Semsa Ethnoecology, weather prediction, and Bioindicators: A case study in SEMKHOR, DIMA HASAO, ASSAM, India

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Abstract - The Semsa of Semkhor usually forecast the weather through extended-standing ethnoecology knowledge applications. In this study, 07 village bioindicators for weather forecasting shall document working with semsa peoples. The bioindicators were based mainly on recognizing unique situations, the behavior of insects, birds, and mammals, plants' characteristics, location, timing, and patterns of clouds, lightning, wind, moon, sun, and stars. Forecasting knowledge successfully applies based on comparing past events, good prognosis, close observation, and a thorough understanding of the local environment. Community members, cultural leaders, and local elders have observed recent anomalies in the weather, with unusual rains and abrupt temperature changes. Due to this phenomenon, some plant species are changing their growth patterns. This type of Traditional Knowledge has excellent potential for broader application, yet, in semkhor, as elsewhere, there is a threat to people's livelihoods and biocultural diversity. Today, more than ever, there is an urgent need to document all traditional knowledge and folklore among the diverse ethnic communities before the traditional cultures may be entirely lost.

Keywords: Biodiversity, Semkhor Weather forecasting, Ethnoecology Knowledge, Bioindicators.

I.   INTRODUCTION

Ethnoecology is a theoretical orientation derived from the work of several writers. The focus on and practical assessment of ethnoecology is inspired mainly by Darrell Posey and his co-workers. They broadly define ethnoecology as 'indigenous perceptions of "natural" divisions in the biological world and plant-animal and human relationships within each division. Ethnoecology, in various aspects, is argued to have applications in development (Posey et al. 1984: 97).

Ethnoecology is mean to employ innovations, knowledge, traditional practices by Indigenous and local communities embodying traditional lifestyles. It is wisdom developed over many generations of conventional, holistic utilization of the lands, natural resources, and environment. This knowledge is generally passed down from generation to generation by experiential learning and by word of mouth and is, for the most part, undocumented in written form. Semkhor, the 23rd MAC constituency of the Dima Hasao Autonomous Council, lies between 25.260N latitude and 93.300E longitudes, covering an area of 700 hectares.

Weather forecasting ensured the success of farming operations, except for intermittent disasters. From the very beginning, weather conditions significantly influenced the life and life support strategy of the people of the study area.

The traditional weather forecasting knowledge was in the form of bioindicators and other physical factors, including wind direction, time of the year, the sky's color, and the stars' position. Weather-related knowledge is, at the same time, beneficial, especially for villagers.

Relocating settlements, temporarily or permanently, developing and imposing restraints on harvesting specific resources, sharing resources from family to family or across communities, and developing economic and social alliances have all been responses of indigenous communities to environmental crises. As such, all strategies reflect the resilience of traditional and local communities of many societies. Concerning climate change, perhaps even more important than responding to Environmental crises are the "soft" lessons by which people can anticipate and avert calamity, thus precluding the need for the "hard" studies of drastic resource depletion or other undesirable outcomes of inaction. This study will highlight and demonstrate the indigenous knowledge of weather forecasting and focus on the research-based recording, the observations of the community regarding changes in the local environment, and on getting into collective experiences rather than on a cross-sectional comparative study of the influence of climate change.

II.   STUDY AREA AND METHODOLOGY

2.1 Study Area

Semkhor territory is in the foothill of Borail Hills adjoining Assam, Nagaland, and Manipur Tri-junction, an area rich in plant diversity that is still unexplored today. (Fig. 1). There are a variety of hills ranges of Borail Hills

in the semkhor which are of immense value to humankind. These forests are threatened by various anthropogenic disturbances, including shifting cultivation, industrial logging, extraction of fuel wood by local villagers, industrialization and urbanization in Mailing subdivision. In Dima

Fig-1. Map of Dima Hasao Showing Semkhor

Hasao, Assam, where the economy is predominantly agricultural and rural, nearly 90 percent of the population depends on agriculture. Semsa peoples working in subsistence agriculture constitute about 27% of the population, and almost 87% of the people reside in a depressed economic area in nearly 1378 populations.

2.2 Methods

Purposive sampling selects geographical areas and villages taken up under the present study. This method will use in the current qualitative research to maximize relevant representation based on prior knowledge. This sapling will base on primary and secondary sources of info, and an extensive desk review will undertake before designing the research process and instruments.

This study shall base on the selected villages' responses recorded using a specially designed semi-structured questionnaire. The focused group discussions (FGD), in-depth interviews (IDI), and key informant interviews (KII) will also do to record the perception of 71 persons on climate change, its impact, and traditional methods of weather forecasting. Older adults will specially select for the study as they have memories of a more extended period.

Data collection was complex because people hesitated to give the details to outsiders. A significant portion of the fieldwork had thus to will devote towards confidence building with local communities. There is, at the same time lack of healthy – documented information or secondary data on this subject from the area. The data collected is mainly qualitative and based on percentages, and an attempt will assess the community's perception of forecasting relevant weather events. The focus was on collecting and documenting the information from the

public and cross-checking and analyzing the same with various secondary sources.

The word forecast, as used in the study, refers to short–term assessment of weather conditions; for up to one week. Traditional knowledge is explained as the knowledge of a group or a community from a particular area, based on their environmental understanding, interacting with nature and experiences within their area. As defined by De Boef and others, the term traditional knowledge is used here as the knowledge of the people of the study area based on their interactions and experiences within that area, their traditions, and their incorporation of knowledge emanating from elsewhere into their production and economic systems.

## III.   RESULTS AND DISCUSSION

3.1 Results

Responses of 71 persons from 7 areas of the semkhor regions will record by using a specially designed semi-structured questionnaire for interview (Table 1). Besides this, a total of 15 FGDs, 25 IDIs, and 31 KIIs will also conduct. Information contained in the folklores, sayings, folksongs, folktales, and various religious-magical rites and traditional practices of the masses will, at the same time, analyze for a better understanding of their efficacy in effective resource management.

Table 1. Details of respondents (n = 71).

Areas		Number of Respondents	
		Male	Female
Semkhor Region	Semkhorma	8	2
	Jaibra	4	6
	Medukol	3	7
	Makalu	5	5
	Sabailing	4	6
	Soonapur	2	8
	Lailong	6	4
	Total	32	39
		71	

Gender balance adhered to in the study, and 54 percent of the respondents are females. As for the age profile, almost half of the respondents (49 percent) are over 50 years old (Fig. 2).

The emergence and growth of new leaves indicate that the temperature is increasing and the winter season is drawing to an end. The abundant blossoming of peach, apricot, and other trees indicates an excellent rainy season. The flourishing of both edible and wild mushrooms means imminent rain associated with high humidity. The physical state and flexibility of pine (Pinus sp.) cones will traditionally utilize by the study area's people for assessment.
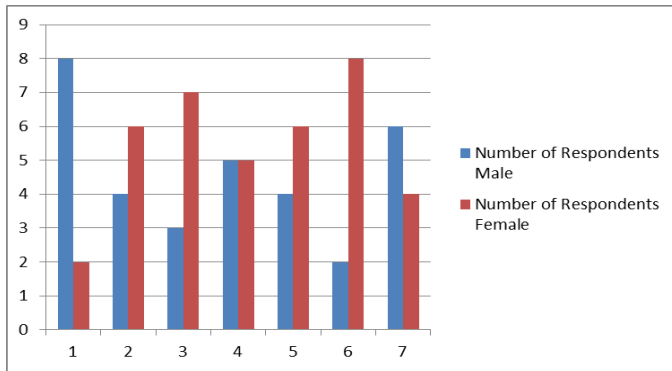
The age group of the respondents in the study area

The forecast and bio-indictors used for weather forecasting in the study area shall be observed based on their long-standing familiarity with seasonal patterns of precipitation, temperature, wind and cloud design, the position of stars, the behavior of animals and birds, and other similar indicators and observations. These groups will base on the parameters used for weather forecasting, summarizing the same in Table

2.3.1.1 Floral as Indicators

Blossoming peach (Prunus persica), apricot (Prunus armeniaca), fig (Ficus sp.), or budding in other trees in the surrounding farms will consider indicating the onset of rainfall. The pine cones generally open up and become stiff in dry weather, but in the presence of high humidity, these become flexible and often regain their original shape. This variation in the pine cones' physical state with changing humidity will utilize to assess humidity content in the air and predict rainfall. Flowers of certain lower plants open up in fine weather, and if the petals of these plants remain closed, it will indicate rain and bad weather.

3.1.2 Cloud Colour and Pattern as Indicators

Dark clouds will consider indicating heavy rainfall within a few hours. Dark clouds approaching from the north will believe in bringing rain. Red/pink clouds in the morning indicate the possibility of rain, whereas red/pink clouds in the evening will suggest that there will be no rain. Dark clouds preceding strong winds will consider indicating a thunderstorm in a few hours. Wind getting fast with a particular color and movement pattern of clouds will mean rain.

3.1.3 Moisture as Indicators

In the village, elderly farmers usually carry a small bag of damahkho (tobacco) for damah(traditional smoking pipe). Moisture over the damah will indicate rain, and dew on dried chilies or tobacco leaves is supposed to mean high humidity and imminent rain.

3.1.4 Other Abiotic as Indicators

A red sky in the morning indicates rain, while a red sky in the evening will consider suggesting that there would be

no rain. The rainbow's shadow near the water source shows clear weather.

People assess soil moisture by physically crumbling the soil with a hand and observing its structure and dryness. The soil moisture evaluates before deciding the timing of sowing, and seed or seedling will introduce only when the soil condition is favorable. Otherwise, farmers wait for rainfall to occur. People turn over stones near the river, hillside, or under the shade of trees to check soil moisture. Moist soil under the rock during the spring and summer seasons will consider indicating that the summer rain is approaching. Bubbles in water during light rain will feel to forecast more rain. In case the bubbles appear during morning showers, it will consider indicating that the rain would last the whole day. It will consider predicting rain if the waterfalls while taking out to wash hands and legs.

3.1.5 Spectrum/halo around the Sun and the Moon as Indicators

A ring around the moon and sun caused by light shining through sheets like high-level clouds indicates rainfall within the next two to three days. The description of the clouds matches with cirrostratus clouds that consist of ice crystals and are associated with warm fronts and high moisture content.

The spectrum around the sun has a large diameter then rainfall is considered to will assure. All the photometers are luminous marvels produced by the reflection, diffraction, refraction, or interference of light from the sun or moon. The distance from the sun or moon is the visible spectrum of light around the sun or moon, called the halo. If the space is more, it is called the halo phenomenon, caused by a layer of the thin veil of cirrus clouds, i.e., non, rain-bearing clouds. But if the distance is less, the corona phenomenon is produced by somewhat dense clouds that may cause rainfall. The accuracy of this indigenous observation is as high as 50 percent.

3.1.6 Star Constellation as Indicators

The pattern of stars movement from west to east at night under clear skies will indicate the onset of rainfall in 2-3 days, and similar patterns will also use to predict the cessation of rains. The stars' position will traditionally use to sense direction and time, and if all stars are out at night, it indicates a lovely day tomorrow.

3.1.7 Human Response as Indicators

In the study area, people with arthritis will observe to predict the weather based on their joint pain level. If there is a pain in the joints, it will indicate imminent rain. Assess to be associated with the fact that certain weather-related factors can increase pain.

3.1.8 Insects as Indicators

The appearance of ants and the rapidly increasing size of anthills, which are moist, are considered to indicate good rains. Variations in insect populations do exist throughout the year. The appearance of mushrooming of anthills and the ants will indicate the temperatures will hot enough to come out for the ants from hibernation and roam around in/on the soil.

The appearance of ants and an increase in the size of anthills will indicate the weather's warming. Based on this observation, people start sowing crops sensitive to low temperatures. If ants come out in large numbers and change places, it will indicate rain. Winged termites coming out of the soil after rainfall will predict fair weather for some time.

The appearance of winged termites after a dry spell of some days will indicate rains. If the spiders leave their webs, this will show rain. Spiders generally abandon their web and seek shelter with a drop in atmospheric pressure, and people utilize this observation for predicting showers. The sound of crickets calling or chirping throughout the night indicates a change in weather. When the bees come out of their hives, it is considered a sign of clear weather. The sight of bees moving untimely and in large numbers toward their store will indicate bad weather and rain.

3.1.9 Bird as Indicators

A flock of small birds like common swallows (Hirundo rustica) and proceeding black clouds will indicate rain. Birds taking a dip in the water will show imminent rain. The sight of red-billed chough (Pyrrhocorax pyrrhocorax) will suggest that the higher reaches have experienced snow, and winter conditions will set in.

Crow spreading and moving its wings near a river or water source indicates a dry spell. Flocks of birds flying high in the sky will consider predicting fair weather. If the birds fly below their average flight height, it indicates rain or bad weather. Fall in air pressure due to bad weather conditions causes discomfort in birds' ears, and to alleviate it, and they fly at lower elevations. An increase in humidity, at times of bad or wet weather, draws insects to the surface, and this is another reason for insect-seeking birds to fly low.

A sparrows flying around the sky with scattered clouds means rain in the afternoon. Ground nesting bird species making their nest on higher ground will consider meaning a likely increase in the water level of the water body (river/stream). The red-wattled lapwing (Vanellus indicus) generally lays eggs on bare ground and never constructs a nest. Laying eggs by the lapwing on a high basis will indicate a rise in the water level of streams and rivers.

Migration and immigration of birds are considered an indicator of changing seasons. The loud chirping of birds in groups and taking a dip in water indicate rain.

Particular Sounds of birds and the atmosphere becoming unusually calm will indicate rain.

3.1.10 Animal Behaviour as Indicators

Grazing cows jump in local parlance, returning home. Early is considered to indicate rain or bad weather. Well-fed cows/calves jumping in a herd on their way home from mountain pastures will deem to predict rain or bad weather. Grazing cows returning home early with raised tails will indicate rain. Consumption of excess fodder by cattle shows harsh weather or dry conditions. Frogs' croaking during the afternoon means imminent rain during all seasons. The sight of domestic hens / cocks searching for food during rain indicate that the rain would continue. But if these do not search for food during rain, it will mean that the rain will stop soon. If the goats do not graze, it will indicate snowfall.

If burrowing animals like rats come out of their caves and start to dig the ground, it indicates some natural calamity. Weeping, like the sound of animals, is regarded as a bad omen and correlated with natural disasters.

3.1.11 Appearance of Reptiles as Indicators

The sight of certain snakes moving down the mountain will consider indicating good rain. Snakes generally come out of hibernation and proceed to downhill areas in search of prey and mating partners to reproduce in the early summer season. They ensure that the eggs will hatch in time, and baby snakes get enough time to fatten their bodies and prepare for the cold season when they have to hibernate.

3.1.12 Earthquakes as Indicators

Although not in the weather forecasting category, animals, birds, and insects will believe to sense the approaching earthquake waves well in advance. They will induce abnormal behavior in these, which is considered an indicator of an imminent earthquake.

It will believe that a few minutes before the earthquake, everything becomes entirely still (no movement and no sound), e.g., birds chirping and flying around. Insects cease to make noise and stop to move around, and there is total silence and stillness. This unusual calm will consider indicating earthquake activity.

Seconds before the earthquake, it believes that the dogs start to howl, and other animals become agitated and restless. After the earthquake has passed, similar silence will repeat for a few minutes. Animals and birds will also know to leave an area or region up to 48 hours before a major earthquake, not returning until well after the event.

The appearance of young leaves and grass in the mountains, particularly in the pastures, indicates good rains. I was dropping fruits or drying flowers before maturity means the forthcoming dry season.

Table 2. Traditional weather forecasting / prediction indicators

Indicator	Observation	Indicates
Floral indicators	Blossoming peach (Prunus persica), apricot (Prunus armeniaca), fig (Ficus sp.)	Onset of spring.
	Budding or emergence and growth of new leaves in other trees	Increasing temperature & end of the winter season
	The abundant blossoming of peaches, apricot, and other trees.	The forthcoming good rainy season.
	Flourishing -both edible and wild mushrooms.	High humidity, imminent rain.
	Opened and stiff pine cones.	Dry wind/ weather.
	Flexible pine cone.	Good humidity content in the air and imminent rain.
	Opening and closing of flowers of certain lower plants.	Open up - fine weather. Closed -indicate rain and bad weather.
	The appearance of young leaves and grass in the mountains/pastures.	Forthcoming good rain.
	Dropping of fruits or drying of flowers before maturity.	The forthcoming arid season.
Cloud color and pattern	Dark clouds	Heavy rainfall within a few hours
Indicator	**Observation**	**Indicates**
	Dark clouds approaching from the north	Imminent rain
	Red / pink clouds in the morning	Possibility of rain
	Red / pink clouds in the evening	No rain
	Dark clouds preceding strong winds	Thunderstorm in a few hours
	Wind getting fast with a particular color and movement pattern of clouds	Indicates rain
Moisture	Moisture over the *chukka* (traditional smoking pipe)	High humidity, imminent rain
	Moisture on dried chilies or tobacco leaves	High humidity, imminent rain.
Other abiotic indicators	Red sky in the morning	Rain
	Red sky in the evening	No rain
	Shadow of the rainbow near the source of water	Clear weather
	Soil easily crumbled with hand	Dry condition
	The soil most soft when crumbled with a hand	Good moisture content in the soil

Indicator	Observation	Indicates
	Moist soil under the stones near the river or hillside or under the shade of the tree during spring and summer season	Summer rain approaching
	Bubbles in water during light rain	More rain
	In case the bubbles appear during morning showers	The rain would last the whole day
	If the water falls down while taking it out for washing hands and legs	Imminent rain
Human Response	If there will increase pain in the joints in patients with arthritis	Imminent rain
Spectrum/halo	A ring around the moon and sun caused by light	Rainfall within the next two to three
Around the sun and the moon	shining through sheets like high-level clouds.	days
	The spectrum around the sun has a larger diameter	Assured rain
Indicator	**Observation**	**Indicates**
Star constellation	The pattern of stars and movement of stars from west to east at night under clear skies	The onset of rainfall in 2 - 3 days
	All stars are out at night	Clear weather the next day and vice versa
Insect as indicators	The appearance of ants and the rapidly increasing size of anthills, which are moist,	Indicate good rains
	The appearance of ants and an increase in the size of anthills	Increase in temperature
	If ants come out in large numbers and change place	Indicate imminent rains
	Winged termites coming out of the soil after rainfall	Fair weather for some time.
	The appearance of winged termites after a dry spell of some days	Indicate rains
	Spiders leaving their webs	Indicate rains
	The sight of bees moving untimely and in large numbers toward their hives	Indicate lousy weather and rain
	When the bees come out of their hives	Sign of clear weather
	Sound of crickets calling or chirping throughout the night	Change in weather
Bird as indicators	The flock of small birds like common swallows(*Hirundo rustica*) together with proceeding black clouds	Indicate rain
	The flock of sparrows flying around the sky with scattered clouds	Rain in the afternoon.
	Flocks of birds fly If they fly below their standard flight height	Rain or bad weather
	Flocks of birds flying high in the sky	Fairweather
	Crow spreading and moving its wings near river or source of water	Indicate dry spell

Indicator	Observation	Indicates
	The sight of red-billed chough (*Pyrrhocorax pyrrhocorax*)	The higher reaches have experienced snow, and winter conditions are setting in
	Birds taking a dip in water	Imminent rain
	Ground nesting bird species make their nest on higher ground	Likely increase in the water level of the water body (river/stream)
	Laying of eggs by the species like The red- wattled lapwing (*Vanellus indicus*)on high ground	Rise in water level of streams and rivers.
	Migration and immigration of birds	Changing season
Indicator	**Observation**	**Indicates**
	The loud chirping of birds in group and taking a dip in water	Rain
	The particular sound of the birds, together with the atmosphere becoming unusually calm	Rain
Animal behavior	Grazing cows/Buffalo, Baffalo returning home early	Rains/snowfall or bad weather
	Well-fed cows/calves jumping in a herd on their way home from mountain pastures	Rains/snowfall or bad weather
	Croaking of frogs during the afternoon	Imminent rain during all seasons
	Grazing cows returning home early with raised tails	Rain
	Consumption of excess fodder by cattle	Harsh weather or dry conditions.
	The sight of domestic hens/cocks searching for food during rain	Rain would continue and vice versa
	Weeping like the sound of animals	Bad omen and is correlated with natural calamities
	If burrowing animals like rats come out of their caves and start to dig the ground	Some natural calamities like earthquake
	If the goats do not graze	Rainfall.
Abnormal behavior of animals	Everything becomes entirely still (no movement and no sound) e.g.	
	Dogs start to howl, and other animals become agitated and restless.	Earthquake
	Insects cease to make noise and stop to move around, and there is total silence and stillness.	
	Birds chirping and flying around	
Appearance of reptiles	The sight of certain snakes moving down the mountain	Good rain

3.2 DISCUSSION

Traditional weather forecasting refers to the use of various indicators for assessing weather conditions. However, the mechanisms and indicators used for forecasting differ across communities, cultural backgrounds, and environments. In Western Kenya and South Africa, inhabitants use toads, birds, and white ants to predict the summer season and the onset of rains. Based on their observation, they, at the same time, can expect temperature variation in the range of 18°C to 26°C [37,38]. In northeastern Brazil appearance of crickets is used, while in Semsa, a forecast is made based on the behavioral patterns of birds and mammals. Activities of arthropods, such as cockroaches, housefliesfleas, , spiders, and many others, indicate the summer season's arrival in Japan. Similar indicators and forecasting methods are observed all over the world.

The main advantage of traditional weather forecast is its simplicity and timeliness; a person can make an independent observation without using complicated instruments and use the information when needed without resorting to complex analysis of the collected data. There is no need for consultation with experts. The indicators people observe in their immediate environment provide more accurate information than forecasts interpolated from data from weather stations located at distant places. Traditional weather forecasting is suitable for remote and inaccessible terrains such as Semkhor, where most meteorological observatories will restrict to district headquarters. The data from the same will extrapolate for making predictions over large geographical areas. The remoteness of the places also hinders the accessibility of people to scientific weather forecasts through television, newspapers, or radio.

Traditional weather forecasting is important because before the onslaught of modern scientific methods for climate prediction and , farming, and weather forecasting other livelihood pursuits were sustained by this conventional knowledge. Traditional knowledge can thus be used in conjunction with scientific weather forecasting information from the meteorological department, significantly improving the timing of agro-horticultural activities and disaster risk reduction.

The challenges to integrating this traditional knowledge with mainstream science include that observed environmental indicators need more scientific data for validation. The ability will base on the cultural belief system of the people. It often varies with different cultures, and formal intergenerational knowledge transfer still needs to be among the communities.

The indicators will base on ecological interactions and responses of the indicator species, which will alter by increasing variability in climate, thus making these predictions increasingly less reliable.

For the possible integration of scientific weather forecasting and traditional knowledge, there is a need for comprehensive research to correlate local indicators used for weather prediction with meteorological parameters. Agricultural decisions like sowing, planting, and harvesting will still make according to traditional

knowledge and understanding of local environmental conditions. Understanding peoples' perceptions of weather and climate are essential in facilitating and promoting research on modern science–powered traditional agro – meteorological knowledge.

IV. CONCLUSION

They are bereft of external interventions; the geo-environment around most local communities behaves as a closed system with little faunal and floral changes. Moreover, there were little variations in the weather pattern. Though based upon intricate observation and record keeping of generations, the likelihood of the predictions being correct was at that time relatively high. However, changing ground realities and changes introduced in weather conditions by climate change make traditional weather forecasting tools increasingly unreliable. Climate change leads to mistrust amongst the masses regarding the efficacy of conventional indicators. The older people, however, have faith in these, and based on their experience, they resort to using multiple hands for effective and reliable predictions. In the changed ground, the traditional art of weather forecasting is fast losing ground and will transmit through oral tradition; this knowledge will indeed and lost soon as the community is disinterested in sharing irrelevant knowledge. This knowledge is, however, the product of in-depth observation and detailed documentation of natural phenomena over an appreciably long period. Therefore, detailed scientific documentation of this knowledge and standardization of still relevant indicators are necessary. Scientific weather indicators will do in the right spirit, and results available to the masses could greatly empower local communities.

At the same time, this effort would have the scope of initiating an altogether new line of research wherein modern weather forecasting skills could be further sharpened by incorporating real-time inputs on the standardized indicators from the community.

Besides empowering the local communities, this effort would benefit the state and others as improved weather forecasting would translate into better decision-making, enhanced economic scenarios, and reduced loss from recurring disasters.

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REFERENCES

[1] Singh R K & Bhowmik, Climate change and Indigenous Peoples: Community adaptation and sustainability of biocultural diversity in eastern Himalaya, Arunachal Pradesh. Paper presented in 2010 Climate change adaptation conference: Climate adaptation futures, preparing for unavoidable impacts of climate change, from June 29th to July 1st, 2010, Gold Cost Queensland, Australia: 300.

[2] Salick J & Ross N, Traditional peoples and climate change: Introduction, Global Environ Change, 19(2009)137-139.

[3] Turner N J & Clifton H, "It's so different today": Climate Change and Indigenous life ways in British Columbia, Canada, Global Environ Change, 19(2009)180-190.

[4] Turner N J & Turner K L, Where our women used to get the food: cumulative effects and loss of ethno botanical knowledge and practice; case studies from coastal British Columbia, Botany, 86 (1) (2008) 103–115.

[5] Turner N J & Turner K L, Where our women used to get the food: cumulative effects and loss of ethno botanical knowledge and practice; case studies from coastal British Columbia, Botany, 86 (1) (2008) 103–115.

[6] Turner N J & Clifton H, The forest and the seaweed'': Gitga'at seaweed, Traditional Ecological Knowledge and community survival, In: Eating and Healing, edited by Pieroni A & Price LL, 2006.

[7] IPCC-II (Intergovernmental Panel on Climate Change, Working Group II), 4th Assessment report: Impacts, adaptation, and vulnerability-summary for policy makers.

[8] http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf (Online), 2007.

[9] Krupnik I & Jolly D, The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, Alaska and The Smithsonian Institution, Washington, DC, 2002.

[10] Camberlin P. Rainfall anomalies in the source of the Nile and their connection with the Indian Summer Monsoon. J. Clim. 1997;10:1380-1392.

[11] Patz JA, Campbell-Lendrum D, Holloway T, Foley JA. Impact of Regional Climate Change on Human Health, Nature. 2005; 438(7066):310-317. DOI:10.1038/nature04188

[12] Fisher RJ. If rain doesn't, come: An Anthropological study of Drought and Human Ecology in Western Rajasthan, Sydney Studies, Manohar Publishers and Distributors; 1997.

[13] Cruz RV, Harasawa H, Lal M, Wu S, Anokhin Y, Punsalmaa B, Honda Y, Safari M, Li C, Huu Ninh N. Asia. Climate Change, Impacts, Adaptation and Vulnerability. In Parry ML, Canziani OF, Palutikof JP, Van Der Linden PJ, Hanson CE, (Eds.) Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. 2007;469-506.

[14] Barnett TP, Adam JC, Lettenmaier DP. Potential Impacts of a Warming Climate on Water Availability in Snow-dominated Regions. Nature. 2005;438:303-309.

[15] Xu J, Grumbine RE, Shrestha A, Eriksson M, Yang X, Wang Y, Wilkes A. The Melting Himalayas: Cascading Effects of Climate Change on Water, Biodiversity, and Livelihoods. Conservation Biology. 2009; 23:520-530.