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A socio-ecological survey in Jalantai Area, Alxa League, Inner Mongolia, China

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Abstract: This article concerns with new and traditional practises in agriculture in Alxa League in the Inner Mongolia of China. For such a purpose, the DISPAA Department of University of Florence (Italy) collaborated with the University of Tuscia (Italy), which has been one of the Italian executives for the Beijing Wind Dust Control Project under the framework of the Sino-Italian Cooperation Programme on Environmental Protection.
In the context of ADAM Project [1], the Inner Mongolia was indicated as a potential hot-spot due to the combination of climatic change, human activities and the general phenomenon of desertification, which is an ongoing process in this area. During the past centuries, arid and semi-arid general environmental characteristics of Inner Mongolia's landscape have conditioned the main course of economic development in rural areas. Into the Alxa League, a sub-case study situated around Jarantai City in the Alxa Left Banner was selected.
During 2005-06, the work analysed the agricultural activities of the local rural population to evaluate if these might be able to cope with desertification and, more in general, with climatic change impacts.
In particular, field surveys were implemented among local peasants, which were old herders or new
farmers immigrated in the area, following a non-structured interview approach where the length of the interview was calibrated on the characteristics of the single interviewed.
The interviews showed that soil fertility and water requirement (e.g. water

[1] This article refers to the Inner Mongolia "case study" of UE ADAM Project (2006-2009). It was coordinated by the UK's Tyndall Centre for Climate Change Research. ADAM has been an integrated research project running from 2006 to 2009 that leaded to a better understanding of the conflicts and opportunities of climate change adaptation and mitigation policies. ADAM was funded by the European Commission under the 6th Framework Programme Priority: Global Change and Ecosystems.

drawdown and high evaporation rate that cause superficial salt crust formation) are yet the main constraints to social and economic development of agriculture.

Keywords: Inner Mongolia, climate change, agricultural adaptation.

Introduction

The work described in this article came out as the main result of a field – trip carried out in Inner Mongolia by the technical team of DISPAA Department. The main aim was the investigation in new and traditional crop production practise in Alxa League agriculture. To pursue this aim we established an academic collaboration with the Department for Innovation in Biological, Agro-food and Forest systems (DIBAF) of the University of Tuscia. The University of Tuscia has been in fact one of the Italian executives for the Beijing wind dust control project (WINDUST) under the framework of the Sino-Italian Cooperation Programme on Environmental Protection 2 [2]. This project has been part of the Sino-Italian cooperation program established in 2000 among Italian Ministry for the Environment, Land and Sea, the State Environmental Protection Administration of China (SEPA), the Ministry of Science and Technology (MOST) of China, the Chinese Academy of Social Sciences (CASS) and Beijing and Shanghai Municipal Governments.

Twelve prefecture-level divisions compose the Inner Mongolia Autonomous Region, including nine prefecture-level cities and three leagues. The Alxa League is one of the tree leagues of Inner Mongolia, that have been chosen as a paradigmatic reference area in Asia cause of eco-environmental problem due to desertification and adaptation and mitigation policies adopted (ADAM, 2007). Indeed the pilot project area in WINDUST project is located in the Alxa League as one of the main source of dust storm in North of China.

The study area (38- 42 ° Lat. N; 104 – 108 ° Long. E) is located in the west side of the Helan mountain in the surroundings of Jalantai City (18,160 inhabitants). This territory stands on lacustrine deposits of Late Pleistocene Megalake Tengger characterized by a sandy top-soil over a weathered brownish-red layer about 50 cm depth. Three meters below a clay–loam layer overlap a sandy-gravel aquifer (Zhang *et al*., 2004). Gobi desert and desert steppe represent the main landscape of the area.

The Helan Mountains 3 [3] that represent a boundary between temperate grassland and desert scrub, between agriculture–pasture land and pure rangeland, crosses the

[2] See: WINDUST – Sino – Italian Cooperation Project to Combat Dust Sandstorms in Northern China- Phase I, Final Report, October, 2006.

[3] The mountain range stretches more than 200 km from north to south, 20–60 km from east to west, and the elevation for much of the range is between 2000 and 3000 m The west of the range faces the Tengger (or Tenggeli) Desert, the second largest desert in China. The east side faces the Mu Us desert. The climate of the Helan Mountain range is mainly controlled by the Asian summer and winter monsoons (Liu, 2005).

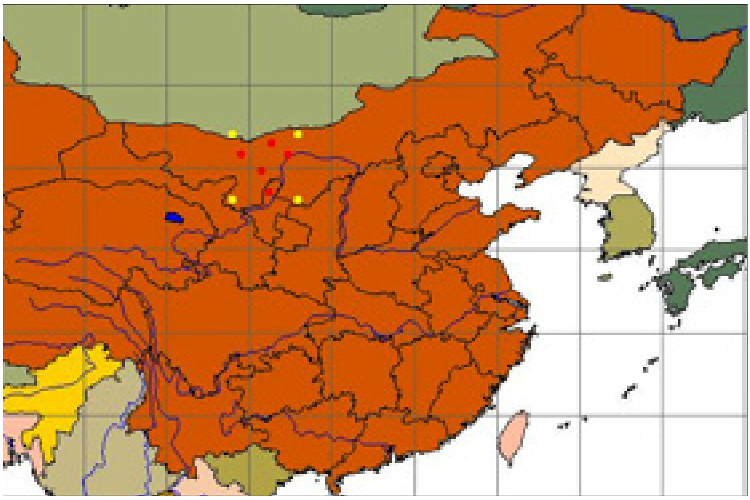

Figure 1 – *Inner Mongolia and sub – case study area localization in Alxa Left Banner in yellow point vertex. In red points are indicate WMO-Meteorological Stations (Elaborated by the DISPAA Dept., University of Florence).*

study area. Because of its position, the Helan Mountains are important in the physical geography of China (Liu *et al.*, 2005).

Brief overview on climatic aspects of Northern China, Inner Mongolia and Alxa League

Precipitation and temperature distribution patterns change considering different geographical scales and temporal periods, so according to the IPCC Report (2007), in the north part of China, a decreasing trend in annual mean rainfall was observed during the past few decades (IPCC, 2007).

In particular, in the northwest of China, from the end of Little Age to about 1980, the main trend in climate has been warm-dry recording an increase of 1-1.3 °C of air temperature. More than twenty years ago, it changed to more warm-wet climatic conditions. Moreover, in the sub-period 1987 - 2000, the average air temperature has been as more high as the precipitation (+ 10-30 %) respect to former period (Shi *et. al.*, 2007).

If we focus our attention on Inner Mongolia as a whole, the pluviometric regime has been characterized by a sharp annual rainfall gradient, from 600 mm in the east to less than 100 mm in the west. Most of the rainfall occurs from May to September, coinciding with high temperatures (Yu *et al.*, 2004). Thus, a climate pattern follows a strong east-to-west gradient. The coefficient of variability of annual precipitation ranges from 0.25 to 0.40, indicating the non-equilibrium ecosystem characteristics in this region (Yu *et al.*, 2004). In the future, it has been forecast a precipitation increase of 14% in Inner Mongolia (Shi *et. al.*, 2007). Moreover, as reported by some authors (Lu *et al.,* 2009) the climate change trend in Inner Mongolia from 1955 to 2005, was characterized by warmer and dried conditions. The annual daily mean, maximum and minimum temperatures increased and the decreasing trend of annual precipitation was not significant. However, the vapour pressure deficit increased significantly. On the decadal scale, the warning and drying trends were more significant in the last 30 years that the preceding 20 years. The climate change varied among biomes, with more pronounced changes in the grassland and the desert biomes than in the forest biome.

Alxa League climate is arid or extremely arid. Annual average temperature is around 7°C and its extreme values are: - 36.4°C and + 41.7 °C; rainfall ranges from 40 to 200 mm per year and only one rain season happens in July, August and September. Rainfall distribution follows a decreasing pattern: from southern-east to northern-west, while evaporation distribution is increasing from southern-east (2400 mm/year) to northern–west (4200 mm/year) (ADAM, 2007).

In general, according to the literature, we can summarize how a general negative trend in precipitation at a small geographical scale can correspond to positive one, at a greater scale (regional and sub-regional levels).

In the study area the elaborations of meteorological data (from National Climatic Data Center - U.S. Department of Commerce) have confirmed the micro-climate conditions: aridity and cold semi-aridity with an annual average temperature medium-low (8.2 °C), strong daily-night temperature variation (47.1 °C) and an annual average rainfall very low (174.9 mm). The rain season is characterised by sporadic evens in spring and autumn and higher precipitations in summer. Wind regime is strong in spring (dust storms in April) and its average daily value is 3.3 m/s[4]. There is a longitudinal negative trend about these data, shifting from east to west (Table 1).

Climate change and desertification process

The combination of climatic change and human activities (represented by the

[4] Wind speed range increases from East (1.58 m/s) to West (5.49 m/s). It is linked to dust storms rising; anyway, dust emission by wind erosion is an intermittent phenomenon, which is much more related to the instantaneous wind speed rather than to the average wind speed; it means that a daily dust emission value derived by a daily wind data is to be considered as a very rough estimation. As an example, consider the following situation: a day a constant speed of 7 m/s might have zero emission, if no "spikes" of wind occur. On the contrary, a daily average of 4 m/s with several spikes up to 12-14 m/s could give high emissions (Fratini, 2007).

Table 1 – Summarising main meteorological data about the sub-case study in Alxa League along a longitudinal trend.

Parameters/ Long East	104°	105°	106°	Average values
Annual average temperature	6.7	9.1	8.9	8.2
Maximum daily temperature variation	48.9	48.5	44.1	47.2
Annual average rainfall (mm) (°C)	149.9	160.2	214.6	174.9
Wind speed (daily average) (m/s)	4.49	3.09	2.17	3.3

number of livestock, human population size and area of arable lands) determines the general phenomena of desertification, which is considered as a process of environmental degradation under fragile ecological conditions (Zhu *et al.*, 1993).

In north China, over the past half-century, the human activities did not play the key role in environmental change in this region, even if some authors, as Wang *et al.*, (2006), considered the desertification in the semiarid north China as a product of human activity. Government policies have also accelerated desertification to some extent.

From the late 1950s to the mid-1970s the rate of desertification in north China averaged 1560 km^2/year while was 2100 km^2/year from the mid-1970s to the late 1980s (Wang *et al.*, 2006); in early 1990s it was 2460 km^2 /year (Zhao, 2000). Nevertheless these abovementioned data, the estimates about the area of desertification in China are quite controversial (Yang *et al.*, 2007). Spatial distribution of desertification caused by various activities in China is 30.1% by over-grazing, 26.9% by agricultural cultivation, 32.7% by wood collections and 9.6% by mismanagement of water resources (Yang *et al.,* 2007), and 0.7 by other.

Wind erosion has a significant influence on desertification in semiarid China (Wang *et al.*, 2006) and the aeolian accumulation landforms have been used as one of the main indicators for evaluating the degree of desertification (Yang *et al.*, 2007). Sandy-desertification driven by wind erosion is one of the main types of desertification (Zhao, 2005). There is not an unanimous accord about the origins (sources) of dust and sand storms and about which are the lands more susceptible to aeolian erosion. Even if a general consensus admit that the dune fields do not give rise to the dust and sand storms in China, it is not very clear if dust-sources are located in the areas classified as Gobi-desert [5] or in the degraded grasslands or even in

[5] The traditional desert classification in China distinguishes between Gobi and Tala deserts. The first one occurs in general arid condition. It is characterized by a superficial gravel pavement with different vegetation covers, sometime. Gobi desert can be divided in five ecoregions. The Gobi desert can be also divided into two genetic types: erosional (denudational) and depositional. These can also be subdivided again into denudational rock gobi, denudational- diluvial gravel gobi, erosional-diluvial gravel gobi, diluvial-alluvial gravel gobi, alluvial-diluvial sandy pebble gobi etc. These gobi type and sub-types are distributed in sequential succession (Sung- Chiao, 1986).

abandoned croplands (Fratini *et al.*, 2005). The first landscape typology (Gobi-desert) is situated in not- anthropized area of Western Alxa League and the other one (degraded grasslands) is typical of anthropized area in Eastern Alxa League. The Alxa desert is considered one of the most important sources for both dust storms and Asian atmospheric dust although the exact location of dust sources is not yet known (Fratini, 2007). The northern part of the west Alxa League is the area where dust storms occurs most frequently and for this reason the UNCDD indicated the Alxa League as the first "Focus Area" [6] in the Regional Master Plan For The Prevention And Control Of Dust And Sandstorms, in northeast Asia.

Inner Mongolia territory as a fragile ecosystem

During the past century, arid and semi-arid environmental characteristics have conditioned the main course of economic development in rural areas of Inner Mongolia where approximately 67% or 78 million hectares of total land is classified as rangeland. These rangelands are primarily temperate grasslands that are further classified into one of three general type: the mesic meadow steppe with aboveground biomass of 800-2,700 kg/ha and 28-45 characteristics plant species; the drier typical steppe with aboveground biomass of 500-2,500 kg/ha and 10-40 characteristics plant species; and arid desert steppe with aboveground biomass of 315-1,170 kg/ha and 10-17 characteristics species. The typical steppe is the most prevalent type covering 28 million hectares, and occurs between the desert steppe to west and meadow steppe to the higher elevations in the east (Angerer *et al,* 2008).

For these environmental reasons, the rural system in Inner Mongolia has deviated respect to the main trends that through the modern agrarian history in the rest of China. Nomadic pastoralism can in fact be considered a result of adaptation process to the ecological conditions of arid pasturelands or rangelands. It was mainly based on seasonality of pastureland where the main restrain is represented by the water availability. In the past, as result of this adaptation process, the human density on the pastureland was socially controlled with a density of 1-2 people/km^2 or 0.9 – 0.2 people/km^2 in the very arid steppes (Krader, 1955). About Asian Central grazing-land carrying capacity in XIX-XX centuries, some authors report a value of 1,8 animals/km^2 with an animals/man ratio that ranges from 3.5:1 to 16:1 (Krader, 1955). Usually, human growth of nomadic people was followed by an increase of herds, and as consequence, the rate of grazed-land per each family increased.

In the 1949, the Chinese Government took administrative control of the Inner Mongolia. It changed the livestock management and land use patterns, improved the

[6] Each focus area was representative of grassland ecozone and the Alxa League represented the desert grassland bio-geographical formation.

immigration of Han Chinese people and it mandated grazing mixed with cropping land use (Christensen, *et al.*, 2005; Sneath., 2000). Then, in consequences of the Household Registration System, established in 1955, most Mongolian families remained in the rural areas as herders. The internal immigration together with the natural increase of the Mongolian population had determined the expansion of herds and the consequent enhance of antrophic pressure more over the natural resources available (Neupert, 1999).

Between 1947 and 2003 the number of livestock head in Inner Mongolia raised from 8.4 to 71.1 million (Mayer, 2006) and particularly concerned the number of sheeps and goats. Inner Mongolia administration considered the pastureland of the region to be saturated, and this overstocking has been the cause of widespread grassland degradation (Sneath, 2000). The rangelands have been steadily deteriorating at rate of approximately 2% of the land area annually (Angerer *et al,* 2008).

The number of animals in Inner Mongolia exceeded not only the traditional stocking rates but also the sustainable level (Neupert, 1999). Anyway, the today's degradation of Inner Mongolia grasslands can not be simply assumed to be caused by the high number of animals. In a long temporal scale, the change in herd management seams to be the main problem of the region. Although statistics on the extent of degradation vary, it is generally estimated that productivity in the region has decreased by at least 30% in recent years. Part of the overgrazing problem has been attributed to a shift away from the historical nomadic livestock grazing practises to a more sedentary system since the mid-20th century as a result of several major policy shift by the central Chinese government (Angerer *et al,* 2008).

In the last century, a large amount of grassland was also damaged by the failed attempts to cultivate it during the Great Leap Forward (GLF) (1958-1962) and during the Cultural Revolution periods (Sneath, 2000).

A major human population increase occurred in the 19th and early 20th centuries when Han Chinese moved into the more humid eastern areas of Inner Mongolia to expand crop cultivation (Brogaard & Li, 2005). Over the past 50 years, the human population has continued to increase (Brogaard & Xueyong, 2002), and during the same five decades the rangeland productivity has declined 50-70%, 30-40%, and 50% in the meadow steppe, typical steppe, and desert steppe grassland areas, respectively (Angerer *et al,* 2008).

Brogaard *et al*. (2002) reported also that some farmers of east Inner Mongolia stressed that the livestock is not the triggering factor of grassland deterioration, but rather cultivation. Han's agricultural colonization caused in fact the topsoil degradation in steppes and desert-grassland of the Mongolian Plateau because of their traditional agronomic practises based in deep plough and vegetation cover uprooting. These techniques were indubitably well adapted to different rainfall regimes in the central Plain of China, where Han people lived.

In the Mongolian arid steppes, rainfall ranges from 140-350 mm (Yu *et al.*, 2004) per year and the sandy top soil of sandy grasslands is exposed to strong winds, in particular during spring and autumn. Thus, the old deeply ploughed soil is nowadays eroded by the wind that starts the sandy desertification process and sandy dunes formation. The dunes can cover up to eight times the area of the grasslands destroyed by blowouts (Zhang *et al.*, 2007). The recovery of the damaged surface soil layer and its structure is very slow and soil organic materials are extremely low. As a parallel phenomenon, authors as Angerer *et al.* (2008) have outlined that there have been significant shift in species composition as a percentage of perennial grasses and legumes have decreased with a concomitant increase in weedy species.

Uncultivated grasslands are able to recover quickly once the damaging elements are eliminated. By contrast, the formerly cultivated soil layer is especially vulnerable to wind erosion. This is because once the surface soil layer of sandy grassland has been totally broken, by deep ploughing, the loose sand underneath is exposed to wind erosion. Once this starts and underlying sand comes to surface, it can develop rather quickly into a blowout that can measure up to 190 m long, 90 m wide and 12 m deep. Blowout dunes on the leeward side develop simultaneously. These can measure up to 700 m long, 300 m wide, and 5 m thick in its central part (Zhang *et al.* 2007). Damage to the top soil layer occurs frequently from uncontrolled traffic and by sand drift from mobile dunes formed in recent decades.

Grassland ecosystem constitutes an ecological barrier against wind erosion and desertification. Conversion of grassland to cropland, totally destroys the grassland ecosystem's function (Zhang *et al.*, 2007). A recent work, Zhi-Ping *et al.* (2007) have outlined how the conversion of grasslands to croplands induced a slight loss of soil

Figure 2 – Desert steppe in Inner Mongolia with evident sandy top soil and its thin herbaceous cover (Orioli, 2007).

Figure 3 – In very arid climate condition we have phenomena of salt efflorescence on top soil in Inner Mongolia site (Orioli, 2007).

organic carbon (1.36 kg C m^{-2}), in the 0-100 cm soil depth over about a 35-year period in the temperate Inner Mongolia, and how moderate grazing can be used to increase soil organic carbon stock in the grasslands. However, the effects of grazing management on soil organic carbon sequestration have not been sufficiently evaluated in the grasslands of Inner Mongolia (Zhi-Ping *et al.*, 2007). In photo 1 and 2 are showed two landscape types of Inner Mongolia.

For the pedological proprieties of the study area we refer to 4 soil samples collected 20 cm depth that were extracted in 2006 and analyzed at the Yinchuan Soil Fertilizer Testing Centre. Sand prevails in the soil texture. The average fine sand is about 55 % as showed in picture 1. Gravels (> 2 mm) are not present. Clay fraction is about 10%; pH is around 8.5 and total salt content is around 1.54 g/kg. It is well know that this value is typical of the alkaline soils (Bonciarelli, 1989).

The sodium content expressed as Exchangeable Sodium Percentage (E.S.P.) is 66.5 %; this value is very high and if it is associated to high pH value it determines bad physical soil condition, not well adapted to be cultivated. In table 2 we summarize the other exchangeable cation values. The main of C.E.C. is around 2.4 mc (+)/kg that is meaning low exchangeable capacity of soil complex, due both to low organic matter (average 0,43 %) and clay fraction content. Total nitrogen content, which is linked to organic matter content, is consequently very low (0.28 g/kg); also, total phosphorous is very low (0.28 g/kg). Low phosphorous soil content together with the low K content is a huge limiting factor for the crop growth. In Inner Mongolia fertilizer is dominantly N based, ($60.5 * 10^4$ t on the 2005), while K fertilizer use is unusual ($9.2 * 10^4$ t on the 2005).

CATION	EXCHANGEABLE VALUE	LEVEL
Sodium	66.5 %	very high
Calcium	19.3 %	Low
Potassium	7.0 %	High
Magnesium	7.3 %	Moderate

Table 2 – Exchangeable cation value of soil stratum (20 cm depth) in Jalantai area (Yinchuan Soil Fertilizer Testing Centre, 2006).

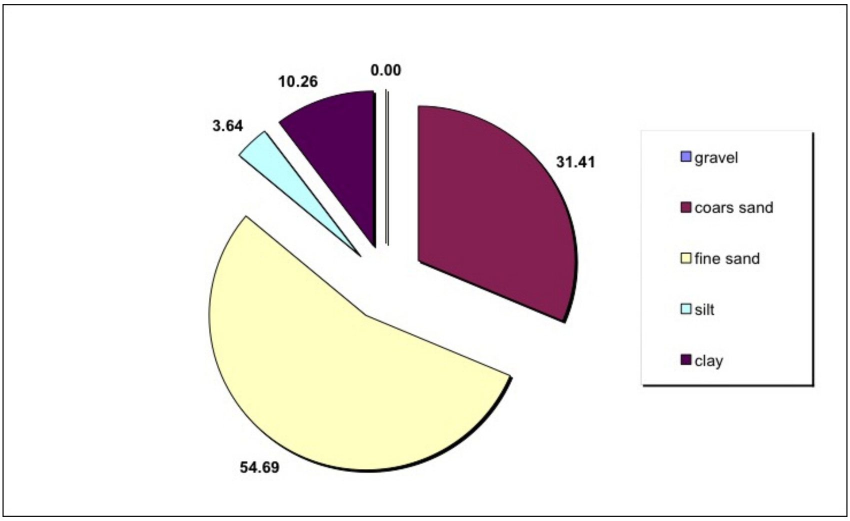

Figure 4 - Soil texture of soil sample, extract in Jalantai area on a farmland (Yinchuan Soil Fertilizer Testing Center, 2006).(Modified from Da Canal, 2007)

Material and Methods. The Socio-economic survey

It is well known that the historical Chinese farm household economic model can not be assimilated to the coeval European rural model because of its economic exchange system based on the standard marketing area (Giura Longo, 1998; Skinner, 1964) [7]. The development of standard marketing area was different between southern and northern of China (Giura Longo, 1998). This traditional economic system in rural China lasted up to the XIX century, when the *Treaty Ports* (1842) happened. Up to 1930 agricultural production and prices grown even if the agricultural sector was characterised by a prevailing subsistence economy. Only after 1950, there was an economic recovery of agricultural production. Small peasant proprieties characterized

[7] Skinner coined the term "standard" such as that type of rural market which met all the normal trade needs of the peasant household: what the household produced but did not consume was normally sold there, and what it consumed but did not produce was normally bought there. The standard market provided for the exchange of goods produced within the market's dependent area (Skinner, 1964).

Table 3 - Schematic description of little farmer production in Chine from -1949 up to 1978.

Small Peasant Proprieties	Before 1949	1949-1978	After 1978
Household Labour	Dominant	Present	Dominant
Labour Market	Present	Absent	Present
Market-oriented Production	Dominant	Present	Dominant
Long-range trade	Present	Absent	Dominant
Land Market	Dominant	Absent	Present
Means of production owned	Dominant	Present	Dominant
Capitalistic accumulation	Absent	Absent	Present

This scheme has been modified and elaborated from Giura Longo (1998).

the main land tenure system in northern China, because of low fertility of soils and lower development of road network (Giura Longo, 1998).

To set the agricultural activity referred to our case study in a historical background it is important and necessary to understand its present dynamic.

Briefly, the Chinese agrarian history is divided in three main phases: the period before 1949; all long the Maoist period (1949-1978) and after the 1978 in the post-collectivist period. During all these periods, the economy was based on household production, short-range trade and small land properties; it suffered different alterations, caused by external influences and governmental rural policies. In Table 3 we attempt to summarize this evolution of Chinese rural economic system.

The persistence of farm household activities in rural China could be explained by the natural resources shortage in face to the high demographic growth. Land arable shortage in China is a very old phenomenon and agronomic techniques and practises intensified the agricultural activities during the centuries. High agriculture productivity combined with an high manpower availability have historically influenced the chinese agricultural development based on the small peasant propriety. The failure of the Maostic rural communes (People's Communes) seems to confirm the persistence of small peasant propriety in rural China and its adequacy to social-environmental condition of this immense territory (Giura Longo, 1998). With the post-Mao "pragmatic" period, at the beginning in 1978, attention shifted to de-collectivization socio-economic phase; moreover, with the Household Production Responsibility System (HPRS), agricultural lands was parcelled out to every family based on family size and labour availability and a move was started to a market-oriented economy (Brogaard & Li, 2005).

In Inner Mongolia, the land was confiscated and distributed to farmers and herders from 1947 to 1948 and livestock were either handed over to the herders' families or the wages of the herders were raised. Cooperatives were established in 1953, and in

1958 all the cooperatives became communes. Land previously distributed among farmers and herders returned to the communes (Brogaard *et.al.,* 2002); with the Great Leap Forward (1958-60) and during the following two decades, the agrarian policy was to expand cultivation into grazing-lands. Some authors state that the conversion of grassland to cropland totally destroys the grassland ecosystem's function (Brogaard & Li, 2005); other ones, instead, think that in the Inner Mongolia, considered as a whole, limited area brought into cultivation has been small and, therefore, crop-farming has not had an overall degradation effect as significant as the increases in animal densities (Neupert, 1999). Some other authors have argued that land degradation is not a simple outcome of land use intensification and mismanagement; it is an outcome of the combination of land use intensification and biophysical dimensions such as soil properties, rainfall variability and global warming (Christensen, *et al.*, 2005). It is important to recognise that the potential for vegetation shifts in grassland with climate change can lead to permanent and sudden ecological change with little forewarning (Christensen, *et al.*, 2005).

Even if the HPRS reform has greatly improved agricultural production efficiency in the early years, high labour/land ratio (a fundamental feature of Chinese agriculture) has consequently given rise to minute operational scales. In addition, household's land parcels were further fragmented in the HPRS distribution process to take account of differences in land quality (such as soil conditions and irrigation) and the distance of farm plots. A second problem with the HPRS has been a lack of long-term investment in land (Wu *et al*., 2005). In the IM the cropland was first contracted to families on the 1979 or early 1980s (Brogaard *et.al.,* 2002). From 1997, a 30-year contract on cropland was introduced and families have nowadays inheritance rights to the land (Brogaard & Li, 2005).

Interviews with farmers in villages in the Jalantai area were carried out during spring-summer 2005 in cooperation with Alxa-SEE Ecological Association . These activities has been part of "WINDUST" Project. The Jalantai area is 80.412 km^2 wide and the rural population living in that area has been calculated in 6053 people. Moreover, if we consider that the average demographic dimension of rural communities is around 10 peasants, we have esteemed 600-800 people living into economic survey area in the study area (Da Canal & Ding Janqi, *pers. comm.*, 2008, University of Tuscia).

On field, activities was organized following a non-structured interview approach where the duration of interview was calibrated on the characteristics of the single interviewees and the main aim was to comply with cultural prospectives of subject

[8] Alxa SEE Ecological Association (SEE), founded on June 5, 2004, is an environmental protection organization sponsored and initiated by some 100 well-known entrepreneurs. SEE is a non-profit, environmental, membership NGO for public interests (www.chinacsrmap.org).

interviewed. It is characteristic of qualitative interviews do not use a representative sampling from statistical population of interviewees but to cover all possible social situations that can came out from a particularly social context. Thus, the statistical sampling representativeness of interviewees' population is not a priority in the qualitative social methodology research (Corbetta, 1999). That consented to organize a high flexible interview-plan. In the same time, in the interviews executed in co-operation with Alxa-SEE Ecological Association members, the Chinese counterpart refereed to a interviews-protocol that was used in rural areas by Red Soldiers during the Great Leap Forward (Da Canal, *pers. comm.*, 2008, University of Tuscia). It seems that it was based following a participative approach where the interviewers spend some days in the villages or close to households. The main questions are usually related to: family composition; family history before present day; breeding and agricultural activities and household production (Table 4).

People interviewed above all belong to Han ethnic group. In general, they immigrated here from Hoasibuer, or from Gansu Province. Historically, from 1949 to 1976, the Chinese government sponsored internal migration of Han people; this migration in fact served as an integral part of the Communist project of 'civilizing' the ethnic minorities. Large-scale Chinese migration into Inner Mongolia took place in these main patterns: sending Han specialists to positions in administration, education, commerce, and in industry, forestry and mining enterprises; transferring the whole of medium and small enterprises with their staff and workers from the interior; mobilizing Han peasants from the interior to go to Inner Mongolia for land

Table 4 - Resuming main questions and answers of interviews plan.

MAIN QUESTIONS OF INTERVIEWS	MAIN EXAMPLE OF ANSWERS
What are the main income sources?	*- Breeding* *- I can prepare forage for herds*
What skill do you have got in breeding experience?	- *I well know my herds and I use traditional breeding methods* - *To give my labour*
What do you now need? What your work is missing?	- *Increase my forage resource* - *Feeding techniques for breed* - *I need someone able to teach me new breeding techniques* - *To built up a fence to keep herds* - *I need money and a project* - *Good improved animals such as sheeps*

reclamation; placing spontaneous Han migrants under government administration [9] (Pan, 2006).

During the inquiry period seven heads family was interviewed. Their families are nuclear (Table 5). They are living in Yudamogacha, in the Silingaole locality of Alxa Zouqui (Alxa Left Banner). 199 people on 56 households built up local inhabitants that are each other in different ways related to. This aspect is correlated both to exogamic/endogamic ratio [10] into the household structure and solidarity identity sometime expressed as:

"*We are one only group, we have the same roots*".

During the 70s, some of this people lived on only cattle-breeding activities together to autochthonous Mongolian residents in Talatu area; later, they migrated in this area as consequence of pastureland degradation and the governmental incentives. The agriculture will result the only possible economic activities into closed farmsteads. In the others cases, during the 80s, some farmers came here because of land shortage (1 mu per farmer) [11] in their original lands.

It was hard to set in these lands at the beginning (1985) for the ex-herder people that in general, from a cultural point of view, can be referred to social agrarian group (Zhang, 2007). Someone said that he had found here a very arid bad soil, hard to cultivate wheat and with only 75 yuan per each one [12]. Peasants come from elsewhere obtained about 5 mu for each one of farm land. They become to farm the same crop of resident peasants and to breed domestic animals, but without good agricultural techniques. People without agricultural experience imitated other farmers or more enterprising people to attempt new crop on their land. A farmer said:

"*Before the 2000, we was only five-six families that breed cattle, but in small quantity. Later, when cattle grown up all people understood that to breed is good! In the same way we begun to grow chili because earn was favourable* "

[9] Large scale Han migration began towards the end of the XIX century, and especially after 1902, when the Qing government lifted the ban on the migration of Han farmers to Mongolia. During the Republic era (1912 – 1949) Han immigration continued. From 1912 to 1949, the Han population in IM increased from 1.5 million to 5.2 million. Under the PRC, the government policy in effect continued the colonization of IM. The number of Han population increased to 16 million in 1982. The percentage of the Mongols decreased in contrast to the Han population. In 1953 in a population of 6.1 millions, the ratio of Han to Mongol was 5.8 to 1; by 1982 the ratio was 6.5 to 1 in a population of 19 million.

[10] The demographic parameter S/N (S as number of family names and N as number of people) (Girotti *et al.* 2006) could be usefully employed to calculate exogamic/endogamic degree in rural community of Inner Mongolia. In our survey, S/N is 18/199.

[11] 1 mu = 0.067 hectare

[12] 1 yuan = 0.0944 euros (data on the March 2008).

Table 5 – Family composition of local population sampling.

FAMILIES	HEAD FAMILY	WIFE	DAUGHTER	SON	MARRIED D.	MARRIED S.	OLD PARENTS
1	x	x		1	1		
2	x	x	1	1			
3	x	x		1			
4	x	x					2
5	x	x	1	1			
6	x	x	1	1			
7	x	x	1	1			

Farmlands have been wheat, maize, sunflower, watermelon, chili growing on it. Soil fertility and water requirement are the main constraints to agricultural development in this sub-case study. Water drawdown and high evaporation rate cause superficial salt crust formation that might stop ploughing and other cultivation and practises.

From the responses to questionnaires results that more than 50% of annual household income came from agriculture activities. Consequently, the agricultural expenditures represent from 1/3 to ½ of the total family monetary outputs. The main costs are related to water requirement and electrical energy [13]. Some agricultural inputs as seeds represent only 1/5 of family total costs estimated in 350 yuan/mu. In the other sites of eastern Inner Mongolia, as reported in (Brogaard *et al.*, 2005), the combined costs of fertilizers, seeds and pesticides normally constitute the second largest expense for families (assuming that school fees are also paid by the family) and have lately been increasing mainly due to rising fertilizer prices. The fraction of the total income spent on food was on average one third but varied from about 10 % for a wealthy family up to 100% for a poor family. In general, the crop choice falls onto these that have a certain demand on local market and that guarantee steady incomes. In other cases, the prices per kg of the grain to some degree influences the type of crop that a family chose to cultivate, but as the variations are not very large, climatic conditions are more crucial for the choice of crop (Brogaard *et al.*, 2005).

We have ascertained a contrast amongst water exigent crops use such as maize, watermelon and pepper that give high incomes, and low water exigent crops use such as wheat, that gives low incomes. In this sense, public water availability from wells supply represents a serious constraint. Local market selling of crops there is not a big problem for local peasants and in particular for maize which is sold to herders for feeding. Main dangers for household economy come from water overuse and waste

[13] The unitary cost for electric energy was variable, for example from 0.39 to 0.32 yuan/kWh or 150 yuan / mu.

and from non-consciousnesses to environmental problems and tendency of local market demand.

At the beginning, first attempts to cultivation lands from immigrated people was set up a crop rotation system between wheat and maize, following a 1/9 ratio upon the same piece of land. Not all people make up this crop rotation.

The interviews point out that average maize yield is around 39 t/household/year and the land cultivated by maize is 2.9 ha/household; yields per hectare are around 1270 – 1350 kg (850-900 kg/mu).

At the household level production, if we consider price variation of maize and its average yield we have ascertained that average income from maize sale is around 47.6 % of total household income. Part of maize production is doomed to auto-consumption. It is used for both human and feeding. Water consumption is due to irrigation time per year: from 420 to 720 minutes per irrigated land (expressed in mu).

It could be useful to make now a comparison amongst crop productions in China. We can ascertain how the abovementioned yields data are higher respect to other one carried out from other rural sites in Inner Mongolia, where the farmers reported both 2250 -3000 kg/ha (150–200 kg/mu) of harvest of maize in a bad year and 4500 -6000 kg/ha (300– 400 kg/mu) in a good year (Brogaard *et.al.,* 2002).

To contextualize the local crop yield data, could be also interesting to refer to maize production that has increased in last years. This increase is partially attributed to the increase in the total area of maize up, from 53 to 58% of the total grain area, between 1979 and 1996 (Brogaard & Li, 2005). Percentage of maize planting area from the national level on the 2006 was 6.9 % in Inner Mongolia and its yield was 5900 kg /ha (www.ppi-ppic.org).

Household yields of wheat range from 8,900-9,000 kg/ha up to 14,900 kg/ha. In Inner Mongolia the harvest of the 2007 spring wheat crop (the minor wheat crop) was completed in August and output was estimated at some 5 million tonnes, 830,000 tonnes below that of last year as a result of droughts in two major producing provinces (FAO, 2007). [14] The main constraint to wheat growth is due to dust storms and strong winds. Part of wheat (14.7% of total yield) is doomed to family uses. Average farmland has wheat growing on it is around 13,4 ha per household. Sunflower is another crop considerate as catch crop. Watermelon, chili and pepper are the main cash crops cultivated by local people. These crops are water exigent: 400-500 minutes/year of irrigation for watermelon and 780 minutes/year of irrigation for pepper [15]; yields are

[14] www.fao.org

[15] To quantify water consumption has been hard. It has been calculated as number of irrigation turns or watering length. Energy consumption is a indirect estimate of water consumption.

around 52,220 kg /ha up to 104,440 kg/ha, respectively. Difficulties to grow watermelon can be expressed from these sentences of local farmers:

"*Lately many watermelon crops are failed in June. We do not which are the reasons, may be the soil types. That do not depend on seed quality. When the climate is dry watermelons grow well!* "

Breeding represent the second main household economic activity, even if the absolute number of animals per household (cattle, sheep, goats and horses) is however low. Pastureland free breeding knowledges are spread locally and many people were herders before their move into sub-case study area. They was obligated to reduce the number of animals and to keep them into fencing. Stalling of domestic animals is not usual for this Han people and they know only traditional techniques. Lack of knowledges on feeding is dept and farmer would like to know more about it. Usually they feed animals with wheat or maize. An important exigent coming out from farmers concern crossbreeds techniques to obtain better sheep race. Thus, the main restrain to improve breeding is due to ignorance on both feeding and breeding techniques, in the case of permanent housing.

In any case, the nomadic system for livestock management is the most adapted way to live in the desert, typically. Anyway, following the climate change and the increase of population, the breeding in housing became more attractive. The fodder production as secondary products of agricultural fields is a common practice in the Ordos Plateau. Fodder costs breeding can be very high. The number of animals is restraint to system stalling. Mainly goats are breed to sell meat and wool (about 10 heads/household).

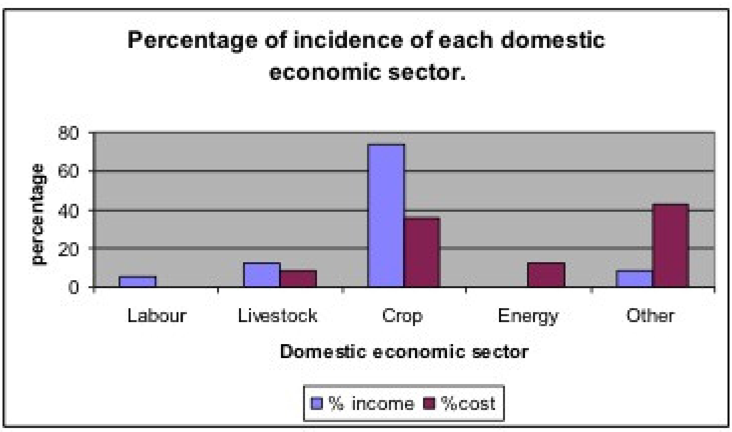

Figure 5 - Household budget in Jalantai sub-case study.

Finally, the Figure 5 shows household budget where main incomes come from crops growing more than 70% while costs are due to not agricultural expenditures or energy consumption lies to water requirement. Cash crops such as watermelon, pepper or chili represent main incomes respect cereal eves if their unitary price is highest (0.5 yuan/kg) than other cash crops (0.26 yuan/kg). That maybe depends on high local demand in neighbouring markets. Maize and wheat are kept for auto-consumption. Agricultural earning out of household is less represented.

In eastern Inner Mongolia, an example of a good household income for an agro-pastoral family in the year 2004 is as follows: 10,000 yuan income from grain production, 15,000 yuan from beef production and 5,000 yuan from mutton production. The main expense for this family is a 10,000 yuan in school fees for two children, while the second large expense is related to fertilizer, seeds and pesticides, estimated to 5,500 Yuan per year. A more average income family with irrigated crop land estimates their total income to 10,000 yuan; 2,000 from chili pepper, 3,000 from maize and 5,000 through slaughtered livestock. (Brogaard *et al.*, 2005).

Results: agronomic evaluation and adaptation strategies in agriculture

Even if wheat crops can tolerate a certain soil alkalinity and salinity its optimal pH growth condition is around the neutrality (6.5-7.8); on sandy soils wheat yields are generally scarce. Late –winter or first spring sowing could meet strong winds such as sand storms on the April, when wind speed can reach 30 m/s (Da Canal, *pers. comm.*, 2007). These hot winds cause yield loss during the wheat maturity phase. Soil proprieties (soil texture, O.M., C.E.C and E.S.P) in sub-case study area are thus not well adapt to wheat cultivation. Maize crops generally grow on well drained soil and their water requirement is higher that wheat. From information gathered locally, traditional water use per each irrigation has been estimated to 200-250 m^3/ha. This value is however low respect water requirement in arid areas, generally. Farmer of Jalantai area reported 8-9 irrigations per year or 560- 810 minutes of irrigation per year for maize, while for wheat some farmer stated:

"*I have three mu of wheat and I water them six times per year*".

Really, water consumption is proportional to water use costs from wells pumping. These costs weigh upon household agricultural budget. Italian Co-operation experience in Alxa League focused on household energy and water saving by introducing appropriate technologies, where water for crops is set to solar cycle and a gravity tank allows the necessary head. The rationale of this system is based on calibration between plant water requirement and energy use without fuel consumption. A deep explanation of this experience is reported in Fratini *et al.* (2005).

To simulate crop production about wheat and maize we have used *CropSyst*, a crop growth simulation model. Daily meteorological data set come out from five stations which localization is showed in Figure 1 (104.50° E and 40.75 N; 106.38 E and 41.45 N; 105.75 E and 39.78; 107.40 E and 40.76; 106.21 E and 38.48 N). *CropSyst* simulates the soil water budget, soil plant nitrogen budget, crop phenology, canopy and root growth, biomass production, crop yield, residue production and decomposition, soil erosion by water, and salinity. These processes are affected by weather, soil characteristics, crop characteristics, and cropping system management options including crop rotation, cultivar selection, irrigation, nitrogen fertilization, soil and irrigation (Stockle et *al*., 2003). In our simulation we have introduced data that are next to farming technological level present in the case study area, assuming similar fertilization and irrigation practises and labour. We have also taken in account the irrigation management information as reported in Li *et al*. (2003).

If *Cropsyst* ascribes essentially meteorological condition on crop yield output level, we have infer that the difference amongst local crop yields and statistical data at sub-national level (Inner Mongolia) is due to a supposed technological gap; when instead yield trend between crop yields at national (China) and sub-national level is similar as showed in the Figure 6, in this case for wheat. Figure 6 shows in fact similar growing trend of wheat production between China as whole and Inner Mongolia during 1979-2005 period. Data series are from FAO and USDA, respectively. Here the implicit correlation is high (R^2 = 0.83). In the Figure 7a and 7b we report wheat and maize yields, respectively, both for local (simulated data) and sub-national level (statistical data). The correlation amongst these data is not significant as for wheat (R^2 = 0.02) as for maize (R^2 = 0.11). Highest correlation can be as much achieved when we compare sub-national yield data against adjusted simulated yield data: in the case of maize, the correlation is as significant (R^2 = 0.38) as for wheat (R^2 = 0.44) (Figure 8a and 8b). We have thus adjusted simulated crop yields to technological progress that has supported grain national product. To explain this fact we have to outline how with the 1978 political reforms in China, grain output per head rose again respect to the past decades and reached a peak in 1985, after which stagnation seems to have prevailed. The years 1980–1984 were a period of rapid increase in total grain production in China, subsequently from 1984 to 1989 grain production fluctuated below the 1984 peak. In Inner Mongolia, a real boom in production occurred later (Brogaard & Li, 2005). During the 1990s, China has been a net grain exporter in some years and a net grain importer in other years (Johnson, 2000). In addition, since 1999, after several years of decline in food crop yields in the country as a whole, food security emerged as a major national issue and led to a new national policy in promoting grain production in 2004. (Xiu *et al*., 2007).

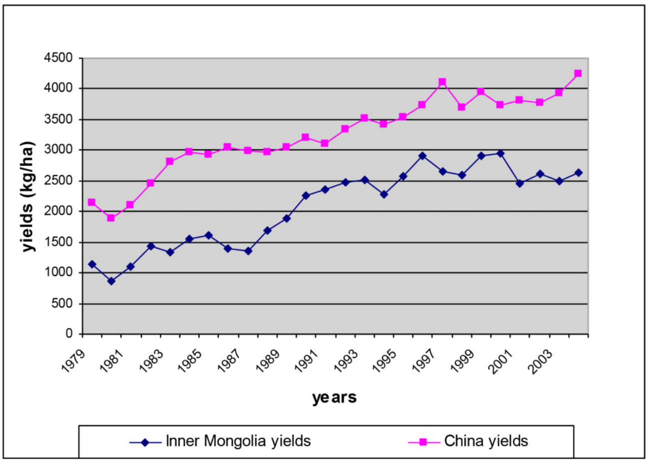

Figure 6 – *Historical series (1979-2005) for wheat yield at national (China) and sub-national level (Inner Mongolia).*
Data elaborated from FAO and USDA data set.

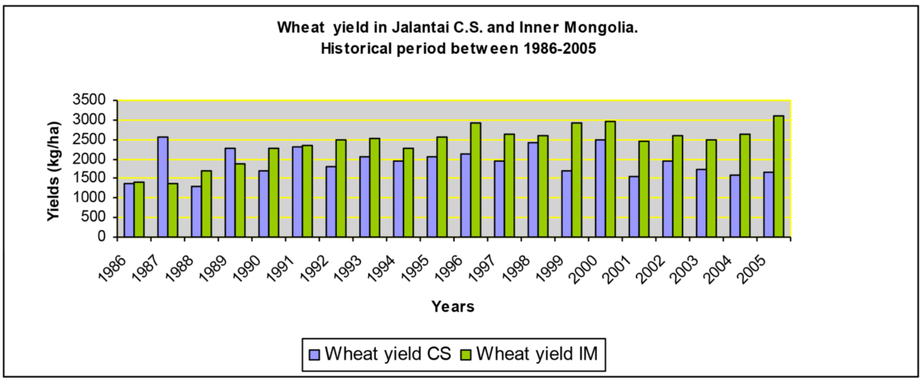

Figure 7a

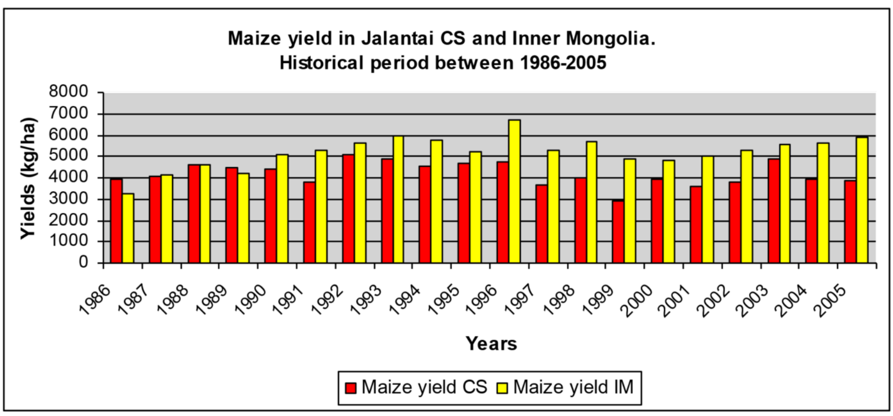

Figure 7b

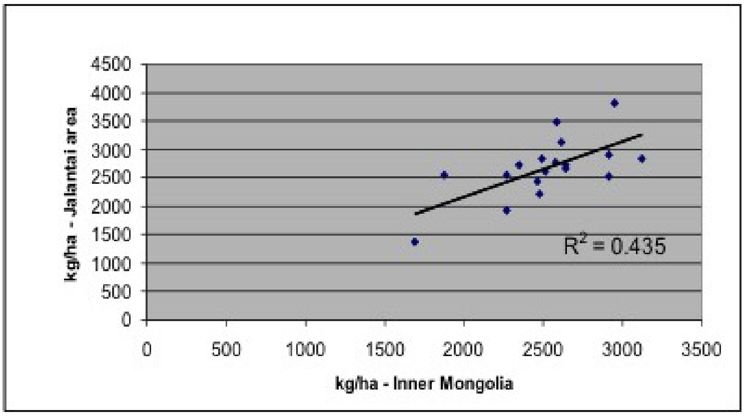

Figure 8a - *Wheat adjust-yields to technological improvement. Correlation between local and sub-national levels. Data from 1988 to 2005.*

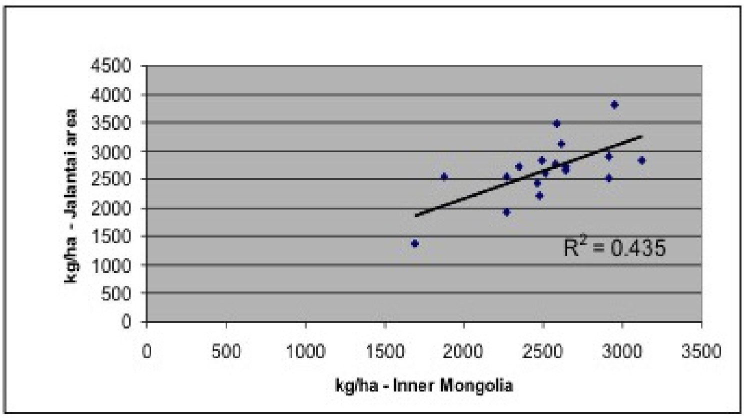

Figure 8b - *Maize adjust-yields to technological improvement. Correlation between local and sub-national levels. Data from 1988 to 2005.*

If technological improvement to production has represented in the last years an important aspect to agricultural progress in China, we have to consider now as this increases will cope with future climatic change trends. Generally, it can be seen that the temperature in northeast China, north China and northwest China would increase while the precipitation would decrease (Yue *et al.*, 2007).

At the national level (China), based on PRECIS climatic model, with regard to baseline simulation (1961-1990), future (2010-19; 2040-49; 2070-79) temperature increase for IPCC A2 Scenario (medium -high emissions) will probably be around 2.33 °C per decade, while precipitation will increase from 3.3% (2010-19) to 12.9 % (2070-79) (Yue *et al.*, 2007).

In consequences, adaptation strategies in agriculture will cope with these changes and in the same time, it is clear how climate changes have taken mixed effect on agriculture in different regions of China. We know, for example, how climate warming over the past two decades has caused in northeast China winter wheat plantation shift northward and westward. Certain varieties of maize that have a relatively long growth period and high yield have been grown more widely in north-east China, resulting in increased output. Again, in the last two decades, pasturelands in Inner Mongolia have enjoyed an increasingly warming climate, with a noticeable increase of temperature in winters. In the meantime, spring droughts have become increasingly frequent in occurrence, with more episodes of sand and dust storms (Yue *et al.*, 2007).

During the 1980s, farmers in North China, systematically begun to plant winter wheat instead of spring wheat, in order to raise yields and improve the wheat-flour quality. This change led the northern boundary of areas with winter wheat to move further north and west. In the southern part of northeast China, two-crop per year systems replaced one-crop systems with the result of again higher crop yields. New varieties were adopted and the timing of crop maturity changed from early to mid and late maturity. (Xiu *et al.*, 2007).

According to the current planting management approaches in north China, the temperature increase of 1-4 °C will cause additional water requirement of 2.6 - 28.2% for winter wheat and 1.7 - 18.1% for summer maize that will make current water shortage situation more worse (Yue *et al.*, 2007).

Adaptation to climate change is crucial for China due to its huge population and diverse ecosystems (Xiu *et al.*, 2007). It can delay or reduce impacts of climate change on agriculture through practices such as: crop rotation; improved irrigation and water-saving technologies; selection of planted crops based on changed climate and prices; adoption of heat-resistant crops and water-efficient cultivars (Yue L. *et al.*, 2007).

About our work, at the local level, we can specify how shifting sowing data to not meet drought events (spring dust storms) or to meet late spring/ first summer rains can represent simple adaptive agricultural strategies for the peasants [16]. More exigent needs to implement this strategies instead come from structural aspects of local agrarian economy such as: introduction drought-resistant cereal varieties; new breeding techniques for permanent housing; establishing water saving systems; preventing and managing desertification and promoting regional social and economic sustainable development. Conscious that dedicated financial support to reduce adverse climate change impacts is very rare at the present in China, (Xiu *et al.*, 2007) it has been highlighted, from the interviews, how a rural credit system is necessary to support and drive private enterprises from small farmers.

An example of valorisation of local resources came from Sino -Italian co-operation experience. Saving water irrigation system was applied to typical plant species of arid

[16] In eastern part of Inner Mongolia, a main adaptation strategy for farmers engaged in rain fed farming if the spring is dry is to shift the crop sown from corn to sorghum, millet, or sunflower. If the spring rains are still not enough the land is left without any crop (Brogaard *et al.*, 2005).

environment such as saxoul (*Holoxylon ammodendron*) and the *Cistanche salsa* [17], which is potentially important from an economical point of view. Saxoul plantation represents an economic and ecological favourable alternative to conserver desert and semi-desert ecosystem. In this sense, at the University of Tuscia, Italy, has been carried out a micro-propagation *in vitro* program on *Haloxylon ammodendron*, how possibility to extent its cultivation in Alxa League (Fratini, 2005) (photo 5). In the same co-operation program an other adaptive strategy regarded the introduction of plant forage species such as *Sorghum sudanensis, Trifolium repens, Festuca ovina, Festuca arundinacea, Dactylis glomerata* that can represent a valid alternative to natural grassland (Fratini, 2005).

Summarizing the ADAM project outcomes in the Inner Mongolia Alxa league, we show in the table 5 the main impact of climate change and drivers of adaptation and mitigation strategies.

Table 6 – Synoptic table about the climate trend, adaptation and mitigation (source: Tabara et al.*, 2008).*

Region	Climate Change		Adaptation domain		Mitigation domain	
	Recent trends and signals	Main impacts	Some responses	Triggers and driving forces	Some responses	Triggers and driving forces
Alxa League, Inner Mongolia, China	Increased temperature: about 1°C from 1970s to 1990s. Increased aridification (desertification). General environmental deterioration and biodiversity loss.	Reduced agriculture and livestock productivity and water availability. Impact on human settlements leading to migration.	Desert enclosure and fencing changes in livestock; State organized ecological emigration; conversion of farmland into forestland or grassland; aerial seeding and artificial precipitation; reforestation to stop the expansion of the desert.	Sand storms and increased water stress. Political reorganization. Institution changes regarding land ownership regimes. Poverty alleviation policies linked to new development opportunities elsewhere. New scientific findings and concepts now to informing local and regional policies. Opportunity for international cooperation in the form of research and development projects. Increased participation of local and private agents.	Still not developed at the regional level, but huge potential within the coal power generation and electricity sector.	New opportunity and potential for large international investments: e.g. in Carbon Capture and Storage (CCS) and Integrated Gasification Combined Cycle (IGCC) technologies. Increased participation of local and private agents. Increasing role of transnational epistemic communities.

[17] *Cistanche salsa* is a perennial fleshy herbaceous autoecious plant that parasitizeson the root of saxoul (ADAM Project, 2007).

Figure 9 – Saxoul plantation in experimental field in Jalantai area. (Da Canal, 2006).

Discussion and Conclusions

Modernization processes applied on traditional Inner Mongolian rural society during the collectivist phase (1952-59) imposed remarkable modifications in its nomadic organization. Pre-revolutionary society was based on an "fluid residential form" (Sneath., 2000), that latter underwent a sedentarization process with the establishment of semi-permanent structure of households life (Sneath, 2000). With the introduction of the Household Production Responsibility System (1978) a corporate family ownership was asserted; here the household as a whole managed the propriety. Historically, the *baogan daohu* system (HPRS reform) meant thus a return to farm household economic model as a bottom-up modernization processes in the rural life (Giura Longo, 1993).

The main impact of agricultural reforms on herder system happened in particular during 1987-1996 period. The collectivization impact has not changed in depth the domestic structure of rural households (Sneath, 2000) and for this reason could be still possible to hypothesize small peasant proprieties permanence in Inner Mongolia following hypothesis research carried out by Giura Longo (1998).

The interviews made during this work attempt that the family structure observed in Jalantai area is conceived in the same way that the small peasant proprieties above-mentioned. Practically, principal adaptation processes have begun with the agricultural reform in China since the early 1980s (Xiu *et al.*, 2007).

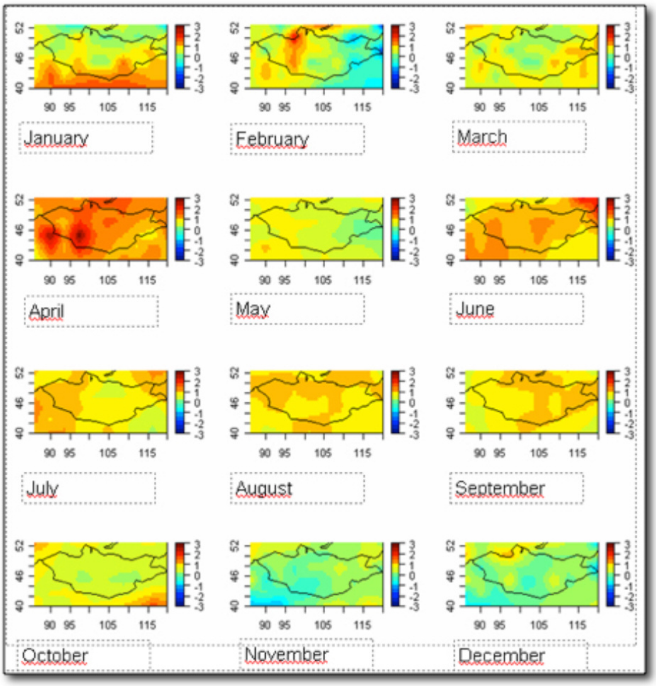

Figure 10 - Relative variation of monthly temperature on Mongolian Region with regard to SRES A2 scenario. Baseline period: 1975 –2005; future period: 2066- 2099.

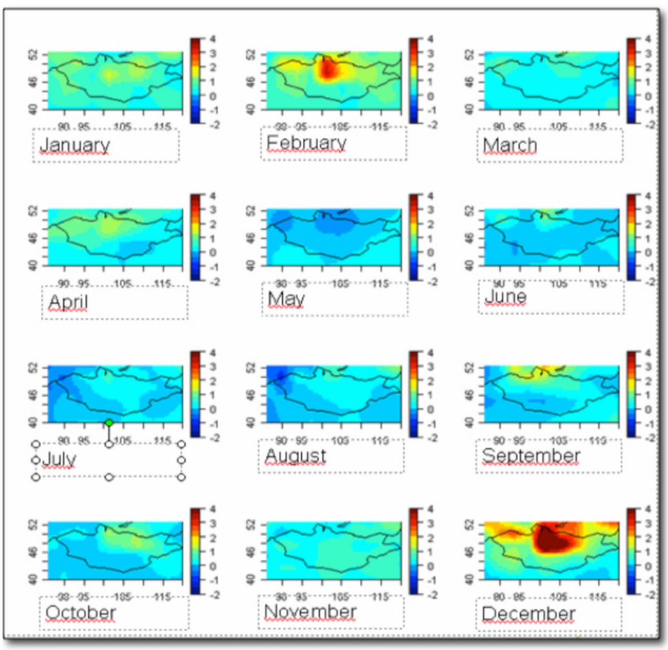

Figure 11 - Relative variation of monthly precipitation on Mongolian Region with regard to SRES A2 scenario. Baseline period: 1975 –2005; future period: 2066- 2099.

With this article, we have wanted to link briefly the historical roots of agrarian reform happened in China since 1952 to the present situation about smallholder agriculture in Inner Mongolia, and to refer all this to climate change scenario. According to this, it is possible to foresee that the temperature in North China would increase in the future while the precipitation would decrease (Yue L. *et al.*, 2007); that is according with University of Florence climatological elaboration on Mongolian Region (Figure 10 and 11). Adaptation actions demonstrate that some eventual positive effects of climate change do not come across automatically but require communities to be supported with resources such as extension services, new crop varieties and institutional frameworks that allow experimentation and reward entrepreneurship (Xiu *et al.*, 2007).

To fill the technological gap in agriculture has been here considered how an adaptive strategy to cope with climate change. With regard to farm structure system, state-owned farms have technological advantages for adaptation respect to small peasants, as they run field production like factories with high use of machinery. In recent years, in fact, state-owned farms have adopted many modern techniques to react on temperature increases (Xiu *et al.*, 2007). For these reasons, we have attempted to adjust simulated wheat and maize yields data to technological level associated to crop yield statistical data of Inner Mongolia. Technological adjustment is conceived here as an adaptive response as whole to climate change: from agricultural inputs use (fertilizers) for small farmers to new crops variety; from the adjustment of cropping system to institutional financial support to farmers; from new breeding techniques to grazing land conservation.

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