Promotion of Sustainable Buildings in China
Integration of Bamboo and Renewable Energy Technologies

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INTRODUCTION

Conservation of natural forests is a key issue in China's sustainable rural development. One of the problems in rural China is the use of large quantities of wood and red bricks in house construction. So is the extensive use of firewood as the fuel for space heating and cooking. This causes destruction of forests, and the consequent water shortage and soil erosion problems. The annual consumption of fuel wood accounts for some 60% of the total forest consumption after commercial logging was banned in 2000.

With the increase in living standards in rural areas, demand for housing is growing. So is the market demand for high quality and attractive hotels for tourists. Another market is also important. Majority of the school in the Southwest regions needs to be rebuilt and the government is to invest more than 1.5 billion RMB for the development of schools over the next few years. Construction of ecologically friendly schools will improve the living environment for teachers and students, and help increase their understanding of renewable energy applications and the concept of sustainable development.

The scarcity of traditional forest wood resulting from conservation oriented management practices, and constraints associated with the acquisition or use of non-wood materials have attracted attention on the need to find suitable substitutes. In this context, use of bamboo has emerged as an ideal material.

BAMBOO

Bamboo has a long history as a building material in many parts of the world. It is light, strong and it can grow quickly and sustainable, even on degraded land. In addition, it has the potential for creating employment opportunities for the rural poor, in particular for women. Bamboo can therefore address three major global challenges:

- Livelihood security (generation of employment through bamboo plantation and primary processing for manufacturing mat-based composites and other products)
- Ecological security (conservation of forests through timber substitution, efficient carbon sequestration, alternative material to non-biodegradable and high embodied energy materials such as plastics and metals).
- Sustainable food security (bamboo based agro-forestry systems, maintaining the fertility of adjoining agricultural lands, bamboo shoots).

A large portion of the rural housing in Asia, Latin America and Africa is constructed from bamboo. In recent years, the use of bamboo in popular housing construction has increased because of the cost and scarcity of other building materials. In Central America, for example Costa Rica and Ecuador, technology has been developed for the construction of low-cost, safe and durable bamboo housing that can withstand earthquakes and typhoons. It is reported that in Limon, Costa Rica, only bamboo houses from the national Bamboo Project stood after the violent earthquake in 1992. Quality bamboo housing has become socially acceptable in many parts of the world, especially in Latin America (Ecuador, Colombia, Costa Rica) where large-scale public housing program exist. In the last two decades, the imaginative research has encouraged the use of bamboo both for structural and decorative uses.

China has abundant bamboo resource, available in 18 provinces and regions. Bamboo is an important resource to substitute for wood and forest products. It is cheap and locally available. There is a big potential for its wider use as a building material, particularly in Southeastern and Southwestern China. Promotion of bamboo as a building material will have the following benefits: reduce wood consumption and the pressure on forests; limit the use of red bricks as building material; low-cost for the rural poor, a new model to combine energy savings and renewable energy technologies in buildings with wide use of bamboo; provide employment opportunities in rural areas; and stimulate bamboo resource development and industrialization. It also has other social benefits such as reduction of health effects of wood burning in traditional rural houses.

ENERGY-EFFICIENT BUILDING PROGRAM WWF

In China, the concept of sustainable building development is in the early stage of development and is not widely known to the general public. In some regions in China, there are abundant renewable energy resources, such as solar, wind, small hydro. To promote wider use of these renewable energy resources will help promote sustainable rural development, and reduce the dependence on fossil fuels burning, which is the main cause of global warming. The main challenge is how to use these resources and related technologies cost-effectively, and at the same time, to preserve local traditional and cultural heritage. Social acceptance of sustainable building development is the key to success.

The buildings and houses will be bio-climatically designed with the concept of passive solar house and installed with solar thermal water heater, integration of solar PV system, and micro wind turbines if local resource is available in order to utilize solar energy resource more efficiently, particularly in cold high mountain areas. Biogas technologies will be used to utilize the wastes from the humans and pigs. Other energy saving measures will also be used to be adaptable to local climate conditions, such as the use of natural cooling measures and other techniques. Water saving measures will also be used to conserve water and minimize environmental impacts of wastewater discharge.

The key concept of this project is to link energy savings and the utilization of renewable energy technologies with the use of bamboo and bamboo panels as the main building material when appropriate. The WWF "Panda house" logo, together with INBAR logo will be used in all the buildings/houses, and in communication and media promotion activities, and commercialization with the involvement of property developers and local governments. Through communication campaign, wider use of energy efficient bamboo buildings and houses will be promoted.

WWF China (www.wwfchina.org) and the International Network for Bamboo and Rattan (INBAR) (www.inbar.int) have jointly launched the project "Promotion of Energy Efficient Buildings: Integration of Bamboo and Renewable Energy Technologies" in March 2002. The objective of the project is to design model houses, hotels and school buildings for rural people in southwestern China, particularly in Yunnan Province where abundant bamboo resource is available and has a tradition of using bamboo as building materials. Because of the climatic variations in Yunnan, the design and construction work should take into consideration of different local conditions and use the available resources in cost-effective perspectives.

As part of the project, a joint field visit to Baimaxueshan, Jinghong and Honghe of Yunnan Province has been made. With the local officials it was decided to design/ build the following prototype energy efficient buildings:

1) Tibetan Community School in Baimaxueshan
   Phase 1 will be a school for 50 students (6 – 12 years). Phase 2 will be an extension to 150 students. The construction of the school should be completed by October 2003.
2) Energy-efficient house for the Dai ethnic group, Jinghong.
   A typical Dai-style house (100 m2) has to be designed that meets modern comfort and requirements. The same knowledge can be used to improve the existing Dai houses without changing the cultural heritage. Important is the typical roof style with clay tiles.
3) Energy-efficient hotel in Dai style, Botanic Garden in Xishuangbanna
   The plan is to build a tourist's hotel (50 rooms) within the Botanic Garden in Xishuangbanna. Bamboo and bamboo panels will be used as decoration building materials. The use of bamboo floor is considered appropriate.
4) Energy-efficient house for the Hani and AXi, Honghe
   Main difference is between houses in the valleys (warm) and in the mountains (cold). This can be seen in traditional architecture as well. Mountain houses are mainly made of clay. Valley houses use more wood (less thermal mass).
   The house will be around 100 m2. This is based upon clay / brick walls and use of wood and bamboo.
5) Energy-efficient School in Pingbian.
   The elementary school will be for 200 students and 14 teachers. Construction shall be started in October 2002 and complete in May 2003.

The design of buildings/houses will be jointly made by BEAR Architects, the Netherlands (www.bear.nl) and the Urban & Rural Planning & Design Institute of Yunnan Province, China, taking into consideration of local climate, economic, social and cultural conditions. Dutch bio-climatic and solar architect, Tjerk Reijenga, from BEAR Architects, the Netherlands is key expert in the project. Detailed designs of the above buildings will be completed by August 2002 and the construction completed by 2003.

CLIMATE CULTURE AND TRADITION.

As China is located on the southeastern sector of the Eurasian continent towards the Pacific Ocean, air masses of either continental or maritime origin will affect its climate. The monsoons represent the overwhelming climate and weather regime for China, which govern the climatic conditions throughout the year [16]. In general, winter monsoon from mid-Siberia and Mongolia brings cold and dry air masses to China during the winter period; summer monsoon from the subtropical anticyclone in the Northwest Pacific and the cross-equatorial flow from the southern hemisphere generates precipitation and warm weather during the

summer period. The two distinguished monsoons together create large differences in seasonal climatic conditions.

The province of Yunnan is mainly located in the Warm Climatic Region. This means that the coldest month average temperature is between 0 and 13 °C and the hottest month average is between 18 to 25 °C. The days with a daily average temperature under 5 °C is between 0 and 90 days a year.[1][2] Local conditions are strongly influenced by altitude and prevailing wind. Altitudes in the province of Yunnan differ between 500 and 6000 meters. The main plateau around Kunming has an altitude around 2000 meters.

The province of Yunnan has diversity in nature and in culture. About 25 of the 56 minorities in China can be found here. This is the only province were Han Chinese don't have the majority. Because of the mountains, transportation and communication were difficult. These circumstances resulted in independent ethnic groups with their own culture and architecture. Some of the main styles of traditional residences are: bamboo pillar or stilt houses, wood log houses and the adobe (mud) houses. The influence of Han Chinese is visible in the brick courtyard houses or the One-Chinese-Seal house.[3]

1) The pillar or stilt house. [picture 1]
   Very characteristic are the pillars or stilts that are made from wood or bamboo. The living area is on the first floor, high above the ground.
   Main construction is bamboo. Nowadays a lot of pillars are made of wood.
   People live on the floor and don't use furniture.
   The reasons for such a house are periodical flooding of the river, the mostly sloping terrain, to avoid disturbance by animals and the people has the habit to live on the floor.
   The house is well-ventilated and shaded inside and outside. The space under the house is used for animals, working space and storage.
2) The wood log house.
   This house is built with wood logs with their typical construction details in the corners of walls. The roof is made of wooden shingles.
   The reason for such a construction has to do with the easy access of wood in that region and the easy construction. The houses are flexible and strong and can resist earthquakes and animals. Wooden tiles keep in very good shape also with very low temperatures.
3) The adobe (mud) house. [picture 2]
   The basic structure is wood or a combination of wood and adobe brick. The adobe brick is covered with a layer of adobe to get a smooth surface.
   In the west of Yunnan (Tibetan area) the houses are made from rammed earth and painted white. [picture 3]
   Houses have in general two or three (partially) stories. The ground floor for livestock, the first floor for people and storage. If there is a (partial) third floor, this floor is also used for storage.
4) The One-Chinese-Seal house [picture 4]
   The structure is based on the traditional Chinese wooden post and beam frames. The house is regular and symmetrical organized around a courtyard. In different areas are different variations in materials and ground plan layout. The house is a combination between the local architecture and the traditional Han architecture.[3] Materials used are wooden post and beams, rammed earth, adobe or ceramic bricks and ceramic tiles.[4]
5) The 'modern' style

Today many traditional materials are replaced for glass, aluminum, steel and concrete. Ceramic tiles protect the concrete outside surface. This style can be seen from the north to the south of China. These buildings are not responsive to local climate and culture. For that reason most houses need an air-conditioner to survive the house.

New designs have to respond to the local climate and the culture. Wood is used for fuel (heating and cooking) and as building material. Because of the shortage of wood and the protection of forest it is necessary to build energy-efficient and to use other more sustainable materials. This is a great opportunity for the use of bamboo products.
In traditional villages it is necessary to improve the quality of living with respect for history, nature and culture. The new architecture should be climate responsive like the traditional architecture. Other aspects are sanitation and economics. Both has to be improved and can work together to make houses more energy-efficient.


Fig. 1. Typical house in traditional Dai style


Fig. 2. Typical adobe house in traditional Hani style.

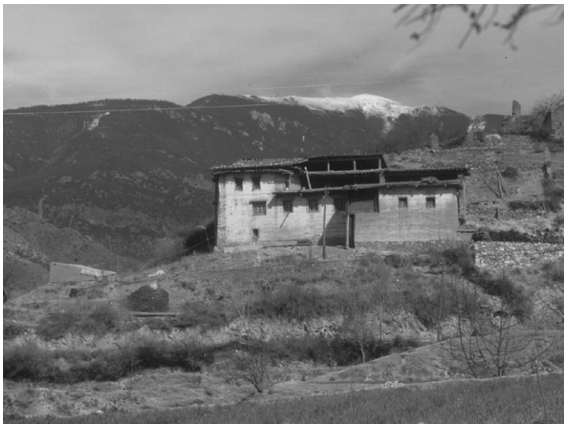
Fig. 3. Typical adobe house in Baimaxueshan.


Fig. 4. Typical One-Chinese-Seal house

The modern cities have a more divers architecture. The traditional architecture is a source of inspiration and knowledge. New designs should learn from tradition and climate responsive. Mechanical installations like HVAC can be avoided or made more efficient by the bio-climatic design of buildings.

AN ENERGY EFFICIENT BIO-CLIMATIC APPROACH.
The different local climates give completely different circumstances for every project. In the west part of Yunnan Province, heating, passive and thermal solar will be the most important

issues. In the southeast part the main topic will be passive cooling. Some of these areas will have a small heat demand at night.

Sanitation has to be improved and the combination between toilet, biogas installation, live stock (pigs) and a greenhouse can also improve the income of farmers. In the west of Yunnan province these combinations can be seen on a small scale. The quality of the greenhouse has to be improved to last longer. Especially the plastic covers sheets. Sources of energy for household energy use will be biogas (for cooking) and solar thermal systems for hot water.
The principal of passive cooling and heating means in summer: minimise heat gain and maximize heat removal. In winter it means: maximize heat gain and reduce heat lose.

The energy efficient Dai house will use passive cooling. This will be done with the following strategies: ventilation during the day, night ventilation, earth cooling and solar cooling.

To demand for cooling will be reduced by: building layout and orientation, window size and location, external sun control and shading, evaporation around the building and efficient daylight without heat building (indirect lighting or optical systems)

On higher altitudes, with big temperature drops at night, thermal mass will be particularly beneficial. Where mass is used for warmth, it should be exposed to incident solar radiation. Buildings may be pre-cooled using night-purge ventilation (opening the building up to cool breezes throughout the night), although this requires significant amounts of exposed mass, and may be necessary only at certain times of the year.

In cooler areas on higher altitudes heating demand is the main question, Because of the high amount of sunhours, passive thermal solar energy is very appropriate.

TIBETAN COMMUNITY SCHOOL IN BAIMAXUESHAN (28°N, 99°E, ALT. 2690 METERS)
The south facing sloped site is part of a Buddhists holy place. The school is designed as 2 buildings around a courtyard. The courtyard is closed on the East Side and open to the West Side. From here, one has a good view on the Buddhist village and temple of Dongzhulin. The east part of the site and the slope on the north will be planted with trees to protect the school against the cold eastern winds.

The two buildings are built in the slope in a way that all educational functions are around the courtyard. Heat from the classrooms will go up and warm the floor of the dormers. A glassed corridor in front of the dormer rooms act likes a solar collector and keeps the heat inside. Kitchen and dining room are on a lower level and the upper training room, offices and bathrooms will gain heat losses from these rooms.

The passive solar design has large south facing windows, roof top windows and smaller north facing windows for extra daylight. Solar thermal panels are integrated in the roof and the heated water is used for radiant floor heating and domestic hot water. Auxiliary heating is done with biomass. Some greenhouses and a biogas installation are used for growing food and natural gas for the kitchen.

Phase 1 will be a school for 50 students (6 – 12 years). Phase 2 will be an extension to 150 students. The construction of the school should be completed by October 2003.

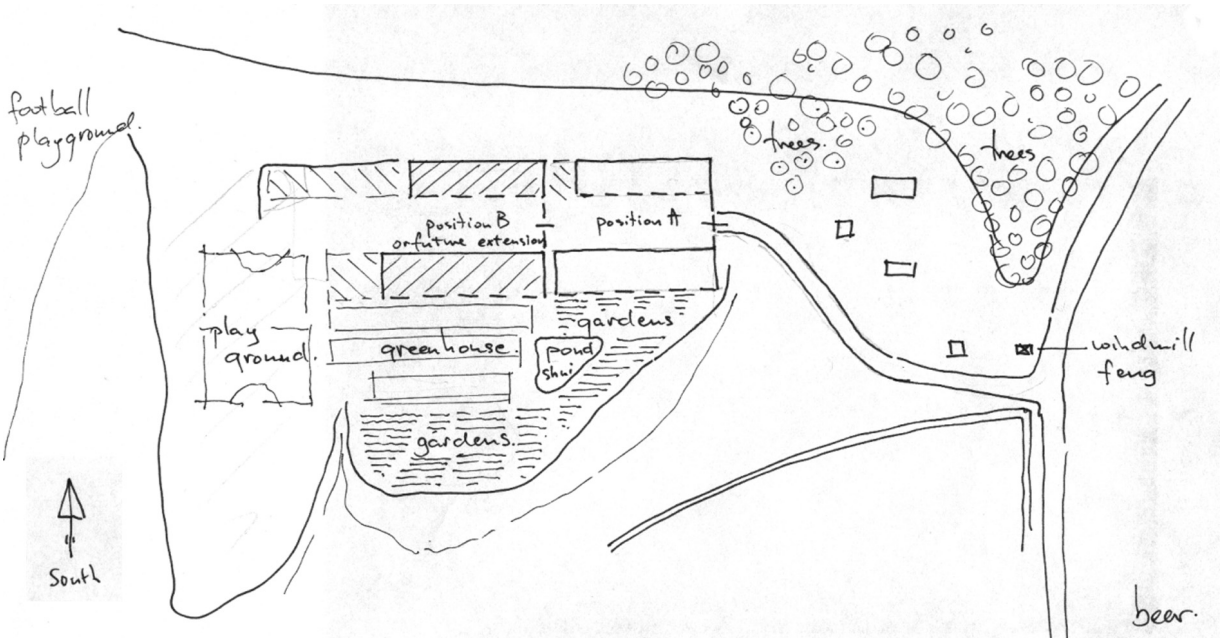

Fig. 5. Site lay-out for the Tibetan Community School in Baimaxueshan

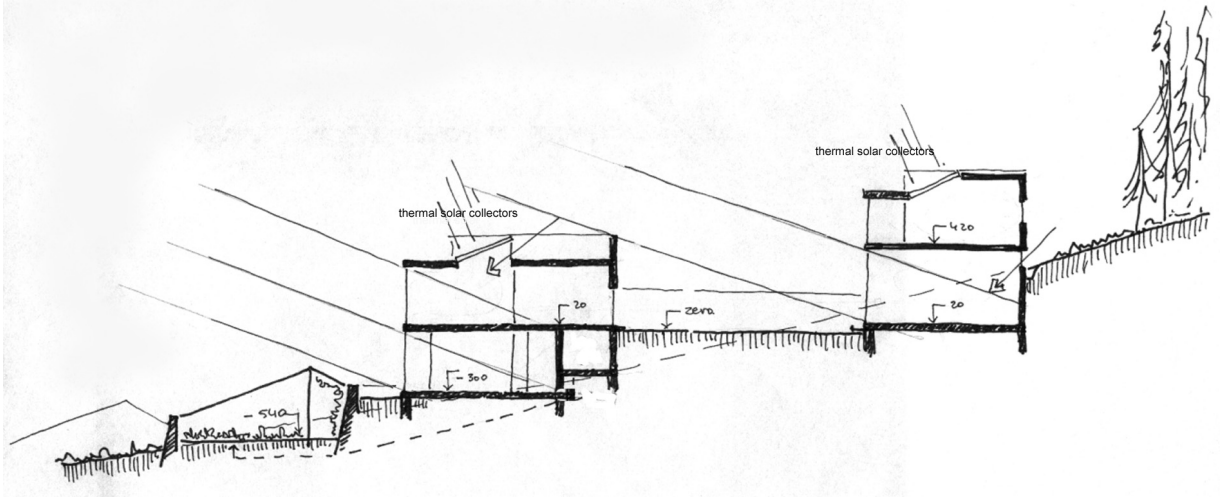

Fig. 6. Cross-section on the school with solar and daylight features.

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