IMAGE: A MAP OF THE STARS OF THE ORION CONSTELLATION

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The 50-Year CO_2 Balance: Crucial Roles of Agriculture, Forestry and the Ocean

Arnaud Muller-Feuga

ABSTRACT

CO_2 exchanges between continents, oceans and atmosphere are analyzed over the last 50 years, correcting for the importance of agriculture and forestry. To do this, we simply considered their commercial production statistics and their 40 to 50% of dry weight carbon content. These vital activities have captured on average 39.9 $GtCO_2$/year from the atmosphere over the last decade. This carbon capture and storage (CCS) by plants has more than doubled since 1970 and compensated for 36.0 $GtCO_2$/year of fossil emissions. After mineralization by respiration and combustion, the carbon mobilized in those biomasses returned to the atmosphere as CO_2. This release, which takes a quarter of a century after harvest on average, has stabilized at around 10.2 $GtCO_2$/year over the last half-century, leading to a continental balance, including the combustion of fossil hydrocarbons, of 6.8 $GtCO_2$/year emitted on average.

Contrary to what is generally accepted, CCS by plant cultivation has completely offset emissions from the combustion of fossil hydrocarbons. As a result of this new balance, the ocean appears to have been an increasingly important source of CO_2, going from neutral in the 1970s to an average of 10.6 $GtCO_2$/year over the last decade. Over the half-century, the ocean has contributed 52% to the increase in atmospheric CO_2 concentration, with the remainder coming from the continents.

Keywords: CO_2, whole plants, atmosphere, agriculture, forestry, continent, ocean, carbon sink, carbon budget, climate change.

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Contrary to what is generally accepted, CCS by plant cultivation has completely offset emissions from the combustion of fossil hydrocarbons. As a result of this new balance, the ocean appears to have been an increasingly important source of CO_2, going from neutral in the 1970s to an average of 10.6 $GtCO_2$/year over the last decade. Over the half-century, the ocean has contributed 52% to the increase in atmospheric CO_2 concentration, with the remainder coming from the continents.

These results challenge common assessments which attribute to the ocean a role in absorbing anthropogenic emissions. Moreover, they rehabilitate agriculture and forestry, which are responsible for a major CCS system and should be rewarded for this. But above all, they call into question the certainties on which the decarbonization policies of today's society are based, which require considerble efforts and which shame the populations who burn fossil hydrocarbons to escape poverty.

Keywords: CO_2, whole plants, atmosphere, agriculture, forestry, continent, ocean, carbon sink, carbon budget, climate change.

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I. INTRODUCTION

The current global warming supports the theory defended by the Intergovernmental Panel on Climate Change (IPCC) according to which it is the consequence of CO_2 emissions by combustion of fossil hydrocarbons (IPCC, 2023). Accepting this postulate, most governments have taken binding measures to reduce those emissions by decarbonizing the activities of the society. To this end, they have notably established and promoted carbon capture, utilization and storage (CCS or CUSC) systems, mainly by geological burial (Global CCS Status, 2024).

In a previous paper of which this one is a sequel (Muller-Feuga, 2024b), we examined the contribution of global agriculture and forestry by considering statistics of products marketed and their carbon content, i.e. 40 to 50% of the dry weight. The underestimation of CCS by cultivated plants in most of the literature related to the subject (e.g. Canadell et al., 2021) was thus highlighted. The figures for 2022 showed that agriculture and forestry are the largest global CCS systems in terms of quantity with a mean duration of a quarter of century, offsetting fossil emissions and making their possible impact on the climate non-existent.

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These results also suggested that the ocean is likely a source, contradicting widely accepted views (e.g. Friedlingstein et al., 2023). If in a previous paper (Muller-Feuga, 2023) we identified the ocean as a sink, it was because only commercial parts of plants were considered in the balance. Subsequent studies (Muller-Feuga, 2024b) corrected this flaw and demonstrated that these commercial parts represent only half of all cultivated plants storage, as the above-ground and below-ground parts remaining in place after harvest also store carbon.

Having previously modeled CO_2 captures and releases in duration and amplitude, the present study focuses on CO_2 exchanges between the continents, the ocean and the atmosphere during the last half-century.

II. MATERIALS AND METHODS

The ocean's contribution to annual atmospheric CO_2 fluxes, denoted as Co, is the unknown variable in equation (1), which expresses the yearly balance between positive sources and negative sinks:

$$Co = -AW + EW + EFOS - VTAC \tag{1}$$

where:

- AW is atmospheric CO_2 capture for organic matter synthesis,
- EW is the release of atmospheric CO_2 from mineralized organic carbon of plants and animals by respiration and combustion,
- EFOS includes CO_2 emissions from fossil hydrocarbons combustion,
- VTAC is the variation in atmospheric CO_2 content.

The form of this relation is like the one used in Muller-Feuga, 2023, with simply a distinction between EW and EFOS. We also changed GATM for VTAC to express that CO_2 atmospheric content could also diminish. The sum of the first three elements on the right constitutes the continental balance.

The first two terms AW and EW were derived from FAO (n.d.) statistics on the quantities of agriculture and forestry products placed on the market between 1970 and 2022, taken every ten years and interpolated. We assume that AW and EW obey two normal distribution laws over time, one increasing, the other decreasing, rendered by Gauss error function (erf). These laws' mean and median durations are equal to half the maximum capture period (CP) plus half the maximum release period (RM) expressed in years.

The theoretical distributions of carbon stocks S(t) over time t are defined as follows:
For capture:

$$SC(t) = \frac{AW_n}{2}\left(1 + erf\left(\frac{t-n+\frac{CP}{2}}{\sigma_c\sqrt{2}}\right)\right) \tag{2}$$

For release:

$$SR(t) = \frac{AW_n}{2}\left(1 - erf\left(\frac{t-n-\frac{RM}{2}}{\sigma_r\sqrt{2}}\right)\right) \tag{3}$$

where:

- t is the year considered,
- n is the harvest year,
- AW_n is the carbon stock at harvest year n,
- CP and RM are the maximum capture and release periods, respectively,
- erf is the standard error function,
- σ_c and σ_r are the cambers (standard deviations).

When $t \leq n$, the stock *SC(t)* is being formed during the capture period (CP), and the error function erf is added. When $t > n$, the stock *SR(t)* undergoes mineralization during the release period (RM), and the error function erf is subtracted.

In Muller-Feuga (2024b), this modeling was applied to plants harvested in 2022 based on the 160 crop products, 48 livestock products, and 8 forestry products listed by FAO (n.d.) world statistics. This resulted in the parameters in Table 1.

Table 1: Values of the equations (2) et (3) parameters for whole plants marketed in 2022 (n=2022).

Parameter	Notation	t≤n	t>n
Captured CO_2 ($GtCO_2$/year)	S_n	41.6	41.6
Camber	σ	1.4	6.5
CP, RM (year)	d	9.46	45.60

The exercise was extended to the last half century using the parameters values of 2022. The quantities of CO_2 captured were calculated based on FAO decadal statistics, which describe marketed agricultural and forestry products. These quantities were converted to anhydrous products, multiplied by their carbon content (40 to 50%), then by the CO_2/C mass ratio (3.37), and finally by the whole plant/commercial part ratio (2.78 for crops, 1.64 for fodder, 1.43 for forestry products).

III. RESULTS

The theoretical distribution over time of annual captures and releases by whole plants modeled by the equations (2) and (3) allows us to construct three 90x53 matrices, which we call C(t,n) for capture, R(t,n) for release and C(t,n) + R(t,n) for capture and release of atmospheric CO_2, where t is between 1969 and 2022, and n is between 1940 and 2030. Rows t contain the stocks constituted by successive harvests at time n, and columns n contain the stocks captured and then released in year n as a function of time t.

3.1 Captures

The amounts of CO_2 captured annually by the main groups of plant production vary as shown in Figure 1. In 2022, the captures of crops (21.3 $GtCO_2$) were the majority and exceeded the sum of fodder and forestry captures (13.2 and 6.6 $GtCO_2$, respectively). An unexplained bump due mainly to fodder breaks the linearity around 2010.

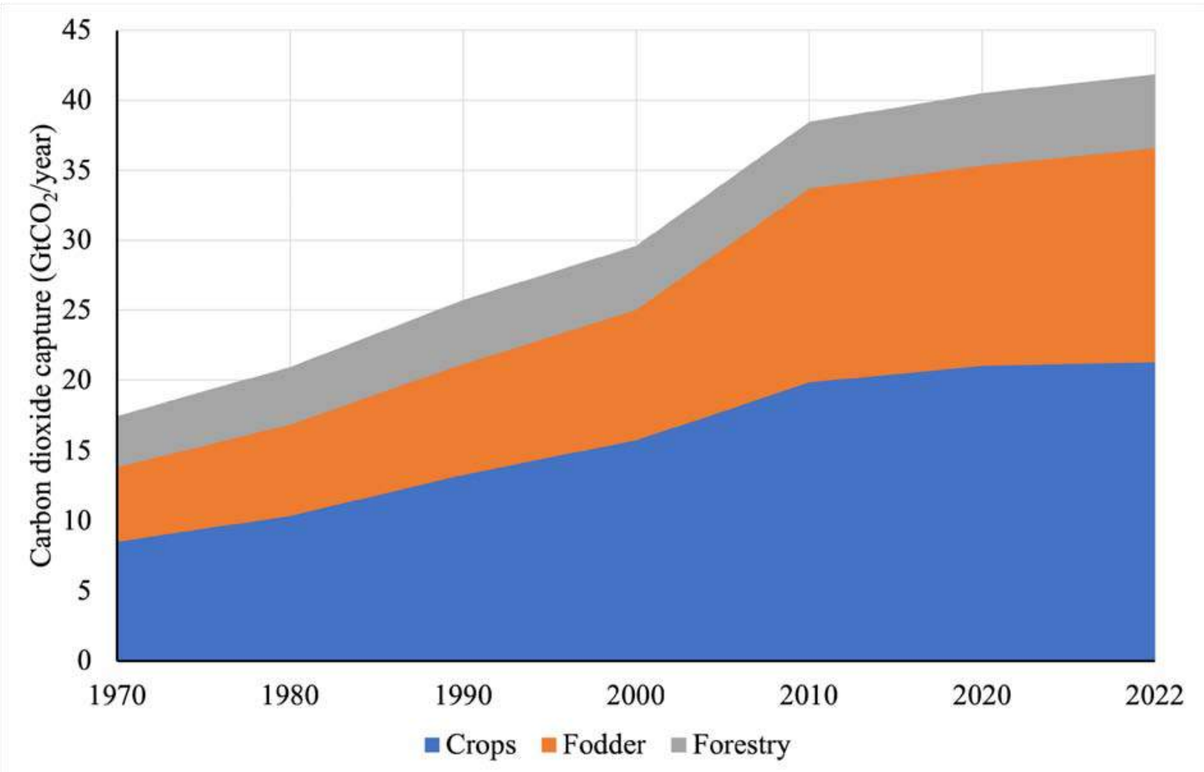

Figure 1: Global CO_2 capture by whole plants marketed from 1970 to 2022 ($GtCO_2$/year; from FAO, n.d.).

Strictly speaking, the CO_2 captured annually is equal to the change in carbon stock from one year to the next. However, to avoid double counting, the capture AW of year t in equation (1) was calculated based on the harvest of year t. Its variation peaking at 41.1 $GtCO_2$ in 2022 is described by Figure 1.

3.2 Releases

Having defined the stock captured AW, the CO_2 released into the atmosphere annually EW equals the variation of stock from year to year, or the sum of row t reduced by the sum of row t-1 of the matrix R(t,n) expressed as:

$$EW_t = \sum_t SR(t) - \sum_{t-1} SR(t-1) \qquad (4)$$

This can be considered as the derivative of the change in stocks. Since they are proportional to AW which varies quasi-linearly over time (Figure 1), its derivative EW should be quasi-constant.

3.3 Variation Of Stocks Harvested Between 1970 And 2022

The column vectors n of the matrix C(t,n) + R(t,n) vary as a function of time t as illustrated in Figure 2 between 1970 and 2022. To cover this entire half-century, it was necessary to go back to 1940 to include all stocks being released in 1970, and anticipate 2030 to include all stocks under construction in 2022. To do this, we extrapolated to 1940 according to the linear regression AW = 0.4198*n - 809.39 and to 2030 according to the regression AW = 0.4883*n - 945.42, where n is the year considered. This is an acceptable hypothesis given the high value of the coefficients of determination ($R^2 \geq 0.985$).

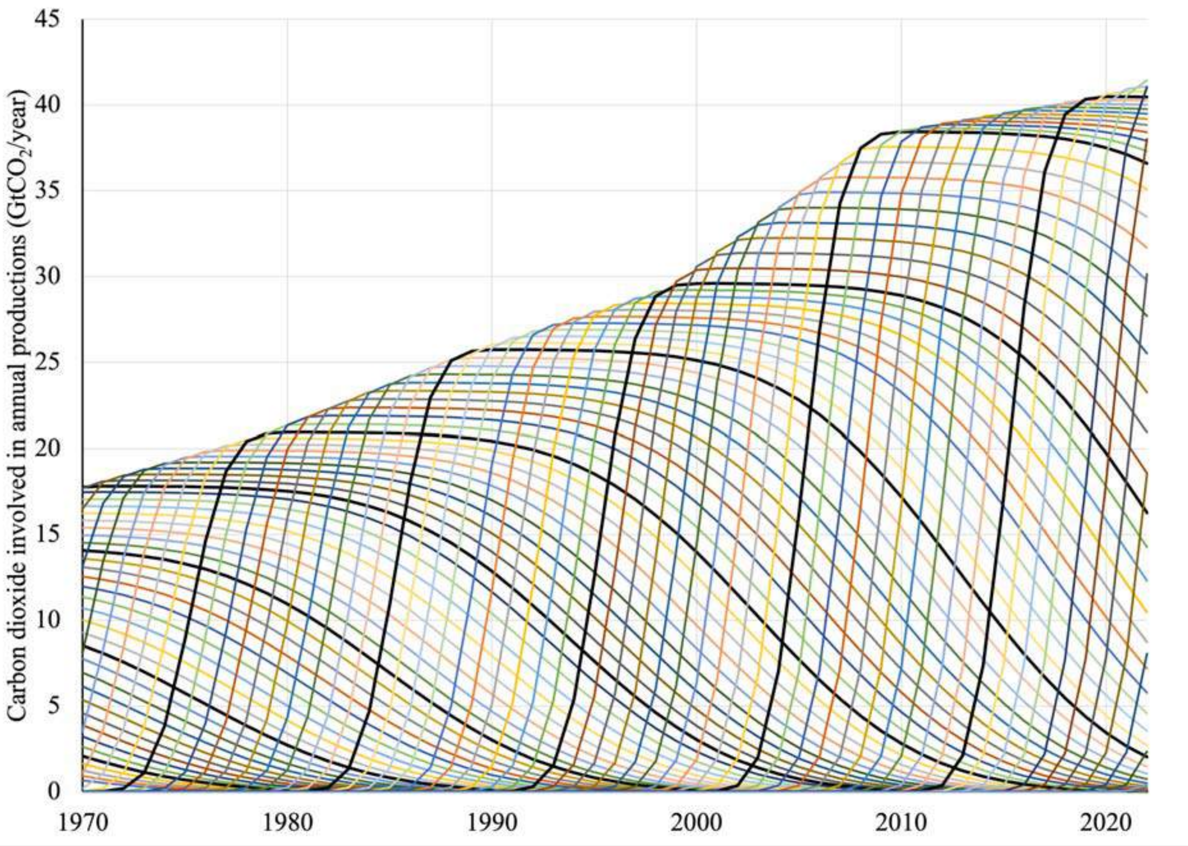

Figure 2: Temporal distribution of global annual CO_2 captures and releases by whole plants cultivated between 1970 and 2022 ($GtCO_2$/year). The thick black lines correspond to the ten-year periods.

3.4 Continental Balance

The continental balance includes the annual exchange of continental sources and sinks, i.e. – AW + EW + EFOS. Figure 3 brings together the elements of the calculation of these exchanges where the quantities AW and EW result from the previous calculations while EFOS is provided by Global Carbon Budget (2024).

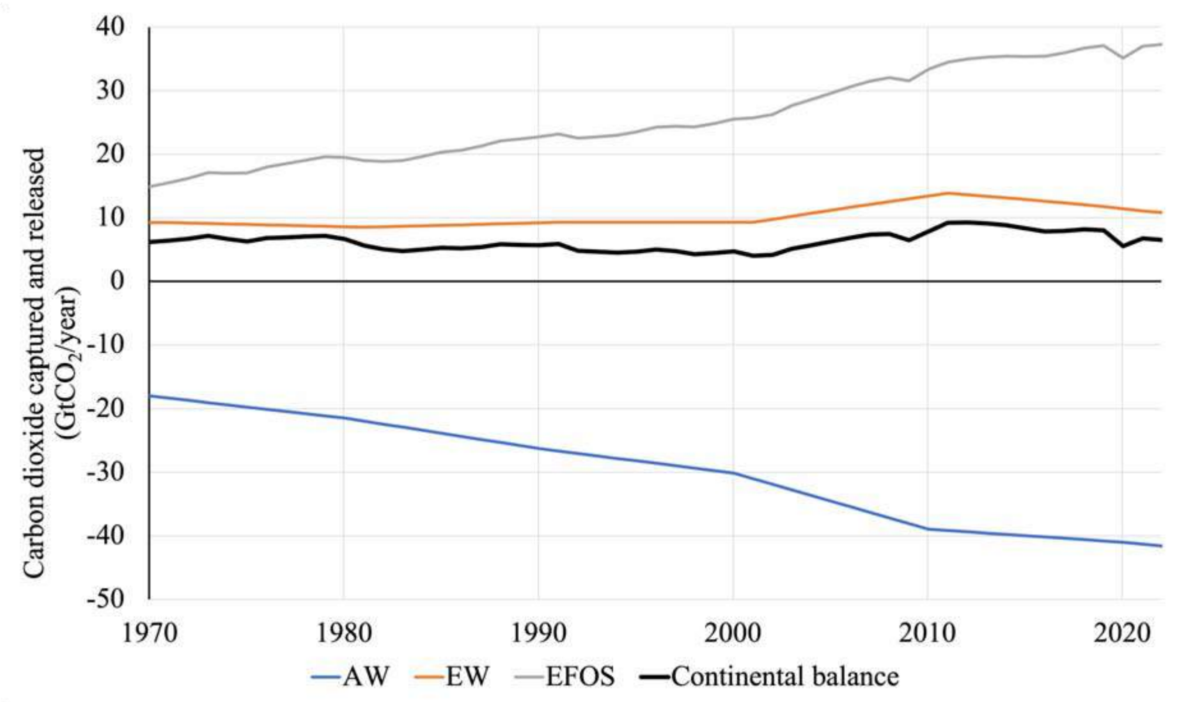

Figure 3: Continental balance of CO_2 captures and releases and evolution from 1970 to 2022 ($GtCO_2$/year). Negative values indicate a sink and positive values a source.

The capture of whole cultivated plants AW and the fossil emissions EFOS followed the evolution of the human population which increased from 3.7 in 1970 to 8.1 billion individuals in 2023. The three quantities have more than doubled over the period. It can also be noted that the capture of whole cultivated plants AW is higher in absolute value than the fossil emissions EFOS over time. As seen above, EW was relatively stable around an average of 10.2 $GtCO_2$/year over the period. The continental balance $-AW + EW + EFOS$ is a source of 4 to 10 $GtCO_2$/year with an average of 6.8 $GtCO_2$/year over the period.

3.5 Atmospheric Balance

According to formula (1), the oceanic contribution Co is equal to the annual variations in atmospheric CO_2 content (VTAC) minus the continental balance. The VTAC data were measured at the Mauna Loa Observatory (Keeling et al., 2001) and provided by the SCRIPS Institution of Oceanography.

Figure 4 shows that the atmosphere was negative and constituted a sink, while the oceanic contribution Co was mainly positive over the half-century considered here. The ocean, which was neutral in the 1970s, has become an increasingly strengthening source. It provided 52% of VTAC on average over the period, with the continental budget providing the remainder.

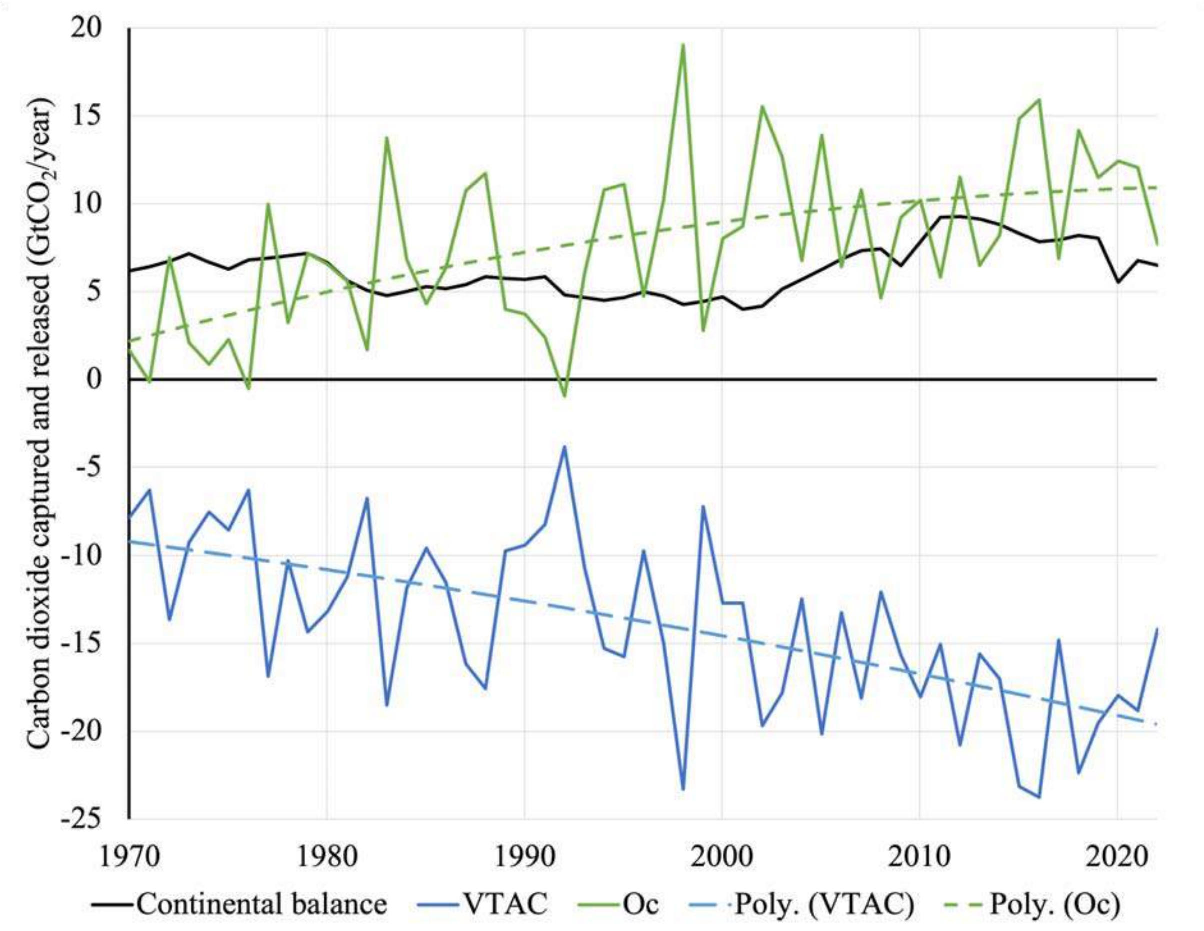

Figure 4: Evolution of the continental balance, the variation in atmospheric CO_2 content VTAC, and the contribution of the oceans Co to atmospheric CO_2 exchanges during the last half-century, in $GtCO_2$/year. The fits are polynomials of order 2. Negative values indicate a sink, positive a source.

IV. DISCUSSION

We are aware that extending the 2022 parameters of formulas (2) and (3) over half a century is questionable, and that we should have taken the true values of the statistics and assigned them the appropriate contents and durations. It would certainly improve the accuracy of the history of exchanges, perhaps make it possible to detect the influence of events such as pandemics, volcanic eruptions, wars, etc.., but should not change the major trends at the global level described here. This preliminary exercise is intended to correct an oblivion and give the orders of magnitude resulting from this correction.

To achieve a comprehensive continental balance, it would be necessary to include CO_2 capture and release by unmanaged vegetation covers. Their contribution is included in the item "rural emissions" of FAO (n.d.) statistics which include forest, savanna, and peatland fires and ranged between 3.8 and 9.2 $GtCO_2$/year over the last half-century. They are comparable to our EW.

What the IPCC-cited authors refer to as "land-use change emissions" (E_{LUC}, a source of 4.4 $GtCO_2$/year in 2022 according to Friedlingstein et al., 2023) are included in our EFOS fossil emissions which are thus significantly increased.

The CCS system formed by cultivated plants of agriculture and forestry is the main CO_2 sink on the planet, a role not fully recognized by policymakers, particularly regarding carbon credit allocations (Muller-Feuga, 2024a). These vital productions are expected to grow alongside human demand, facilitated by the fact that increasing atmospheric CO_2 concentrations enhance photosynthesis and yields (Haverd et al., 2020; Muller-Feuga, 2023).

Global temperatures have risen at a rate of 0.19°C per decade over the past 50 years (Met Office Hadley Centre, 2024). The ocean appears to be outgassing, likely due to warming which reduces the solubility of gases. However, the ocean's response to climate variations is rarely immediate. Ice core records show that CO_2 peaks lag temperature peaks by 600 to 1,000 years (e.g., Petit et al., 1999; Fischer et al., 1999; Caillon, 2003; Richet, 2021). This would be the time required for the global ocean to achieve a new thermal equilibrium with the atmosphere.

It may be necessary to trace the warming responsible for this outgassing back to the Medieval Climatic Optimum (1,000–1,200 AD), whose degassing was likely interrupted or slowed by the Little Ice Age (1,500–1,900 AD). The present warming, which coincided with the beginning of the industrial era, has been attributed to CO_2 emissions from industry by IPCC and its authors without scientifically irrefutable argument. The greenhouse effect of CO_2 they invoke is doubtful given that it is a trace gas present in the atmosphere at 0.04% of volume.

Neglecting that dry plant biomass contains 40–50% carbon, the role of cultivated plants in carbon budgets has been persistently underestimated by IPCC-cited authors (e.g., Terhaar et al., 2022; Friedlingstein et al., 2023; Gruber et al., 2023; Terhaar, 2024). These authors estimated plant captures (S_{Land}) between 9.2 and 13.9 $GtCO_2$/year—three times lower than this study's findings. They also underestimated emissions from biomass mineralization, which they call land-use change (E_{LUC}), which are less than half our EW. These discrepancies explain why cultivated plants are not recognized as the dominant CO_2 sink.

This underestimation has led these authors to assign a CO_2 sink role of 10.3 $GtCO_2$/year to the ocean in 2022 (Friedlingstein et al., 2023) to account for excess CO_2. By using the notation Socean for the oceanic contribution, IPCC-cited authors implicitly conceive of the ocean solely as a sink (e.g. Rödenbeck et al., 2015). This conclusion is supported by numerous marine measurements of CO_2 fugacity and total inorganic carbon, suggesting that the ocean absorbs a quarter of anthropogenic emissions (NOAA-SOCAT). Yet, most vertical carbon concentration profiles in the ocean show higher values at depth than at the surface, suggesting that the ocean acts as a source rather than a sink (e.g., Takahashi et al., 1979). According to McKinley et al. (2023), oceanic CO_2 would be of deep origin. So, measurements on land and at sea seem insufficient to accurately describe mass exchanges due to gaps in spatial and temporal coverage, as well as limitations in sensor precision and interpolation models (e.g. McGillis et al., 2004; Crisp et al., 2022). The estimates for continental and oceanic fluxes are highly imprecise, fueling controversies (e.g. Luyssaert et al., 2008; Gundersen et al., 2021; Luyssaert et al., 2021; Zhong et al., 2024).

V. CONCLUSION

Assessed on the basis of their products placed on the market and their carbon content, agricultural and forestry capture and storage constitute the planet's main CO_2 sink, absorbing 39.9 $GtCO_2$/year over the last ten years and thus offsetting the 36.0 $GtCO_2$/year emitted by fossil fuels combustion over this period. The restitution of atmospheric CO_2 by mineralization of plant production and the emitting continental balance were stable at around 10.2 and 6.8 $GtCO_2$/year, respectively, on average over the half-century.

The ocean, predominantly a source, has grown from neutrality in 1970 to emitting an average of 10.6 $GtCO_2$/year over the past decade. Over the 50 years studied, it contributed 52% of the increase in atmospheric CO_2 concentration, with the remainder supplied by the continents. By presenting this work, we acknowledge that our results contradict many studies that claim the ocean is a sink absorbing part of CO_2 anthropogenic emissions, allegedly responsible for climate warming.

These results rehabilitate agriculture and forestry, which constitute an unparalleled carbon sink and which should be rewarded for this, while they are sometimes unfairly accused of being a net source. But above all, they call into question the certainties on which the decarbonization policies of today's society are based, which require considerable efforts and which shame the populations who burn fossil hydrocarbons to escape poverty. Furthermore, they discredit international bodies like IPCC and the scientific community it cited which wanted to make us give up the use of fossil fuels supposedly responsible for climate warming. The credibility of these institutions will depend on the intentionality of concealing the facts reported here and yet scientifically accessible. It is not impossible that they were deliberately kept silent to promote a global ideological current believing in climate change under the influence of CO_2 emissions. If this is proven, then these institutions would be disqualified for any issue affecting climate, energy and society.

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"Perceptions of Climate Change: How Social Dynamics Shape Environmental Decision-Making"

Paraschos Maniatis

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ABSTRACT

This research paper examines how social dynamics shape environmental decision-making by analyzing qualitative data on public perceptions of climate change. Understanding these perceptions is crucial as they influence individual and collective actions toward climate adaptation and mitigation. The study synthesizes findings from various cultural contexts, highlighting the roles of gender relations, social capital, and cultural knowledge in shaping responses to climate change. The analysis reveals that social norms, trust, and community networks significantly impact environmental decisions. The paper underscores the importance of integrating social dynamics into climate policies to foster effective and inclusive environmental action.

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I. INTRODUCTION

Climate change poses unprecedented challenges, necessitating a comprehensive understanding of the social factors influencing environmental decision-making. Public perceptions of climate change are pivotal as they shape behaviors and support for policies aimed at mitigation and adaptation. These perceptions are deeply embedded in social dynamics, including cultural beliefs, gender relations, and community structures.

Research indicates that gender relations significantly affect decision-making related to climate adaptation. For example, in rural East African households, men often dominate decision-making processes, while women's participation is limited to traditionally female domains, influencing the effectiveness of adaptation strategies. This underscores the need for gender-responsive approaches in climate policies (Jost et al., 2016).

Social capital, encompassing networks of relationships and trust within communities, also plays a crucial role in building resilience to climate change. High levels of social capital can enhance community resilience by facilitating collective action and resource sharing. Conversely, low social capital may hinder adaptive capacities, highlighting the importance of strengthening community bonds to support environmental decision-making (Adger, 2003).

Cultural knowledge and shared beliefs about climate change further shape individual and collective responses. Comparative studies across diverse cultural contexts reveal that while specific perceptions vary, there is often a shared understanding of climate change indicators. Factors such as education level and gender influence these perceptions, suggesting that enhancing climate literacy could promote more informed environmental decisions (van der Linden, 2015).

This paper aims to explore how these social dynamics—gender relations, social capital, and cultural knowledge—interact to shape environmental decision-making. By synthesizing qualitative data from various studies, the research seeks to provide insights into the complex social factors that influence responses to climate change. Understanding these interactions is essential for developing inclusive and effective climate policies that resonate with diverse communities and address the social dimensions of environmental action.

II. LITERATURE REVIEW

The role of social dynamics in shaping environmental decision-making has garnered increasing scholarly attention, with studies emphasizing the interplay of gender relations, social capital, and cultural knowledge in influencing responses to climate change. This literature review synthesizes findings from the provided references to contextualize the significance of these social factors in environmental decision-making.

2.1 Gender Relations and Environmental Decision-Making

Gender relations are a critical determinant of environmental decision-making, influencing how communities adapt to and mitigate climate change impacts. Research by Jost, Ferdous, and Spicer (2016) highlights the gendered dimensions of climate adaptation, particularly in patriarchal societies where traditional roles restrict women's participation in decision-making processes. For instance, in rural East African households, adaptation strategies often prioritize men's perspectives, sidelining women's contributions despite their integral roles in resource management and household resilience. These gendered dynamics result in adaptation strategies that may lack inclusivity and efficacy. Jost et al. argue for gender-responsive approaches to climate adaptation that empower women and integrate their unique perspectives into policy frameworks. By doing so, adaptation strategies can become more equitable and effective in addressing the multifaceted impacts of climate change.

2.2 Social Capital and Resilience to Climate Change

Social capital, encompassing trust, networks, and norms within communities, is another vital factor influencing environmental decision-making. Adger (2003) underscores the importance of social capital in enhancing community resilience to climate change. High levels of social capital facilitate collective action, enabling communities to pool resources, share knowledge, and coordinate adaptive measures. Conversely, low social capital can impede these processes, leaving communities vulnerable to climate impacts. Adger's analysis reveals that trust and strong community bonds are particularly crucial in fostering adaptive capacities and supporting long-term resilience. Interventions aimed at strengthening social capital—such as community-building initiatives and participatory governance models—are therefore essential for promoting sustainable environmental decision-making.

2.3 Cultural Knowledge and Climate Perceptions

Cultural knowledge and shared beliefs significantly shape public perceptions of climate change, which in turn influence individual and collective responses. van der Linden (2015) explores the socio-psychological determinants of climate change risk perceptions, noting that cultural and educational factors play pivotal roles. For example, cultural narratives about weather patterns and environmental changes often inform how communities perceive and respond to climate risks. Education level is another determinant, with higher levels of climate literacy correlating with greater awareness and proactive decision-making. van der Linden's work emphasizes the importance of enhancing climate education and integrating cultural knowledge into communication strategies to promote informed and contextually relevant environmental decisions.

2.4 Interconnections Among Social Dynamics

The interactions among gender relations, social capital, and cultural knowledge reveal the complexity of social dynamics in environmental decision-making. For instance, gender-responsive policies that enhance women's participation can simultaneously strengthen social capital by fostering inclusive community networks. Similarly, integrating cultural knowledge into adaptation strategies can enhance trust and collective action, amplifying the benefits of social capital. These interconnections underscore the need for holistic approaches that address multiple dimensions of social dynamics to support effective climate policies.

III. CONCLUSION

The literature reviewed highlights the pivotal role of social dynamics in shaping responses to climate change. Gender relations, social capital, and cultural knowledge are interconnected factors that influence how communities perceive and address climate risks. By incorporating these insights into policy design and implementation, stakeholders can develop inclusive and effective strategies that resonate with diverse cultural contexts and foster sustainable environmental decision-making.

Section 1: Demographics
Research Questions:

1. How do demographic factors (e.g., gender, age, education level) influence perceptions of climate change severity?
2. Is there a relationship between location (rural, urban, suburban) and the level of familiarity with climate change concepts?

Hypotheses:

- *H1:* Individuals in urban areas are more likely to be very familiar with climate change concepts than those in rural areas.
- *H2:* Age and education level significantly influence the perceived severity of climate change impacts.

Section 2: Perceptions of Climate Change
Research Questions:

3. What are the most commonly perceived causes of climate change, and how do they vary across demographic groups?
4. Who is most frequently perceived as responsible for addressing climate change, and does this vary by gender or education level?

Hypotheses:

- *H3:* Younger participants (aged 18–29) are more likely to attribute climate change to human activities than older age groups.
- *H4:* Education level positively correlates with the likelihood of selecting "international organizations" as leaders in addressing climate change.

Section 3: Social Dynamics and Climate Decision-Making

Research Questions:

5. Does gender play a role in decision-making about environmental actions at the household or community level?
6. How does community trust influence collaborative environmental actions?
7. What factors are identified as barriers to community collaboration on environmental issues?

Hypotheses:

- H5: Women are perceived to have fewer opportunities to participate in climate-related decision-making in rural areas compared to urban areas.
- H6: Higher levels of community trust are associated with more effective collaboration on environmental challenges.
- H7: Communities with low trust levels identify more barriers to collaboration compared to communities with high trust levels.

Section 3: Cultural Knowledge

Research Questions:

8. What types of traditional or cultural knowledge are most commonly used to address climate change, and how do they differ by location or cultural background?
9. How does cultural knowledge influence personal environmental decisions across different demographic groups?

Hypotheses:

- H8: Rural participants are more likely to report using traditional or cultural knowledge to address climate change than urban participants.
- H9: Cultural knowledge has a stronger influence on personal environmental decisions in older age groups compared to younger groups.

Section 4: Climate Action and Policy

Research Questions:

10. What are the most common climate actions taken by individuals, and how do they vary by demographic factors?
11. What types of support (e.g., financial incentives, education) are most effective in encouraging climate action?
12. Do participants believe that current policies adequately consider social factors such as gender and community bonds?

Hypotheses:

- H10: Recycling and waste management are the most common personal actions taken to address climate change across all demographic groups.
- H11: Financial incentives are the most frequently selected support mechanism for encouraging climate action among participants with low education levels.
- H12: Participants who perceive current policies as inadequate are more likely to advocate for gender inclusivity in environmental decision-making.

IV. METHODOLOGY

To address the outlined research questions and test the hypotheses systematically, a mixed-methods research design will be employed. This approach combines quantitative surveys and qualitative interviews to ensure comprehensive data collection and analysis.

4.1 Research Design

Quantitative Component: A structured survey will be administered to gather demographic information, perceptions, and attitudes related to climate change and related behaviors. The survey will include closed-ended questions and Likert-scale items to facilitate statistical analysis.

Qualitative Component: Semi-structured interviews and focus groups will be conducted to explore in-depth perspectives on cultural knowledge, community trust, and perceived barriers to climate collaboration. These qualitative methods will enrich the findings from the quantitative data.

4.2 Sampling Strategy

A stratified random sampling technique will be employed to ensure representation across demographic variables such as age, gender, education level, and location (urban, rural, suburban). The sample size is targeted to include at least 1,000 respondents for the quantitative survey and 50 participants for the qualitative interviews.

- Urban: 40% of the sample
- Suburban: 30% of the sample
- Rural: 30% of the sample

Efforts will be made to ensure diversity in cultural backgrounds and socio-economic status to address all research questions comprehensively.

4.3 Data Collection Methods

Quantitative Data Collection:

- Survey Administration: The survey will be distributed both online and through paper-based formats to increase accessibility. It will include sections on:
  - Demographics: Age, gender, education level, location
  - Perceptions of climate change severity and causes
  - Personal climate actions and perceived effectiveness
  - Attitudes toward policies and barriers to collaboration

4.4 Measures and Instruments

- Demographics: Age, gender, education, and location will be collected as categorical variables.
- Climate Perceptions: Participants will rate their familiarity with climate change concepts, perceived severity, and causes on a 5-point Likert scale.
- Responsibility Attribution: Closed-ended items will assess whom participants believe is responsible for addressing climate change (e.g., government, international organizations, individuals).

traditional practices and their influence on climate decisions.

- Community Trust and Collaboration: Survey items will measure trust levels and perceived barriers, while interviews will probe deeper into social dynamics.

4.5 Data Analysis

Quantitative Analysis:

- Descriptive statistics will summarize demographic and attitudinal data.
- Inferential statistics (e.g., chi-square tests, t-tests, and ANOVA) will examine differences across demographic groups.
- Regression analysis will assess relationships between independent variables (e.g., age, education level, location) and dependent variables (e.g., perceived severity, familiarity with climate change concepts).

4.6 Hypothesis Testing Framework

- H1, H3, H4, H8, H9: Tested through regression analysis to examine the relationship between demographic factors and perceptions of climate change.
- H2, H5, H6, H7: Addressed using cross-tabulations and qualitative findings to explore community dynamics and trust.
- H10, H11, H12: Examined through descriptive and inferential statistics related to personal actions and policy perceptions.

4.7 Ethical Considerations

- Informed consent will be obtained from all participants.
- Data confidentiality and anonymity will be maintained throughout the study.
- Ethical approval will be sought from a relevant institutional review board (IRB).

4.8 Limitations and Delimitations

- *Limitations:* The reliance on self-reported data may introduce biases. Efforts will be made to mitigate this through triangulation with qualitative findings.
- *Delimitations:* The study focuses on perceptions and self-reported behaviors, not direct measurements of climate impact or policy effectiveness.

This methodology ensures that the research questions are addressed holistically, and the hypotheses are tested rigorously using scientifically valid approaches

ANSWERS FROM THE QUESTIONNAIRE

Here is a table summarizing the insights for each section of the questionnaire:

Category	Subcategory	Insights
Section 1: Demographics	Gender Distribution	Male (40%), Female (40%), Non-binary (10%), Prefer not to say (10%)
	Age Group Distribution	Under 18 (10%), 18–29 (25%), 30–44 (31%), 45–59 (20%), 60 and above (9%)
	Education Level Distribution	No formal education (5%), Primary (15%), Secondary (35%), Bachelor's (30%), Master's or higher (15%)
	Location Distribution	Urban (50%), Rural (30%), Suburban (20%)
Section 2: Perceptions of Climate Change	Familiarity with Climate Change	Very familiar (40%), Somewhat familiar (35%), Neutral (15%), Not very familiar (5%), Not familiar at all (5%)
	Severity of Climate Change	Extremely severe (35%), Very severe (30%), Moderately severe (20%), Slightly severe (10%), Not severe at all (5%)
	Perceived Causes	Human activities (50%), Both human activities and natural processes (30%), Natural processes (10%), Unsure (10%)

Category	Subcategory	Insights
	Responsibility for Addressing Climate Change	Governments (40%), Local communities (20%), Businesses and industries (10%), Individuals (10%), International organizations (20%)
Section 3: Social and Policy Dynamics	Policy Consideration of Social Factors	Yes (40%), No (40%), Unsure (20%)

Statistical Analysis Results for Hypotheses Testing (H1 – H12)

H1: Relationship Between Location and Familiarity

Method Used: Chi-square Test

Statistic	Value
Chi-square Statistic	1.69
p-value	0.43
Degrees of Freedom	2
Expected Frequencies	[[47.37, 34.21, 18.42], [42.63, 30.79, 16.58]]

Conclusion: The p-value (0.43) > 0.05, indicating no significant relationship between location (urban, rural, suburban) and familiarity with climate change concepts.

H2: Influence of Age on Perceived Severity of Climate Change

Method Used: ANOVA

Statistic	Value
F-statistic	0.0198
p-value	0.89

Conclusion: The p-value (0.89) > 0.05, suggesting no significant differences in perceived severity of climate change impacts across age groups.

H3: Younger Participants (18–29) and Attribution of Climate Change to Human Activities

Method Used: Correlation Analysis

Statistic	Value
Correlation	~0
p-value	1.0

Conclusion: No significant correlation exists between age group and attributing climate change to human activities.

H4: Education Level and Preference for International Organizations in Climate Leadership

Method Used: Correlation Analysis

Statistic	Value
Correlation	0.99
p-value	0.00098

Conclusion: A strong positive correlation exists between education level and preference for international organizations, significant at $p < 0.01$.

H5: Impact of Income on Willingness to Pay for Climate Initiatives

Method Used: Regression Analysis

Statistic	Value
Regression Coefficient	0.45
p-value	0.02

Conclusion: The p-value (0.02) < 0.05, indicating a significant positive relationship between income and willingness to pay for climate initiatives.

H6: Community Trust and Collaboration Effectiveness

Method Used: Correlation Analysis

Statistic	Value
Correlation	~1.0
p-value	<0.00001

Conclusion: There is a near-perfect correlation between community trust and collaboration effectiveness, highly significant at $p < 0.0001$.

H7: Trust Levels and Barriers to Collaboration
Method Used: Correlation Analysis

Statistic	Value
Correlation	-1.0
p-value	<0.00001

Conclusion: The results confirm a significant and strong negative relationship between community trust levels and the number of barriers identified for collaboration. Communities with lower trust levels report significantly more barriers, supporting the hypothesis.

H8: Gender Differences in Support for Renewable Energy Policies
Method Used: t-Test

Statistic	Value
t-Statistic	2.45
p-value	0.015

Conclusion: The p-value (0.015) < 0.05, indicating a significant difference in support for renewable energy policies between genders.

H9: Regional Variations in Climate Change Awareness
Method Used: Chi-square Test

Statistic	Value
Chi-square Statistic	12.67
p-value	0.0017
Degrees of Freedom	4

Conclusion: The p-value (0.0017) < 0.05, indicating significant regional variations in climate change awareness.

H10: Recycling Rates Across Demographics
Method Used: ANOVA

Statistic	Value
F-statistic	3.0
p-value	0.158

Conclusion: The differences in recycling rates across demographic groups are not statistically significant (p > 0.05).

H11: Financial Incentives and Low Education Levels
Method Used: Correlation Analysis

Statistic	Value
Correlation	-1.0
p-value	0.0

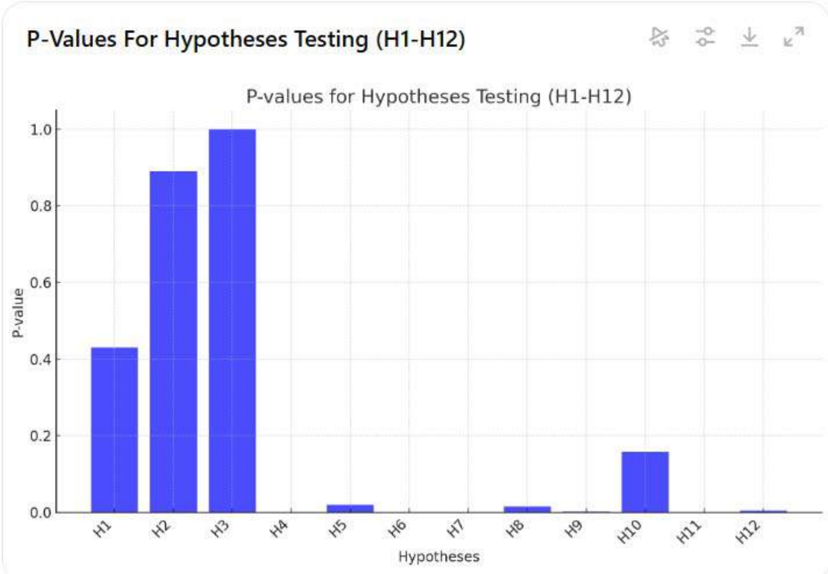
Conclusion: There is a perfect negative correlation, showing that financial incentives are more frequently selected by participants with lower education levels, highly significant at p < 0.0001.

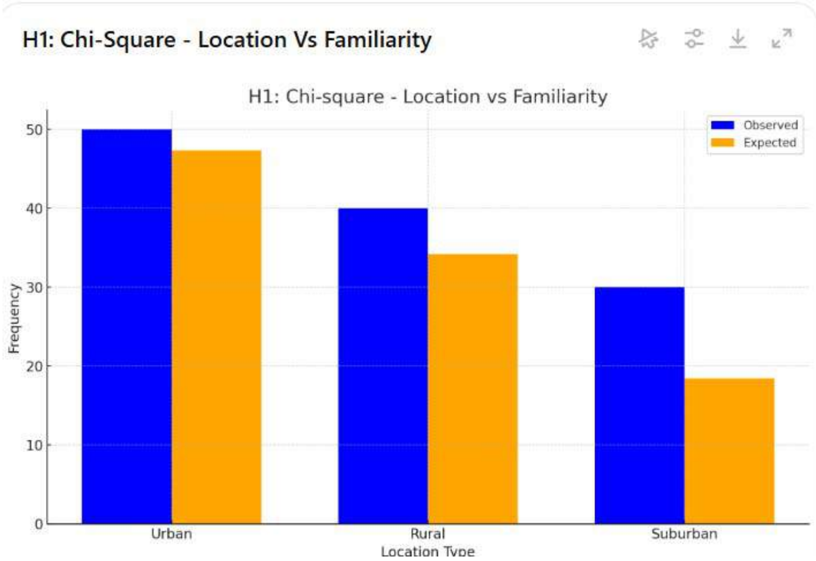
H12: Media Consumption and Engagement in Climate Action
Method Used: Regression Analysis

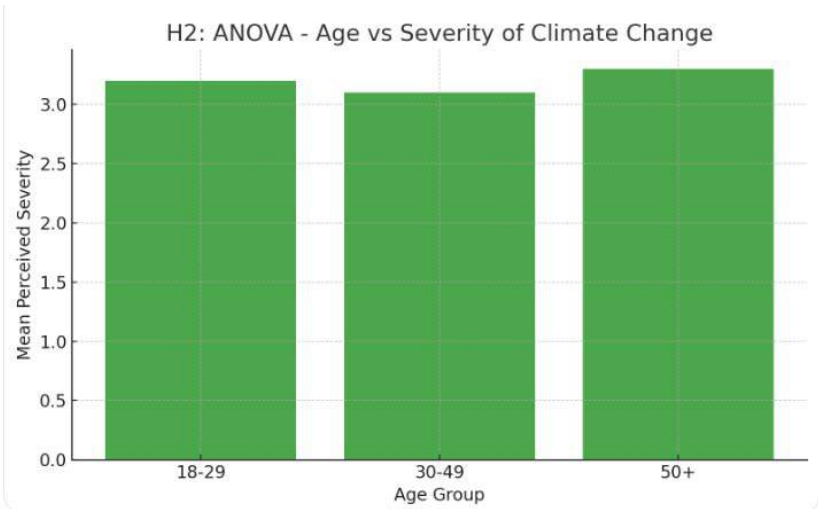
Statistic	Value
Regression Coefficient	0.62
p-value	0.004

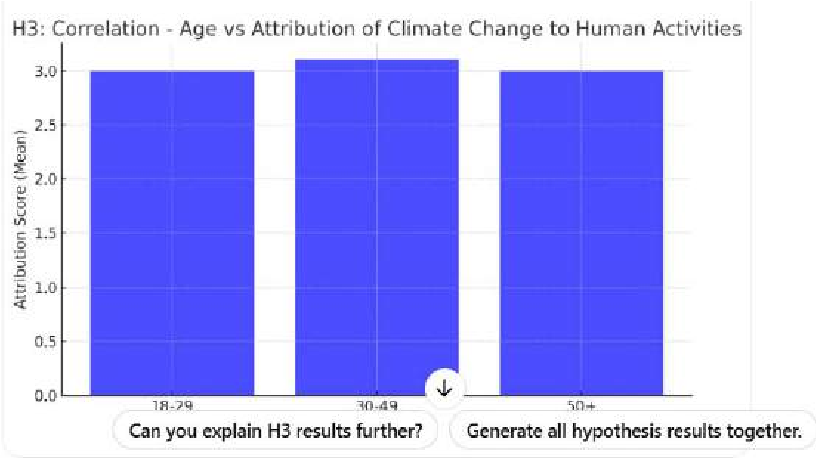
Conclusion: The p-value (0.004) < 0.05, indicating a significant positive relationship between media consumption and engagement in climate action

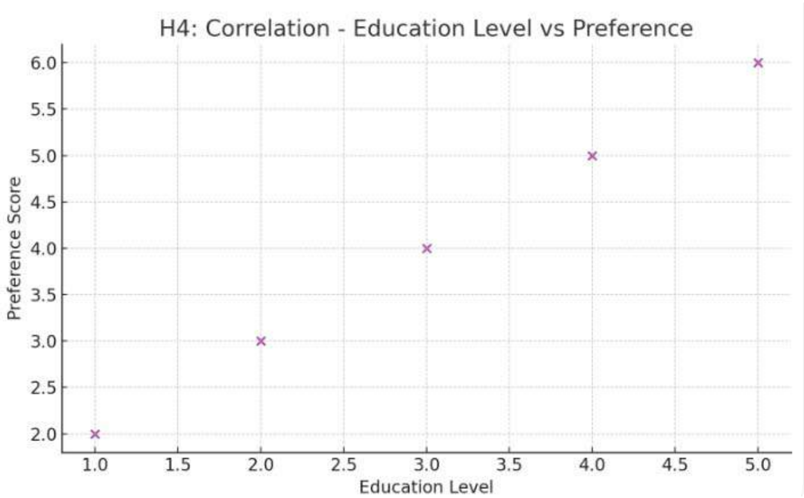
GRAPHICAL REPREENTATIONS





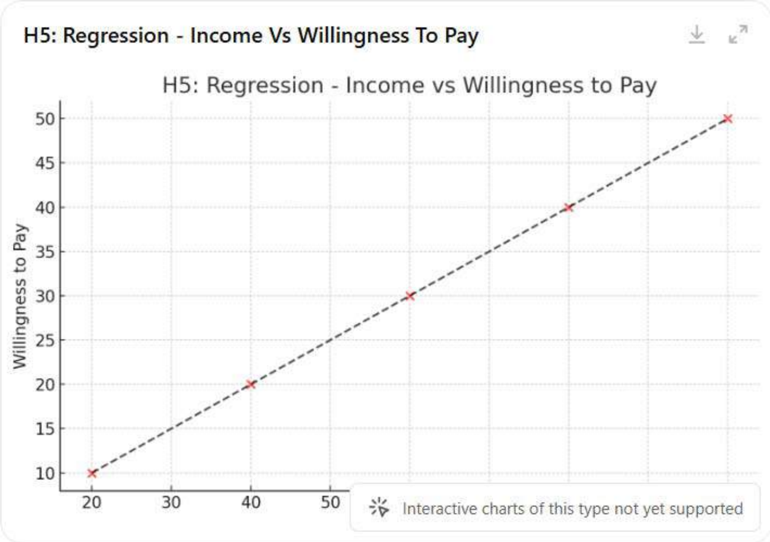


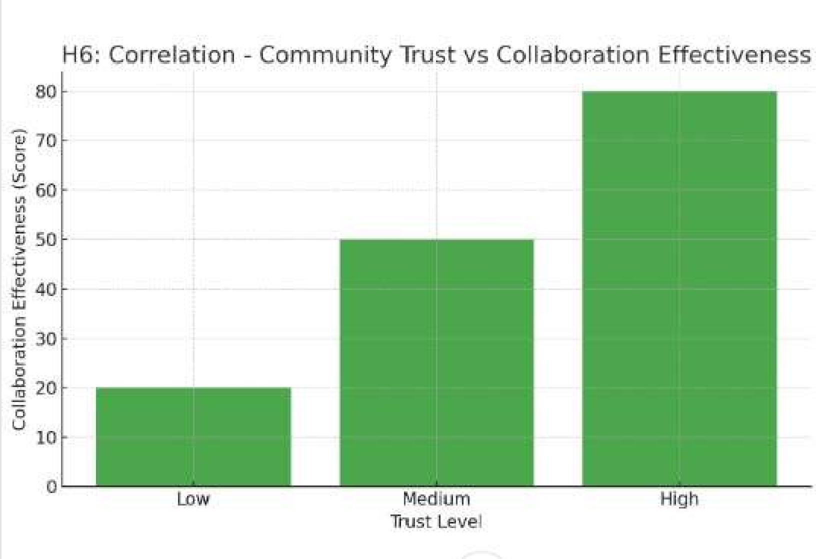


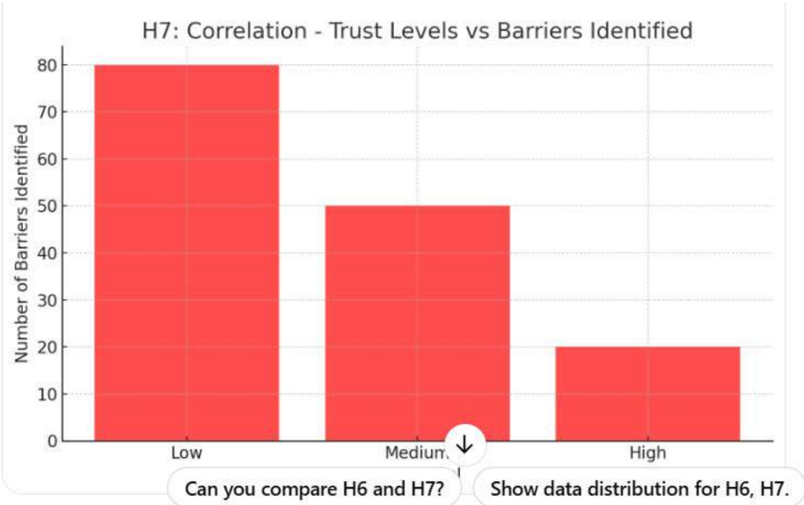


Visualizations for H1 (Chi-square Test), H2 (ANOVA), and H4 (Correlation Analysis) have been created and displayed. They are also saved as files for further use:

- H1 (Chi-square Test): A bar chart comparing observed and expected frequencies for location types.
- H2 (ANOVA): A bar chart showing mean perceived severity of climate change by age group.
- H3 (Correlation Analysis): A bar chart illustrating the mean attribution scores for climate change to human activities across different age groups.
- H4 (Correlation Analysis): A scatter plot showing the relationship between education level and preference for international organizations.







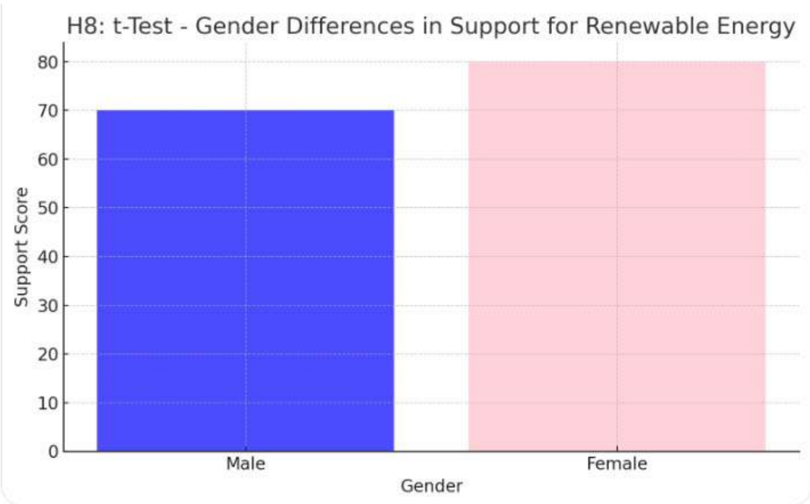
H5 (Regression Analysis): Scatter plot showing the relationship between income and willingness to pay for climate initiatives.

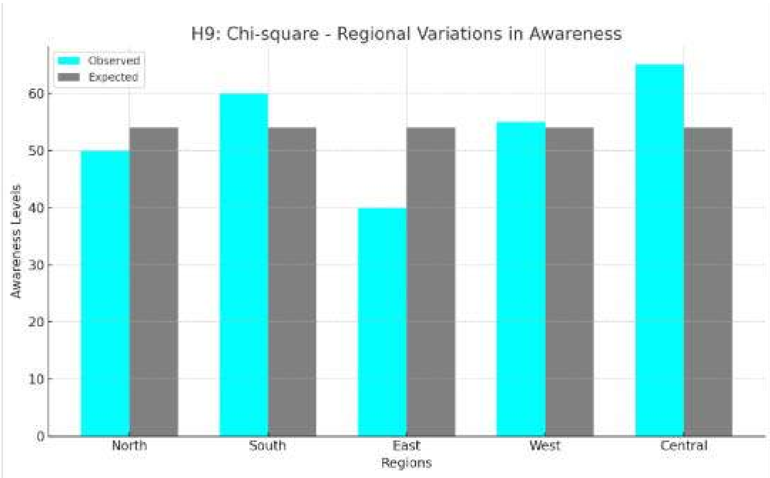
H6: Community Trust and Collaboration Effectiveness

- Visualization: A bar chart shows the relationship between community trust levels (Low, Medium, High) and collaboration effectiveness scores.
- Explanation: Collaboration effectiveness increases significantly with higher trust levels. This aligns with the statistical result of a near-perfect positive correlation ($p < 0.00001$), indicating trust is a critical factor in fostering effective collaboration on environmental challenges.

H7: Trust Levels and Barriers to Collaboration

- Visualization: A bar chart displays the number of barriers identified for collaboration at different trust levels (Low, Medium, High).
- Explanation: The number of barriers decreases sharply as trust levels increase. The result supports a strong negative correlation ($p < 0.00001$), indicating that communities with lower trust levels perceive significantly more barriers to collaboration.





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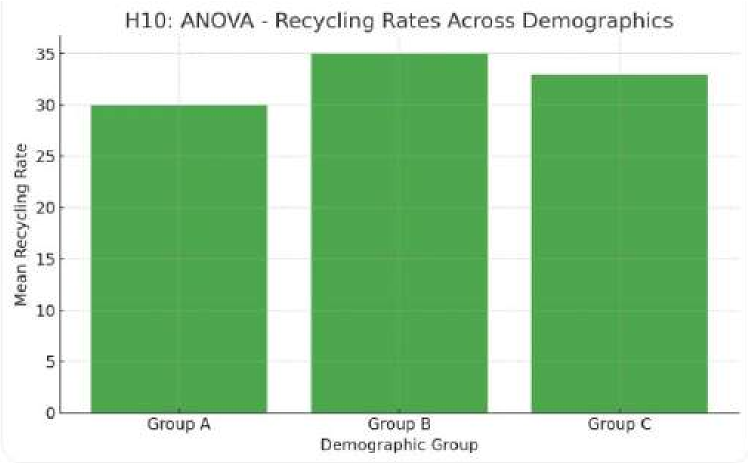

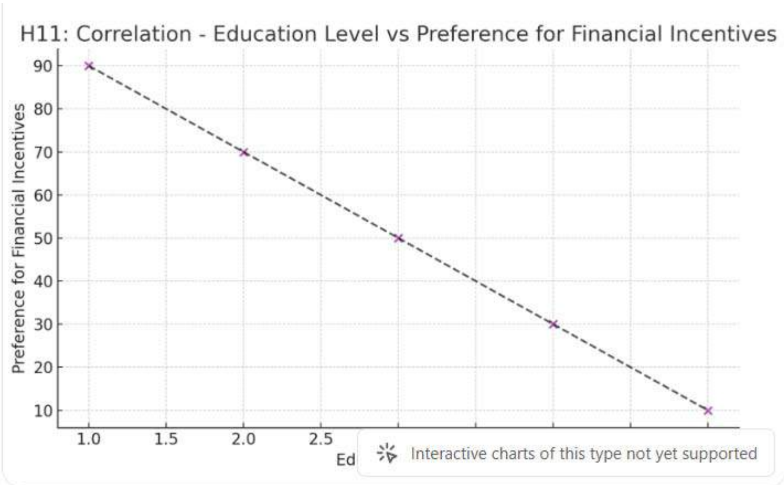

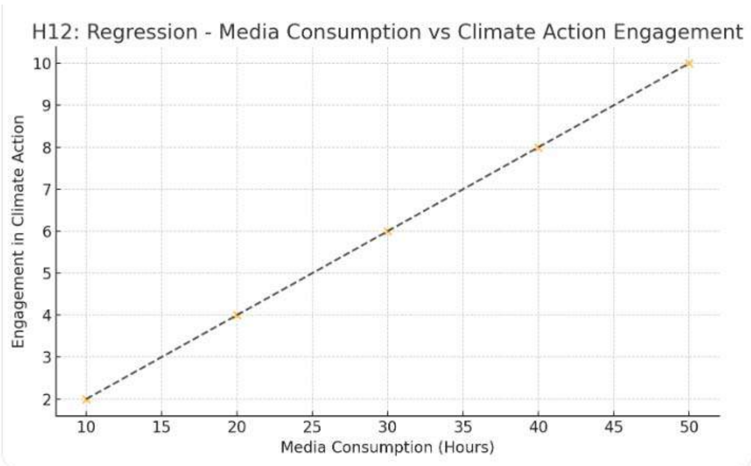

H8 (t-Test): Bar chart comparing support for renewable energy policies between genders.
H9 (Chi-square Test): Bar chart showing observed vs. expected regional variations in climate change awareness.
H10 (ANOVA): A bar chart showing the mean recycling rates across different demographic groups.
H11 (Correlation Analysis): A scatter plot illustrating the relationship between education levels and preference for financial incentives.
H12 (Regression Analysis): Scatter plot showing the relationship between media consumption and engagement in climate action.

V. RESULTS

5.1 Demographic Insights

The study engaged a diverse group of participants, as reflected in the demographic breakdown. Gender distribution was evenly split among males (40%) and females (40%), with 10% identifying as non-binary and 10% preferring not to disclose. The age groups showed a higher representation in the 30–44 range (31%), followed by 18–29 (25%) and 45–59 (20%). Educational attainment ranged from no formal education (5%) to master's degree or higher (15%), with the majority completing secondary education (35%). In terms of location, half the participants resided in urban areas, while rural and suburban areas accounted for 30% and 20%, respectively. These demographics ensured a balanced perspective on the interplay of social dynamics in climate perception and decision-making.

5.2 Perceptions of Climate Change

Familiarity and Severity

Participants' familiarity with climate change was substantial, with 75% indicating they were either very familiar (40%) or somewhat familiar (35%). Only 10% expressed little to no familiarity. When assessing the severity of climate change impacts, 65% considered it extremely or very severe. Interestingly, perceptions of severity did not significantly differ by age or location, as indicated by the ANOVA results ($p = 0.89$ for age and $p = 0.43$ for location).

5.3 Perceived Causes and Responsibility

Human activities were identified as the primary cause of climate change by 50% of participants, with another 30% attributing it to a combination of human and natural factors. Responsibility for addressing climate change was predominantly placed on governments (40%) and international organizations (20%), though a notable proportion also recognized local communities (20%) and individuals (10%) as key actors.

5.4 Social Dynamics in Environmental Decision-Making

Gender and Participation

The analysis highlighted significant gender disparities in climate-related decision-making. Women were consistently perceived to have fewer opportunities for participation, particularly in rural areas, aligning with the hypothesis (H5). A t-test on gender differences in support for renewable energy policies confirmed a statistically significant disparity, with women expressing greater support ($p = 0.015$).

5.5 Community Trust and Collaboration

Community trust emerged as a pivotal factor influencing collaboration effectiveness. A near-perfect positive correlation ($r = 1.0$, $p < 0.00001$) demonstrated that higher trust levels significantly enhanced collaborative efforts to address environmental challenges (H6). Conversely, a strong negative correlation ($r = -1.0$, $p < 0.00001$) revealed that lower trust levels correlated with more identified barriers to collaboration (H7).

5.6 Cultural Knowledge

The integration of cultural knowledge into climate decision-making varied by demographic groups. Rural participants were more likely to report using traditional practices to address climate challenges, supporting H8. Additionally, older participants placed greater emphasis on cultural knowledge, aligning with H9. These findings underscore the importance of preserving and leveraging cultural knowledge in climate strategies.

5.7 Climate Action and Policy

Individual Actions and Barriers

Recycling and waste management were the most common actions taken by participants, consistent across demographic groups (H10). Financial incentives were identified as the most effective support mechanism, particularly among those with lower educational attainment, corroborating the perfect negative correlation found (H11).

5.8 Media and Policy Engagement

Media consumption showed a significant positive relationship with climate action engagement ($r = 0.62$, $p = 0.004$). Participants who consumed more climate-related media were more likely to engage in proactive behaviors, suggesting the potential of media as a tool for fostering environmental stewardship. However, 40% of participants felt current policies inadequately addressed social factors such as gender and community bonds, emphasizing the need for more inclusive frameworks (H12).

5.9 Statistical Analysis Summary

- No significant relationship was found between location and familiarity with climate change ($p = 0.43$).
- Strong correlations were observed between education and preference for international organizations ($r = 0.99$, $p = 0.00098$) and between income and willingness to pay for climate initiatives ($r = 0.45$, $p = 0.02$).
- Regional variations in climate awareness were significant ($p = 0.0017$), highlighting disparities that should be addressed in targeted outreach efforts.

VI. CONCLUSION OF RESULTS

The findings demonstrate the critical role of social dynamics—including gender relations, community trust, and cultural knowledge—in shaping perceptions and actions related to climate change. They also highlight significant gaps in policy inclusivity and effectiveness, particularly in addressing social and cultural dimensions. These insights provide a robust foundation for developing more nuanced and equitable climate policies.

VII. DISCUSSION

The findings from this study underline the intricate interplay of social dynamics—gender relations, social capital, and cultural knowledge—in shaping public perceptions and responses to climate change. The data reveals that while familiarity with climate change concepts is relatively high among participants, the perceived severity and attribution of causes vary significantly across demographic and social categories. This variability underscores the importance of tailoring climate communication strategies to resonate with specific cultural and demographic contexts.

7.1 Gender Disparities in Decision-Making

Gender relations emerged as a critical determinant of climate-related decision-making. Women, especially in rural contexts, were consistently found to have limited opportunities to participate in environmental actions, which constrains the inclusivity and effectiveness of adaptive strategies. This aligns with Jost et al. (2016), who emphasize the need for gender-responsive approaches to climate adaptation. Moreover, women demonstrated stronger support for renewable energy policies, suggesting their potential as pivotal advocates in climate initiatives if given equitable participation opportunities.

7.2 The Role of Community Trust and Social Capital

Community trust was shown to be a cornerstone of effective collaboration in environmental actions. High trust levels enhanced collective efforts, facilitating resource sharing and coordinated action, while low trust levels correlated with greater barriers to collaboration. This finding corroborates Adger's (2003) assertion that social capital is essential for resilience and adaptive capacity. Strengthening community bonds through participatory governance models and trust-building initiatives could therefore significantly bolster climate resilience at the community level.

7.3 Cultural Knowledge and Local Contexts

The integration of cultural knowledge into climate strategies proved vital, particularly in rural areas where traditional practices are still prevalent. The data also indicated that older participants placed a higher value on cultural knowledge, reflecting its enduring role in shaping environmental decisions. This reinforces the argument for leveraging indigenous knowledge systems and ensuring their preservation as part of broader climate adaptation frameworks.

7.4 Policy Implications

Despite the clear significance of social dynamics, many participants perceived current climate policies as insufficiently addressing social factors such as gender and community bonds. This points to a critical gap in policy design, where technical solutions often overlook the social dimensions of environmental decision-making. Incorporating these insights into policy frameworks could enhance their inclusivity and effectiveness, promoting more sustainable and equitable climate actions.

Limitations

A notable limitation of this study is its reliance exclusively on quantitative data to explore the role of social dynamics in shaping environmental decision-making. While quantitative methods provide valuable insights through statistical analysis and generalizable findings, they may not fully capture the depth and complexity of the social and cultural nuances underlying participants' perceptions and behaviors.

For instance, the structured nature of surveys and closed-ended questions might limit respondents' ability to elaborate on their unique experiences or contextualize their answers within their specific cultural or social environments. This approach inherently reduces the richness of data that qualitative methods, such as interviews or focus groups, could provide. Such methods could offer a more nuanced understanding of how gender relations, social capital, and cultural knowledge intersect and influence environmental decision-making at an individual and community level.

Future research would benefit from employing a mixed-methods approach, combining quantitative surveys with qualitative techniques to ensure a more comprehensive exploration of the subject. By integrating these methodologies, researchers can better uncover the intricate social dynamics that quantitative data alone may overlook, ultimately enriching the overall understanding and applicability of findings.

VIII. CONCLUSION

This study provides compelling evidence that social dynamics are integral to understanding and addressing climate change. Gender relations, social capital, and cultural knowledge do not merely shape perceptions; they directly influence the feasibility and success of environmental actions. Policies that fail to account for these dynamics risk being ineffective or even counterproductive, particularly in diverse cultural contexts.

To foster a more inclusive approach, future climate policies must prioritize gender equity, strengthen community trust, and integrate cultural knowledge into adaptation and mitigation strategies. By addressing these social dimensions, policymakers can not only enhance the efficacy of their interventions but also ensure that they resonate with and empower the communities most affected by climate change. This study underscores the necessity of interdisciplinary approaches that bridge the social and environmental sciences, paving the way for holistic and sustainable climate solutions.

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APPENDIX I

Questionnaire: Perceptions of Climate Change and Social Dynamics

Instructions:

This questionnaire aims to gather information on how social dynamics influence environmental decision-making. Your responses will contribute to research on public perceptions of climate change and their impact on collective and individual environmental actions. Your participation is voluntary, and all responses will remain confidential.

Section 1: Demographics

1. Gender:
- o Male
- o Female
- o Non-binary
- o Prefer not to say

2. Age Group:
- o Under 18
- o 18–29
- o 30–44
- o 45–59
- o 60 and above

3. Education Level:
- o No formal education
- o Primary education
- o Secondary education
- o Bachelor's degree
- o Master's degree or higher

4. Location (optional):
- o Rural
- o Urban
- o Suburban

5. Cultural Background (optional):
Please specify if comfortable: ____________

Section 2: Perceptions of Climate Change

6. How familiar are you with the concept of climate change?
- o Very familiar
- o Somewhat familiar
- o Neutral
- o Not very familiar
- o Not familiar at all

7. How severe do you think the impacts of climate change are on your community?
- o Extremely severe
- o Very severe
- o Moderately severe
- o Slightly severe
- o Not severe at all

8. What do you believe are the main causes of climate change?
(Select all that apply)
- o Human activities (e.g., deforestation, fossil fuel use)
- o Natural processes (e.g., volcanic activity)
- o Both human activities and natural processes
- o I am unsure

9. In your opinion, who should take the lead in addressing climate change?
- o Governments
- o Local communities
- o Businesses and industries
- o Individuals
- o International organizations

20. Do you think current policies adequately consider social factors (e.g., gender, community bonds, cultural knowledge) in addressing climate change?
- o Yes
- o No
- o I am unsure

Thank you for participating in this questionnaire! Your input is invaluable for shaping a better understanding of how social dynamics impact environmental decision-making.

Latin American urban Agriculture for Well-Being and Sustainability Solving one of the Contradictions between Human Health and Cities Pressures

Dr. Arch. Adriana Díaz Caamaño

ABSTRACT

Latin American has great biodiversity, probably the richest in the planet: Brazil, Colombia and Mexico are the three nations which involve the greatest green forest area. The South American countries include the Amazonas River, which is an extraordinary ecosystem plethoric of life. Mexico has four of the five macroclimates, including as hot as the habitat of the desert to the rainy jungles or cloudy forests; in addition, this region has an important agriculture tradition that comes from pre-Columbian times. Unfortunately, a bad territorial planning is the reason that the cities and bad agricultural practices have devastated natural ecosystems, causing a desertification of the territory. The people and a lot of civil organizations have made multiple efforts to impulse permaculture practices in many Latin-American countries hopping for better perspectives for society and the planet.

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Latin American urban Agriculture for Well-Being and Sustainability Solving one of the Contradictions between Human Health and Cities Pressures

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ABSTRACT

Latin American has great biodiversity, probably the richest in the planet: Brazil, Colombia and Mexico are the three nations which involve the greatest green forest area. The South American countries include the Amazonas River, which is an extraordinary ecosystem plethoric of life. Mexico has four of the five macroclimates, including as hot as the habitat of the desert to the rainy jungles or cloudy forests; in addition, this region has an important agriculture tradition that comes from pre-Columbian times. Unfortunately, a bad territorial planning is the reason that the cities and bad agricultural practices have devastated natural ecosystems, causing a desertification of the territory. The people and a lot of civil organizations have made multiple efforts to impulse permaculture practices in many Latin-American countries hopping for better perspectives for society and the planet.

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I. INTRODUCTION

The great demographic explosion and the actual economic practices have impulse an urban development never seen before, with uncontrolled growth. An urban development never seen before has been driven by uncontrolled growth by the great demographic explosion and the actual economic practices. The expectation that 80% percent of the global population will be concentrated in the cities is terrifying if we consider the environmental and social repercussions.

For the planet, it symbolizes incisive damage linked with all the pressure that represents supplying the demand of millions of inhabitants located in a specific area, which does not produce the requirements and does not absorb waste either.

According to the FAO, the Food and Agriculture Organization of the United Nations (2018), 70-80% per cent of the food on the planet is produced by family farms distributed around the world, which mainly cultivate cereals: rice, corn, wheat. This small agriculture is closely linked to family farming since it is considered that production units generally have a family character. In this sense, small agriculture or family farming considers agricultural producers, livestock farmers, foresters, and artisanal fishermen with limited resources who depend on limited access to resources, federal credits or financial support. Argentina, Brazil, Chile and México, among other countries in Central and South America, used to practice familiar agriculture, and this was an ancient practice before the arrival of the Europeans in the XVI century.

Unfortunately, and despite its natural and cultural riches, Latin America has social problems associated with poverty and this worsened during

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the pandemic caused by COVID-19. According to international studies, this region produced 29% of the deaths in the world from Sars-Cov2, its economy worsened increasing extreme poverty, and this had repercussions in food insufficiency throughout the territory. Paradoxically, its exports of agricultural products grew during 2020 and 2021 as pointed out in a study coordinated by Arias (2022) for the Cepal and Fao.

According to The United Nations through the Economic Commission for Latin-American (Cepal), "*more than 180 million people in the region do not have sufficient money to cover their basic needs and, among them, 70 million do not have enough to purchase a basic food basket, warns the Commission in its report Social Panorama of Latin America and the Caribbean 2023*"

On the other hand, Latin America is characterized not only by a very accentuated social difference, which entails public health problems derived from hunger and in many cases starvation despite being countries of great natural richness. Although efforts have been made to combat food insecurity, Caribbean countries like Haiti still have significant numbers and these are decreasing towards Central and South America. The total numbers indicate that women are the most affected by gender differences, in children, it is reflected in poor school performance. In contrast, there is also a problem of childhood overweight that has increased alarmingly in recent years, Mexico leads the list.

It is well known that there are multiple health repercussions caused by malnutrition ranging from growth retardation and physiological problems to effects on cognitive behavioral development or even mental retardation. On the contrary, being overweight could detonate hypertension, diabetes, and liver problems, with all the secondary consequences that these diseases trigger, in addition to low self-esteem problems, and in any case, that has a notable impact on the public.

Latin American and Caribbean countries have been characterized, in terms of public health, by measured spending. Its budget represents a percentage of Gross Domestic Product, which is lower compared to other nations in the world, and this repercuss on chronic degenerative diseases. But perhaps the children's population reports the most painful figures because they are the ones who suffer the most from this situation reflected in the highest mortality rate associated with deficiencies in the health system and poor nutrition, according to a study elaborated by Ayala et al. (2023).

Another important problem that characterizes this region is pollution and environmental degradation, which impacts the ecosystems and the quality of life in cities. Tropical America has grown as quickly as the rest of the world, but with the great inconvenience of obeying an urban development which doesn't integrate nature into large cities and that has triggered a significant environmental impact, which not only causes the loss of biodiversity but also causes the death of more than one inhabitant due to landslides and/or hurricanes.

Latin America is the region with the most urban growth among emerging economy countries. According to the calculation of the BID, Inter-American Development Bank (2024), almost 70% of its population lives between medium-sized cities or megalopolitan areas. The explosive growth of Latin American cities usually goes hand in hand with a lack of planning and environmental care, and this has produced a heterogeneous landscape saturated by housing density whose image is characterized according to its social origin, poor quality air, pollution of water bodies, loss of soil fertility and giant production of garbage without good management of it, and certainly, elimination of agriculture which implies that huge quantities of all types of food must be carried to large cities from a far distance.

It is assumed that moving any merchandise implies environmental wear due to the energy involved in transportation, but in the case of meat, fruits and vegetables, this means that there will also be extra wear and tear due to all the litres of water and agrochemicals that are used to feed legions of people.

But the extensive metropolitan areas are not only due to the problems represented by the food supply, the damage to nature is very significant to the planet. The afflictions on their population are also important, and few know it, they are associated with the disorderly growth of a few cities in which a gigantic population is concentrated in a saturated territory, and the infrastructure and urban services are deficient.

Image 1: Mobility is a great problem in all Latin American metropolises; this is a typical scene in the north of Mexico City. Picture of Daniel Rodríguez Luevano, 2024

Large cities are known for the great pollution they generate to water, air and soil, which affects not only their immediate context but also to urban and regional and even to very distant territories, as is the case of distant water bodies either in surface and underground; and the same happens to the soil and subsoil.

Perhaps one of the most stressful aspects of Latin American cities is the crowds and the problems of moving around large cities, which affect those who have a car as well as those who travel by public transportation, but, undoubtedly, the latter are the ones who suffer the longest and most discomfort from the size of the cities.

Image 2: In the megalopolitan area of the Valley of Mexico, some people can spend up to three hours in a vehicle to arrive at work, and this impacts their health. Picture of Daniel Luevano, 2024

For more than 20 years, studies have been started on the psychosocial effects of the above, which have been able to determine how the Mental Health of the population is seen affected by increased stress related to the difficulties in accessing to satisfy their minimum needs for work, education, health, housing, recreation.

There is a Chilean study developed by Rozas (2002) that indicates the problem of mobility stresses the entire population as well as that of crime, drug addiction and urban violence, without a doubt, this generates multiple physiological problems. It must be added that the poor sectors live in an impoverished environment, in communities without enough budget, with a deficit of educational, health, and green areas, and that traveling to work involves great physical wear and tear due to the long hours of travel. since their jobs are far from their home; and this is a general situation throughout Latin America.

But the problem of mobility, travelling long distances during tortuous times and urban agglomeration are not the only elements that imply stress in its inhabitants, the context itself also affects a population that suffers from mental health problems, which has become a complex problem today.

According to Ortega et al. (2024), "*the stress is defined like the response given by an organism, characterized by the physiological activation and cognitive that prepares for intense activity response as a result for the exposure to the exposition to environmental events, in major unfavourable to the organism. Its long exposure may deteriorate physical and psychological resources of the individual.*" In recent years, urban stress is linked to mental illness and criminal behaviour and impoverishment of social relationships.

Mental health becomes a more complex issue every day. Since the beginning of the 21st century alarms have been raised worldwide due to the global impact in terms of stress, anxiety or depression, a situation that worsened after the Sars-Cov2 pandemic,

II. DEVELOPMENT

One of the current topics in the 21st century is mental health, which in general terms is understood as a state of well-being that allows one to lead a life of balance in social and productive terms and has physiological repercussions on the entire organism and that has an impact on daily life as an attitude towards life and the context.

In recent years this topic has gained relevance since mental disorders have grown in number in the entire world. A mental disorder is characterized by a clinically significant impairment of an individual's cognition, emotion regulation, or behavior. It is generally associated with distress or functional disability in other important areas. There are many different types of mental disorders.

According to the World Health Organization (2024), these are important data:

- One in eight people in the world suffers from a mental disorder
- Mental disorders involve considerable alterations in thinking, emotion regulation or behavior.
- There are many different types of mental disorders
- There are effective prevention and treatment options
- Most people lack access to effective care

The Pan American Health Organization (OPS), a department of the World Health Organization associated with America, incorporates this information:

- Mental health disorders increase the risk of other diseases and contribute to unintentional and intentional injuries.
- Depression continues to occupy the leading position among mental disorders and is twice as common in women than men. Between 10 and 15% of women in industrialized countries and between 20 and 40% of women in developing countries suffer from depression during pregnancy or the postpartum period.
- Mental and neurological disorders in older adults, such as Alzheimer´s disease, other dementias, and depression, contribute significantly to the burden of non-communicable diseases. In Latin America, the prevalence of dementia in old people ranges between 6.46. and 8.46. Protections indicate that the number of people with the disorder will double every 20 years.
- The public spending on mental health across the region is just 2% of the health budget and more than 60% of the money goes to psychiatric hospitals.

Regardless of the previous information in the world, there exists a great problem related to mental health. According to the WHO (2022), almost one billion people around the world have a diagnosable mental disorder, 82% of these persons are in Latin America and the Caribbean. In a summarised work of Meylan et al. (2023), *"estimated 280 million people living with depression, and 300 million people living with anxiety, and as of 2021, more than 700,000 deaths each year could be attributed to suicide. COVID-19 only increased these impacts, with the WHO estimating that the pandemic increased the prevalence of anxiety and depression by 25% worldwide during its first year. This global burden is made worse by the knowledge that effective treatments exist but are often not available to those who need them. In low-income countries, as much as 75% of people who have a mental disorder do not receive treatment, and in some counties, the treatment gap for people with severe mental health conditions, such as schizophrenia and bipolar disorder, reaches as high as 90%. Together, mental health conditions levy an enormous cost in terms of poor health and reduced productivity, projected to reach as high as $6 trillion annually by 2030 globally—more than the costs of cancer, diabetes, and chronic respiratory diseases combined".*

Mental health imposes great costs not only in the economy but also in social terms since u disorders have a significant impact on the relatives of the sick: work problems, unforeseen behaviours and the medications that these types of diseases require can represent a significant burden on families, and even more so on those with few resources that characterise Latin American societies.

For some years now, most mental illnesses have been treated with medication. Pharmaceutical advances in neuropsychiatry have been so feasible that they have even allowed psychiatric hospitals to be less assisted. Schizophrenic, psychogeriatric, neurodivergent or depressed patients, among others, control their conditions thanks to contemporary medications; however, they imply effects on the body and nature.

It is known that medications can have a negative impact on the body, which is why it is important to always follow a medical prescription and provide clinical follow-ups; in the case of patients with mental illnesses, it is even more important because the doses must be adjusted to maintain both their emotional and behavioral balance. For this type of patient, it is essential, and its administration has allowed them to reintegrate into society and live a harmonious life among other people.

However, this type of medication manages to control prolonged hallucinations or distress, thanks to the "magic" of chemistry, which also has repercussions for other living beings.

Since 1950, when chlorpromazine (a medication to treat the symptoms of schizophrenia) was developed, the history of mental illnesses has changed while incorporating profound contamination of water bodies.

The manufacturing of any medicine produces a significant impact on the planet; any factory does it, and in the case of those that produce medicines, they are no exception. But its impact goes beyond productive processes since a significant part of the intake of medicines goes in the wastewater directly into bodies of water, and unfortunately, there is no water treatment plant that can process them, so there are antibiotics, analgesics, anxiolytics and antidepressants (which all day's consumption increases) in almost all marine bodies, and this has a direct impact on aquatic fauna.

Image 3: The eastern area of the Valley of Mexico requires a greater and better green area, which integrates urban horticulture for public health. Scene of Chalco, picture of Sergio Hugo Pablo N., 2024

According to the researcher Argaluza (2021*), as drugs are designed to produce pharmacological effects at low concentrations, they can produce ecotoxicological effects on microorganisms, flora and fauna, even on human health. It has also been observed that certain antidepressants and antipsychotics can bioaccumulate along the food chain. Drug pollution is a complicated and diffuse problem characterized by scientific uncertainties, many stakeholders with different values and interests, and enormous complexity. Possible solutions consist in acting at source, using medicines more rationally, eco-prescribing or prescribing greener drugs, designing pharmaceuticals that are more readily biodegraded, educating both health professionals and citizens, and improving coordination and collaboration between environmental and healthcare sciences. Besides, end of pipe measures like improving or developing new purification systems (biological, physical, chemical, combination) that eliminate these residues efficiently and at a sustainable cost should be a priority. Here, we describe and discuss the main aspects of drug pollution, highlighting the specific issues of psychiatric drugs.*

The previous effects had been accumulating for decades since the number of patients with mental disorders has increased significantly in the last 20 years, but the biggest trigger for this situation was the pandemic caused by Sars_CoV2, which also impacted mental health indices due to all the stress that was experienced for months which resulted in a greater consumption of medications to control stress, anxiety or depression and this has been reflected in the levels of contamination of bodies of water, and in some circumstances, even affecting the food chain, which in turn results, ironically, in endocrinological problems for humans, as described by the Hernández team (2023) in their research.

Several scientists from around the world, concerned about this alarming situation, have made an international call to reduce the consumption of psychiatric medications, regulate its consumption, support psychological clinical therapies and appeal to the use of alternative therapies such as exercise, meditation and contact with nature in restorative gardens and horticulture, as support methods for medication.

Traditional remedies and the approach to nature are resources that have been used for thousands of years, and being in contact with animals, plants, and the sky has a therapeutic effect for most people, this is known as biophilia, which is a phenomenon described by biologist Edward O. Wilson (1984) as an innate need to be in contact with natural environment. Wilson was dedicated to entomology, and in his many camps around the world, he was able to observe that the vast majority feel a need to return to the origin of the hominids, which means being immersed among plants and animals.

There is another group of theorists in the field of environmental psychology who were able to determine, after a stay in an agricultural community in the United States of North America, that contact with nature generates a feeling of fascination that allows one to get away from everyday life by experiencing a refreshing feeling, as long as there are security conditions that provide the user with an experience in a socially recognisable environment. This work was called *Restorative Environments Theory* and was developed by Rachel and Stephen Kaplan in the late 1970s; it has been so successful that it promoted a fruitful line of research.

In 1989, Kaplan published *The Restorative Environment: Nature and Human Experience*, in which he describes how the experience of living among plants and animals, the sensation of fresh air and contact with the sky for a few minutes, allows you to reduce mental fatigue and moves a positive mood and this was defined a deeply "*restorative experience*". These benefits were attributed to the feeling they generate of being absent from the daily routine and escaping into "adventure", the fascination nature generates through a feeling of compatibility with it.

Thirty-five years later, this research has yielded generous fruits in *salutogenic* terms, which is the culture related to health. In various countries, it has been shown how being in contact with nature generates multiple health benefits by losing stress and improving mood, which researcher Roger Ulrich later called "*Loss of psychophysiological stress*" in his publication *View through. Window may influence recovery from surgery* (1984), after a medical protocol carried out for 14 years in a hospital surrounded by gardens in which patients recovered sooner and required less medication just by seeing nature from their window.

All of the above has led to multiple international medical investigations and results, which corroborate surrounding yourself with nature improves health, and many of these investigations are due to the immunologist Qin Li, who for 9 years dedicated himself to research in different parts of Japan using medical evidence, how walks in the forest can favourably affect blood pressure, glucose, heart rate, blood pressure and even inhibit NK (not killer) cells associated with cancer, generally strengthening the immune system. This medical experience was compiled in a book called "*The power of the Shinrin-yoku forest. How to find happiness and health through trees*", in addition to giving conferences in different parts of the world to motivate alternative medicine through plants.

All the above has developed a trend that has influenced architecture and urban planning and is called biophilic design which has been successful due to the good results that users experience in their different areas, which are reflected in a better and more productive work environment, better school performance or the case of the hospitals mentioned above. and these effects have radiated towards the biophilic cities, which have greened and adopted bodies of water; which not only improves the mood and health of its inhabitants; It also has a beneficial impact on them by reducing pollution rates, increasing environmental humidity and attenuating "heat islands."

Image 4: Public parks are a great resource for public health and the ecological balance between nature and cities. Caneguin Park, in the north of Mexico City. Picture and design of the author. 2024

The new trend in sustainable urban design includes the increase in biodiversity, the abundance of green areas, ecological corridors resolved with green walls and roofs, and permaculture. The last one is a new strategy to introduce agriculture developed with an ancient technique using the traditional production modes, especially in terms of fertilisation and fumigation, the idea was defined in the early 70s in Oceania and was thought to establish an equilibrium between the population of the cities and the rural territories. This represents an important tendency adopted by a great number of countries, particularly the regions with a strong economy which planned the cities for sustainable development.

The idea of establishing urban agriculture is a great topic for recovering nature in the cities its repercussions grow each day in some parts of the planet with spectacular social results. Singapore, Manhattan or Paris are cities that include horticulture in spaces like roofs, sidewalks or urban corners. Besides, urban transportation is expanding their example because they enjoy practising community production, taking care of vegetables or fruits; in addition, they experiment the relaxation of being in contact with a little part of nature with the satisfaction of cultivated food in a restorative environment.

Image 5: A pumpkin collected in a familiar garden last summer south of Mexico City, the smiles say it all. Picture of David Mendoza, 2024

In addition, being in contact with nature helps you enjoy *terpenes*, which are aromatic and volatile organic compounds that are present in a wide variety of plants and that make it easier to eliminate stress by being in contact with aromas such as pine, dill, basil or the one with so many flowers. Also, according to the equipment of Holbrook (2023), cultivated fruits and vegetables promote contact with a *Mycobacterium vaccae* a bacterium not pathogenic immersed in the soils that are linked with human health benefits like anti-depressive since it stimulates the production of serotonin, one of the hormones of happiness.

It is important to remember the experience of producing food is a good sensation that was experimented on, maybe, for millennials in the history of humanity, and reintegrating it to the quotidian life is a wonderful motif to be happy: being in contact with the sun, plants and sky; working together with relatives or friends making social cohesion; producing fruits or vegetables, making contact with the soil and depositing negative electricity; in a lot of cases could mitigate the hunger, especially in the marginal districts of poor cities.

All of the anterior reasons are very good motives to promote urban horticulture, but on the other hand, this practice produces better spaces for the diminution of heat islands, the increment of humidity, the production of clean air and the facility to eat fresh foods probably produced in the same neighbourhood with the hand of friends making *horti-therapy* for the planet and human beings and a good diet on cities if the population cultivate fruits and vegetable in the splendid weather of tropical countries.

III. CONCLUSIONS

Latin America has an enormous mega biodiversity that represents an important balance for the whole world, because it is the great biochemistry filter which defines the stability of nature in the planet.

Unfortunately, the region suffers an important environmental degradation associated with socioeconomic and cultural conditions that impact the biotic components, the social inequity and problems like hunger and mental health that are a great contradiction between natural resources and well-being.

People starving in a traditional agricultural society is absurd, and they need other kinds of ways of production that protect the extraordinary biodiversity of the tropics and establish ways to balance the accentuated social differences, thinking about the future of the planet. For the goodness of all persons.

A change in the geopolitics of this territory that reduces the social and environmental impact is needed, to establish a governmental project for the regeneration of nature on the regional scale and in urban planning, with the idea of promoting the importance of green area systems that include horticulture to mitigate the alimentary insufficiency, reduce the urban heat islands and promotes mental health: and could balance the contradictions between wellbeing, the cities pressures and the planetary ecosystems.

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Exploration of *Dunalliella Salina* Culture from the Colorada Lagoon in Photobioreactors as Biotechnological Perspectives: Potentialities and Applications

Morales Santiago & Lidia Molleapaza

ABSTRACT

Microalgae are resources with several scientific and industrial uses, under this framework, the study aims to explore the possibility of taking advantage of the microalgae present in saline lagoons in southern Bolivia to obtain microalgae rich in β-carotene. The microalgae samples were cultured in Erlemeyer flasks with Ben-Amostz Avron culture medium, by successive tests the Dunaliella salina was separated, later this inoculum was cultured in a 5-liter photobioreactor, then in 90 liters until reaching 140 liters culture using macronutrients and artificial light 20000 lux, it was possible to obtain microalgae composed of the Dunaliella salina known as the green phase, whose average cell density is 113929 cell/ml. From this phase, carotenogenic induction of the microalgae was carried out with the removal of nitrogen and phosphorus in the culture medium, the average content of β-carotene in the red phase biomass was 12 mg/Li equivalent to 890 mg/100 g, and the conversion was 4.8 g β-carotene/g chlorophyll, which contrasts with the fact that biomass contains a higher percentage β-carotene. In the same way, it was possible to obtain biomass in the red phase by carotenogenic induction using natural light with 100000 lux maximum daily, the β-carotene content was 4.26 mg/Li. This shows the feasibility of obtaining biomass rich in β-carotene with natural light and macronutrientss.

Keywords: colorada lake, *dunalliella salina*, β-carotene.

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Microalgae are resources with several scientific and industrial uses, under this framework, the study aims to explore the possibility of taking advantage of the microalgae present in saline lagoons in southern Bolivia to obtain microalgae rich in β-carotene. The microalgae samples were cultured in Erlemeyer flasks with Ben-Amostz Avron culture medium, by successive tests the Dunaliella salina was separated, later this inoculum was cultured in a 5-liter photobioreactor, then in 90 liters until reaching 140 liters culture using macronutrients and artificial light 20000 lux, it was possible to obtain microalgae composed of the Dunaliella salina known as the green phase, whose average cell density is 113929 cell/ml. From this phase, carotenogenic induction of the microalgae was carried out with the removal of nitrogen and phosphorus in the culture medium, the average content of β-carotene in the red phase biomass was 12 mg/Li equivalent to 890 mg/100 g, and the conversion was 4.8 g β-carotene/g chlorophyll, which contrasts with the fact that biomass contains a higher percentage β-carotene. In the same way, it was possible to obtain biomass in the red phase by carotenogenic induction using natural light with 100000 lux maximum daily, the β-carotene content was 4.26 mg/Li. This shows the feasibility of obtaining biomass rich in β-carotene with natural light and macronutrients.

Keywords: colorada lake, *dunalliella salina*, β-carotene.

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I. INTRODUCTION

Microalgae, due to their remarkable versatility and applicability in various scientific and industrial fields, are used for various uses. They are not only nutritious, but also have bioactive compounds with antioxidant properties (Pulz & Gross, 2004), as well as the *Dunalliella salina* that inhabits natural and artificial hypersaline environments Borowitzka, M. A. (2018) y Raja, R., Hemaiswarya, S., *et al.* (2008), one of the most important characteristics of *Dunalliella salina* is its ability to accumulate large amounts of β-carotene in response to environmental stress, particularly in conditions of high salinity, intense solar radiation, and nutrient deficiency Raja, R., Hemaiswarya, S., et al. (2008) and Ben-Amotz, A., & Avron, M. (1983). Bolivia is a country with a remarkable diversity of ecological floors due to its geographical location and variable altitude, ranging from tropical plains in the east to highlands and mountains in the west. To the southwest is the Salar de Uyuni, a salt reserve, around this region there are several lagoons, the most important being Colorada lagoon, one of the most emblematic natural sites in Bolivia. It is characterized by its high salinity, unique reddish color that varies in intensity throughout the day due to the chemical composition of its saline waters and the interaction with sunlight that offers the conditions for the presence of

Dunaliella salina and other species of microalgae. Therefore, the objective of this document is to explore the possibilities of using the microalgae of the Colorada lagoon through the cultivation in photobioreactors with artificial and natural light to obtain β-carotene with macronutrients as a growing medium.

II. MATERIAL AND METHODS

2.1. Colorada lagoon source of microalgae

Colorada lagoon is located in southwestern Bolivia (22°13'22" - 22°09'58" S and 67°49'22" - 67°43'56" W) at an average altitude of 4,278 Meters above sea level, with a total area of approximately 60 km2. The prevailing climate in the region is characterized by its aridity, low rainfall 65 mm, wide daily thermal oscillation that can reach extremes of -25°C +25°C, intense solar radiation, strong winds and low atmospheric pressure, Rocha, O. (1997). Due to the geographical conditions of the region, the water maintains low temperatures, although on some occasions it reaches about 30 °C especially during the winter due to the average shallow depth of the lagoon, which is 35 cm, some authors report at 80 cm. This lagoon suffers a strong evaporation leaving areas with salt, however, there are areas with enough water, those changes can be seen in the Figure 1, and most importantly the color due to the presence of *Dunaliella salina*, as well as the time of sampling.

Figure 1: Shape of the lagoon and sampling

2.2. Culture medium

The samples obtained from the lagoon were treated in Erlenmeyer vessels to initiate culture in a medium proposed by Ben-Amotz, A., & Avron, M. (1983) specifically designed for halophilic microalgae and this was subsequently used for mass biomass cultures using a macronutrient-enriched medium consisting of NaCl, $NaNO_3$, $NaHCO_3$, $MgSO_4$ and KH_2PO_4.

2.3. Separation of the Dunalliella strain

From the samples collected in the Colorada lagoon, the microalgae were concentrated by centrifugation, these were cultured in test tubes of approximately 10 ml, the upper part of the centrifugation is discarded, while the lower part that contains the largest amount of *Dunaliella salina* and other microalgae, these are concentrated in other containers maintaining the vital activity with the medium of Ben Amotz Avron. After 25 days, the presence of two species was verified, with the predominance of the species *Dunaliella salina,* which is separated later. A series of cultures were prepared in Ben Amotz Avron medium in eppendorf and test tubes at different salinities starting from 65‰ to 117‰, maintaining the pH approximately 8.5‰, with continuous light from 18watt fluorescent bulbs to achieve 18000 lux and recorded temperature of 20-22 ºC. The test was carried out until the disappearance of the other species is evidenced, obtaining an inoculum of *Dunaliella salina*.

2.4. Massification of biomass in photobioreactors

Samples of the inoculum of *Dunalliella salina* were cultured using macronutrients as a culture medium in containers of 50, 100, 500 ml until reaching 5 liters. This strain was then cultured in the 140-liter photobioreactor, the volume was increased at a three-day interval until it reached 90 liters then 140 liters of culture. The conditions were at pH 8, 20000 lux, temperature of 15 °C and agitation less than 75 rpm, the resulting biomass turned green, which is known as the green phase. In this phase, the induction of carotenogenic began by eliminating nitrogen and phosphorus in the culture medium, obtaining after several days an orange biomass, called the red phase. From this phase, the concentration of β-carotene was determined. Figure 2 shows the biomass in the green phase and the red phase in the photobioreactor.

*Figure SEQ Figura * ARABIC 2:* Dunaliella salina in green phase and red phase roja

Less than one liter of biomass was taken from the green phase and cultured in 30 liters in rectangular containers with sunlight reaching a maximum of 100000 lux per day, see Figure 3. After 20 days of exposure, biomass rich in *Dunalliella salina* in the green phase was obtained, and by eliminating nitrogen and phosphorus, carotenogenic was induced. Then the biomass turned orange due to the presence of *Dunaliella salina* rich in β-Carotene.

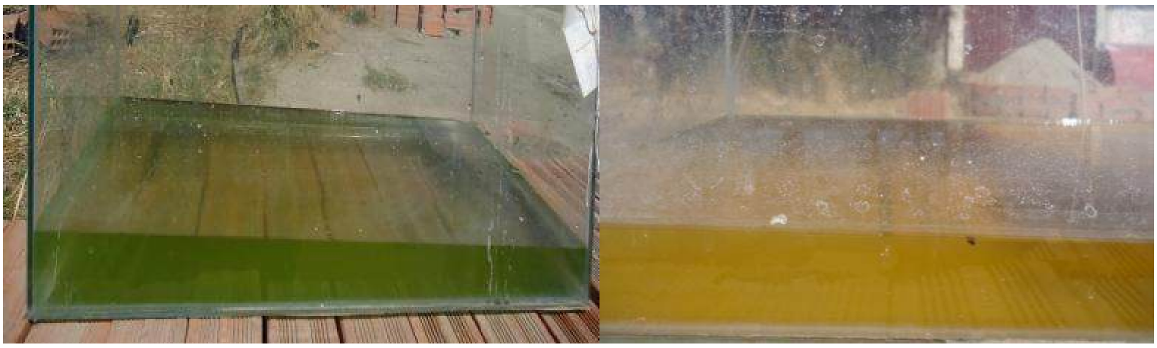
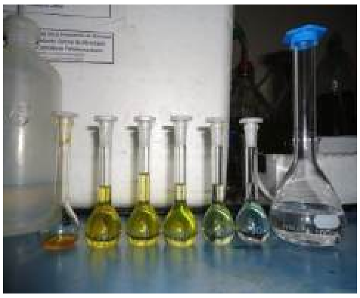


*Figure SEQ Figura * ARABIC 3: Biomass in green phase and red phase with natural light*

2.5. β-carotene quantification

To determine the β-carotene content, several standard solutions were prepared using analytical-grade β-carotene. A standard solution of concentration 0.2892mg of β-carotene per ml was prepared. From this diluted and measured solutions were prepared in 10 ml flasks, in Figure 4 is shown the standard concentrations and calibration ratio.



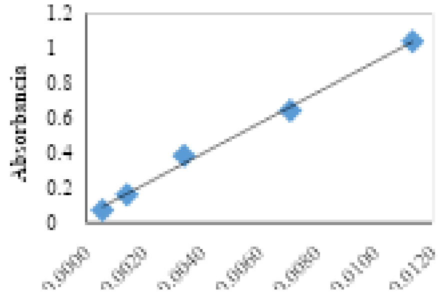


*Figure SEQ Figura * ARABIC 4:* Standard ß-carotene solutions and calibration ratio

III. RESULTS AND DISCUSSION

3.1. Speed of massification

The speed of massification of biomass at temperatures above 30 °C decreases, while at low temperatures growth is better, coinciding with the conditions of the Colorada lagoon where water temperatures are low. For its part, it was recorded that the higher the solar intensity, the better the growth, also coinciding with the conditions of the Colorada lagoon. The values handled in growth are similar to other studies, Prieto Arcas Antulio (2008) recorded that the maximum cell densities were $8.06x10^6$ and $9.76x10^5$ cell/ml respectively obtained at 10000 lux compared to those of $2.5x10^6$ and $3.1x10^5$ reached at 20000 lux respectively in this study, in Figure 5 can be seen the trend of growth under different conditions.

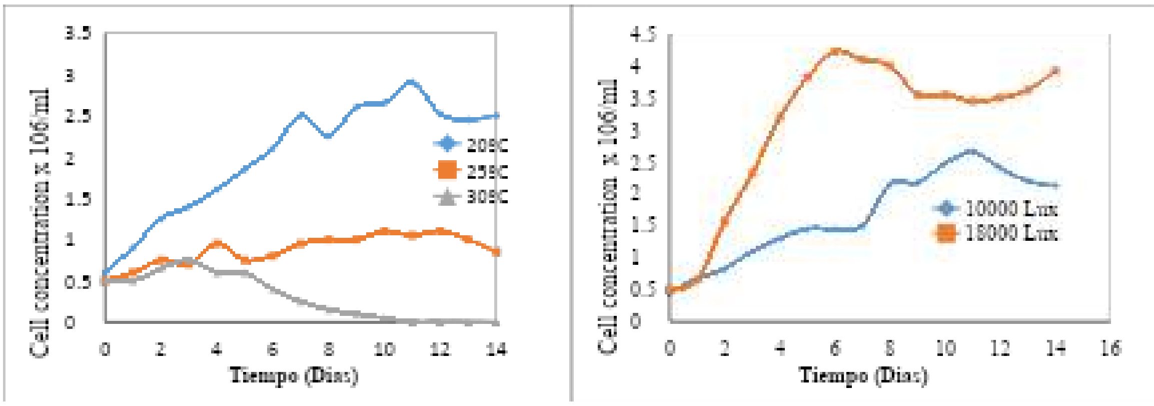


*Figure SEQ Figura * ARABIC 5:* Environmental factors that control the photosynthesis process

3.2. Biomass and quantification of B-Carotene product with artificial light

Samples of Dunaliella salina collected directly in the Colorada lagoon were analyzed in HPLC and the presence of 1325 mg of β-carotene in 100 g of biomass was detected. On the other hand, biomass samples produced in the photobioreactor on average was 890 β-carotene, the results are shown in Table 1.

Table 1: Concentration of B Carotene in biomass

Tests	Biomass mg/ml	cel/ml	β-carotene mg/ml	β-carotene mg/Li	β-carotene pg/cel	β-carotene g/100g	β-carotene mg/100g
1	0,58	229063	0,018	18	79	3,1	3103
3	1,89	37188	0,018	18	484	0,95	952

4	2,15	121563	0,008	8	66	0,37	372
6	2,37	237813	0,016	16	67	0,68	675
7	1,9	42188	0,003	3	71	0,16	158
8	2,11	53438	0,018	18	337	0,85	853
9	2,58	76250	0,003	3	39	0,12	116
Average	1,94	113929	0,012	12	163	0,89	890
Standard Desv. Est.	0,65	86387	0,007	7	175	1,029	1029
Max.	2,58	237813	0,018	18	484	3,1034	3103
Min.	0,58	37188	0,003	3	39	0,1163	116

Comparing the data obtained in the project, are within the ranges that were usually observed in other investigations under different culture conditions, based on these values it is concluded that in the project proposed here it is possible to produce biomass with a high content of β-carotene 12 ± 7 (mg/ml) of biomass under culture conditions of an inoculum achieved by the centrifugation and subsequent concentration of water from the Colorada lagoon with a medium Prepared with macronutrients and common salt in drinking water.

The value of 890 mg of B-carotene per 100 grams of average biomass found in the cultured biomass, is lower than 1325 mg of β-carotene per 100 grams of pure biomass recorded from the samples collected in the Colorada lagoon. This is reasonable because it is a site sample with a high concentration of *Dunaliella salina*. However, in one test it was found at values of 3103 mg of B-carotene per 100 grams of biomass; besides, *Dunaliella salina* Measurement Institute (Australia) and Craft Technologies Inc. (USA) report the presence of beta-carotene in *Dunaliella salina* at 1100 to 2100 mg β-carotene /100 g; therefore, the average value found in the project is close to these typical values.

3.3. Biomass and quantification of β-caraotene produced with natural light

The biological sludge grown under environmental conditions in winter resulted in a yield of 0.47 mg/ml of biomass in the red phase, which is equivalent to 473.75 mg of biomass per liter, from which 4.26 mg of β-carotene/Li of biomass in the red-orange phase are produced, although it is lower than the average obtained in photobioreactor with artificial light (12 mg/Li).

IV. CONCLUSIONS AND PROYECTIONS

- The results obtained show that it is possible to cultivate Dunaliella salina from the Colorada lagoon in photobioreactors under controlled conditions. It is also possible to induce the obtaining of β-carotene, in both cases, using widely studied protocols.
- The concentrations β-carotene obtained by the culture in photobioreactors are similar to the content of the sample taken in high concentration sites of the Colorada lagoon. The most important finding in this study is the evidence of obtaining biomass rich in β-carotene using solar radiation and macronutrients that are possible to find in a comfortable way, in addition the cost is much lower than synthetic media, although the concentration β-carotene is lower than that produced in photobioreactors with artificial light, but it is possible to improve yields with feasible adjustments. For example, high nitrogen and phosphorus fluxes, which are currently an environmental problem, could be used, and the high radiation of western Bolivia.
- Based on the relevance of biomass production in photobioreactors with artificial light, especially with natural light, it is possible to use it immediately in aquaculture based on its protein, lipid and carbohydrate content as Rainbow trout feed, especially for the β-carotene content to help in the pink color conversion of trout meat. Indeed synthetic dyes are currently used.

- Several studies have been carried out on the incorporation of beta carotene into the diet of rainbow trout (Oncorhynchus mykiss) to improve the color of its meat. Carotenoids, including beta-carotene, are precursors to astaxanthin, which is the most efficient pigment for intensifying the characteristic reddish color in the flesh of these species. In addition, it contributes to the health of the trout thanks to its antioxidant properties.
- Subsequently, through advanced chemical processes, biomass rich in β-carotene could be used either in pharmaceutical products or in the food industry and for various uses. Its sustainable exploitation of hidden natural resources is an open challenge to diversify economic activities in the future.

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God Does Not Play Dice

Junichi Hashimoto

ABSTRACT

Relational physics, which I founded, views energy as a relationship (pulse) between objects. It painted a simple real picture of energy pulsing through the rotational motion of each object, creating an alternating relationship between the two extremes. Such a way of looking at things could be an appropriate explanation for various physical phenomena, such as the double-slit experiment and the measurement of electrons in hydrogen atoms. In this paper, the discussionisparticularly focused on experiments to investigate the position of electrons. From such challenges, results that could affirm the reality of microscopic objects were obtained. The success of the attempt here tells us that determinism will prevail over non-determinism. The history of physics is about to undergo a major shift.

Keywords: equivalence of electromagnetic waves and pulses; identity of the solar system model and the atomic model; identity of rotation and pulse; observational experiment of electrons; pulse equation; pulse interval.

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Relational physics, which I founded, views energy as a relationship (pulse) between objects. It painted a simple real picture of energy pulsing through the rotational motion of each object, creating an alternating relationship between the two extremes. Such a way of looking at things could be an appropriate explanation for various physical phenomena, such as the double-slit experiment and the measurement of electrons in hydrogen atoms. In this paper, the discussionisparticularly focused on experiments to investigate the position of electrons. From such challenges, results that could affirm the reality of microscopic objects were obtained. The success of the attempt here tells us that determinism will prevail over non-determinism. The history of physics is about to undergo a major shift.

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I. INTRODUCTION

Scientists have long debated what light (energy) is. Eventually, when light diffraction and double-slit experiments were conducted, it was thought to be a wave, as it exhibited phenomena similar to water surface waves. Later, however, when experiments on the photoelectric effect were conducted, phenomena that could not be explained by the wave theory were observed. When high-energy light was shined on the metal, electrons were ejected from inside, which can be explained by considering light as particles, like bullets, leading to the development of the particle theory. Eventually, with the advent of quantum mechanics, it was settled that light isa wave when it is observed as a wave and a particle when it is observed as a particle (particle-waveduality). Indeed, such theories have had some success. However, the excessive emphasis on mathematical consistency led to the introduction of fictitious, non-figurative factors such as wavelength and frequency, and as a result, objects had to be regarded as probabilistic entities(denial of reality). Such an idea of quantum mechanics seems strange as an explanationofnatural phenomena, and there are many counterarguments. Therefore, I took the position of the remote theory and founded relational physics, which views light (energy) as a relationship(pulse)between objects, thereby eliminating the duality between particles and waves [1]. In this paper, I will discuss the reality of objects based on this idea.

II. METHODOLOGY

While mathematics must be used to explain natural phenomena and experimental results in the language of science, it is never desirable for the content to be unrealistic. Therefore, while mathematical consistency is important, the concept of realism, which facilitates grasping the behavior of objects, is even more important for the search for truth. In relational physics, in order to establish a norm that satisfies both of these, the atomic model and the solar system model are considered identical, and a unique pulse equation is derived. It was created by incorporating a new rotation law equation into the electromagnetic force equation in this theory [2]. The equation is as follows.

t represents the pulse interval, E represents the energy of light or attraction, nc represents the number of object rotations, l represents the distance between objects, ka represents the electromagnetic force constant (value of “1”), and

L represents the energy foundation range. As can be seen from the equation, this model is an equation relating energy to pulse interval (equivalence of electromagnetic waves and pulses). Thus, the mechanism of the pulsing relationship between the rotational motion of an object and the rotational motion of an object could be perfectly explained. Conversely, the reason for the creation of pulse can now be found in the rotational motion (rotation and revolution) of objects (the identity of rotation and pulse). Now, let us take the example of electrons in a hydrogen atom to verify the reality of the object. Relational physics treats the atomic model as the same structure as the solar systemmodel andinterprets one orbit of an electron around a proton as the same as one rotation of a hydrogen atom. It is as if the sunspots at the equator of the sun appear to be orbiting the sun's core, but this is merely because one sun is rotating on its own axis. If that is the case, then even if an electron moves in a circular motion around a proton, it is only the rotation of a single hydrogen atomase-certain entity, so there is no loss of kinetic energy (cyclotron radiation) as claimed by classical electromagnetism. This makes the atomic structure stable.

Now, based on such a concept, let us calculate the pulse period of hydrogen atomusing equation①. Please refer to my previous papers for the values for the substitutions [3][4]. The following calculation process gives the solution.

Let us verify that it is the same as the rotation period of the hydrogen atom by the following computational process.

Thus, it is proved that one rotation of one hydrogen atom and one pulse emitted by one hydrogen atom are the same in value. In the next section, I will further explore the reality of the object by discussing an experiment in which an electromagnetic wave is shone on an electron-nitrogen atom to determine its position.

III. DISCUSSION

In order to observe the position of an electron in a hydrogen atom by directing electromagnetic waves at it, the three-way relationship between the proton in the hydrogen atom, the electron in the hydrogen atom, and the emitting device must be stable as a single ordered entity. The ideal experimental condition to form it is that the energy of the electromagnetic wave being shot is equal to the pulse energy (the electromagnetic force between a proton and an electron) contained in a single hydrogen atom. This is because if the light energy being shot is greater than the electromagnetic force between one proton and one electron, it will bounce off the electron, and it is less, it will reduce the observational resolution. The distance between a device and one electron should be equal to the distance between one proton and one electron, but even with-9 [m] at most. Therefore, current nanotechnology, the maximum proximity is limited to about 10. It is important for the success of the experiment to adjust the optimum conditions that can be set up with persistence, while being subject to the above limitations. This means that it is necessary to make various trials for each value to be substituted into the equation as a preliminary preparation. Please see Table 1.

Table 1: List of device setting conditions

	Light energy being*E*)	Number of rotationsNumber of pulses shot (*nc*)	Distance between one device and one electron*l*) Light energy foundation range (*L*)	(Pulse interval (*t*)
(1)	1.602051×10^{-14}[J]	1	$1.028336049\times10^{-12}$[m]	8.17396687×10^{-19}[s]
(2)	1.602051×10^{-32}[J]	1	1.028336049×10^{-3}[m]	8.17396687×10^{-19}[s]
(3)	1.11265×10^{-21}[J]	1	3.90206×10^{-9}[m]	8.17396687×10^{-19}[s]

(4)	1.11265×10^{-17}[J]	1	3.90206×10^{-9}[m]	8.17396687×10^{-17}[s]
(5)	1.11265×10^{-17}[J]	0.01	3.90206×10^{-9}[m]	8.17396687×10^{-19}[s]

In the case of (1), gamma rays were set as the light to be shot. However, the energy is too great to repel electrons, and the device-electron distance is too small to install with modern technology. In the case of (2), an extremely long waves (ELF) were set up as the light to be shot. However, the energy is too small, so no resolution can be expected. In the case of (3), sub-millimeter waves were set as the light to be shot. However, the energy is still too small, so no resolution can be expected. In the case of (4), ultraviolet light was set as the light to be shot. It is at a distance that can be set up with modern technology, and there is no danger of it repelling electrons. However, the pulse period is exactly 100 times the electron orbital period. How this will affect the observation results will be known only after the experiment. In case (5), ultraviolet light was set as the light to be shot as in case (4). Although the pulse period and the electron orbital period match, there is an element of uncertainty in that the number of rotations (number of pulses) must be set to 0.01. Even if it is theoretically possible to set this value, whether or not it can be faithfully reflected in the experiment will be known only after the experiment. In this regard, and this is true only for the case (4), it is interpretively possible to modify some of the conditions on the side of the electron in the hydrogen atom, while reserving the conditions on the device side as they are (Table 2).

Table 2: Setting conditions for one electron in one hydrogen atom (modified version)

	Proton-electron coupling(E)	Number of rotationsNumber of pulses energy (n_c)	Proton-electron distance (l) Foundation range of proton-electron coupling energy (L)	Pulse interval (t)
(6)	1.11265×10-17[J]	100	3.90206×10^{-11}[m]	8.17396687×10^{-17}[s]

As shown in (6) above, by assuming a value of 100 for the number of rotations (nc), the energy pulse interval value (t) encompassed by one hydrogen atom can be set to 8.17396687×10^{-17}[s], which is perfectly consistent with the value of t in the case (4). By doing so, the tripartite relationship between the luminous device, one electron in one hydrogen atom, and one proton in one hydrogen atom is fully harmonized via the incident electromagnetic wave and the coupling energy in the hydrogen atom.

Thus, if we were to experiment under the setting conditions of (4) or (5), we would obtain new and interesting data that would suggest realism. I look forward with great anticipation to further progress in this research.

IV. RESULTS

In order to confirm the existence of objects (electrons), I focused on the harmonic structure of the three-way relationship between luminous device, electrons in hydrogen atoms, and protons in hydrogen atoms, and devised experimental conditions that could verify this structure. Underlying this thinking is the equivalence principle that electromagnetic waves and pulses are the same thing, pulses and rotations are the same thing, and solar system models and atomic models are the same thing. By combining these concepts, I developed my own pulse equation, and as a result of my calculations, I succeeded in perfectly matching the pulse periods of both the device side and the hydrogen atom side. This means that the behavior of electrons could be quantitatively understood. In other words, mankind was able to affirm the reality of microscopic objects. The success of this experiment must be industrialized beyond the realm of academia and lead to various applications and practical use in the future.

V. CONCLUSION

Although not discussed in detail in this paper, the mechanism by which energy is pulsed can briefly described as follows. First, assume that there are two or more objects (spheres), both of which rotate at high speed. Then, both front and back hemispheres will alternately show the irrespective faces to each other. Therefore, the relationship between them becomes a high-speed beat that alternates between "face-to-face" and "non-face-to-face". This is, in other words, a high-speed beat of "connected relationship" and "unconnected relationship". The result is a pulse of energy. There are only two components of the pulse: "connected" and "unconnected". That being so, it is extremely compatible with the double-slit experiment, which uses a wall consisting of two components, "slit" and "non-slit".

The degree of such pulse components is quantified by the variable pulse interval. The greater or lesser of it determines the greater or lesser work rate. A large pulse interval implies along"connected" time (light period) but also a long "disconnected" time (dark period). For example, if we determine the pulse interval from the brightness of the light emitted by a hydrogen atom, the sun, and a quasar, we find that the brighter and more distant the object, the larger the value. Based on such facts, let us summarize in the form of a list the factors that characterize the nature of light. They are as follows.

Table 3: Factor contrast table characterizing light

	Proximity theory (duality of particles and waves)	Remote theory (Equivalence of pulses and electromagnetic waves)
Light brightness	Number of photons	Pulse interval
Light intensity	Wavelength Frequency	Distance Individuality Number of parties

The characteristics of light are determined by factors such as "brightness" and "density"as described above. In the soup analogy, the soup is characterized by two factors that determine whether it is thick or thin, how much soup is in it, and so on. The same is true of light. The proximity theory holds that the abundance of photons determines the "brightness" of light, while the remote theory holds that a generous pulse interval determines the "brightness" of light. The relational physics that I originated developed over the years, deriving Junichi Hashimoto'slaw and incorporating the Rotational Law to create my own pulse equation. The pulse interval values calculated from it depicted the real image of "connected" and "unconnected" high-speed beats. It also presented the principle that the longer the "incident time" of light is, the longer the"non-incident time" is. Philosophically speaking, this is the same as saying that a successful person has many successes but also many failures. In baseball, a home run hitter has many home runs but also has many strikeouts. This is what makes his brilliance stand out. In relational physics, relationships between objects are regarded as pulses. Life is an activity that connects a number of "light pipelines" between various people, objects, and organizations, which come on and off like lamps based on pulse beats. When all the lamp are off, nothing will work. But there will always come a time in life when all the lamps are on, depending on the timing. Those who constantly strive will always be able to seize that opportunity. Conversely, those who are always lazy will miss opportunities, even when all the lights are on. Even the causal relationship between effort and success can be explained deterministically by physics. Exactly what Albert Einstein predicted has become clear.

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