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Multiple Indicators & Multiple Cause of Public Administration of Zoos in the Sustainable Development Goals

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Zoo management has been approached from its financial guidelines in accordance with the SDGs, but without considering its adjustment to the SDGs. Therefore, the objective of this work was to compare the theoretical structure reported in the literature with respect to the observations of this work. A cross-sectional and retrospective study was carried out with a sample of administrative managers linked to zoos committed to the implementation of the SDGs. The results suggest that age and gender determine the financial factor. In relation to the state of the art where dimensions related to learning financial administration are reported, this work suggests that age is a determinant of social responsibility.

Keywords: Confirmatory Factor analysis, Management Zoo, Multiple Indicators & Multiple Cause, SDG`s

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Introduction

The public administration of zoos within the framework of the Sustainable Development Goals (SDGs) follows a diversified agenda if it is considered that they are global objectives with local incidence. Such a process from the global to the local can be demonstrated from a systematic review of the dimensions that explain the determinant variables of a public administration of zoos. Therefore, the objective of this study was to establish the axes and themes of the research agenda around the public administration of zoos within the framework of the Sustainable Development Goals (see Table 1).

Table 1

Comparative of dimensions zoological management

Dimension	Description	Key Considerations	Examples of Best Practices
Animal Welfare	Ensuring the physical and psychological well-being of animals in captivity.	Animal housing, enrichment, health care, nutrition, behavior monitoring	Regular vet checks, behavioral enrichment programs, naturalistic habitats.
Conservation Efforts	Contribution to the conservation of endangered species and biodiversity.	Breeding programs, collaboration with conservation orgs, habitat preservation	Participation in Species Survival Plans (SSPs), educational campaigns for visitors.
Education and Awareness	Providing educational experiences for the public about wildlife and conservation.	Designing interactive learning experiences, engaging school programs, interpretive signage	Partnerships with schools, interactive exhibits, informative workshops.
Sustainability	Implementing environmentally-friendly practices in zoo operations.	Waste reduction, energy conservation, sustainable sourcing, water usage	Recycling programs, renewable energy use, water-saving technologies.
Financial Management	Ensuring financial sustainability through revenue generation and cost control.	Ticket pricing, donor engagement, budgeting, public funding	Tiered pricing structures, membership programs, public grants.
Visitor Experience	Enhancing the overall experience of zoo visitors to drive attendance and support.	Attraction design, customer service, accessibility, visitor satisfaction	Well-designed exhibits, diverse food options, easy navigation, visitor feedback systems.
Research	Conducting scientific studies to benefit both zoo animals and broader wildlife.	Collaboration with universities, research grants, data sharing	In-house research facilities, collaboration with academic institutions, publishing in scientific journals.
Safety and Security	Ensuring the safety of both animals and visitors within the zoo.	Emergency protocols, staff training, facility maintenance, escape-proof enclosures	Routine safety drills, trained security staff, comprehensive emergency response plans.
Ethical Standards	Adhering to ethical guidelines related to animal care and public engagement.	Transparency, ethical breeding, respect for animal rights	Accreditation by organizations like AZA (Association of Zoos and Aquariums).
Community Engagement	Involving the local community in zoo initiatives and programs.	Volunteer programs, local partnerships, community events	Hosting community outreach programs, collaborations with local businesses, volunteer opportunities.

Are there significant differences between the guidelines of public administration and the SDGs in the evaluations of students at a public university in central Mexico?

Hypothesis 1. Given that the public administration conforms to the SDGs, the dimensions that explain the management of zoos will conform to the guidelines of 4, 5, 9, 10, 12, 13, 15, and 17.

Hypothesis 2. Since the public administration of zoos conforms to the guidelines of the SDGs, then the perceptual differences of the students should not be significant.

Hypothesis 3. If the expectations of the students regarding the public administration of zoos are similar, then the SDGs would demonstrate their importance as academic axes around the care of species.

Method

A cross-sectional, exploratory, and correlational study was carried out with a sample of 100 students (M = 21.23, SD = 2.4 age, and M = 8,978.00, SD = 1,456.00 monthly income), professional practitioners, and social workers from a public university in central Mexico.

The SDG Public Administration Expectations Inventory (see Annex A) was used. It includes six dimensions related to (1) planning and public policies, (2) coordination and collaboration, (3) resource management, (4) monitoring and evaluation, (5) transparency and accountability, (6) innovation and adaptation. The items that make up the instrument are answered with five response options ranging from 0 = "not at all in agreement" to 5 = "quite likely". The reliability and validity of the instrument reached alpha and omega values between 0.767 and 0.780, as well as factor weights between 0.432 and 0.654.

Students were contacted through their institutional email. The objectives and those responsible for the project were reported. The homogenization of the concepts was established by means of a focus group and the Delphi technique. The application of the instrument was carried out remotely: https://meet.jit.si/FollowingPaths UndermineHappily.

Data were captured in Excel and processed in JASP Version 16 (see Annex B). Centrality, clustering, and structuring parameters were estimated. The contrast of the hypotheses was established with the proximity of the values to unity, which suggests the prevalence of nodes as moderators of the entry and exit of other nodes.

Results

Analysis of the predictive coefficients suggests the impact of the independent variables on the emerging factor (see Table 1). The values of the relationships between the variables indicate that age is a predictor of the financial management of zoos.

Table 2

Predictor coefficients

					95% Confidence Interval		Standardized		
Predictor	Estimate	Std. Error	z-value	P	Lower	Upper	All	LV	Endo
Age	0.077	0.038	2.037	0.042	0.003	0.150	0.151	0.076	0.076
Gender	-0.081	0.149	-0.543	0.587	-0.374	0.211	-0.040	-0.080	-0.080
Income	1.757×10^{-8}	3.914×10^{-5}	4.489×10^{-4}	1.000	-7.669×10^{-5}	7.672×10^{-5}	3.215×10^{-5}	1.736×10^{-8}	1.736×10^{-8}

The analysis of the coefficients of the indicators indicates the emergence of a common factor that the literature identifies as financial management of zoos (see table 2). The results indicate that four of the five indicators are reflective of the financial management of zoos.

Table 3

Indicator coefficients

					95% Confidence Interval		Standardized		
Indicator	Estimate	Std. Error	z-value	p	Lower	Upper	All	Latent	Endo
fm1	0.196	0.060	3.268	0.001	0.079	0.314	0.248	0.199	0.248
fm2	-0.601	0.081	-7.386	< .001	-0.761	-0.442	-0.753	-0.609	-0.753
fm3	-0.364	0.059	-6.194	< .001	-0.479	-0.248	-0.496	-0.368	-0.496
fm4	-0.365	0.074	-4.952	< .001	-0.509	-0.220	-0.404	-0.369	-0.404
fm5	-0.103	0.101	-1.022	0.307	-0.300	0.094	-0.073	-0.104	-0.073

The multiple cause and indicator analysis suggests a direct relationship between the dependent variables and the emerging factor of zoo financial management indicators (see Fig. 1). The results show that age and gender interacting with income are two predictors of zoo financial management, which is reflected by five indicators.

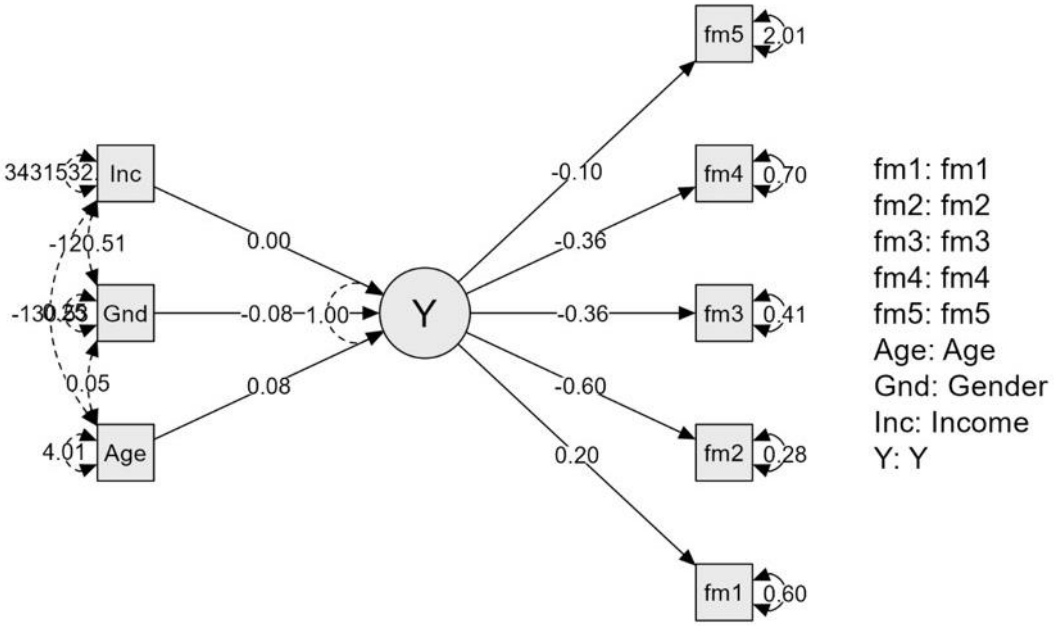

Figure 1. Multiple Indicator & Multiple Cause of Management Zoo.

The fit and residual values $\lceil \chi 2 = 646.015$ (25 df) p > 0.0001; CFI = 0.967; Tli = 0.952; NNFI = 0.952; NFI = 0.942; RFI = 0.915; IFI = 0.967; RNI = 0.967; GFI = 0.998; MFI = 0.966; RMSEA = =0.912; SRMR = 0.047$\rfloor$ suggest that the hypothesis regarding significant differences between the theoretical structure of financial management in zoos and the model observed in the present study is not rejected.

Discussion

The contribution of this work to the state of the art consists in the establishment of a learning neural network in which the surveyed sample associates the dimensions of public administration with the SDGs. In this sense, the results show that SDGs 1, 5, 7, 12, and 15 are binding nodes with the dimensions of public administration related to (1) planning and public policies, (2) coordination and collaboration, (3) resource management, (4) monitoring and evaluation, (5) transparency and accountability, (6) innovation and adaptation. These findings correspond to the theory of public administration within the framework of the SDGs, although the studies do not associate sustainable development with human development or public administration. Therefore, it is necessary to extend the study towards the link between sustainable development and human development. That is, the analysis of the interaction of humans with other species can clarify the barriers or the reasons for humanity to develop sustainably. In addition, the Comprehensive Disaster Risk Management (GIRD) studies warn that both sustainable development and human development are binding if the dangers, threats, and risks that make individuals, groups, and societies more vulnerable, resilient are considered, helpless, and happy. The GIRD studies also point to the possibility of communicating to reduce and prevent risks, threats, and dangers, although in this paper it is noted that public administration is linked to five SDGs. Such a relationship between SDGs and

public administration can be analyzed as risk prevention since the awareness of zoo visitors can indicate preventive risk communication. In this way, the area of opportunity of the study lies in the establishment of a preventive relationship of the public administration of zoos in the face of the challenges of the SDGs.

The nodes that make up the public administration and the SDGs are distributed according to node 15 corresponding to the life of terrestrial ecosystems. This finding corroborates the theoretical assumption that the public administration of zoos directs its capacities and resources to this SDG as it consolidates as an area of development of local sustainability. In other words, SDG 15 regulates the other nodes related to public administration and the SDGs in the context of the management of species in captivity for research, recreation, and appreciation. Very different from the centrality of the node that represents SDG 15 is the node that symbolizes SDG 5 related to gender equality. A grouping of the dimensions of public administration with respect to the SDGs can be seen in the first Barrat coefficient. Next, the grouping is established according to the node linked to SDG 12 corresponding to responsible production and consumption. In other words, SDGs 5 and 12 suggest that the public administration of zoos is established around gender equality and production with responsible consumption. The two remaining parameters Ws and Zhang indicate that SDG 7 linked to affordable and clean energy, as well as the distinctive Node 1 for the end of poverty, is the SDGs on which the public administration of zoos is configured. In other words, the diversification of nodes to which the configuration of a structure is attributed is different according to the coefficients that measure them. Unlike the centrality where SDG 15 is the node in charge of regulating the other nodes, the cluster has four different nodes that attract the other nodes. The nodes related to security and planning begin and end the learning process of the public administration of zoos within the framework of the SDGs. Node 15 regulates the other nodes and Nodes 1, 5, 7, and 12 group them together. In other words, the zoo management network is represented as part of the SDGs associated with the end of poverty, gender equality, affordable and clean energy, as well as responsible production and consumption. The values of centrality, grouping, and structuring suggest the non-rejection of the hypotheses. The public administration of zoos is associated with SDGs 1, 5, 7, 12, and 15.

Conclusion

The objective of the study was to establish the learning neural network around the public administration of zoos in relation to the guidelines of sustainable development. The results show that Objective 15 related to life in terrestrial ecosystems is the central axis, grouping and structuring on which the other objectives revolve. In relation to the state of the art where the prevalence of other objectives is appreciated, this work recommends the protection of plant and animal species in ecosystems such as zoos.

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Annex A

Zoo Management Assessment Survey

Instructions:

Please rate the following statements based on the current practices of your zoo. Use the following scale to indicate your level of agreement with each statement:

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Animal Welfare

1. The zoo provides adequate space and naturalistic habitats for all animals.
2. Veterinary care is regularly available and sufficient for all species.
3. Animals in the zoo receive proper nutritional diets.
4. Behavioral enrichment activities are implemented regularly.
5. The zoo tracks and monitors the physical and mental health of animals effectively.

Conservation Efforts

6. The zoo actively participates in conservation breeding programs.
7. Conservation partnerships with other zoos or organizations are well-established.
8. The zoo contributes to in-situ (natural habitat) conservation projects.
9. Educational programs at the zoo highlight conservation issues.
10. The zoo's conservation goals are clear and well-communicated to staff and visitors.

Education and Awareness

11. The zoo provides interactive and engaging educational programs for all visitors.
12. The zoo partners with schools to offer structured learning opportunities.
13. Interpretive signage throughout the zoo is informative and easily understood.
14. Staff and volunteers are well-trained to deliver educational experiences.
15. The zoo organizes regular workshops or talks on wildlife conservation.

Sustainability

16. The zoo has effective waste reduction programs in place.
17. Renewable energy sources are used in zoo operations.
18. Water conservation practices are regularly followed.
19. The zoo sources materials and products sustainably (e.g., eco-friendly vendors).
20. Environmental sustainability is a key component of the zoo’s mission.

Financial Management

21. The zoo operates within its budget while maintaining high standards.
22. The zoo has multiple streams of revenue (e.g., tickets, donations, grants).
23. The zoo actively engages with donors and sponsors for financial support.
24. Financial transparency and accountability are maintained within the organization.
25. The zoo has a long-term financial plan to ensure future sustainability.

Visitor Experience

26. The zoo provides accessible facilities for visitors of all abilities.
27. Zoo exhibits are designed to enhance both animal welfare and visitor enjoyment.
28. Food and drink options at the zoo meet visitors’ expectations.
29. The zoo regularly collects and acts on visitor feedback.
30. Visitors are provided with a clear and easy-to-navigate zoo map and signage.

Research

31. The zoo collaborates with academic institutions for wildlife research.
32. Scientific studies conducted by the zoo contribute to animal welfare improvements.
33. The zoo allocates funding for research initiatives.

34. Research findings are regularly shared with the public and scientific community.
35. The zoo encourages staff to participate in research activities.
Safety and Security
36. The zoo has comprehensive safety protocols for animal escapes or emergencies.
37. Zoo staff are regularly trained in emergency response procedures.
38. The zoo ensures that all enclosures are secure and escape-proof.
39. Visitor safety is prioritized through clear signage and crowd management.
40. Security personnel are present throughout the zoo during operating hours.
Ethical Standards
41. The zoo adheres to high ethical standards in animal care and public engagement.
42. Breeding programs prioritize the genetic health and well-being of animals.
43. The zoo ensures transparency in decision-making related to animal care.
44. Ethical concerns are regularly discussed and addressed by zoo management.
45. The zoo is accredited by recognized professional organizations (e.g., AZA).
Community Engagement
46. The zoo engages with local communities through outreach programs.
47. Volunteer opportunities are available and well-structured.
48. The zoo collaborates with local businesses and organizations on initiatives.
49. Community events hosted by the zoo are popular and well attended.
50. The zoo encourages input and feedback from the local community.
Scoring Interpretation:
- Scores between **200-250**: Excellent management practices.
- Scores between **150-199**: Good management practices, with areas for improvement.
- Scores between **100-149**: Fair management, with significant areas requiring attention.
- Scores below **100**: Poor management, requiring immediate improvements.

Annex B

```
# Install necessary libraries
!pip install semopy pandas numpy openpyxl
# Import the necessary libraries
import pandas as pd
import numpy as np
from semopy import Model, Optimizer
from google.colab import files
# Load the ODS file (if saved as an Excel file, else you can change to load an ODS file)
file_path = '/mnt/data/SEM MIMIC Zoo.ods'
# Pandas currently does not support ODS format directly, so convert ODS to Excel if needed and then load as a DataFrame
# For this example, we'll assume you've converted the file to Excel format
df = pd.read_excel(file_path, engine='openpyxl')  # Change engine if not openpyxl
# Display first few rows of the dataset to understand its structure
df.head()
# Step 1: Define the SEM Model - adjust the model based on your causes and indicators
# Define a MIMIC model with multiple indicators and multiple causes
# For example:
desc = """
# Latent variable definition (Zoo Management dimensions, etc.)
latent_variable1 =~ indicator1 + indicator2 + indicator3
latent_variable2 =~ indicator4 + indicator5
# Regressions (causes affecting latent variables)
latent_variable1 ~ cause1 + cause2 + cause3
latent_variable2 ~ cause1 + cause2 + cause3
```

```
"""
# Step 2: Create SEM model
model = Model(desc)
# Step 3: Load the data into the model and fit it
# Ensure your data has the relevant columns for 'indicator1', 'cause1', etc.
opt = Optimizer(model)
opt.fit(df)
# Step 4: Output the model fit and summary statistics
results = model.inspect()
print(results)
# Step 5: Output model fit indices (such as RMSEA, CFI, etc.)
print(model.fit_statistics())
# Optional: Save the results as a file
results_file_path = '/mnt/data/SEM_MIMIC_Results.xlsx'
results.to_excel(results_file_path)
print(f"Results saved to {results_file_path}")
# Download the results file
files.download(results_file_path)
```