

Yak and people on the Asian Highland

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Outline



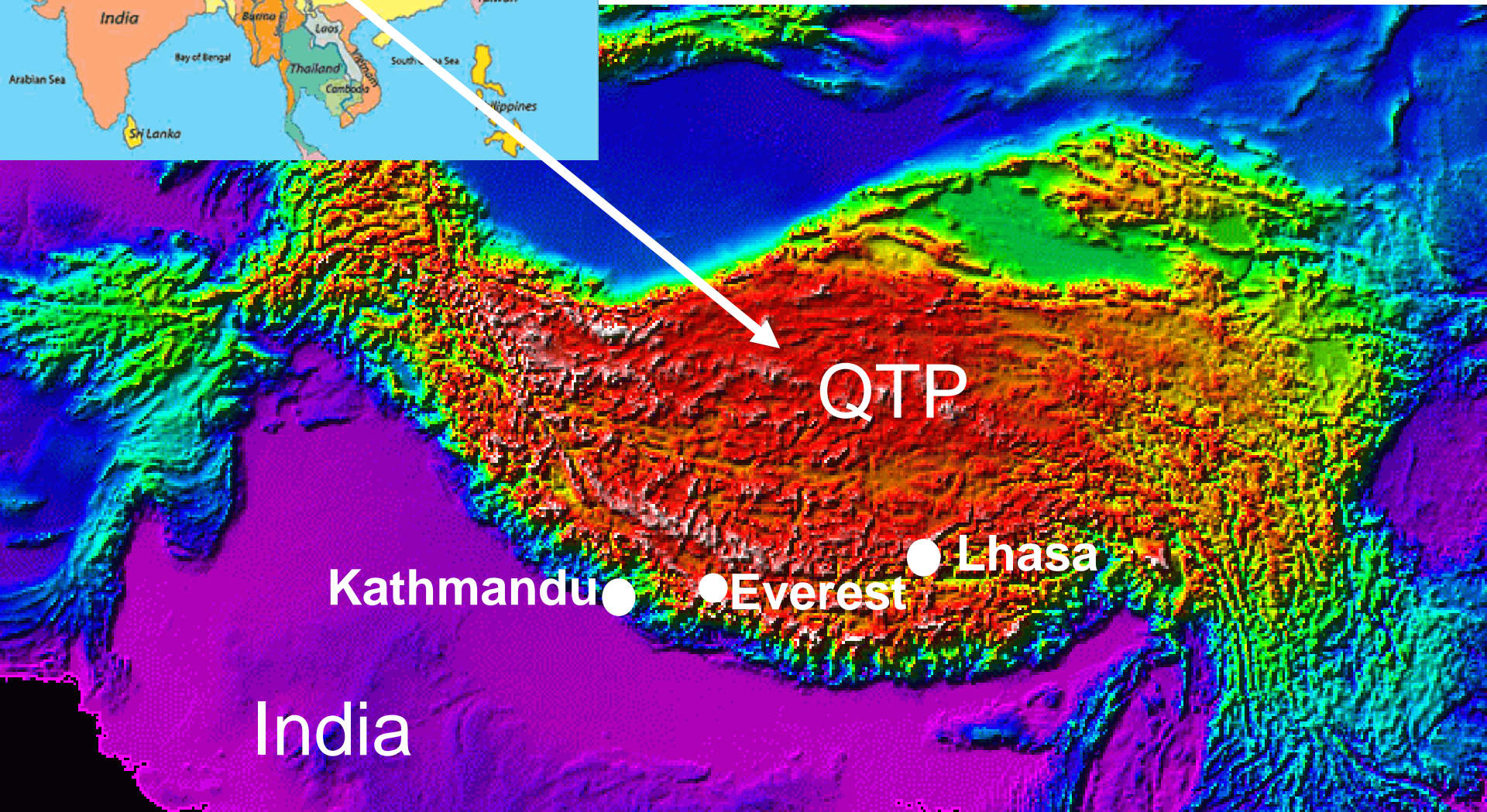
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FOR MOUNTAINS AND PEOPLE

- ◆ *Where the yak comes from?*
- ◆ *Why the yak be able to live on the highland?*
- ◆ *What type of relationship exist between Tibetans and yak?*
- ◆ *How to manage the nomadic livestock industry in a sustainable way?*



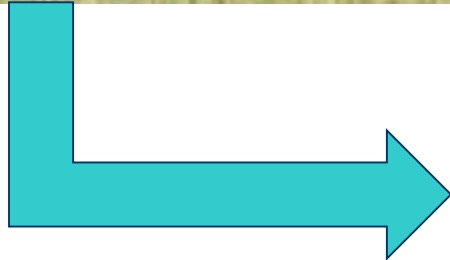
The Qinghai-Tibetan Plateau, China



Where the yak comes from?



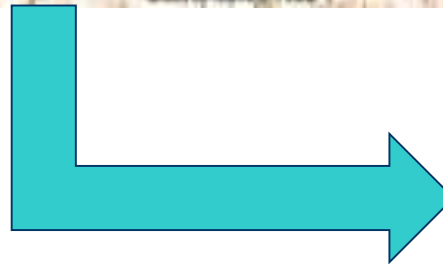
Cattle (*Bos taurus*)



Yak has diverged from cattle 4.5 million years ago



Yak (*Bos grunniens*)



Bison has diverged from yak 2.5 million years ago



Domestic yak



Bison (*Bison bison*)

The yak was domesticated about 8,000-12,000 years

Distribution of yaks in the World



~15 million in the World
~90% in China



The Qinghai-Tibetan Plateau

India

From N to S: ASL - higher
Rainfall - more
From E to W: ASL - higher
Rainfall - lesser

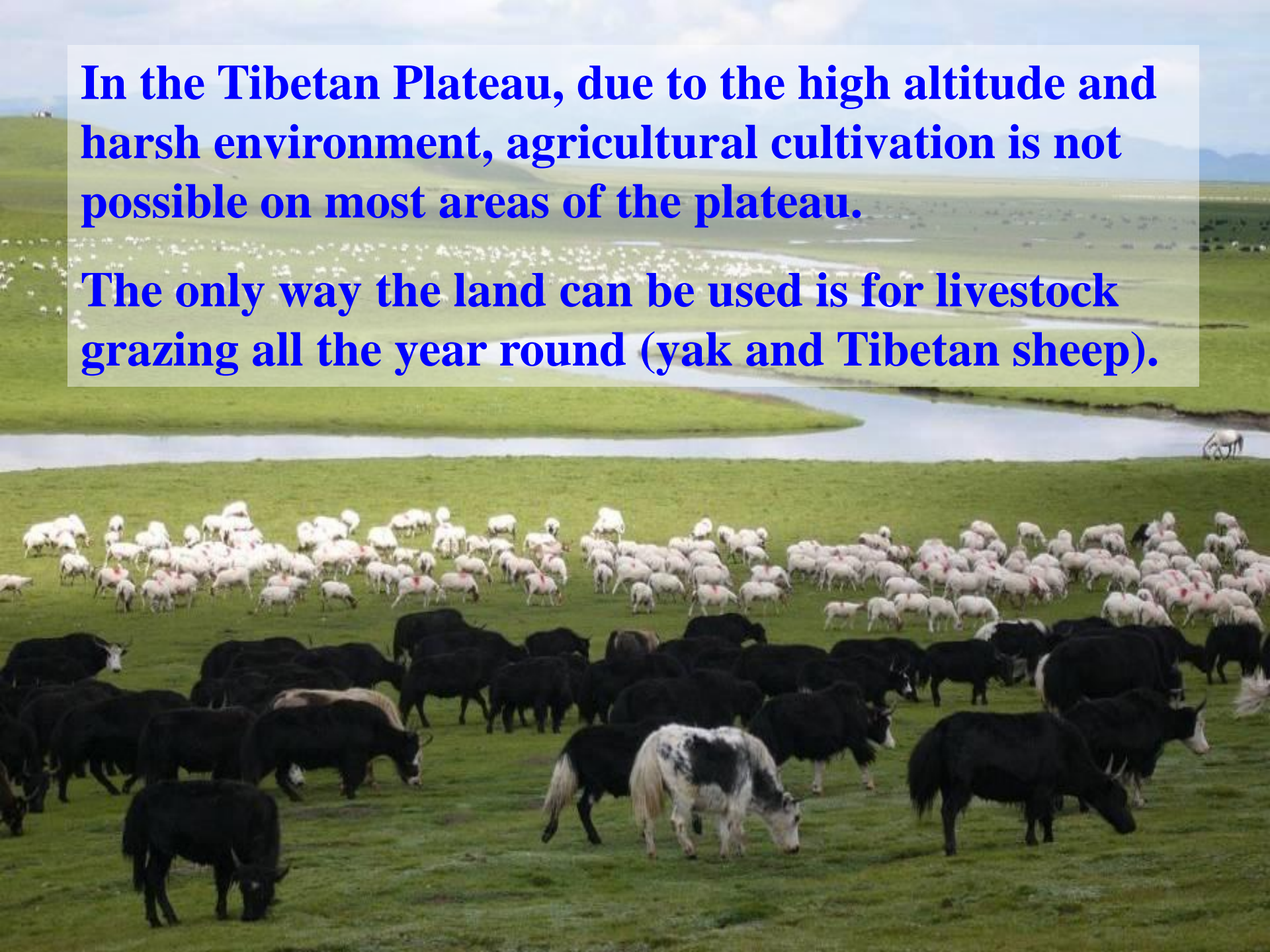
The area: 2.5 million sq km²
The highest in average: > 4,000m
Rangeland area: >51%
Climate: Cold and dry



The third pole

In the Tibetan Plateau, due to the high altitude and harsh environment, agricultural cultivation is not possible on most areas of the plateau.

The only way the land can be used is for livestock grazing all the year round (yak and Tibetan sheep).



Polar bear



Hoarding fat & Dormancy



Yak ?



Penguin

Hoarding fat

North pole



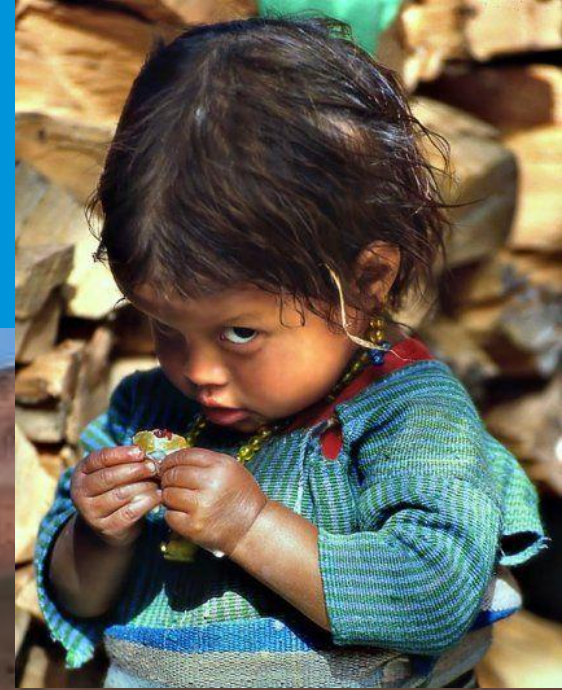
The third pole

Why the yak is able to live on the highland?

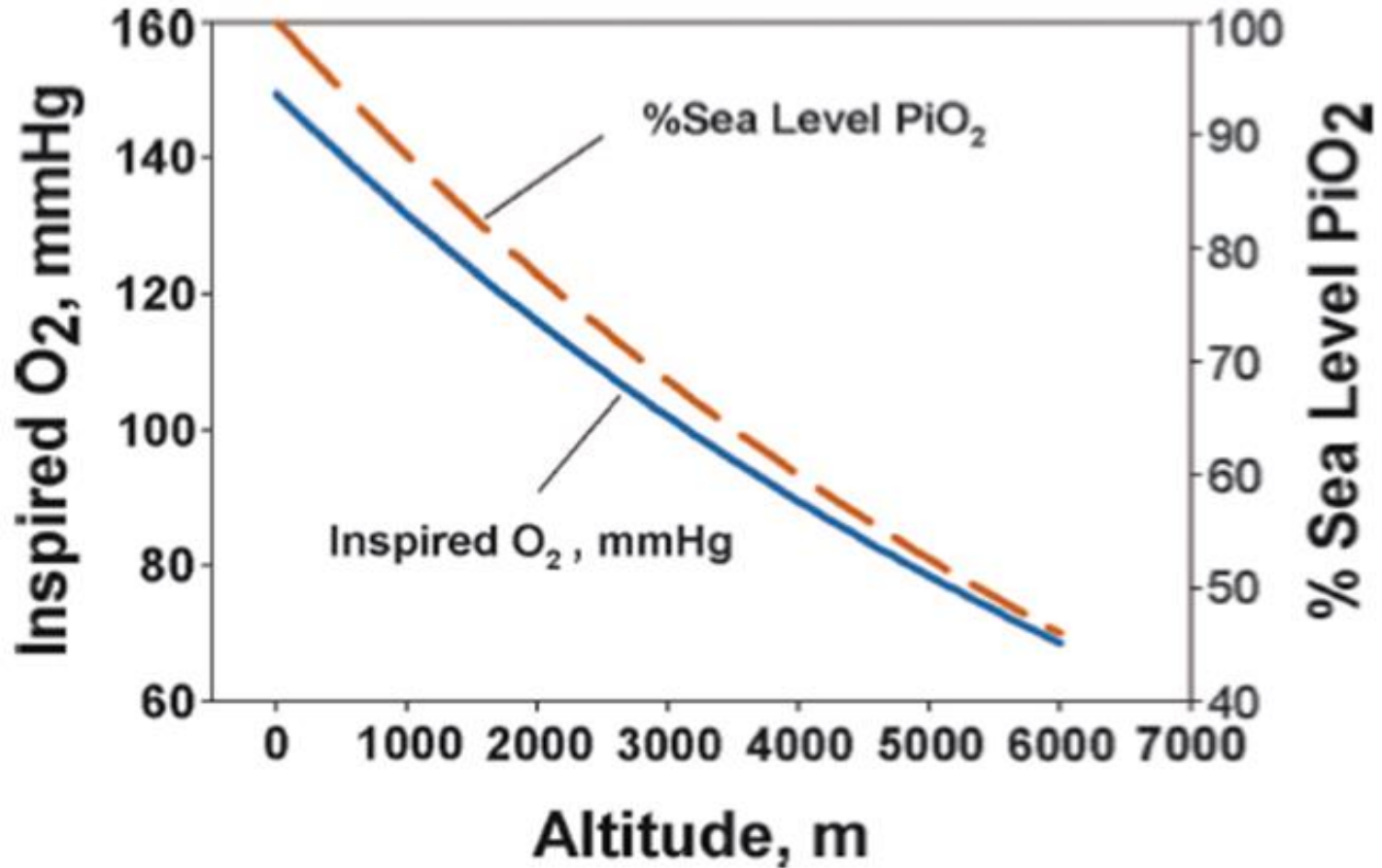
South pole

How does the yak adapt to the alpine harsh environment ?

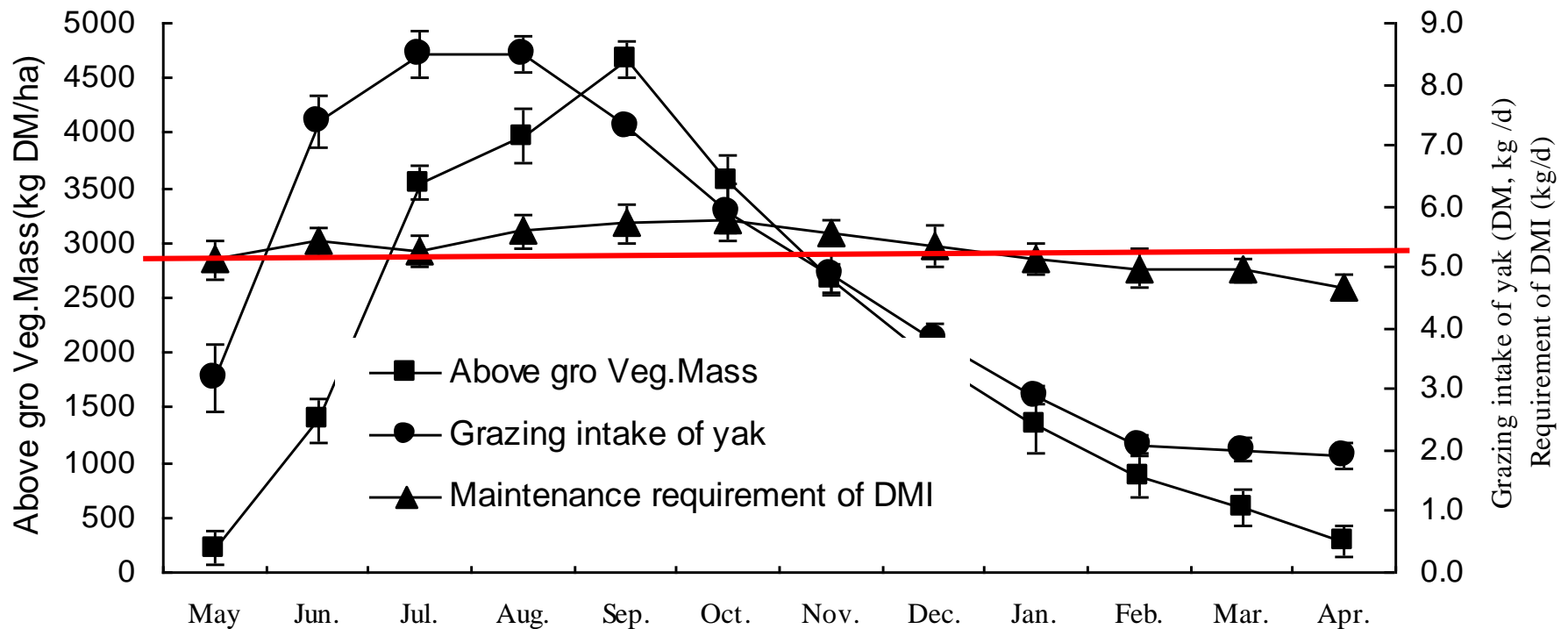
- ◆ Low O_2 (3,000m-5,000m:70-45% of sea level)
- ◆ Cold in winter (-20 to -40 C°)
- ◆ Insufficient forage in cold season



Oxygen levels decrease with altitude increase

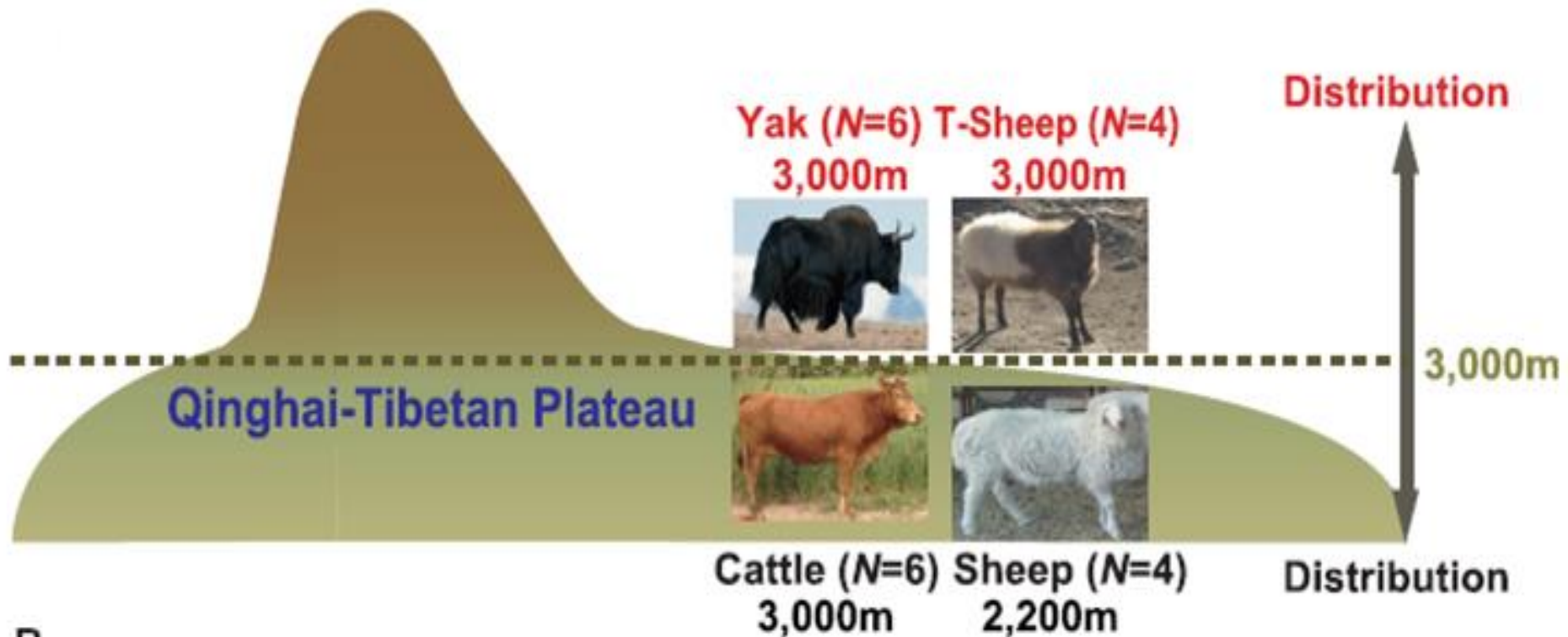


Model of forage supplied from native rangeland VS daily maintenance requirement by yak across a year



From Long, 1995

Yak (*Bos grunniens*) **vs** Cattle (*Bos taurus*)

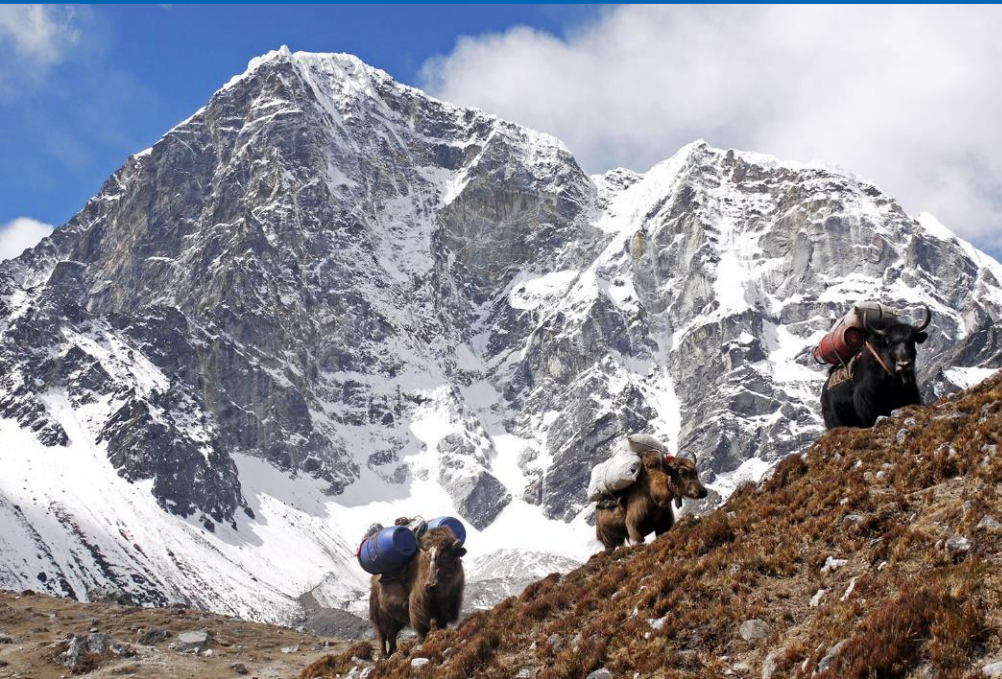


Adapt to hypoxic environment

In contrast to cattle, yak has:

- ◆ A larger heart & lung

- ◆ The foetal haemoglobin in their blood throughout life, transport greater O_2 through them.



Adapt to cold environment



In contrast to cattle, yak has:

- ◆ A thick layer of subcutaneous fat
- ◆ Without functional sweat glands
- ◆ Long shaggy hair with a dense woolly undercoat over the body.
- ◆ Reduce about 50% of heart rate in winter



Daily heat production of grazing yak measured by the heart rate and GPS location system

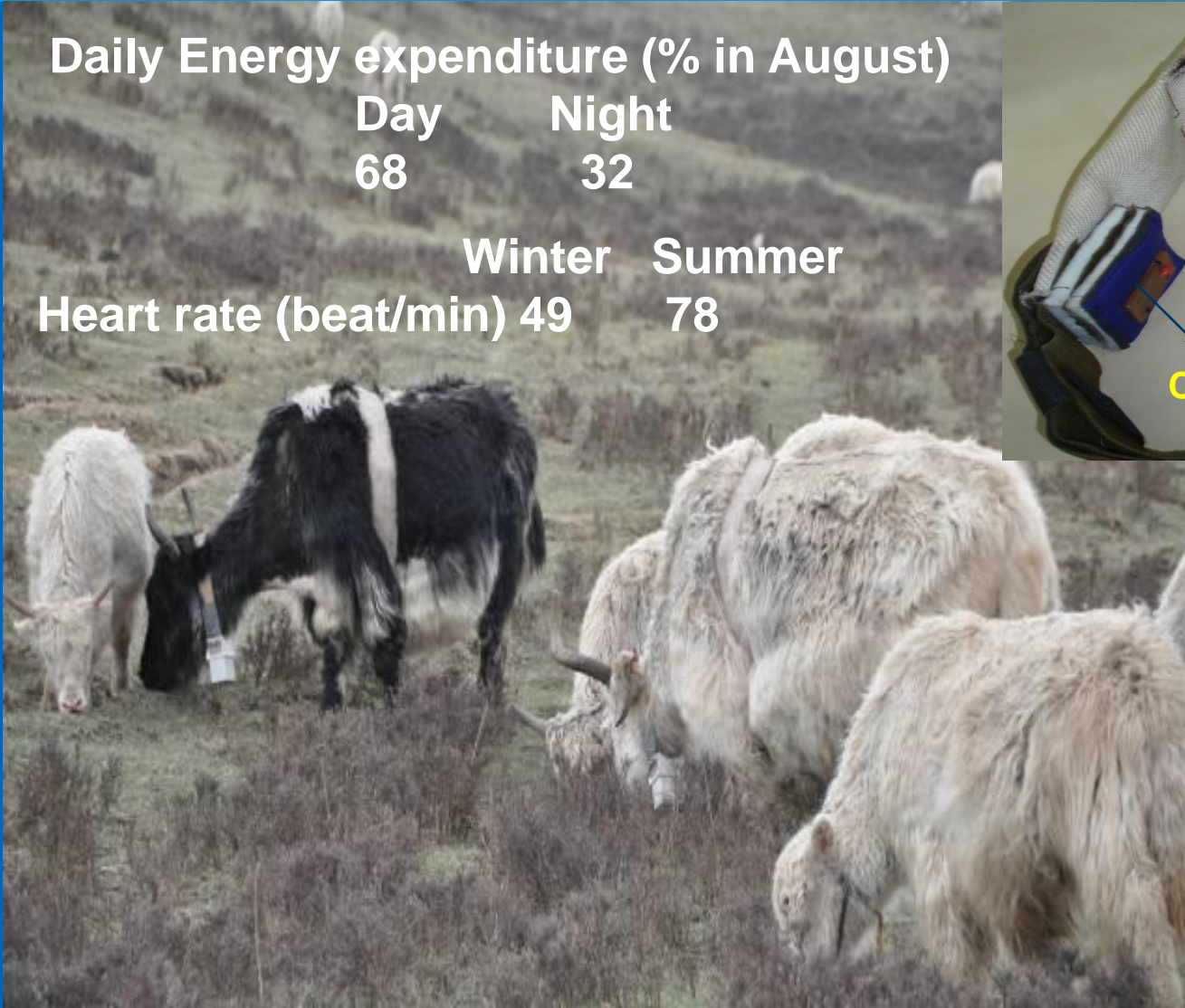
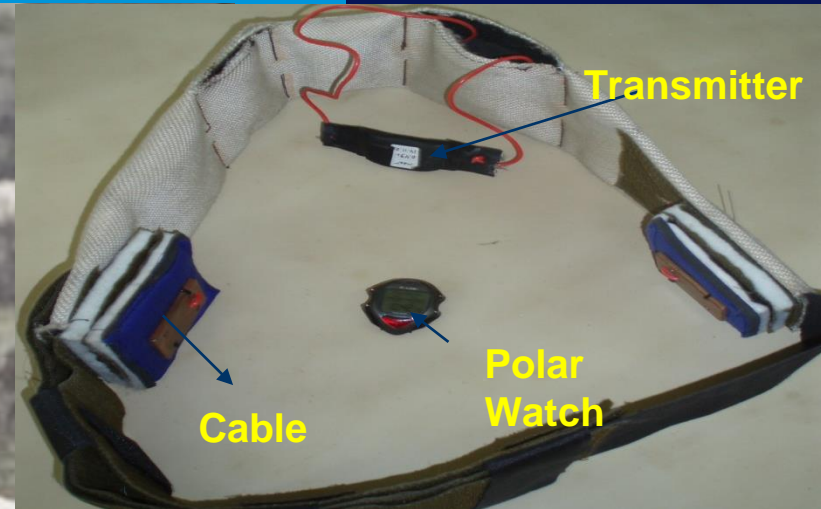
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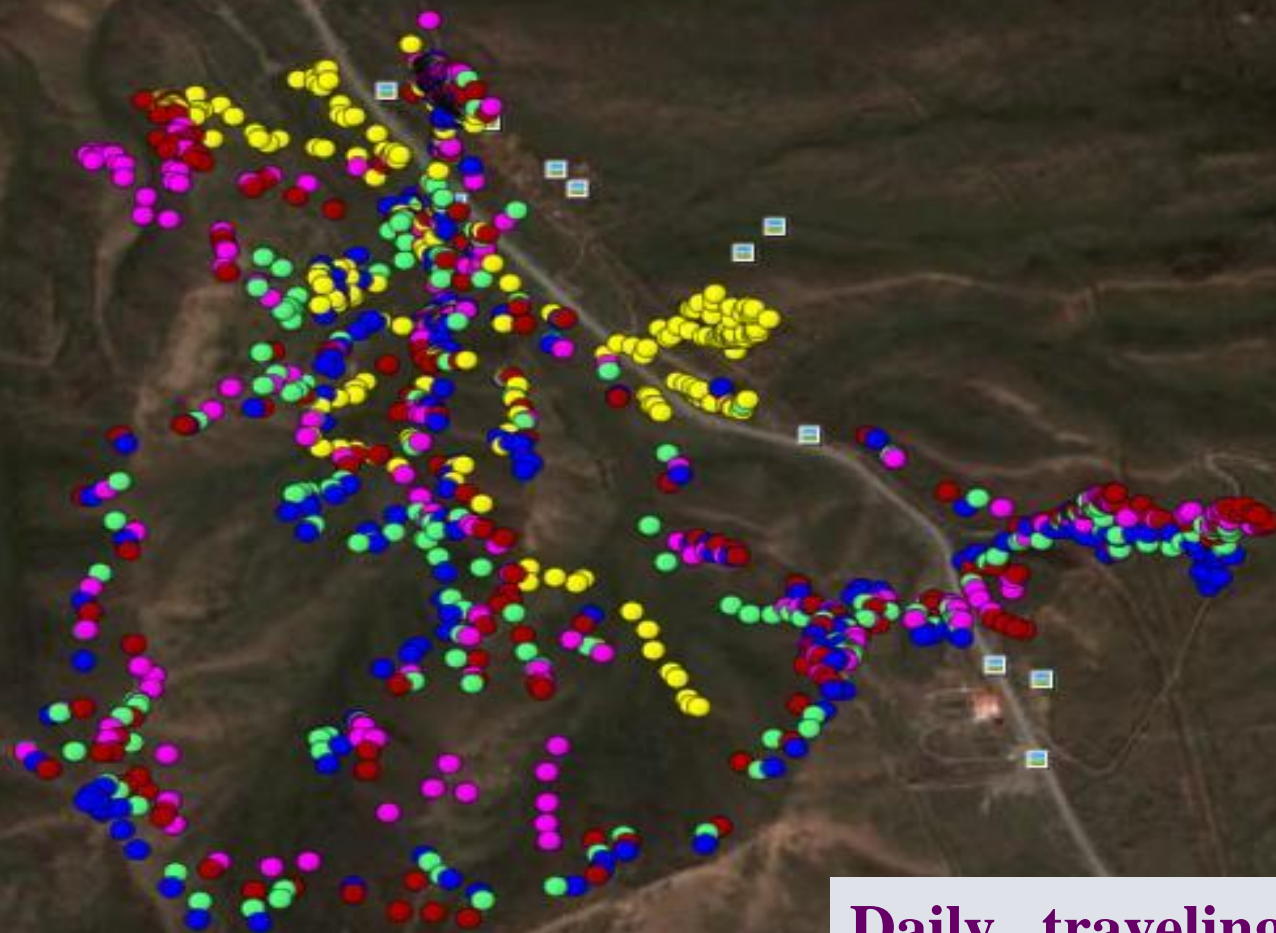
Daily Energy expenditure (% in August)

Day	Night
68	32

	Winter	Summer
Heart rate (beat/min)	49	78



GPS track of individual grazing yak daily



© 2010 Mapabc.com
Image © 2010 GeoEye

Daily traveling distance
(km/day, $P < 0.05$):

December: 3.2 ± 0.21

May: 5.3 ± 0.13

Adapt to harsh forage environment-1

In contrast to cattle, yak has:



◆ A shorter tongue, yak intake forage by using the labia oris, likes sheep, more efficient.



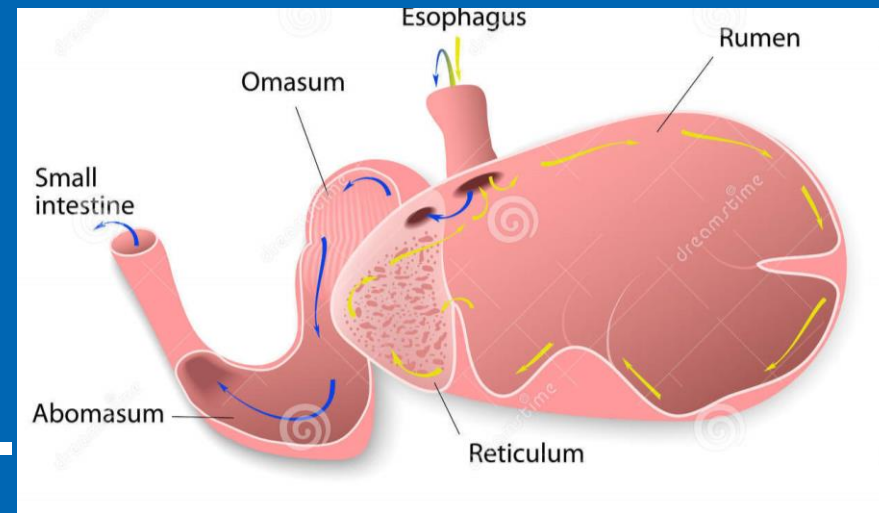
◆ A weaker taste, able to have a broad eating patterns.

Adapt to harsh forage environment-2



In contrast to cattle, yak has:

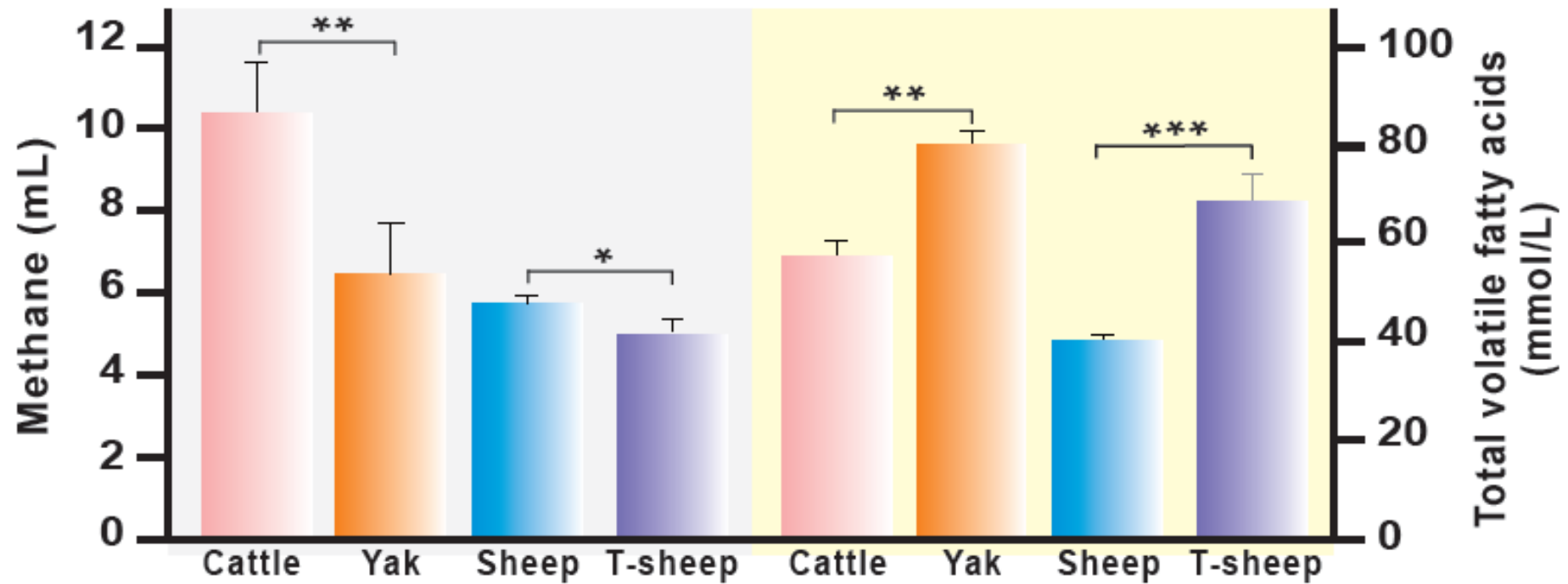
- ◆ A larger rumen, consume greater quantities of poor food, longer fermentation, to extract more nutrients.
- ◆ Produce lesser methane & more volatile fatty acid (VFA).



Ruminant stomach

Metabolic phenotype convergence in high-altitude ruminants

Low-methane and high-VFA productions



CH₄ production from grazing yaks measured (*in vivo*)

SF₆ permeation tubes:

Brass tube+Swagelok nut,
9/16"

(NIWA, New Zealand)

Permeation rates:

2-6 mg (SF₆/d)



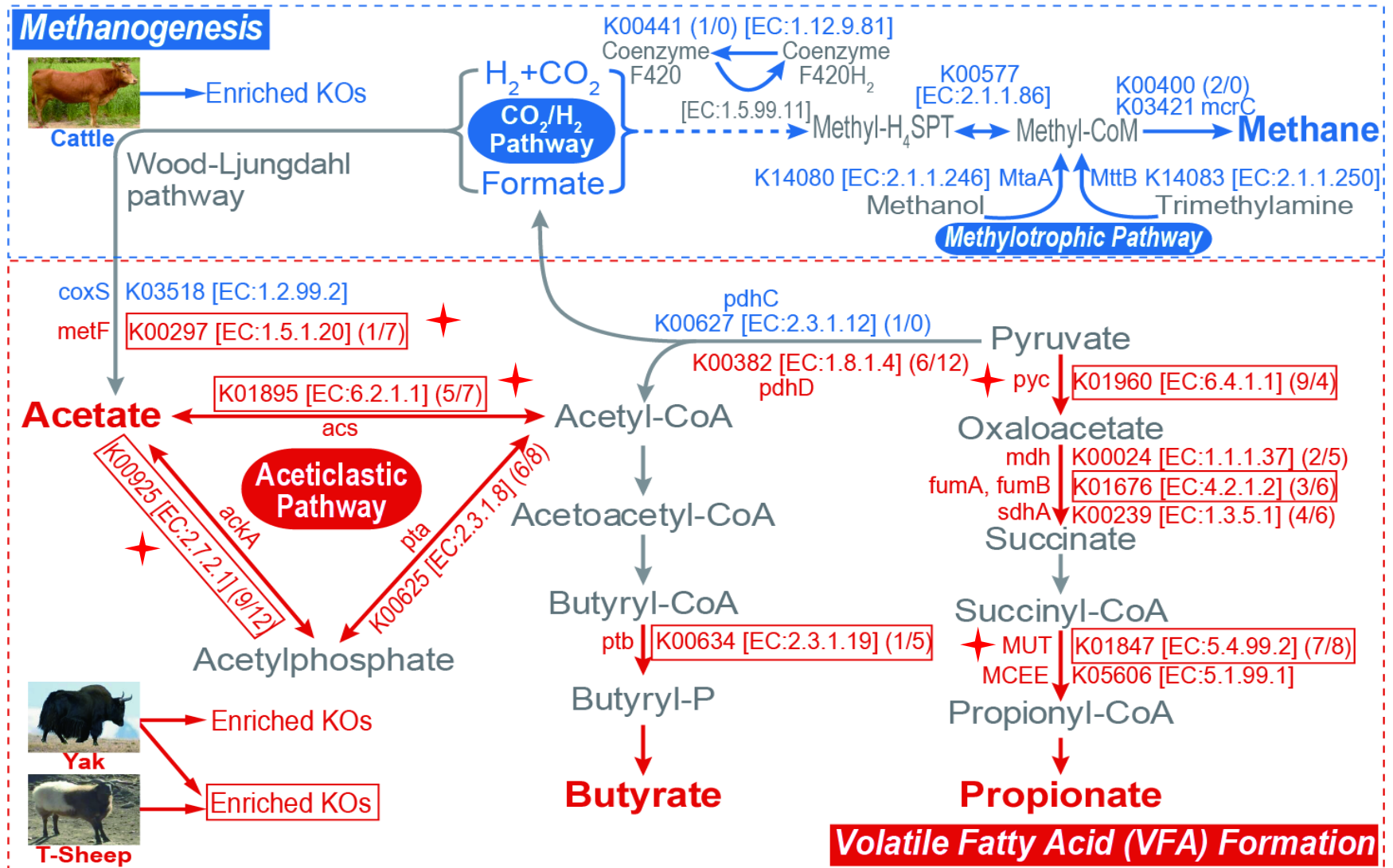
CH₄ emission per day:

The yak(178kg): **81g, 1.68g/kg W^{0.75}**

Beef cattle (NZ) (475kg): **431g, 4.23/kg W^{0.75}**

Ding and Long etc. 2011 AFST

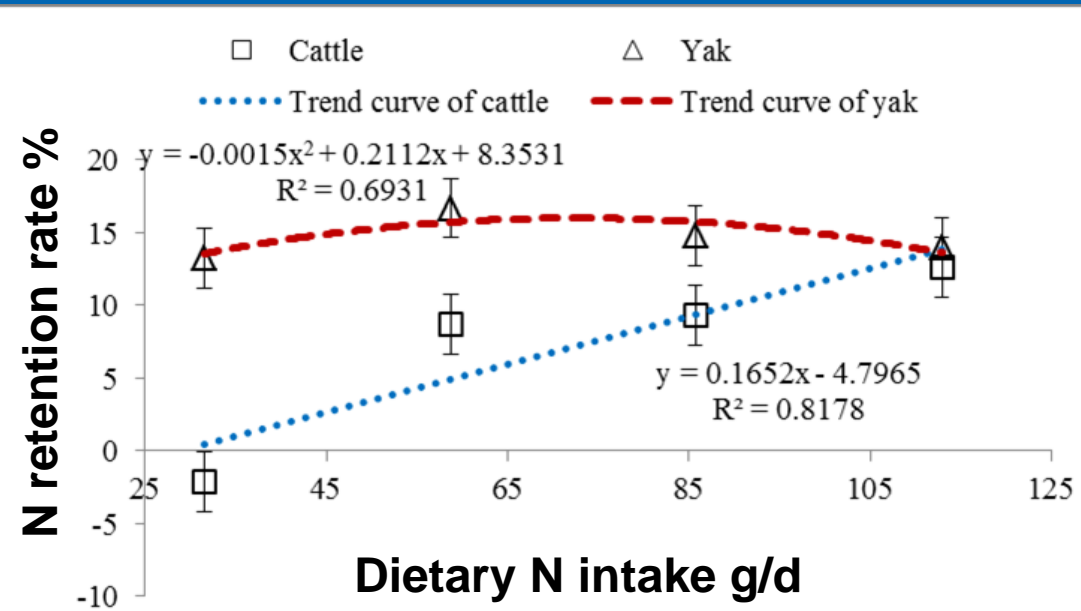
Convergent evolution of rumen microbial genes in high-altitude species



Adapt to harsh forage environment-3

In contrast to cattle

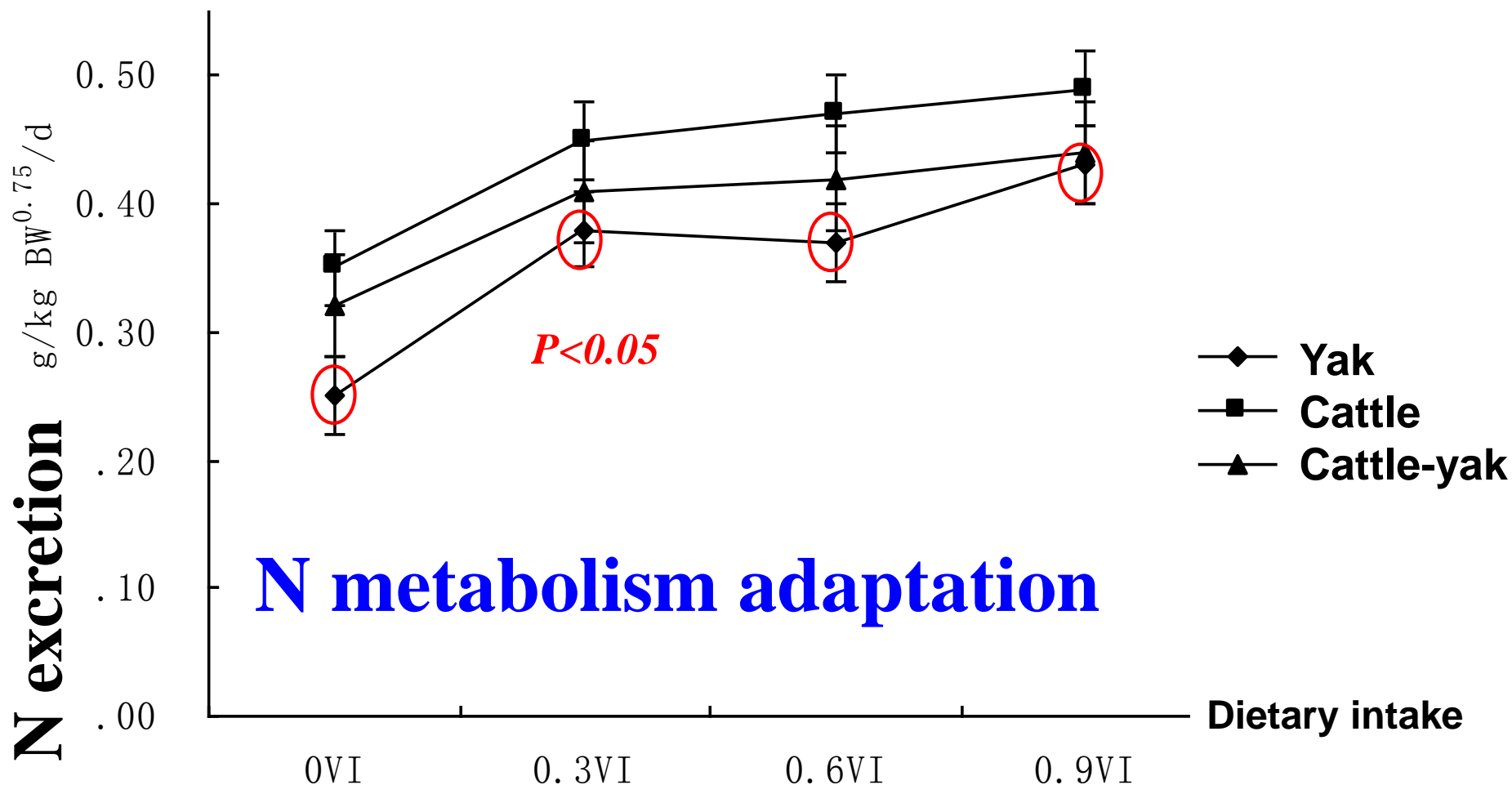
◆ The yaks can utilize more feed nitrogen through faster N-recycling in the body.



N retention rate at various levels of dietary-N in yak & cattle

Zhou et.al, 2017, JAS

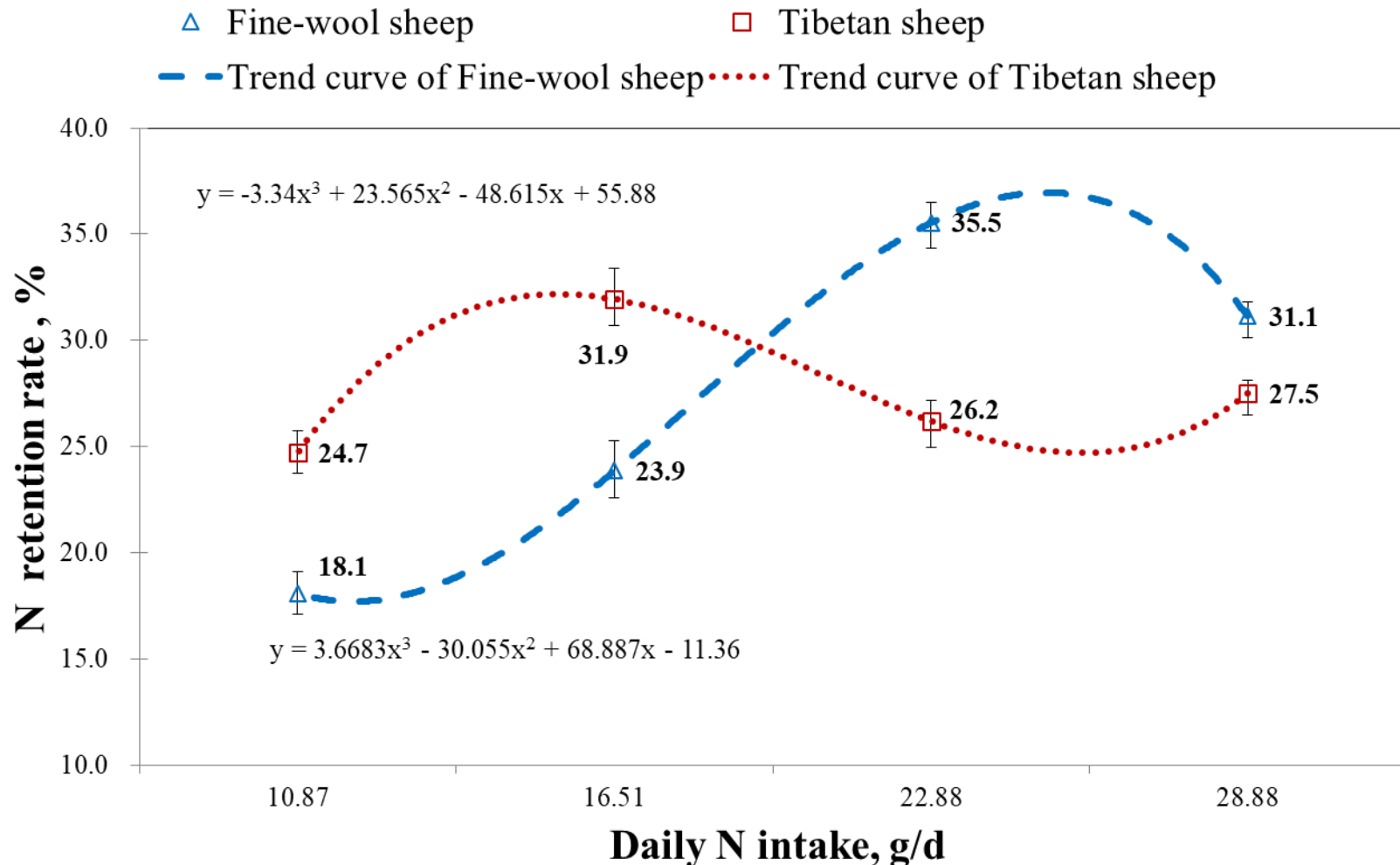




Response of urinary N excretion to feeding levels in yak, cattle and cattleyak fed oat hay

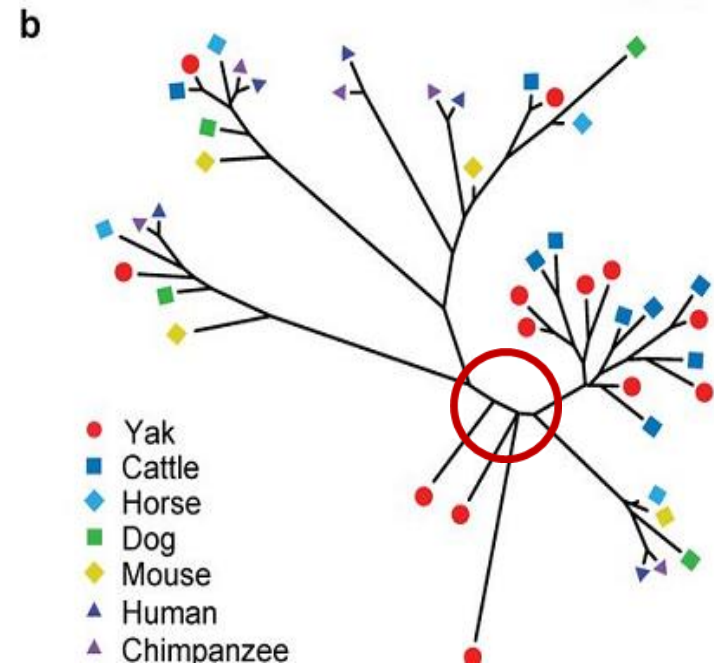
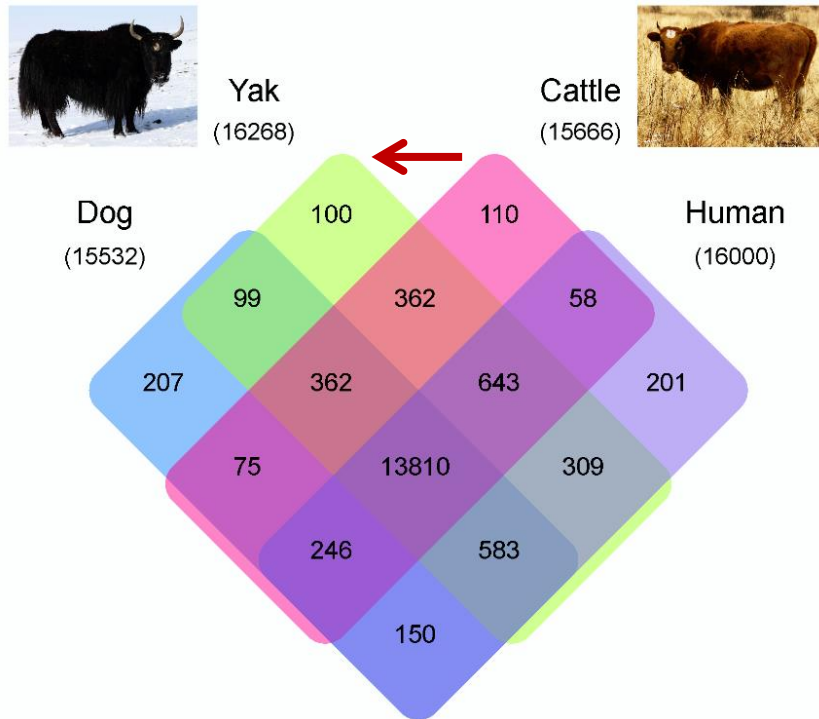
From Wang & Long et al. 2011, AAJAS

N retention rate at varying levels of dietary N in Tibetan and fine-wool sheep



(Zhou & Long, *Animal Feed Science and Technology*, 2017)

Alpine adaptive evolution in the yak genome



Gene family expansions in yak are mainly involved in the **nutrition-energy** metabolism and **hypoxic stress**, **five positive selection genes** are identified

Key message



In contrast to cattle

- ◆ **Yak genetics and physiology are well adapted to high altitudes**
- ◆ **The yak is a nitrogen-saving animal**
- ◆ **The yak is a low-carbon animal**

Wang & Long et al. 2011, AAJAS; Zhou & Long 2017 JAS

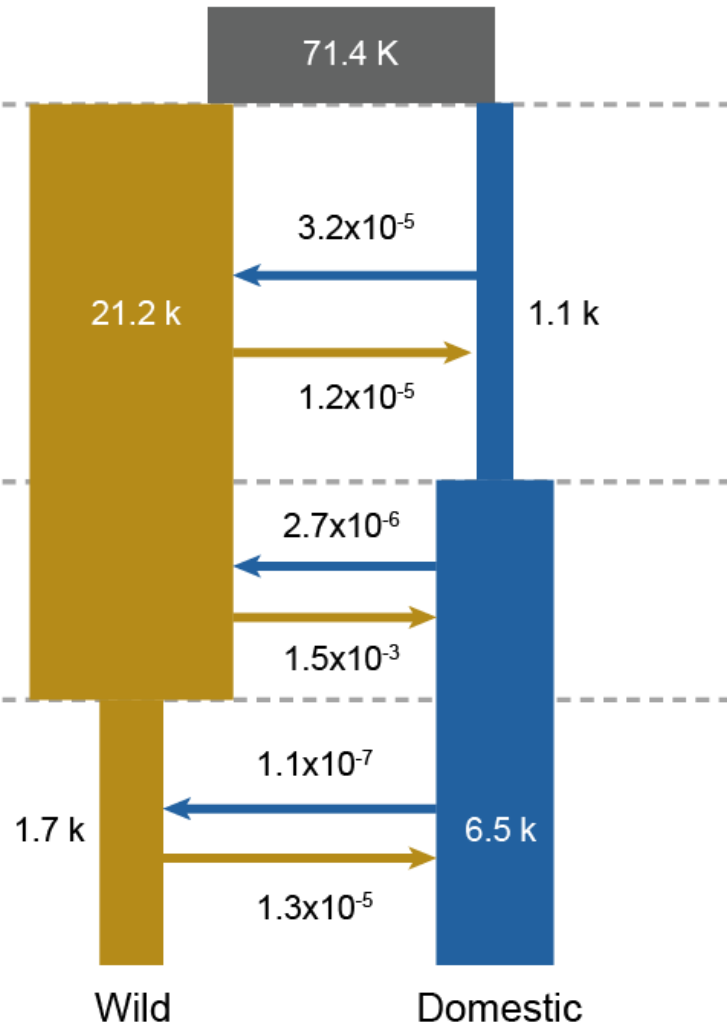
*What type of relationship
exist between Tibetans and yaks?*



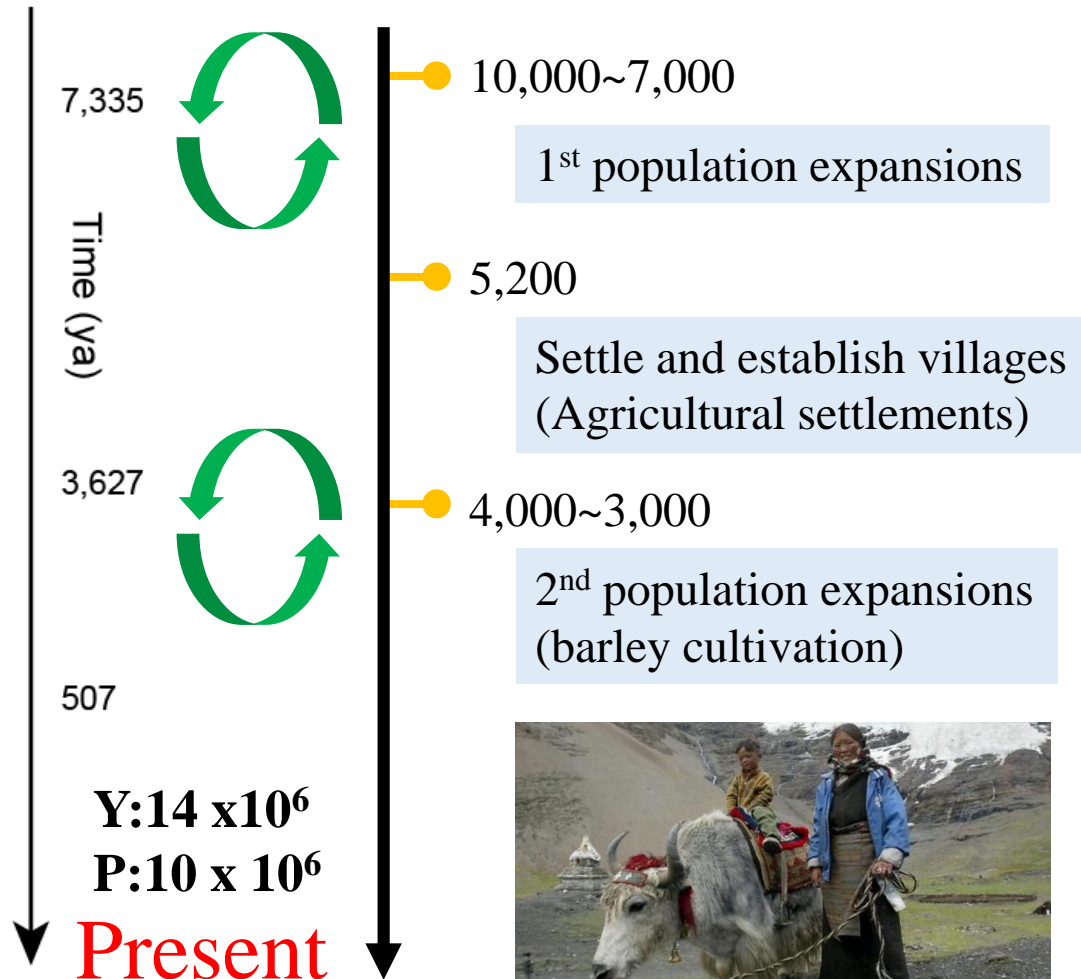
Yak domestication *vs* Human expansion in QTP

NC, 2016

Science, 2015



Domestication of yak



Human colonization in QTP



Yaks are the Tibetan family members



Source of milk and meat for Tibetans

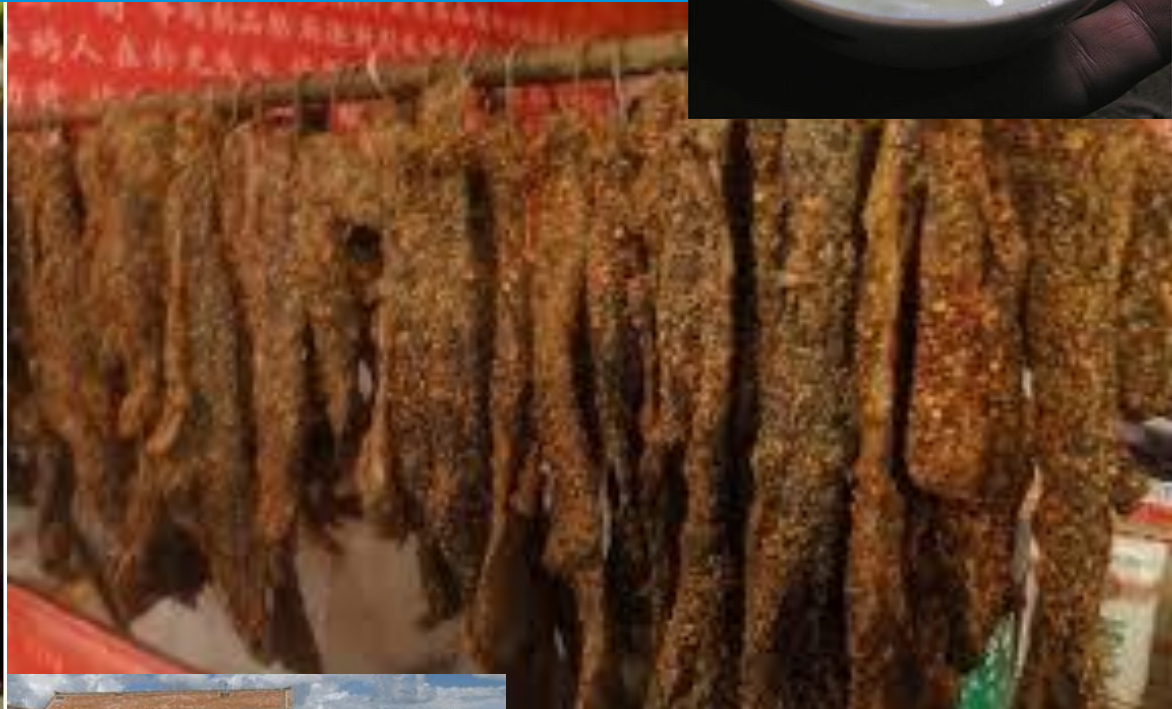


- ◆ Milk: < 90% for drinking milk, 100% butter and curd cheese the nomads' daily consumption are provided by yaks.
- ◆ Meat: < 60% of meat are from yaks



- ◆ Vitamins: V_C , V_A , V_E and others
- ◆ Minerals

Yak milk & meat products



Transportation and plowing





Ya

Fibre and skin



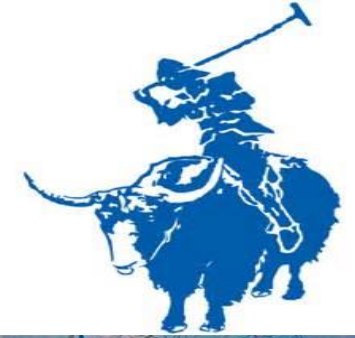


Religion, arts



Beautiful and powerful beasts worshiped by herdsman

Nomadic sports & recreation



Polo



Cowboy



nce





Settled/semi settled transhumance farming

Winter pasture



Settled/semi-settled an



Settled/semi-settled transhumance farming

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Winter settled house



Key message



- ◆ Yak is a multipurpose animal for providing necessities for herdsman (food, shelter, fuel, transport, and social status); its milk & meat provide essential nutrients (functional food) for maintaining nomads health.

- ◆ Yak is not only a key species to maintain rangeland ecosystem functions, but also a key element in the Tibetan culture

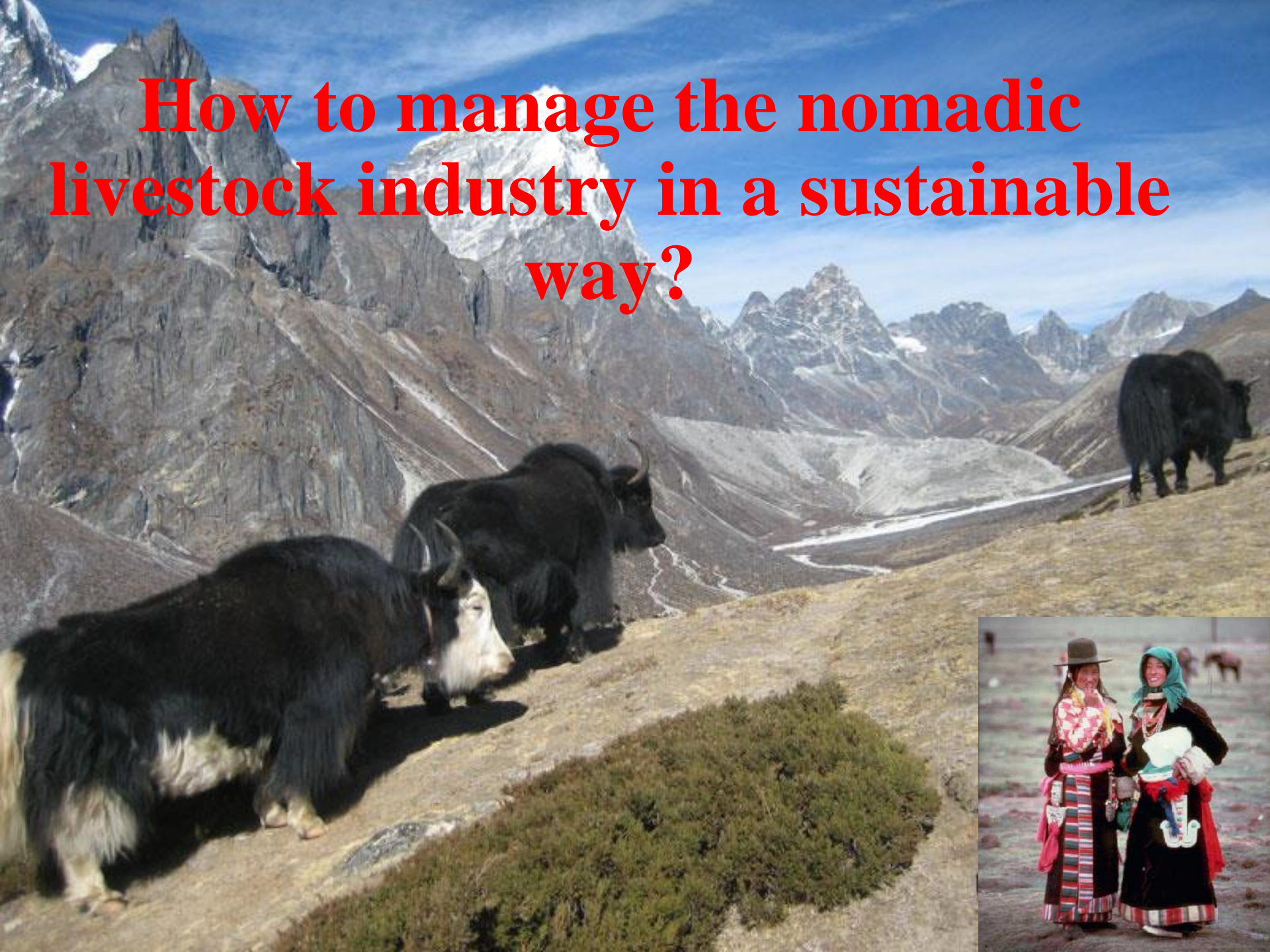
- ◆ During the early time, the human population might heavily rely on the yak domestication

- ◆ Without the yak's capacity to live in the high-altitude area, civilization might not have established in this remote area

The 10th Panchen Lama said that if no yaks, would no Tibetan people



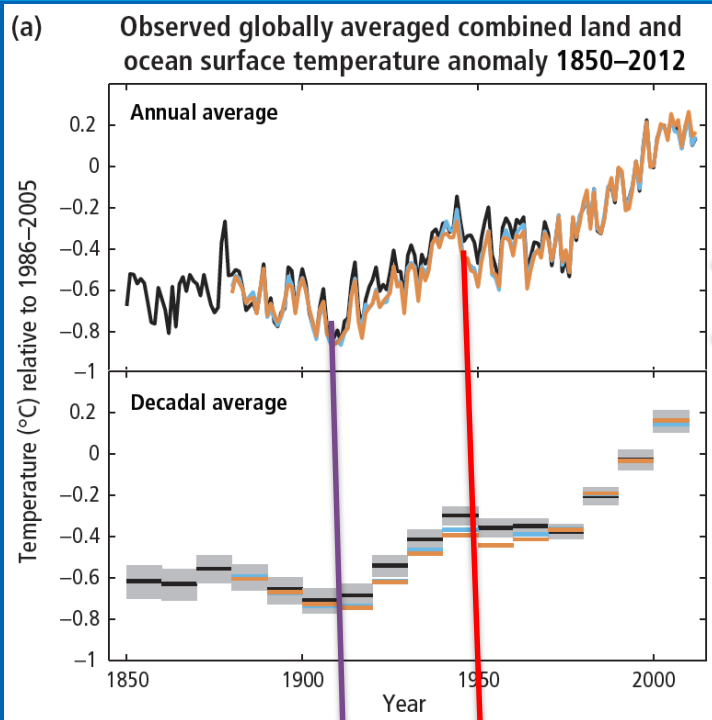
How to manage the nomadic livestock industry in a sustainable way?



Services provided by Tibetan rangeland ecosystem

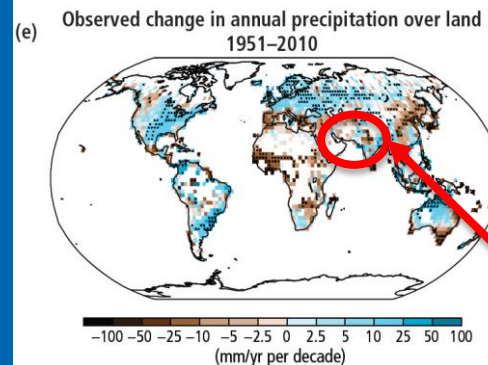
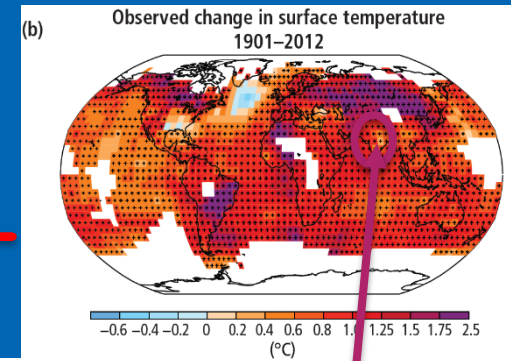


Challenges: Global Climate Trends and Himalayan-Tibetan region



≈1° C since 1900

≈0,6° C since 1950



Himalaya region ≈ 1.5° C increase since 1951

Himalaya region both wetter and drier regions since 1951

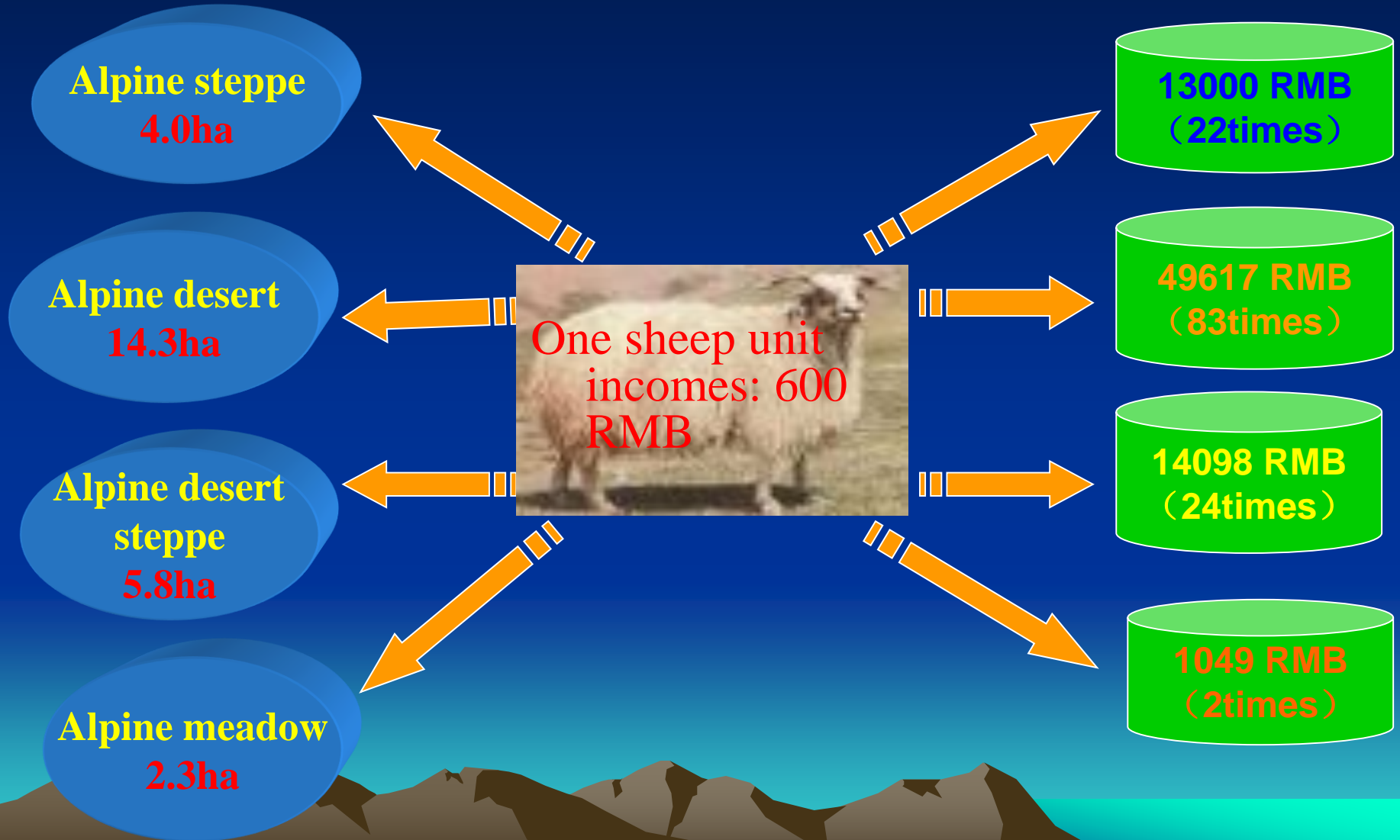
Overgrazing + climate change

ACI

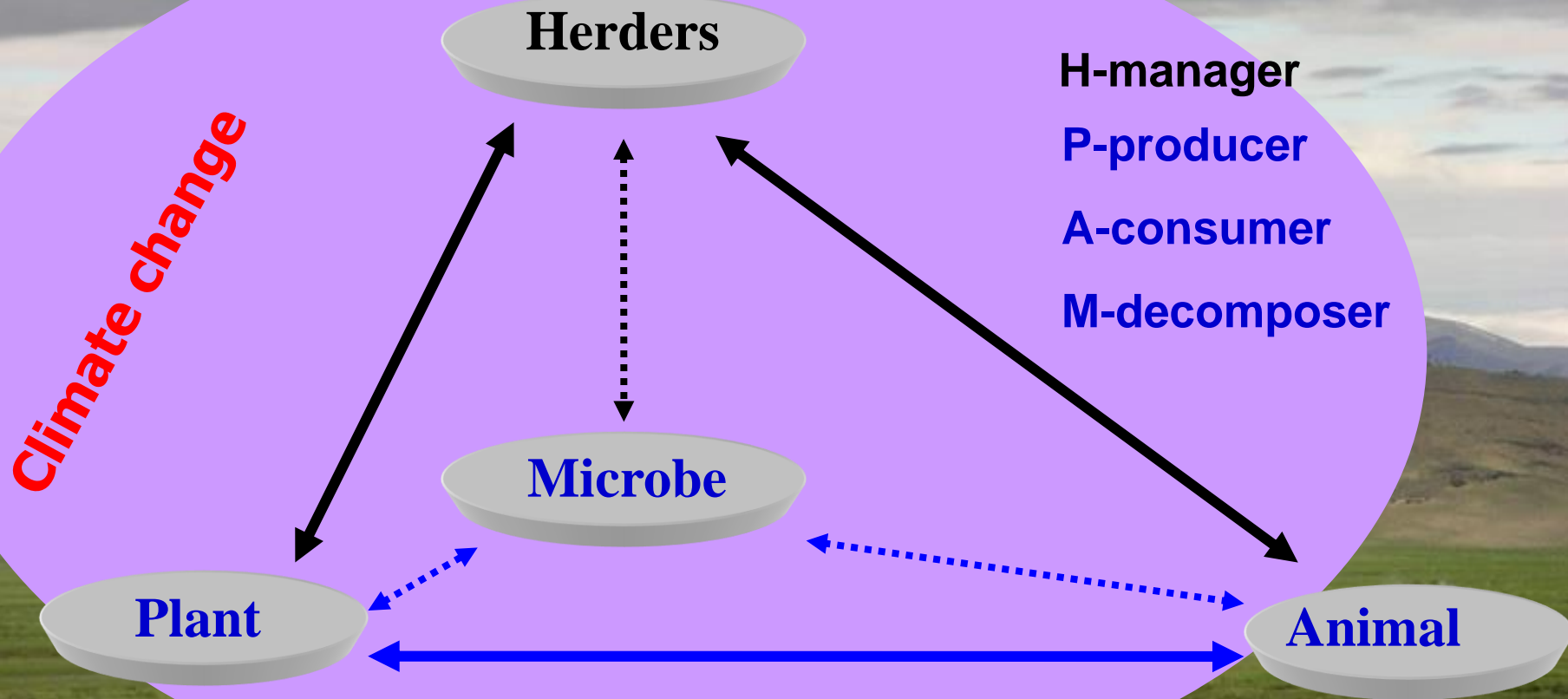


Degradation of alpine meadow in headwater
area of the Yellow River

Value of grazing one sheep unit VS value of ecological service offered from its grazing pasture

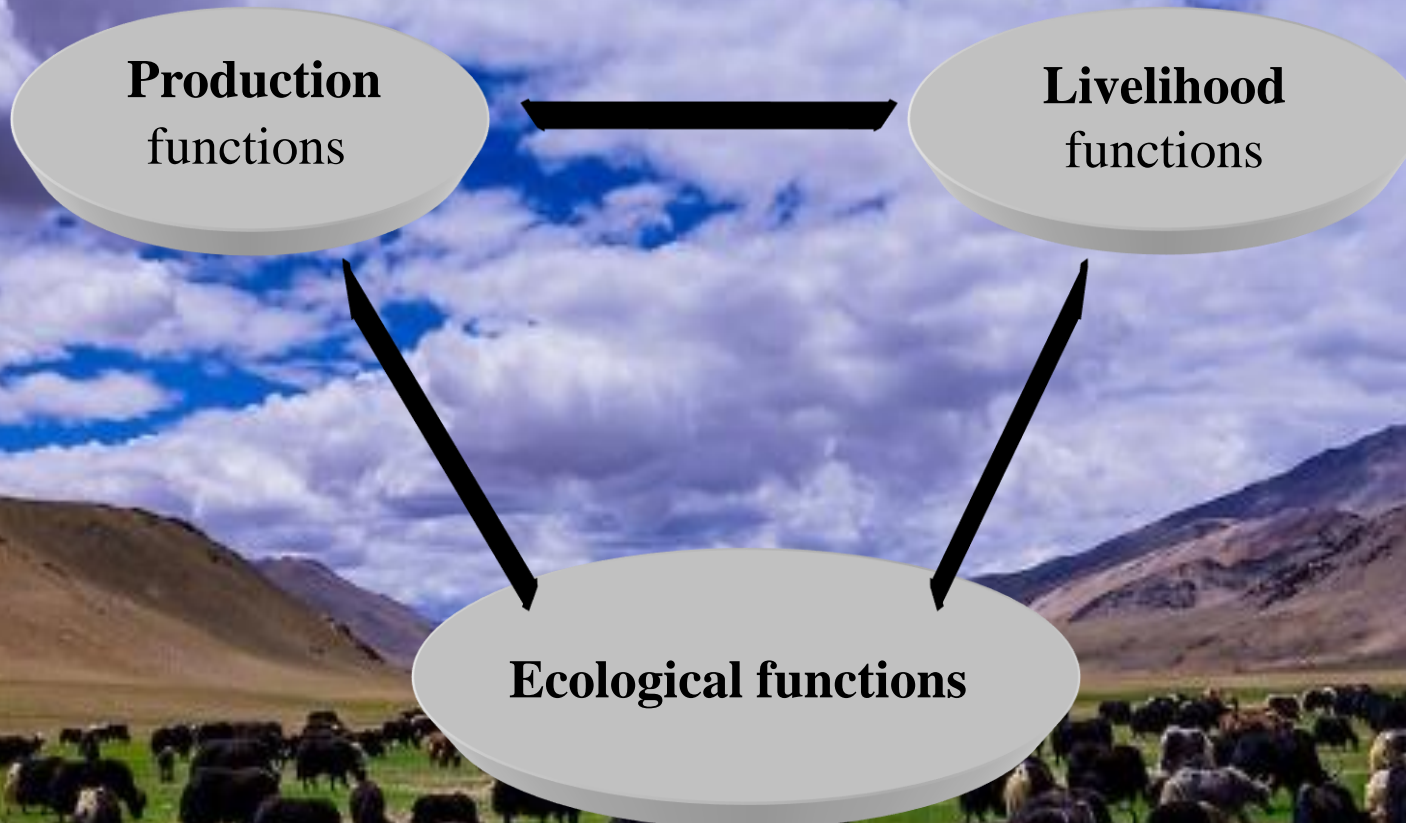


Opportunities: Biological structures of the Tibetan rangeland ecosystem



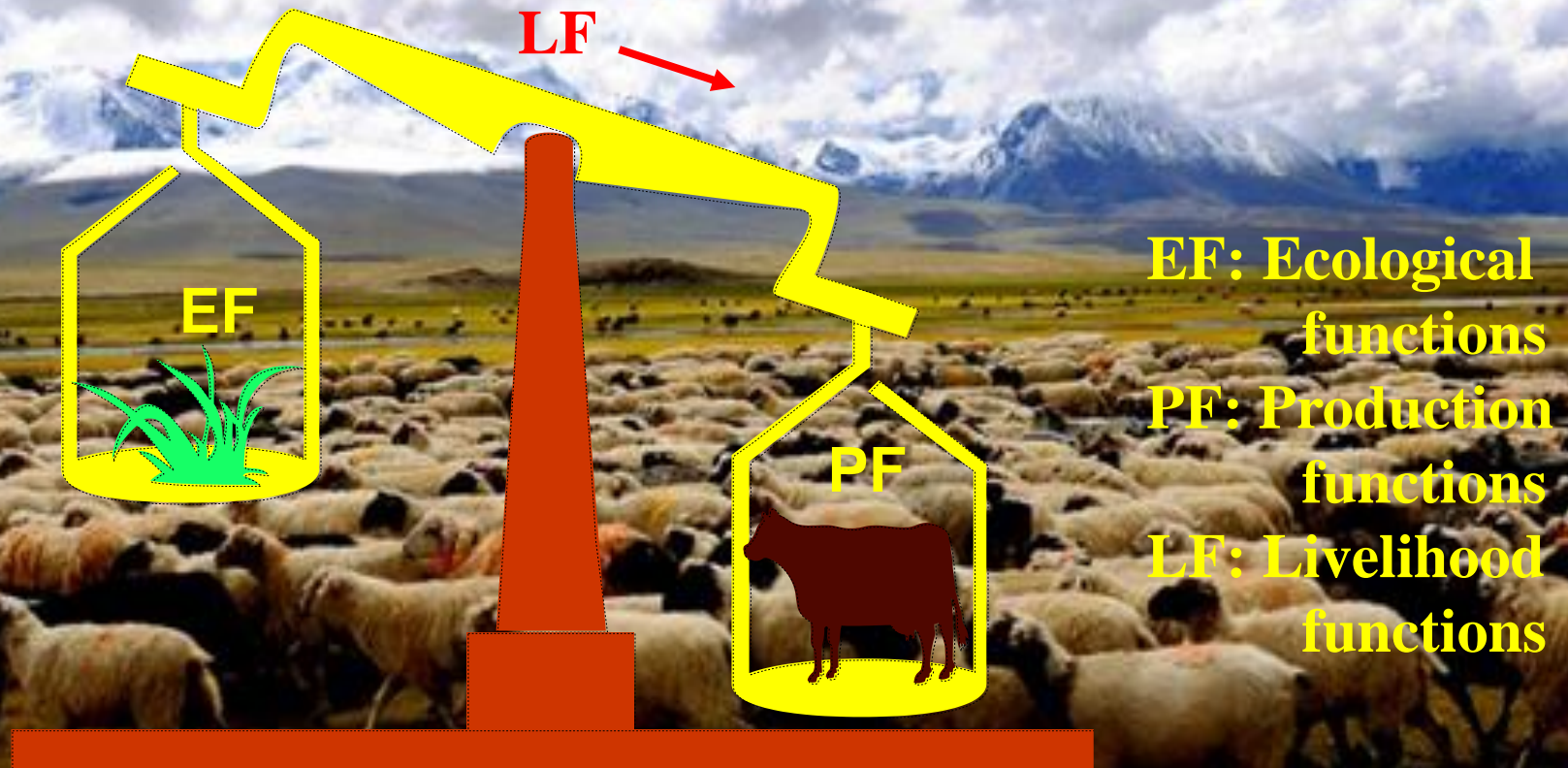
Willian Davies, 1950s

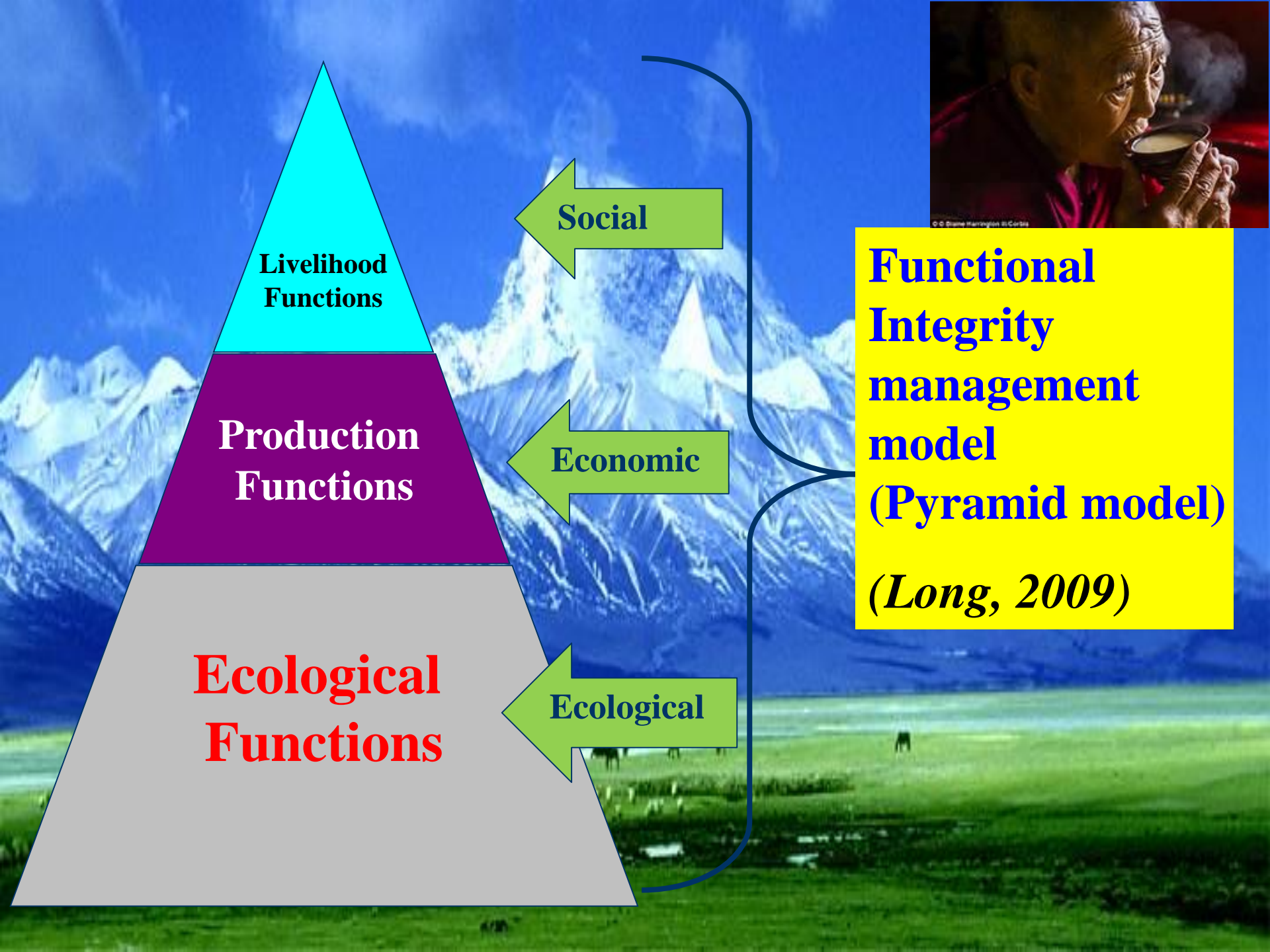
Long, 2007



Tibetan rangeland ecosystem functioning (Long, 2007)

Balance among the three functions in the Tibetan rangeland ecosystem





**Livelihood
Functions**

Social

**Production
Functions**

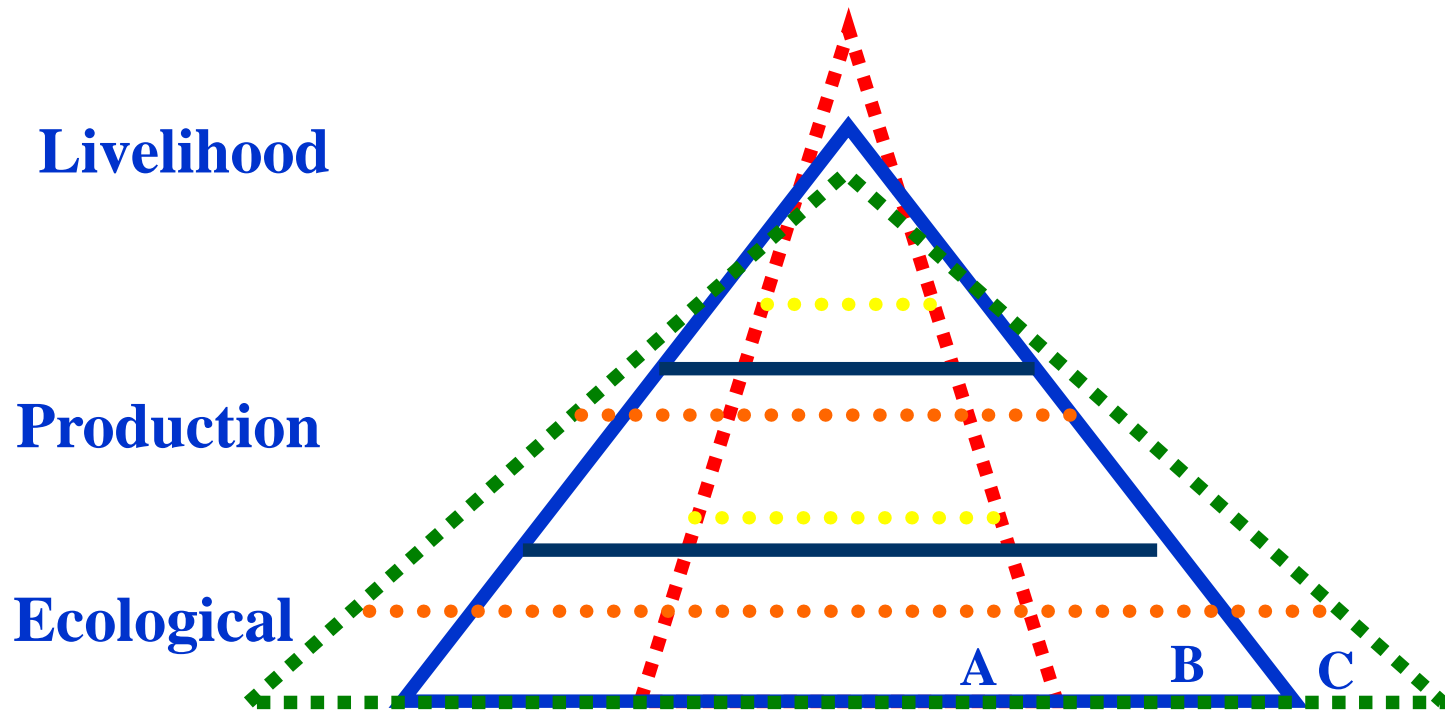
Economic

**Ecological
Functions**

Ecological

**Functional
Integrity
management
model
(Pyramid model)
(*Long, 2009*)**

Relationship of the three functions in a given rangeland ecosystem



A: LPE unbalanced ecosystem

**B: LPE balanced ecosystem,
need inputs from outside to
maintain its sustainable
development**

C: LPE Ideal ecosystem



Our R & D work focus on:

Climate Change

Rangeland Ecosystem

Animal

C

B

Herder

Soil

Vegetation

A

Sustainable development of Tibetan pastoralism

Summary



- ◆ The lifestyle changed: from nomadic to transhumance (settled or semi-settled)
- ◆ The production pattern changed: from collective farm to household farm
- ◆ The function of QTP ecosystem changed: from National Livestock Production Base to provide ecosystem services
- ◆ Multidisciplinary and innovation approach and ecosystem thinking are much needed to plan and manage QTP ecosystem, particularly facing natural and human challenges.

Mountain agriculture

- Have we fully understand mountain agriculture ecosystem and its native species in terms of adaptation, environmental-friendly, productivity..... ?
- Can we add value to the native species? for example: niche, organic, off-season products?
- Animal vs people?



Thank you