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Overview of PARDYP Research: Promising Approaches to Watershed Management

Roger White
PARDYP Regional Coordinator, ICIMOD, Kathmandu, Nepal

with an
Overview of the PARDYP Watersheds and Components
by the PARDYP Teams

Abstract

Over the last seven years PARDYP has carried out research on watershed management in the Midhills of the Hindu Kush-Himalaya region. The research has been carried out by national research institutions in five watersheds of between 60 and 100 km² in area. This work has improved the understanding of impacts of hydrometeorology on the land, land use dynamics, the community management of natural resources, and hydro-meteorological patterns. In this introduction chapter, we summarise the major learning from PARDYP Phase 2, based on the findings presented at a wrap-up workshop held in December, 2003. Ten of the options for development that have been tested, demonstrated, and promoted by PARDYP are proving popular with farmers across the region and are described. Some of the broad research findings that need further investigation and clarification during PARDYP Phase 3 (2003-2005) are presented.

PARDYP Research

It is generally accepted that environmentally sound land use practices are needed in upper catchments to maintain downstream water quality and quantity. In turn, secure livelihoods for upland farmers are essential to maintain these environmental services for downstream users. This can best be promoted by fully involving those who live in the upstream catchments in measures to improve environmental conditions and local livelihoods. In this way, between 1997 and 2003, the People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas Project (PARDYP), has developed approaches in its five watersheds that reflect local priorities, practices and norms (see p.11 below for a description of the project and its watersheds).

External evaluations carried out by the project's donors in 1999 and 2002 found PARDYP's success to have been due to:

- its long term commitment to working with communities and building up relations with them with no great rush to get results;
- it placing young staff in the watersheds who have been willing to learn from local farmers; and
- the low expectations of the communities as PARDYP is recognised as a research project and not a development project.

Testing options with communities – PARDYP's success has been largely due to the way it has built up the credibility of its research teams with local people so that local people have

become willing to trust the teams' recommendations and try out the new ideas and methods being promoted. PARDYP's approach has led to farmers and researchers working together to try out these new ideas.

Understanding the environmental context – In the middle mountains of the Hindu Kush-Himalayas (HKH), with its predominantly monsoonal climate, farmers have to deal with excess water in the monsoon and water shortages during the dry season. The area's increasing population and intensifying farming practices have made it crucially important to manage the area's water supplies more efficiently. PARDYP has worked on developing and demonstrating water management techniques to overcome the problems of excess and deficient water for domestic and cropping needs. It has promoted water harvesting, pond tanks, cisterns, groundwater recharge, drip irrigation, and micro-sprinklers as options to improve water availability and the more efficient use of water.

What then has PARDYP achieved in Phase 2?

Impacts of Hydrometeorology

In Phase 2 PARDYP has given much attention to collecting information on the hydrology and meteorology of its study areas. The resulting hydro-meteorological data sets provide a long-term baseline against which the impact of changes in land use and land management on water quality and quantity can be measured. This is an important source of information for understanding the impact of processes and of changes in these processes. This information reinforces much of the knowledge already available on the intensity and distribution of rainfall. Such information is useful for other researchers, in particular for understanding issues to do with global climate change.

In addition PARDYP has drawn together the data from its five watersheds to analyse parameters such as soil erosion, rainfall intensity, and high flows. The data collected on rainfall, runoff intensities, variability, seasonality, and other facets has been published in yearbooks. This information is useful and unique. As a final product PARDYP will produce a consolidated yearbook containing all the hydro-meteorological data from its watersheds.

PARDYP has not been able to detect changes in hydrology regimes, such as reduced low flows or increased incidence of floods, probably because its network has not been sensitive enough to detect this, or, where it has been sensitive enough, the changes have not been large enough to detect over the relatively short observation periods. However, the baseline should prove useful for future researchers on climate change in mountain areas. Its findings have led PARDYP to conclude that water shortage is a more important issue than floods.

A second strand of PARDYP's research on water has been on the management of water resources. The work in each watershed has reflected the different conditions, available skills, and local priorities. For example PARDYP China has developed a cascade system of underground tanks for domestic and irrigation water with help from government agencies (see Li Zhinan 2005 in this volume) These tanks are fed by perennial springs. PARDYP has also supported farmers to build smaller surface tanks for irrigating maize crops.

The same approach has generally not been possible in Nepal's Jhikhu Khola watershed where most perennial springs and streams are already used to capacity. Some water tanks have been installed by the water supply board at Bela in this watershed, and communities tap streams by

diverting spring and streamwater from the sources with plastic pipes. Therefore, the work on water management options in Nepal has concentrated on the better use of water through sprinklers and drip systems and by enhancing domestic water supplies by collecting rainwater from roofs and by channelling runoff into underground tanks for irrigating dry season crops. In India water from perennial streams and springs has been channelled into plastic lined ponds. Some of these have been used to raise fish. This has been very successful and there are over 70 fish ponds in the PARDYP India watershed.

Nearly all households in the Pakistan watershed have day-long access to piped water. This gives enough water for kitchen gardening and so little need is felt to improve either water management or to expand irrigation into the dry season. No water harvesting structures are planned for this area, but trout farming is being tested with the poor Gujar communities in the upper watershed.

The monitoring of spring and river sources has highlighted problems with drinking water quality. Water quality studies found faecal coliform contamination in most spring sources in all watersheds, often at many times the maximum World Health Organisation limits. New piped water supply schemes have benefited many villagers in the watersheds; but this has often led to the old springwater sources being abandoned and the user groups ceasing to function. The problem with this is that when the new supply systems fail there is no alternative source to fall back on.

PARDYP has recognised the importance of reacting to results arising from its research. The development of options for improving water quality is one example of how research findings have helped change PARDYP's research priorities.

Land use research

PARDYP has supported studies to understand how changes in land use and husbandry innovations are impacting the local hydrology in terms of water quality and quantity at sub-catchment level and for seasonal flows. The most important types of changes in land use to record are in the balance between forest, dry land agriculture, and irrigated agriculture.

The studies have found that existing systems are far more resilient that previously thought. Trials are underway to look at the hydrological impact of converting grasslands to hybrid poplar and vegetables in Hilkot watershed, Pakistan. Such changes may lead to detectable increases or decreases in seasonal water discharge at the sub-catchment level (20 ha in this case), but may not have an effect at the watershed level (in this case 1600 ha).

All visitors to the Nepal watersheds are interested to see how local farmers continually transport litter and fodder from the forests to the households, and the subsequent movement of compost to the fields. In the Jhikhu Khola valley bottoms, up to 50 tonnes of farmyard manure are commonly added to each hectare of agricultural fields each year.

An early PARDYP finding was the problem of acid soils. Much work was carried out to look at acidification processes including the contribution of pine needles in compost and livestock bedding. Trials carried out in 2003 on liming rainfed fields showed promising results. However, it would appear that acid soils are not really such a big problem in the other watersheds and certainly not in the Chinese watershed with its karstic limestone. Soil results from Pakistan indicate that soils there need to be acidified if tea is to be grown successfully. It

would appear that the very intensive nutrient management manifest in the heavy workloads of compost making and additions in Nepal has developed to overcome the problem of acid soils. This hypothesis needs further testing and in 2004 the Nepal team will try to find out if land management methods differ on the soils derived from limestone within the Jhikhu Khola. The results of project studies on soil fertility dynamics in the Nepal watersheds are presented later in this volume by Shah (2005).

PARDYP'S research on farming systems and cropping intensities has recorded the great intensification of cropping on the best quality valley bottom lands. Some marginal areas have become less intensively cultivated because of out-migration. There been no extensification of land use.

Integrating research findings from land and water

PARDYP has looked at the interactions between land use and climate parameters, and at the levels of soil erosion and sedimentation. PARDYP and other studies have found that rates of soil erosion have been lower than expected in all the PARDYP watersheds. Soil erosion from agricultural land tends to be low, whilst degraded land consistently shows much higher rates. This indicates the effectiveness of measures taken by farmers to conserve soil and shows that most attention needs to be given to reducing soil erosion on degraded lands, most of which is common property land. The findings that soil erosion occurs mostly on degraded land reinforce PARDYP's earlier findings from Jhikhu Khola.

The analysis of soil erosion data is beginning to give very interesting results although PARDYP is reluctant to make concrete statements based on only a few seasons' findings from its erosion plot studies. However, the Jhikhu Khola research has now reached a stage – with 44 plot-years of data, and other results from China, Pakistan and India, and from other studies carried out by the Lumle Agricultural Research Station, Nepal – where concrete statements can be made. These studies indicate that soil erosion from rainfed land, in terms of volume of transported soil, is not a significant problem. This directly contradicts the problem and situation analysis produced during PARDYP's planning and replanning exercises. It also goes against the widely held views that soil erosion is a significant problem in the middle mountains of the Himalayas. This analysis clearly shows that farmers' land management practices are very effective in minimising soil erosion. The erosion rates in the PARDYP watersheds have been found to be low compared to the rates reported from Asia by the International Board for Soil Research and Management's (IBSRAM – Bangkok) research.

Jehangir (2005) in this volume presents the results of the climate-soil erosion links for the PARDYP watersheds. This has been a difficult job as the work started without a clear hypothesis which meant that erosion rates from different land uses cannot be compared. The results focus on rainfall amount, its erosivity, and its timing. The broader implications for land managers are not so clear.

Developing Options for Farmers

Water management

For improved water management PARDYP recommends:

- protecting spring sources, promoting local management rules by strengthening user groups, and planting vetiver grass to filter overland flow;

- treating water at the household level through the SODIS solar distillation method using one litre discarded plastic water bottles, and treatment with chlorine where contamination remains;
- installing plastic-lined ponds for harvesting rainwater and perennial water sources;
- installing 500 litre tanks for harvesting rainwater from roofs for domestic supplies throughout and following the monsoon; and
- installing simple, locally available, cheap drip irrigation sets (with or without plastic mulches) to cut water needed to grow some crops by up to 60%.

An important area that PARDYP has identified is the amount of leaching of nutrients from soils in farmers' fields. This seems to be significant and can have a large impact on farmer's costs and groundwater quality. From 2004 PARDYP plans to look at ways of improving the time and rates of fertiliser application through lysimeter studies of nutrient movements.

On-farm research

PARDYP seeks to identify sustainable farming practices that reduce negative environmental impacts and increase farmers' incomes without increasing women's workloads.

On-farm trials in Pakistan, India, and Nepal have raised many questions. The few failures have helped to provide a broader understanding of issues of adoption and scaling-up. In Pakistan the responses from the local community have been excellent and this has led to high credibility and the consequent adoption of many practices promoted by the project including vegetable seed production, line planting maize, and intercropping.

One of PARDYP's greatest successes has been encouraging farmers to learn about new techniques from each other. For a number of years the PARDYP network has wanted to try out the planting of hybrid maize in rows. Maize was already planted in rows in the Xizhuang watershed in China, but in a very intensive way that was not really replicable elsewhere. Following successes with improved maize varieties in Hilkot in 2001, the Pakistan team started to look at composite and synthetic types of hybrid maize. The high cost of the seed meant that the traditional practice of broadcasting seed and later thinning out the plants was not appropriate. The Pakistan team has been able to double yields and grow other crops in between the rows of maize, whilst also, probably, improving the use of fertilisers.

These successes have prompted the Nepal team to try out this new practice. They plan to start work in 2004 with the International Maize and Wheat Improvement Centre (CIMMYT) and the Swiss Agency for Development and Cooperation-funded Hill Maize Project. Although maize is less important to farmers in the India Bheta Gad watershed, hybrid maize could be usefully demonstrated to farmers there.

PARDYP needs to also learn from outside initiatives. Work on improved composting has not been a success in Nepal partly due to the lack of follow-up by PARDYP's local partners. However, the Swiss-funded Sustainable Soil Management Program (SSMP) is promoting the use of black plastic sheet covers to improve compost quality. This will be tried by PARDYP Nepal in 2004.

PARDYP has had some clear successes but now needs to clarify and consolidate these results and decide what to do next. One approach would be to get each country team to consider the five or so best options, pieces of information, or advice that has come out of their work; then

describe them and plan the next steps including perhaps more research and testing, and then consider how to get more farmers to adopt the new techniques.

The following PARDYP-tested measures show great promise for farmers of the HKH region:

- line planting, incorporation of legumes, and improved fertilisation to improve maize yields;
- improved terracing;
- fish ponds in areas with perennial watersources using three species of carp to exploit different niches within ponds and provide income and nutritious food;
- the application of biofertilisers such as rhizobium and azotobacter to improve crop yields;
- planting crops in mixtures to lessen the risk of complete crop failures and to diversify incomes;
- drip irrigation to reduce water demand and labour inputs; and
- using the system of rice intensification technique of planting rice to increase yields.

The demonstration of alternative pest management with bio-pesticides has shown promise but has not been adopted because it is too time consuming and is less effective than the cheap readily available pesticides. Work on the application of lime to acid soils needs elaborating.

Soil fertility

PARDYP has documented soil fertility dynamics on intensively-used land since 1989 in various publications and has linked these dynamics to changing land use and land use practices in the Jhikhu Khola watershed. It has become clear that farmers are able to detect change and come up with solutions faster than researchers. The details of this work are detailed by Shah in this volume (2005).

Common property resources

The rehabilitation and management of common property resources has been an important theme in PARDYP's research. One of the main conclusions has been that the handing over of management responsibilities for common property to user groups often improves management. The research has also shown how developing community responsibility by forming user groups and applying a range of technical options including recommended species for planting will most often lead to the rehabilitation of degraded land.

Land use dynamics

PARDYP has mapped the land use in its five watersheds and either by repeating these surveys over time or by using historical data has been able to see land use dynamics. Further work is needed and repeat surveys will be carried out in 2004 using new satellite data. The main finding so far has been that all of the watersheds have either stable or increasing forest cover. These findings cannot be generalised as different approaches to land management in the watersheds have different impacts. However, in Nepal there appears to be a reduction in the quality of forest cover probably due to the on-going insurgency. Separate analyses and country studies need carrying out to quantify change.

PARDYP's studies of common property resources have found that the degraded parts of forests in its watersheds, although they make up about only five percent of the total area, contribute about 50% of the river-transported sediment that leaves the watersheds. The lasting rehabilitation of these areas will only happen if local users benefit. In Nepal, forests provide fodder for livestock and litter for bedding that end up as compost to fertilise arable land.

Technical solutions to biomass production (planting fodder trees and grasses, improving forest management) and reducing soil erosion (by plugging gullies and reducing surface flows) are relatively easy to put in place. The challenge is more in terms of the institutional arrangements needed for the long-term sustainable management of these areas.
But ideas cannot be merely transplanted from area to another. For example, Nepal's community forestry approach needs modifying to fit different national conditions for use in other countries.

Adoption of options

PARDYP has found that the adoption of innovations it has promoted relies on it:
- establishing the credibility of its research teams with local farmers;
- having sensible and workable options for improvements to be tested and demonstrated; and
- involving farmers as research partners.

The basket of sensible and workable options considered suitable for research farmers to test and adapt consists of many well-know technologies and practices. As research continues many of the possible options are dropped by farmers for being judged unsuitable for local conditions. Local farmers have tried green manuring and growing button mushrooms but have not wanted to adopt them. However, these options may be suitable for other conditions. Combinations of options can have a significant impact such as improved composting combined with line planting, water harvesting, and drip irrigation. Simple changes can have dramatic results.

Some examples of transfer of innovations from one area to another have been:
- broom grass from northeast India to Uttaranchal;
- large cardamom from Sikkim to Nepal; and
- fish ponds from Pithoragarh to the Bheta Gad watershed in India.

Some examples of transfer of innovations between PARDYP watersheds have been:
- the system of rice intensification from Nepal to Bheta Gad, India and Hilkot, Pakistan;
- fish ponds from Bheta Gad to Hilkot; and
- broom grass and large cardamom from Nepal to Bheta Gad and Pakistan.

Popular Options

PARDYP's research has found the following ten options to be the most popular as they lead to significant improvements in farmers' livelihoods.

1. Biofertilisers – Trials in India, Pakistan, Nepal and China have shown that the application of certain microorganisms has consistently increased yields by around 25% for beans and wheat. Phosphorous mobilising bacteria and *Azotobacter* species have shown the most promise. Also, yield increases of 40% have happened when legumes have been inoculated with the right strain of rhizobium.

2. Improved seed – Good quality seed makes a large difference. In 1999 maize farmers in the PARDYP Pakistan watershed doubled their yields by planting improved varieties. In 2002 farmers planted hybrid maize and doubled their yields again. In India wheat yields doubled when improved varieties were planted. However, improvements in one area may lead to other

kinds of problems emerging. For example, using more demanding improved varieties may lead to shortages in micronutrients. Farmers too recognise that it is crucial to maintain soil fertility and hence techniques for improving the quality and quantity of compost are very popular.

3. Napier grass – The growing of Napier grass is spreading through farmer-to-farmer diffusion. Napier grass for fodder grown on field margins and terrace risers has been promoted by NGOs, projects, and line agencies for many years. PARDYP Nepal is promoting 11 grasses and fodders suited to a range of altitudes and soil types and a wide range of farmers' needs.

4. System of rice intensification – Rice farmers can increase their yields by up to 50% by adopting aspects of the system of rice intensification (SRI) such as early transplanting using 7-10 day old rice plants. This doubled the number of tillers over traditional practices in all farmers' trials in the Pakistan and Nepal watersheds. But so far trials in the PARDYP-India watershed have been unsuccessful. In 2003, 10 farmers in the Nepal watershed tested SRI. All of them selected small blocks of their poorest paddy land as they were not convinced it would work, but they went ahead because of their previous successes with PARDYP's recommendations. In all cases farmers reported that their highest yields came from their SRI plots. PARDYP is planning to try the same approach in 2004 in India and Pakistan. It looks like it is the stress caused to the plants by the early transplanting that leads to quadrupling the number of tillers per plant and yield increases. The significantly more labour needed for weeding has not dissuaded small farmers from adopting this technique as their primary concern is to increase yields.

5. Fish farming – Another success has been with fish ponds in the Bheta Gad watershed, Uttaranchal. What started as one trial with a water harvesting pond fed by a small perennial water source for irrigating vegetables has been developed and adopted by many farmers. There are now more than 70 fish ponds in this watershed. This backyard fish culture has been modified and adopted by farmers. Ninety percent of fish pond owners are poor scheduled caste people. PARDYP is receiving many requests from watershed management practitioners to know how to set up and run these ponds.

6. Off-season vegetables – It is important that mountain farmers take advantage of their 'niche' climatic conditions. This is often their only comparative advantage over agricultural enterprises in the plains. If market access is good, off-season vegetables and temperate fruits can give very good returns. While some farmers in Nepal have been quick to intensify the valley bottom production of irrigated vegetable crops, there has been virtually no improvement in crops like papaya and lychee which are both seen as crops for home consumption and the surplus for giving away to friends and neighbours. In Pakistan, the raising of grafted fruit trees for sale to meet increasing local demand, and the growing for sale of improved pears (sold at 10-20 rupees per 25 kg) and walnuts in Uttaranchal may also prove to be successful enterprises.

7. 'New crops' – In some areas it may be possible to grow fruit commercially or semi-commercially. Fruit can also improve family nutrition. The introduction of new fruits such as 'low-chilling' apples that do not need low temperatures to fruit, and kiwi fruit for October/November harvesting extends the period when fruit is available. This spreads both the labour requirements and the income through the year. Marginal degraded land is often the only land available for expanding agricultural activities. The establishment of fruit trees on this

land is difficult but not impossible. New approaches used in Pakistan have combined the use of eyebrow terracing and porous pitchers to establish apple trees on stony dry areas. Fortunately rainfall is quite evenly spread throughout the year in the Pakistan watershed and so, by concentrating on collecting water from the small but frequent rainfall events, it has been possible to achieve good establishment.
Other promising new crops include shitake mushrooms grown on alder logs for selling to East Asian markets, and asparagus for sale to urban markets and for export.

8. Improved composting – The adoption of new practices often leads to agricultural intensification and more demand for nutrients. The imposition of the stall-feeding of livestock following the introduction of community forest management has significantly increased the availability of farmyard manure in Nepal. The use of improved forages can also increase the amount of farmyard manure. Improved composting can also make significant improvements in soil fertility management. Significant improvements in quality (10%) and rates of composting (40% faster) by covering compost heaps with black plastic sheets have been demonstrated in Nepal and is proving popular.

9. Degraded land rehabilitation – In the Bheta Gad watershed in India, the out-migration of young people from farming families has led to a large area of agricultural land being abandoned. This land is now being used for open gazing and is threatened by degradation. PARDYP has promoted the rehabilitation of these sites by mobilising families to informally consolidate their individual plots. It has promoted the rehabilitation of these degraded lands by increasing green cover through planting fodder trees and grasses, by improving forest management, and by reducing soil erosion by plugging gullies and reducing surface flows.

This has led to farmers in four other villages doing the same to overcome their fodder and timber shortages. An important reason for the success of this has been the testing and demonstration of new technologies and species by the PARDYP researchers including both native local and exotic species and techniques. The challenge is now to establish the institutional arrangements for community management that will lead to access and benefit sharing to promote long term sustainable management of these areas.

10. Drip irrigation – In areas of water scarcity the use of locally available and inexpensive drip irrigation systems enable farmers to grow off-season vegetable crops; the use of eyebrow terraces and pitcher irrigation enable farmers to establish fruit tree orchards; and the use of water harvesting in ponds can significantly increase income. Small mud-lined farm ponds of 10 m^3 size are providing income of $100 or more per year in PARDYP India's watershed.

Conclusions

In summary PARDYP's research findings have found that:

- although there are many good options for farmers, many are not being adopted because farmers are unaware of them;
- on and off-farm demonstrations, with many options at one location serving as a kind of 'beacon' for farmers, can greatly increase adoption by farmers. However, for up-scaling local extension staff need to well-trained and to have established their credibility and trust with farmers;
- working with farmers to develop ideas can be rewarding and lead to good results;
- natural systems seem to be more resilient than generally thought to changes in land use and farming practices. But there may be a strong 'buffering' effect where changes in

environmental parameters such as increasing nitrogen levels in water or increasing soil acidity only become visible later;
- the health of the five research watersheds over the last 10 years has at least been maintained or has improved significantly in terms of tree cover;
- the rates of soil erosion from agricultural land are much lower than originally thought, while soil erosion from degraded land may be the source of most river-transported sediment
- the most important hydrological issues are the low flows in watercourses during dry periods and how to improve water management, rather than about floods and how to reduce peak flows; and
- new unforeseen problems are arising in farmers fields including new nutrient deficiencies resulting from more intensive cropping.

An important lesson that PARDYP has learnt is the importance of tailoring its recommendations to meet farmers' preferences. Unsuitable options will be ignored. An example of this came from the PARDYP-Pakistan area. Here, the bulk of agricultural land is owned by the Swati ethnic group, but it is farmed by the Gujars who keep livestock. They operate a sharecropping system with the landlords. Crop residues are a very important source of fodder for the tenant farmers. Consequently PARDYP's attempts to introduce high yielding, short-straw varieties failed. The doubling of grain yield was very attractive to the landlords, but the new varieties were not adopted by the Gujar farmers because of the poor fodder straw yields. PARDYP is now searching for high yielding long-straw varieties. This was a good lesson for the project.

As PARDYP conducts more research and gains more credibility new avenues of funding have opened up. It seems that government agencies, NGOs, and projects are willing to make money available for development activities in all the PARDYP watersheds. What seem to be missing are new promising ideas from all development actors. One problem is that projects often have an intervention cycle that is too short for the PARDYP process of building up credibility, understanding communities' needs, and identifying credible solutions. PARDYP has taken seven years to gain credibility. Many large projects such as the Bagmati and Wang watershed management projects are only five-years long. Success can be very difficult to achieve in such short time horizons.

All projects have strengths and weaknesses. Only when PARDYP networks in an honest and frank way can it learn from other projects in terms of successes and failures. PARDYP and other projects need to give more attention to this.

PARDYP's Five Watersheds and Six Components

The PARDYP Teams

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PARDYP is a research for development project, funded by the Swiss Agency for Development and Cooperation (SDC), the International Development Research Centre (IDRC) of Canada, and the International Centre for Integrated Mountain Development (ICIMOD). It operates in five middle mountain watersheds across the Hindu Kush-Himalayas (HKH) with two in Nepal and one each in China, India, and Pakistan. The location, drainage pattern and basic characteristics of the watersheds are given in Figure 1 and Table 1.

PARDYP is coordinated and managed by ICIMOD and implemented by the following partner institutes:

- Kunming Botanical Institute and the Centre for Biodiversity and Indigenous Knowledge (CBIK) in China;
- G.B. Pant Institute of Himalayan Environment and Development (Almora) in India;
- Pakistan Forestry Institute (Peshawar) in Pakistan; and
- ICIMOD in Nepal.

PARDYP Phase 1 ran from October 1996 to September 1999, Phase 2 from October 1999 to December 2002, and Phase 3 runs from January 2003 to December 2005. These workshop proceedings show the progress made in Phase 2.

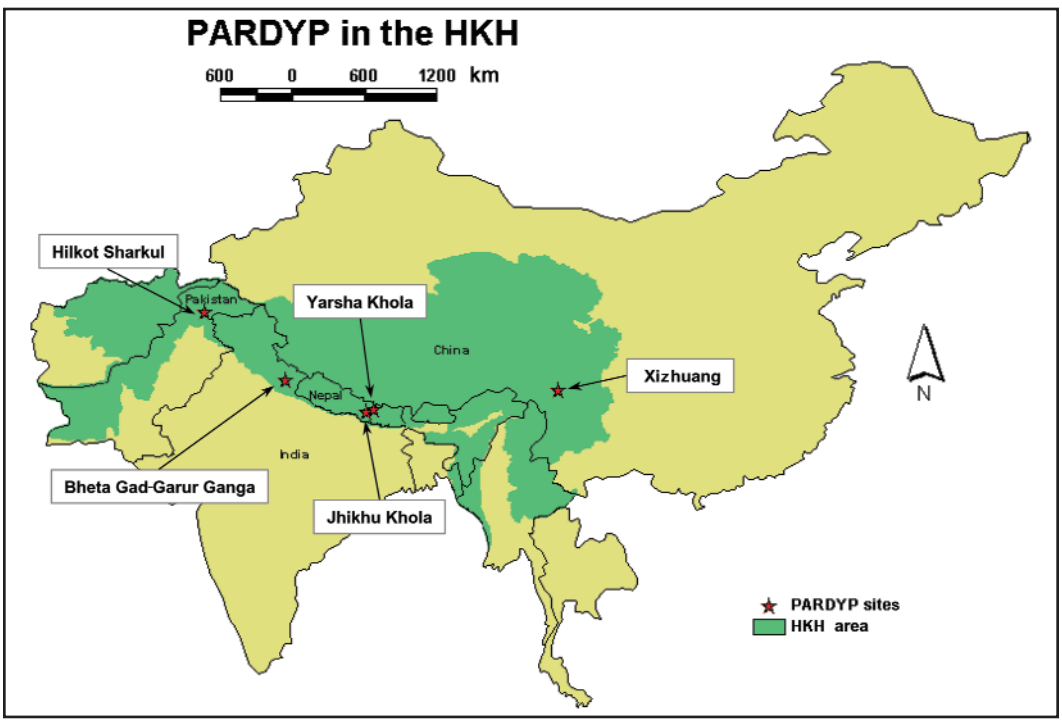
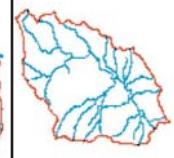
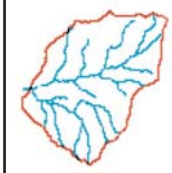
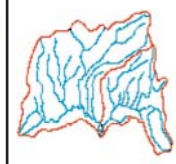


Figure 1: **Location of PARDYP watersheds**

Table 1: **Characteristics of the PARDYP watersheds**

					
	Xizhuang	**Bheta Gad-Garur Ganga**	**Jhikhu Khola**	**Yarsha Khola**	**Hilkot- Sharkul**
	China	**India**	**Nepal**	**Nepal**	**Pakistan**
Physiography	Xizhuang	Bheta Gad-Garur Ganga	Jhikhu Khola	Yarsha Khola	Hilkot-Sharkul
Total area	3,456 ha	8,481 ha	11,141 ha	5,338 ha	5,230 ha
Elevation range (masl)	1700-3075m	1090-2520m	800-2200m	1000-3030m	1448-2911m
Climate	Wet and dry seasonal variations	Sharp wet and dry seasonal variations	Humid sub-tropical to warm temperatures	Humid sub-tropical to warm temperatures	Humid sub-tropical to cool temperatures
Average rainfall (mm/yr)	1413 mm	1291 mm	1316 mm	2276 mm	911 mm
Dominant geology	Limestone and sandstone	Schists and gneiss	Mica schist and limestone	Gneiss and slate and graphitic schist	Micaceous schist, and slates
Population	4016 (1997)	14,524 (1998)	48,728 (1996)	20,620 (1996)	11,322 (1998)
Population density (people/km^2)	116 (128 in 2002)	171	437 (587 in 2001)	386	243
Average family size	4	7	6	5	8
Dominant ethnicity	Han Chinese	Brahmin, Rajputs, scheduled castes	Brahmin, Chhetri, Tamang, Danuwar	Brahmin, Chhetri, Tamang	Gujar, Swati, Syed
Major cash crops	Tea, tobacco, fruit	Winter vegetables, fruit, tea, fodder	Potatoes, tomatoes, rice, fruit, vegetables	Seed potatoes, fruits	Fruit, fodder
Main staple crops	Maize, wheat, beans, potatoes, rice	Mixed cereal grains, rice, wheat	Rice, maize, wheat, potatoes, millet	Maize, rice, millet, potatoes, wheat	Wheat, maize, rice

PARDYP evolved from the following IDRC-funded initiatives:

- the three-year long Soil Fertility and Erosion Project and the follow-on four-year Mountain Resource Management Project (1989-1996) that undertook resource dynamic studies in the Jhikhu Khola watershed, Nepal; and
- the Rehabilitation of Degraded Lands in Mountain Ecosystems Project (1992-1996), undertaken by research institutes in China, India, Nepal and Pakistan involving the rehabilitation and regreening of patches of degraded and denuded land on HKH valley slopes.

The project was launched in response to concerns about the pressures on the resources and people in the HKH middle mountains. Issues of particular concern were the marginalisation of the mountain farmer, the declining availability of water and land, forest degradation, declining soil fertility, declining carrying capacities of the resource base, the lack of natural regeneration, and the challenges to providing for the needs of the increasing population.

PARDYP is carrying out research for development in hydrology and meteorology, farming systems, land cover, water availability and management, soil erosion and fertility, on- and off-farm conservation, land rehabilitation, community forestry, agronomic and horticultural initiatives, and social, economic, gender and marketing issues.

Three international institutions have provided advice, support, and consultancy services to PARDYP since its inception. The University of British Columbia provides inputs mainly in Nepal on soil fertility management and productivity through periodic visits by its staff. The University of Berne provides expert advice on hydrology through periodic visits and a permanent research hydrologist based in Kathmandu. Inputs from the University of Berne cover all five watersheds. From January 2003, the Geography Department of the University of Zurich has been assisting PARDYP with issues relating to access to natural resources and by providing broad backstopping in the social sciences. Representatives from these three institutes are members of PARDYP's Technical Advisory Committee.

In Phase 2 project activities were organised around the six components of 1) community institutions, 2) gender and equity, 3) water resources, 4) common property resources, 5) on-farm activities, and 6) livelihood potentials. The highlights of the Phase 2 work were as follow.

Community institutions

PARDYP has reviewed natural resource policies and decentralisation and accountability in watershed management through:

- carrying out work on decentralisation in China;
- making an inventory of community based organisations in the PARDYP Nepal watersheds;
- carrying out studies in India on the impact of resource dynamics on people's occupations, drinking water, community forestry, and joint forest management; and by
- looking at watershed management issues in Pakistan concerning ethnic groups, land tenure, and conflicts, and by trying out joint forest management.

Gender and equity

PARDYP's Phase 2 work on gender and equality has included:

- in China, running activities to build the gender awareness of government staff that has encouraged them to use gender equality indicators to evaluate the work of government leaders and staff;

- in India, by organising meetings and motivational activities to empower women and women's groups, and by promoting off-season vegetable production, improved composting, and small-scale nurseries;
- in Nepal, by mainstreaming gender issues into most of its activities including in the water, common property resource, on-farm resources, livelihood potentials, research studies, and field action programmes. These programmes have concentrated on the role of women in managing natural resources and have highlighted their central role in managing and harvesting these resources; and
- in Pakistan, by appointing female social mobilisers and a female horticulturalist to support savings and credit and kitchen gardening activities though the project's women's groups, and also by holding women's farmer's days.

Water resources

The daily monitoring of PARDYP's network of 44 meteorological stations, 27 hydro-stations, and 23 erosion plots continued in the four countries. Data has been analysed and published in annual yearbooks for all the watersheds and provides valuable information on climatic conditions, stream flows, and sediment transport. This unique data series is comparable between sites and is extremely valuable for designing hydropower stations, improving irrigation, preventing storm destruction, and other uses.

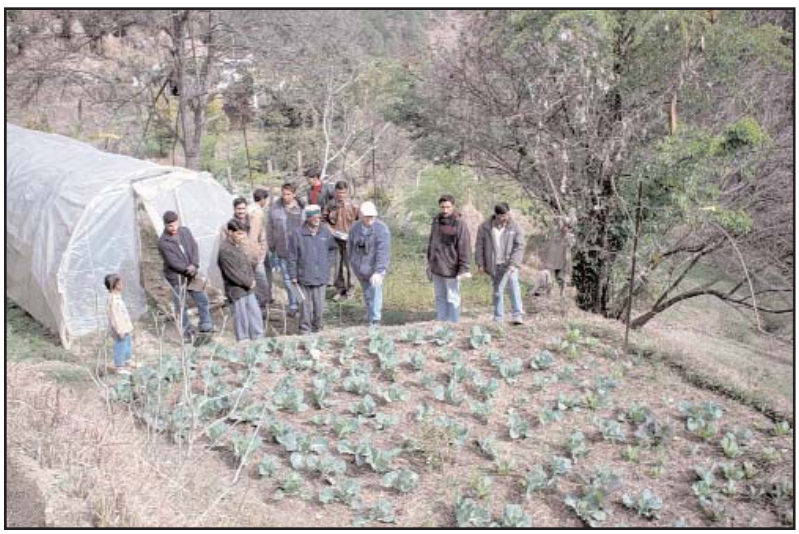
A PARDYP station, Nepal

Common property resources

PARDYP's common resources programme has focussed on community forests in Nepal, village forest panchayats in India, community owned gujara forests in Pakistan, and the central role of women in this work. The rehabilitation of heavily degraded sites is one of the most challenging tasks in these forests. The PARDYP Nepal team has carried out a successful six-year long programme with a user group to rehabilitate such an area. The condition of this area has greatly improved with soil erosion reduced and soil fertility improved. It is now producing much fodder and serving as a demonstration site for other user groups to see the potential of degraded areas.

On-farm activities

- In China, on-farm trials have been carried out to introduce new crops and varieties; experiments have been run on agroforestry, reforestation, and water harvesting; and local farmers have been trained in growing tree seedlings and fruit tree grafting.
- In India, the introduction and piloting by farmers of biofertilisers has led to significant increases in grain crop yields.
- In Nepal, many on-farm demonstrations and species performance trials have been carried out. Results look promising for the wider dissemination of alternative pest management, improved rice varieties, the growing of grasses and hedgerow species for fodder and composting, the growing of new cash crops, and the use of drip irrigation.
- In Pakistan over 140 on-farm trials have been conducted including on the effects of organic fertilisers, biofertilisers, intercropping, and cover crops; the performance of new varieties of maize and rice; and on tea growing. Initial results have been promising and farmers have started to adopt many of these new technologies.



Innovations to increase productivity

Livelihood potentials

- In China, PARDYP has supported the establishment of nurseries that are growing forest and agroforestry tree species and tea plants.
- In India, the project has successfully introduced small-scale fish farming and improved bee-keeping using an indigenous species of bee.
- The PARDYP Nepal team has identified a set of strategies for improving livelihoods and has found that increasing cash crop production, although generally beneficial, comes with health hazards due to the overuse of chemicals.
- PARDYP Pakistan has collected data on medicinal plants, trained farmers on keeping local honey bees, promoted the planting of thousands of fruit trees, trained farmers in mushroom production, and run farmer-to-farmer visits to observe alternative ways of farming.

Phase 3 approaches

New approaches are being adopted in Phase 3 (2003-2005) with research activities being carried out in the following four 'expected result areas' through 20 sub-projects.

- Options for improved farming systems productivity developed and tested (ER1 – 7 sub-projects).
- Options to increase productivity of agricultural land tested and disseminated (ER2 – 6 sub-projects).
- Water management options for equitable access identified, tested and disseminated (ER3 – 2 sub-projects).
- Options and approaches to impact sustainable and equitable access to water land and forests are identified and disseminated (ER4 – 5 sub-projects).

More information on PARDYP is available at www.pardyp.org