Workshop “Climate Change and Natural Rubber Systems”

Worldwide climate typologies of rubber tree cultivation. Risks and opportunities linked to climate change

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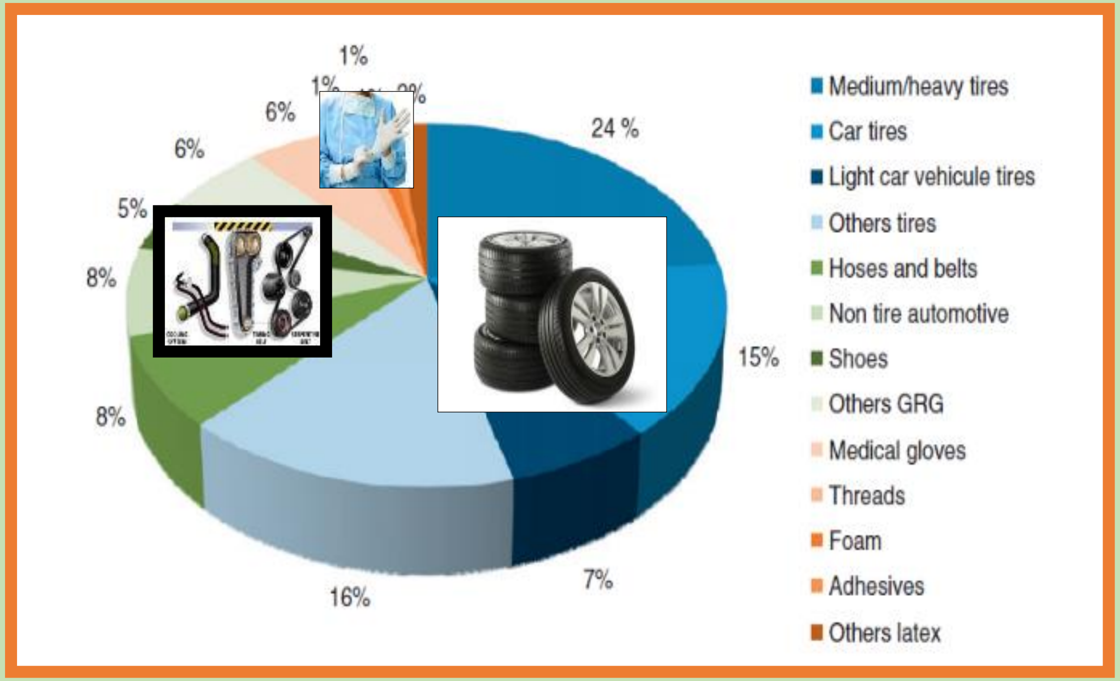
Importance of NR produced from *Hevea brasiliensis*



COVID-19 Crisis !

WHAT WOULD BE THE WORLD STATUS IN CASE OF A NR SHORTAGE RESULTING IN FREIGHTERS (planes and trucks) OPERATION DISRUPTION ?

Total disruption of international medical supplies (masks, medicines, respirators…)
Total disruption of food supply and delivery…

- ➔ « Green » substitute to petrol, representing about 47% of the global elastomer market…
- ➔ No credible or sustainable substitution by other compounds at the moment (*cis*-polyisoprene)…
  - ➔ Adhesive properties, high resistance to physical constraints (pressure, heat)…
  - ➔ Car radial tires, truck/plane/bulldozers tires, anti-vibration systems, anti-sismic equipments…

➔ Strategic material : NR Shortage = Civilization shock (freight and transport disruption…).
➔ No choice except adaptation in case of changes in production conditions

General description of CC as related to NR

➔ All IPCC scenarios forecast an **increase in temperature** (T°C min , T°C max and T°C mean) : +2° to + 3.5° before 2100.

➔ **Stability of the total Pmm amount** but **modifications of the Pmm annual display**

- ➔ **Increased rainfall during the rainy seasons is likely**
- ➔ **Decreased rainfall during the dry season (increased water stress, longer dry seasons..) is likely**
- ➔ **Increased frequency of « extreme events » : storms, typhoons, winds, floods and droughts**
- ➔ **Unprecise downscaling at local/regional levels : Difficult precise forecasts**

➔ **Raise in atmospheric CO2 concentrations**

➔ **Possible/likely development of new pests/diseases**

In brief, those new climatic conditions **WILL** impact the biology and the physiology of the rubber tree (effects on growth, yield… and even survival)

Climatic zoning for rubber tree cultivation (current)
Gohet *et al*. 2015, Ngoc & Nguyen 2016

VARIABLE	POSSIBLE	TRADITIONAL	MARGINAL
Temperature (year average)	$23°C \leq T°_{year} \leq$ **28°C**	$25°C \leq T°_{year} \leq$ **28°C**	$23°C \leq T°_{year} \leq 25°C$
Precipitation (year cumulate)	$P_{year} \geq 1100$ mm	**AND** $P_{year} \geq 1500$ mm	**OR** $1100 \leq P_{year} \leq 1500$ mm
Number of dry months (<50mm)	$0 \leq D \leq 5$	**AND** $0 \leq D \leq 3$	**OR** $4 \leq D \leq 5$
Number of cold months (<23°C)	$0 \leq C \leq 5$	**AND** $C = 0$	**OR** $1 \leq C \leq 5$

- ➔ Definition of 5 climatic indices : $IT°_{year}$, IP_{year}, $ID_{dry\ months}$, $IC_{cold\ months}$ & IA (T° Amplitude)
  - ➔ CCM index (Gohet *et al* 2015, Ngoc and Nguyen 2016)
  - ➔ 4 main climatic classes (1 Traditional : WARM/HUMID + 3 Marginal (WARM/DRY, COLD/HUMID & COLD/DRY)
  - ➔ 20 different possible climatic types, 5 intensities of climatic marginality

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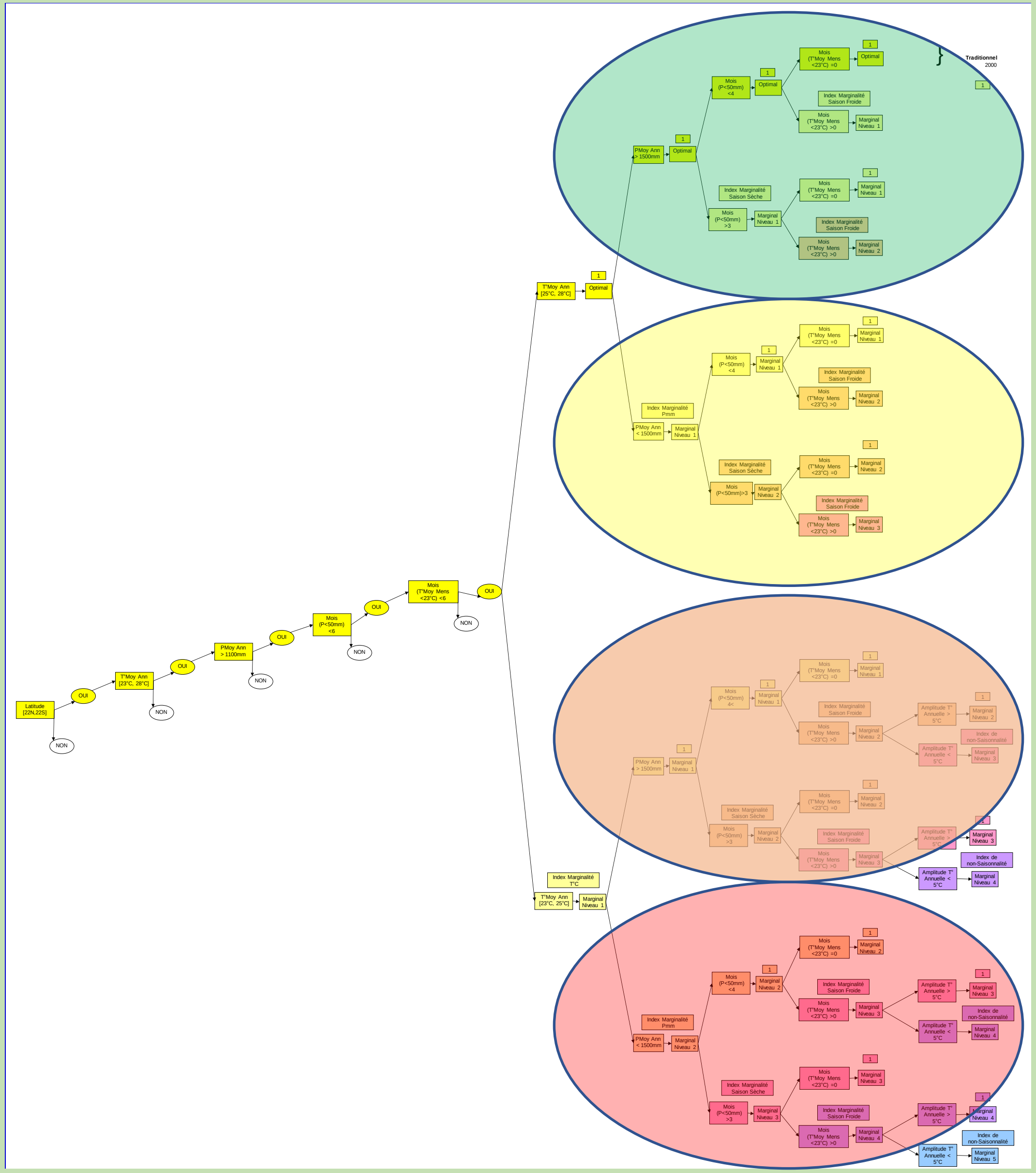
➔ No description of climatic marginality for high temperatures, because the rubber tree has never been planted, until now, in areas with mean annual T°C > 28°.

➔ The possible effect of higher temperatures (planned by all IPCC climatic scenarios) on growth, yield and even survival of the rubber tree is therefore almost **UNKNOWN.**

Climatic zoning for rubber tree cultivation (current)



Climatic Typology / décision tree based on those climatic indices

Class1 : Typical subtropical climate
WARM / HUMID (Marginality level from 0 to 2)

- Zero to medium impact on growth (immature) and yield (mature)
  - > 90% + of the current rubber growing area

Class2
WARM / DRY (Marginality level from 1 to 3) :

- Recent extensions to less favorable areas (less rainfall and longer dry seasons)
- Little to severe impact on growth (immature) and yield (mature)
  - Côte d'Ivoire (Nzi Comoue), North East Thailand, North West Cambodia

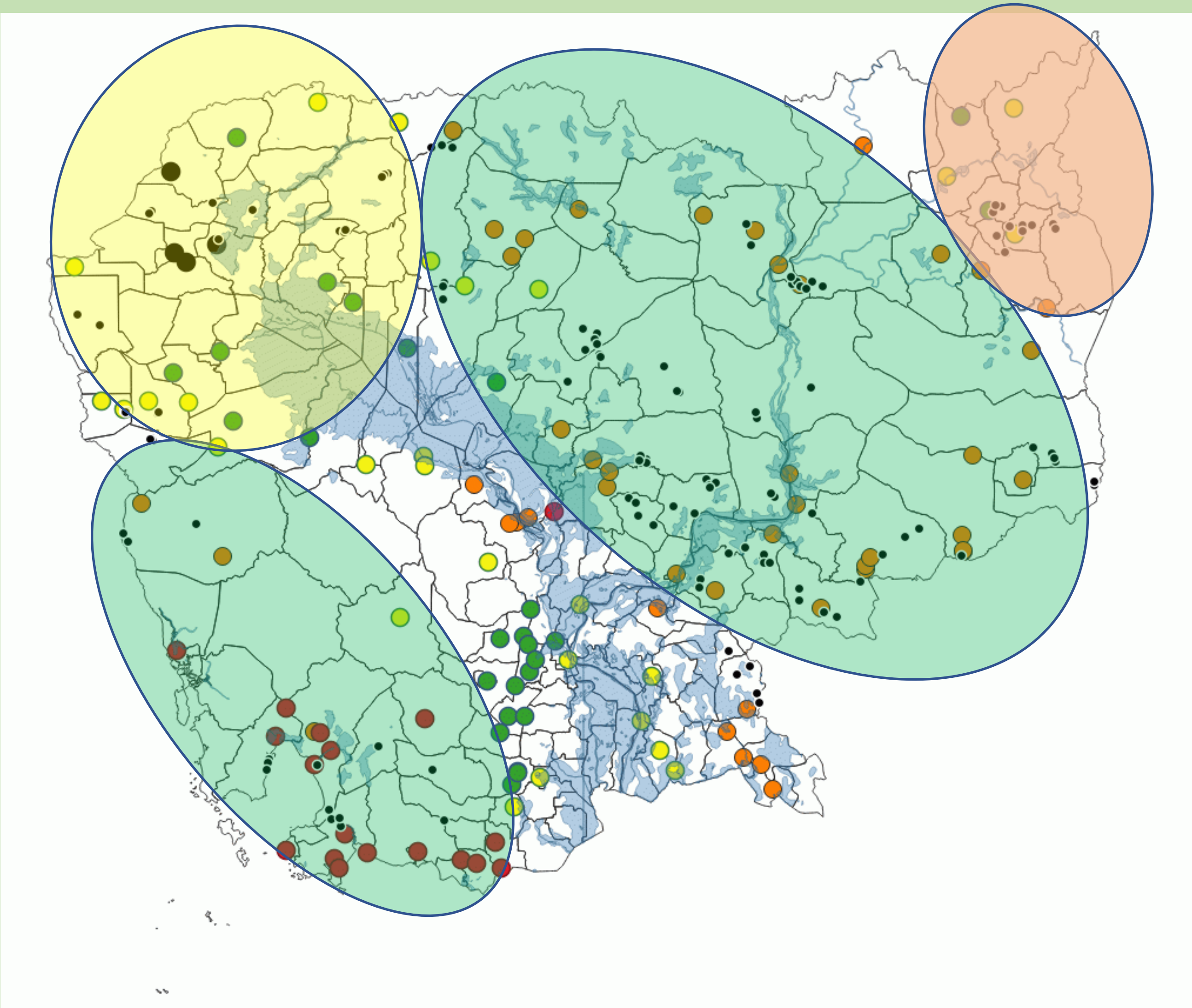
Class3
COLD / HUMID (Marginality level from 1 to 4) :

- Recent extensions to higher latitudes or altitudes
- Little to very severe impact on growth (immature) and yield (mature)
  - China (Yunnan, Hainan), Brazil (Sao Paulo), India (Assam), North Vietnam, North East Cambodia, Gabon, South East Cameroon

Class4
COLD / DRY (Marginality level from 2 to 5) :

- Trend to continental climate
- Medium to very severe impact on growth (immature) and yield (mature)
  - Brazil (Mato Grosso), North Thailand (Phayao…)

Climatic zoning for rubber tree cultivation (current)



Geographic distribution of the climatic marginality (CCM index) in Cambodia (rubber production provinces)

Meteo data obtained from www.climate-data.org

Class 1 WARM&HUMID : South West, Center and South East

Class 2 WARM&DRY : North West

Class 3 COLD &HUMID : North East

- Adaptation of GAPs.
- Different incidence of CC depending on each region is likely

Climate change and rubber : Risks

Scenarios IPCC (SRESA2, SRESB2):
Increase in T°C planned (T°Mean, T°Max, T°Min) : +2°C to + 3.5° C (from 28°C now to 30°C -31.5°C, « global warming »)
Slight increase or stability of Pmm. Increase of Pmm during the rainy season, decrease of Pmm during the dry season. Increasing length of dry seasons (P<50mm)

Many questions arise !

- Impact on the sustainability of the NR production under a warmer and drier climate (increased temperature, increased contrast between dry and wet seasons and longer dry seasons…) ?
- Impact on the current climatic classes (1/Warm&Humid, 2/Warm&Dry, 3/Cold&Humid, and 4/Cold&Dry) ?
- Uncertainty / Reliability of the models (especially for Pmm) ?
- Possible downscaling of the climate predictions at local / regional level ?

Climate change and rubber: Risks

RISKS LINKED TO INCREASED TEMPERATURE :

- Behavior of the rubber tree under annual mean T°C above 28°C is unknown and unpredictable (until now, rubber tree has been planted only between 23°C and 28°C). Impact on growth ? Impact on yield ?

- **Growth and adaptation of rubber clones under these new coming high temperatures ?**

- **Impact on the yield ?**
  - Latex flow after tapping (duration of flow especially) is linked to internal turgor pressure in the latex vessels (this is the reason why all rubber planters tap at night or in the early morning, when the daily temperature is the lowest and latex turgor pressure is the highest).
  - What will happen if the temperature raises by 2 or 3°C at the time of tapping ?

Climate change and rubber: Risks

RISKS LINKED TO INCREASED TEMPERATURE :

- Increase in air temperature will lead to higher vapor pressure deficit (VPD), and altered stomatal conductance, tree transpiration and water status.
- It will also affect photosynthesis, respiration, carbon allocations and physiology of the latex vessels.
- Too high temperatures will increase the risks of water stress disorders (xylem embolism / cavitation creating disruption in water uptake)
- May have impact on soil functioning/quality (soil moisture and flora/fauna)

- **As the latex production totally depends on carbohydrate availability and tree water status (latex itself is composed of about 60-65% of water, as it is a cytoplasm), there are large uncertainties and knowledge gaps.**

Climate change and rubber: Risks

RISKS LINKED TO INCREASED TEMPERATURE ASSOCIATED WITH WATER STRESS:

« Die-Back » and Trunk Necrosis

Thailand, CRRC, 2005.

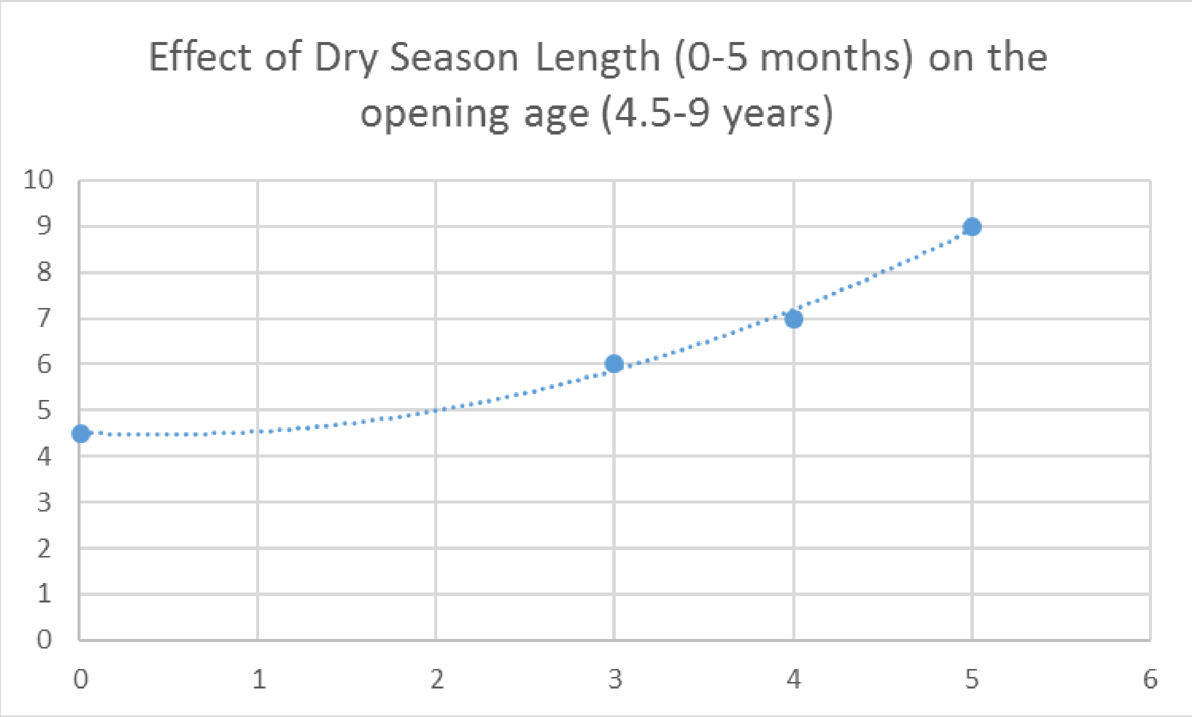
Dec 2003-May 2004	295mm
Jun 2004 -Nov 2004	696mm
Dec 2004-May 2005	299mm

1300 mm/18 months + extreme temperatures in March-April and May

Climate change and rubber: Risks

RISKS LINKED TO INCREASED CONTRAST BETWEEN SEASONS

- **Lengthening of dry seasons** affects the **immature growth**.
- Rubber has never been planted in areas where the number of dry months (<50mm) is >5



Adaptation:

- **Clones adapted to drought**
- **Planting techniques**
- **Mulching/soil coverage to maintain soil moisture and to limit evaporation**
- **Irrigation (?)**
- **Selected rootstocks for increased WUE (?)**

Climate change and rubber: Risks

As other aspects linked to climate change (frequency of extreme events as **typhoons** causing **wind damage**, increased risk of **flooding**, possible development of **new diseases/pests**, increase in **atmospheric CO_2 concentration**, etc.) may also strongly impact latex production, they have to be anticipated by ***ad hoc* research for adaptation**.

Climate change and rubber: Risks and opportunities
Hypotheses per climatic classes

The complexity of climate change impact is that rubber cultivation marginality is mainly determined by 2 rather independent climatic factors (Temperature and Rainfall), quantitatively and qualitatively (distribution)

The possible impact is therefore anticipated as different depending on the climatic classes :

Climatic class 1 (WARM & HUMID / Traditional areas) :

- **Risk of a progressive SHIFT to class 2 (WARM & DRY)**
- **Research on adaptation of practices (clones, planting (soil cover), mulching, irrigation, stimulation display, agroforestry/cover crops (synergy/competition for water/nutrients uptake…) and soil functioning in a changing environment.**

Climate change and rubber: Risks and opportunities
Hypotheses per climatic classes

Climatic class 2 (WARM &DRY)

- **Likely the FIRST AFFECTED if temperatures higher than 28°C are confirmed to be detrimental to rubber growth and production.**
- **The risk of increasing severity of dry seasons questions the future sustainability of rubber cultivation in those areas**
- **Adaptation of practices unlikely able to solve the problem…**

Climate change and rubber: Risks and opportunities
Hypotheses per climatic classes

By contrast the situation of **class 3 (COLD & HUMID)** and **class 4 (COLD & DRY)** might **IMPROVE**.

Current **class 3 (COLD & HUMID)** zones might even **become the best areas for rubber cultivation if temperatures increase by 2-3°C (Possible SHIFT to class 1 (WARM & HUMID).**

Beware ! This might be a possible cause for land use change (LUC) :

It should be very well monitored to avoid possible future land grabbing and deforestation, as these areas are currently still mainly covered by forests.

Climate change and rubber: Opportunities and Perspectives for Research

Setting up multidisciplinary research programs (associating breeding, physiology, ecophysiology, technology, climatology, bioclimatology and socioeconomics) appear as a priority to guarantee the sustainability of the NR supply chain in this context of global climatic change, in order to:

- **Fill the numerous knowledge gaps and improve the downscaling / reliability of forecasts at local/regional levels;**
- **Adapt the GAPs to the new growing conditions (technical packages)**
- **Generalize the adoption of the CSA concept (Climate Smart Agriculture) for CC adaptation and mitigation.**
- **Orient decision making and planting policies on scientifically sounded criteria.**

Together with the other global challenge (labor shortage risk), it should be the main goal of natural rubber research in the next decades.

Thank you very much for your attention