Importance of Indigenous Adaptation Practices inEcosystem-based Adaptation at Medir Haor, Bangladesh using DPSIR framework

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Abstract

Indigenous Adaptation Practices in the wetland basin have proven evidenceof coping with climate extremes. Since the 80s the intensity of the hydro-meteorological hazards has increased. The community of the Medir Haor under Nasirnagar upazila of Brahmanbaria district, Bangladesh. Primarily farmers and fishermen are practicing indigenous adaptation practices since the structured adaptation projects are yet to be implemented in this area. The study wasconducted from January 2017 to September 2022 in the villages of the Medir Haor having community consultations, Focus Group Discussions, and Key Informant Interviews. The DPSIR (Driver-Forces-Pressures-State-Impacts-Responses) framework has been used to identify the responses toward the betterment of the ecosystem and the Ecosystem-based Adaptation options. The community has identified (1) Protection of fisheries resources and diversification of fisheries-based livelihoods; (2) Crop diversification and introduction of winter crops in thecrop fields of Haor; (3) Strengthen the communication

system including the roadnetworks; (4) Make available the extreme weather information for community preparedness; (5) Improve the health supports as Ecosystem-based Adaptation options where tradition practices like dry sowing of paddy; Seedbed sowing for the second time; Bhura, a roundish water hyacinth floating bed; Early harvesting for diga dhan; Cultivating Dhaincha, Sesbania bispinosa; Khola; Bathan, the grazing land; Peritana, taking out the mud from the deep pools; Mana, traditional fishing is forbidden side; Changari and Airbandh may have potential uses. The study has identified the contribution of indigenous knowledge towardEcosystem-based Adaptation.

Keywords: Adaptation to Climate Change, Indigenous practice, Ecosystem-basedAdaptation, (Haor) Wetland Basin, DPSI

Introduction

Bangladesh is one of the most vulnerable countries to climate change. To survive the communities have been practicing a wide range of adaptation options, both planned and spontaneous. Planned adaptation initiatives by development actors in implementation were in different forms. The Ecosystem-based Adaptation (EbA) in Bangladesh initiated science in 2012. EbA is a strategy for adapting to climate change that harnesses nature-based solutions and ecosystem services. EbA uses sustainable management, conservation, and restoration of ecosystems to provide services thatenable people to adapt to the impacts of climate change. It is a people-centric concept. The traditional practices are community resources and skills that were gained over hundreds of years by a community. Local and traditional knowledge and skills are increasingly being recognizedas vital resources for adaptation. The purpose of this paper is to explore traditional coping

practices that may enhance EbA in the wetland basin of Bangladesh.

Literature Review

The scope of study of using indigenous knowledge towards executing the EbA actions is an attempt to analyze the scope of integrating community knowledge with the EbA. There were some studies conducted on documenting Traditional knowledge, but the potential of traditional practices in coping with climate vulnerabilities was studied a little. Kumar (2015) highlights some indigenous mitigation and adaptation skills that have been practiced in North-western India. Indigenous Knowledge is also used in cultivation techniques in extreme climatic conditions. Rahman and Rahman (2015) studied natural and traditional defense mechanisms to reduce climate risks in coastal zones of Bangladesh and suggested the integration of traditional coping practices and wisdom with modern approaches. Laths Kid (2018) has suggested Indigenous knowledge that helps the agricultural production of the communities to develop sustainably for generations. UNEP (2018) has compiled the knowledge of indigenous communities regarding climate actions. Ghosh (2021) studied the contribution of indigenous knowledge towards community resiliencein the Indian state Meghalaya, adjutant to the Haor basin of Bangladesh. Adaptation responses with Indigenous knowledge

and local knowledge influence recorded higher evidence of risk reduction compared to responses without Indigenous knowledge and local knowledge. Many African countries have included indigenous knowledge and local knowledge in adaptation planning in the

intended nationally determined contributions (iNDCs). Barua and Rahman (2018a) studied the role of indigenous knowledge in coastal resource management addressing Climate Change. They also have studied the traditional ecological knowledge in the coastal island of Bangladesh (Barua and Rahman, 2018b). The scope of EbA in Bangladesh was first explored by the Bangladesh Climate Change and Environment Outlook 2012, the Hakaluki Haor area and the coast of Shyamnagar were studied to identify the opportunity. Ahmed (2013) studied the opportunities for ecosystem-based adaptation in the coastal zone in Bangladesh. The study recommended the stabilization of coastal lands with appropriate mangrove species plantation as cost-effective and long-term biodiversity conservation measures in Bangladesh that are relevant to EbA. Haq et. al. (2013) noted that the EbA approach has the potential to significantly increase the functionality of current adaptation practices and reduce the tension between the" hard" and" soft" approach by following three major ways: a) valuing ecosystems and biodiversity in adaptation b) promoting development in adaptation and c) building long term resilience with multiple socio-economic benefits. Vulnerability and Impact Assessment to Climate Change and Ecosystem-based Adaptation in the drought-prone area of Bangladesh was studied by Rahman et. al. (2014). The study was conducted by applying DPSIR Framework. The nature-based solutions through EbA were given as a potentially cost-effective means to cope with drought and protect the environment. Re-excavation of traditional ponds and integrated fish farming were suggested as EbA to increase capacity and maintain ecosystem services. EbA's effectiveness in terms of how such approaches support community adaptive capacity and resilience at two sites in Bangladesh: Chanda Beel Wetland and

Balukhali Village in the Chittagong Hill Tracts was studied by Raid et. al. (2017). Results show that the many diverse natural resources available and utilized at each site have increased the number of different subsistence and livelihood options available in the community and hence local adaptive capacity, especially for poorer households. Saroar et. al. (2018) studied the Opportunities and Challenges of EbA. According to the study, EbA is linked to cropping practices, soil and nutrient management, water management, erosion control, and food and livelihood security. It proposes integrated institutional approaches to bolster EbA's potential. This study also suggests that EbA strategies should conform to scientific knowledge, which would help improve community resilience and ecosystem health.

Materials and Methods

The study has been conducted in Medir Haor. The Medir Haor is located in Brahmanbaria district under Nasirnagar Upazila. It is swallowed Haor compared with the northern Hoars. The area of Medir Haor is around 17.38 square kilometers and the population dependent on the resources is about 25,000 The Haor is connected with the river Meghna. The Indigenous practices of the community to cope with the extreme climatic events were identified by observing the community practices and consultations

with the community. The villages (1) Nasirnagar, (2) Monoharpur, (3) Goalnagar, and (4) Kistopur were visited frequently to study the indigenous community practices from January 2017 to September 2022. The Driving Forces-Pressures-State-Impacts- Responses (DPSIR) framework was used to assess the ecosystem

and the sustainable management approach against climate vulnerability. The DPSIR is an analytical framework to trace the changes in and to look at the drivers of these changes, and to evaluate the impacts of these changes. Within this model, drivers are defined as the underlying factors causing or influencing a variety of pressures in an ecosystem. Pressures are defined as the variables that directly cause the changes and the state is the measure of the physical, chemical, and biological conditions within the eco-system. Impacts describe the effects of changes in coastal wetland states on measures of ecosystem function. The response is defined as the efforts of society to solve the problems resulting from changes in wetland function. There are four major steps in the DPSIR framework; (1) interpreting the drivers and the pressures; (2) describing the state changes; (3) describing the impacts; and (4) reviewing the human response. The DPSIR Framework was launched by the European Environmental Agency, and it has been used by the United Nations. Furthermore, the framework has been adopted by the US Environmental Protection Agency (EPA) in the Sustainable Puerto Rico initiative (Kristensen, 2004). The DPSIR framework is a tool by which the cause-effect relationship between social, economic, and environmental issues can be joined to perform their functions (Omann et al., 2009). The DPSIR framework has been used for many environmental resource applications, including the management of agricultural systems (Omann et al., 2009), and water resources (Laura et al., 2009). In recent years DPSIR has most commonly been used for ensuring environmental management to connect ecological and socioeconomic factors (Yee and Bradley, 2015) for taking decisions on environmental issues (Gari et al., 2015). Ahmed et. al. (2020) used this framework for ecosystem services in the

Mekong Delta for coping with mining challenges. Based on the response identified in the framework the Ecosystem-based Adaptation (EbA) options are being identified by the community. The DPSIR Framework has been used by Rahman et. al. (2016) to suggest EbA in a River Bank Erosion Prone Area of Bangladesh. UNEP, UNDP, and IUCN have conceptualized Ecosystem-based Adaptation in the DPSIR framework (UNEP 2012). The EbA involves conservation, sustainable management, and restoration of ecosystems that can help people adapt to the impacts of climate change. Ecosystem-based Adaptation EbA is a nature-based solution that harnesses biodiversity and ecosystem services to reduce vulnerability and build resilience to climate change. Data Collection and Analysis: This paper is based on the data collected from 9 community consultations, 6 Focus Group discussions (2 with Fisher, 2 with farmers, 1 with women, and 1 development actor), and 12 Key Informant interviews.

Results and Discussion

Historic Climatic Extreme Events in Medir Haor: The erratic rainfall has increased inthe Medir Haor areas after the flooding of 2004. Before that early flooding and late flooding was the major livelihood concern. The cultivation of high-yielding rice varieties started in Haor on the year 1963 but cultivation on a wide scale started in 1974; before that only the local boro, specifically the varieties (1) tapi Boro and (2) Jagli dhan being cultivated. For the cultivation of the high-yielding variety of rice under a government scheme two canals were excavated in the Medir Haor, namely Abbair Khal and Nilokhiar Nala. Table 1 details the extreme event and the community's coping mechanism. Up to the 80s, the livelihoods of the Medir

Haor community were mostly natural resource based. In 1982 urbanization started centering the administrative town of Nasirnagar.

Table 1 Table1: Extreme climatic events and community coping followed in the Medir Haor

Year	Extreme event	Community Coping mechanism
1998	Flood	Take sheltered in school, No cultivation
2004	Flood	Harvested green paddy, cultivated in water hyacinth made a small floating bed
2006	Late monsoon	Dry sowing of paddy
2012	Late monsoon	Dry sowing of paddy
2018	Late monsoon	Sowing of germinated seeds
2021	Thunderstorm	Seedbed sowing for the second time

Community Responses to the Climate Extremes:

1. Dry sowing of paddy: The transplanted and the broadcast Aman paddy are sowing germinated in the common practice, but when there was no rain or less rain the farmers spread the non-germinated rice on the paddy field. The amount required for such sowing is around 1.5 times that of regular germinated sowing. Such sowingis called Doilla Bain since it is put in dry plowed soil. By the first rain, it grows. According to the farmers, weed growth is comparatively less in such dry sowing.

2. Seedbed sowing for the second time: This practice of creating a seedbed for a secondtime is done to cope with prolonged inundation during the early stage of paddy cultivation. The study found that such a practice is very common in thewestern part of the Medir Haor which is close to the river Meghna.

3. Bhura, a roundish water hyacinth floating bed: Haor basin is wave prone. Such heavy wave action is

locally known as Afal. The floating bed that the community of the Beel Basin is practicing traditionally is not a traditional one in theHaor. Though different development interventions are willing to promote such long rectangular floating beds in Hoar but not working as assumed; according to the local community not even functioning as those were documented. Haor has its formof floating bed, locally known as Bhura, which is a roundish water hyacinth-made floating bed of 1 to 1.5 meters in radius. The objective of such a bed was to cultivatewater guard at the right time since the early seventies.

Early harvesting for diga dhan: If there was less production in paddy caused forany reason the Haor community harvested only the top of the Sheaf of paddy and Then another new paddy sheaf grows. Cultivating Dhaincha, *Sesbania bispinosa* to protect wave action: Haor village mounds look like islands in the sea during the rainy season. Since there are no berries common in such a widespread waterbody, heavy wind causes strong high waves in the Hoar that result in land erosion of the village mound. To reduce the wave speed, the community of Haor planted Dhaincha surrounding the village. The Dhaincha plant is high and an grow in water. The biology of the Dhaincha is that the stem part that teaches water becomes puffy. Dhaincha was used as a float in the nets.

4. Khola: The first regular flash flood in the Medir Haor comes just after the harvestingseason. The community does not have a big yard in every family but the harvesting season too short; there are some common harvest processing sites in the Haor. Those sites are usually close to the village mound and also well connected with waterways. Such a harvesting site is

called Khola. A few Kholas are on the raised plinth.

5. Bathan, the grazing land: The comparatively high lands of the sallow Hoar wereused as grazing lands. Those grazing lands are known as bathan. Bathan land is not good as cropland as it is undulating and usually sandy. There was no cultivationand changes in landscape allowed in the bathan land. The connecting road from villages to the bathan is named go-pat, literally meaning path for the cows
6. Peri-tana, taking out the mud from the deep pools: In Hoar, there are scattered many beep pools of an average 5-meter radius. Such pools are perennial, and water remains year-long. Usually, no irrigation is allowed from those pools, locally knownas Koa. If in any year the siltation is high due to the flash flood community removesthe mud using bamboo-made pots, which is called Peri-tana, meaning take away the mud, otherwise, it was done every 3 to 4 years based on the sild stored in the bottom.
7. Mana, traditional fishing forbidden side: in the Haor conservation of fish and fish- series is a traditional practice. In the Medir Haor, there are around 12 Manas recorded. Mana means forbidden, and an area marked by Bamboo with leaves and branches is demarcated as no fishing area. The demarcation of the area has no boundary, but the fisher believes and respects the center of it as the core area and the periphery as a buffer zone and has no fishing
8. Changari: Since the fish-drying land of the Haor basin goes underwater regu larly. The practice of making bamboo-made platform for sundry fishes is called Changari. Usually, it is made close to the village mound and its size varies from400 square meters to 1000 square meters.
9. Airebandh: The village mound is subject to wave

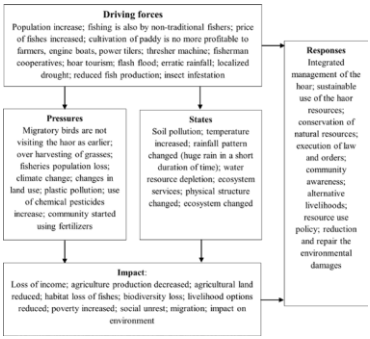
action and land erosion. To protect the village, mound the community using the bamboo railing. Also, use different grasses and straws inside the bamboo fence.

Changes recurring in the Medir Haor and theircauses and impacts

The forces-Pressures-State-Impacts-Responses (DPSIR) framework for the Medir Haor has been detailed by the Hoar community as follows:

Fig. 1 The Forces-Pressures-State-Impacts-Responses (DPSIR) framework for the Medir Haor

Ecosystem-based Adaptation Options in the Medir Haor:



This is noted that no adaptation projects are being implemented in the Medir Hoaryet. The following are the proposed EbA options identified by the community for the MedirHaor

1. Protection of fisheries resources and diversification of fisheries-based livelihoods: Conservation of the fisheries to increase production and promote sustainable harvesting. Diversification of fisheries business. In the Medir haor fish-drying is one of
2. the most common practices. There is sun-drying of fish and making the farmed fish which is known as “Shidol”. According to the local community, diversification of the fish market by introducing external knowledge and practices will increase the income of the community
3. Crop diversification and introduction of winter crops in the crop fields of Haor: The paddy production in the Medir Haor is dominated by the BRRI Dhan 28, and there are a few native varieties. During the winter many cropping possible lands remain uncultivated where cultivation of vegetables is possible. For that technology and farming techniques need to be promoted.
4. Strengthen communication system including the road networks: The village mounds are scattered as isolated islands during the rainy season. The boat is only transported during the rainy season. But the current boats both equipped with a powerful engine named engine beat and regular boats are not strong enough to cope with the high Afal.
5. Make available extreme weather information for community preparedness: The flash flooding in the Medir hoar is devastating since it is located in the down of the Haor basin. The lead time for flash flooding from the Tanguar Haor is 3 days. But other hazards have increased in intensity. If the community has the climate change projection as well as weather prediction with a good lead time the community can plan the adaptation action properly. The hazard calendar identified by the Medir Haor

community is noted in Table 2. The hazard calendar identified by the Medir Haor community is noted in **Table 2**.

6. Improve health support: According to the community, the major challenge for the Hoar Basin is health services. Treatment and medicine availability are the major concerns of medical service. Floating hospitals and water ambulances were recommended by the community.

1.1 Hazard calendar:

In the Medir Haor Early flood is a common hazard. There is a riverine flood. Local- ized drought is becoming a common phenomenon nowadays. Only a small area in the crop field suffers from drought. Huge fog is a new phenomenon that started in 1984.

1.2 Newly formed livelihoods options

In the Media Hoar earnings from the marketing of snail and cow-dung-made cooking fuel are blooming after the Covid19 pandemic. Snail collector: The snail collection for duckery is increasing drastically since duck rearing is increasing in the community.

There are more than 200 snail collectors collecting snails in the Medir haor dailythough it's illegal by law. The average collection is around 4 kg per individual. They are mostly hand-picking and also there is the use of nets. Cow dung collector: The cow dung collection is for household-based cooking fuel-making industries. The cow dung is collected from the grazing land to make fuel. The average harvesting is 22 per collector kg per day. More than 400 cow dung collectors are collecting dung from theMedir Haor.

Table 2 Hazards of the Medir Haor

Hazards of the Medir Haor	
Jan	Dry
Feb	Drought
Mar	
Apr	Early Flood,Insect,Infestation
May	Flood, Northwestern sides
Jun	Flood
Jul	Flood
Aug	Standing water
Sept	Standing water,Thunderstorm
Oct	Standing water,Drought
Nov	Dry weather, Fog
Dec	Dry weather, Fog

1.3 The potential of the traditional practices towards EbA:

To achieve the target of the EbA the traditional practices of the community can have potential use. The mana is a conservation action for fisheries. Since the early monsoon the harvesting of the fish Punti (Swamp barb), Puntius chola is high the market price for that goes down. The Punti is the most preferable fish for making the Shidol. But in the Haor sun-drying is a challenge as no ground is available as drying land. The Changari since made in the inundated areas serve the purpose. Changari is made of bamboo and longevity is usually one year. Using treated bamboo canstrengthen the quality of the Changari and that will last for longer days. To protectthe fish breeding sites and to increase the number of fisheries breeding sites Peri-tana is very important. In the Medir Hoar

around 35 deep perennial water bodies, namely Kuya, were reported as important fish breeding sites. Through the use of Kanta, thatis putting branches of the trees Hijol, Barringtonia acutangula, and Sheora, Streblus asper is a practice of harvesting more fish but also plays an important role by creating habitat for fisheries, specifically the small fishes, mollusks, and turtles. There is poten- tial for winter vegetable cultivation in Haor. It was found that considering the weather warming and climate change prediction the community can choose the crop- ping pattern. It was estimated that by creating a culture of winter crop cultivation in the Medir Haor and adding an area size of around 15The highest use of the Dhaincha plant was as a float for the net. The availability of alternatives, like plastic floats, has challenged the market of the Dhaincha and its cultivation as well. The Dhaincha is bio-degradable and environment friendly whereas the practice of pollution is a major threat to the ecosystem. Dhaincha is a good fuel. Collecting cow dung for making cooking fuel is challenging the natural manuring process. In the Airband there was a use of Chailla grass, *Hemarthria protensa*, which has been reduced in practice because of its unavailability. Protection and facilitation of growing Chaillagrass will benefit nature, it creates a habitat for many birds and also the ecological balance. Chilla grass reduces the risk of erosion. The community has its own belief in weather prediction. The local proverbs like Khonar bachon (Verse of the philosopher Khana) and folk poetries give an assumption of weather and a short period, which is not more than one year. But for long-term climate change projects such proverbs were

Fig. 2 Table 3: Scope of using indigenous practices towards Eb

Table 3: Scope of using indigenous practices towards EbA

Ecosystem-based Adaptation	Indigenous practices that can contribute
Protection of fisheries resources and diversification of fisheries-based livelihoods	Peri-tana; Mana; Changari
Crop diversification and introduction of winter crops in the crop fields of Haor	Dry sowing of paddy; Seedbed sowing for the second time; Bhura; Early harvesting for diga dhan; Khola
Strengthen the communication system including the road networks	Cultivating Dhaincha to protect wave action; Airband; Hijol plantation
Make available the extreme weather information for community preparedness	Bathan; Airbandh; Dry sowing of paddy; Bhura
Improve the health supports	Medicinal plants gardening

not reported. The use of mobile phones is common, it will be a path of sharing early warning predictions. Increasing health services was identified by the community as an EbA for the Haor. Though there was no historical evidence available where traditional medicine resulted in coping with extreme health crises, the use of medicinal plants wasfound common by the community. In the remote isolated villages, the use of medicinalherbs though common through the practice of gardening the medicinal plants is not common.

Discussion

The study found that traditional practices have potential output on the EbA. Rahman et al. (2014) have identified the re-excavation of traditional ponds, and integrated fish farming as EbA to increase capacity and maintain the ecosystem in the Barind ecosystem. The community in the Haor basin also identified sustainable fisheries asthe EbA opportunities where they have a wide number of practices that maintain the ecosystem. Department of Environment (2015) noted that changes in the climate are affecting the traditional

cropping patterns and cycles. Rahman et. al. (2016) found that river bank erosion, increasing population, elevated use of fertilizers and Agro-chemicals, siltation of land, lack of technological support for irrigation, the irritating pattern of temperature, and the late arrival of monsoon rainfall, excessive monsoon rainfall, land-use changes, and flow alterations are the major driving forces in the riverine ecosystem; the current study also identified same for the Madir Haor. Like other areas, the COVID-19 pandemic has created threats to natural resources too. Collecting snails in huge numbers will hurt the demographic composition of the population of the species and there will be an impact on the hoar ecosystem. The fast observation of theecosystem of the Medir Haor shows that the sail may not be the keystone species of the Medir Haor but the Ghechu, Aponogeton spp. Collecting cow dung will interfere with the natural fertilizing process. Crop diversification to minimize the risk of har- vest failure is an adaptation strategy in many indigenous communities (Macchi, 2008). Some of these varieties are adapted to different environments/field locations, like near rivers, high on mountains, close to a primary forest, etc. Identification of such crops and crop varieties have more market value. For example, the wild chailla variety Naga Morich, which was wild in the hillocks near the Haor basin in Sylhet and Sunamganj, is being cultivated now in farms and kitchen gardens. The use of chailla grass for erosion control is a common practice in the Haor basin. Due to the current scarcity of chailla, villagers find it hard to protect their homesteads against wave erosion. The project Sustainable Environment Management Programme piloted the use of both geo- textile and chailla together (IUCN Bangladesh 2004). According to the UNEP (2012), the implementation of EbA

remains hampered by three key challenges: lack of information, lack of financial resources, and institutional resistance. Lack of information includes uncertainties in future projections of climate impacts, ecological and societal vulnerability, and economic growth. These forecast uncertainties are exacerbated by the relative paucity of information from monitoring and evaluation of the effectiveness of past and ongoing EbA interventions. Developing climate risk analyses and vulnerability assessments that make use of scientific and traditional knowledge on ecosystem services and adaptation potential are possible solutions. The importance of Traditional Ecological Knowledge in climate change adaptation is not in doubt, but still, there is a limitation of awareness besides the scientific and some local communities. Scal ing up Traditional Ecological Knowledge is very important in resource management as well as in minimizing the effect of climate change. (Lemi, 2019). There is a rapid decline of wetland-related traditional knowledge amang the indigenous communities. Degradation and loss of wetlands, which are also accelerated by the effects of climate change, pose a threat to communities whose livelihoods are derived from wetland-based products (Adhikaria Poudel, 2018). Revitalization of environmentally friendly traditional values and formulation of effective environmental protection policies are required to improve management that would promote ecological and economic benefits for local communities and national interests. (Barua Rahman, 2018a). Barua Rahman, 2018b identified these traditional practices are becoming unpopular in the coastal island areas in recent years because of modern technology, which seems similar in the Medir Haor too. Despite knowing about these practices, the community is relying more

on information technology, but it is for knowledge management only.

Conclusion

Since EbA solutions are cost-effective solutions, they can be incorporated to address issues related to water management in the developing region. The worldwide scientificcommunity has recognized the importance of integrating nature-based solutions for long-term policy planning in the context of climate change, soil, and water conservation, and so on (Khaniya, 2000). The traditional practice of a community is not onlythe skill of the community but also an identity and pride. The traditional coping mechanism of the community is derived from the local environment. It was found that the 11 traditional practices in coping with the climate extreme have proven effective. There is a gap in transfer of Indigenous knowledge between the generations. The indigenous practices of the rural community need to be documented. The practices that have significant impact and effectiveness could be an activity towards aching the EbA out- come. If required, a blended combination of modern technology may be incorporated with traditional practices to make it more effective and appropriate in the current climate change context. For that more empirical and action research are necessary.

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