PRAGACC: A System to Identify Vulnerabilities and Classify Livestock Farms

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ABSTRACT

PRAGACC is a system designed to classify cattle units, determine their weaknesses and make decisions to mitigate them. This system is composed of two matrixes or subsystems: (I) natural resources and (II) other resources. Each matrix comprises the following variables: microclimate (A), soil (B), hydrology (C), flora and vegetation (D), and on-production animals (E) for subsystem I, and economy (F), production (G), and human resources (H) for subsystem II. Variables are determined according to 26 and 28 components for subsystems I and II, respectively. Criteria to evaluate each variable were gathered by applying a 34-question inquiry to a farmer from the studied cattle unit. A previously fixed value for each answer according to the questions contributed to the answer-related components and these, in turn, to the variables. Units classification under a subsystem depends on the number of variables showing any kind of weakness. This classification is useful in determining measures to be implemented and their priority.

Key Words: *cattle farm weaknesses, sustainability, climate change, adaptation*

INTRODUCTION

World authorities admit that climatic change will significantly affect the availability of food for human and animal consumption (FAO, 2011). In the face of that situation, producers should adopt timely measures to strengthen their economic activities and withstand current instability and coming changes. But sure knowledge of what to give top priority is fundamental. This is important for cattle raising, where changes may be definitive, to achieve more or less efficiency, as reported by Luening (1996) and Guevara *et al*. (2005) in bio-economic analysis of dairy systems.

The aim of this paper is to design a system to identify the main vulnerabilities found in cattle farms, in order to set up priority mitigation actions that provide economic sustainability despite instability and climate change.

MATERIALS AND METHODS

The matrix method used for assessment of environmental impact according to Leopold *et al*., (1971), was used to design the system. Versions of this method proposed by Gómez-Orea (1999) and Pastakia (2002), and the fundaments presented by FAO (2008), regarding the elements considered in an agricultural production system, were included in the study.

The variables and components for the assessment of cattle farms were proposed by Acosta *et al.* (2006) y Acosta (2008).

RESULTS

As a result of the analysis of information included for the system design, it was made clear that the vulnerabilities of the dairy farms can be identified and quantified through a set of matrices composed of two subsystems: (I) Natural Resources and (II), Other Resources.

Every subsystem has a set of variables: microclimate (A), soil (B), hydrology (C), flora and vegetation (D), and production animals (E), in subsystem (I). Subsystem (II) comprises economy (F), production (G), and human resources (H), which are determined according to 26 and 28 components, respectively (Table 1).

The criteria for farm assessment were collected from a 34-question survey to the producer. All questions have a preset value in each answer, which provides the related components with information and then sets the variables. The key questions in the survey were determinant, for a greater number of components, variable and subsystems. The process was concluded as explained below,

1. - The size of your farm is (5 points)
- More than 70 ha: 0
- Between 70 and 30 ha: 2.5
- Less than 30 ha: 5

The answer gives information to quantify variables B5

2. - The sloping degree in the soil is (5 points)
- Very sloppy (more than 16.0 %): 0
- Sloppy (16.0-8.1 %): 1.5
- Moderately sloppy (8.0-4.1 %): 2.5
- Slightly sloppy (less than 4 %): 5

This response offers information to quantify variable B6.

3. - Do you use any of these alternatives of forest grazing?
- Areas with trees where cattle can graze, whether they are natural or set up (fruit trees, wood trees, and honey producing trees), protein stocks, hedges, other not mentioned (100 points).
- No: 0
- Yes, less than 15 % of the cattle area: 25
- Yes, 15-30 % of the cattle area: 50
- Yes, 30 %-50 % of cattle area: 75
- Yes, more than 50 % of the cattle area: 100

This answer provides information to quantify variables A1, A2, A3, A4, B1, B2, B3, B4, D2, D5, E1, F3, F9, G3, G6 and H9.

4. - Use of solid and liquid wastes from animals on the farm. (35 points).
- They are not given proper used and are disposed of in the field: 0
- They are partly used deliberately: 10
- They are partly used with proper organization: 20
- They are all used (organic fertilizer, minidam fertilization, they are directly incorporated into the soil): 25

The answer provides information to quantify variables A4, C1, F9, G2 and G5.

5. - Use of legumes as animal feed. (90 points).
- They are not used, or only the native ones are used: 0
- They are poorly used, in hedges and isolated clusters: 25
- Less than 30 % of the area is used: 50
- Between 30 and 50 % of the area is used: 75
- Fifty percent or more of the area is used: 90

The answer provides information to quantify variables: A3, A4, B1, B3, B4, D2, D3, D4, E1, E4, E5, F3, F9 y G2.

6. - Area used for grazing: (55 points).
- Less than 50 % of the area available is used: 10
- Between 50 and 75 % of the area is used: 15
- More than 75 % is used, but diversification is poor: 40
- More than 75% is used with diversification: 55

The answer provides information to quantify variables A4, B2, B4, D6, E1, E3 y F4, F9.

7. - How do you assess the behavior of undesirable plants on you farm? (85 points).
- More than 50 % of the area is useless and considerable amount of resources are required for recovery: 25
- More than 50 % of the total area is useless, but it can be recovered with some resources: 45
- Less than 50 % of the areas are covered with undesirable plants and considerable amount of resources are needed for recovery: 75
- Less than 50 % of the areas are covered, but they can be recovered with some resources: 85

The answer provides information to quantify variables A4, B1, B2, B4, D1, D2, D6, E1, E3, F4, F5, F9, G3, and H3.

8. - Feed quality on your farm is: (80 points).
- Native pasture and grass lands, 50 % or more: 20
- Native pasture infested with less than 50 % of undesirable plants: 35
- Native pasture with few undesirable plants: 50
- Native pasture with more than 10 % introduced pasture: 65
- High quality introduced pasture: 80

This answer provides information to quantify variables D1, D2, D3, E1, F3, F9, G6, G7, G8, G9, G10, and H3.

9. - What are your requirements to improve pasture lands (125 points).
- I do not have fences for handling: 20
- I can only handle pasture with perimeter fences: 50
- I have enclosures, but not enough: 80
- I have all the grazing area under enclosures for rotation: 125

This answer provides information to quantify variables: B1, B2, B4, D1, D2, D3, D6, E2, E3, E4, E5, F3, F5, F9, G6, G7, G8, G9, G10, and H3

10. - Do you have enough staple feed for your cattle? (85 points)

- No, because I do not have forage: 0
- No, because I have forage in less than 20 % of the area: 40
- Yes, I have forage in more than 20 % of the available area: 65
- Yes, I have forage in more than 20 % of the available area, plus other sources of my own: 85

This answer provides information to quantify variables B1, B4, D2, D6, E1, E4, E5, F3, F9; G6, G7, G8, G9, and G10.

11. - What alternatives have you used for water supply? (15 points).

- I need more solutions for water supply: 0
- I mainly use surface water: 5
- I get my water supply from windmills and wells: 10
- I have several sources: 15

This answer provides information to quantify variables C1, C2 and E7.

12. - Have you altered the course of rivers to provide your cattle with water? (10 points).

- Yes, I have built several dikes to dam water: 0
- I haven´t changed the landscape or altered rivers: 10

This answer provides information to quantify variables C1 and C3.

13. - Facilities for cattle management. (25 points).

- Insufficient or in bad conditions: 5
- Insufficient, but in good conditions: 15
- Sufficient, but deteriorated: 20
- I have no problems with facilities: 25

This response provides information to quantify variables: E2 and F5

14. - Does you herd genotype match the main purpose of your economic activity? (30 points).

- No: 0
- Partially: 15
- Yes: 30

This response provides information to quantify variables E6 and G9 and G10

15. - In the last three years the incidence of infectious diseases on you farm has been (45 points).

- Very high, diseases have affected 50% of cattle: 0
- Outbreaks affecting 30 % or less of animals have appeared: 10
- Some outbreaks have appeared, but they have been quickly controlled: 30
- No significantly affecting disease has appeared: 45

This response provides information to quantify variables E3, F4, F9, G7, G8, and H3

16. - Mortality in the last three years behaved like this, (35 points).

- Over 10 %: 0
- Below 10 %: 10
- Below 3 %: 35

This answer provides information to quantify variables E3, F9, G8, and H3

17. - What are milk and beef yields in the last three years regarding the plan? (40 points).

- Accomplishment was below 50 %: 0
- Accomplishment was between 80 % and 50 %: 10
- In this period, accomplishments were above 80 %: 20
- Milk and beef production plans were accomplished: 40

This answer provides information to quantify variables E4, F9, G9, G10, and H3

18. - Milk production was as follows, (35 points).

- Less than 500 kg of milk per total cows: 10
- Around 1 000 kg of milk per total cows: 20
- More than 1 750 kg of milk per total cows: 35

This answer provides information to quantify variables E4, E5, F9, and G9

19. - Beef yield was as follows, (35 points).

- Less than 50 % of top quality animals: 10
- 50 % top quality animals: 20
- 80 % top quality animals: 35

This answer provides information to quantify variables E4, E5, F9, and G10

20. – The birth rate on your farm for three years has been like this, (35 points).

- Less than 30 %: 0

- Between 60 and 30 %: 10
- Between 80 and 60 %: 20
- Higher than 80 %: 35

This answer provides information to quantify variables E5, F9, G9, and G10

21. - For five years the age for young cows to start reproducing has been, (35 points).

- More than 30 months old: 0
- Between 24 and 30 months old: 15
- Betwen 18 and 24 months old: 25
- 18 months old or less: 35

This answer provides information to quantify variables E5, F9, G9, and G10

22. - Considering the economic indicators you handle, your cattle raising practices are, (40 points).

- Unprofitable without compensations: 0
- Unprofitable, but I can compensate with other productions and sales to workers: 20
- Profitable: 30
- Cost-effective: 40

This answer provides information to quantify variables F1, F2, F3, F4, F5, F9, and H3

23. - Expenses on electric energy. (15 points).

- More than 200 kW are consumed every month: 0
- Energy consumption is moderate (up to 200 kW a month): 5
- I produce energy with mills, biogas, from wood or other: 15

This answer provides information to quantify variables F6, F9 and G1

24.- Annual fuel consumption. (10 points)

- More than 5 000 l are consumed: 0
- Between 5 000 and 1 000 l are consumed: 2
- Less than 1 000 l are consumed: 5
- No fuel consumption: 10

This response provides information to quantify variables F6 and F9

25. - Other non-cattle productions form your farm are marketed and offer and additional source of income. (35 points).

- It is unnecessary, because cattle production is sufficient: 10
- Yes, other items are produced for sale, but their number is very limited: 15
- Yes, there is continuous production of other marketed items: 35

This answer provides information to quantify variables F8, F9, G3, G4, G5 and H3

26. - Do you have enough labor force to perform all the farm activities? (10 points).

- No, the labor force is insufficient: 0
- Yes, but we need to hire skilled workers for some services: 5
- Yes, the labor force is sufficient and multifaceted: 10

This answer provides information to quantify variables: F2 and F9

27. - Stability of the labor force behaves as follows (10 points).

- The labor force is unstable: 0
- The labor force is stable (10 years of work as average): 8
- The labor force is young and it is motivated and stable: 10

The answer provides information to quantify variables H1 and H2

28. - The mean salary in the last three years is (20 points).

- Low and variable: 0
- Between 300 and 500 pesos: 10
- Over 500 pesos: 20

This answer provides information to quantify variables F1, H1, H2 and H3

29. - Do you think your labor force is trained for the activity they perform? (10 points).

- It is not sufficiently trained: 0
- Yes, it is trained, but more knowledge is needed to incorporate new technologies: 5
- Yes, it is trained, and can incorporate technological changes: 10

This answer provides information to quantify variables H4, and H5

30. - Housing for the labor force. (5 points).

- It is inexistent and keeps worker instability: 0
- It is partially supplied: 2
- It is supplied and has no influence on labor force: 5

This response provides information to quantify variable H6

31. - The conditions of roads and worker transportation are (10 points).

- Both are to be solved: 0
- Roads are in bad conditions, but transportation is guaranteed: 5

- Roads are repaired, but transportation is not guaranteed: 5
- Roads and transportation are not a problem: 10

This response provides information to quantify variables H7, and H8

32. - The behavior of cultural traditions in the area is (5 points).

- Traditional activities are not performed: 0
- Working traditions are preserved, but traditions have been lost: 2
- Working traditions are not manifested, but other traditions are present: 2
- Working and cultural traditions are present: 5

This answer provides information to quantify variable H9

33. - Do workers have basic services in the vicinity (electricity, family doctor´s home and schools)? (5 points).

- No: 0
- Partially: 2
- Yes: 5

This answer provides information to quantify variable H10

34. - Are the water supply needs satisfied in your productive system? (120 points).

- Less than 50 %: 0
- Between 50 and 70 %: 60
- Between 70 and 90 %: 90
- Between 90 and 100 %: 120

This answer provides information to quantify variables B4, C2, D3, E3, E4, E5, E7, F1, F4, F6, F8, G3, G4, G6, G7, G8, G9, and G10

To identify the vulnerabilities the total values of components and variables were considered. Also, permissible limit values were previously determined and used as selection criteria. As a result, variables were considered to be affected if:

Microclimate (A): the total variable value is lower or equal to 180 points and if by analyzing components in particular, some of them reach the 35-point value.

- Soil (B): the total value of the variable is lower than 570 points, also when B1 is below 125.
- Hydrology (C): the total value is lower than 80.
- Flora and vegetation (D): the total value is lower than 750 points.

- Production animals (E): the total value is lower than 855 points.
- Economy (F): the total variable value is lower than 1 210 points, and when F1 is lower than 100, or F3 is lower than 180, or F6 is lower than 37, or F8 is below 400 points.
- Production (G): the total value is inferior to 1 710 points.
- Human resources (H): the total variable value is inferior to 360 points, also when H1 is less than 18 points, or H3 is less than 280 points.
- Classification was combined; (I) was used to identify the subsystem of natural resources, and (II) for other resources. In that sense, each Farm classifies as (I$_j$II$_j$), with subscript for every Roman number, equal to the number of variables affected in each subsystem. When no vulnerabilities were observed, the subscript value was 0. For instance, an entity may be classified as I$_2$ II$_3$, when two variables are identified within subsystem I and three variables within subsystem II, all with difficulties.

Finally, as a complement of the system, a set of ideas was formulated per variable affected, which could be adopted by the producer, to mitigate problems that might occur on the farm.

Measures to be accepted according to the variable affected.

Variable A: Microclimate

Components determining climate behavior in productive ecosystems are affected. To adapt to climatic changes and achievement of sustainability, these measures must be taken.

1. Plantation of trees in grasslands (forage, arborescent, fruit, wood, animal feed, medicinal, etc.). Species must be well adapted to the soil and rainfall conditions of the area. Trees should be planted at the right distance from each other, which allows pasture to grow and improve quality.

2. Establishment of biomass stocks with forage-producing graminaceae, legume, or mixed species.

3. Establishment of species association at different layers (trees, shrubs, graminaceae, legume and crawling species pratense).

4. Establishment of wind breakers made of trees, or hedges to protect pasture lands and provide cattle with feed, shade from the sun, honey, or other resources.

5. Improve the quality of cattle feed, so the results from digestion can generate lower levels of greenhouse gases. Grains are recommended to accompany the fresh and properly preserved feeds.

Variable B: Soils

Components determining the state of soils and productive ecosystems indicate soils are affected. These measures are suggested to achieve sustainability and adjustment to climatic changes.

1. Guarantee the vegetable covering on the soil for protection from rain erosion and strong winds. Hence, priority should be given to localized quality pasture sets, their protection and care, and the establishment of forest pasture systems in any variant, but preferably tree-pasture associations in no less than 50% of every farm area.

2. Use manure and other organic materials for soil balance.

3. Guarantee the accomplishment of the standards in terms of soil preparation and use. 4. Guarantee the required number of enclosures so pasture is managed properly, without overloads.

5. Establish an integrated program aimed at recovering the areas infested by undesirable plants, in order to incorporate the lands to grazing. Check that undesirable plant replacement is made with the appropriate plant species and quick. The soil is not to be left barren for a long period of time.

Variable C: Hydrology

Components determining the state of water resources in their ecosystems have signs of deterioration. The following measures are suggested.

1. Tree plantation in grass lands (forage, arborescent, fruit, wood, animal feed, medicinal, etc.).

2. Re-assess the water supplies and their effective potentialities before developing new actions for water distribution.

3. Cleaning of dikes and plantation of trees in hydro regulating stripes.

4. Installation of windmills.

5. Assessment of possible changes in the productive goals, according to the loads, global water requirements and animal transportation to achieve favorable supply. Variable D: Flora and Vegetation.

If components determining the state of ecosystems of pasture and forage in their productive ecosystems, indicate they are affected. The following measures are proposed.

1. Plantation of trees in grasslands (forage, arborescent, fruit, wood, animal feed, medicinal, etc.), with species easily adapted to the soil and rainfall conditions of the area. Trees should be planted at the right distance from each other, so pastures are allowed to grow with improved quality.

3. Fence repair and pasture land enclosing, in no less than eight enclosures per farm for pasture management.

4. Application of a program to combine mechanical and biological methods (clearing and reforestation) to eradicate undesirable plants.

5. Rational area increase, with quality pastures. To accomplish that goal the results from the localization program of pasture and multipurpose trees and shrubs, along with combined sowing of graminaceae and legumes in the grasslands.

6. Systematic monitoring of grass availability, grazing pressure on land and pasture land deterioration, in order to adopt new measures or changes in the productive activities, if the production goals are met.

Variable E: Animals under exploitation.

Components determining the state and behavior of cattle in their productive ecosystems indicate they are affected. To adapt to climatic changes and the accomplishment of sustainability, the following measures are suggested.

1. Guarantee that nutritional requirements are met for the different animal categories, preferably with feed generated on their farms. Adjust grazing load and pressure.

2. Repairing facilities for proper cattle management should be given a high priority.

3. Develop a program for young cow care, seeking at incorporating them at 18 months old.

4. Keep health surveillance and permanent anti-epizootic measures, and complete the integrated program for parasite control.

5. Provide cattle with stable and safe water supply.

6. Create shade areas to protect animals from the sun.

7. Develop a care program for gestating cows.

8. Develop a program for calf assistance.

9. Create feed and supplement reserves for different animal categories in harsh times.

10. Set up selection strategies to achieve good correspondence between the animal genotype and its ecosystem.

Variable F: Economy

Components determining the economic factor on the farm indicate that their production management is not adequate. For climatic changes adaptation, the following measures are suggested.

1. A system of personal training should be created, to properly use the labor force and cut down on hiring

2. Adequate land use and recovery of unused lands should be improved. Increase biodiversity

3. Set up the necessary conditions for pasture management, especially enclosing.

4. Set up a liquid and solid waste recycling program.

5. Set up a program for efficient water use and power saving. The agro meteorological information available on rainfalls, sun radiation, recurrent droughts and wind features should be considered to implement the program.

7. Guarantee cattle nutrition from local sources.

8. Find production alternatives to produce incomes, and project and diversify production with new resources for marketing.

9. Guarantee water supply for animals and other processes.

10. Set up a program for human resources assistance.

11. Keep constant surveillance and application of anti-epizootiological measures.

12. Increase product quality, trace controls, added value and prices.

Variable G: Production

Components determining production on the farm indicate that productive management is inadequate. The following measures for climate change adaptability and sustainability are suggested.

1. Set up systems for power generation and use (biogas).

2. Produce organic fertilizers for soil improvement and crop development.

3. Increase the variety of products on the farm.

4. Create appropriate conditions for pasture management, especially enclosing.

5. Guarantee cattle nutrition with local productions.

6. Guarantee water supply for animals and other processes.

7. Implement programs for young and gestating cows, and calves.

8. Set up a program for human resources assistance.

9. Keep constant surveillance and application of anti-epizotiological measures.

10. Attend alternative productions of fruit, wood, honey, plant fiber, royal palm nuts and other species for marketing.

Variable H: Human resources

Components determining human resources behavior indicate they are inadequate. The following measures for climate change adaptability and sustainability are suggested.

1. Set up a system of incentives based on production results.

2. Train the labor force on regular bases.

3. Set up a human resources assistance program to guarantee minimum working conditions, especially in housing and transportation.

DISCUSSION

Previous goals are integrated by PRAGACC in a more practical and simple way (Acosta *et al.*, 2006 and Acosta, 2008). This system, like others before is based on environmental diagnosis, but PRAGACC relies on more quantifiable questions for many important ecological and productive factors. Quantifications correspond to realities from the recent past and current productive levels and features on cattle producing farms in the main cattle raising regions of the country (Soto *et al.*, 2010; Guevara *et al.*, 2010 and Loyola *et al.*, 2010).

Farm classification is based on the behavior of a group of variables, which are determined by a set of components. Complexity and multifactorial status of inherent processes to a single productive system (FAO, 2008) are part of the study, which is more objective than other classification methods.

Moreover, different methodologies used to assess environmental impact, including the ones used as design for PRAGACC (Gómez-Orea, 1999 and Pastakia, 2002), though applied to cattle within a hydrographic setup (Acosta *et al.*, 2006 and Acosta, 2008), do not comprise a proposal of measures for the affected variables, in order to guide producers into tackling farm problems.

PRAGACC does not simplify the application of the sequence proposed by Acosta (2008) to organ-

ize bovine milk production in Cuba. It focuses on the productive Farm by identifying vulnerabilities, classifying them more integrally, and proposing measures to mitigate actual vulnerabilities.

CONCLUSIONS

PRAGACC is a useful tool for producers to make decisions; it facilitates identification of production vulnerabilities, classifies units and applies measures for ecosystem improvement. The productive systems are driven into sustainability and adaptability to climate change and irregularities.

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Table 1. Subsystems, variables and components included in the system design

Subsystem I.- Natural resources		Subsystem II.- Other resources linked to production	
Variables	Components	Variables	Components
A.- Microclimate	A.1.- Maximum temperature.	F.- Economy	F.1. - Expenses on labor force.
	A.2.- Mean humidity (soil)		F.2. - Expenses on hiring and assorted services.
	A.3.- Wind speed		F.3.- Expenses on feed supplements
	A.4.- Greenhouse gas emissions		F.4.- Expenses on medications
B.- Soil	B1.- Erosion and fertility.		F.5.- Expenses on repair and maintenance materials
	B2.- Soil compaction		F.6- Expenses on energy and fuels
	B3.- Drainage		F.7.- Sales management.
	B4.- Use of grazing lands		F.8.- Economic efficiency
	B5.- Dimensions of production entity assessed	G.- Production	G.1.- Power generation
	B6.- Pending		G.2.- Biofertilizer production.
C.- Hydrology	C.1.- Pollution of surface and ground water		G.3.- Diversification of production
	C.2.- Water use (availability)		G.4.- Surplus production for marketing
	C.3. - Diversion of courses, or water consumption cut down.		G.5. - Local processing of products.
D.- Flora Y Vegetation	D.1.- Undesirable plants		G.6.- Mean daily weight gain per animal.
	D.2.- Species diversity in ecosystems		G.7.- Birth
	D.3.- Grass quality.		G.8.- Mortality
	D.4.- Legume availability for nutrition.		G.9.- Beef yield.
	D.5.- Trees.		G.10.- Milk yield.
	D.6.- Pressure of grazing.	H.- Human resources	H.1.- Worker permanence.
E.- Animals in Production	E.1.- Alternative sources of nutrition		H.2.- Management worker permanence.
	E.2.- Facilities for handling		H.3.- Economic incentives
	E.3.- Incidence of infectious diseases		H.4.- Training.
	E.4.- Beef and milk production		H.5.- Education.
	E.5.- Productive behavior		H.6.- Housing.
	E.6.- Herd breeding		H.7.- Roads
	E. 7.- Water supply		H.8.- Transportation
			H.9.- Traditions.
			H.10. - Availability of basic services.