Towards an integrated approach to soil conservation

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Experiences from several research project are summarized, especially two European Union Framework Programme (FP) Projects. These projects were SHASEA (Sustainable Highland Agriculture in South-East Asia; FP 4) and BORASSUS (FP 6). Specific project design and management lessons were gained from both projects, which can be employed by similar research projects promoting sustainable agro-environmental development in the tropics and subtropics. Both projects postulated that environmental protection and socio-economic development were complimentary, synergistic and achievable aims. These aims can largely be achieved by adopting holistic and integrated approaches to soil conservation. While soil conservation is largely an environmental engineering problem, we need to recognize that effective conservation has social, economic, educational and political dimensions. The case for an integrated environmental and socio-economic approach to soil conservation is supported by detailed case studies from Yunnan Province (China) and São Luís (Brazil). Specific lessons from the reviewed projects include:

1. Recognizing the importance of both ‘north-south’ and ‘south-south’ co-operation in development projects. For instance, a particularly important aspect of the SHASEA Project was the Chinese-Thai collaboration in developing viable solutions for agro-environmental problems in the highlands of South-East Asia. In the BORASSUS Project, Brazilian and South African scientists are jointly developing gully rehabilitation strategies.
2. Integrating local stakeholders as full partners in the research programme. This should include genuine consultation and feedback of research information, so that stakeholders see tangible benefits from the project.
3. Addressing the problem of ‘time horizons.’ Farmers usually have short time horizons, while government policy tends to be much longer-term (five years plus). Matching these different aspirations poses many challenges to the development of appropriate agro-environmental policies.
4. Multidisciplinary teams must be developed to include biophysical scientists and socio-economists. Due to differences in approaches, this can be challenging and, therefore, necessitates regular and persistent dialogue and information exchange.
5. For soil conservation initiatives to be effective, it is imperative farmers’ gain income from their activities. Many well intentioned projects have floundered because local farmers do not embrace the technologies. While the soil conservation technologies may be technically feasible, they have not been implemented because farmers cannot efficiently gain income by their adoption.
6. Short project duration was one of the most cited reasons for impaired dissemination and adoption. Longer duration projects were usually considered as more successful in addressing more holistic issues. It is difficult to produce tangible outputs from agro-environmental projects within five years. Considering the slow changes in the system, agricultural and environmental sustainability projects are advised to plan for a minimum of 5-10 years, depending on the nature of activities.
7. Education is the key to success. Urbanized societies are becoming progressively remote from the food resource base and generally have vague and sanitized views of agricultural production systems. Educators have a pivotal role to play in increasing knowledge, awareness and understanding of soil system dynamics at multiple levels, from school to University level and to the general public. To achieve long-term and sustained success, developing ‘land literacy’ amongst people is crucial.

Case Study 1. Agro-environmental lessons from the ‘Sustainable Highland Agriculture in South-East Asia’ (SHASEA) Project

To promote sustainable agro-environmental development in the highlands of South-East Asia, an international multidisciplinary research team, funded by the European Union, examined the effectiveness of selected agronomic and soil conservation treatments (both modified and novel cropping practices) using farmer-managed runoff plots on a natural and representative catchment (Wang Jia) in the highlands of Yunnan Province, China (25°28'N, 102°53'E). The Project involved five co-ordinated work-packages: (i) background agricultural and environmental assessment of Wang Jia Catchment; (ii) implementation and evaluation of modified and novel

catchment cropping systems for wheat (*Triticum aestivum*), maize (*Zea mays*) and soybean (*Glycine max*); (iii) cost-benefit analyses of the socio-economic impacts of cropping practice changes; (iv) comparative scientific evaluation of cropping techniques in the highlands of northern Thailand at Pang Mapa, Mae Hong Son Province (19°33'N, 98°12'E) and (v) dissemination of project outcomes and establishment of training programmes for best practice in highland rural development. The 'Sustainable Highland Agriculture in South-East Asia' (SHASEA) Project was implemented with an integrated and holistic approach to increase the productivity and sustainability of cropping systems in the highlands of South-East Asia:
http://www.wlv.ac.uk/science/environment/SHASEA/

The Project involved the participation of scientists from diverse disciplines (agriculture, biology, economics, geology, hydrology and soil science), from different West European and Asian countries, working alongside local farmers and their families in South-East Asia. Particular attention focused on conservation treatments and cultivation effects on crop productivity and water erosion rates on subtropical arable red soils of the Upper Yangtze basin in the Central Plateau of Yunnan Province. Within this context, this paper summarizes lessons gained from the SHASEA Project. These lessons can be employed by similar research projects that promote sustainable agro-environmental development in tropical and subtropical highlands.

A Project team was assembled to provide multidisciplinary analyses of the complex agro-environmental problems. The SHASEA team consisted of scientists from Belgium, China, Ireland, Thailand and the UK. Plot studies were used to develop and test novel cropping techniques. This on-going programme has established experience-sharing links with the local community (farmers, villagers and township officials), which was crucial for incorporating *'end users'* in the research programme and for promoting *'bottom-up'* development. The participative research strategy, sharing experience between European and Asian partners, facilitated a holistic approach, which was essential to long-term programme success. The Project aimed to disseminate information to international research communities, regional training agencies, local agricultural and conservation services and village communities. The team believes the interchange of research information between SHASEA team members in China and Thailand will be particularly beneficial for sustainable development in the highlands of South-East Asia

Results from the SHASEA Project have been presented in several publications (Barton *et al*., 2004; Cuddy *et al.,* 2004; Fullen *et al*., 1997, 1999, 2000, 2001, 2004) and Ph.D. theses (Barton, 2000; Huang Bizhi, 2001; Milne, 2001; Wang Shu Hui, 2003; Li Yong Mei, 2004; Subedi, 2006). Collation of the experimental data draws together several items for discussion, which should assist future similar studies focusing on the development of sustainable agro-environmental systems in subtropical highlands. Firstly, where the priority is to increase maize yields on sloping land under conditions where the risk of soil erosion is low, contour planting with single ridge polythene mulch is recommended. Secondly, where the risk of soil erosion is higher, but rainfall is likely to be limiting early in the growing season and irrigation water is available for application prior to the application of polythene mulch, the INCOPLAST (INtegrated, COntour cultivation, PLastic And Straw mulch Technique) is recommended (Fullen *et al*., 2001, 2004). Thirdly, on steep land where erosive rains are likely in the early or throughout the rainy season, alley cropping should be applied (with straw mulch if sufficient straw is available). Finally, where these techniques are adopted, straw must be readily available to be applied as a mulch. However, in all cases, the availability of sufficient manure and straw may be major constraints. The availability of sufficient water for early season irrigation will also be a constraint when rainfall in May and June is considerably below average.

Soil and water conservation benefits of polythene mulch, plus intercropping with soybean, have not been evaluated in this study but, if the effects are similar to those of INCOPLAST, this practice may be recommended where soybean production is important, without sizeable reductions in maize yield. However, soybean yield is less reliable than maize. It has been demonstrated that maize productivity can be increased $\leq$50%, compared to traditional methods on sloping fragile land, using simple cost-effective technologies, which in parallel plot studies have been shown to improve soil and water conservation. Detailed scientific evaluation has been conducted in Wang Jia Catchment to quantify the effectiveness of these technologies and develop explanations of how crop responses have been produced.

Improvements in maize cropping practices have been linked to a land management plan to develop a more sustainable agricultural system in Wang Jia Catchment. This has included a range of engineering measures to control erosion, such as gully rehabilitation works (Plates 1 and 2). In addition, there has been the installation of an irrigation system to improve the reliability and level of crop yield (including maize and winter wheat), tree planting as cash crops (sweet chestnut and prickly ash) on the steeper slopes, pine tree planting on the upper catchment to return land to forestry and development of a monitoring system to evaluate the effectiveness of these measures over the longer-term.

The land management plan has been based on a comprehensive survey and description of the biophysical catchment characteristics. This has provided a baseline for subsequent change and, furthermore, established the representativity of the catchment in relation to the surrounding area. The catchment has been shown to be representative of the mountainside where it occurs, and the soils at the different sites to be representative red soils, dominated by the influence of limestone and strongly affected by contributions from colluvial material. Such areas are extensive in the highlands of Yunnan Province. Site descriptions and analyses are ongoing, as changes to the catchment proceed. These are being developed into a GIS-based land management and evaluation system for other subtropical highland catchments, similar to Wang Jia.

The SHASEA Project was subject to an independent late-stage and post-project evaluation (Subedi, 2006). The evaluation concluded that the Project was successful in achieving its short-term scientific and technical objectives, but was too short to determine the level of adoption by local farmers. Participatory approaches were used wherever possible; including detailed household surveys, participatory rural appraisal (PRA) workshops and discussions with key informants. Field surveys and direct observations were also made, together with economic analysis of the modified cropping practices introduced into the catchment.

Subedi (2006) found that farmers had different perceptions about the range of introduced practices. Some were clearly preferred, such as contour cultivation and were likely to be adopted, while others were deemed inappropriate, such as straw mulching and intercropping, and were unlikely to be adopted. The benefits of INCOPLAST were not fully appreciated by the farmers. Other practices would only be adopted if the financial returns were favourable, such as the use of polythene mulch. Longer-term measures, such as tree planting schemes, were regarded favourably, but adoption would still depend on economic returns and related issues such as land security. The farmers suggested an irrigation scheme but, after installation, it was not used extensively for the staple crops in the catchment. It was found that farmers planned to use the irrigation for higher value crops, such as tobacco, after completion of the Project.

Subedi (2006) concluded that, despite the technical and scientific success of the Project, long-term adoption of many of the practices introduced into Wang Jia will be low, unless much more effective dissemination techniques are employed or considerable incentives are used. It is also considered that the outcomes would have improved considerably if participatory approaches had been used from the outset, to engage farmers more fully with the Project, to ensure that the practices introduced were as appropriate as possible, to achieve greater ownership of the objectives and outcomes, leading to higher adoption rates. More emphasis should have been given to the dissemination of the outcomes at farmer level, outside the study catchment and there should have been more involvement with regional policy makers and extension officials throughout the programme. Longer-term improvements in sustainability at the catchment level have not yet been demonstrated.

The collaborative research in Yunnan Province was not achieved in one step, but evolved and developed in a ‘stepping stone’ fashion, progressing into larger and more substantive projects. Initial funding was from the British Council and the Yunnan Science and Technology Commission. This progressed into funding from the UK Government (Overseas Development Agency and then the Department for International Development), followed by the EU. Therefore, in developing long-term development projects, this ‘stepping stone’ evolutionary process can be helpful. These discussions lead to the question of what is the optimum project duration? Subedi (2006) identified that short-term projects are challenged in achieving their laudable dissemination objectives. On the other hand, quasi-permanent projects are likely to become increasingly bureaucratic and lack focus.

Photo 1 Gully in Wang Jia prior to the planned rehabilitation programme, July 1999

Photo 2 Gully in Wang Jia during the rehabilitation programme, July 2001

Case Study 2. An integrated approach to gully erosion control in São Luís, Brazil

Field and laboratory studies indicate that geotextile mats constructed from palm leaves are an effective, sustainable and economically viable soil conservation technique. The EU-funded BORASSUS Project (Contract Number INCO-CT-2005-510745; 2005-09) is evaluating their effectiveness in controlling soil erosion and assessing their sustainability and economic viability. These studies are in progress in 10 countries, both in the 'industrial north' (in Europe) and in the 'developing south' (Africa, South America and South-East Asia). This section focuses on the value of an integrated approach to soil conservation, using the specific case study of Brazil. Further information can be obtained from the BORASSUS Project website:
www.borassus-project.net

Inappropriate land management, particularly deforestation, has paved the way for accelerated urban expansion in São Luís City (São Luís Island, north-east Brazil). In turn, this has promoted severe soil erosion and caused the formation of extensive gully systems ($\leq$10 m deep, 8 m wide and 150 m long), which have caused loss of lives and homes (Plate 3). For instance, between 1997-2003, gully erosion was responsible for five deaths and the destruction of 350 homes in São Luís City.

Gully erosion has been monitored since 2000 at Sacavém, São Luís City. An integrated package of measures associated with the BORASSUS gully reclamation project are reported. Geotextile mats are being constructed from the leaves of local Buriti (*Mauritia flexuosa*) palms and this soil conservation technology is proving effective in gully head and slope stabilization (Plate 4). In addition, there are several related socio-economic benefits. Soft Buriti timber is sustainably used to produce wooden items (e.g. small gift boxes) for sale by local people. High quality Buriti palm leaves are used for fibre goods (e.g. hats and tablemats). Excess coarse fibres, which were previously discarded as waste, are now used to produce inexpensive geotextiles. Buriti fruit is used for fruit drinks and ice cream. Furthermore, Buriti palm oil is an important source of beta-carotene and vitamin A and evidence suggests the oil may aid the prevention of skin cancer.

Community-based environmental education, supported by a 'land literacy' programme, is proving instrumental in securing people's participation in landscape remediation and has close affinities with the Australian Landcare system. Gully erosion data are used to explain the problems, threats and risks posed by soil erosion to the local community. After engagements with community leaders, weekly classroom and field-based lessons are being provided for children and youths (mixed-gender; aged 9-14; n = 70) from impoverished backgrounds. A 'learn-by-doing' methodology, including art-design lessons and theatrical performances, helps to convey the message in an interesting way and promotes participation in the development of practical sustainable remediation techniques. This is enhancing the personal development of participants (technical training, behavioural improvements, improvements in self-esteem and self-belief and concepts of good citizenship), plus the development of a teamwork ethos (Plate 5). These activities have widened community participation by attracting other family members (n = 40 parents) to attend project events and demonstrate an affiliation with the development and remediation of degraded areas. The same community is gaining stakeholder interest, as they gain income from the production of Buruti mats.

Initial project results recommend the design of comprehensive and holistic gully reclamation projects, integrating environmental, social, economic, health and educational dimensions. The São Luís model may form the basis of a generic protocol for gully reclamation in the humid tropics. The approach seems very promising for combining sustainable environmental protection with socio-economic development. With carefully designed management schemes, these goals can be complimentary, with environmental protection and socio-economic development being synergistic and achievable aims.

Photo 3 The gully system of São Luís, 2006. Photograph by Professor Antonio Guerra (National Co-ordinator of the BORASSUS Project in Brazil)

Photo 4 Gully reclamation work in progress in São Luís, February 2008. Photograph by Professor A. Guerra.

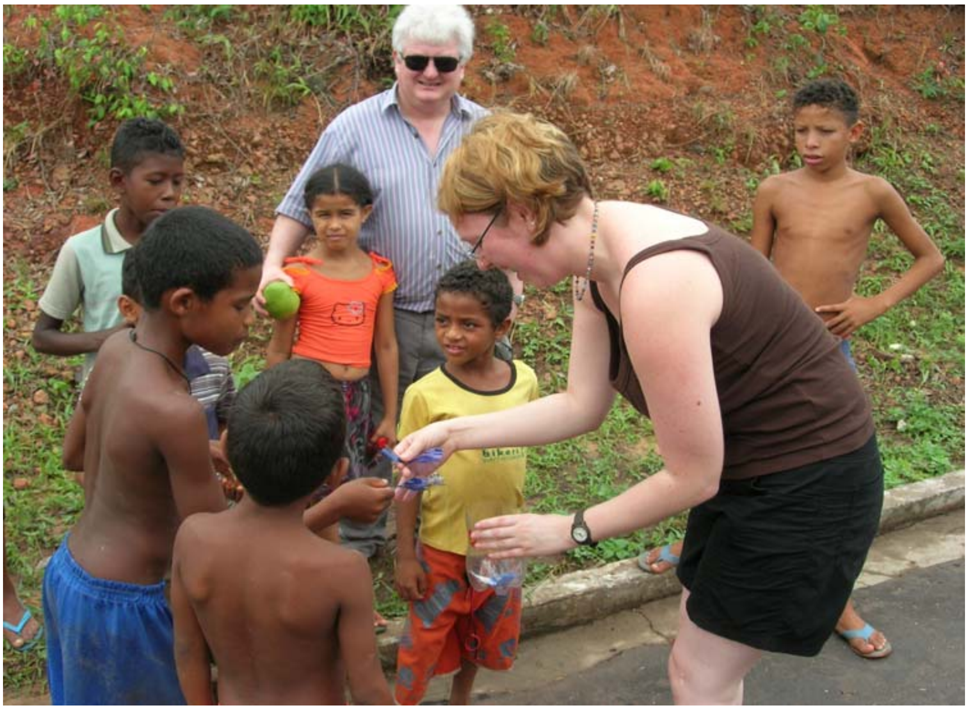

Photo 5 The children of São Luís presenting gifts of book-marks, made from recycled plastic bottles, to be given to the children of the European Union. The book-marks are being received by Claire Corkill (Centre for Manx Studies, Douglas, Isle of Man and the University of Liverpool, UK)

Discussion

A core thesis of the research projects is that environmental protection and socio-economic development are complimentary, synergistic and achievable aims. These aims can largely be achieved by adopting holistic and integrated approaches to soil conservation. While soil conservation is largely an environmental engineering problem, we need to recognize that effective conservation has social, economic, educational and political dimensions. Specific lessons from the reviewed projects include:

1. There has been a tendency to view research programmes as perceived wisdom from the 'industrial north' donor countries being bestowed on the 'developing south.' However, experience stresses the importance of both 'north-south' and 'south-south' co-operation in development projects. Positive examples include the pooling of experience between Chinese and Thai scientists in developing viable solutions for agro-environmental problems in the highlands of South-East Asia and between Brazilian and South African scientists in developing gully rehabilitation strategies.
2. To achieve success, local people must be integrated as full partners in the research programme. This should include genuine consultation and feedback of research information between stakeholders and the research team. Scientists can learn much from the knowledge-base of local communities.
3. A recalcitrant problem is that of addressing 'time horizons.' Farmers usually have short time horizons (i.e. a cropping season or even less), while government policy tends to be much longer-term (five years plus). Matching these different aspirations poses many challenges to the development of appropriate policies. Intermediate term strategies are necessary to enable local stakeholders to continue receiving sufficient income in the transition period to the development strategy achieving full agro-environmental and economic productivity and stability.
4. No one discipline holds the key to these complex issues. Therefore, multidisciplinary teams must be developed to include biophysical scientists and socio-economists. Due to differences in approaches, this can be challenging and, therefore, necessitates regular, continued and persistent dialogue and information exchange.
5. For soil conservation initiatives to be effective, it is imperative farmers' gain income from their activities. Many well intentioned projects have floundered because local farmers do not embrace the developed technologies. While the soil conservation technologies may be technically feasible, they have not been implemented because farmers cannot efficiently gain income by their adoption. This again emphasizes the need to genuinely integrate local stakeholders as full research partners.

6. Short-duration projects often fail to fully disseminate outcomes due to insufficient time and identify dissemination as areas for future work. In contrast, longer projects, for example 'Thai-German Highland Development Project (TG-HDP)' and 'Thai-Australian Highland Agricultural and Social Development (TA-HASD) Project', which lasted for 18 and 12 years respectively, were able to disseminate the long-term activities and reported the impact of such activities on living standards of target communities, farming systems and environmental conditions within the target area. Longer duration projects are able to both commit more time to dissemination and to follow through the processes of adoption and adaptation and possibly achieve greater long term success. Perhaps it is time for funding agencies to reconsider their tendency to fund shorter duration projects.
7. Education is the key to success. Urbanized societies are becoming progressively remote from the food resource base and generally have vague and sanitized views of agricultural production systems. Educators have a pivotal role to play in increasing knowledge, awareness and understanding of soil system dynamics at multiple levels, from school to University level and to the general public. To achieve long-term success, developing and maintaining 'land literacy' amongst people is crucial.

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Full BORASSUS and SHASEA Project publications can be accessed on the University of Wolverhampton WIRE free-access web site:
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