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CONTRIBUTION TO DEVELOP A METHODOLOGY THAT EVALUATES SUSTAINABILITY FROM INDIGENOUS COMMUNITY SCALE

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— Abstract—

The measurement of the sustainability levels that have been achieved in indigenous rural communities is an issue that remains very complex because it has not been possible to define a methodological guide given the complexity of the topic; however, it is imperative to continue constructing and providing new forms applicable to this type of studies. In this context, the purpose of this study is to contribute establishing a reliable, timely and truthful methodological basis for assessing the levels of sustainability achieved on a scale of analysis of indigenous communities, that is, from the community perspective, Not only as the analysis of the agro-ecosystems that are found there and that are part and sustenance of the community's life, but rather involves the human population and its interactions and/or problems that are generated in it from its economic-productive and socio-cultural actions. The study subject to which this methodology was applied is the community Golonchán Nuevo fraction two, municipality of Sitalá, Chiapas, Mayan-Tseltal community. The methodological route was first to locate the context of the study within the framework of the concept of sustainability proposed by the Bruntland commission, later the scale of analysis was sustained and the indicators were developed. Both the diagnostic workshops and the application of pre-elaborated surveys, direct observation and semi-structured interviews were used for the data collection work. The data obtained were analyzed with the General Index of Sustainability (IGS), Agrobiodiversity Index (IDA), the Vester matrix for the analysis of the problems and an analysis of agricultural activities manifested in cultural and even religious activities. The results indicate an IGS of 0.52 and an ADI of 0.47 while the problems were the prevalence of diseases and the lack of access and availability of food as the active problems of high influence on others. With these results we can conclude, on the one hand, that the study community is located in an unstable and unacceptable system, and there is even a threat of consideration on cultural wealth and, on the other hand, that the application of this methodology at the community level is timely and can provide reliable data for studies on sustainability levels to a scale of community analysis.

Keywords

Indicators; sustainability; community; scale of analysis; agrobiodiversity.

It is known that one of the biggest problems in the context of sustainability is precisely the measurement of the sustainability degree that has been achieved at different scales of application; therefore, it can be recognized that there is no single "ideal" form of measurement, as other researchers have also stated (Bolívar, 2011). Defining a reliable, timely and accurate methodology that can be applied at the level of indigenous rural communities is therefore a very topical challenge and therefore it should be put to the consideration of the scientific community dedicated to this topic.

In this context, the central axis of a methodology based on a community perspective must not be closed to the human population and its interactions and the problems that derive from it; but in an inverse sense, this human population should be seen as one more factor of the community, in a holistic sense, in the same way that agro-ecosystems intervene, natural resources, and that as a whole economic-productive, agro-ecological, sociocultural interactions are promoted which sustain the life of the community.

In this sense, the construction of indicators to make the measurements of sustainability necessarily involves recognizing the importance of traditional knowledge that is reflected in the agro-cultural activities, that is, in the cultural manifestations that have to do with the activities of the cycle agricultural sector whose wealth of knowledge manifests itself primarily in indigenous populations (Toledo and Barrera, 2008). That is why the methodology for the analysis of indigenous rural communities must contemplate variables that measure the permanence of this knowledge, which is also evident in clothing and gastronomy.

On the other hand, it is also of vital importance that the study of sustainability levels in communities must necessarily contemplate a careful analysis of the problems that arise in community life that is integrated and complements other indicators for the measurement of sustainability for this the application of participatory diagnostic techniques, that provide timely information of the community's people is necessary.

Derived from these premises, the following study is proposed whose objective is to contribute to the development of a reliable, timely and accurate methodology for the analysis of sustainability levels at the level of the indigenous rural community. From this perspective, a methodology was designed and applied in order to evaluate the level of sustainability of an indigenous rural community called Golonchán Nuevo fracción dos, which is located in the central highlands of Chiapas, in one of the six most marginalized municipalities in Mexico: Sitalá, Chiapas. It should be considered that this community is of Mayan origin where the mother tongue spoken is *Tseltal*.

MATERIALS AND METHODS

Study area

According to the Comité Estatal de Información Estadística y Geográfica de Chiapas (CEIEG, 2017), the Nuevo Golonchán community, fracción dos, is located in the southwest part of the municipality of Sitalá, Chiapas, Mexico. It is located 16 kilometers from the municipal seat, at an altitude of 1100 meters above sea level, its geographical coordinates are: length -92.395556 and Latitude 17.015833. It borders to the north with the community Golonchán Nuevo Primera Fracción; to the south with San Juan Cancuc, to the east with the municipality of Pantelhó and to the west with the community of Cópatil.

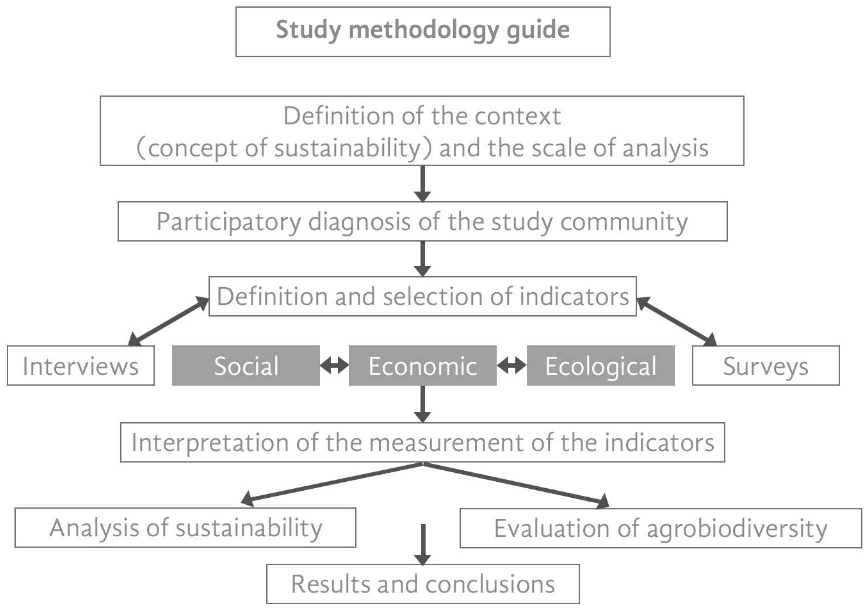
Applied methodology

Sample size. Regarding the sample size, it was done taking into account two methods: on the one hand, the convenience or non-probabilistic method was used (Torres, 2013; Morales, 2012), in which the people who best adapted to the persecuted goals of this study were chosen, in general terms were those that have stood out for their participation and leadership in sake of the community who voluntarily had the disposition to answer the surveys and participate in the interviews; and on the other hand, surveys were applied to an equivalent of 60% of the population chosen at random. It should be noted that considering the size of the population by its inhabitants, as well as the number of families and therefore of producers, 60% of them were surveyed considering that it is a probabilistic sample representative of the community in terms of application of information to the rest of the population. The observations made were direct in the sites of interest for the study, through tours with the accompaniment of members of the community.

The methodological design follows a critical path that starts from the location within a framework of the concept of sustainability (Sarandón, 2006, Sarandón and Flores, 2009), proposed by the Brundtland Commission that says "...Sustainable development is the one that allows us to meet the needs of present generations, without compromising the needs of future generations..." under this logic, then, the question is: how viable are communities to leave necessary natural resources for future generations and that they can enjoy a full life?, in other words "are communities consuming natural resources faster than they are conserving them?" "Is the conservation capacity greater or less than the capacity to conserve for future generations?"

The next step is to locate the scale of analysis, which, as stated in the paragraphs above, is at the level of the indigenous rural community. The general scheme of organization of this study can be seen in Image 1 where it defines the scale of measurement once the concept of sustainability and the objectives of the study have been determined.

Image 1. Methodological route followed in the investigation.



Source: self-made

The work scheme or the methodological guide continues with the application of a participative diagnostic workshop, which allowed to recognize or characterize the community that is, what do they have? Which resources do they count with? What do you do? How much do they have? Why are they like this? What problems do they have? What economic-productive and socio-cultural activities do they carry out? Etc. It is important to keep in mind, during the implementation of the participatory workshop that the agro-cultural activities (especially of ancestral or of Mesoamerican origin) that are developed in the community and that derive from agricultural activities in connection with conservation of the culture are manifested in the language, clothing and gastronomy, but also in the rituals of the productive cycles.

On the other hand, the participatory diagnostic workshop had the same purpose of recognizing the current state of the community regarding the problems that affect it, which are analyzed through the Vester matrix, which allowed the problems to be classified and because of this it is possible to build better solutions that reinforce sustainable life strategies. For the analysis of this information, the participation of researchers, facilitators and members of the community was important.

Once the three dimensions of analysis and the selection of indicators that are pertinent and viable for the purpose of the study were determined, a survey was constructed to collect the data of interest, the format for semi-structured interviews and direct observation; it is very important to bear in mind when selecting the indicators that these will be processed through the Índices General de Sustentabilidad (IGS) (General Sustainability Indexes) and the other one of Agrobiodiversidad (IDA) (Agrobiodiversity), which are two measurement index that have proven their relevance and reliability (Gravina and Leyva, 2012).

The procedure for the evaluation by IGS and IDA was based on a sequence of terms and mathematical equations to determine first **the value of the variables**, and **then the value of the indicators**, the final operations yield the result of both the General Sustainability Indexes and the one of Agrobiodiversity.

For the case that concerns us in the Nuevo Golonchán community, the information obtained through the diagnostic workshop, surveys and interviews were captured in the Excel program and later analyzed by the IGS and the IDA. In the IGS, 11 indicators were used, of which four are of the economic dimension, four of the social dimension and three of the ecological dimension, that is, a balance was observed in the three dimensions. All the indicators totaled a total of 47 variables.

The systems studied General Sustainability Index was determined by calculating using the formula:

$$\mathbf{IGS} = \Sigma^{1}{}_{n}\ (\mathrm{VI}) / \mathrm{VMI}*n$$

Where: VI is the value of the indicators; VMI is the maximum possible value of an indicator and *n* is the number of indicators.

Taking into account that the selected variables have different units of measurement (percentages, monetary values, indexes, qualitative data), which does not allow direct comparison between them, a standardized scale was constructed (value of judgment-*VJ*-) that represented the value that they have in relation to the desirable situation, defining maximum and minimum conditions and taking into account the main characteristics and particularities of the area, according to recommendations of López *et al.* (2002) and Harold *et al.* (2006). In this case it was assigned a value of 1-10 related to sustainability levels for each variable. The standardized scale allowed organizing all the information and converting the different values into a homogeneous value.

The numerical value of the variables was assigned through an interactive process with the participation of the facilitators and actors involved in the research. The value of the variables corresponds to the value of judgment assigned in the scale of values. The value of the sustainability indicators was calculated by adding the variables that make up each indicator:

$$\mathbf{IGS} = \Sigma^{1}{}_{n}\,(\mathrm{VV})\ /S$$

Where: VV is the value of the variable and *S* is the number of variables that constitute each indicator.

The interpretation of the value of the IGS indicator follows the criteria indicated by Sepúlveda *et al* (2002), who estimate that an index below 0.2 is a state of the system with a high probability of collapse; for levels between 0.2 and 0.4, they indicate a critical situation, from 0.4 to 0.6 it is an unstable system, while from 0.6 to 0.8 it speaks of a stable system and finally from 0.8 to 1 it is considered as the optimal situation of the system. The indicators selected and studied are shown in Table 1.

Table 1. Indicators studied to assess the General Sustainability Index

Indicators:	Variables (V):
Soil	1. Soil properties. 2. Structural quality of soil. 3. Cultivable area/total area ratio. 4. Cultivable discovered (fallow/year)
Biodiversity	5. Vegetable biodiversity managed (in the plot and the backyard). 6. Animal biodiversity managed and breeds (in the plot and in the backyard). 7. Diversity/species options
Water	8. Availability. 9. Access. 10 Quality
Economic resources	29. Agricultural resources and their status. 30. Labor force/area ratio. 31. Work force and its quality. 32 Warehouses for crops and others. 33. Corrals/animals, live fences

Economic efficiency	11. Cost/benefit ratio. 12. Agricultural performance. 13. System productivity. 14. Self-financing. 15. Total profit. 16. Numbers of productive items. 17. Market diversity. 18. Other income
Input independence	19. Independence of external inputs. 20. Inputs for animal feed. 21. Varieties of crops
Alternative technologies	22. Sustainable management technologies. 23. Use of nutritional alternatives. 24. Management of pests and weeds. 25. Produce and conserve seeds. 26. Animals sustainable management. 27. Crop preservation. 28. Irrigation systems
Quality of life	34. Comfort and access to media. 35. Access to health. 36. Access to education. 37. Food availability (quantity). 38. Food diversity.
Conservation of culture	39. Conservation of culture (language, clothing, gastronomy). 40. Practice of rituals and ancestral rites related to the agricultural cycle (agro-cultural)
Management capacity	41. Knowledge about agriculture (modern and traditional). 42. Innovation capacity. 43. Socialization of knowledge. 44. Acceptance to training
Government support	45. Payment facilities. 46. Access to credits. 47. Support for agro-ecological agriculture.

It is important to highlight that the IGS took into consideration the family backyard area as a substantial part of the study since this is a very important complement for peasant-type production that permeates this indigenous region (Velazquez and Perezgrovas, 2017).

For the IDA, the methodology proposed by Leyva and Lores (2012) was followed and included several indicators, which are the following:

IFER: biodiversity index for human nutrition
IFE: biodiversity index for animal feed
IAVA: biodiversity index to improve soil resources
ICOM: complementary biodiversity index

It is important to keep in mind that key informants and direct observation are indispensable to gather information for the IDA. The IDA values are considered optimal when they approach the unit (1), for this it is necessary that each of the specific indexes (IFER, IFE, IAVA and ICOM) reach maximum values and thus know how far or near we are from the biodiversity in a community (Table 2). The formula used for the IDA was the following:

$$\mathrm{IDA} = S1IFER + S2IFE + S3IAVA + S4ICOM \,/\, St$$

Where: St: number of components of each of the specific indexes.

IFER: Index of biodiversity for human consumption (it is the index that represents the biodiversity used for human consumption and is the families' main source of income), IFE: Index of biodiversity for animal feed (index that represents the biodiversity used for animal feed), IAVA: Index of biodiversity to improve the soil resource (it is the index that represents biodiversity to improve the physical, chemical and biological properties of soils) and ICOM: Index of complementary biodiversity (it is the index of non-food species but necessary for humans and agro-ecosystems).

Table 2. Diversity by species or variables to determine the ADI.

Subscript	Species groups and diversity groups (variables)
IFER	I. Trainers I.1. animal. I.1.1. eggs. I.1.2. meat I.1.3. milk I.2. vegetables. I.2.1 legumes II. Energy II.1. roots and tubers II.2. cereals II.3. oilseeds III. Regulators III.1. fruits III.2. vegetables
IFE	IV. Trainers: vegetables IV.1. arboreal and creeping legumes V. Energetics V.1. pastures and fodder
IAVA	VI. Organic wastes VI.1. harvests VII. Bio-products VII.1. bio-fertilizers VII.1.1. fungi-bacteria VII.1.2 other like composts VIII. Green fertilizers VIII.1. legumes VIII.2. grasses
ICOM	IX. Supplement to the quality of life IX.1. food IX.2. non-food X. Spiritual complement X.1. artistic works X.2. religious XI. Agro-system complement XI.1. natural: the forest XI.2. induced: live fences XII. Complement free animals

DISCUSSION AND CONCLUSION

Observed biodiversity

The biological diversity observed in the community can be located in several components, in a quadrinomy: animal-fruit-vegetable-medicinal (ornate) that are used by community members as food and/or sale of surplus for family support. In Table 3, the range of crops and animals identified in the community is described by their common name. It can be observed that there are 19 species of fruit and shade trees for coffee while the cornfield is regularly composed of corn, beans, squash, chayote and chili, as well as other species. Of the animal production only four species are of economic importance: chickens, turkeys, pigs and ducks. It should be noted that the animals are maintained with corn and free grazing in the areas that occupy the family backyard.

Table 3. Observed biodiversity of domestic flora and fauna in Golonchán Nuevo.

Animals	Vegetables	Fruits	Medicinal
Hen, Pig, Ducks, Turkey	Corn, beans, cucumber, squash, chayote, chile, tomato, radish, puero, cane, cabbage, peppermint, epazote, basil, cilantro, sweet potato	Tangerine, grapefruit, orange, coconut, coffee, avocado, mango, paterna, guanabana, lime, jocote, banana, lemon, cacaté, papausa, tuca, coczan, ishum	Purple maguey, te zacate, aloe, epazote, basil

Main problems

The problems detected are mainly six: Public health problems due to open defecation due to the lack of latrines and bathrooms, little access and availability of water, little access to health services because there is no health home in the community, insufficient food for the maintenance of the family, little availability of land to cultivate and little support from public institutions (Table 4).

According to the Vester matrix, it can be observed that both poor access to health services and insufficient food are critical problems (these are understood as problems of great impact in other processes). On the other hand, passive problems are understood as problems without great causal influence on others but which are caused by the majority while the indifferent ones are problems of low priority within the system analyzed. Active problems are problems of high influence on most of the rest but that are not caused by others (Velazquez F. 2008).

Table 4. Analysis of the problems detected in the diagnosis.

Critical problems	Liabilities	Actives	Indifferents
Little access to health services. Insufficent food to feed	Little support from public institutions	- Prevalence of public health diseases - Little access and availability of water	Little availability of land to cultivate

General Sustainability Index (IGS)

For the purposes of the present study, 11 indicators were used and 47 variables were developed, whose results were processed using the corresponding formula explained in previous paragraphs. The selected indicators represent the three dimensions of sustainability in a similar proportion. The value of the variables is described in Table 5. It can be seen that the variables with the lowest value correspond to the Water indicator, both in terms of availability and access. It is also observed that the Government Support indicator is the lowest of all the analyzed indicators. The management capacity is the most relevant, followed by the capacity of the inhabitants to provide their own inputs and maintain activities in their agro-ecosystems, including the backyard.

Table 5. Value of the indicators obtained from the analysis of the variables.

Indicators.	Value of indicator:
Soil	4.938
Biodiversity	5.917
Water	4.083
Economic efficiency	5.250
Input independence	6.500
Alternative technologies	5.571
Economic resources	5.700
Quality of life	4.500
Management capacity	8.438
Government support	3.667
General Sustainability Index	**0.546**

The general index of sustainability obtained is 0.54 which shows that the sustainable development of the study community ranges between 0.4 and 0.6 and indicates that it is an unstable system and is located far below even the goals proposed in the Millennium Development Goals by Mexican public institutions. These results are very similar to what was found by Gravina and Leyva (2012) in Bolivia who reported an IGS of 0.52 and an ADI of 0.37 in their study carried out at the cooperative San Jerónimo R.L. concluding that they are values very far from the sustainability of the agro-system studied.

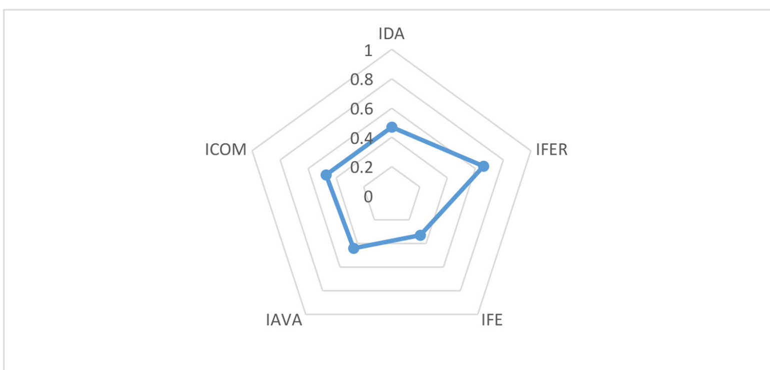
Agrobiodiversity Index (IDA). To calculate the ADI, 11 variables were applied in four sub-indices (IFER, IFE, IVA, ICOM), as described in Table 2. The results obtained from the application of the formula were as follows:

$$IDA = S1IFER + S2IFE + S3IAVA + S4ICOM \,/\, St$$
$$IDA = 0.66+0.33+0.44+0.47/4$$
$$IDA = 0.47$$

From these results it can be seen that the sub-index IFE is the lowest value which corresponds to that of biodiversity for animal feed, which suggests that the community does not have sufficient levels of legume plants or grasses and weeds to feed the animals, while the indicator with the best results is the IFER corresponding to biodiversity for human consumption, which indicates the community's concern to obtain the necessary provisions to cover the their families' needs, and the ICOM index is also kept low, although they receive complementary resources in the form of support from public institutions (welfare programs of government) and ecclesiastical.

The general index obtained is 0.47, which is below 0.7, which is the minimum necessary to be considered efficient (Image 2), in other words, agro-biodiversity is very limited and explains why the soils are not sufficiently productive to provide for the population and the animals, and the forests are not enough to shelter a greater fauna that controls pests and better face the climatic and economic uncertainties.

Image 2. Values of the IDA and the subscripts that determine it.



Agro-cultural activities

According to the observed results we can say that the community has a great agro-cultural wealth that is manifested in its diverse rituals and of which some very ancestral ones stand out, such as the ritual of the beginning of the sowing cycle (Table 6). However, due to the results obtained in the IGS and the IDA, the cultural wealth observed is also in a situation of instability and therefore threatened by its possible extinction if the situation continues to worsen.

Table 6. Cultural activities related to production and biodiversity.

Months of the year	Cultural Activity	Productive Activity	Biodiversity
January		Cleaning of jilote and coffee	Rain and wind
February	Main Ritual in 6 hills, the principal of the community participates with other principals		Leaves fall from the trees. Rain and wind.
March	Ritual in the community	Rosa and grave. Harvest corn and vegetables.	Month of winds and heat. Dry streams. Fruit trees bloom. Mulatto and cedar's leaves grow.
April		Clean for corn planting.	Plenty of butterflies, little ones and beetles.
May	Ritual in hills with tatikes (elderly) and the population	Sowing: corn, beans, squash, banana and cilantro.	Streams are dried. A lot of heat. The leaves fall from the trees.
June		Cleaning of milpa. Squash bloom.	There is little heat. Rain time
July		Flowering corn.	Rain, hail and wind.
August		Harvest of corn.	Wild honey abounds.
September		Harvest of corn and pumpkin. Coffee plantation	Heavy rains
October		Prepare tornamilpa. Coffee harvest starts	Heavy rains
November		Sowing of tornamilpa without beans (does not grow). Harvesting, pulping and drying of coffee	Heavy rains
December	December 12 Virgin Mary	Clean milpa. Coffee drying	Rain and cold

CONCLUSIONS

Estimating the observed biodiversity of plants, animals and vegetables in which 19 species of fruits and trees are registered, to which four species of animals are added, it is possible to consider them as sources of protein and energy for human and animal food as well as those of greater economic importance for the inhabitants of the place, although it is also recognized that it is a very limited contribution for the sustenance of the families that live in Golonchán Nuevo fracción dosand it is even one of the central problems diagnosed in the Vester matrix.

The more detailed assessment of the IGS indicators shows that the most harmful sum is precisely the one that refers to the available resources such as soil and water as well as the quality of life and whose effect has a strong negative impact on the General Index of Sustainability. In the same way, it happens with the IDA in which the greatest negative effect is shown in the indexes that refer to human food and complementary resources, even though in the latter, support is received from other communities, such as the ecclesiastical one or from government institutions with their assistance programs do not substantially improve this index.

Therefore, considering the result for IGS of 0.54 and for the ADI of 0.47 and adding the diagnosed problems we can conclude that the fundamental premise of sustainability that the quote says "...satisfy the present needs without compromising the resources for future generations..." this community is below what is desired to talk about a sustainable community and even the agro-cultural wealth observed is also in a situation of instability and threat, in other words, it is possible that the community is consuming the resources at a faster rate than what it is conserving for future generations, so it is not possible to speak of a community that develops sustainably; so it is necessary and urgent to develop strategies that lay the foundations for a promising future of wellbeing and sustainability, considering as priority the indexes that show the least development.

On the other hand, in relation to the purpose of this study, which is to contribute to a reliable, timely and accurate methodology for the analysis of sustainability levels at the community level, it is concluded that the application of this methodology at a community scale is timely and can provide reliable data for studies on levels of sustainability at a scale of analysis of rural and indigenous communities as the ways of approaching and analyzing the results (Participatory diagnosis, prioritization of problems with the Vester matrix, analysis of agro-cultural activities, IGS and IDA), are able to complement each other and both the indicators and the registry of the problems give a global and at the same time specific view of the situation that the community keeps, they detect which are the strong and weak points that influence the level of sustainability. In addition, the use of the proposed techniques to collect the information allowed interacting with social actors and observing in greater detail the environment or place of research.

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