Integrating the Culture of Indigenous Species with Climate-Smart Aquaculture

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Introduction

In an era of global climate change and a growing demand for animal protein, increasing the production of fish through sustainable and environmentally sensitive practices is critical. The concept of climate-smart agriculture is applied to aquaculture, in which management strategies for increasing production integrate climate resilience. Incorporating the use of native species, particularly air-breathing species, in climate-smart aquaculture may provide the potential to grow local economies, and potentially addresses some of the concerns about environmental impacts by leveraging the evolutionary ecology of certain fish species in their native landscape. Developing new native species for aquaculture must still be approached in a responsible manner that diminishes the chance for negative environmental, economic, and social impacts.

People around the world rely on fish as a primary source of protein and income, and the growing aquaculture industry provides roughly half of the global fish supply. However, to meet the demands of a rapidly expanding population, a rising middle class, and an increasingly urban population, protein consumption is expected to increase by 25% to 45kg per capita by 2020. The development of sustainable, climate-smart aquaculture will provide responsible options to the growing industry.

Aquaculture, like agriculture and other human activities, will feel the effects of long-term climate change. Among the myriad challenges, temperature increases, ocean acidification, and sea level rise (Figure 1) will affect the world's coastal aquaculture operations, much of which occurs in poorer countries. Temperature changes will test the resiliency of domesticated varietals. The shifting distribution of global freshwater supplies and habitats will pose challenges and potential for new opportunities for the aquaculture industry, small farmers, and the marketplace.

Research challenges and opportunities involve:
- Understanding the adaptive range of these species under climate change.
- Developing cultivation techniques for new species, such as air-breathing fishes.
- Domestication of indigenous species for contributing to the development of local communities as well as protecting ecosystems.

Fish farmers in Bangladesh carry baskets of air-breathing *Pangasius* grown in brackish water. The responsible expansion of *Pangasius* culture across Bangladesh can provide additional opportunities for communities, already imacted by climate change. (*Photo by Dr. Md. Lokman Ali*).

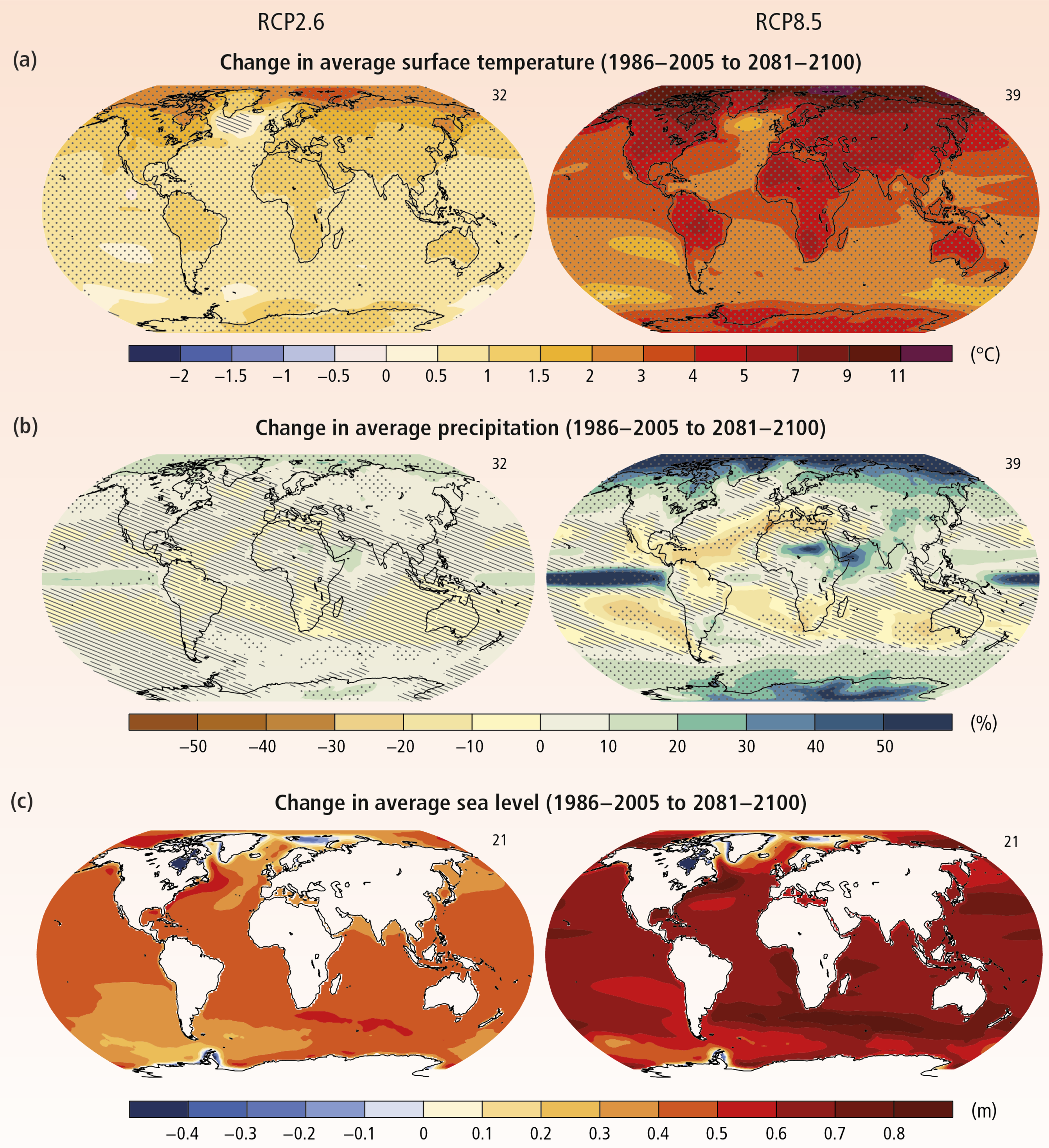


Figure 1- IPCC AR5-CMIP5 multi-model mean projections for the 2081–2100 period under the RCP2.6 (left) and RCP8.5 (right) scenarios for (a) change in annual mean surface temperature and (b) change in annual mean precipitation, in percentages, and (c) change in average sea level. Changes are shown relative to the 1986–2005 period. (IPCC, 2014).

Air-Breathing Fish

A diverse group of fish has developed the ability to utilize atmospheric oxygen for respiration through a variety of air-breathing organs. This development allows them to survive in aquatic environments with low-oxygen to anoxic conditions, low water levels, and poor water quality—presenting unique advantages for aquaculture. Towards the goal of climate-smart aquaculture, this research is focused on exploring the various tradeoffs associated with the farming of indigenous air-breathing fish and developing more sustainable practices. Predicting that air-breathing fish will be more resilient to many of the impacts of climate change, it is likely many species from this group will be valuable assets for diversifying the aquaculture industry if farmed responsibly. Already, the culture of air-breathing fish species has increased over the past decade and is a growing source of protein (air-breathing fish species in aquaculture listed in the table to the right). The following workflow (Figure 3) is planned to develop a decision support system that helps decision makers and stakeholders evaluate the environmental, social, and political tradeoffs associated with farming indigenous air-breathing fish to meet the three primary objectives of climate-smart aquaculture listed at the right.

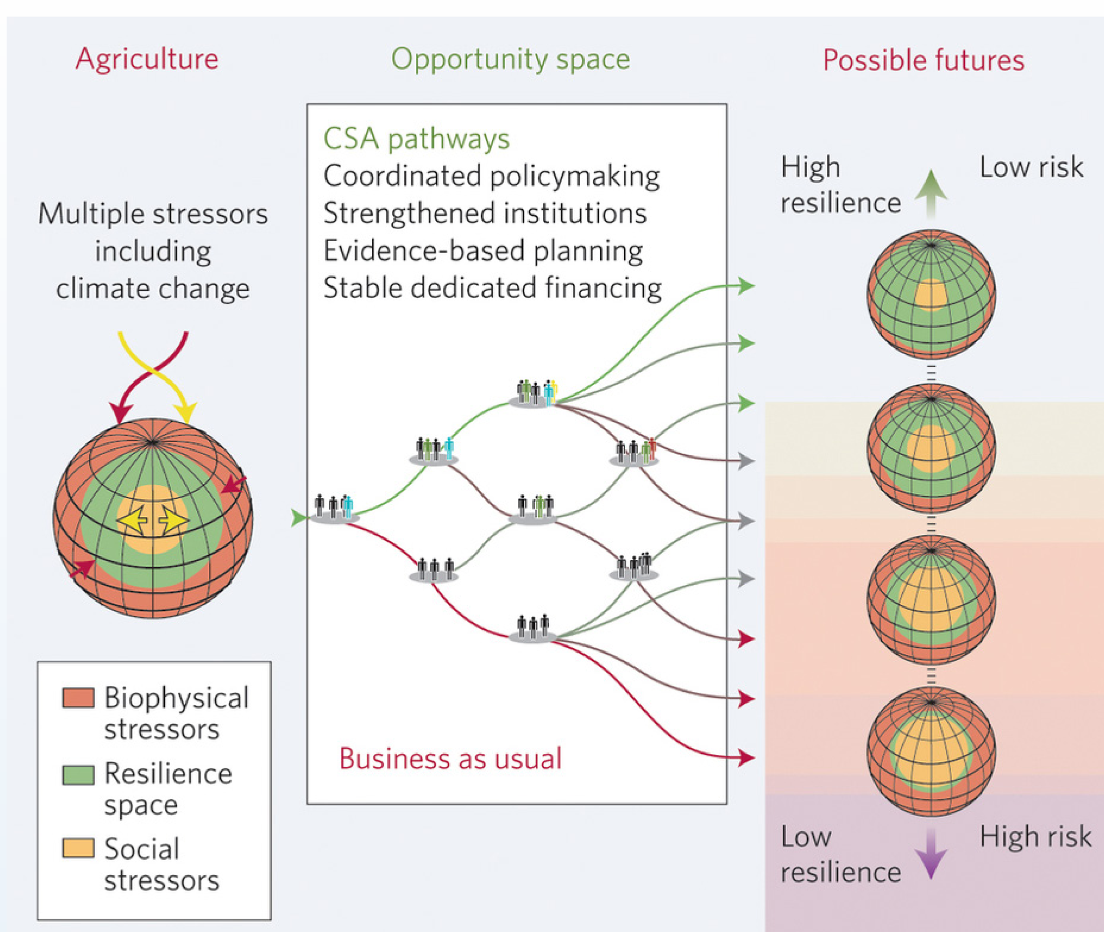


Figure 2- Climate-resilient transformation pathways for climate-smart agriculture. Actions taken at various decision points along a climate-smart pathway results in higher resilience. Alternatively, business as usual leads to higher risk and low resilience. (Figure from Lipper et al., 2014).

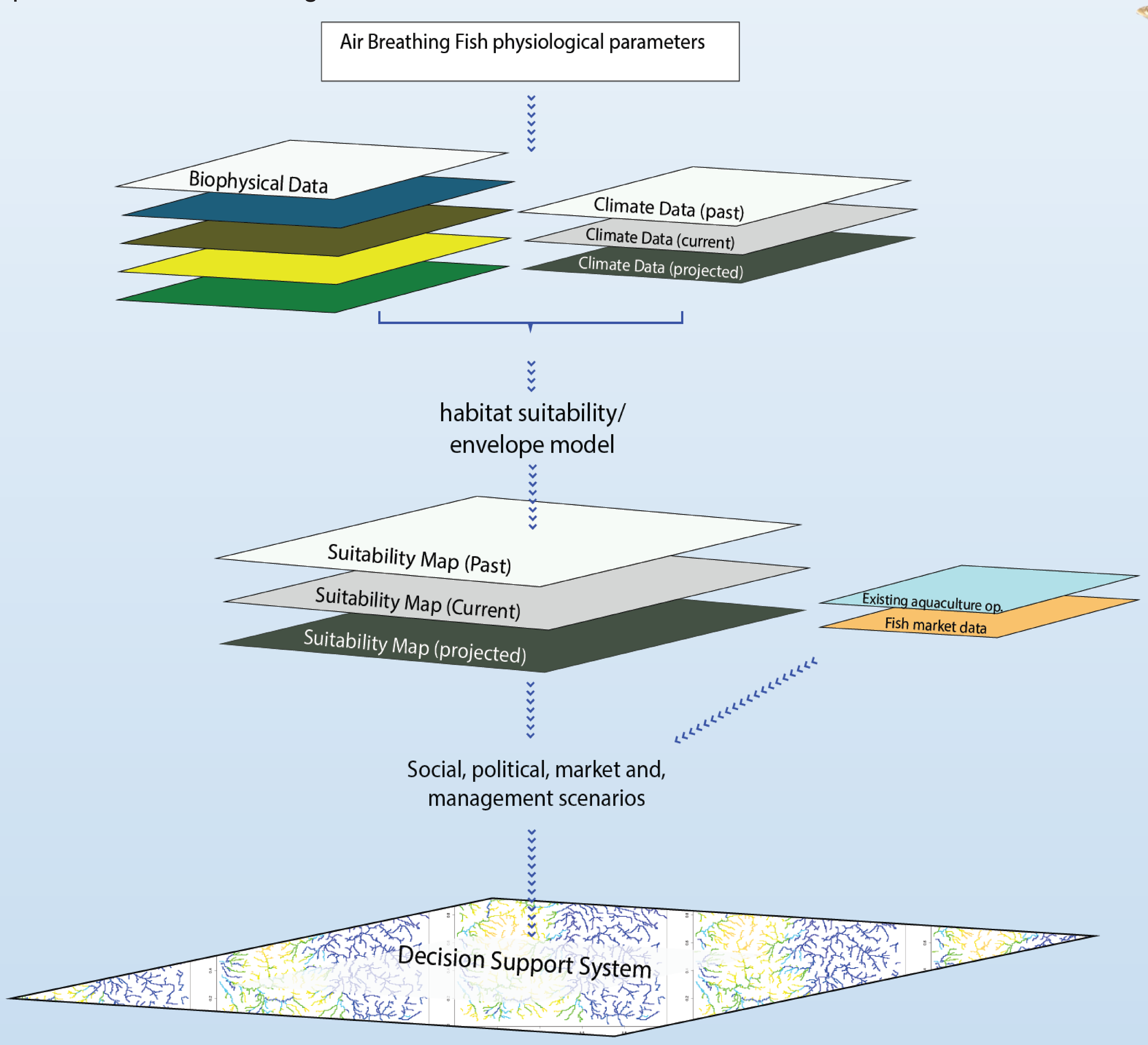
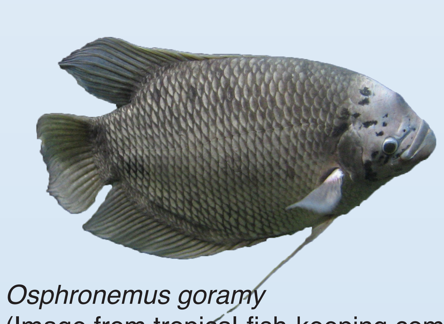


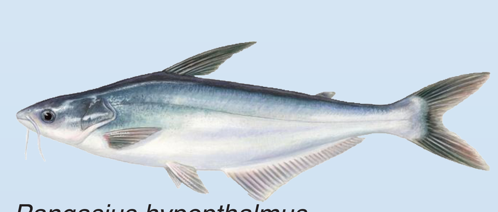
Figure 3- Air-breathing fish and Climate-Smart Aquaculture Workflow

Channa striata
(Photo by Hap Navy)

Heteropneustes fossilis
(Image from fishbase.com)



Osphronemus goramy
(Image from tropical-fish-keeping.com)



Pangasius hypopthalmus
(Image from tepbac.com)

Climate-Smart Agriculture

The variability in the climate and the associated impacts exacerbate production risks and challenge the coping capacity of farmers at all scales. The climate-smart approach to agriculture can easily be adapted for aquaculture, by which increased production is managed for sustainability, climate adaptation, and climate mitigation. This provides an approach to build resilient food production systems to more effectively support development and ensure secure sustainable food security in the face of climate change.

The climate-smart approach pursues three primary objectives towards reconciling tradeoffs for building resilient systems on a local and a global scale across time:

1. Sustainable increase production and incomes
2. Climate change adaptation
3. Climate change mitigation

Names and type of air-breathing organ (ABO) of air-breathing fishes occurring in aquaculture. Table adapted from Lefevre et al. (2014), which is based on data from Graham (1997) and FAO (2012).

Family	Genus species	Common name	Air Breathing Organ
Anabantidae	*Anabas testudineus*	Climbing perch	Labyrinth organ
Anguillidae	*Anguilla* spp.[a]	Eels	Skin, swimbladder
Osteoglossidae	*Arapaima gigas*	Arapaima	Suprabranchial chamber
Gobiidae	*Boleophthalmus pectinirostris*	Blue-spotted mudskipper	Skin, mouth
Channidae (pictured at left)	*Channa* spp.[b]	Snakehead	Suprabranchial chamber
Notopteridae	*Chitala chitala*	Clown knifefish	Swimbladder
Clariidae	*Clarias* spp.[c]	Walking catfish	Suprabranchial chamber
Helostomatidae	*Helostoma temminckii*	Kissing gourami	Labyrinth organ
Clariidae	*Heterobranchus bidorsalis*	African catfish	Suprabranchial chamber
Heteropneustidae (pictured at left)	*Heteropneustes fossilis*	Asian stinging catfish	Air-sacs
Osteoglossidae	*Heterotis niloticus*	African arowana	Suprabranchial chamber
Callichthyidae	*Hoplosternum littorale*	Tamuatá	Intestine
Loricariidae	*Hypostomus plecostomus*	Suckermouth catfish	Stomach
Cobitididae	*Misgurnus anguillicaudatus*	Weather loach	Intestine
Synbranchidae	*Monopterus albus*	Asian swamp eel	Mouth
Notopteridae	*Notopterus notopterus*	Asian knifefish	Swimbladder
Osphronemidae (pictured at left)	*Osphronemus goramy*	Giant gourami	Labyrinth organ
Eleotridae	*Oxyeleotris marmorata*	Marble goby	Mouth
Pangasiidae (pictured at left)	*Pangasianodon hypophthalmus*	Striped catfish	Swimbladder
Notopteridae	*Papyrocranus afer*	Reticulate knifefish	Swimbladder

[a]*Anguilla* spp. = *Anguilla anguilla* and *Anguilla japonica*.
[b]*Channa* spp. = *Channa argus, Channa marulius, Channa micropeltes, Channa punctata* and *Channa striata*.
[c]*Clarias* spp. = *Clarias batrachus, Clarias gariepinus* and *Clarias gariepinus* × *Clarias macrocephalus*.

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