

Carrying Capacity of Degrading Environments

The Case of the Sahel

E. Heleen van Haften¹, Fons van de Vijver², Johan
Leenaars³ & Paul Driessen¹

- 1 Wageningen Agricultural University, The
 Netherlands
- 2 Tilburg University, The Netherlands
- 3 LEECON, Wageningen, The Netherlands

1. Structure of this presentation

- **Short introduction**
- **Introduction of the general model of our studies**
- **Two previous studies with this model**
- **The present study**
- **The psychological instruments**
- **The instruments to assess the carrying capacity of land**
- **The results**
- **Conclusions**

Previous studies of environmental stress by Lumsden (1975), Berry, Wintrob, Sindell, & Mawhinney (1982) and:

- **Author:** Carry and Weston (1978)
- **Sample:** dairy farmers in Australia
- **Stressor:** sudden and serious decline of income due a high inflation and to a fierce decline of world market prices of meat and milk powder.
- **Results:**
 - higher stress level than rest of population
 - high level of hostility
 - farmers with low self-esteem who blamed themselves for the problems suffered more from anxiety and depression

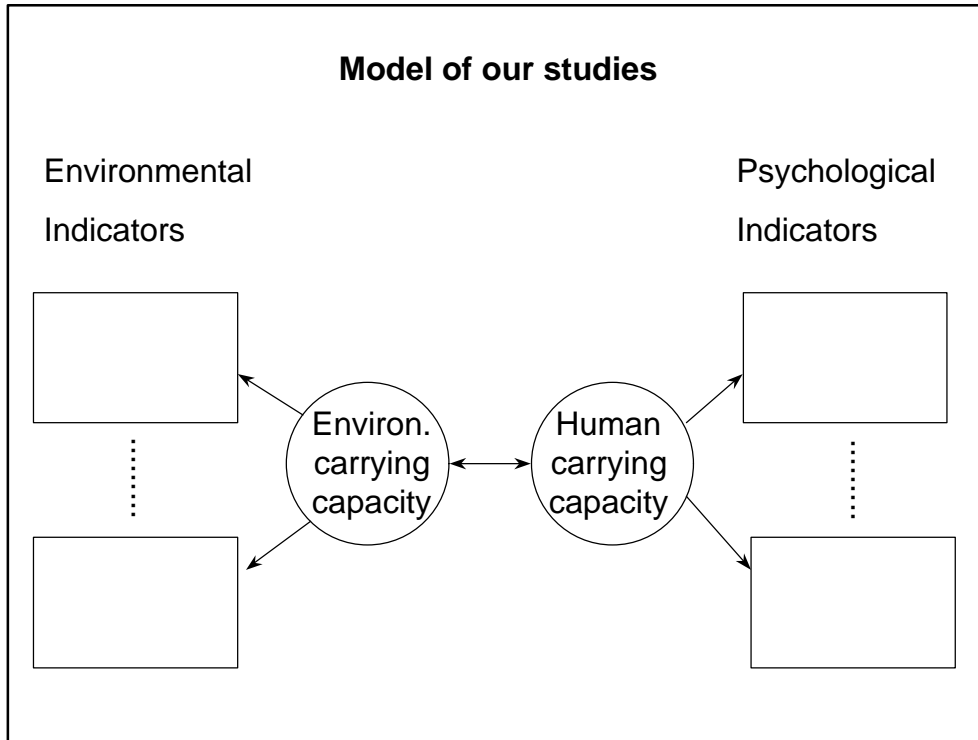
2. Previous studies of environmental stress:

2.1 Author: Lumsden (1975)

- **Sample:** villagers who had to move
- **Stressor:** construction of the Akosombo Dam (Ghana) with the largest lake ever made by people: the Lake Volta. 80.000 people had to be resettled in 52 new villages.
- **Results:** increase in suicides, a raise in alcoholism, provocative manslaughter, and a higher activity of witchcraft

2.2 Author: Berry, Wintrob, Sindell, & Mawhinney (1982)

- **Sample:** Cree Indians
- **Stressor:** a hydro-electro project
- **Results:** high stress and marginality correlated positively with separation attitudes, and negatively with integration and assimilation attitudes.



3. Models of our Studies

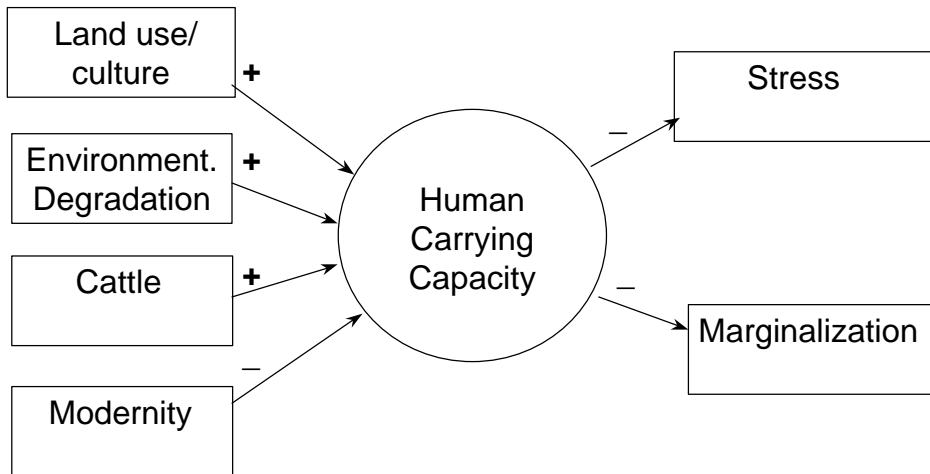
The study investigates the influence of changes in the environment on the possibilities of adaptation of humans and vice versa. Changes in the environment are assessed by environmental indicators that define the environmental carrying capacity. Psychological indicators define Human carrying capacity. The concept of Carrying Capacity is chosen as it exists already in psychiatry and ecology.

Study 1 (1996a): The impact of environmental degradation on human carrying capacity in a degraded environment.

Author: Van Haaften & van de Vijver

Sample: Males and females of autochthonous cultural groups in the Sahel

Results:



4. Study 1

- This first previous study assessed the impact of environmental degradation on Human carrying capacity amidst other independent variables. Land use and culture, (which meant in this study being a settled Mossi farmer or being a nomadic Fulani pastoralist), the amount of cattle, the degradation of the region and being modern were of influence on Human carrying capacity.
- In this study being a pastoralist, having a lot of cattle living in the region with the most degradation and not being modern gave the highest human carrying capacity.
- Psychological Stress and Marginalization indicated the Human carrying capacity. Less stress and marginalization gave a higher Human carrying capacity.

Study 2 (1996b): The impact of environmental degradation on human carrying capacity in a rapidly degrading environment.

Author: Van Haaften and van de Vijver

Sample: Males and females of different cultural groups living near two forests in Ivory Coast

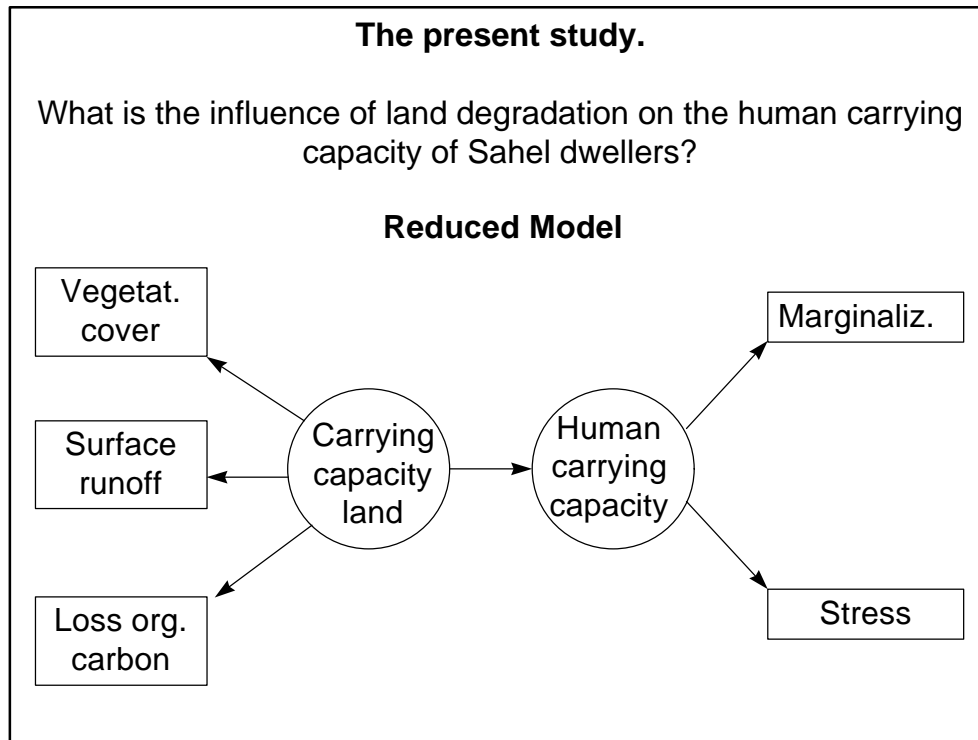
Stressor: two different degrees of forest degradation

Result:

- Stress and marginalization are positively related to environmental degradation

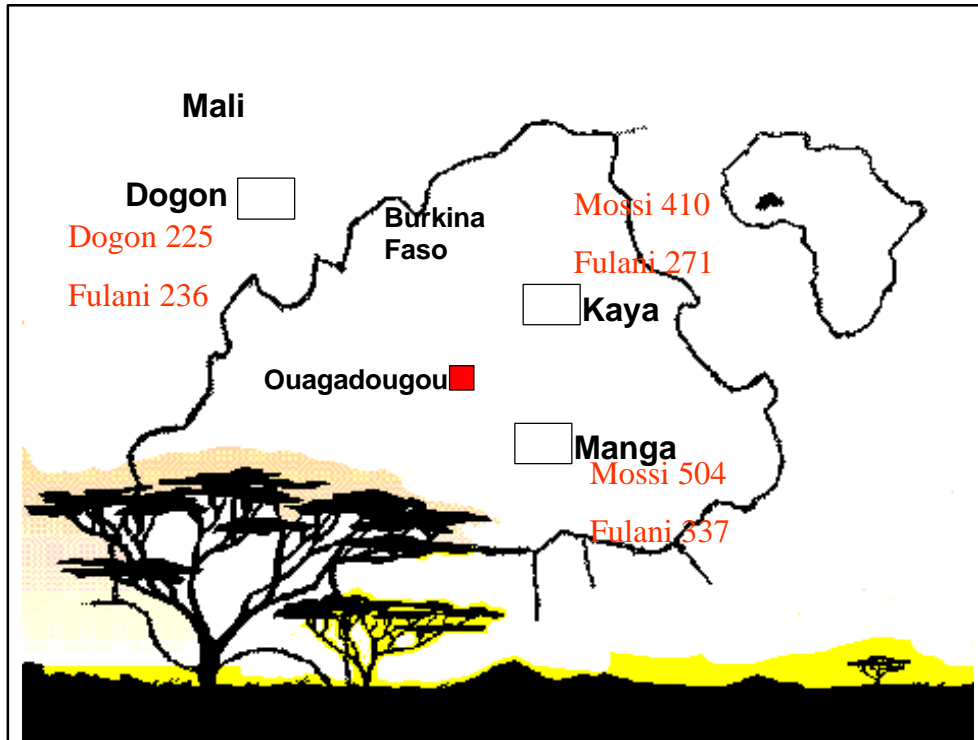
5. Study 2

- In the second study, which was also published last year, around two forests with a different rate and state of degradation in Ivory Coast, the research was done as a part of a large research project into criteria and indicators for sustainable forestry by CIFOR.
- The sample consisted of males and females of different cultural groups living near two forests with a different degree of degradation.
- As stressor those different degrees of degradation were taken.
- The results confirmed that:
- Stress and marginalization are positively related to environmental degradation
- This is considered of importance for the policy of participative management of natural resources as a condition for sustainability. Psychological stress and marginalization frustrate this management, while it leads to
 - collective coping behavior
 - prohibits effective communication
 - increases vulnerability to psychological problems



6. The Present Study

- To answer the question “What is the influence of land degradation on the Human carrying capacity?”, the general Environmental carrying capacity is in the model reduced to the physical Carrying capacity of land.
- So, in this model the vegetational degradation is not considered.
- Vegetation cover, Surface runoff and Loss of organic carbon express the Carrying capacity of land.



7. Study Area

In the Dogon region in Mali, and in the Kaya and Manga region in Burkina Faso the psychological data have been collected. The agricultural system was a symbiosis between the Dogon and Mossi as settled farmers and the Fulani as nomadic pastoralists. In total over two thousand interviews were done. We limit ourselves for this presentation to the 844 nomadic Fulani pastoralists, as only they were present in all three regions. Research into the relation between settled farmers and nomadic pastoralists is in preparation.

Instruments

Psychological instruments:

- **Marginalization:** Mann's (1958) 14-item marginality scale
- **Stress:** an adaptation of the general symptom checklist SCL-90

8. Study Instruments

- To assess psychological marginalisation the 14-item marginality scale of Mann was used. This scale is used in intercultural research and is known as reliable. This reliability was confirmed in this research (alpha Fulani = .78)
- The 20 item scale of the general symptom checklist for stress by Derogatis (SLC-90) was used to assess psychological stress. Also for this instrument the reliability was confirmed (alpha Fulani = .78)

Land Instruments

I Definition of reference land

II Definition of the change of carrying capacity of land:

I Definition of reference land

Scales of measurement of reference land:

- Regional
 - Weather data
 - Soil distribution FAO
 - Vegetation cover AB-DLO / Bunasols
 - Vegetation cover Satellite images
 - Organic carbon IB-DLO / Bunasols
- Local (on village level)
 - Aerial photographs (if available)

9. Land Instruments 1

- To assess the instruments to indicate the carrying capacity of land
 - the reference land and
 - the processes of change of Carrying capacity of land were defined.
- The regional measurement of land was assessed by
 - Weather data
 - Soil distribution FAO
 - Vegetation cover AB-DLO / Bunasols
 - Vegetation cover Satellite images
 - Organic carbon IB-DLO / Bunasols
- The Local measurement of land was assessed on village level by Aerial photographs (if available)

II Definition of the change Carrying capacity of land:

1. Surface runoff
2. Loss of vegetation cover
3. Loss of organic carbon

1. Surface runoff :

Runoff is function of

- daily rainfall
Ouagadougou and Dori; 1960-1992
- infiltration rate
- surface water storage capacity

10. Land Instruments 2

- The change of Carrying capacity of land was defined by Surface runoff, Loss of vegetation cover and Loss of organic carbon.
- Surface runoff was assessed
- as a function of daily rainfall from the data bases from Ouagadougou and Dori from 1960 to 1992
- by the infiltration rate interpreted from the FAO Soil Map
- and by the surface water storage capacity, which was estimated

2. Loss of vegetation cover derived from:

- TM satellite images 1986
- Normalization relative to 1960
- Tabulated values AB-DLO

3. Loss of organic carbon:

1 % per year under cultivation (Pieri 1989)

11. Land Instruments 3

- The second indicator, the Loss of Vegetation Cover was derived from satellite images from 1986, and from tabulated values of AB-DLO the indicator was assessed. Those were normalized relative to 1960.
- The third indicator was assessed by assuming a fixed yearly loss of organic carbon of 1 percent.

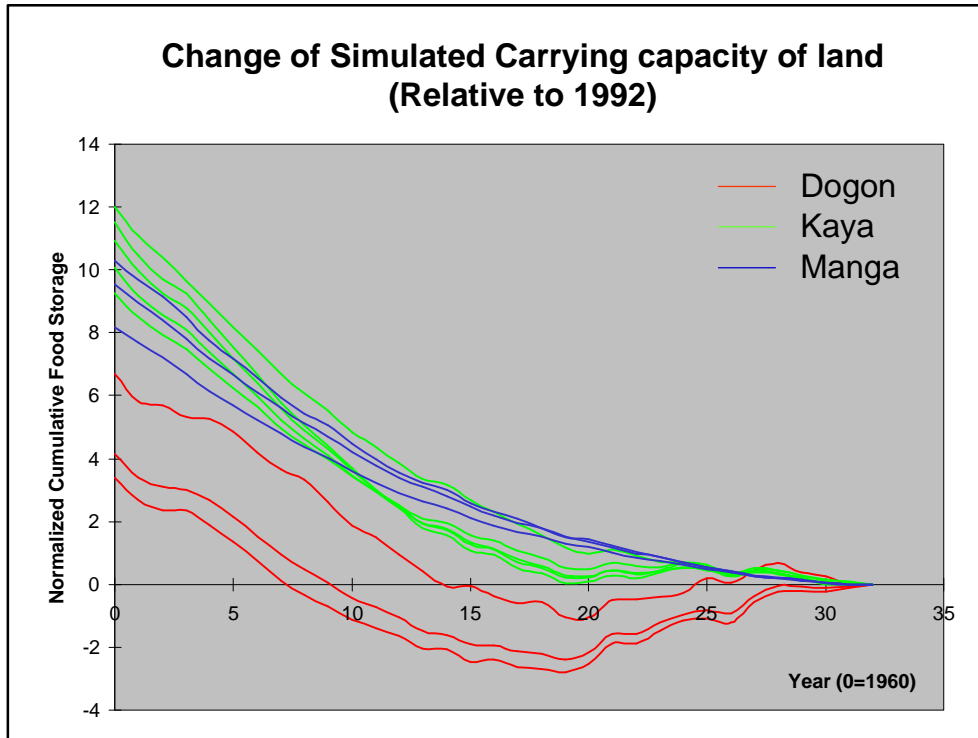
Results

For this presentation only the results of the Fulani are presented:

1. Time horizons
2. Multivariate Analysis between psychological variables and land degradation data
3. Lisrel: test of model

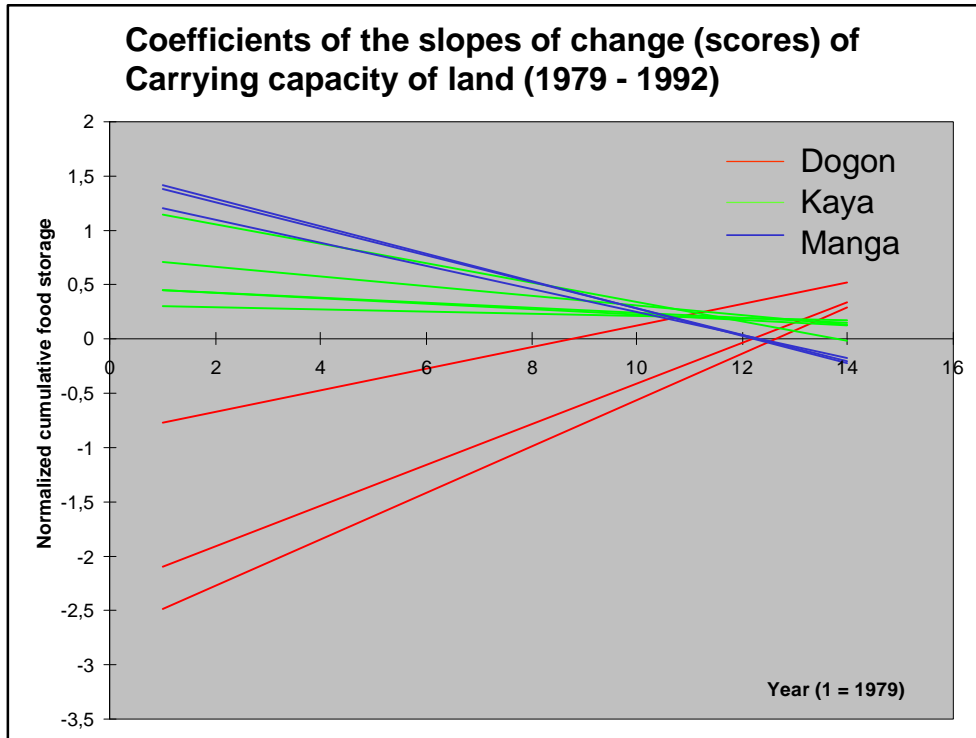
12. Results 1

- **The Time horizons of the land indicators are explained**
- **A multivariate analysis between independent and dependent variables is presented**
- **And a Lisrel analysis of the variables to test the model is discussed**



13. Results 2

On the X-axis is the period from 1960 to 1992. On the Y-axis the simulated cumulative Carrying capacity of land can be seen. This can be considered as the yearly changing storage of food. This cumulative food storage was normalized by defining a constant consumption equal to the storage in 1992. For each region and each village the storage drastically decreased since 1960. From about 1980 onwards these trends appear to differentiate.



14. Results 3

- The differentiation is made more explicit by the linear slope of the trends. The red lines of the Dogon area indicate regeneration, the green lines of the Kaya area indicate a certain stability, and the blue lines of Manga suggest an ongoing degradation.
- The coefficients of slopes were used as scores to quantify the change of carrying capacity of land.

Means of indicators of Human carrying capacity (marginalization and stress) per region and gender for the Fulani

Region	Marginal.		Stress	
	Females	Males	Females	Males
Dogon	23.58	22.55	32.94	28.44
Kaya	17.31	20.24	30.55	26.59
Manga	17.27	20.02	30.03	25.51

15. Results 4

- The highest marginalisation and stress levels for the Fulani were found in the Dogon region for as well males as females. In the region of Kaya lower scores, in Manga the lowest means of stress and marginalisation were measured. The largest jump in differences was between the Dogon region and the Kaya region.
- Only in the Dogon region the females were more marginalized than the males
- In all regions the females were more stressed.

16. Multivariate Analysis of Variance

- Independent variables:
 - Gender (2 levels)
 - Regions (3 levels of degradation)
- Dependent variables:
 - Marginalization
 - Stress

Results of MANOVA

Source	Multi-variate	Marginal-ization	Stress
Region (R)	.22***	.37***	.08***
Gender (G)	.32***	.09***	.23***
G x R	.06***	.10***	.00

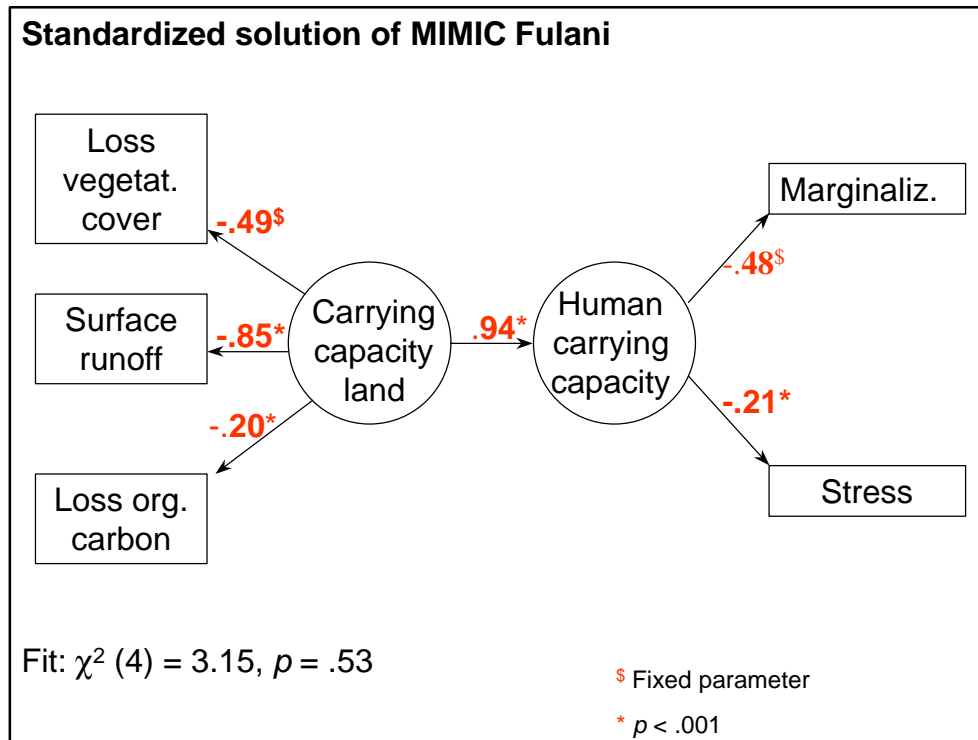
*** $p < .001$

17. Results of MANOVA

- the main effect of region was significant, both multivariate and univariate. In regions with the highest degradation the highest stress and marginalization scores were found.
- Gender differences were also significant, both multivariate and univariate. Compared to women, men scored higher on marginalisation and lower on stress. Finally, the interaction of gender and region was significant for marginalization; gender differences across the three areas were larger for women than for men.

18. In Words

- The Regional differences are significant
- The Gender differences are significant
- The Gender differences across regions are larger for women than for men



19. Results of the LISREL/Mimic (Multiple Indicators Multiple Causes) Analysis

- Fit measures:

Chi-Square with 4 Degrees of Freedom = 3.15 (P = 0.53) $p < .001$

- A good fit was found for a model in which the three indicators define the single underlying latent variable, called Carrying capacity of land. Runoff surface and Loss of organic carbon showed significant loadings on the factor, as could be expected. Similarly, the two psychological measures, define a single latent variable, labeled Human carrying capacity. Stress showed a significant loading on Human carrying capacity. Interestingly, Carrying capacity of the land showed a highly significant positive influence on Human carrying capacity; 88% of the variance of Human carrying capacity was explained by the Carrying capacity of land. This finding means that for the Fulani Human carrying capacity, as measured by stress and marginalization, is functionally related to changes in the level of environmental degradation.

20. Conclusions

- **Carrying capacity of land has a strong influence on psychological carrying capacity.**
- **Carrying capacity of land has a larger influence on marginalization than on stress.**
- **The Surface runoff has the highest impact on the carrying capacity of land in comparison to the Loss of organic carbon and the Vegetation cover.**

21. General Conclusion

The concepts of Human carrying capacity and Carrying capacity of land make it possible to relate environmental indicators to social indicators for different cultural and gender groups.