Adaptation and Livelihood Vulnerability among People in the Lhasa Sub-basin of TAR

-- an assessment of the impacts of Climate Change in Lhasa River sub basin

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1. Introduction

Tibetan Plateau is regarded as a weather vane or startup of global climate change (CC) which has attracted the attention of scientific community. Climate change impacts are becoming increasingly evident within this highly vulnerable and fragile region.[1] Temperatures are rising at rates substantially higher than the global average, and significantly more so in higher altitude areas[2]. Research shows that the annual

1 Zomer RJ, Trabucco A, Wang M, Rong L, Chen H, Metzger M, Smajgl A, Beckshafer P, Xu J (2014). Environmental stratification to model climate change impacts on biodiversity and rubber production in Xishuangbanna, Yunnan, China. Biol Conserv 170:264–273; Zomer RJ, Oli KP (2011). Kailash sacred landscape conservation initiative: feasibility assessment report. ICIMOD: Kathmandu. SBN: 978 92 9115 211 7

2 Liu X, Cheng Z, Yan L, Yin ZY (2009). Elevation dependency of recent and future minimum surface air temperature trends in the Tibetan Plateau and its surroundings. Glob Planet Chang 68:164–174

average temperature in the TAR rises at a rate of 0.32℃ every 10 years, higher than in any other area nationally[3]. The change in temperature results in glacial retreat, permafrost melting, grassland degradation, desertification and soil erosion, it threatens biodiversity and eventually triggers extreme weather, geological and biological disasters, inevitably affecting the life of farmers and herdsmen and their socio-economic condition[4]. Large-scale climatic and phonological changes in plants have been documented across the Himalayan region5. Specific to Tibetan plateau and Lhasa river sub-basin, studies on climate change and its impacts on socio-economy and livelihoods of the people are very scanty, sparsely documented, and generally under-researched. A research on climate change and its countermeasure carried out in the Tibetan Plateau through the analysis of the dynamic changes of agricultural resources from 1960 to 1989, shows an average temperature rise in crop growing season (from May to September) by 0.7℃ in Lhasa, 0.4℃ in Tsetang and 0.2℃ in Shigatse, Gyangze and Nyingchi and 0.3 ℃ in Bomi[6]. Further, analysis of both the temporal and spatial distribution of plants' productivity in Tibet for nearly 30 years and the incongruity in changes between 1960s and 1980s due to climate change impacts on Plants' Productivity reported that "warm wet" climate is favorable in Tibet; "cold dry" climate is unfavorable; "warm dry" climate does harm in rural areas along the rivers, Ali prefecture, and greater part of Nyingchi; "cold wet" climate is adverse in Nagqu, the southern edge of Tibet, and the agricultural and pastoral areas of Nyingchi[7]. For addressing the Eco-environmental Fragility and Ecological Security development, Strategy is recommended[8] which is now in place and being implemented. Another study analyzed the impacts of precipitation due to Climate change on barley growth in different climatic Zones from 1961 to 2000. In warm semi arid areas, the

3 Liu X, Chen B (2000) : Climatic warming in the Tibetan Plateau during recent decades. Int J Climatol. 20: 1729-1742. 10. 1002/1097-0088 (20001130) 20: 14 <1729: AID-JOC556> 3.0.CO; 2-Y.

4 Rural Economy Division of the Office of the National Development and Reform Commission (2009). Notice of the Office of the National Development and Reform Commission on Issuing the "Tibet's ecological security barrier protection and construction planning (2008-2030)"

5 Shrestha UB, Gautam S, Bawa KS (2012). Widespread climate change in the Himalayas and associated changes in local ecosystems. PLoS One 7: e36741

6 Pubu Ciren, Jiala (1995). Research on Climate Change and its Countermeasure in the Tibetan Plateau. Tibet's Science and Technology. Vol70, Publisher Tibet's Science and Technology. pp 28-34

7 Du Jun (1996). The Impact of Climate Change on Plants' Climate Productivity in Tibet. In: Tibet's Science and Technology. Vol 71. Publisher -- PP 40-45

8 Zhong Xianghao, Liu Shuzhen, Wang Xiaodan, Li Xiangmei (2003) Eco-environmental Fragility and Ecological Security Strategy in Tibet. In: Journal of Mountain Science. Journal of Maintain Science. Vol. 21. pp 1-6

precipitation is on decreasing trend, while in warm semi humid areas, precipitation is on increasing trend therefore conducive to barley differentiation and panicle formation.[9] Both positive and negative impacts of CC on crop production impacting on the livelihood of the people has been reported[10]. Some researchers reported a shift in cropping season, pattern and grain yield response to climate change[11]. There is an upward trend in temperature, occurrence of extreme weather conditions[12]. Study on impacts of CC on the Lhasa sub river basin also shows that the temperature and precipitation are at a rise and the scale of impacts in terms of change will be pervasive[13]. Another study showed an upward trend in average annual rise in temp14, with potential of occurring many diseases in plants and animals never witnessed in the past.[15] For this, protection of agricultural ecosystem and improving crop diversity for livelihood has been suggested[16].

Although some research has been carried out to examine the impact of climate change in the Tibetan region, studies focusing on the socio economic aspect of the people are rare in the literature. This may be due to sensitivity of the area and researchers mostly concerned on the on going debate of climate change, biodiversity loss, glacier retreat and degradation, the livelihood issue of impacts of CC is neglected. A better and deeper understanding of the potential impacts of climate change on food security, livelihoods, and local economies of the area is important for informed

9 Du Jun (2004). Characteristics of Climatic Change in Precipitation During the Period of Tibetan barley in Desperate Need of Water in Tibet. In: Agricultural Research in the Arid Areas. Vol: 22, Publisher Agricultural Research in the Arid Areas Editorial Office. pp 23-27

10 Gesang, Zhuoma(2007). Analysis of Climate Change in the Tibet Plateau and Its Impacts on Farming and Range-based Production. In: Tibet's Science and Technology. Vol 168, Publisher - Tibet's Science and Technology. Editorial Office pp 53-55

11 Deji, Deji Baima and Chen Gongyan (2007). The Impact of Climate Change on Seedtime of Winter Wheat in the Central Areas of Linzhi. In: Tibet Science and Technology. Publisher Tibet Science and Technology Editorial Office Vol.168.pp48-49

12 Zhuoma, Laba Zhuoma (2007). The Impact of Climate Change on Crop Climatic Potential Productivity in Main Agricultural Areas in Tibet. In; Tibet's Science and Technology. Vol: 177 pp 57-59.

13 Du Jun, Hu Jun, Zhou Baoqin (2008). The Response of Climatic Productivity of Crops in Three-river Areas in Tibet to Climate Change. In: Agricultural Research in Arid Areas. Publisher Agricultural Research in Arid Areas Editorial Office Vol 26 pp 141-145. Nuozhu Nima, Wang Jianqun, Xu Xin (2012). Analysis of the Evolutionary Trend of Factors in Water Cycle in the Lhasa Sub-basin. In : water resources protection. Publisher: water resources protection Editorial Office. Vol. 28. pp51-53

14 ZHANG Hezhen, Zhuoma, XIANG Fei, Zhuoga and Gesang (2015). Effect of climate factors on the runoff over Lhasa River basin during 1981- 2013. In: Jer. of Glaciology and Geography -05. Tibet Climate Center; Hydrological Survey Bureau of Tibet Autonomous Region.p333.1.

15 Zuo Huilin, Fu Pingshun, Du Jun (2009). The Climatic and Environmental Changes in Tibet and Their Countermeasures. In ; Tibet Sci and Technology.

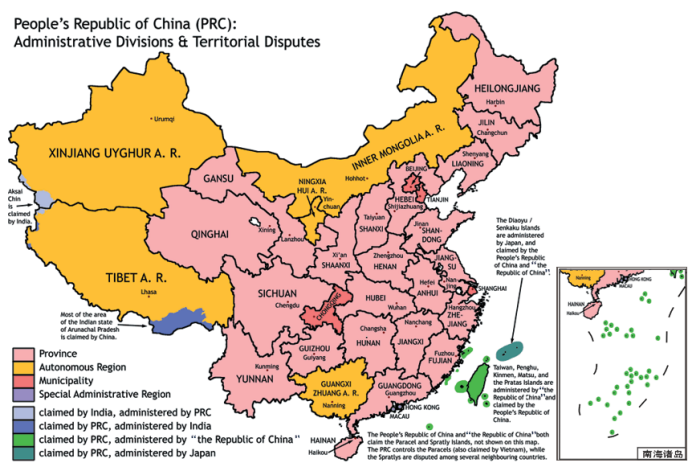
16 Tang Xiaolu, Jin Xiaobing, Sheng Li, Zhou Yinkang, Sun Tao (2008). Research on Response of Grain Output to Climate Change Based on Wavelet Analysis: A Case Study in Tibet. In: Geography and Geo information Sci. Vol 24, Publisher: Geography and Geo information Sci Editorial Office pp 88-92.

planning, decision making and developing adaptation strategies[17]. Tibet is rich on its Traditional knowledge system in managing biological resources for livelihood improvement. It is important to learn from it and advance ahead in the face of CC. In this study sociological survey was used to explore the perception of communities living in the sub river basin of Lhasa on the impacts of climate change on their socioeconomic life and their biological resources. On the basis of the information gathered, this study brings a case on the vulnerability and adaptive capacity of farmers to climate change and herdsmen in the Lhasa river sub-basin and government initiative to address the issue.

2. Study Area

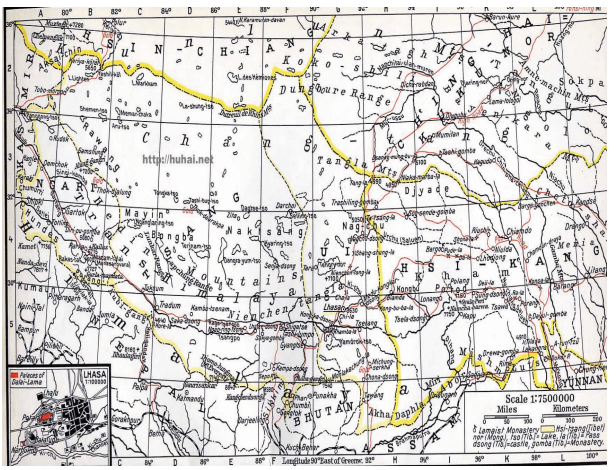
Located in the hinterland of the Qinghai-Tibet Plateau, the Lhasa river sub-basin comprises of, 2.7% of the Tibetan Autonomous Region (TAR's) total area (Fig. 1a and b). It supports an estimated population of 559,400, 15% of the TAR'S total population. Fig 1a Location of study site and occupies 15 % of arable land of TAR. The Lhasa sub river -basin mainly refers to the valley through which the Lhasa River (skyid chu in Tibetan) flows. The elevation of Lhasa river basin ranges from 35800 - 7000 m asl[18]. The study site lies within the latitudes between 29°32′N and 31°28′N and the longitudes between 90°06′E and 93°36′ E, located at 3580 meters up to 5200 meters, and having a total basin area of 32869 km^2, the Lhasa River is the largest tributary of the Brahmaputra or the Yarlung Zangbo river, accounting for 13% of the latter's total basin areas, including 702 km^2 glacier areas.

Location of study site (Fig 1 a)

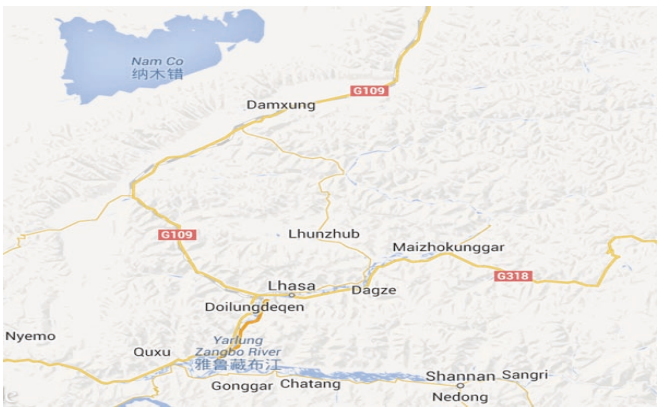


17 Robert J. Zomer & Antonio Trabucco & Marc J. Metzger & Mingcheng Wang & Krishna P. Oli & Jianchu Xu (2014). Projected climate change impacts on spatial distribution of bioclimatic zones and ecoregions within the Kailash Sacred Landscape of China, India, Nepal. In ; Climatic Change. # Springer Science+Business Media Dordrecht 2014. DOI 10. 1007/s10584-014-1176-2

18 L.Qiu, D.Peng, J. You and F. Qiao (2014) Simulation of Snow Melt runoff in ungauged basin based on MODIS; a case study of lhasa river basin. In; Stock Environ Res Risk Assess . Springer. 28:1577 – 1585.



(Fig 1b) Study site Lhasa sub river basin



The study sites are located; Lunbugang Community (Site A) in Maizhokunggar County (mal-gru gung-dkar), 100 kilometers away from Lhasa City in the upper reach of the Lhasa River, Zebu Community (Site B) by the Duilong River (stod-lung chu), a main tributary of the Lhasa River, 30 kilometers away from Lhasa City, and Chabala Village in the downstream of the Lhasa River, 50 kilometers away from the city.

At 3900 m, Lunbugang Community is located in the Village of Gesang Village, Gongka Town, Maizhokunggar County, 13 kilometers from the county seat, through which flows the Mozhuma River originating from the Rezhen Lake. Zebu Community belongs to Jiaru Administrative Village, Gurong Town which has an average altitude of 4,000 meters, Doilungdeqen (stod-lung bde-chen) County, the county seat of which is about 20 kilometers away. Chabala Village is in Chabala Town, Qushui (chu-shur) County, about 30 kilometers from the county government. The sub basin is rich in biodiversity (including agricultural biodiversity) and culture, inhabitants. The altitudinal zonation of bioclimatic zones in the sub region, ranges from below 3580 m

to 5200 m asl. Bioclimatic conditions found here are arid, high altitude cold deserts, and permanent snow and ice with alpine meadows and grasslands stretching high above the tree line. This habitat supports numbers of threatened wildlife including musk deer, blue sheep, Tibetan antelopes and many other charismatic, endangered and relic/or rare species. Many of the TAR's industry, agriculture and range-based production units are located here therefore have major human impacts. The impact of climate change associated with anthropogenic activities on this region is typical across the Tibetan plateau, a daunting environmental and socio economical challenges for the government and to the community to cope with.

Like other arid regions across the world, the sub basin is ecologically fragile and highly vulnerable to climate change. Estimate of the national census shows the resident population of Lhasa in 2010 was 559, 400, consisting of 429,100 Tibetans, 121,000 Hans, and 9,000 other ethnic minorities[19].Over 450 thousand people live in this sub region, most of them depend on natural resource; Sedantarise farmers and semi-nomadic/ nomadic pastoralists. The traditional farming systems found here, with staple crops ranging from highland barley, wheat, buckwheat, amaranth and potatoes, rapeseeds and are integrated with nomadic and Sedantarised livestock systems of raising yak, sheep and horse, which is traditionally adapted for their livelihood under these harsh climatic conditions. In recent years modern form of farming (both crops and livestock) has been introduced and is increasing with modern form of irrigation facilities. There is widespread collection of non-timber forest products, medicinal and aromatic plants, notably Yartsagunbu (Cordyceps sinensis), many fungus species and their trade are important livelihood activities. When bioclimatic conditions change, this impacts upon natural ecosystems, and eventually to the livelihood of the people.

3. Methodology

Initially three communities were purposively chosen in the sub river basin to administer survey. They include; Lunbugang Village, Zebu Village by the Doilung River (the main tributary of the Lhasa River,) and Chaba Village (situated in the Lower Lhasa River,). In collaboration with the International Center for Integrated Mountain Development (ICIMOD) based in Nepal, checklist was prepared. Experts from ICIMOD were invited and a joint workshop was held with a view to provide training on the subject and survey methodology to the selected field researchers, local field workers and pre testing of questions were conducted in the project sites. Following workshop, literature on climate change and adaption, environmental vulnerability and protection

19 The Census Office of the State Council (2012). The 2010 Population Census of the People's Republic of China. Beijing: China Statistics Press. p56.

was reviewed.

As part of the study and testing the questionnaires an interview with senior citizen of over 70 years in each community was undertaken. Then, informal interviews with purposively selected 10 people of over 60years half male and half female in each community was carried out respectively. In addition, information on impacts of climate change on women and energy consumption were also gathered. During the field survey two workshops in each of the community were conducted. An analysis of the survey was carried out and discussed in the light of current knowledge on impacts of CC on environment, socioeconomics, of the area.

Results

4. Socio-economy of the Lhasa sub-basin

In 2012, the GDP in the Lhasa sub basin was 26.004 billion Yuan, 12.2% more than the previous year and 1.45 times more than that in the year 2010. The GDP share of three industrial sectors such as agriculture (0.94 billion Yuan), forestry (0.039billion Yuan) and animal husbandry (0.94 billion Yuan). The proportion of agriculture, industry, tertiary indutries was roughly 1 to 8.41 to 14.71respectively. The municipality's gross output value of farming, forestry, animals husbandry and fishery was 1.771 billion Yuan, comprising 752 million Yuan coming from agriculture, 39 million from forestry, 940 million Yuan from animal husbandry, 39 million Yuan from services for these sectors[20]. It has a total annual cultivated land of 38,500 hectares, in which 16,508 hectares were on Tibetan barley, 8997 hectares on wheat, 3940 hectares under rapeseed and 4627 hectares was under vegetable cultivation. The total number of livestock in the year 2012 (including Yak, Sheep, Horse cattle) was 1,354,200 heads, the meat output was 31,400 tons, the output of eggs was 583.61 tons, the milk production was 32,800 tons, and the aquatic products were 155.24 tons. All industrial added value reached 3.23 billion Yuan, 2.698 billion Yuan of which came from above sectors, and the total investment in fixed assets was 28.505 billion Yuan. The number of days with the urban air quality above AQ was 364 a year21. The water quality both in source areas for centralized drinking and flowing out of the Lhasa sub basin -meet prescribed criteria. Per capita disposable income of urban residents was 19,545 Yuan with per capita expenditure 13,952.7 Yuan and per capita net income of rural residents was 7082.1 Yuan, an increase of 17.7%.

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20 Lhasa Municipal Bureau of Statistics. The 2012 Statistical Bulletin of the National Economic and Social Development of Lhasa Municipality. http://www. tjcn.org/plus/view.php?aid=27105

21 AQ refers to air quality.

5.Climate Change in the Lhasa sub-basin

The climate in the Lhasa sub-basin is cold, dry, and stormy, especially in winter and spring. The average annual precipitation is between 400mm to 500 mm. Most of the rainfall occurs during the period from May to September; it is arid with little snowfall in winter. The average temperature in January is 0℃, while in July is 17℃, and the extreme minimum temperature is -14℃ whereas the extreme maximum temperature goes up to 31℃[22].

In Lunbugang community, the perennial maximum temperature varies from about 23℃ to 29℃, whereas the minimum temperature is from -20℃ to -15℃, its annual precipitation is about 515 mm, and the annual hours of sunshine are 2,813 hours. Jiaru Village has 3000 hours of sunshine, 120 days free from frost, and an average rainfall of about 440 mm a year. The place where Chabala Village belongs is in a semi-arid plateau temperate monsoon zone, characteristic of a big difference in temperature between day and night and long time of sunshine with strong radiation. There are nearly 3,000 hours of sunshine, 150 days free from frost and a rainfall of 441.9 mm in a year there; and the region frequently witnesses hail, mountain torrents, landslides, drought, wind, pests and other natural disasters.

In the contemporary climate change scenario rural people in the study sites are disproportionately vulnerable to the loss of biodiversity and ecosystem services. Although they are responsible for emitting the lowest levels of greenhouse gases, they suffer most from the impacts of climate change, damage done in the earth system elsewhere. In recent years, people in the sub region felt and reported that the temperature and rainfall tends to rise, resulting in direct impact on annual runoff. Almost all respondent report that increase in precipitation is good for their crop production. However, they also cautioned on the rise of different insect vectors such as mosquitoes which may bring diseases not experienced by the people in the river basin. As for the adaptation to change people in the urban area have more adoptive capacity than their rural partners . This due to the formers better economic status compared with the later. Many researchers have also come to the same conclusion.

6. The environmental situations, biodiversity and vulnerability in the Lhasa sub-basins

In the northern part of the Lhasa sub-basin, the basin has the altitudes of 5000 meters to 5500 meters at its alpine peaks and 4000meters to 4500 meters at its bottoms, a relative elevation of about 1000 meters; in the southern part, the altitudes of its

22 Local Chronicles Compilation Committee of Tibet Autonomous Region(2010). Records of Chengguan District of Lhasa City. Beijing: China Tibetology Publishing House. Chapter 3 Climate.

peaks vary from 4,000meters to 4,500 meters above sea level, while the altitudes of its bottoms has a variety of 3,580 meters to 4000 meters. The high river drop, rich topography, and diverse types of environment provide this region with a unique position to enjoy a variety of plant species and refugia for many species in the face of CC.

Botanically, the Lhasa sub-river basin is covered with 72 families, 285 genera and 793 species (including variants) of wild seed plants, accounting for 43.90% of the families, 24.89% of the genera, and 14.97% of the species of the TAR's total wild seed plants. Majority of these are Medicinal and Aromatic plants as the survey has found that 54 families, 145 genera and 262 kinds of wild seed plants in the region are of medical value, constituting of 75 %, 50.9%, and 33.0% respectively.

In recent years, the climate in the Lhasa sub-basin tend to more warm and more humid which the respondent consider may have two effects: one is that the more precipitation and the higher temperature are conducive to plant growth in the basin, and the other is that glacier retreat and permafrost melting resulting from the rise in temperature in this region which has a huge area of glacier and permafrost in it, will affect the fragile ecosystems badly. The rising temperatures, increasing precipitation, and resulting reduction in the volume of glaciers can create a host of "cascading effects"[23] and will have major impacts on ecosystems, biodiversity and livelihoods. the environmental vulnerability increased clearly with increasing elevation (vertical distribution). How these biological species will response to this pervasive impacts is very hard to imagine. However, as the respondent feel that insect vectors are already entering into the new territories and we may not have noticed and are not aware as yet that plants may have been changing their physiology or creeping towards hospitable new territories. New ways of doing things must be evolved. For the domesticated crops new methods of adaptation such as selection of drought resistant crops and those suited in the rainfall areas being increasingly practiced.

7. The current socio-economic situation and vulnerability in the survey communities

At present, Lunbugang has in all 49 households with 268 people in them, 267 of whom are Tibetan and 1 Han (married into the village). The villagers are mainly engaged in farming as well as range-based production system. The village has 91.1 acres of arable land, which produces Tibetan barley, rape, potatoes, peas, spring wheat and 352.22 acres of alpine meadows, which offers grass to yaks, cattle, horses, sheep, goats and others.

23 Xu J, Grumbine R, Shrestha A (2009) The melting Himalayas: cascading effects of climate change on water, biodiversity, and livelihoods. Conservation Biology 23(3):520–530

According to the statistics in 2009, Chabala is a village of 560 inhabitants belonging to 105 households. The village enjoys about 1300 Kes of arable land (traditionally, a "Ke" (khal) is a unit equal to 0.33—0.82 acre) where mainly they grow Tibetan barley, rape, wheat and other crops, and has 830 heads of livestock such as cows, dzhos, sheep, horses, pigs and other livestock, a total of 3,350 heads in sheep unit[24].

Given the difficulty in processing Zebu community's related information, the data of Jiaru Administrative Village to which it belongs are used here to show its current socio-economic status. According to statistics by the end of 2013, Jiaru Village has a total of 201 villagers belonging to 54 households, mainly planting Tibetan barley in the arable land of 245.22 acres, and having an annual grain harvest of about 31.6 tons, 1972.75 kilograms an acre. Villagers mainly get their income from subsidiary occupations, which turns out a total of 1,60 million Yuan annually. In 2013 the villagers' per capita net income was 7986.7 Yuan, an increase of 904.6 Yuan over the year of 2012.

In the three survey areas of Lhasa River sub basin, villagers are engaged mainly in farming like planting Tibetan barley, rape, wheat and other crops in its valleys below the altitudes of 3700 meters, as well as in range-based animal production like raising livestock in the mountains of the altitudes between 3700 meters and 4200 meters. Extreme fragility of the environment in this area is mainly manifested in three aspects: 1, Irregular rainfall has greater impact on agricultural production; 2, villagers do not have a strong ability to bear risks brought about by frequent natural disasters such as drought and flash floods; 3, as a result of climate change, range-based production (mainly from livestock and non timber forest products) is at a decline owning due to grassland degradation and desertification.

8. Impacts of Climate change on inhabitants' livelihood - Impacts on farming

Most frequently question is asked on the impacts of CC is on agriculture (crop and livestock production), and from a broader perspective on our food supply. In other words, how animal production and thus the production of foodstuffs of animal origin and their quality are influenced by climate change through feed crop production? In the study area people responded that they have started to adopt more drought resistant variety of crops in dryer areas such as Tibetan Barley 2000 while where rainfall has increased people preferred new variety which perform better in the wet areas. They reported a reduction by 30 % of yield while using traditional crop verities. Because of this traditional knowledge on agricultural systems may be insufficient. They reported desertification and degradation of grassland have a direct influence on forage's species,

24 Traditionally, a horse is equal to 5 sheep, a yak equals 6 sheep, and a donkey equals 5sheep, etc.

both on yield and quality. The decrease in pasture areas and in forage yields result in a lower stocking rate which reduced the villagers' income from range-based production slightly in comparison with the past. Therefore farmers are forced to adjust livestock population structure and have started to adopt new animal breeds. The study showed that 20-40 % of herdsmen are forced them to undertake other off farm activities which is a swift from their former jobs which will have the impacts on loosing traditional local knowledge system in pastoral communities.

Since the replacement of traditional crop varieties in the drier areas which used to produce bulk of stalks and straw, replacement by dwarf verities farmers approximately 15 to 25 % less straw biomass production and straw output than the traditional cultivars. This has direct bearings on the availability of animal feed and consequently on the animal waste production leading to lower manure production. Because the available energy from bio resources has been declined, there is increasing demand from the farmers on the new form of energy such as the the cooking gas and electricity.

In the recent past the impacts of CC on the human health has also been reported during the survey. Specifically, all the respondents emphasized on the arrival of mosquitoes in the Lhasa sub-basin, which have never been seen in the past and were worried that this vector may bring communicable and vector born disease. They have witnessed an increased in frequency of influenza, pneumonia in the sub basin.

9. Adaptation of inhabitant's communities to climate change

In order to adapt to climate changes, the farmers are adapting water-saving irrigation systems in the drier areas. This is followed by rational grazing management, alpine grassland fencing and introduction of more resilient varieties of grass planting measures are taken, to lower the negative impacts of climate variability on the alpine grassland ecosystem. Many adaptation measures such as management of cordyceps and fungus, increasing tourism and number of tourists are being implemented in the communities by Civil organizations in cooperation with the communities to cope with climate change and extreme weather condition.

From Tradition, people are observing events and establishing some indicators of climate change through their own perception and observations .They have accumulated many indicators in the form of folk lore's about farming and range-based production in their daily life. For example, Less snow in winter; heavier snow in spring, Warm in spring; cold in spring, continual rain in summer; Droughty in spring; stormy in July and August. If there is less rain and snow in winter and spring, spring comes earlier and there is more snow in autumn; If fish hurries to migrate upstream, there is less rain early in summer; If yaks and sheep are grazing voraciously, a widespread rain or snow

comes shortly afterwards; If flocks are flustered to winter pasture, it will be heavy snow throughout the winter; and if there is more snow than usual at the coldest time of winter, spring comes earlier next year; but if there is more snow not at the coldest time of winter, spring comes late. These are some practical observation and indicators of people in the sub river basin which they have been learning and adapting from generation to avoid risk of human casualty and manage their day to day livelihood.

10.Taboos, local rules and regulations about ecological ethics valid for the whole village in daily life

Traditionally Tibetan Buddhism is the main philosophy of people's life living along the river sub basin. Much of the socioeconomic life was governed under this philosophy. Although the way of life has been changed in the contemporary world, philosophical views are still persistent when it comes to resources management in the sub basin. For example, the sub basin's Lama's view on climate change is "*like that of life of people. People born, grow become old and die. Similarly, over period of every 120 years there is change in climate from very cold to dry and cold and this is a gradual and cyclical process. The cycle continues and therefore we have witnessed CC now. They say the nature has its own law and intervention on these laws by man results in many changes as we have been experiencing. In the modern discourse we called this anthropogenic impacts on climate change*".

Ecological ethics are of great importance in the local communities. For example, people do not allow animals to graze adjacent to the wetlands during rainy season. As this season is considered growing season. Harvest from wetlands is prohibited. These areas are specific niches for the biological resources to grow and propagate and dispersal of their seeds. They opined that many of such areas are now under pressure from, infrastructure development, traditional value systems are not really appreciated and leading to increased vulnerability of the people due to resources depletion and impact of modern science. With increased in vulnerability due to drought, floods, over the past decades people have initiated plantation of trees in the rangelands as well as near the homestead through support from government. People say this has several advantages; the trees keep the place cool, allow grass to grow understory and provides safe birthing place to the animals and prevents sand stroms.

11. Measures taken by governments in response to climate change Policy Measures

The central government has always attached great importance to the protection and improvement of the ecology of Tibet. The high level political leadership the

country have given special attention in dealing with the cc in the TAR region. Since the late 1990s, the central government has continually intensified its efforts to protect the ecology of plateaus, invested more funds in its construction, and implemented series of projects for ecological protection and construction. The Central Government made it clear at the Fifth Forum on Work in Tibet that doing a good job for the TAR is a desperate need for the construction of the nation's ecological barrier for security and the accomplishment of a sustainable development, and proposed that more attention should be paid to the protection of the ecology of the plateau to make Tibet an important barrier for national and ecological security, important strategic resource reserve base, important plateau-characteristic agricultural base and important world tourist destination. In accordance with the principle that has priority to conservation, takes actions that suit local circumstances, and gives top priority to what is the most important. The government coordinates with many of its departments; for the conservation of environmental ecology, development of economy, social progress and improvement of people's wellbeing, promotes the coordinated development between environmental protection and economic improvement, and enhances a simultaneous optimization of the environment and improvement of people's wellbeing, to achieve a healthy cycle of the ecosystem in Tibet. This is a people centred approach where local communities are effectively collaborated. To support the local people and local administration, it also strengthens environmental protection, particularly the improvement of ecological environment in key areas, accelerates the establishment of long-term ecological compensation mechanism, and actively builds the plateau of an ecological security barrier to keep Tibet permanently green and clean.

In accordance with the spirit of the Fifth Forum on Work in Tibet and the Party's principal leaders' instructions, the governments started a lot of ecological protection projects, implemented the mechanisms for grassland ecological protection and compensation, approved the establishment of a large number of ecological and environmental protection areas, and invested over 22 billion RMB Yuan in wetland conservation, wildlife protection, river management, and addressing the livelihood of the people in the Tibet Autonomous Region.

12.Local level policies

At par with the central government's policy, the Tibetan local government formulated a series of laws, regulations and policies. For example, the Standing Committee of the Tibet Autonomous Regional People's Congress amended "*The Tibet Autonomous Region's Environmental Protection Act*"(2003) examined and promulgated 7 provincial laws and regulations on the protection of resource and environment in

Tibet. The Regional People's Government has presented nine government regulations, including *The Implementation in the TAR of Regulations of the People's Republic of China on Nature Reserves and the Administrative Methods for the Environmental Protection of Drinking Water in the Tibet Autonomous Region*. The Standing Committee also embarked on the monitoring of the implementation of laws and regulations such as the People's Republic of China's *Environmental Protection Law (1989), Grassland Law (1985), Mineral Resources Law(1986), Wild Animal Protection Law(1988) and Environmental Protection Regulations of the Tibet Autonomous Region(2003) and others. The committee formulated and implemented The Planning for the Protection and Construction of the Ecological Security Barrier in Tibet (2008-2030).*

Parallel to the promulgation and amendments of policies and legal measures, the government launched surveys on *The Research on the Division of Ecological Functions and Exploitation and Conservation of Resources in the TAR, The Research on the Fragility of the Ecological Environment and the Ecological Security in the TAR, The Research on the Ecological Restoration and Reconstruction of Lalu Wetland in Lhasa*. In addition efforts are under way on the protection of natural grassland, implement projects for returning to grazing on the grasslands, seriously degraded in the past, research on grassland for their improvement with adaptable grassland species in order to promote an increase in the income of farmers and herdsmen. Many of such package of work is being implemented in the Lhasa sub river basin to address the vulnerability of the area. Further, protected areas for conservation are intended to contain the environmental conditions that enable species and ecosystems to exist long. In the sub river basin, there are 26 wetlands, including Lalu Wetland National Nature Reserve, which cover an area of 30,912 hectares. Government and local people have given importance in the protection of such areas.

13.Conservation of water and control of soil erosion.

With a view to conserve water and control soil erosion, in the TAR, *The Project for Constructing the Network to Monitor Water Conservation in the Tibet Phase 1, The Plan for Water Resource Conservation in the TAR*, was implemented in the year of 2001. This project initially prepared the inventory of rivers in Tibet and an action plan for conservation was prepared which is now being implemented in the sub river basin also. Parallel to this, large scale tree plantation has begun, which focuses on the improvement of shelterbelts on the lowland along the "three rivers", namely the Yarlung Zangbo River, the Lhasa River and the Nyangqu River and their tributaries. Some specific practices such as resting of land for re-vegetation, planting grass for soil water conservation, afforestation for soil and water conservation, and active implementation

of comprehensive management of small sub-basins programmes by integrating such measures as forestation, planting grass and cultivation with small auxiliary projects for water and soil conservation like reservoirs, ditches and soil-retaining walls are on going.

Of the most important aspect of re-vegetation in Tibet and in the sub river basin is the energy programme currently being implemented. Traditionally biomass heavily dominates Tibet's energy consumption. In 2003, total energy consumption was about 2 million tce (ton coal equivalent), traditional biomass accounting for nearly 70%[25]. With population and economic growth, traditional use of biomass has become major factor responsible for deforestation, grassland degradation, desertification, and soil erosion. To address this issue, renewable energy resources such as hydro, solar and wind energy along with improved bio mass efficiency has been introduced by the government.

The area is rich in renewable energy sources, such as biomass, hydro, solar, geothermal, and wind power. This potential energy supply in Tibet can be juxtaposed to what drives Tibetan energy consumption, its economic motivation and its cultural traditions. To eradicate the negative impact of the traditional use of biomass on the eco-environment in Tibet, a series of effective countermeasures are investigated. Among these are improved efficiency of stoves, widespread use of solar energy, hydroelectricity as a substitute for traditional biomass, and the development of biogas. Currently in the sub-river basin, in urban areas 20% of the people use improved biomass burning, 30 % solar power and 50 % hydro electricity for their daily lives whereas in rural areas 40% use improved biomass burning, 10% solar power and 50% hydro electricity in nomadic areas. This has tremendous impacts in the protection of biomass products traditionally used in burning and has helped control soil erosion watershed conservation and curve in reducing co2 emission from house hold level. Further studies on this area is required.

14. Tibetan women in the context of climate change

The threat of climate change, in the increase of extreme weather conditions such as, droughts, storms or floods, has been recognized as a priority in the area to take action. Climate change is a challenge, with broad impacts not only on the environment but also on economic and social life of the people. The effects of climate change vary between women and men.

Women in rural Lhasa river sub basin are highly dependent on local natural resources for their livelihood, because of their responsibility to secure child bearing and rearing, ensuring water, food and energy for cooking and heating. The effects of climate change, including drought, uncertain rainfall and deforestation, make it harder to secure

25 Qiang wang (2009). Prevention of Tibetan eco-environmental degradation caused by traditional use of biomass. In:Renewable and sustainable energy review. Elsevier. 13(9)2562 -2570

these resources to them. By comparison with men, women face historical disadvantages in the area, which include limited access to decision-making and economic assets that compound the challenges of climate change.[26] In case of sub-basin women are usually the backbone of family labor, engaged in all kinds of arduous works mentioned above. Historically a large number of men became monks in monastery, leaving the much production labor to their females, and resulted in a serious shortage of labor which the women had to meet. Secondly, various arduous housework deprived women off their right for social contacts and for acceptance of new emerging culture and education and put them in a difficult position. In addition, they used to pay taxes and work for the local government of Tibet and their feudal lords, as written in *Illustrated Book on Tibet*[27]. "It was common that the Tibetan women doing forced and unpaid work for the government or landlords were more useful than their men." Women therefore had low social status in the eyes of law and religion in the past. They were only allowed to visit the religious sites by permission.

Despite women were deprived from many rights, however, their dominance over domestic production system and family management gave them higher role in their economic activities, right to own or inherit property, without any control or containment of their husbands. After the democratic reform, today in the sub river basin, women exercise equal freedom in social contacts, men and women are equal in marriage, young women shared the same equality and freedom with young men; and in occupation, there is no discrimination against women, either. However, in recent years, the Tibetan men go outside as migrant workers in the urban centers while women are left at home for farming and taking care of the family. The men are exposed to modern forms of life experienced in the city which is low is women leaving at home. Because their income, social experience and knowledge are less than those of migrant worker, their status seems to be in downward trend, and this deserves urgent attention by the concerned. In the face of climate change women folks seems to be more vulnerable than the menfolk since they are in direct contact with nature and are ecosystem manager on the ground.

15. Summary and Conclusion

In summary it can be concluded, that climate change has a major impact on food production (crop and livestock) as it has direct impacts on the ecosystem and socio economy of the area. We conclude that engaging stakeholders at multiple levels

26 52nd session of the Commission on the Status of Women (2008) "Gender perspectives on climate change," Issues paper for interactive expert panel on Emerging issues, trends and new approaches to issues affecting the situation of women or equality between women and men. http://www.un.org/womenwatch/daw/csw/csw52/issuespapers/Gender%20and%20climate%20change%20paper%20final.pdf

27 Huang Peiqiao(1982). Illustrated Book on Tibet, vol 6, Lhasa: the Tibet people's Publishing House, p188, 193.

followed by support from government will be highly effective in addressing locally relevant aspects of climate change vulnerability, impacts and applicable adaptation options in the Lhasa sub River basin. Based on this preliminary assessment, a sub-basin in-depth research on different aspects of CC impacts is recommended for evaluating, especially for water resources, vegetation and agricultural production systems, impacts on human and animal health and overall livelihood of the people through multi-level stakeholder input.

As the area is very sensitive to CC and will face more stress in consequence of higher temperatures and of any eventual decline /increase in the annual amount and/ or change in the annual distribution of precipitation, there is need for in-depth study on different aspects of environment that impacts the socio-economy of the area. For example, to start selective breeding of plants and animals to focus on selecting for drought resistant or adaptable breeds and varieties, cultivate and plant those in order to feed the growing population and sustaining the socio-economics and restoring the ecosystem of the area. Efficient use of biomass and alternative energy promotion will help improve the livelihood of people and reduces the vulnerability.

16.Recommendations

This is a preliminary survey undertaken within a very short period of time. In the longer term it is recommended to undertake the some of the following works that includes different aspects of socioeconomics of the people is the face of climate change.

(1) Draw a curve which shows climate change's impact on the life of people and nomads in the three communities and sum up their countermeasures and outcomes by conducting a long-term tracking survey there and making a historic comparison of key socio economic data.

(2) Carry out a comparative study of the effects of climate change in the areas around the Himalayas. Make a comparison of different groups of people's adaption to climate change under similar natural environment, find out similarities and differences between their adaption, analyze the influence of tradition, culture, modern form of development and psychology on interpreting climate change and document traditional ecological knowledge system.

(3) Carry out the related work in response to climate change by entering into dialogue and actively communicating with the local government and related institutions, such as capacity building, project support, introduction of adaptable breeds, verities and species with a backing from technical services.