (Creencias, percepción de riesgo, obstáculos e intención de actuar. Un modelo explicativo de conductas de mitigación y afrontamiento ante el cambio climático). *Psyecology* **2021**, 1–19. [CrossRef]
31. Tesfahunegn, G.B.; Ayuk, E.T.; Adiku, S.G.K. Farmers' perception on soil erosion in Ghana: Implication for developing sustainable soil management strategy. *PLoS ONE* **2021**, *16*, e0242444. [CrossRef]
32. Orchard, S.E.; Stringer, L.C.; Manyatsi, A.M. Farmer Perceptions and Responses to Soil Degradation in Swaziland. *Land Degrad. Dev.* **2016**, *28*, 46–56. [CrossRef]
33. Abbasian, A.; Chizari, M.; Bijani, M. Farmers' Views on the Factors Inhibiting the Implementation of Soil Conservation Practices in Koohdasht, Iran. *J. Agric. Sci. Technol.* **2017**, *19*, 797–807.

34. Janmaimool, P.; Khajohnmanee, S. Enhancing university students' global citizenship, public mindedness, and moral quotient for promoting sense of environmental responsibility and pro-environmental behaviours. *Environ. Dev. Sustain.* **2018**, *22*, 957–970. [CrossRef]
35. Vicente-Molina, M.A.; Fernandez-Sainz, A.; Izagirre-Olaizola, J. Environmental knowledge and other variables affecting pro-environmental behaviour: Comparison of university students from emerging and advanced countries. *J. Clean. Prod.* **2013**, *61*, 130–138. [CrossRef]
36. Yusliza, M.; Amirudin, A.; Rahadi, R.; Athirah, N.N.S.; Ramayah, T.; Muhammad, Z.; Mas, F.D.; Massaro, M.; Saputra, J.; Mokhlis, S. An Investigation of Pro-Environmental Behaviour and Sustainable Development in Malaysia. *Sustainability* **2020**, *12*, 7083. [CrossRef]
37. Corral-Verdugo, V.; Fraijo-Sing, B.; Pinheiro, J.Q. Sustainable Behavior and Time Perspective: Present, Past, and Future Orientations and Their Relationship with Water Conservation Behavior. Interam. *J. Psychol.* **2006**, *40*, 139–147.
38. Tapia-Fonllem, C.; Corral-Verdugo, V.; Fraijo-Sing, B.; Durón-Ramos, M.F. Assessing Sustainable Behavior and its Correlates: A Measure of Pro-Ecological, Frugal, Altruistic and Equitable Actions. *Sustainability* **2013**, *5*, 711–723. [CrossRef]
39. Zimbardo, P.G.; Boyd, J.N. Putting time in perspective: A valid, reliable individual-differences metric. *J. Pers. Soc. Psychol.* **1999**, *77*, 1271–1288. [CrossRef]
40. Semenza, J.C.; Ploubidis, G.B.; George, L. Climate change and climate variability: Personal motivation for adaptation and mitigation. *Environ. Health* **2011**, *10*, 46. [CrossRef]
41. Bentler, P.M. *EQS 6 Structural Equations Program Manual*; Multivariate Software, Inc.: Encino, CA, USA, 2006.
42. Nas, S.E.; Çalık, M. A cross-age comparison of science student teachers' conceptual understanding of soil erosion. *Probl. Educ. 21st Century* **2018**, *76*, 601–619. [CrossRef]
43. Ateş, M. A Research on High School Students' Concepts of "Erosion" by Using Phenomenographic Analysis. *Educ. Res. Rev.* **2013**, *8*, 449–453. [CrossRef]
44. Ceyhan, G.D.; Mugaloglu, E.Z. The role of cognitive, behavioral and personal variables of pre-service teachers' plausibility perceptions about global climate change. *Res. Sci. Technol. Educ.* **2019**, *38*, 131–145. [CrossRef]
45. Bofferding, L.; Kloser, M. Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environ. Educ. Res.* **2014**, *21*, 275–294. [CrossRef]
46. Boyes, E.; Stanisstreet, M. Environmental Education for Behaviour Change: Which actions should be targeted? *Int. J. Sci. Educ.* **2012**, *34*, 1591–1614. [CrossRef]
47. Moser, S.C.; Dilling, L. Communicating Climate Change: Closing the Science-Action Gap. In *The Oxford Handbook of Climate Change and Society*; Oxford University Press: Oxford, UK, 2011. [CrossRef]
48. Kuthe, A.; Kuthe, A.; Keller, L.; Keller, L.; Körfgen, A.; Körfgen, A.; Stötter, H.; Stötter, H.; Oberrauch, A.; Oberrauch, A.; et al. How many young generations are there?—A typology of teenagers' climate change awareness in Germany and Austria. *J. Environ. Educ.* **2019**, *50*, 172–182. [CrossRef]
49. Neisi, M.; Bijani, M.; Abbasi, E.; Mahmoudi, H.; Azadi, H. Analyzing farmers′ drought risk management behavior: Evidence from Iran. *J. Hydrol.* **2020**, *590*, 125243. [CrossRef]
50. Huang, H. Media use, environmental beliefs, self-efficacy, and pro-environmental behavior. *J. Bus. Res.* **2016**, *69*, 2206–2212. [CrossRef]
51. Mayer, F.; Frantz, C.M. The connectedness to nature scale: A measure of individuals' feeling in community with nature. *J. Environ. Psychol.* **2004**, *24*, 503–515. [CrossRef]
52. Barrera-Hernández, L.F.; Sotelo-Castillo, M.A.; Echeverría-Castro, S.B.; Tapia-Fonllem, C.O. Connectedness to Nature: Its Impact on Sustainable Behaviors and Happiness in Children. *Front. Psychol.* **2020**, *11*, 276. [CrossRef] [PubMed]
53. Ball, B.C.; Hargreaves, P.R.; Watson, C.A. A framework of connections between soil and people can help improve sustainability of the food system and soil functions. *Ambio* **2017**, *47*, 269–283. [CrossRef] [PubMed]
54. Wilson, G.; Pretorius, R. Adding Value to Open and Distance Learning Programmes in Nature Conservation through Sustainability Related Work-Integrated Learning. In *Universities as Living Labs for Sustainable Development, World Sustainability Series*; Leal Filho, W., Lange Salvia, A., Pretorius, R.W., Londero Brandli, L., Manolas, E., Alves, F., Azeiteiro, U., Rogers, J., Shiel, C., Do Paco, A., Eds.; Springer: Cham, Switzerland, 2020; pp. 449–469. [CrossRef]
55. Tabernero, C.; Hernández, B. A motivational model for environmentally responsible behavior. *Span. J. Psychol.* **2012**, *15*, 648–658. [CrossRef]
56. Milfont, T.L.; Wilson, J.; Diniz, P. Time perspective and environmental engagement: A meta-analysis. *Int. J. Psychol.* **2012**, *47*, 325–334. [CrossRef] [PubMed]
57. Zareie, B.; Navimipour, N.J. The impact of electronic environmental knowledge on the environmental behaviors of people. *Comput. Hum. Behav.* **2016**, *59*, 1–8. [CrossRef]
58. Ajates, R.; Hager, G.; Georgiadis, P.; Coulson, S.; Woods, M.; Hemment, D. Local Action with Global Impact: The Case of the GROW Observatory and the Sustainable Development Goals. *Sustainability* **2020**, *12*, 518. [CrossRef]
59. Alvarado, C.M.M.; Rendon, A.Z.; Pérez, A.D.S.V. Integrating public participation in knowledge generation processes: Evidence from citizen science initiatives in Mexico. *Environ. Sci. Policy* **2020**, *114*, 230–241. [CrossRef]
60. Head, J.; Crockatt, M.; Didarali, Z.; Woodward, M.-J.; Emmett, B. The Role of Citizen Science in Meeting SDG Targets around Soil Health. *Sustainability* **2020**, *12*, 254. [CrossRef]