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END OF PROJECT REPORT

(December 1, 1989 - August 7, 1994)

MANAGEMENT OF AGRICULTURAL RESEARCH AND TECHNOLOGY/ARID ZONE RESEARCH COMPONENT (MART/AZR) (MART Project 391-0489)

A special report prepared under the provisions of the USAID Grant 391-0489-G-00-0501-00

by

Euan F. Thomson
Chief of Party, MART/AZR Project
International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

July 1994

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(December 1, 1989 - August 7, 1994)

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(The views expressed in this report are those of the author)
(and do not necessarily represent those of ICARDA or USAID)

FOREWORD

The Arid Zone Research Institute (AZRI) battles to survive in a hostile climatic, financial, administrative and cultural environment. But, perhaps most significant of all, it battles with itself. The climate is harsh, with low rainfall and low winter temperatures being the principal abiotic constraints to crop and animal production. The 1993/94 cropping season was extreme since the total rainfall was only 104 mm at AZRI, compared with a long-term average of about 240 mm. During the last 14 years AZRI's budget has gradually diminished in real terms and it has only been able to survive the last nine years due to support from the Project. Funding under the federal component of the ARPII loan will delay until 1997 the day when AZRI has to survive on its own merge operating budget. Like many other PARC institutes away from Islamabad, AZRI is at a severe administrative disadvantage compared to PARC HQ and NARC. Even its location on the periphery of Quetta adds to its difficulties. The majority of staff live in the adjacent colony which makes even daily shopping a struggle since there are few shops nearby. Many of its staff and their families are also from other provinces which makes them feel foreigners in Quetta. The condition of the houses they live in is steadily deteriorating due to a complete lack of routine maintenance. All these difficulties, and the cultural tensions that are just below the surface in the Province, act as obstacles to progress within the institution. It is therefore hardly surprising that staff getting overseas MSc and PhD degrees escape from AZRI for more favourable locations. Despite these difficulties, AZRI has shown a number of significant achievements during the nine-year life of the Project.

This end-of-project report has five chapters. The first chapter examines the goal, purpose, objectives and activities of the Project. The second chapter presents an overview of the Project's achievements and indicates what might have been done differently. Chapter 3 outlines the resources available for research at AZRI, and Chapter 4 - called Looking Ahead - makes suggestions about future research priorities and directions. The last chapter presents some final comments about AZRI.

It is assumed that this report will be primarily read by officials at AZRI, PARC, ICARDA and USAID who have a general knowledge of the agriculture, natural resources and climate of Balochistan. To maintain brevity, the report therefore contains a minimum of descriptive information about the Province. More detailed information can be found in the reports cited in Annex 1. This report also concentrates on Phase II of the MART/AZR project from December 1, 1989 to August 7, 1994, whereas a final report on Phase I is presented elsewhere[1].

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[1]ICARDA. 1990. High-Elevation Research in Pakistan: The MART/AZR Project Annual Report 1989. ICARDA, Aleppo. ICARDA-158En.

ACKNOWLEDGEMENT

The MART/AZR project ends in August 1994 after about nine years. Phase II of the Project started in December 1989 and Dr Dyno Keatinge, the Chief of Party (COP) during Phase I, ably steered the Project through the transition period until July 1990 when I took over as COP. I received loyal support during Phase II from Dr Alister Allan, the Agronomy, Water Harvesting and Germplasm advisor who arrived in March 1990, and from Dr Abelardo Rodríguez, the Agricultural Economics Advisor, who arrived in May 1990. Dr Allan and Dr Rodríguez completed their contracts in March and July 1992, respectively. My own responsibilities included being overall project leader, advisor on Range and Livestock and advisor to the Director of AZRI on research management. I left Quetta on August 3, 1994.

The former Director of AZRI, Dr Bakht Roidar Khan, worked closely with me for about two-and-a-half years and gave me tremendous support. He was the principal AZRI colleague who bridged Phases I and II of the Project. His successor, Dr Abdul Sattar Alvi, became Director during the final 18 months of the Project. Taking over as Director when the Project was so close to finishing was not an easy task but he still gave me tremendous backing. In his former capacity as MART Project Secretary at PARC, he came to AZRI with several years of experience about the Project.

Many other people gave their support to my colleagues and myself. Dr Zafar Altaf, Chairman of PARC, was always a staunch supporter of the Project and AZRI. He was always ready to meet me at short notice to discuss the numerous and often intractable issues on the AZRI agenda. Mr Muhammad Rafiq and his successor Dr Sulaiman Hamid in their capacity as Member (Natural Resources) at PARC and direct superiors of the AZRI Director, handled the many administrative matters sent to them by the Director.

The succession of MART Project Officers at USAID, Drs Curtis Nissly, Ron Senykoff and Muhammad Khalid, all provided essential back-stopping to the Project. They were always there when needed. Drs Pat Peterson, Arnold Radi, John Swanson, Dennis Weller and Muhammad Saeed also gave their support and encouragement at critical times.

The AZRI staff in general also deserve mention. They had to tolerate a range of moods which were largely determined by the progress that the Project was making. Hopefully I imparted some knowledge to them. I wish I could have given them more of my time.

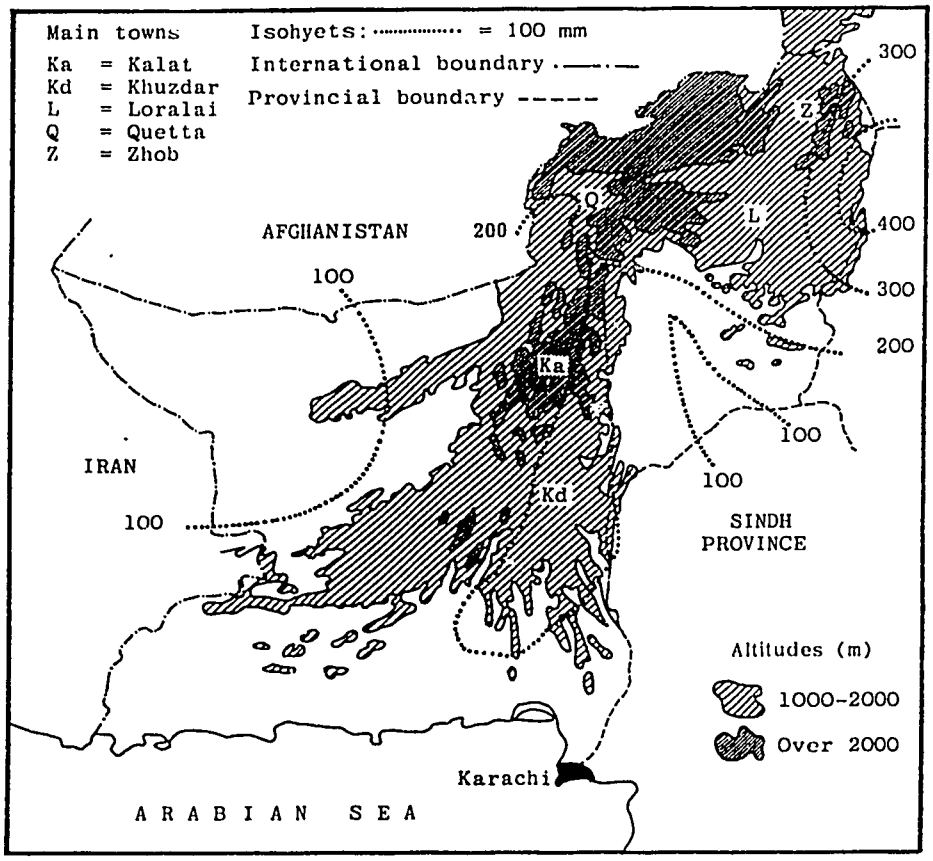
Many staff at ICARDA Headquarters in Syria helped the Project run smoothly. Dr Keatinge, who on leaving AZRI became Coordinator for the ICARDA Highland Region until August 1993, was always ready to provide instant advice and support as and when required. He provided an essential liaison function when all efforts to communicate with ICARDA headquarters failed. Dr Booth, Assistant Director General for International Cooperation at

ICARDA, was always working in the background to enable the smooth running of the Project. Similarly, Mr Barmada, Mr Sitaraman and Mr Eduardo handled with skill the Project's accounts from afar. Many ICARDA scientists visited AZRI during Phase II. Their willingness to make the short but relatively tiresome overnight journey from Syria is appreciated.

The ICARDA office staff in Quetta deserve particular mention, above all Mr Pesi Amaria who was the key person who kept the wheels of the Project turning on a day-to-day basis and found solutions to problems before they developed into crises. The ICARDA staff showed a commendable degree of devotion and several of them stayed almost to the end. It was very painful having to release them from employment.

July 1994

Euan F. Thomson
MART/AZR Project Leader
and USAID Chief of Party,
ICARDA Livestock Scientist



Map of Balochistan Province in south-west Pakistan, showing areas over 1000 and 2000 m altitude, isohyets and main towns. The Arid Zone Research Institute (AZRI) is situated in Quetta. It has its main range/livestock stations at Zarchi (near Kalat) and Tomagh (near Loralai). Most of AZRI's on-farm sites are close to Quetta (altitude 1600 m).

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LIST OF COMMON ABBREVIATIONS

ARI	Agricultural Research Institute (Sariab Road, Quetta)
ARPII	Agricultural Research II Project (loan from World Bank)
AZR	Arid Zone Research (the AZRI component of the MART project)
ASO	Assistant scientific officer
AZRI	Arid Zone Research Institute
BOSTID	Board of Science and Technology for International Development, National Research Council, Washington
BRSP	Balochistan Rural Support Program
CBWH	Catchment-basin water-harvesting
CDRI	Crop Diseases Research Institute (of PARC)
CIMMYT	Centro Internacionale de Mejoramiento de Maiz y Trigo
COP	Chief of Party
CV	Coefficient of variation
DRMP	Dryland Resource Management Project (of ICARDA)
FAO	Food and Agriculture Organization of the United Nations
FSR	Farming System Research
FWSB	Fourwing saltbush (*Atriplex canescens*)
GOB	Government of Balochistan
GOP	Government of Pakistan
ICARDA	International Center for Agricultural Research in the Dry Areas
LRRI	Land Resources Research Institute (at PARC)
LTT	Long-term training
MART	Management of Agricultural Research and Technology
NARC	National Agricultural Research Center
NGO	Non-governmental organization
PACD	Project Actual Completion Date
PARC	Pakistani Agricultural Research Council
PCSIR	Pakistan Council for Scientific and Industrial Research
PCRWR	Pakistan Council for Research in Water Resources
PEP	Productivity Enhancement Program
PSO	Principal Scientific Officer
RRI	Range Research Institute (at NARC)
SO	Scientific Officer
SSO	Senior Scientific Officer
STT	Short-term training
SWU	Sheep and Wool Unit (at NARC)
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WRRI	Water Resources Research Institute (at NARC)
YR	Yellow Rust (*Puccinia striiformis*)

EXECUTIVE SUMMARY

The February 1989 MART Project Evaluation Report[1] states: "The objective of a fully functional, well organized and well managed Arid Zone Research Institute, staffed with competent professionals by the end of the contract (November 1989) will not be reached by the Project Actual Completion date (PACD). Current staff lacks the capacity and experience to design and manage research independently. Technical assistance should continue for an estimated four to six years." This statement provides a background for the Executive Summary.

1. This report is about Phase II of the Arid Zone Research component of the Management of Agricultural Research and Technology (MART/AZR) project, funded by the USAID Mission to Pakistan as a grant to the International Center for Agricultural Research in the Dry Areas (ICARDA). Phase I of project covered the period June 1985 to November 1989, and Phase II December 1989 to late July 1994. The project aimed to strengthen the Arid Zone Research Institute (AZRI) in Quetta, the capital city of the mountainous and arid to semi-arid province of Balochistan. This strengthening took the form of technical assistance to guide the staff in the design and implementation of a research program, the analysis and reporting of the results, and the initiation and implementation of a short and long-term training program.

2. AZRI is an institute of the Pakistan Agricultural Research Council (PARC) responsible for research into solutions to the problems facing the large areas of Pakistan where water is limited for irrigation. Phase I of the MART/AZR project - the 'Project' - had a budget of some $4.5 million which was used to provide 4-5 technical advisors, operating budget and commodities. Phase II used $1.5 million saved from Phase I, to provide three technical advisors for the first two years and one for the remaining two years, as well as a budget for research operations and some commodities.

3. AZRI battles to survive in an hostile climatic, financial, administrative and cultural environment, and, most significantly, it battles within itself. The climate is continental Mediterranean, with annual rainfall as low as 50 mm and as high as 450 mm depending on the part of the Province. It falls mainly in winter although monsoon rains are received along the eastern border with Punjab and Sindh Provinces. The winters are cold because of the altitudes which range from 1000 to 3500 m in the central and northern areas. Summers are hot and dry. Financially AZRI has had a shrinking budget in real terms over the last 10 years, and currently 80-90% is used for staff salaries and benefits. Administratively, AZRI is at a severe disadvantage because of its isolation from PARC. This can be seen when allocation of long-term training (LTT) slots and special project funding is made, even if

[1]See MART (1993). MART Project Evaluation Report (Final Draft). PARC-USAID, Islamabad. Page vii.

AZRI has a right to defined allocations. Efficient management of the institute is also hindered by an out-dated set of administrative rules and regulations. The Province has a very different cultural environment to the rest of Pakistan, whereas AZRI draws many of its scientific staff from outside the Province. This partly explains why it is so difficult to create a team spirit. Although these factors combined to have a profound influence on the performance of AZRI and the Project, there were some significant achievements.

4. The scope of the activities proposed in the Phase II project documents was far too wide for the existing staff to handle. This induced a gradual narrowing of the research focus over the four years of the Phase, accomplished during the annual research planning process held each year starting in 1987. The output of this planning process was an annually revised book of research protocols. In 1993 an arduous and lengthy review of the whole AZRI research portfolio took place, with further narrowing of the research focus. Even as the number of protocols in the portfolio decreased, the rate at which protocols were completed remained very low.

5. The Project was seriously flawed by the incongruence between the number of technical advisors and the quality of the staff. Thus, there were 4-5 advisors during Phase I when the best staff were being selected and sent to start LTT at overseas universities, whereas during Phase II when the number of advisors gradually declined to one, staff completing LTT had less access to advice at a time when they needed it most.

6. The most visible research effort during the Project was, arguably, the seven-year program on catchment-basin water-harvesting (CBWH). This is because it is only through more efficient use of the limited rainfall that crop yields will be increased. The difficulties of applying the technique, even under experimental conditions, were highlighted by the poor yields generally achieved in the trials. The economic benefits of the technology were also shrouded in controversy although a degree of risk reduction was apparent. However, there were signs that the technology has promise which led to an expanded on-farm program in Kovak Valley, which was then thwarted by the extremely low rainfall in 1993/94. The comprehensive survey of farmers' perceptions of water harvesting conducted in 1992 highlighted the need for a flexible technology that allows farmers to vary the area planted as a function of rainfall. The rigidity of the CBWH approach in this respect could be its Achilles tendon.

7. Fourwing saltbush (*Atriplex canescens*) was the main focus of the Range Section's activities. A modest experimental program was largely completed and an on-farm program gradually expanded. The experimental program showed that this drought tolerant shrub has considerable potential to provide additional feed to the poorly nourished small ruminants of Balochistan. In experiments, forage reserves allowed 10-20 g daily gains of nearly 30 sheep per hectare for 3-4 months, equivalent to 1.5 million sheep on 100,000 hectare for a third of the year, assuming a 50 percent lower utilization rate at the farm level. Also, it can

provide 300-600 kg of fuelwood per hectare each year. But the shrub is far from being the panacea to solve the range degradation problems of Balochistan. It has a limited niche on marginal lands, its quality is highest in summer but declines in winter at a time when the feed is most needed, and it will require an extremely well-run on-farm testing program using the farmer participatory approach to achieve adoption of the technology. However, at the present it is the only species known that could be grown for feed and fuelwood on lands marginal for the cultivation of rainfed crops. This 'all-the-eggs-in-one-basket' problem will need to be borne in mind when planning future research.

8. The 'hare and the tortoise' fable could be applied to the steady progress made towards identification of germplasm that either yields more grain than local genotypes, resists local biotic stresses, or both. Several lines of bread wheat with resistance to yellow rust were identified and seed multiplied, and by July 1993 there were also stocks of seed of several promising lines of barley, lentil and woolly-pod vetch. But the greatest challenge to the germplasm efforts of AZRI remains, that is the use of the improved lines by sufficient farmers to make an impact on overall production. To reach this ultimate goal will require the staff in the Section to focus on wheat and barley alone, and to leave their scientific pride in the experimental plots. They will need to work in close harmony with a group of farmers who test the germplasm and multiply it. AZRI will need to establish a small commercial seed unit to market the improved seed once it has been certified, in collaboration with the provincial authorities and NGOs.

9. Several years of trials into factors influencing ewe fertility indicated how the Harnai ewe can lamb every year although this level was not quite achieved in the Balochi breed, for reasons that remain unclear. The studies also showed, to nobody's surprise, that only ewes in poor body condition need feeding to become fertile. Unfortunately a simple net benefit analysis was never performed to show whether the additional revenue from better offtake would cover the costs of even a low level of supplementation. The Livestock Section will have to put all its efforts into on-farm activities to find whether there is any chance of farmers adopting flock management practices that improve offtake and profits.

10. Improving marketing systems complement efforts to improve offtake of animals through better fertility and growth of offspring. The notion that better marketing would lead to better animals being offered for sale, was the reason for studies on the price expectations of producers and market agents ('middlemen') and on the marketing of skins. These pioneering studies for Balochistan merely scratched the surface of this complex subject and need to be followed up. This will require a commitment in the Economics Section to free staff for this work and also need professional guidance from outside.

11. The MART/AZR Project Research Report series is one of the greatest achievements of the Project. It is probably one of the most comprehensive series of any PARC institute and serves as a unique institutional memory. However, this achievement must be tempered by

the gradual fall in the output of research reports since the peak in 1990 when the number of advisors started to gradually decreased towards one. There has been a steady stream of papers published in national and international journals.

12. One of the main weaknesses of the Project was the poor involvement of farmers in the on-farm testing of promising technologies. This is due to several factors, in particular the lack of courses in most agricultural undergraduate and postgraduate degree programs on social sciences and involvement of farmers in the research process.

13. The Project left AZRI with a full set of functional computing equipment that should serve it until the year 2000. It also purchased field and laboratory equipment which will enable AZRI to conduct a modest field program of applied research. The Library was strengthened by purchasing a number of books, as well as 19 journals on microfilm for 10 years until the present. A feed mill was installed and made operational, as were an agricultural workshop and a seed cleaning unit.

14. Short-term training was specialized rather than general and thus involved training and attendance at workshops at ICARDA HQ and visits to universities and research stations in the USA. This strategy aimed to give AZRI staff specialized knowledge and occasion to develop professional contacts with scientists outside Pakistan.

15. Long-term training (LTT) centered on sending staff for MSc and PhD programs at universities in the USA. A total of six staff were sent for PhD and four to MSc programs, and by the end of the Project, three had completed PhD and two had completed MSc degrees. Of these staff, two with PhDs transferred to PARC and NARC soon after returning to AZRI and one remained in the USA. Out of the original 10 staff sent for overseas LTT (including one from AZRI Sub-station Umerkot), it is anticipated that 1-2 with PhDs may return to AZRI for the mandatory five years, whereas four with MSc degrees will remain for longer. Thus, the LTT aspect of the Project failed to reach its target of creating a cadre of better trained staff that are needed to run an effective research institute. A policy of giving priority to the LTT of staff domiciled in Quetta or nearby was therefore recommended and partially implemented in the case of the next batch of staff eligible for overseas LTT. However, the majority of staff sent for LTT are still from outside Balochistan. Indeed, many of them moved to AZRI to exploit the training slots and have little intention of remaining at AZRI after completing their degrees.

16. Questions are raised about the wisdom of sending staff from institutes such as AZRI to attend conventional postgraduate degree programs at overseas universities. This is because these programs generally create specialists with little interest in, or ability to, develop and implement an applied on-farm research program with full participation of farmers. Such a focus is felt to be imperative during the formative years of a small research institute, even more so when there are already some technologies that need to be taken off the shelf and

tested with farmer participation. Newly graduated staff are highly knowledgable about a few disciplines. But they have difficulty stepping outside these disciplines to formulate a research program that is based on real problems identified by farmers rather than perceive problems identified by themselves. This, and the language difficulties that many AZRI staff face when meeting farmers, is one of the main hindrances to multi-disciplinary research and results in a bias towards on-station research.

17. The need for an on-farm research focus driven by farmer participation was emphasized during the Project and some progress was made. This progress must be consolidated in the future.

18. Despite the need for a significant farmer-driven on-farm program at AZRI, it is likely that the discipline-oriented focus will prevail unless there are radical changes in staff attitudes. Moreover, their would need to be a change in the mix of disciplines and the approach to post-graduate training, which seems most unlikely. For this reason it may be more realistic to let AZRI continue with a discipline-oriented focus provided the research is defined by farmers, that is demand rather than desire drive. However, AZRI needs to persevere with some on-farm studies, such as the Kovak Valley project that has the potential to show the impact of 10 years of research on farm output in one valley. Other entities, such as NGOs, will help convey to AZRI what farmers' needs are, and AZRI will find adoptable solutions to these problems.

19. Closer collaboration between AZRI and NARC staff was encouraged but little progress was made apart from the spontaneous cooperation on yellow rust in wheat. If better collaboration between these two PARC institutions is seen as desirable, which is certainly the case, this will have to be facilitated by a mechanism such as linking collaborators through jointly financed projects.

20. Links between AZRI and ICARDA have remained tenuous, because of 1) the disproportionate time expended to travel between Aleppo and Quetta and back relative to the distance, 2) the steady erosion of ICARDA's core budget during the last few years, and 3) the difficulties AZRI staff have keeping to a workplan agreed with their ICARDA collaborators. These links will only be strengthened if evidence is forthcoming that collaboration leads to mutually beneficial progress.

21. AZRI will have to persevere in its efforts to collaborate with the provincial departments. It may, however, find it more rewarding to expand its links with NGOs, such as the Balochistan Rural Support Program.

22. AZRI and PARC will have to find ways to improve the quality of life of staff living in the colony. In particular the houses need urgent and extensive maintenance and a winter fuel allowance should be provided, or an alternative hardship allowance. These small

improvements will make the staff and their families more willing to stay at AZRI for a long time.

23. AZRI management should experiment by giving greater autonomy to Section Heads to run their own projects according to the rules used under the very innovative Productivity Enhancement Program (PEP) and Board of Science and Technology for International Development (BOSTID) competitive research program. AZRI staff would write proposals to compete for funds and successful projects would be given a budget and a separate bank account. This approach would give staff a considerable incentive to conduct quality and relevant research and deliver their results according to a strict timetable. It would also help ensure that a research program relevant to solving the problems of Balochistan was pursued at AZRI.

24. The research program of AZRI will be assisted under the World Bank Agricultural Research II Project until mid-1997. By that time it should have shown which technologies have a high potential for adoption and impact. AZRI must maintain a narrow focus on these promising technologies, rather than let itself be side-tracked into esoteric research. Retaining this narrow focus and impressing on its critics that it can make an impact, is the only way that it will successfully attract additional funds after 1997, whether from provincial, federal or foreign sources. To reach the goal of being an effective and viable research institute that contributes to solving some of the intractable problems of Balochistan in particular, will require resolute, aggressive and assertive leadership. Otherwise AZRI will slowly succumb to the harsh and unpredictable climate, lumbering bureaucracy, fickle administration, declining budgets and provincial culture. This will not happen provided innovative ideas arising from within AZRI are marketed with skill at PARC headquarters.

LIST OF RECOMMENDATIONS

The following section presents a list of recommendations which were written in the light of the experiences gained during the Project.

1. Appoint Director of Research. An experienced, active and creative scientist should be appointed as Director of Research.

2. Improve living conditions at AZRI colony. As part of a comprehensive policy to improve the living conditions of AZRI staff and their families living in the colony, extensive maintenance is needed as a matter of extreme urgency.

3. Budget for routine-maintenance. The Director should make a strong case that in the future the budget of AZRI should include generous provision for routine building maintenance, and a mechanism should be found to pay AZRI staff living on the colony a heating allowance.

4. Training bond. The bond that PARC employees sign before embarking on long-term training should explicitly state the institute, center, department or unit they will return to after completing their degree, rather than just stating returning to PARC in general.

5. Strengthen the small ruminant research at AZRI. Two or three small ruminant specialists need to be transferred from NARC to strengthen the AZRI Livestock Section.

6. Maintain on-farm research orientation. AZRI should avoid any tendency to become research-station-oriented and wherever possible expand its on-farm trials with community and farmer involvement using the participatory approach. AZRI management will have to show strong leadership to consolidate the shift towards more on-farm research achieved during the last five years.

7. Maintain a narrow research focus and consolidate past achievements. AZRI should maintain a narrow research focus based on the most promising achievements of the last nine years. It then has a good chance that some of its promising technologies will be adopted by farmers, and only then will AZRI make an impact in Balochistan.

8. Avoid esoteric research. AZRI should avoid starting new research projects that have doubtful relevance and impact.

9. Assign more time to analyze data. The research load on staff should be adjusted to ensure that they analyze and summarize the previous season's data before starting the next season's program.

10. Hold annual planning meeting and publish an annual workplan. It is imperative to hold an annual planning meeting in July or August and to produce an annual workplan showing the coming season's research activities.

11. Close Zarchi station. Because of the poor quality of the range, the Zarchi site should be closed and the sheep moved to the Maslakh Range site of the GOB Department of Livestock where collaborative studies should be conducted on the genetic potential of the three main sheep breeds of Balochistan - the Balochi, Harnai and Bibrik.

12. Keep Tomagh station. Tomagh station should be kept as long as possible, particularly since the surrounding Asghara Valley is being used by the FAO/UNDP Integrated Range/Livestock Project as one of its pilot areas. AZRI should complement that project's range studies with on-farm studies on small ruminants that started in 1992 as part of the BOSTID project.

13. Management Plan for Maslakh Range. AZRI should meet with the Secretaries of the GOB Departments of Forestry and Livestock to design a management plan for Maslakh Range involving the local livestock owners.

14. Donor contacts. To obtain additional funds for AZRI, the Director should familiarize himself with the various donor agencies in Islamabad and visit them twice a year.

15. Special project funding. AZRI must be more aggressive in its efforts to supplement its operational budget since additional funds similar to the PEP funds will certainly become available periodically.

16. Analytical services. Eventually one member of the scientific staff with a knowledge of analytical methods should be made responsible for analytical services. Section Heads should delegate one member of staff from their Section to conduct the analytical work.

17. Computers. A computer hardware specialist from the NARC computer unit should visit AZRI once every six months to conduct routine maintenance on the AZRI computers and peripherals and, if possible, make simple repairs.

18. Library catalogue. All the holdings in the AZRI, ARI Sariab, and the GOB Departments of Agriculture, Livestock and Forestry, and the University of Balochistan should be catalogued and kept updated, and copies of the catalogue should be made periodically available to each of the relevant libraries in Quetta.

LESSONS LEARNT

1. The Project had excessively ambitious objectives for an institute that was still in its formative stage.

2. Strengthening an institute is a 15-20 year task, even when resources are available.

3. Fixing a project agenda and activities for a four year period, however understandable and desirable this may be, seems inappropriate since it can burden a project team with a plan that may not be suited to the circumstances that were poorly understood when the Project was conceived. For example, the importance of rangelands and livestock to the economy of Balochistan was emphasized in early MART documents. However, during Phase I one advisor was expected to handle both the range and livestock aspects, a seemingly impossible task given the quality of the staff then available at AZRI. A second example is the inclusion of an extension advisor during Phase I when the identification and design of better technologies was at an early stage. However, during Phase II when these technologies needed to be tested with farmer participation, there was no extension advisor.

4. Five advisors were employed during Phase I when AZRI was filled with staff most of whom were extremely junior. Therefore the advisors acted as research leaders in defining and executing the research program, rather than acting as advisors. However, during Phase II when some of the staff returned with postgraduate degrees and needed guidance about their research programs, there was a declining number of advisors. It is clear that such guidance is needed for at least five years to cover the post-doctoral period.

5. The choice of a university for a long-term (LT) trainee should depend on the future development plan of the institute rather than on the desire of the trainee. For example, the need to change the staffing balance between two Sections should be the determining factor when making decisions about where to send a LT trainee. This gives a margin of certainty that the field of research of the trainee has been decided in advance, rather than by the university in cases where an inappropriate choice of university was made. This also helps ensure that the trainee's research program addresses problems facing Balochistan, rather than the interests of the university. For example, one LT trainee studied poultry viruses rather than some aspect of small ruminant pathology. Another used growth chambers (since radio-isotopes were used) to study the nitrogen and phosphorus nutrition of wheat plants under varying levels of salinity. Responses of plants to nutrients under different levels of moisture would have generated useful information, even if the studies had been conducted in growth chambers.

6. LT trainees should conduct part or all of their research program in Balochistan. This helps them identify more closely with the area they are going to return to. Only three out of the six LT trainees on PhD programs conducted part or all of their research in Balochistan.

7. When the institute being strengthened has almost no experienced scientific staff, it is first important to have a number of generalists who can guide the specialists who would be trained later. Generalists are defined here as staff who have a wide knowledge of the principles of the plant, soil, water and animal sciences, socio-economics, agro-climatology and natural resource management. They should be trained in approaches to developing farming systems such as the participatory approach, identification of production constraints and giving priorities to these constraints, and also be trained to feel comfortable communicating with farmers. Unfortunately, there are few universities which have graduate programs that train staff in this way. They are geared to produce specialists who find it almost impossible to step outside their specialization, even when it is clearly inappropriate to the problems faced by farmers. The present undergraduate and postgraduate degree structure at most universities reinforces the attitude of most agricultural scientists who like to do research in the laboratory or on the research station. They feel that contact with farmers is for the extension service or for social scientists.

8. Keep Directors informed and involved in decisions about LT trainees. For example, when decisions are taken about extending the training period of a trainee or about the research program, consult the Director at the very least. This was not the case during the Project. The Director was the last person to hear about developments since the decision chain included at least six links: trainee --> university advisor --> Academy of Education and Development (AED) office, Washington --> AED office, Islamabad --> USAID Mission, Islamabad --> PARC --> AZRI Director.

9. If you are going to test a technology, do it thoroughly or not at all. Otherwise there is a high risk that the technology will be labelled as inappropriate and unsuitable for the wrong reasons. For example, in the on-farm testing of saltbush it is necessary to persevere if small ruminants initially show reluctance to graze it. Indeed, some authorities have pronounced saltbush as unpalatable since sheep and goats have been known to reject it to start with. However, it is well known that after a time they get accustomed to it. In fact, a degree of unpalatability is an advantage. A highly palatable plant would soon be overgrazed and killed unless carefully managed. Careful management is extremely unlikely under the present circumstances in Balochistan. Other examples can be given, such as the catchment-basin water-harvesting project where poor management or inappropriate timing of operations resulted in poor crop uniformity which reflected badly on the technology.

10. Only embark on an ambitious project that cuts across disciplines when there is a strong commitment to test a technology, with genuine support from a multi-disciplinary team. An example is the camel planter project which needed a team that included staff with an advanced knowledge of agricultural engineering, animal traction and animal nutrition.

11. Use simple experimental designs and techniques until it is clear that staff are competent enough to handle more complex designs and techniques. Address one factor at a time rather

than several. With four or more treatment levels applied to one factor over a wide range, it is possible to describe the shape of responses more precisely, even if interactions between factors are sacrificed. A parallel follow-up experiment with a 2 x 2 factorial design could study the interactions between factors.

12. Make an *ex ante* economic analysis of the technology before embarking on the field work.

13. If a project's aim is institutional strengthening, it seems prudent to continue the Project as long as there is clear evidence that a cadre of well trained staff is emerging according to the project's plan of activities. This cadre is the foundation of all successful research programs. Without it an institutional strengthening exercise will only be a partial success.

Chapter 1

THE PROJECT GOAL, PURPOSE, OBJECTIVES, SCOPE AND ACTIVITIES

Pre-amble

In 1969 the United States Agency for International Development (USAID) started supporting agricultural research in Pakistan through its Agricultural Research Project (391-0296). The Management of Agricultural Research and Technology (MART) Project formulated in 1984 followed up this earlier endeavour. One of its five components was the Arid Zone Research (AZR) component which started at AZRI in 1985, with ICARDA as the main contractor. The range/livestock component was sub-contracted to Colorado State University. The MART/AZR project will be referred to as **the Project** for the remainder of this report. Sections copied verbatim from other reports are indicated in *italics*.

The MART/AZR *component addresses the substantial gap that has existed in arid high altitude research for non-irrigated areas, which is especially important for the western regions of the country. Such research is critical to achieve significant increased agricultural yields in Pakistan. Under this component funds will be provided to strengthen the capability of AZRI, which is located in Quetta, Balochistan, to generate and disseminate quality and relevant technologies applicable to the non-irrigated areas of the country, which represent 47 percent of the country's total land area* (MART, 1984, page 2-3). *The existing staff* [at AZRI] *lack proper training,* [and] *the Institute lacks adequate supplies and equipment to conduct research* (MART, 1984, page 50).

This chapter presents the overall framework concerning the Project so that the information presented in subsequent chapters can be better understood and assessed. The goal and purpose of the original contract (MART, 1984, page 32) and grant (MART, 1990, page 15) phases of the Project are compared in the first section of this chapter. These are referred to as Phase I and II, respectively. Then follows a section quoting verbatim the objectives, scope of work and the specific activities of Phase II (MART, 1989a). These are accompanied by comments about the changes made to these during Phase II. The final sections cover a number of issues, including the BOSTID grant awards and the Productivity Enhancement Program of PARC.

The MART Project Goal

Phase I: The broad goal was to:

Increase agricultural production, farm income and rural employment.

Phase II: The goal was changed to:

Improve the incomes of resource poor farmers, sustain an increase in food and fibre production, and conserve the natural resource base. The goal for Phase II was more narrowly focused and better suited to the case of Balochistan.

The MART Project Purpose

Phase I: The purpose was to:

Strengthen the performance of the national agricultural research system to generate and disseminate quality and relevant technologies to the farmers of Pakistan.

Phase II: The purpose was to:

1) *Develop and disseminate improved technology and information through key research institutions*, and

2) *foster a collaborative relationship whereby research institutes serve private agri-business and farmers and use the private sector to disseminate marketable, improved technologies.*

Thus, the main change in focus of Phase II over Phase I was the inclusion of agri-business in the research process in such a way that public sector research institutions would respond to the demands of the private sector, as well as to farmers and government agencies. This amended purpose seems to have been written for the rapidly developing agricultural sector in Punjab, and to a lesser extent in North-West Frontier Province (NWFP) and Sindh. Balochistan, in contrast, is still the least developed of the four provinces of Pakistan with its tribal *sardari* system which is still largely intact. Indeed, the embryonic nature of the agri-business sector in Balochistan was highlighted by the agri-business consultancy (AZRI/ICARDA, 1992, pages 4 and 58-60). The uniqueness of, and difficulties facing, Balochistan were quite obvious to the three ICARDA advisors at the start of Phase II.

Objectives of Phase II (MART, 1989a)

The *objectives of this grant are to:*

1. *Ensure the continuity of the collaborative research program between ICARDA and AZRI, headquartered in Quetta, Balochistan. To help strengthen and develop AZRI to become a key PARC institute for arid-lands research. Strengthen the capability and capacity of AZRI to plan and conduct applied research and to generate appropriate technologies that will improve livestock production and availability of animal feed (range improvement, forage production, dual purpose crops etc.) in the arid and semi-arid uplands of Pakistan.*

2. *To reinforce the link between federal, provincial and international agencies to provide Pakistan with an integrated research effort in finding solutions for the problems of agricultural production in the dry, rainfed, high elevation areas of the country; and in addition, coordinate activities with other research agencies working in the arid, subtropical ecological zones of the country.*

At the end of the grant period it is envisaged that AZRI and its staff will have the competency to play a leading role, in partnership with the provincial agricultural agencies and ICARDA, in helping Pakistan achieve its goals of developing the dry, rainfed areas of the country in which small ruminant production is the predominant sustainable agricultural activity.

To achieve these objectives the grantee [ICARDA] *shall assist AZRI scientists in the joint planning and implementation of a research program relating to:*

a. *Improved animal feed supply from rangeland rehabilitation, creation of forage shrub reserves, annual and perennial forages crops, and improved production of nutritious crop residues from dual purpose crops (wheat, barley, lentil, etc.);*
b. *Improved livestock management especially concentrating on ruminants;*
c. *Improved techniques of water management in crop and rangelands to ensure a more sustainable level of production over time;*
d. *Improved understanding of the socio-economic issues influencing the currently poor offtake and yield levels of livestock and crop producers.*

Given the collaborative research and institutional strengthening focus of this grant, it is expected that the grantee shall also contribute to the research program outlined by providing on-the-job training for AZRI staff in all aspects of the research process, that is, management, administration, planning, implementation, reporting, evaluation and determining impact. In addition, ICARDA will continue to supply to AZRI advanced germplasm from its crop breeding programs and will share information on new dryland agricultural technologies developed under ICARDA's auspices in other areas of W. Asia and N. Africa.

Scope of work

The grantee will work in three general areas of research which are emphasized in AZRI's strategic research plan (Keatinge *et al.*, 1988):

a) Improvement of livestock and rangeland management;
b) Forage and dual purpose cropping assisted by water harvesting techniques and;
c) Socio-economic aspects of small ruminant and animal feed production and marketing.

These *will involve a mixture of field activities in both outreach and on-station locations, laboratory studies and surveys as well as the development of economic and social strategies. All these research efforts will be complemented by appropriate modes of training for both AZRI staff and collaborating provincial scientists. Research work will be carried out in an integrated interdisciplinary manner in fulfilment of the goals of AZRI's strategic and development plans.*

In each research group linkages with the appropriate provincial extension agencies will be fostered to ensure their commitment to extend AZRI generated technologies.

Opportunities for training will be maximized in a variety of ways including on-the-job training, in-country workshops and training courses, etc. Grantee assistance to AZRI in determining suitable candidates for short, medium and long-term training will be given and help with their placement overseas, where appropriate, will be provided.

Project Activities

A deliberate but gradual narrowing of the focus of the project activities was made during Phase II since it was quite clear that AZRI was unable to cope with the large research program inherited from Phase I when there were five ICARDA advisors for most of the time. This narrowing was achieved by getting staff to draft research protocols during the period March and April each year. Protocols were then accepted after revision or rejected. An annual planning meeting was then held at which the coming season's research plan was finalized. In addition, it was essential to shift the focus of the AZRI research portfolio from technology identification and development, the main effort during Phase I, towards on-farm testing of technologies with farmer participation. This always proved to be a difficult task since most staff at AZRI are trained in disciplinary fields. However, the shift was essential and must be sustained since **technologies that are not acceptable to farmers are not adopted.**

The following tables list the proposed Project activities in the Phase II document (MART, 1989a) and the changes that occurred to these activities during 1990-94, according to the disciplinary sections at AZRI.

Proposed Phase II Activities	Actual Phase II Activities
Range/Livestock	**Range/Livestock**
a. Examination of options for the rehabilitation of rangeland vegetation. This will include testing introductions of perennial grasses, forage legumes and forage shrubs into the range plant communities. In conjunction with these introductions, land treatment practices designed to improve precipitation, capture and moisture retention in the root zone such as ripping, contouring, micro-catchment formation and other types of runoff capture technology will be tested in order to improve plant establishment and productivity.	a. Testing of perennial grasses was terminated in October 1990 because of staff constraints at AZRI. In any case these were not felt to be an appropriate solution to range degradation. Neither was the introduction of forage legumes into range plant communities. Only saltbush, a perennial forage shrub, received special attention throughout Phase II. Land treatment practices were tested at four sites in a three year trial that ended in July 1993.
b. Alternative grazing management strategies will be examined in the light of their effect on range rehabilitation and long-term sustainable forage production.	b. This activity was not started due to staff constraints.
c. Effect of improved quantities and quality of animal feed on sheep and goats throughout the annual cycle of production will be studied. The relationship between different and variable sources of feed and key animal production parameters will be determined.	c. This activity was addressed in trials with only sheep at Tomagh and Zarchi. The studies were included as part of the BOSTID project which focused on the genetic potential of local sheep breeds. The growth rate of these breeds was also studied.
d. Use of alternative management feeding strategies which could include the use of introduced forage plants in flushing and for supplemental feeding pastures, the use of mineral/protein/energy blocks for rangelands, allocation of dam's milk to offspring and alternative breeding schedules will be examined.	d. This activity was largely addressed under c. Studies on mineral/protein/energy blocks were not commenced since such blocks, although nutritionally a promising technology, were almost certainly uneconomic in Balochistan and unlikely to be adopted.
e. Relationships between livestock diseases and parasites to fertility, mortality and productivity of grazing animals will be investigated.	e. This topic was not addressed due to a lack of expertise at AZRI. One long-term trainee who completed a PhD in mid-1992 should have started the parasite work but remained in the USA.

Proposed Phase II Activities	Actual Phase II Activities
Agronomy/Water-harvesting	**Agronomy/Water-harvesting**
a. Examination of water capture strategies and distribution within fields for growth of annual crops. This will include study of contour bund design, desert terraces, spillways in bunds, field levelling with locally available technology, surface sealing technologies, etc.	a. This topic received considerable attention. However, desert terraces and surface sealing technologies were not addressed due to the high costs involved. Moreover, a reduction in the scope of this activity was implemented during Phase II.
b. Utility of range forage shrub reserve plantations will be examined on marginal crop land and sites with preferential sub-soil moisture availability and the potential for water harvesting. This will include the possibility of dual purpose forage and fuel wood species.	b. This topic received considerable attention, based on saltbush.
c. Alternative agronomic strategies will be investigated in the presence of improved methods of water harvesting to determine if they can be profitable and can assist in ensuring better, and more stable return to investment by farmers than the current uncertain, subsistence system. Emphasis would be placed on producing more abundant and alternative sources of animal feed for sale or for direct consumption in mixed livestock-crop enterprises. In conjunction with the agricultural economist, the social and economic acceptability of alternative water harvesting strategies will be assessed.	c. Research on agronomic strategies was gradually phased out during Phase II since the difficulties of managing complex trials made it difficult to test hypotheses. However, a comprehensive analysis of the economics and risk-reduction potential of catchment-basin water-harvesting was conducted, as well as a survey of the perceptions of farmers regarding water harvesting, the latter as part of the ICARDA Dryland Resource Management Project (DRMP).
d. Range management specialist will be assisted in examining ways in which small scale runoff catchment technology can assist in the achievement of better and more sustainable productivity of range vegetation.	d. This activity was not addressed since land treatments to improve the productivity of range vegetation were not seen to be economic, let alone socially acceptable.
e. The introduction of improved germplasm of forage and dual purpose crop species (barley, vetch, lentil, wheat, etc) with improved water catchment systems will be studied.	e. This activity received considerable attention although a narrowing of the focus to wheat and barley, and more emphasis on certification and release of improved varieties, was given as Phase II progressed.

Proposed Phase II Activities	Actual Phase II Activities
Agricultural Economics	**Agricultural Economics**
a. Profitability and compatibility of AZRI-generated technologies with current agricultural systems will be examined. This will require the assessment of both individual technologies and enterprise option studies in order to optimize farm/flock production efficiency and minimize the long-term risk experienced by communities supported largely by agriculture.	a. Staff shortages made it necessary to narrow these activities to the economics and the risk-reduction potential of water harvesting technologies.
b. Socio-economic constraints to livestock production in the upland areas of Pakistan such as marketing, credit and collateral relationships, influences of potential GOP price support, feed subsidies and other policies generally affecting upland livestock producers will be investigated. Aspects of off-farm employment, labour availability, etc. will be assessed.	b. Staff shortages made it necessary to narrow the scope of these activities to studies on the marketing of small ruminants and skins.
c. Investigative surveys in upland areas to assess additional constraints to production not being addressed, or given due emphasis, by AZRI's research program.	c. Apart from the survey of farmers' perceptions of water harvesting (see c. above under the Agronomy Section), no other surveys were conducted due to staff shortages.
d. Ongoing and future impact of AZRI technologies and the likely impact of research in progress will be assessed.	d. This activity was not addressed due to staff shortages.
e. AZRI linkage with and assistance to provincial Farming Systems efforts will be provided mainly by this (Economics) group.	e. Attempts were made to link AZRI to the provincial Farming Systems efforts.

The Project Paper for the amendment period of the Project (MART, 1990; PARC, 1991) superseded the earlier project document (MART, 1989a). It justified (page 11) continued support to AZRI by using a statement: *The objective of a fully functional, well organized and well managed Arid Zone Research Institute, will not be reached in the five years originally provided. Current staff lack the capacity and experience to design and manage research independently. However, useful on-farm researches have been developed and expanded from a very weak base. Personnel are cooperating with provincial FSR representatives to develop*

methods to transfer technology to the farmers. A stronger focus on range/livestock management and agronomy and water harvesting with a systems approach is needed. Linkage with the leather and livestock marketing/exporting industry is a key to increasing the vitality of the livestock program. A strong cooperative linkage with a more advanced center such as ICARDA is needed for four to six years more (MART, 1989b).

The Project Paper (MART, 1990; page 20) also indicated that *AZRI will work on problems relating to the following areas of research to increase productivity from dryland agriculture:*

- *Improvement of livestock management;*
- *Improvement of rangeland management and rehabilitation;*
- *Commercialization of introduced germplasm of annual, perennial grasses and legumes, as well as range forage shrubs and trees;*
- *Improvement of forage and dual purpose crop agronomic strategies by water harvesting techniques;*
- *Evaluation of socio-economic aspects of sheep and goat production and associated forage and dual purpose crop production;*
- *Increasing the quality of hides* ***(cattle and buffalos are less important in highland Balochistan than small ruminants. For this reason attention was given to the marketing of skins).***

By design, AZRI's field work is carried out on private farms in cooperation with the farmers via the FSR (Farming Systems Research) methodology. This forces the researchers to respond to the farmers' concerns in carrying out the research important to Balochistan and North West Frontier Province. AZRI Research products to date, such as the drought tolerant four wing salt bush, have shown good potential in increasing fodder for the important livestock sector. This statement was not altogether true in that farmers were little involved in the on-farm research.

A final request by ICARDA was made to USAID in the autumn of 1991 to extend the Project from November 30, 1992 through to August 7, 1994, the Project Actual Completion Date (PACD) of MART. Since this was a request for a no-cost extension it did not require an amendment to the PC1 (Planning Commission 1 of the GOP) of the Project (PARC, 1991). This would bring the total cost of MART/AZR to $1.5 million. It was hoped that the no-cost extension to the PACD would *allow successful completion of the Arid Zone Research (AZR) component of the MART project by providing sufficient overlap period between the return of the majority of AZRI long-term trainees and the departure of the resident ICARDA technical assistance team.... The proposal takes account of the July 1990* [(MART, 1990]) *amendment of the MART project and indicates how AZRI will respond during the option period. By August 31, 1994 it is expected that AZRI will have reached a level of maturity enabling it to function as a mature research institute in partnership with sister institutions such as the*

National Agricultural Research Center (NARC), Islamabad, and ICARDA (ICARDA, 1991). During the extended period the project activities were similar to those indicated already for Phase II (MART, 1990) (see pages 5-7).

BOSTID Grants

One component of Phase II was the contracting of the Board of Science and Technology for International Development (BOSTID), itself part of the National Research Council in Washington, to administer a $3 million grant component of the MART project to support research on problems facing stressed lands in Pakistan. In September 1990 three proposals for submission under the BOSTID program were written by the ICARDA advisors at the request of the former Director of AZRI. The proposals were submitted in October 1990 and later refereed by a joint PARC/BOSTID committee and specialists from universities and research stations in the USA. Well over 100 proposals were submitted for review. The committee sat in Islamabad in August 1991 and out of a total of eight awards made on a nationwide basis during the first allocation, two of AZRI's three proposals were selected for funding. About 25 grants were eventually awarded, the only two in Balochistan being from AZRI.

The titles of the two proposals were "Use of water harvesting to enhance crop production in arid and semi-arid areas of Pakistan" and "Can the productivity of sheep be increased by better management of indigenous breeds in highland Balochistan?". The two projects were managed by principal (PI) and co-principal (co-PI) investigators, to a large degree independently of the Director of AZRI and MART/AZR COP. Several visits were made to the projects by reviewers from US universities and research institutes. The PIs and co-PIs each made one visit to research institutes and universities in the USA. The two projects eventually started in April 1992 and continued for two years. They each provided $60,000 to $70,000. A national workshop was held at the completion of the projects in May 1994. AZRI staff involved in the projects presented posters and papers based on the results from two years (see Annex 1 for the titles of the posters and papers).

The BOSTID program has given relatively inexperienced staff at AZRI the opportunity to run a largely autonomous research program. The same is true of the Productivity Enhancement Program (PEP) project indicated in the following section. The small ruminant project was largely a continuation of the on-going program and has absorbed most of the time of all the staff in the Section. The project therefore followed fairly closely the original project proposal. This was less the case for the water harvesting project which absorbed most of the attention of all the staff in the Agronomy Section. This project unfortunately covered the transition from the last year of the seven year catchment-basin water-harvesting project to the first year of a new project on the effect of different lengths and widths of catchment areas on the efficiency of run-off. The latter project was designed by Dr Theib Oweis, ICARDA's water harvesting specialist. Added difficulties were the unusually low

rainfall during the 1993/94 season, which made it very difficult to gather any information from the run-off efficiency experiment, and the change of PI in mid-1993. Luckily the project was able to initiate some new water-harvesting activities in Kovak Valley although these too produced no results due to the low rainfall.

Both projects created certain strains at AZRI since they required the full attention of the PI, co-PI and other staff which meant that they had no time for other projects. This may have been a blessing-in-disguise since it forced staff to focus their attention on one project. It was particularly the case of the small ruminant project which had difficulty releasing staff to initiate the livestock component of the new project in Kovak Valley. Furthermore, the PIs and co-PIs were under severe time constraints to prepare drafts of papers for the final workshop. They met their deadlines which indicates what can be achieved when a strict workplan and timetable is set.

It was also noticeable that except in one case, the visiting experts from the USA were different researchers. This made it difficult for them to follow through with their recommendations.

A major weakness of the BOSTID program was that two years is far to short for projects on stressed lands in areas with low rainfall. Such projects need at least five years to produce credible results.

The Productivity Enhancement Program (PEP)

In December 1991 AZRI was awarded Rs1.025 million under the Productivity Enhancement Program (PEP) of PARC. The award to AZRI was part of a project aiming to enhance the productivity of stressed lands. The project helped AZRI expand its saltbush nursery to 100,000 plants. The project lasted two years.

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Chapter 2

AN OVERVIEW OF THE PROJECT's ACHIEVEMENTS

This chapter presents an overview of the Project's achievements during Phase II. During this Phase lasting four years, the number of ICARDA advisors decreased from three to one for the last two years of the Project. There was an obvious momentum carried over from Phase I when there were 4-5 advisors who initiated and executed the research program with the AZRI staff playing a supporting role. Similarly, the advisors led the research program during the first two years of Phase II but thereafter the AZRI staff became largely responsible for the execution of the research program, and the analysis and reporting of the results. The achievements of Phase II should be seen against this background.

RANGE RESEARCH

The achievements of the Range Section should be seen in relation to its staffing strength of three SOs. The head of the Section moved to AZRI from the Range Research Institute at NARC in mid-1992 and had been awarded a PhD from Utah State University in 1991 with sponsorship through the MART long-term training program[1]. The COP gave particular attention to advising the staff in this Section.

Phase II was a transition period for the range research at AZRI, characterized by a major change of focus and several staff changes that caused considerable disruption until May 1992. In mid-1990 the program of the Section was carefully reviewed and a decision taken to narrow the focus of the research. At that time there were studies on exotic grasses, range vegetation surveys and saltbush carried over from Phase I (AZRI/ICARDA, 1991). The first two studies were discontinued since the former head of the Section was transferred to Bahawalpur and it was not possible to complete the analysis of the data[2]. A second member of the Section obtained a transfer to PARC soon afterwards[3]. Thus, from October 1990 onwards all the research activities of the Section focused on saltbush. Only highlights of this research are presented here since it has been reviewed elsewhere (Mirza *et al.*, 1994).

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[1]The Head of the Range Section was promoted to SSO in January 1994.

[2]The information collected about the exotic grasses will hopefully be analyzed and reported when the staff member responsible for the study returns from long-term overseas training. The information from the vegetation survey at Tomagh, Hazargangi and Zarchi was all entered on diskettes which were left with the head of the Range Section. A final analysis could not be completed since the plant species were identified by their local names and it was not possible to obtain their botanical names. It is still hoped that this unique information will be analyzed in the near future.

[3]The first AZRI long-term trainee to complete a PhD program supported by the MART project transferred to PARC only 18 months after returning to AZRI.

The first known exploratory testing of fourwing saltbush (FWSB, *Atriplex canescens*) took place in the mid-1950s when this perennial forage shrub was introduced as part of the USAID supported range project at Maslakh Range[4] near Quetta. In the 1960s the shrub was planted at the farm of the Soil Conservation Department at Mastung. The first FWSB was established at AZRI in the early 1980s and it was given increased attention during Phase I of the Project. The methods for nursery production of seedlings were perfected and nurseries were established at AZRI, Tomagh and Zarchi. Forage reserves were established at the two latter sites and in Kovak Valley. One grazing study using lambs was also conducted at Tomagh (Aro *et al.*, 1990). It showed the high yield potential of FWSB which was related to the trial being sited close to a *nullah* (ephemeral stream). The lambs had modest gains when grazing the shrub alone.

In June 1990 a new research program on FWSB was started which eventually involved five components: 1) planting FWSB in buffer zones of water harvesting trials, 2) agronomy and land treatments, 3) vegetative propagation, revegetating protected areas, competition studies and season of planting, 4) plant spacing and grazing studies, 5) feeding value, and 6) on-farm testing using forage reserves. These components are discussed below in turn.

1. Planting FWSB in buffer zones. This component involved planting FWSB in the buffer zones of the catchment-basin water-harvesting (CBWH) trials. The aim was to remove the excess water collecting in the cropped area, which increased the risk of waterlogging and the associated reduced plant growth, and use it to promote the growth of FWSB. Although the FWSB established quite well, particularly at the Spezand site, no measurements of the shrubs' growth were taken to see if the concept was viable.

2. Agronomy and land treatments. This component involved studies on the agronomy of FWSB, such as the effect of fertilizer and plant spacing, and methods of land treatment to enhance water harvesting around the root zone (AZRI/ICARDA, 1993). The latter aspect was listed as an activity in the original Phase II grant document. However, one can say in retrospect that these topics now seem somewhat academic given that farmers are most unlikely to invest scarce capital in fertilizers and labour resources for making land structures to enhance water harvesting. Indeed, when farmers hardly use fertilizers on rainfed crops, it is highly unlikely that they will use them on forage shrubs, even if these are growing on land where there is some hope of protection. The lesson here is the need to conduct a simple *ex ante* economic analysis before embarking on this kind of trial.

The studies were initiated at AZRI, Mastung, Tomagh and Zarchi but Mastung was soon dropped due to rodent damage to the seedlings which resulted in an uneven stand of shrubs. The shrubs established particularly well at AZRI since they were grown on a site where the soil had been brought in to bury the gravelly land that covers most of the station. The good

[4]The Project intended to use this as one of its range sites but was unable to do so for security reasons.

growing conditions resulted in a remarkably uniform stand of shrubs. However, statistically significant effects of the treatments were seldom expressed, largely because the levels within treatments were too close together. For example, the spacing treatments were 2.0 and 2.5 m between plants, and saucer- and V-shaped micro-catchments are likely to give the same result on level land. Moreover, the composition of the soil was not determined at the start of the trial so it is not certain the extent to which the soils were actually deficient in the macro-nutrients being applied. This makes it difficult to interpret the response, or lack of response, to these nutrients. Indeed, the factorial designs used at all sites had too many factors and too few levels within factors. Two of trials were also so far from AZRI that the necessary level of supervision required for complex trials was not attained.

Establishment of FWSB at Tomagh was highly variable for a number of reasons. First, examination of many plants nearly three years after planting indicated that root development had been poor since transplanting. This results when seedlings remain too long in polythene bags and develop a tangled root system. Second, there was evidence of an impervious and impenetrable calcareous layer at varying depths up to 100 cm in the area where the plots were located. Standing water observed in the saucer-shaped micro-catchments after heavy rain is evidence of this layer. This probably retarded root growth due to waterlogging. However, the ripping treatment, which should have broken up the hard-pan to 30 cm depth, failed to show any benefit since it may have been too shallow. The large variability in plant size across the treatments may have been erroneously ascribed to genetic variability within the species. A more plausible explanation is the variation in the quality of the seedlings and unequal collection of water around each plant. This variability between plants made it difficult to test hypotheses concerning the treatments applied.

Seedlings established poorly at Zarchi since the sites chosen had extremely shallow and degraded soils and there was strong competition from the indigenous sagebrush (*Artemisia maritima*, thought to really be *A. herba alba*). Furthermore, the rainfall, about 200 mm annually at the location, is probably too low for FWSB unless there is some form of water harvesting. For this reason the shrub established well at a nearby site under *sailaba* conditions with deep soils on the valley floor. Unfortunately, the sheep from a nearby flock were not used to evaluate the shrubs and to judge the reaction of the farmer.

The studies at AZRI, Tomagh and Zarchi were completed in July 1993 after three years and a report written based on the results (Thomson *et al.*, 1994). The results from AZRI and Tomagh do give useful information about the seasonal growth pattern of FWSB, but show no statistically significant differences between the treatments except at AZRI when fertilizer was applied.

3) Vegetative propagation, revegetating protected areas, competition studies and season of planting. These pilot studies were initiated between October 1990 and March 1991. **Vegetative propagation** showed little promise since none of the 72 cuttings survived six

months after being planted (Jasra *et al.*, 1994). However, it would be wrong to conclude that the technique is unsuccessful, particularly since the cuttings were grown under rainfed conditions and probably died from desiccation. It is nonetheless unlikely that farmers and commercial nurseries would apply the technique in Balochistan since it probably requires root growth promoters and skilled management.

Several thousand seedlings were planted in Karkassa Valley between January and March 1991, the aim being to **revegetate an area protected from grazing.** One seedling was planted at each end of the 2 m long contour trenches dug in the valley during the 1980s as part of an income generating project for Afghan refugees funded by the World Bank. Practically no seedlings were alive some 30 months after planting, probably because of the poor water storage in the shallow gravelly soils that cover the steep slopes on the valley sides, and competition from the native range vegetation dominated by sagebrush.

An interesting study to investigate the effects of **competition** was also initiated in the same valley at the same time but abandoned when the head of the Section transferred to PARC headquarters. The **season of planting** study at Karkassa and Tomagh was also abandoned since it was soon became obvious that planting should take place at the height of the rainy season, December to late March, provided there is sufficient moisture in the soil. This removes the need to water the seedlings which farmers could never be expected to do.

4) Plant spacing and grazing studies. Studies on plant spacing were initiated in February/March 1991 and a grazing study using older mature plants was conducted for 16 weeks in the mid-summer of 1992 and 1993. The trials are being repeated in 1994. The **plant spacing** trial is somewhat academic since it is highly unlikely that farmers would ever plant 10,000 seedlings per hectare because of the costs involved. However, the three treatments being examined, 1x1, 2x2 and 3x3 m plant spacing, provided valuable data showing that the yield of biomass and the efficiency of rainfall use is so much higher in the 1x1 m treatment, that planting shrubs at high densities deserves serious thought (AZRI/ICARDA, 1993). It was also necessary to have widely spaced treatments to increase the likelihood of detecting the underlying curvilinear relationship between plant density and biomass production. The shrubs were grazed for the first time in the summer of 1993, about 30 months after establishment. They were pruned in the winter of 1994 to assess the fuelwood production from the different treatments and the recovery of the plants before being grazed starting in July 1994.

The **grazing trial** is providing the first detailed information about the carrying capacity of FWSB forage reserves. It has shown over two seasons that a one hectare forage reserve could carry 28 adult sheep for 16 weeks and the sheep would gain 10-20 g each day. Thus, if the estimated 0.9 million hectare of fallow land in Balochistan were used to grow FWSB, it would carry 25 million sheep for one quarter of the year! (There are about 20 million

sheep and goats in Balochistan.) The annual fuelwood production of each hectare is 300-600 kg. This attribute of FWSB has been underrated in the past.

5) Feeding value of FWSB. See the section on **Livestock Research.**

6) On-farm testing of FWSB in forage reserves. The guiding principle of the research program of AZRI during Phase II was the need to test the technologies identified and evaluated during Phase I in on-farm trials with farmer involvement. For this reason a substantial effort was made to increase the number of forage reserves on farmers' land. This effort was made independently by staff in the Range and Extension Sections. First of all though, the AZRI nursery had to be expanded. This was funded from the Productivity Enhancement Program (PEP) of PARC to give a nursery with a capacity of about 100,000 seedlings by mid-1993. Their followed a gradual increase in the number of seedlings distributed and the number of sites involved (Figure 1). Most encouraging was the increasing demand for seedlings from other projects, such as the FAO project in Kanak Valley, the Balochistan Rural Support Program and the Asian Development Bank financed Livestock Development Project.

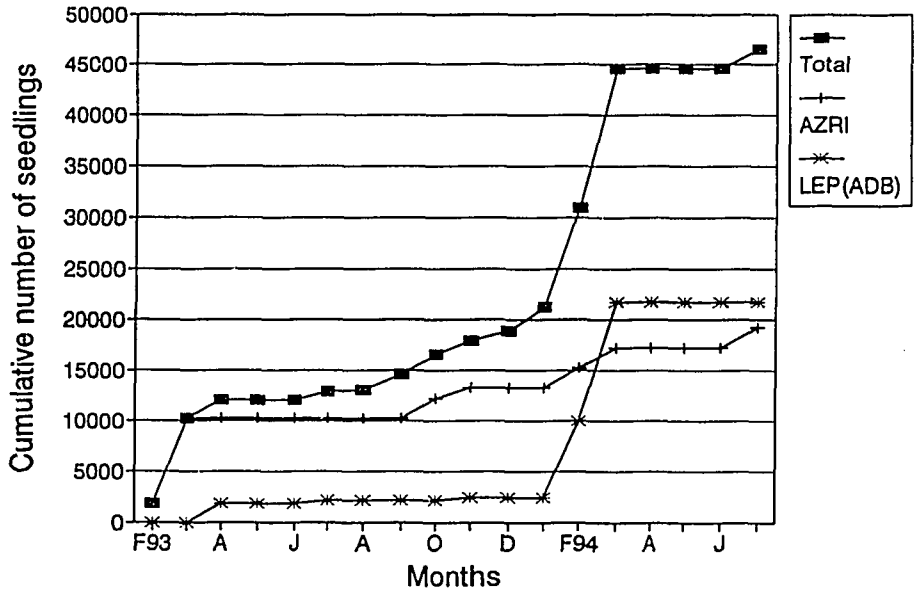

Figure 1. Distribution of seedlings of FWSB since January 1, 1993

All AZRI Sections could learn from these other projects how best to involve farmers in technology testing. All three of them use a different methodology with their own strengthens and weaknesses. The FAO Kanak Valley project is particularly interesting since it uses the farmer participatory approach. However, unless there is a radical change of research

approach at AZRI, it is unlikely that AZRI, apart from Economics Section which has already shown an interest, will start using any of these approaches since it is contrary to the institutional culture. Instead, AZRI is more likely to identify and evaluate technologies which will be tested by other projects. This option, although not ideal, will work provided AZRI identifies and adapts technologies that farmers are likely to adopt, rather than studies on fashionable technologies that staff have seen elsewhere and think farmers should adopt. Staff will therefore need to keep in close contact with farmers and other projects to ensure that their research is relevant and applicable to the prevailing farming situation.

By mid-July 1994 some 20,000 seedlings had been donated to other projects rather than charging them a nominal price for which they have funds. **AZRI missed an opportunity here to generate income. In the future it must sell the seedlings to other projects.**

The recurring main weakness of the on-farm program was that farmers were little involved, despite the advice that staff were given in this respect. This is due to the narrow disciplinary training of staff and the difficulties of working in multi-disciplinary teams. It is not therefore possible to judge objectively at the end of the Project whether the forage reserve technology will be acceptable to farmers or not. However, there are encouraging signs from other projects that farmers are interested.

Every attempt was made to develop a low-cost technology which could be sustained at the village level with no external inputs apart from the initial seed to establish a nursery, and perforated polythene bags for the seedlings. Thus, it is essential for villages to have their own nursery, eventually supplied by seed from a plot of ungrazed plants. Seed would be brought from other sites from time to time to broaden the genetic base. Family labour would plant the seedlings on suitable land, such as areas no longer used for crop production with deep soils that are free from competing range vegetation. A slope of 0.5-1.0 percent would be ideal to allow some water to accumulate around plants. **Land should never be cleared of range shrubs to establish a forage reserve because of the expense involved and the regrowth of the shrubs.** All the micro-catchment land treatments studied are probably too labour intensive and costly for farmers to use, apart from perhaps contour furrows on gently sloping land. Even this simple operation would be probably beyond the capability of village resources and have to be made by government departments.

Final remarks. It is realized that FWSB is not the panacea to reverse the advancing range degradation that has already resulted in about half of Balochistan being described as ecologically dead (Gils and Baig, 1992). Indeed, it must be emphasized yet again that **FWSB is suitable for growing on lands marginal for crop production with deep soils and free of competing range shrubs, not for rehabilitating the degraded ranges. Furthermore, it should only be planted at sites where it will be grazed and after a final grazing in November, pruned every second year to provide fuelwood. The pruning should also encourage better growth the following season.**

LIVESTOCK RESEARCH

The achievements of the Livestock Section should be seen in relation to its staffing strength of one SSO, who is the head of Section and was awarded a PhD in 1988 from New Mexico State University, and two SOs. The COP was responsible for advising the staff in this Section but it did not receive as much support during 1992-4 as was hoped due to other compelling responsibilities. However, the Section was assisted by U.S. advisors linked through the BOSTID project being managed by the Section.

A factor unique to the small ruminant sector, indeed the livestock sector as a whole, is the difficulty of conducting research and demonstrations on animals at the farm level. It is one thing to get a field from a farmer for a water-harvesting experiment, quite another to conduct feeding trials on small ruminants since such trials require close supervision if they are to produce plausible results. AZRI livestock staff even have to grapple with this problem at their two main research stations Tomagh and Zarchi which are, respectively, three and five hours drive from Quetta. The achievements of the Livestock Section should be seen against this background.

Supplementary feeding, body condition and ewe fertility. Designing economically viable and adoptable management systems that ensure regular parturition is arguably the primary goal of research on small ruminants. This is because, apart from her capital value, an infertile female produces no offtake except for some wool or hair and some cull[5] value. Since parturition rates of 60-80 percent are typical in the average flock in Balochistan, ways to increase fertility have been given first priority by the Livestock Section since 1988.

The first two trials at Tomagh and Zarchi attempted to show that 'flushing' improves lambing rate (AZRI/ICARDA, 1991; Rafique *et al.*, 1991). The results were equivocal and even ewes that were potentially fertile were fed. Flushing was therefore seen as an imprecise practice and clearly uneconomic for the extremely poor stock owners. An alternative is to use body condition score (BCS) as an indicator of the potential fertility of a ewe. Ewes with a poor score are generally infertile and have to be fed to bring their score to the critical fertility threshold. Conversely, ewes in good condition need no feeding. Thus, body condition scoring is used to divide the flock into ewes that do and do not need feeding. It should therefore be more economic than flushing provided the farmer is willing to divide up his ewes for feeding, which may not be the case.

The first studies on the effect of BCS on fertility were initiated in July 1990 at the two stations. The results were encouraging (AZRI/ICARDA, 1991). Lambing rate generally improved as BCS increased. Unfortunately the trial was not repeated the following year.

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[5]Culls are animals that are sold or slaughtered for home consumption since they are old, infertile, diseased or for some other reason unproductive.

However, it was continued for two more seasons as part of the BOSTID project. The results are summarized in the reports of that project (Rafique *et al.*, 1994). The results from the spring 1993 lambing indicated that Balochi ewes with a BCS above 2.0 (on a scale 0.5 to 3.5) had lambing rates exceeding 90 percent. However, a similar trial with Harnai ewes showed no improvement in lambing rate as BCS improved.

Supplementary feeding in late pregnancy and early lactation. The trials mentioned above also studied the benefits of supplementary feeding during late pregnancy on lamb birth weight and perinatal mortality of the ewe and lamb, and of supplementary feeding during early lactation on the growth rate of the lamb and liveweight recovery of the ewe. The results were largely as expected. The main criticism of this program was that an economic analysis was never made to see if supplementary feeding, whether during the mating season, in late pregnancy or early lactation, is economic. There are strong indications that it is not at the levels of feeding used. The BOSTID project aimed, *inter alia*, to define the break-even point where the marginal revenue from the additional unit of lambs sold equalled the marginal cost of the additional unit of feed.

Monitoring the management practices and animal performance in farm flocks. This difficult but essential and innovative on-farm research was part of the BOSTID project. Hopefully such research will be expanded in the future since it provides the information needed to decide whether there is any possibility of farmers adopting better management practices that increase animal offtake.

In June 1994 on-farm studies were initiated in Kovak valley concerning the benefits of supplementary feeding on body condition and how this affects ewe fertility. The extremely low rainfall in 1994 provided a unique opportunity to examine this issue since ewes were likely to be extremely undernourished and in poor condition. Some 200 ewes in four flocks were involved.

Studies on the feeding value of fourwing saltbush (FWSB). The results from the two trials on this topic have given somewhat contradictory results. In the first, leaves of FWSB harvested in July/August 1990 had a dry matter digestibility of 69 percent (Thomson *et al.*, 1994). The water intake of the sheep on FWSB leaves alone was higher than sheep offered the leaves with a supplement of barley grain or cottonseed cake. A second trial (AZRI/ICARDA, 1993; Thomson *et al.*, 1994) used leaves of FWSB harvested in November 1991 which were fed with different ratios of chopped wheat straw. Somewhat surprisingly, the estimated dry matter digestibility of the leaves alone was only 42 percent, whereas the wheat straw alone was about 54 percent digestible. The low digestibility of the FWSB leaves was related to the presence of about four percent lignin which reduced the digestibility of the structural carbohydrates in the cell walls.

The marked difference in the digestibility of the leaves of FWSB in the two trials led to a study into the effect of harvesting date on the feeding value of the leaves. The trial started in July 1994. The feeding value certainly declines from a peak in May until mid-winter when the forage is most needed since the range plants are dormant, feed shortages reach a maximum and the nutrient demands of ewes reach a peak since they are either pregnant or in early lactation. However, it appears that after September the feeding value of the leaves is just sufficient to cover maintenance requirements. This certainly diminishes the potential of FWSB as winter feed for the small ruminants of Balochistan.

Fattening potential of local breeds of sheep. Trials on this topic were conducted quite successfully as part of the BOSTID project. One trial investigated diets containing 12 and 17 percent crude protein and was fed to Balochi lambs aged 10 months old at the start of the trial (Rafique *et al.*, 1994). Although the daily liveweight gains of the lambs on the two diets were 189 and 245 g, respectively, the difference failed to reach statistical significance ($P>0.05$). In a second trial using five-month old Balochi and Harnai lambs offered diets containing 2.3 and 2.7 Mcal metabolizable energy per kg of feed (dry matter basis), the daily gains of the lambs were 131 and 167 g ($P<0.05$), respectively. The Balochi lambs had a higher growth rate than the Harnai lambs ($P<0.05$). The higher daily gains of the lambs in the first trial could have been partly related to compensatory growth following a period of poor nutrition. Such trials are being continued to determine the genetic potential of these major local breeds for fattening.

Final remarks. Special care should be taken to use sufficient replication, especially in fattening trials. This can be achieved by having individually rather than group-fed animals. Studies on the carcass composition and meat quality of local breeds is not recommended since this requires special facilities and expertise that is not available at AZRI. In any case, such research should not be conducted since there are many far higher priority topics that need to be addressed.

It is hoped that any desire to expand into classical ruminant nutrition research will be resisted. Thus, the research during Phase II was limited to three simple digestibility and intake trials concerning the feeding value of FWSB leaves. Requests to develop facilities for *in vitro* studies requiring rumen cannulated sheep were refused since it is unlikely that a level of management would be provided to the animals to keep them in good condition.

These various studies have highlighted the difficulties of conducting precise trials even on a research station where supervision of the animals and trial procedures are applied far more rigorously. The trials also suffered because of the non-functioning of the AZRI analytical laboratory because of staff shortages.

WATER-HARVESTING/AGRONOMY/AGRO-METEOROLOGY RESEARCH

The achievements of the Agronomy Section should be seen relative to an effective staffing strength of three SOs[6] since October 1991. The Section was advised for two years by the ICARDA Agronomy/Water Harvesting/Germplasm advisor until March 1992. Reports on the Section's research are found in Annex 1. From April 1992 until May 1994 the water harvesting studies were supported by a grant under the BOSTID program (Qureshi *et al.*, 1994).

Water-harvesting. The catchment-basin water-harvesting (CBWH) research program started in October 1986 and continued for seven cropping seasons. It can be seen as AZRI's most significant yet controversial research effort since better methods of harvesting water hold the key to higher crop yields from non-irrigated farming in Balochistan. Indeed, without it rainfed farming will continue to be based on the traditional *sailaba* and *khushkaba* systems, which depend, respectively, on run-on water from outside the cropped area and on rain falling directly on the cropped area.

The initiation of a program on CBWH in 1986 was based on the premise that many of the soils of Balochistan form a thin impervious crust after rainfall and this allows more efficient run-off of water to the cropped area. The disadvantage of this property is that the infiltration of the water in the cropped area is slow since the soils are relatively impervious. If the rainfall event is intense but short, the amount of water harvested is substantial and the risk of waterlogging is high. Finding the optimal ratio between the catchment (run-off) and cropped (run-on) area thus became an essential part of the program. Catchment-to-cropped area ratios of 1:1 and 2:1 were compared with a control treatment in which the crop was grown on the whole plot area. A 3:1 treatment was tried for the last three years of the program but after heavy rains waterlogging was found to be a serious problem.

The foregoing discussion largely ignores one of the basic principles of the CBWH program, that the catchment area is treated to exploit the sealing capacity of the local soils to improve the efficiency of run-off above 50 percent. This treatment involves cultivating and 'planking' the catchment area with a tractor mounted blade and wooden beam so that the soil is level and pulverized, then sprinkling water on the surface to form a crust. This crust is supposed to last for several years so that the cost of the treatment is spread over several cropping seasons. However, the basic flaw in this procedure is that farmers wish to have a flexible system that allows them to crop the whole field if the rains are good.

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[6]The MART project supported two of the staff for higher degrees. One member was awarded an MSc from Utah State University in late 1991 and the other re-joined AZRI in October 1993 after completing a PhD at the University of Arizona. However, the latter staff member transferred to NARC after spending only seven months at AZRI.

The whole CBWH program was subjected to critical evaluation since the start of Phase II, both from a methodological and economic standpoint. Obtaining a uniform stand of crop appeared to be difficult regardless of the treatment, related in part it seemed, to variable distribution of soil moisture across plots. As a result the grain yields in particular appeared to be low compared to farmers' expectations (Figure 2). Farmers reported wheat yields of 400, 300 and 100 kg/ha and barley grain yields of 300, 200 and 0 kg/ha in good, average and poor years under *khushkaba* conditions, respectively (Rees *et al.*, 1987). Under *sailaba* conditions the respective yields were 800, 600 and 300 kg/ha for wheat and 500, 400 and 200 kg/ha for barley. The lower yield expectations for barley suggest that farmers grow it on poorer land than wheat, since barley usually yields better than wheat under low rainfall conditions.

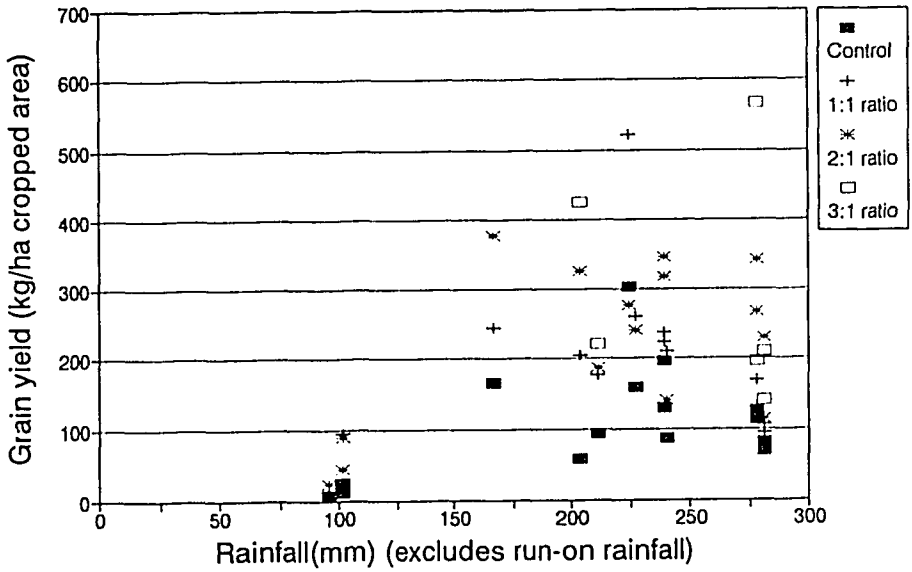

Figure 2. Wheat grain yields (kg/ha) in water harvesting trials from 1987/88 to 1992/93. (The data in the graph should be interpreted with caution since the yields in the water harvesting treatments were obtained from more moisture than is shown in the graph. For example, in the 1:1 treatment, assuming 50 percent run-off efficiency, the yields would have been obtained from 50 percent more moisture than shown in the graph. Thus, the relationship between yield and rainfall is only valid for the control treatment. Only this relationship would give an indication of rainfall-use-efficiency.)

Even though several of the CBWH sites were on farmers' fields, farmers were not participating actively in the testing program. There were also questions about the choice of the control treatment. These arose when the survey about farmers' perceptions of water harvesting in 1992 showed that farmers change the catchment-to-cropped area ratio depending

on rainfall[7]. The 1:1, indeed the 2:1 treatment, therefore seemed closer to what farmers were actually applying.

Perhaps the most controversial aspect of the CBWH program was the basis used to calculate net benefits which indicate the likely profitability of the system (see page 23 of this report). The two bases used were the crop yields either expressed per hectare cropped area or per hectare total area (cropped-plus-catchment area). The first approach assumes that land is unlimiting in Balochistan, whereas the second assumes there is an opportunity cost to not cropping the catchment area, implying that land is limiting. Not surprisingly, these two approaches have a major effect on the net benefits of the two systems, as is discussed below.

It is extremely difficult to take sides in this controversy since both arguments have their strengths and weaknesses. Ridged adherence to economic principles is probably inappropriate in some situations. However, there is evidence that in certain areas and in years of good rainfall the cropping intensity is so high that land becomes limiting. It is also probable that when rainfall is good individual farm size is a limitation, despite the presence of large tracts of uncultivated land nearby belonging to other farmers. The deciding factor in this controversy seems to be that farmers like to have flexibility in the proportion of each field that they cultivate and the CBWH approach takes away this flexibility. If this is true, them it suggests that the economic analysis should be based on the total area of the field. These questions deserve further detailed discussion before a new field program on water harvesting is started.

The foregoing remarks should be tempered by the most encouraging recent developments in Kovak Valley where the Project had a significant extension program during Phase I but dropped the site early in Phase II due to its remoteness. A farmer in the Valley adapted one of the former CBWH sites to give a 1:1 ratio and harvested an estimated 1500 kg wheat grain per hectare in June 1993. This achievement resulted in CBWH plots of 1 ha being established on 10 farms in the valley in December 1993 as part of the BOSTID water harvesting project. The plots were sown with seed of local and improved wheats and barleys. The extremely late first rains followed by exceptionally low rainfall in 1994 thwarted this exciting on-farm program but it is hoped that it will be repeated for at least another four seasons.

The limited involvement of farmers in the CBWH program, the controversy about the economics of the technology and serious doubts about whether farmers would adopt it, resulted in the program being terminated at the end of the seventh season, 1992/93, with the exception of the trials in Kovak Valley. However, a modified research program was

[7]This survey was initiated as part of the Dryland Resource Management Project (DRMP) of ICARDA. The AZRI CBWH program was included in this project as one of six case studies from different countries in West Asia and North Africa.

continued as part of the BOSTID water harvesting project which focused on contour strip cropping as an alternative to CBWH, and on the effect of catchment-area length on run-off efficiency. Unfortunately the yields of wheat and barley in the strip-cropping trial during the 1992/93 season were very low and 1993/94 (Figure 3) was so dry that the trials were abandoned. It is thus too early to judge the potential of strip-cropping (AZRI, 1994).

Agronomy. An extensive research program on the agronomy of cereal and legume crops was conducted during Phase I under the leadership of the ICARDA advisor and several papers and reports were published (see Annex 1). Some of this classical research, such as fertilizer responses and seed rate trials, was continued during the first two cropping seasons of Phase II (AZRI/ICARDA, 1991, 1992). However, the results were highly variable and dependent as much on rainfall as on the management of the trials. Thus, from October 1990 the scope of the agronomy research was gradually reduced so that staff could give all their attention to the water-harvesting research.

Agro-meteorology. It is well known that Balochistan has an extremely variable and harsh climate, in particular large intra- and inter-seasonal variations in rainfall. The latter is illustrated in Figure 3 which indicates that annual rainfall has not decreased during the last 100 years as some people claim. The figure also illustrates that the 1993/94 cropping season, with only 104 mm received at AZRI, was among the 10 driest during the last 100 years. This had a severe impact on AZRI's field program[8].

In 1990 automatic weather stations (AWS) were already installed and operating at AZRI, ARI Sariab, Tomagh, Spezand, Mastung and Mektar (east of Loralai). They provided essential information for the interpretation of, *inter alia*, crop growth patterns. In June 1994 they were sited at AZRI, ARI Sariab, Tomagh and Mastung and two were in store. A special effort needs to be made to ensure that the information is summarized on an annual basis so that complete sets can be made available to users.

GERMPLASM RESEARCH

The achievements of the Germplasm Section should be seen in relation to the staffing strength of two SOs[9] and one ASO. For two years until March 1992 the staff were supported by the ICARDA advisor responsible for Agronomy, Water Harvesting and the Germplasm activities. The small team should be congratulated on being the only one at

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[8]Just to show how variable the rainfall can be, the 1994/95 season started with record monsoonal rains over much of Balochistan in July 1994. AZRI recorded 47 mm at its station by July 20 which is the eight highest amount for July during the last 100 years!

[9]The Head of Section, who was a long-term trainee supported by the MART project and awarded an MSc from Montana State University in January 1991, was promoted to SSO in January 1994.

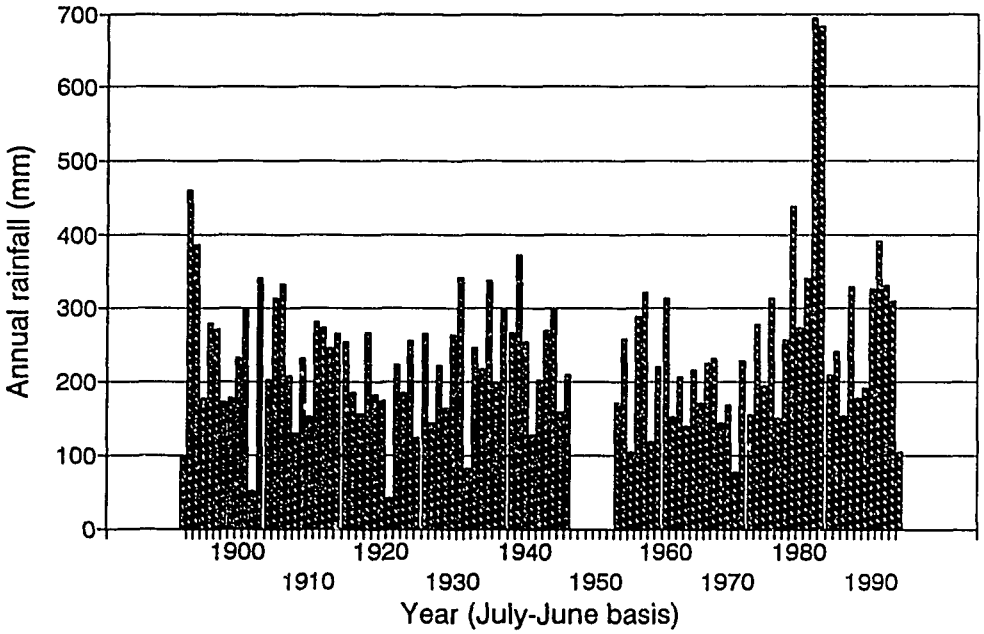

Figure 3. Annual rainfall at Quetta between 1892 and 1994 (July to June basis to coincide with the cropping season). (Rainfall measured at Quetta airport Samungli until 1985, thereafter at AZRI.)

AZRI that has regularly produced an annual report. The staff were set on a firm course during Phase I. The experimental sites used had good soils and were either close-by, on government stations or on farmers' land. The trials were generally well managed and water for irrigation was available. The results of the germplasm research are indicated in the annual reports of the Section (see Annex 1).

The main focus of the germplasm research since the Project started has been the selection of improved lines of bread wheat, barley, lentils and forage legumes. Each year ICARDA's crop improvement programs sent nurseries of promising material requested by AZRI. The material was screened for adaptation to the local abiotic stresses and for resistance to local diseases and pests. Testing took place as several locations in highland Balochistan.

Winter wheat. Winter wheat received particular emphasis since this is the most important winter-sown rainfed crop grown in highland Balochistan. The main achievement was the identification of bread wheats resistant to the yellow rust fungus *Puccinia striiformis*. Using information from a survey conducted during the yellow rust epidemic in 1990, the disease has been estimated to cost farmers growing wheat in three Districts of highland Balochistan some Rs200 million once every five years (Ahmed *et al.*, 1991).

Good progress to identify adapted lines of barley was also made during the life of the Project. The promising lines of barley and wheat now being multiplied to increase the stocks of seed are shown in Table 1. Testing of Gerek started in 1989. It is a bread wheat brought from Turkey where it has been grown for over 20 years. ICW1471 is a selection from a nursery sent from ICARDA for sowing during the 1981/82 season! Although both Gerek and ICW show good resistance to the local strain of yellow rust and yield as well as the local landrace, some doubts remain about the quality of the straw. **There is an urgent need to evaluate the straw quality of these and all new lines of wheat and barley so that they are not rejected by farmers because of inferior straw quality. For such evaluations, which should be made using sheep, at least 200 kg straw from each line are needed.**

Food and forage legumes. Several lines of large-seeded lentils were identified, such as ILL5677 and ILL5865. These large-seeded types have a potential to replace the local small-seeded line which is apparently not popular with consumers. This is said to partly explain the low demand for the local lentil and hence its small area in Balochistan, said to be only about 100 ha. The following vetches were tested: common vetch (*Vicia sativa*), woolly-pod vetch (*V. villosa subsp. dasycarpa*), narbon vetch (*V. narbonesis*), bitter vetch (*V. ervillia*) and common chickling (*Lathyrus sativus*). Particularly promising for winter sowing under favourable moisture conditions provided by water harvesting were common and woolly-pod vetch (Accession 683) and for spring sowing, bitter vetch.

Changing the focus of the Section. Making an impact at the farm level was the main reason why the Section was advised to switch its attention from screening promising lines selected from nurseries sent by ICARDA, to the release of material well adapted to the local abiotic stresses and resistant to the local pathogens and pests. The Section responded during the 1992/93 season by increasing the seed of promising lines and much of this effort was contracted out to farmers. By July 1993 AZRI had stocks of seed as indicated in Table 1. Unfortunately, no seed was multiplied by farmers in the 1993/94 season since it was felt this could be done on AZRI and government stations. Indeed, it was proposed that irrigation facilities be developed at Mastung farm for the purpose of increasing seed there. This proposal is not supported since it is contrary to the efforts made during Phase II to promote an on-farm-based research program with farmer involvement. Development of Mastung station would provide an almost irresistible excuse to irrigate crops as soon as there was felt to be a moisture shortage.

The agronomic practices applied by the Section have been questioned for several years and only some of them have been changed. Noteworthy is the provision of a pre-planting irrigation in October at ARI Sariab so that early planting can take place. The justification for this practice is that plants need sufficient leaf area by December to test for cold tolerance. Additional 'life saving' irrigations are applied in spring if the rainfall is low, on the grounds that the material has to be saved. These irrigations result in the material being selected under

Table 1. List of lines of promising germplasm and amounts (kg) of seed available in July 1993

Crop	Name of line	Seed
Wheat	Gerek (AZRI-931)	2340
	ICW-1471 (AZRI-932)	795
	HAW-16	87
	WOL-8873	36
	WAT-1007	40
	Local	95
Barley	Arabic Abiad (Bolan-93)	228[1]
	39-58	338
	WI2291/WI2269	64
	Di-Jou 3-2-5	29
	Rihane-03	26
	Arabic Abiad (Emir)	32
	Arabic Aswad	69
	Wadi Hassa	69
Lentils	ILL 5865 (Masoor-931)	65
	ILL 5677 (Masoor-932)	87
Vetch	Woolly pod vetch (Shadab-93)	26

[1]AZRI Agronomy Section also has some 1200 kg of seed.

circumstances far more favourable than the rainfed situations they are destined for. It was recommended that only a part of the material should be planted under these conditions just to save the material in the case of drought, whereas the rest should be grown under purely rainfed circumstances. The higher yields of promising lines obtained by the Germplasm Section as compared to the Agronomy Section which tests these lines under true rainfed conditions, is evidence of the favourable circumstances under which the plants are grown.

A further re-orientation of the research in the Section started in October 1993, with a reduction in the priority given to forage legumes and lentils, and an increased priority being given to certification and release of promising lines and to the multiplication, cleaning and commercialization of new varieties. For this reason the Head of the Section made a two week visit to the USA in April 1994 to learn about the operation of the commercial seed industry in that country.

ECONOMICS RESEARCH

The achievements of the Economics Section during Phase II should be seem in relation to the staffing strength of one SO[10], one ASO, one grade 11 and one SO on contract. The Section was guided for two years until July 1992 by the ICARDA Agricultural Economics Advisor. The main research activities relating to agricultural economics during Phase II are briefly indicated in the following sections. Particular attention was given to the marketing of small ruminants, as indicated in the activities of the Project document (see page 7 of this report).

Economic losses associated with yellow rust (YR) in wheat. In the spring of 1990, at the end of a growing season with above average rainfall, a survey of YR infestation was conducted among 110 farmers located in Loralai, Khuzdar and Kalat Districts (Ahmed *et al.*, 1991). Ninety-nine percent of the farmers in the surveyed areas were growing the local landrace of wheat which is susceptible to YR. Field estimates indicated grain losses of 88, 77 and 58 percent, respectively, in these three Districts. Assuming a YR outbreak once every five years which results in losses of Rs200 million, an annual expenditure of Rs10 million for germplasm research into YR resistant varieties is justified, assuming a benefit:cost ratio of 4:1. The importance of this research is highlighted by three consecutive YR epidemics that occurred in the growing seasons 1989/90 to 1991/92. On average, epidemics are likely to occur once every five years.

Marketing of goat and sheep skins. A survey was conducted in the summer of 1991 to investigate the marketing of skins of small ruminants at some of the main towns in highland Balochistan (Rodríguez *et al.*, 1993a). Sixty butchers and 35 *beoparis* (wholesalers) were interviewed. The two main factors affecting prices were season and animal species, with winter prices being higher than in summer, and sheep skins commanding a higher price than goat skins. The marketing margin, which is the increased price received by *beoparis* compared to butchers, was 1 and 16 percent for sheep and goat skins, respectively. Because of poor management, most of the skins in Balochistan are of low quality in terms of size, thickness, flaying cuts and scars. It was recommended that price information be regularly collected, analyzed and disseminated through different media. This information would indicate how price is a function of quality and would be a way to encourage producers to deliver better quality animals to market.

Economics of water harvesting. The data from the seven-year program on catchment-basin water-harvesting (CBWH) was subjected to a simple economic analysis to calculate the net benefit of the different treatments (Rodríguez *et al.*, 1993b). The analysis aimed in particular

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[10]The Head of Section, who was awarded a PhD from the University of the Philippines in 1990 with funding from non-MART sources, was promoted to SSO in January 1994.

to show whether the technology resulted in an reduced temporal variability in net benefits, as expressed by the coefficient of variation (CV). Reducing this variability is seen as an important attribute of the technology since it would contribute to a more stable supply of wheat to farm families and to more stable incomes. The results presented here use data from all seven years of the project (Mustafa *et al.*, 1994a). They illustrate how the outcome of the analysis varies depending on whether the results are expressed on a cropped area or a total area basis (catchment and cropped area) (Figure 4). As indicated already (page 23), the justification for using the total area basis was a hotly debated issue.

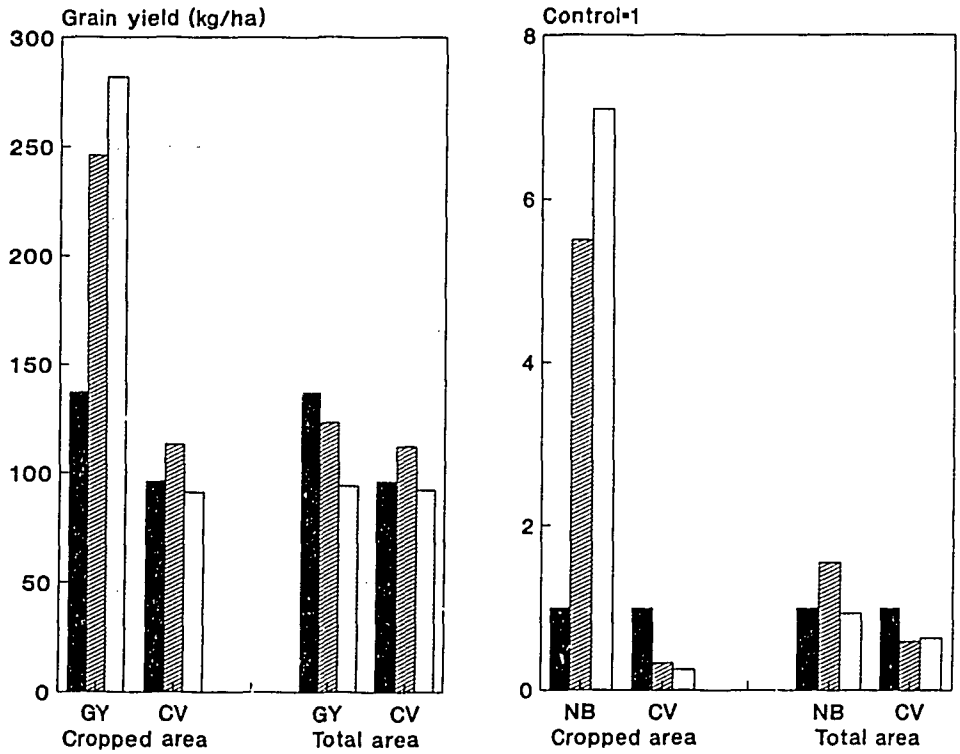

Figure 4. Grain yields (GY, kg/ha) and their coefficient of variation (CV) (left graph), and relative net benefits (NB) and their coefficient of variation (CV) (right graph) for wheat using different water harvesting treatments, expressed either on a cropped or a total area basis. (The values in the right graph are expressed relative to the control treatment.) (Legend: ■ = control, ▨ = 1:1, □ = 2:1.)

The results are markedly influenced by the basis used to calculate the net benefit. If the cropped area alone is used as the basis, water harvesting leads to a substantial increase in grain yields and net benefits, and a reduction in the CV. However, expressed on a total area basis, grain yields decreased as the ratio of catchment-to-cropped area increased. The 1:1

treatment gave a 55 percent improvement in relative net benefit compared to the control. The relative net benefits of the 1:1 and 2:1 treatments expressed as a CV, were about 60 percent of the CV of the control. Judging the economic benefits of CBWH therefore appears to depend heavily on the basis used to make the analysis. It is likely that the controversy concerning the basis used may be less important than the desire of farmers to retain flexibility in the proportion of land they crop. The CBWH technology is too rigid in this respect which may make farmers less willing to adopt the technology. Noteworthy are the relatively low actual yields of wheat grain, as already mentioned. The picture for barley is similar to the one presented here for wheat.

Price expectations of producers and other market agents for small ruminants. A two year study on the price expectations of the producers of small ruminants and of other market agents was completed in December 1992. The study involved visits to Quetta livestock market where 50 prices expected by producers and 50 prices expected by other market agents (*beoparis* (wholesalers), commission agents and butchers) were obtained each month. The expected prices were divided equally between sheep and goats. Also recorded were the animals' measured and estimated liveweight, species, breed, sex and body condition (Rodríguez *et al.*, 1994). A linear regression analysis between expected price per kg liveweight and Julian days indicated a daily price increase of between Rs0.0054 and Rs0.0099 (the regression coefficient). Over the period January 1991 to October 1992 the expected price of sheep increased by Rs5.29 and Rs6.63 per kg liveweight for producers and other market agents, respectively. These represent price increases of 20 and 28 percent, respectively, both of which were substantially higher than the 'official' price increases of 10 percent for that period.

A survey of farmers' perceptions of water-harvesting. This survey was conducted in the spring of 1992 as part of the Dryland Resource Management Project (DRMP) of ICARDA. It produced some interesting results but these have only been partially analyzed (Mustafa *et al.*, 1994b). One finding was that farmers cultivate an area in their bunded fields that depends largely on the rainfall already received. Thus, they have developed a flexible system which is in contrast to the CBWH technology studied by AZRI. The results from the 145 farmers surveyed indicated that 3-5 ha of wheat was grown whereas they needed to sow 13-17 ha to cover the annual wheat flour needs of the family. Does this imply that land is indeed limiting, that labour or seed is limiting, or that only those parts of a farm are sown where good yields can be obtained?

Farmer participatory approach. A welcome development since 1993 has been the increased attention being given by the head of the Section to farmer participatory approaches (Mustafa *et al.*, 1994c). The approach is being applied in Kovak Valley. It is hoped that all staff at AZRI will be involved in such efforts, and that close links will be maintained with the FAO project in Kanak Valley which has experienced staff using the approach.

EXTENSION RESEARCH

The Extension Section was nominally staffed by one SO until March 1993 when one PSO and one SO were transferred to it. Since then the effective strength of the Section has been one PSO and one SO on contract.

Camel Planter. At the start of Phase II there were 10 prototype camel planters manufactured by Niam Company in Faisalabad ready for distribution to farmers. However, this seemed premature since the machine had not been thoroughly tested. Field trials were conducted during the 1990/91 season to compare the camel planter with the traditional camel-drawn plough which is also used for sowing. The results were largely inconclusive, mainly because the soil in the plots was too hard and the seed was poorly covered, resulting in low germination (B. Chowdry, unpublished report). However, the basic problem was the poor design of the prototype. It weighed about 80 kg and was too heavy for the local camel since it had three tines to plant three rows. Attempts to design a lighter version were unsuccessful. It too weighed about 80 kg and was fitted with narrow iron wheels rather than the broad rubber tyres fitted to the original prototype.

Added to these difficulties was the widely varying views among AZRI staff about the adoption potential of the machine. Antagonists said that tractors were taking over from camels, that bullocks not camels were used in many areas apart from the more remote valleys of Balochistan, and that no farmer could afford Rs8,000-10,000 ($250-$320) to buy one machine. Supporters said the machine would be useful in the remoter valleys where camels are still widely used for traction. It was therefore decided in October 1993 to end the project. However, the Balochistan Rural Support Program has reputedly been testing one of the original prototypes although there are no reports about progress to date.

Demonstration of Water-harvesting. This project started in October 1992 but only one site was established at Dasht with the 1:1 treatment being compared with a control treatment. In 1993/94 two demonstration sites were planned but crops were not sown due to the low rainfall.

Establishing Saltbush Reserves. The greatest achievement of the Section during Phase II has been the gradual expansion of the number of sites demonstrating saltbush since June 1990 (Table 2). A whole range of designs were used, from simple forage reserves to inter-cropping. However, although specific guidelines concerning site selection where given, these were either difficult to apply or misunderstood, such as at the new site at Miangundi where a dense stand of sagebrush had to be removed prior to planting. (Important site selection criteria were outlined previously, see page 17.) The main weakness of this on-farm effort was again the minimal involvement of farmers in the establishment of the sites and in the management of the reserves. The new activities of the Section in Kovak Valley have given

Table 2. Saltbush reserves on farmers' fields and on research stations

Site number, code[1] and name	Type of reserve	Establishment year	Area (ha)	Number of seedlings	Condition in Ap 94	Comments
On-farm sites						
1-Ex Zarchi	FWSB alone	1988	0.15	150	Good	No measurements were taken, plants not grazed
2-Ex Kovak I	FWSB alone	1988	0.10	250	Good	No measurements were taken, plants not grazed
3-Ex Kovak II	FWSB alone	1988	0.20	500	Good	No measurements were taken, plants not grazed
4-Ag Spezand	Water-harvesting	1990	0.50	1250	Excellent	No measurements were taken, plants not grazed
5-Ex Spezand	Inter-cropping	1990	0.50	1250	Good	Farmers apparently satisfied with concept
6-Ex Spezand	Inter-cropping	1990	0.25	600	Poor	Used for camel planter studies in 1990/91
7-Ex Miangundi	FWSB alone	1992	1.00	2500	Excellent	Grazed after 9 and 18 months
8-Ag Spezand	Strip cropping	1993	0 10	250	Poor	FWSB established well but site neglected
9-Ag Dasht	Strip cropping	1993	0.10	250	Poor	Plants damaged while cultivating plots in 1993
10-Ex Killi Riasani	Inter-cropping	1993	0.25	500	Good	Inter-cropped with sorghum in 1993
11-Ex Killi Pirwali	Inter-cropping	1993	0.25	800	Destroyed	Site too close to village, grazed while too small
12-Ra Sinjidi	Inter-cropping	1993	3.50	8000	Good	Plants well established
13-Ra Rindozai	Saline soil	1993	0.50	1600	Poor	Most of plants died due to high salinity
14-Ex Miangundi	FWSB alone	1994	1.50	3000	New site	Poor choice of site, high density of sagebrush
15-Ex Hazargangi	Inter-cropping	1994	1.00	2500	New site	Good choice, deep soil
16-Ra Hannah Lake	FWSB alone	1994	1.00	2000	New site	FWSB requested by Army
On research stations						
1- Tomagh	FWSB alone	1988-92				Various studies
2- AZRI	Various	1985-94				Various studies
3- Mastung	Water-harvesting	1989-91				Various studies, heavy rodent infestation

[1]AZRI Section responsible for site: Ag = Agronomy, Ex = Extension, Ra = Range.

particular attention to getting the farmers involved in nursery and forage reserve establishment and management.

The difficulties of applying a multi-disciplinary approach to the concept of forage reserves were again apparent since it was difficult to get staff from different Sections to work together.

Video film about AZRI activities. AZRI has been planning to produce a film about its field activities since 1990 and has made some progress since new equipment was purchased in 1994. It is hoped that eventually a documentary about AZRI will be completed.

Field days. Two field days for farmers were held for the first time in 1992. A third field day was held in August 1993 for a small group of farmers and government officials at the Miangundi site where AZRI has one of its best saltbush reserves. No field days were held in 1994.

Other activities. Since March 1993 the Section Head has been overloaded with other responsibilities, such as coordinating the production of the AZRI Quarterly Report and the 1993/94 research protocols, as well as one issue of the AZRI NEWS series started by the ICARDA advisors.

PROJECT REPORTS AND PUBLICATIONS

The MART/AZR Project Research Report series is one of the greatest achievements of the project (see Annex 1 for the full list of titles). It is probably one of the most comprehensive series of any PARC institute and serves as a unique institutional memory. However, this achievement must be tempered by the gradual fall in the output of research reports since the peak in 1990. During Phase I 65 reports were printed, whereas during Phase II only 15, which is equivalent to four and two per advisor year during Phases I and II, respectively. There has been a steady stream of papers published in international and national journals (see Annex 1).

RESEARCH PLANNING

Considerable efforts were made to strengthen research planning at AZRI. The first annual planning meeting was held in 1987 and these annual events continued until May 1992. Each year a list of the research protocols was published as a MART/AZR Project Research Report. In 1992 and 1993 budgets for each protocol were prepared although this proved an ineffective exercise since principal investigators were not given the authority to manage their own project budget, except in the case of the PEP and BOSTID projects.

The weakness of the planning mechanism was that the advisors did all the planning, much of the writing and all the editing of the protocols. For this reason the whole task was handed over to AZRI in July 1993 although the COP made a substantial contribution to deciding on the final list of protocols. By April 1994 AZRI completed this task and the AZRI Research Protocols for the 1993/94 season were printed as the first report in the new AZRI Research Report series. **AZRI should be proud of this achievement, particularly since it is apparently one of the few institutes in the whole PARC system that publishes an annual research plan.**

The planning process for the 1993/94 season was perhaps the most arduous and excruciating so far since a serious attempt was made to review all the ongoing and proposed research. This review was necessary since the number of protocols had been steadily increasing over the years and a number of proposals about 'hobby' or 'fashionable' research were creeping in, such as work on black cumin, medicinal plants, jojoba and urea-molasses blocks. These were excluded although some of them crept back onto the final list. The review resulted in a shorter list of protocols, a high proportion of which would be implemented, rather than a long list of protocols categorized according to priority.

A simple mechanism to monitor the whole portfolio of protocols was prepared in 1993. It is merely a list of the protocol codes, titles and a letter code to indicate the status of each protocol (Table 3). A small table (Table 4) is used to summarize the numbers of protocols in several categories, such as those that are new, ongoing and finished. The table illustrates the evolution of the research program at AZRI during Phase II of the project. There has been a slow-down in the rate of increase in the total number of protocols, achieved largely through a reduction in the number of new protocols proposed for 1993/94. However, the number is still far too high, despite a rigorous 'weeding out' of protocols that should not be in the list or were cancelled or terminated because they were irrelevant. The number of protocols that were finished is still unacceptably low. This indicates one of the fundamental weaknesses at AZRI, which is a shortage of staff who are capable of analyzing data and writing reports and papers. Hopefully this situation will change as an increasing proportion of the total staff hold overseas postgraduate degrees. AZRI management will also have to insist at future annual planning exercises that staff analyze data from the previous season and write a summary report before starting new projects.

Table 4 also speculates on the distribution of protocols in each category in 1994/95 so that the overall number gradually decreases, leaving more time for writing reports and papers and using the improved library facilities. Attention should be given to analyzing data and publishing significant but uncompleted studies, such as Protocols E03, E05 and R01. Moreover, a special effort is needed to check staff's desire to pursue hobby and fashionable research unless it has a good chance of being adopted by farmers in the short-term. Indeed, the research portfolio should be defined according to problems identified in the field, not by the desires of staff.

Table 3. List of AZRI research protocols, 1990-1995

Protocol codes	Short title	90/1	91/2	92/3	93/4	94/5[1]	Analysis/ reporting responsibility	Comments (July 1, 1994)
E01	Sheep marketing survey	N	O	O	D	F	-----	Rodríguez et al. (1994)
E02	Skin marketing survey	N	F	-	-	-	RR76 out	Rodríguez et al. (1993a)
E03	Seasonal price indices	N	O	O	D	D	Afzal	Data analysis very slow
E04	Risk analysis of WH (DRHP)		N	D	D	D	Usman, Zahid	Workshop paper written
E05	Farmers' perceptions of WH (DRHP)			N	D	D	Usman	Data awaiting analysis
E06	Survey of camel planter			C	-	-	----	Cancelled
E07	Economics of ewe fertility (BOSTID)			P	D	C	Imran	Cancelled
E08	Economics of WH (BOSTID)	O	O	D	F	-	RR77 out	Paper drafted
E09	Agricultural stats. of Balochistan				N	D	Imran	Tables nearly complete
L00	FWSB supplemented with barley/CSC	N	D	D	D	F	Atiq	Some samples missing
L01	Fertility of Harnai/Balochi ewes(BOS.)	O	O	O	O	D	Shahid, Inam	Workshop paper made
L02	Fattening potential of lambs (BOSTID)			N	O	D	Shahid, Inam	Workshop paper made
L03	Nutritive value of cereal straws		N	P	P	O	Shahid	Must conduct in 1994/95
L04	Lamb performance and ewe feeding (BOS.)	O	O	O	O	D	Inam	Workshop paper made
L05	Feeding value of FWSB + straw			N	D	F	Ejaz	Paper in preparation
L06	Flock monitoring/performance (BOSTID)			N	O	D	Riaz	Riaz left in April 1994
L07	Seasonal quality changes of FWSB				N	O	Ershad	Started July 1994
L08	Parasite studies in sheep				C	-	Sohail	Sohail left in late 1993
R01	Vegetation survey at three sites	D	D	D	T	-	----	Botanical names needed
R02	FWSB growth and agronomic factors	N	O	O	D	F	Sarwat, Abid	Paper in preparation
R03	FWSB and WH methods	N	O	O	D	F	Sarwat, Abid	Paper in preparation
R04	FWSB plant spacing/grazing pot. FWSB	N	O	O	O	O	Javed	One more season's data
R05	Season of planting		N	T	-	-	----	Terminated
R06	FWSB reserves on farmers' fields (PEP)			N	O	D	Sarwat (Ex1)	PEP might be extended
---	Vegetative propagation of FWSB	N	D	D	F	-	Javed, Wahid	Wahid left for PARC
R07	Soil media on establishment of FWSB		N	D	D	F	Javed, Wahid	Wahid left for PARC
R08	Grazing potential of FWSB			N	O	O	Sarwat	One more season's data
R09	In-situ range plant collection/herbarium			N	O	O	Begum	New project
---	Nursery production of FWSB (PEP)			N	E	-	Sarwat	Routine work
---	Volume to biomass ratio in FWSB			N	D	F	Sarwat, Javed	Paper in preparation
R10	Ecology of native and exotic range shrubs				N	O	Sarfraz	New project
R11	Ecology of sagebrush (Artemisia)				N	O	Sarwat	New project
G01	Eval. winter/spring wheats	O	O	O	O	O	Anwar	Commercialize lines
G02	Eval. winter/spring barleys	O	O	O	O	O	Anwar	Commercialize lines
G03	Eval. winter/spring lentils	O	O	O	O	D	Sarfraz	Phase out research
G04	Eval. winter/spring forages	O	O	O	O	D	Sarfraz	Give low priority
G05	Seed multiplication of promising lines			N	O	O	Anwar	Little action in 1994
G06	Improving resistance of local wheat			N	O	O	Anwar	On-going
G07	Evaluating lathyrus species (with NARC)				N	O	Sarfraz	On-going
A01	CBWH to increase yields	O	O	O	O	D	Zahid,Islam	Need wrap-up report
A02	Seed multiplication of good lines	O	O	O	E	-	Islam	On-going
A03	Agro-meteorological monitoring	O	O	O	E	-	Zahid	Need summary report
A04	Routine analysis of samples		N	O	E	-	Islam	Routine lab work
A05	Varietal trials of improved lines		N	O	O	O	Babar	On-going
A06	Contour strip cropping (BOSTID)			N	O	O	Zahid,Islam	On-going
A07	Run-off efficiency (BOSTID)			N	O	O	Zahid,Islam	On-going
A08	Nutrient responses of cereals and legumes				N	C	Arshad	Left for NARC Apr 1994
Ex1	Farmer involvement in FWSB	N	O	O	O	C	Hassan	Need activity report
Ex2	Assessing camel seed-drill	O	O	O	T	-	Bilal	Need wrap-up report
Ex3	Video film about AZRI and its research			N	O	O	Hassan	Slow progress
Ex4	Farmer involvement in WH			N	O	C	Hassan	Cancelled
Ex5	Revegetating hill next to AZRI				C	-	Cancelled	Cancelled
Ex6	Testing new technologies in Kovak Vall.				N	O	Hassan	1993/94 difficult year

Codes: C = cancelled before it began
D = lab/field work ended, data analysis and report writing continuing
E = ended as protocol since involves routine work
F = finished (report/paper written and printed)
N = new protocol
O = ongoing (field/lab work continuing)
P = postponed
T = terminated before it was complete

[1]Illustrative values, aiming to show a desirable trend.

Table 4. Summary of the status of the protocols in the AZRI research portfolio

Code	90/1	91/2	92/3	93/4	94/5[1]	Code descriptors
N	9	6	15	7	0	New protocol
O	11	17	18	21	17	Ongoing (field/lab work ongoing)
D	1	3	6	11	12	Data analysis ongoing, reporting started
F	0	1	0	2	7	Finished (report/paper published)
Total	21	27	39	41	36	
E	0	0	0	4	0	Ended since protocol involves routine work
C	0	0	1	2	4	Cancelled before it began
P	0	0	2	1	0	Postponed
T	0	0	1	2	0	Terminated before program was completed
Total	0	0	4	9	4	

[1]Illustrative values, aiming to show a desirable trend.

TRAINING ACTIVITIES

Strengthening the human resources at AZRI was a key element of the Project. It was achieved through three forms of training: 1) long-term training such as postgraduate studies at overseas universities, 2) short-term training which involved attendance at special courses or workshops, usually outside Pakistan, and 3) on-the-job training which involved working with the advisors.

Long-term Training (LTT). The LTT program of MART involved sending staff to MSc and PhD programs at universities in the USA. The first of the staff to complete a program returned to AZRI in 1990 and the last will return in 1995. Table 5 summarizes the latest status of the LTTs who have completed, or have still to complete, their degrees. Five more staff, excluding one AZRI slot that was awarded to a member from the Range Research Institute at NARC, will join the postgraduate programs of overseas universities during the period 1994/95 with support from the ARPII project. Figure 5 shows how the number of staff with overseas MSc and PhD postgraduate degrees might evolve at AZRI according to the best, a probable and a worst-case scenario. These scenarios depend on the number of staff that will leave AZRI soon after completing their degrees. Thus, instead of 19 staff holding overseas postgraduate degrees by the year 2000, there may only be 12 at AZRI. If the worst-case scenario transpires, AZRI will loose over half of its staff trained at overseas universities.

The steady escape of AZRI staff who complete their postgraduate degrees at overseas universities is one of the most serious weaknesses of the LTT program. The creation of a solid cadre of staff with overseas MSc and PhD degrees was the foundation on which to build a stable and effective research institute. Regrettably, by the end of the Project two of

Table 5. List of staff who have, or who will soon have, completed overseas postgraduate degrees with support from the MART project[1]

	Name of trainee	Degree	University	Return to AZRI	Subject
1.	Abdel Wahid Jasra[2]	PhD	Oregon State	10/1990	Range-animal nutrit.
2.	Anwar Khan	MSc	Montana State	1/1991	Barley breeding
3.	Babar Raza Kazi[3]	MSc	New Mexico State	1/1991	Soil science
4.	Zahid Ali Qureshi	MSc	Utah State	1/1992	Irrigation science
5.	Khanwar Nasir[4]	PhD	Ohio State	------	Poultry pathology
6.	Arshad Ali[5]	PhD	Uni. Arizona	10/1993	Plant nutrition
7.	Asghar Ali	PhD	Colorado State	1994	Lentil breeding
8.	Khalid Mahmood	PhD	Oklahoma State	1994/95	Ag. economics
9.	Ghulam Akbar	PhD	Utah State	1994	Range science
10.	Ahmad Samiullah	MSc	Iowa State	1994	Soil/plant science

[1]Not included in this list is Atiq-ur-Rehman who will complete a PhD at the University of Western Australia in 1995 with funding from Australia.
[2]Transferred to PARC in May 1992 18 months after returning to AZRI.
[3]Based at AZRI Sub-station Umerkot.
[4]Remained in U.S.A.
[5]Transferred to NARC in April 1994 seven months after returning to AZRI.

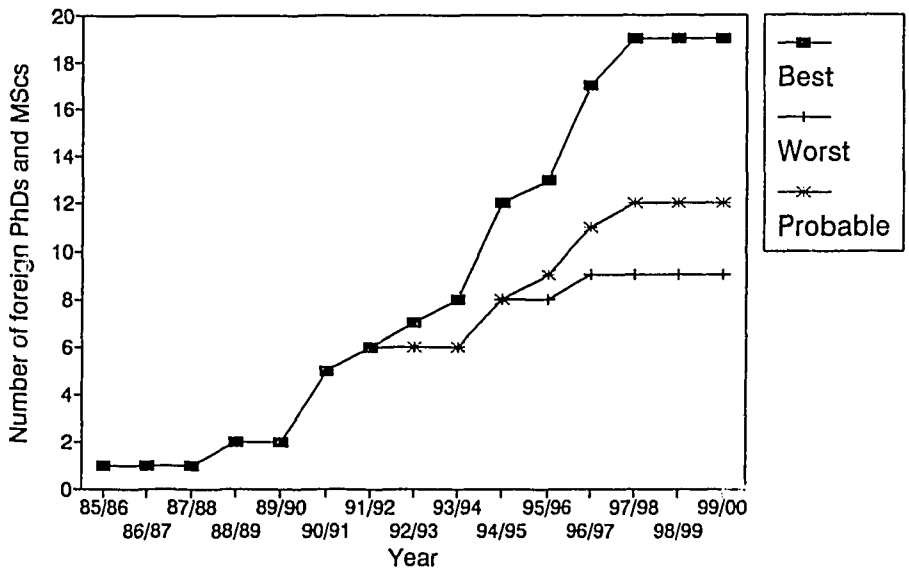

Figure 5. Increase in the number of PhDs and MScs at AZRI until 2000, according to a desirable (best), probable and worst-case scenario. (Based on nine staff trained under MART, four with degrees from other universities and six under ARPII.)

the AZRI staff who completed overseas PhD programs had managed to get transferred to PARC or NARC, and a third never returned to Pakistan. These transfers set an almost irresistible precedent for the remaining four staff who will soon complete their LTT sponsored by MART. (This excludes the one additional staff member who is completing a PhD in Australia.) For this reason alone it is imperative to award future LTT slots only to staff domiciled in Quetta or in Balochistan. There is a reasonable likelihood that they will stay at AZRI for many years. Every effort needs to be made to ensure that the five staff still on LTT return to AZRI for at least five years. Otherwise AZRI will end the century with a scientific cadre that is less well trained and able than it should be.

Short-term Training (STT). During Phase II special emphasis was given to individualized STT that aimed to build on the more generalized subject and English language training given during Phase I. The training involved attending courses and workshops and making visits to research establishments. This approach was applied for two main reasons: 1) an increasing number of AZRI staff had completed postgraduate degrees, and 2) it was desirable to help staff develop contacts with scientists at ICARDA HQ, in the USA and elsewhere, so that when the Project ended there would already be strong personal ties in place. For this reason several staff went to ICARDA HQ as visiting scientists or to attend specialized workshops. Several staff also visited universities and research stations in the USA, either funded by the Project or from the BOSTID component of MART. Some seven staff visited ICARDA HQ as visiting scientists or as participants at workshops and training courses, seven made visits to universities and research stations in the USA, and two attended workshops and conferences. Annex 2 presents a summary of the short-term overseas visits of staff.

On-the-job training. This involved the Agronomy/Water-Harvesting/Germplasm advisor and, in particular, the Agricultural Economics advisor who both spent a considerable amount of time during their two-year tenures with the respective AZRI groups. The COP provided the overall leadership and guidance concerning the research program of the Livestock and Range Sections. Regrettably less time was spent with the staff of these Sections than was wished.

VISITS OF ICARDA SCIENTISTS TO AZRI

An important goal during Phase II was to develop a partnership between the scientific staff at AZRI and at ICARDA HQ. Some progress was achieved in this respect although it was always difficult for AZRI staff to keep to the work plan and deadlines agreed to when ICARDA HQ staff made their visits. Furthermore, the relatively long travelling time to get to Quetta and back to Aleppo, although only requiring about six hours flying time in each direction, made it necessary to have a rewarding trip. Another factor leading to a reduced number of ICARDA staff visiting AZRI was the steady fall in the ICARDA budget during the last four years. This made it necessary for ICARDA staff to steadily re-examine their

outreach activities and priorities. These factors between them reduced the frequency of visits of ICARDA HQ staff to AZRI during the last two years of the project.

AZRI SEMINAR SERIES

Repeated attempts were made to institutionalize a seminar series. However, these were largely unsuccessful due to the reluctance of many staff to present their research, particularly since this made it necessary for them to organize and analyze their data.

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Chapter 3

RESOURCE AVAILABILITY AT AZRI

PHYSICAL RESOURCES

The basic physical facilities at AZRI are one office/lab block, a staff colony, a research station and range/livestock stations at Tomagh and Zarchi. AZRI also has use of the GOB Department of Agriculture's research station at Mastung and the provincial Agricultural Research Institute's station at Sariab (ARI Sariab) in Quetta. AZRI's main research sites are shown in Figure 6.

Office/lab block. The office/lab block was built during the early 1980s with funding from the first USAID Agricultural Research Project and was already occupied when the Project started in mid-1985. The building provides sufficient office space for the existing complement of scientists and support staff and the offices are adequately furnished. The labs have good benches and storage space.

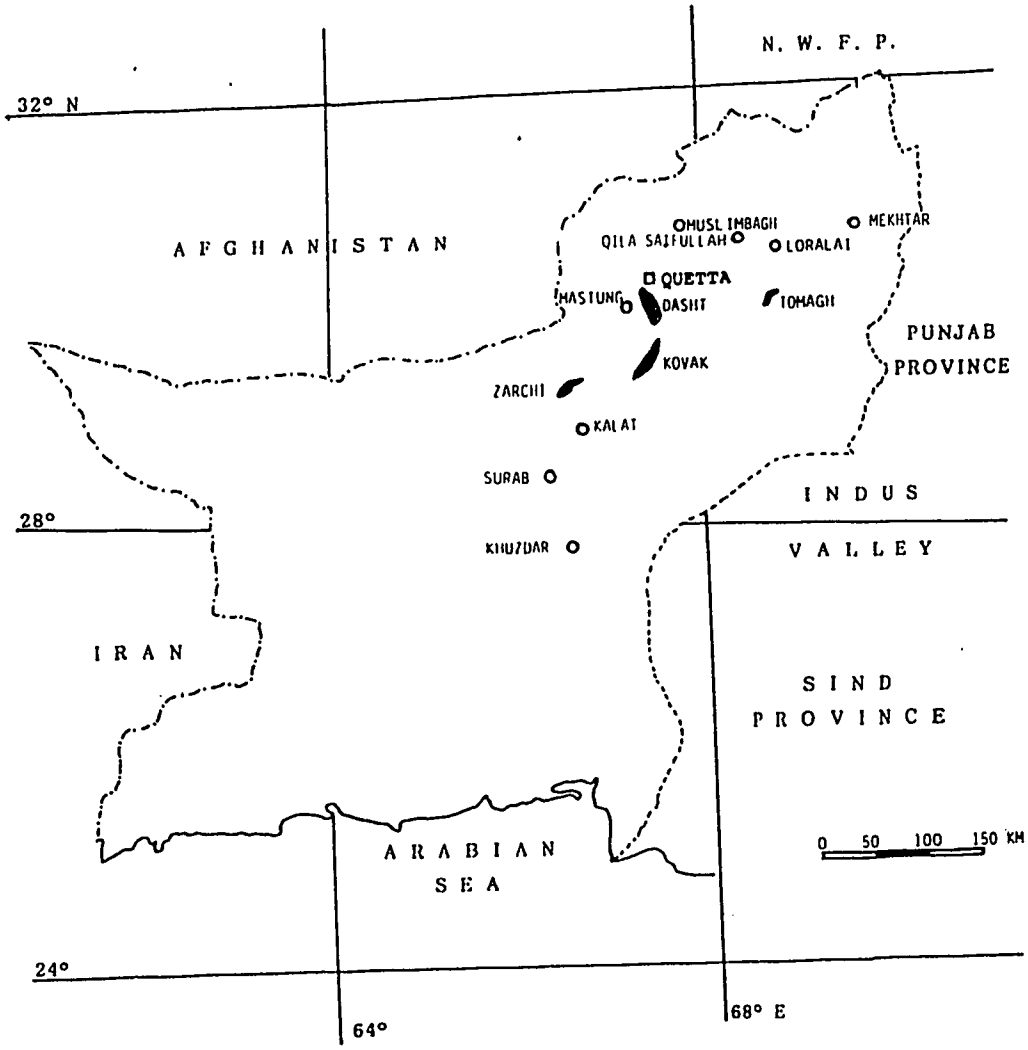
Staff colony: Most of the 24 residential units are occupied by scientists. However, they are poorly furnished and in desperate need of maintenance to stop the seepage of rainwater through the roofs and walls. This has caused extensive peeling of paint and crumbling of plaster. Indeed, no routine maintenance has been performed on the units since they were built some 10 years ago, apart from the concreting of some roofs in 1992 which was expensive but not effective in stopping the leaks.

FIELD STATIONS

AZRI Research Station, Quetta: The AZRI station of 30 ha is situated on a gravel fan which was originally rangeland. Many of the fenced plots are used for saltbush research and in other areas soil was transported in to make plots for experiments, particularly for the Germplasm and Range Sections. During the 1993/94 winter a concerted effort was made to establish plots to demonstrate the different methods of water-harvesting that AZRI has been testing on farmers' fields and at Mastung since 1986. The Animal Nutrition Unit situated on the research station has simple buildings for storing feeds and housing animals. There are also 18 crates for digestibility studies.

The station is exposed to trespassing along much of its 5 km perimeter, in particular at its remotest corner where valuable germplasm is multiplied. Construction of a 1.5 m high wall is certainly needed, if only to show where the actual boundary is and to deter dogs and small

Figure 6. AZRI research sites in highland Balochistan



children from entering. A higher wall could lead to tension with local people who feel they have an historic right-of-way across the area.

Tomagh Range/Livestock Station: This station is about 160 km (5 hours drive) east of Quetta near Sanjavi, a small town about 60 km west of Loralai in Loralai District. The road can be closed in winter by snow. The station has access to range which is adjacent to a 4,000 ha forest reserve established in 1906 by the Forest Department. There are simple buildings, including accommodation for resident *chowkidars* (watchmen) and visitors, animal yards and pens and storage for feed and materials. About 100 Harnai sheep and some goats are kept at the station. The ranges are dominated by the warm season perennial bunch grasses *Chrysopogon aucheri* and *Cymbopogon schoenanthus* (also called *C. jwarancusa)*. The annual rainfall is about 250 mm, with some 40 percent being received during the summer monsoon in July and August.

Zarchi Range/Livestock Station: This station is situated about 25 km west of Kalat, in Kalat District, some 100 km and 3 hours drive south of Quetta. The station has simple buildings, including accommodation for resident *chowkidars* and visitors, animal yards and pens, and storage for feed and materials. The annual rainfall in the area is about 200 mm, with some 90 percent falling in winter and spring. About 100 Balochi sheep and some goats are kept at the station. The surrounding shrublands are dominated by *Artemisia maritima* (this is also thought to be *A. herba-alba*). Range studies spanning Phase I and II of the Project showed that this shrubland has little ability to regenerate. In view of this fact, and due to the remoteness of the site and budget constraints at AZRI, it is recommended that the station be closed in late 1994.

Mastung Station: At Mastung, 50 km south of Quetta, AZRI has a 45 ha block of land belonging to the GOB Department of Agriculture. The site is used for studies on strip-cropping, water-harvesting and seed multiplication. It is not recommended that this site be improved with irrigation facilities since this could exacerbate the 'on-station research' tendency.

Germplasm sites: At various times during the last eight years the Germplasm Section has used sites at the ARI Sariab (Quetta), Kalat, Surab (south of Kalat), Khan Mehtarzai (near Muslimbach, AZRI's highest site at 2300 m altitude), Mekhtar (east of Loralai) and Qila Saifullah.

Karkhassa National Park: Karkhassa National Park is a valley close to AZRI station controlled by the GOB Forestry Department. It has been protected from grazing for about 11 years and has been used for studies on FWSB since 1991.

Farmers' fields: AZRI has used many farmers' fields for its experiments during the Project. Some of the most important locations were at Dasht, Spezand, Kolpur, Hazargangi and Kovak.

FINANCIAL RESOURCES

AZRI, like all the institutes of PARC, is acutely short of operational budget, that is the total budget minus establishment costs. The 1993/94 PARC budget indicates less than Rs40,000 ($1300) operating budget per scientist, excluding Productivity Enhancement Program (PEP) funds. After unavoidable costs such as utilities and diesel for local travel (transport of staff and school children to and from AZRI) are paid from this Rs40,000, almost no funds remain for research operational use. For the three years starting in mid-1994 AZRI will be heavily dependent on ARPII funds. Figure 7 shows the funding to AZRI since 1980. It includes the establishment and operational budgets, but excludes ARPII funds from mid-1990 until mid-1994 since these were not received due to the extension of the Project until August 1994.

Operating costs as a percentage of total costs have fallen steadily from about 50% in 1983/84 during the development phase of AZRI just before the Project started, to 20-25% in the early 1990s. There seems little prospect that the operating funds from the core PARC budget will improve in the short run. Deflating the annual purchasing power of the rupee using official GOP figures makes the budgetary situation at AZRI look even more precarious (Figure 8).

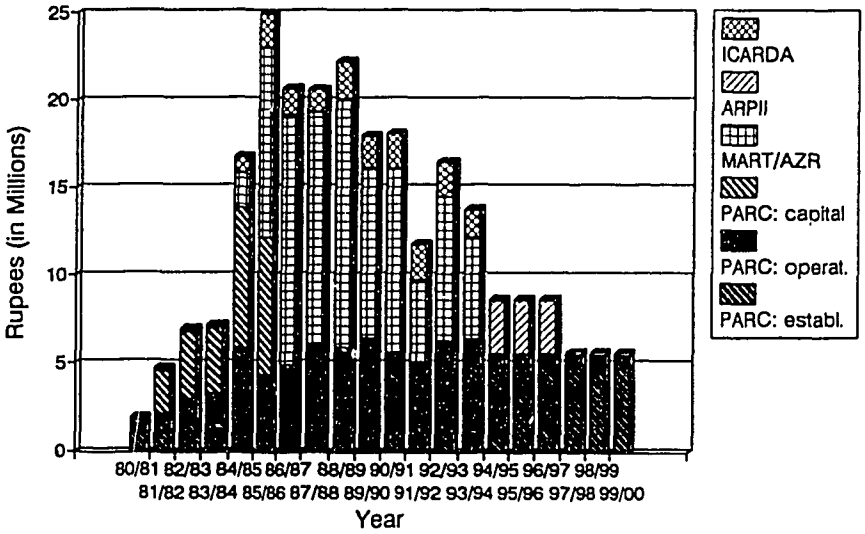


Figure 7. Sources of funding to AZRI from 1980 to 2000

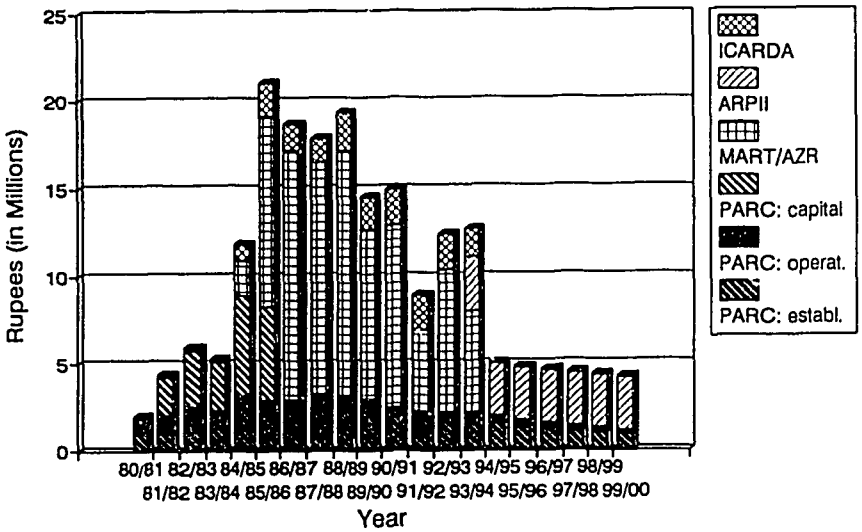


Figure 8. Sources of funding to AZRI from 1980 to 2000, with the PARC contribution adjusted for inflation

The PEP, introduced in April 1991[1] as part of the Federal Government's policy to accelerate agricultural development in Pakistan, released some Rs200 million to cover the operational expenses for research on problems in stressed environments. However, AZRI was slow to tap this source and only received Rs1.025 million over the two years 1992-94 for its research on saltbush. This is evidence of the isolation of AZRI, the weak lobbying power that AZRI has at PARC HQ and the need for an aggressive approach to applying for project funds which are known to be available.

HUMAN RESOURCES

AZRI has some 22 sanctioned positions in the scientific officer grades (Table 6). The staff show a high degree of variability in their qualifications, ability, motivation and performance. The latter two attributes are understandably positively correlated whereas ability appears to be poorly associated with motivation and performance. An important aspect of the Project was to improve the qualifications of the staff since better qualified staff are generally more able. However, their

[1]Economic Survey 1991-92. GOP, Finance Division, Economic Advisor's Wing, Islamabad.

performance can still be variable. The following section addresses the issue of staffing levels and staff motivation and performance.

Staffing levels by Section: Table 6 gives an indication of the regular staff in each Section in mid-1994. The table includes staff on LTT but excludes the Director and two long-term trainees who left AZRI, and one who stayed in the USA. A major effort was made by the COP to advise the Director how best to balance the different Sections, given the research priorities of AZRI. These efforts have been thwarted by the inability to be sure which staff will remain at AZRI after completing LTT.

Table 6. Indicative number of AZRI staff in each Section by the end of the Project, including LTT

Section	PSO	SSO	SO	ASO	Total
Range	0	3	1	0	4
Livestock	0	1	3	0	4
Agronomy	1	0	4	0	5[1]
Germplasm	0	1	2	1	4
Economics	0	1	0	1	2[2]
Extension	1	0	2	0	3
Total	2	6	12	2	22
- adjusted total[3]	2	4	7	2	15

[1]Includes one agricultural engineer.
[2]Excludes one grade 11 and one SO on contract.
[3]Excludes staff who are likely to leave AZRI after completing their overseas LTT sponsored by MART and ARPII.

Staff motivation and performance: Staff have to battle with numerous difficulties that affect their motivation and performance. These include: isolation from their home village or town, particularly if they are not from Balochistan which is often the case; isolation from PARC HQ; a harsh climate with no additional winter heating allowance; poor housing conditions; poor access to shops and schools; complex administrative and financial procedures and variable research leadership. Finding solutions to these difficulties will be no easy task but the Director needs to give the matter special attention.

Staff motivation and performance can only be raised by improving the living conditions at AZRI, increasing the operating budget and providing inspired research leadership, since it is not

possible to change the climate of Balochistan or the isolation of AZRI. Better living conditions, together with inspired leadership, will help the staff returning from long-term training (LTT) launch their research career and increase the likelihood that they will want to stay at AZRI. It is no secret that staff on LTT look for ways to avoid returning to AZRI and if they do return, they soon start a process to get themselves transferred to another station where the living conditions are better. It is also well known that staff move to AZRI just to qualify for a LTT slot. This is most undesirable if it means that a candidate domiciled in Balochistan looses his or her LTT slot due to being slightly less qualified. This is a reflection on the quality of the secondary and tertiary education in Balochistan rather than the ability of the staff themselves who, given time, would catch-up.

FIELD, LAB AND AUDIO-VISUAL EQUIPMENT, COMPUTERS AND LIBRARY

A strategy was pursued during Phase II to ensure that by the end of the Project AZRI was left with an adequate and functional set of field, lab and audio-visual equipment, as well as computers. Modest efforts were made to strengthen the Library. The strategy was based on the premise that in future there will be no funds to purchase commodities (except under ARPII) but that there will be sufficient operating funds for a modest research program, supplemented with funds from ARPII and future special projects such as PEP.

Field equipment: AZRI has modest field equipment purchased during Phase I. This includes four tractors, six automatic weather stations, various small and large threshers, flat-bed trailers, a trailer-mounted water tank, a gravity seed-cleaner, a pneumatic seed cleaner, a tractor-mounted Oyjord planter, cultivators, ploughs and other assorted implements. During Phase II the tractors were repaired on numerous occasions and were all functional at the Project Actual Completion Date (PACD). In 1994, additional equipment was purchased, the major items being a MF375 tractor, mould-board plough, a spring-tined cultivator and post-hole diggers. These and the original equipment provides the minimum needed to allow AZRI to conduct its experimental program. Routine repairs and maintenance of equipment can be financed under ARPII funds until 1997 since the budget of AZRI is totally inadequate for financing all but the simplest repairs.

A modest agricultural workshop was established and equipped using Project funds but a shortage of staff resulted in the workshop being non-functional at the PACD. A building for a feed mill was constructed, and the equipment was installed, wired-up and made functional.

Lab equipment: At the start of Phase II the labs contained basic equipment needed for routine chemical analyses. However, it has been little used, at least during the period 1990-94. This

is largely due to a shortage of technical staff and an unwillingness of scientific staff to conduct their own analyses. The lack or malfunctioning of equipment is only a partial explanation for the under-use of the labs. Some of this equipment became defective during Phase II and efforts were made to repair it. However, this proved impossible since most of it was imported and old, no spares or expertise were available in Pakistan to repair it, and wiring diagrams were not available. For this reason some new equipment was purchased during 1994 (see Annex 3).

Audio-visual equipment: New equipment was purchased in early 1994 since most of the original items purchased during Phase I were broken and beyond repair. The equipment purchased is shown in Annex 3.

Computers: At the start of Phase II AZRI had six IBM AT PCs and three COMPAC portable computers and peripherals (monitors, keyboards, voltage stabilizers and UPSs). New computing equipment was purchased in early 1994 (Annex 3) so that by the PACD AZRI was left with a good inventory of computers and peripherals that should serve it well for the coming five years or so. However, it is likely that budgetary constraints will preclude AZRI from taking out a maintenance contract with a local dealer. Neglecting the routine maintenance of this equipment is a false economy and funds should be found for this purpose. The inventory of computers is indicated in Table 7.

Table 7. List of computers left with AZRI by the Project[1]

Units	Description	Year of purchase
6[2]	IBM AT PCs (all still functional at MART/AZR PACD)	1985
3	COMPAQ portable PCs (one transferred to Bahawalpur)	1985
2	AST Premium 386 (used by ICARDA advisors until PACD)	1991
1	Fujitec 386 (supplied by DRMP)	1992
1[3]	Everex Tempo 386SX/20 (in AZRI Library, funded by MART/ACE)	1992
4	ACER PCs (supplied to PARC, funded from MART/ACE)	1993
4	COMPAQ Prolinea 486DX 50/4	1994
2	COMPAQ Contura 486SL laptops	1994

[1]Not shown in the list below are the following significant peripherals (year of purchase in parenthesis): one HP colour plotter (1985), one HP Laserjet III (1991) and one HP Laserjet IV (1994). All functional PCs have printers, monitors, voltage stabilizers and UPSs.

[2]2 monitors not repairable since spares parts not available. Replaced with black and white models.

[3]Supplied as part of Library Strengthening component of MART.

Library: AZRI has a poorly stocked library and, although staff received training in modern library management and the use of the hard and software, the library could still be far better organized. An antiquated inventory and lending system is still in use which makes it an impossible task to keep a proper track of books. A number of new books were purchased during Phase II, especially during early 1994. A computer, peripherals, CD-ROM equipment and the 1984-90 issues of 19 journals on microfilm were provided in 1992 as part of the MART funded Library Strengthening project. Subsequently the 1991-93 issues of the same 19 journals on microfilm were purchased using Project funds.

Chapter 4

LOOKING AHEAD[1]

PRE-AMBLE

Any discussion about the future directions and priorities of AZRI depends almost entirely on the financial resources available, the quality and the motivation of the staff, and the scientific leadership. The physical and human resources are adequate for AZRI to manage a moderate research program in the future. However, a shortage of financial resources is likely to be a severe constraint once the ARPII support ends in 1997. Even if these were adequate, there are still serious doubts about whether AZRI can, and indeed will, fulfil its national mandate, let alone kept its newly qualified staff. Therefore, the suggestions presented in the following section are based on the premise that the funding situation at AZRI is likely to remain uncertain for the foreseeable future. This may be a pessimistic prognosis, but the only realistic one worthy of consideration. It means that the research focus of AZRI will need to be narrowed still further so that certain modest goals can be reached by the end of the century.

Even outlining a 20 year strategic plan is felt to be inappropriate in the present circumstances. It is also realized that AZRI management and scientists often have different research priorities to those indicated below. Any future plan will be a compromise between the goals and priorities of AZRI's management and the interests, motivation and ability of its present and newly qualified staff. In short, this chapter is not intended as an outline of the future strategic plan for AZRI, but rather a series of sketches about the future research priorities. If anything, the focus of the research should be narrowed compared to the strategy outlined earlier (Keatinge *et al.*, 1988). However, the writer is in general agreement with much of that document and has re-iterated some of the ideas in it. The sub-stations have been completely ignored since their effectiveness remains in serious doubt under the present financial limitations and administrative arrangements.

RE-DEFINING THE ROLE OF AZRI IN PARC

By 1998 the long-term training program of AZRI staff sponsored by MART and ARPII should have created a solid cadre of some 12 officers with overseas MSc and PhD degrees. These staff will become the greatest asset of the institute. To sustain their interest in remaining at AZRI for a minimum period of five years after completing their degrees, it is

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[1]The following staff at ICARDA's headquarters in Aleppo made valuable comments and suggestions concerning this chapter: Bob Booth, Gus Gintzburger, Ahmed Osman, Abelardo Rodríguez, Elizabeth Bailey, Omar Mamluk, Salvetore Ceccarelli and Hazel Harris.

imperative to find ways to make AZRI a well managed institute with a well focused research program. One step in this process is to re-define the role of AZRI within PARC. A number of options in this respect are presented below. They include: 1) maintaining the *status quo*, 2) giving AZRI a provincial mandate, 3) making AZRI responsible for the mountainous areas of Pakistan, and 4) making AZRI the principal range/small ruminant research institute of PARC.

First of all, though, it is worthwhile indicating all the other institutes of PARC that are also part of the Natural Resources Division. These institutes include the Range Research Institute (RRI), the Water Resources Research Institute (WRRI), and the Land Resources Research Institute (LRRI). In addition, the Animal Sciences Division of PARC has its Animal Sciences Institute at NARC that includes the Sheep and Wool Unit (SWU). This unit could justifiably be transferred to AZRI. Having so many institutes causes considerable overlap and makes a radical re-organization of the PARC institutes imperative.

Now, to return to the four options.

1. Maintaining the *status quo*. This option is only worth considering provided there is a substantial improvement in the operating budget of both AZRI and the sub-stations and a radical re-organization of the research management. The latter would involve either the appointment of an extremely competent PSO to serve as Director of Research, or a restructuring into three major sections, each headed by a competent PSO. The restructuring would result in three sections: range and livestock (including range germplasm studies), land and water resources (which might include some germplasm studies on annual crops) and economics and technology transfer. (A structure similar to this was suggested by the mission from ICARDA that drafted a technical proposal for the Project in 1983 at the request of USAID.) However, events in the recent past suggest that these changes are unlikely since the best PARC scientists will evade being transferred to AZRI unless very generous incentives are given. Furthermore, it is also proving impossible to keep freshly qualified PhDs at AZRI.

2. Make AZRI only responsible for Balochistan. This is, in essence, the present situation, given that the sub-stations are too weak to be effective. To implement this option would require an executive decision to transfer the AZRI sub-stations to the Range Research Institute at NARC. On ecological grounds this seems quite logical. AZRI would then become equivalent to ARI Sariab but with a different mandate and direct funding from PARC. This option seems to be the most feasible out of the four. However, to be effective, some of the organizational changes recommended under option 1 would still need to be implemented.

3. Making AZRI responsible for the mountainous areas of Pakistan. This option would divide the country into two zones, one with altitudes above 1000 m and the other below 1000

m. The former would include much of Balochistan and North-West Frontier Province and come under the mandate of AZRI. The latter would include the middle and lower Indus Valley and become the responsibility of the Range Research Institute. However, the geographical spread of the highland area would create the same administrative difficulties as already experienced between AZRI and its sub-stations.

4. Making AZRI the range/small ruminant institute of PARC. This option has been suggested on many occasions and has a sound justification. However, there is a lack of will to implement it. At the very least four additional staff with expertise in small ruminants and range science would need to be transferred to AZRI from NARC.

THE RESEARCH APPROACH

The Farming Systems Research (FSR) approach was conceived during the 1970s as the new paradigm to make agricultural research more effective and thereby contribute to an increased rate of development of the agricultural sector. It aimed to involve the small farmer in the research process which was not the case for the prevailing disciplinary approach. The farmer is involved particularly at the diagnostic and the on-farm testing stages of the FSR approach. However, it was overtaken by events during the late 1980s when **sustainability** became the fashionable word. Since the early 1990s the term **participatory** appears to be gaining popularity, as in participatory rural appraisal. These rapid changes in approaches to agricultural research serve as a backdrop for the discussion presented below. They also illustrate how difficult it is to introduce a new approach into a national program where the scientists see it as merely another passing fashion, and fail to understand the nuances of the approach.

During Phase I FSR was *de rigueur* and there was an Economics-Farming Systems Section at AZRI. The Section conducted numerous diagnostic surveys which proved invaluable for the design of the research program during the subsequent years. The research of the Agronomy/Water Harvesting, Range and Livestock Sections largely concerned the design stage of the FSR approach. Many activities of the former Section were conducted on farmers' fields, but with limited involvement of farmers, whereas those of the latter two Sections were mostly conducted on-station at Zarchi and Tomagh. The activities of the Germplasm Section concerned the testing stage of FSR and were conducted both on-station and on-farm. The Extension Section had a comprehensive on-farm program with farmer involvement, particularly in Kovak Valley.

A major attempt was made during Phase II to shift the focus of AZRI research from on-station to on-farm and to involve farmers in the research process as much as possible, but without emphasizing any one particular approach. Achieving this shift proved to be very difficult, if not impossible, for a number of reasons. **First**, many AZRI staff see working

with farmers as the responsibility of the Economics and Extension Sections and the Extension Department of the GOB. (This attitude, seen across the continents, was one reason why the FSR approach was conceived.) **Second**, but related to the first, most agricultural scientists are trained in one discipline with few or no courses in the social sciences. Their postgraduate training exacerbates this narrowness which makes it even more difficult for them to feel comfortable interacting with farmers. This unease can be even greater if their mother tongue is Urdu whereas the language spoken by farmers in Balochistan is either Pashtoo, Balochi or Brahui. Thus, one should not really blame the staff for their apprehension to work with farmers. It is the university curricula that need to be revised and there is little indication that this is happening. **Third**, on-farm research carries with it major risks such as theft and damage to crops, and it is also seen as less prestigious by peers and less publishable in good journals. The former is true although the risks are much reduced if the community and farmers are actively involved in the research, as is the case with the participatory approach. The latter two reasons have been proved to be untrue. Indeed, there is a large group of agricultural scientists who have more respect for national scientists who publish research which involves farmers than for scientists who publish in conventional discipline-oriented journals.

There have been some success stories regarding the on-farm studies of AZRI during Phase II. As noted in Chapter 2 (page 31), the Range and Extension Sections increased their on-farm activities to a considerable degree and the Livestock Section started monitoring farm flocks as part of their BOSTID project. In December 1993 the Agronomy/Water Harvesting Section, although it stopped its activities at two farm sites in mid-1993, also initiated an on-farm water harvesting project on 10 farms in Kovak Valley.

A reversal of this tentative progress towards more on-farm research should be resisted during the coming years. Evidence of this reversal is the thought being given to developing the research activities at AZRI station and Mastung. Such a development would play into the hands of those who rejected the discipline-oriented on-station research approach and conceived FSR as an alternative.

THE RESEARCH FOCUS

In the future, as in the past, financial and administrative problems and personal interest rather than problems such as feed shortages, range degradation, low crop yields and yellow rust in wheat, will determine the future research focus and priorities of AZRI. Ideally, the reverse should be the case. This tendency must be resisted so that a modest but narrowly focused research agenda can be pursued. The agenda should address the solving of problems facing farmers and the solutions should have a reasonable likelihood of being adopted. In other words, finding solutions to problems identified by farmers should drive the research agenda

of AZRI, not the academic desires of the scientists. Some authorities term this 'demand-driven' research.

The research agenda indicated below will no doubt be criticised by those who argue that AZRI should address key issues such as range degradation and introducing sustainable range management systems. However, the probability of range-users adopting these systems is low and therefore AZRI should give low priority to classical range management, except on the few selected topics indicated below. The record of range management programs in other countries is often one of failures rather than successes, despite the enormous input of funds and expertise that will never be available to AZRI. AZRI should take heed of this record.

The primary focus of AZRI during the coming 10 years should therefore be research into the better use of the 0.9 million ha of fallow land, some 4.7 million ha of cultivable waste[2] and the few million ha of land suited for rainfed cropping[3] in the Province. Some of the fallow land could grow annual crops using water harvesting, with inter-cropping with forage shrubs being applied in some areas. The cultivable waste would be suitable for forage shrub plantations. Classical range research can only be justified if there is a substantial improvement in the financial resources available to AZRI, and even then it is doubtful whether resources should be spent on this topic.

TARGETS BY THE YEAR 2000

AZRI needs to set itself certain quantitative targets that are achievable by the year 2000. The overall target would be the adoption of a number of technologies by 20 farmers divided among say four different villages, located in valleys where AZRI has a long history of involvement, such as at Tomagh, Zarchi and Kovak. More specific targets include:

- Registration and release of four bread wheats with resistance to yellow rust, three barleys, three lentils and one forage legume, in collaboration with ARI Sariab.
- Establishment of a small commercial seed enterprise which sells annually 1000 tonnes of the registered seed to farmers. The seed would be multiplied using contracts with private farmers and the cleaning and processing of the seed would be at AZRI, in collaboration with the Department of Agriculture.
- Applying improved sheep/goat husbandry practices that increase flock and herd offtake by 50%, in a collaborative study with the Department of Livestock.

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[2]See Government of Balochistan agricultural statistics. These do not define cultivable waste but it is considered to be land that could be cultivated. It is not for reasons that remain unclear.

[3]A better understanding into how farmers' decide to crop their land each year would help explain why the cropping intensity in Balochistan is only 20-40 percent. It is a more complex decision-making process than the amount of rainfall received.

- Establishment of 1000 ha of forage reserves using saltbush or another shrub in collaboration with the Departments of Forestry and Agriculture.
- Developing simple *ex ante* bio-economic models to help define AZRI's research agenda and indicate the priority that should be given to promising and sustainable technologies that have a high potential for adoption and that have a substantial impact on farm productivity.
- Revegetation of 1000 ha degraded range with an indigenous shrub such as *Artemisia*, in collaboration with the Forest Department.
- Implementing a management plan for Maslakh Range which involves the local farmers who used to have access to the area, in collaboration with the Forestry and Livestock Departments.

RANGE RESEARCH

The standard justification for giving priority to range research in Balochistan is that ranges cover 93 percent of the Province's area. This is a very erroneous statistic which is usually widely misused. A more accurate estimate indicates that out of 34.7 million ha, 20.3 million ha are barren land, 11.7 million ha are degraded rangelands and only 0.9 million ha non-degraded rangeland (FSMP, 1992). Most people would agree that like water, the rangelands of Balochistan are the most mismanaged resource of the Province. Whereas there is considerable scope for better water management, introducing better range management practices is an exceedingly difficult task given the tribal structures and nomadic system of range use. Classical range research[4] at AZRI should therefore receive a low priority except on the specific topics indicated below. Instead the research should focus primarily on two main topics: 1) continuing the present research on forage shrubs but make sure it is farmer-driven, and 2) survey and analyze the traditional range management systems with a view to identifying potential areas for intervention and improvement. These two topics, just like most of the topics in this chapter, are closely linked to each other but for convenience are presented separately. Several second priority topics are also indicated below.

1. Focus on forage shrubs (on-farm). There is already sufficient experimental evidence to indicate that forage shrubs could make a substantial contribution to the feed supply of Balochistan from June until November. However, it is only worthwhile continuing the substantial effort on saltbush (and other genera such as *Salsola*) if farmers find it acceptable and are willing to introduce it. For this reason the future effort on saltbush needs to emphasize on-farm studies in which farmers are full participants rather than spectators. These efforts will continue to be divided between AZRI and NGOs. The Balochistan Rural Support Program is already receiving saltbush seedlings from AZRI but now needs

[4]This includes *inter alia*: deferred and/or rotational grazing, controlled stocking rates, fencing, fertilizer application and reseeding with exotic species.

encouragement to establish its own nursery or village nurseries. This work would be a joint activity between the Range, Economics and Extension Sections. AZRI must now start selling seedlings to NGOs and other projects at a nominal cost.

2. Examining tribal range management practices (on-farm). It is often claimed that the tribes of Balochistan, in the north at least, used certain codes to control access to their grazing areas. These claims need to be verified by interviewing tribal leaders in the Province. If they existed in the past, do they exist today and how were they affected by the Afghan war? The likelihood that better range management practices will be adopted will be far higher if these codes still exist since better practices can be modified to fit into the traditional system. Another aspect of the surveys would examine whether or not range users have any interest in conservation issues. If they have no interest, or their interest is conditional on others paying the costs, then the chances of successful introduction of better range practices may be too low to be worth the effort. The surveys would be a joint activity between the Range and Economics Sections.

3. Demonstration of better range management practices (on-farm). This activity, which is closely linked to the previous one, should be initiated provided the range users show a reasonable level of interest in better range practices and that these have been defined. The degree of interest at the community level would first be examined using the participatory rural appraisal approach. Assuming there were sufficient interest, the demonstrations would cover several thousand hectares. If they merely altered existing practices without the need for costly interventions, the village community as a whole would implement them without outside assistance. However, if the interventions were costly, such as revegetation of heavily degraded rangeland, pilot areas covering hundreds rather than thousands of hectares would be used and the cost of the revegetation paid by an outside agency. To be successful even this more modest albeit costly option would also need the full agreement and involvement of all the livestock owners with access to the village grazing area. The introduced practices would need to be properly implemented and supervised so that the results could be interpreted with confidence. Even though such demonstrations would be difficult to implement, they are an essential and innovative component of any range improvement strategy. Implementing this activity presents AZRI with an enormous challenge.

One possible demonstration site, although somewhat atypical, would be the 45,000 ha Maslakh Range, the site of a USAID range project from 1955-65[5]. Much of the area has been ungrazed for some 40 years and in this respect must be unique to the whole of Balochistan, if not the whole of south-west Asia. A range management plan would be designed and the villagers who formerly had access to the rangeland involved to implement the plan. Such a project might help remove the continuing resentment of the local people

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[5]Rafi, Muhammad M. 1965. Maslakh range project, Quetta, West Pakistan. Pakistan Journal of Forestry 15: 319-338.

towards government officials. The project would involve the Range, Livestock and Economics Sections of AZRI, together with the GOB Forest and Livestock Departments. A second more representative site would also need to be chosen for demonstration purposes.

4. Studies on range ecology (on-station, on-farm). The focus of the research on range ecology should be on two topics: 1) revegetating heavily degraded ranges with indigenous shrubs, and 2) re-establishing perennial bunch grasses on heavily degraded rangelands. Revegetation of degraded rangelands with indigenous annual grasses, however desirable, is not seen as a viable option due to the complexity and cost of multiplying sufficient seed to distribute over a wide area. It is speculated that in all but the most degraded ranges, sufficient annuals remain to allow self-revegetation provided the grazing pressure is reduced during seed setting in spring and early summer. This, of course, is when grazing pressure reaches a peak which is another reason why the chances of manual reseeding with annuals has only a small chance of succeeding.

A research program aiming at revegetating degraded ranges with indigenous shrubs started in late 1993. It concerns the re-introduction of sagebrush (*Artemisia maritima*) into rangelands from which it had been uprooted as fuelwood. Initially it would be necessary to collect seed and conduct on-station research into the conditions needed for germination and direct ways of re-seeding degraded areas. AZRI station has areas representing the typical shrublands found south of Quetta. The fragile surface of such areas should not be disturbed by any form of cultivation prior to re-seeding in order to mimic the real range situation. At a later stage the technology would be tested on pilot areas adjacent to villages. The degraded watershed included in the Kanak Valley project of FAO would be suitable for this testing. This would provide a way for AZRI to integrate with that project. However, it is fairly certain that farmers themselves would not undertake such activities because of the cost. Thus, if the technology looked promising, the provincial government would have to support the cost of re-vegetation work. Even this is doubtful since their severe shortages of finance results in them only addressing forestry issues, except when they are getting outside assistance as in the case of the FAO/UNDP Integrated Rang-Livestock Development project. Once the technical feasibility of re-vegetating degraded ranges has been demonstrated and village communities have shown a willingness to participate in the management of these areas, a seed production program would have to be started by the Forest Department with technical assistance from AZRI.

Research on re-establishing perennial bunch grasses would be largely based at Tomagh station. Studies would be initiated to define simple land treatment methods that trap any seed produced by *Chrysopogon* and *Cymbopogon*. For example, it was observed at Tomagh that seed of these species incorporated into the surface soil germinated once the soil surface was disturbed by a ripper or spade. Once again, however, the Forest Department would have to undertake such work if it were found to be technically feasible. The seed would be harvested from protected areas and hand-broadcast onto soil loosened with a ripper in contour strips

3 m apart to a depth of 20 cm. The strips would act like bunds and trap some water to allow germination. Ripping using government bulldozers which are already available at subsidized rates seems more appropriate than manual construction of simple pits which is very costly.

5. Saltbush/cereal inter-cropping (on-station, on-farm). The 0.9 million ha of fallow land in Balochistan suggests a cropping intensity of 20-30 percent in highland areas and 40-50 percent for lowland areas. Some of this land as well as some of the 4.7 million ha of "cultivable waste" could be used to inter-crop saltbush and cereal crops. The Farm Resource Management Program (FRMP) of ICARDA has had a project on this topic since 1990 (FRMP, 1993; pages 68-73). The findings need to be reviewed when designing a similar project at AZRI. AZRI established an inter-cropping site at Spezand in June 1990. The farmers have now sown wheat between the rows of saltbush for three seasons which indicates that they either like the concept, or the presence of a trial, or both. However, AZRI has still to monitor in an objective way what the farmers really think of the concept.

A project should be designed that studies the benefits or otherwise of this practice in terms of yields of crop, browse and fuelwood and improved water-use-efficiency. Comparison would be made between different inter-row and inter-plant spacings. Control treatments would be blocks of saltbush and plots of wheat, for example. Levels of rodent infestation would needed to be monitored[6]. Such an experiment would be initially conducted at Mastung and would be ideal for bringing together the Range and Agronomy/Water Harvesting Sections. The encouraging inter-cropping demonstration site at Spezand could also be expanded and replicated on other farms in the village to generate valuable results in a short time. Other follow-up on-farm studies would be added later.

6. Collection, conservation and evaluation of indigenous and exotic species (on-station, on-farm). AZRI has already made a modest but encouraging start in this area. The collection and conservation efforts using an *in situ* herbarium should be the responsibility of one officer but no more. The officer should maintain close links with colleagues at the National Herbarium at NARC and elsewhere. This collaboration has already started. A second officer should study alternative perennial forage shrubs to broaden the focus away from FWSB. This study should include *A. nummularia* and *A. halimus* which grow well at AZRI but are cold susceptible. However, it is probable that they are sufficiently hardy to withstand the cold provided the leaf has been grazed off before the onset of the winter cold that can start in December. After the final grazing, the woody growth would be pruned to leave 10 cm stocks once every two years. Additional studies would investigate the phenology of the different species of saltbush, such as their tolerance to defoliation in different seasons, and leafiness. The latter might be positively related to yield of edible biomass. However,

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[6]The problem of rodent infestation seemed to be particularly severe at Mastung since the site is fairly well protected against predators and has a sandy soil. Most on-farm saltbush reserves had few problems with rodents.

there could be a trade-off between leafiness and water requirements that makes leafy plants less drought tolerant. The promising start to evaluate *Salsola vermiculata*, imported through ICARDA from Syria, should be pursued. The ability of this shrub to self-seed has already been confirmed.

7. Establishing permanent range monitoring sites. Monitoring long-term changes in the condition of representative range-types at several sites would give valuable information about trends in the degradation process. The information would be particularly useful when attempts are made to convince government officials about the gravity of the situation. Permanent transects would be established to monitor species dynamics, species composition and ground cover, and steel pegs inserted deep into the ground would serve as indicators of soil losses. The sites chosen could be those already monitored in 1989/90 (see next section) and additional sites could be added, such as Maslakh Range. These efforts should be complemented by satellite images selected at five-year intervals starting in 1970. Aerial photographs from the 1950s and 1960s should be obtained. Photos should be available in archives for the period before Partition (of Pakistan and India) in 1947. The aim of this study would be to quantify the dynamics of the degradation process at these sites over a 50 year period. This would give an insight into the shape of the degradation curve for different range types and the stage of the degradation process reached at each site. Such information would eventually be used to map the rangelands of Balochistan according to their recovery potential and optimal carrying capacity. This would allow an estimation of the small ruminant population that could be carried by the rangelands of the Province. This project should be developed into a research proposal and submitted to a donor agency for funding.

8. Analysis of data collected in 1989/90. Two valuable studies were made during this period. One evaluated exotic warm-season grasses planted at Tomagh and Mastung and the other measured the biomass in protected and grazed areas at Zarchi, Tomagh and Hazargangi (Chiltan National Park). In the former study, the survival rate of those species still alive in July-August 1994, should be monitored before the trial is finally abandoned. In the latter study all the data were transferred to diskettes by the COP but could not be analyzed at the species level since the species were only identified according to their local names. Unfortunately, the specimens of the plants that were collected were damaged because of poor storage conditions. They were therefore discarded. This means that it is almost impossible to reliably assign botanical names to the local names. It would be a valuable exercise to make two or three more samplings at the three locations, spaced six months apart. This would show whether there has been further degradation or recovery during the intervening period of four or five years. Specimens of the same species could again be collected together with their local names. It would then be possible to assign botanical names to the specimens collected during the 1989/90 period. This earlier data could then be analyzed. It has immense historical value since it would provide the baseline data for comparison with information collected in the future at these sites. It is the only information of its kind for these locations.

LIVESTOCK RESEARCH

The two most important functions of the rangelands of Balochistan are 1) to serve as watersheds to trap rainfall which then replenishes the ground water reserves and 2) to carry over 20 million small ruminants which are though to derive an estimated 90 percent of their feed from these rangelands. Assigning an economic value to the watershed function is difficult whereas the offtake of small ruminants can be given an economic value with relative ease. This offtake is the most tangible expression of the economic value of the rangelands and represents at least one-third of the total value of agricultural output in the Province. Small ruminants therefore assume an important place in the agricultural economy and a modest improvement in offtake would have a substantial impact on the overall performance of the agricultural sector. These considerations help explain why research on small ruminants at AZRI should be given equal first priority with range research. However, this priority is not reflected in the staffing level of the Livestock Section.

1. Livestock in the farming systems of Balochistan (on-farm). The dilemma facing livestock research is very similar to that facing range research - how can one convince farmers to adopt the well-known management practices that increase offtake of animals, given that farmers are generally too poor to adopt the practices? The only way this might be possible is to define the priorities that farmers give to livestock. Such a study would cover the whole spectrum of farmers from those that are totally dependent on livestock to those that own a few livestock just to provide milk products and some meat to the household. This would be a joint project with the Economics Section.

2. Monitoring the management practices applied to farm flocks and the performance of the animals started by the BOSTID project should continue, primarily at the Tomagh and the Kovak sites (on-farm). Asghara Valley in which the Tomagh station is located is one of the pilot sites of the Integrated Range-Livestock Development project of FAO/UNDP. The objective of this research would be to see how animal performance relates to flock management so that appropriate management practices can be introduced to improve performance. It may be found that farmers are too poor to implement better flock management or that they would invest first in fruit trees, then in food crops and lastly in livestock. This is already considered to be the case although it needs to be verified. If confirmed, then the likelihood of farmers adopting practices to improve range-based small ruminant production is extremely low. This will mean that small ruminant production will become less important as the ranges steadily degrade. In the long-term only village-based small ruminant production systems will remain that use crop residues and some irrigated green forages, making them less dependent on the ranges. If the prospects for improving range-based systems are indeed so poor, then AZRI will have to change its research priorities towards the village-based systems where small ruminants play a minor role in overall terms, but an important role as suppliers of milk products and as a ready source of cash for the family.

3. Measuring the ruminant population in pilot areas (on-farm). There are always doubts about the accuracy of livestock population censuses. It would therefore be useful to get more accurate estimates for selected areas, such as the Tomagh, Kovak and Zarchi locations which have fairly well defined boundaries because of the mountain ranges along their borders. Or the monitoring could be extended to incorporate the whole of the *tehsil* (a smaller administrative unit than a District). It would then be possible to compare the estimated ruminant population with the values derived in the next official census. The samplings would be made once every four months for one year. The results could be used to estimate the grazing pressure during the period of the samplings, and this could be related to the condition of the rangeland.

4. The genetic potential of local sheep and goat breeds (on-station). Such research already started as part of the BOSTID project but much remains to be done. An essential element of this research is to monitor the feeding levels used so that the animal output can be related to the feed input. Discussions should be held with the GOB Livestock Department to use their facilities at Maslakh Range. The Balochi sheep at Zarchi should be moved to Maslakh and the station closed since the shrubland there shows little sign of recovering[7]. About 100 head of each of the three main fat-tailed breeds in Balochistan, the Balochi, Harnai and Bibrik, could be kept there rather than at the Yatebad Station which is two hours drive from Loralai and thus about seven hours drive from Quetta. Much as the Livestock Department would like AZRI to assist it at Yatebad, the station is just too far away to be practical. The closeness of Maslakh to Quetta makes it a far more attractive site.

5. Animal nutrition (on-station, on-farm). A program sufficient for one scientific officer should be defined. It should focus on topics that are relevant to the livestock owners of Balochistan and on technologies that have been shown to be economic in a simple *ex ante* analysis. Fashionable research, such as studies on urea-molasses blocks, should only be conducted when it is clear that the adoption potential of the technology is high. This is certainly not yet the case for urea-molasses blocks in Balochistan. Some of the studies requiring carefully controlled experiments, such as measuring the genetically controlled growth rate of lambs and milk yield of local breeds, would be conducted at AZRI station.

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[7]The shrub range at Zarchi, which is representative of the ranges over much of the Kalat Division, is degraded in the sense that the annual grasses that were apparently more widespread in the past have largely disappeared, probably due to overgrazing earlier in the century. This has exposed the soil between the shrubs and erosion is obviously progressing at quite a pace. The shrubs' roots alone hold the remaining soil in place. As the erosion advances more of the roots are exposed and this leads to the gradual death of the shrubs. Most of them are still present and they give the appearance of being under-grazed since they have reached mature size. Studies by AZRI confirm this suggestion since the shrubs remained the same height when left ungrazed for three years (Ghulam Akbar, unpublished data). This is evidence that the grazing pressure changed from being excessive to very low at some point during the last 50 years, probably because there was too little water in the area to support small ruminants in summer. The animals with their owners move to the lowland areas in winter due to the cold and lack of feed (Castillo *et al.*, 1987). Thus, we have the hypothesis that there was overgrazing in the past which later turned to under-grazing more recently due to the loss of the annuals and a shortage of water. This hypothesis needs to be tested.

WATER HARVESTING AND AGRONOMY RESEARCH

Water is the first factor limiting the growth of cultivated and range plants and there are sound *a priori* reasons why water harvesting should allow better crop yields. For this reason research on water harvesting must be continued despite the difficulties it faced in the past. Such research should take priority over agronomic studies since these have indicated already how crops only respond to an improved nutrient supply, for example, when water no longer limits plant growth. If agronomy research is conducted, it should be within the context of water harvesting. Research on water harvesting technologies to enhance range plant growth deserves low priority since these are almost certainly too costly for farmers to implement. The exception here may be the use of contour furrows where forage shrubs would be planted. Even this would have to be part of a government supported campaign.

Once again, activities should focus on simple on-farm trials using designs that are acceptable to farmers. This seems to be the case in Kovak Valley where an encouraging start was made in December 1993 but crop failure resulted from the season's extremely low rainfall. However, there is a good chance that the farmers in Kovak Valley will adopt the modified water harvesting practice demonstrated by AZRI since farmers are already receptive to the concept. The more detailed component research that has already started at Mastung should continue, such as the water-use-efficiency of landraces and improved crop varieties in relation to moisture supply, and defining the size and shape of run-off areas. Modelling water harvesting systems should only be attempted if sufficiently precise yield and water-use data have been collected over several seasons. Economic evaluation of water harvesting technologies should be an integral part of the research. To stand any chance of being adopted by farmers, such technologies will have to result in substantially higher net benefits or markedly reduced risk. The later goal is probably more important to the resource poor farmers of Balochistan who use low input methods to produce rainfed crops.

ECONOMICS RESEARCH

Even after nine years of the Project, many gaps remain in the knowledge base about farming and range-based systems in Balochistan. More surveys on specific topics are still needed, such as into traditional tribal range management practices (see page 56). However, conducting yet more surveys is not the only activity of the Economics Section. Attention should also turn to providing leadership to all AZRI Sections in farmer participatory approaches, to sector studies such as livestock marketing, and to the development of simple *ex-ante* economic models for testing promising technologies. The economists should also be involved at the planning stage of all experiments to ensure that a cost-benefit analysis can be made on the results at a later stage. The Section should not merely act as a service to the other Sections, they should all collaborate together.

Some other topics that should be considered are outlined below. However, these should only be addressed when the large volume of information collected during the "farmers' perceptions of water harvesting" and the "seasonal price indices" projects has been analyzed and published. The first of these projects took place in April 1992 as part of the DRMP project of ICARDA and the second completed two years of data gathering in December 1992. The seasonal price indices could be used by provincial policy makers and extensionists, and for advising farmers how best to schedule their multi-product operation.

Resource use in peri-urban production systems. In Balochistan disposable income and population growth is higher in urban than in rural areas and the increasing demand for fruits, vegetables, poultry, red meat and livestock products will tend to be met from the peri-urban production systems. However, these systems, which often make intensive use of land, are under constant threat from urban expansion which puts their sustainability in jeopardy. The use of contaminated waste water, fertilizers and pesticides to produce vegetables and fruit also raises questions about the quality of the commodities and the impact on human health. The importance of these systems in relation to the total output of such commodities needs to be ascertained.

The future of the major settlements in Balochistan will be shaped by the increasing scarcity of water and priorities given to use of water for agriculture, urban, domestic and non-domestic use. Supplementary irrigation will become more of an issue in the future. AZRI economists and agronomists should join forces with the Water Resources Research Institute (WRRI) at NARC to implement farmer participatory approaches to improve water-use efficiency in peri-urban agricultural systems.

Planning agricultural supply in Balochistan. Rainfall variability in time and space determines the supply of agricultural and livestock commodities in Balochistan. Weather variability shapes not only the degree of self-sufficiency in the Province, and the imports of food and fiber from other Provinces, but also the welfare of the inhabitants. The linear expenditure system presented by Burney and Ahmad (1991) could be adapted for Balochistan and be used to estimate expected demand for food and fiber in the next decades. The estimates could also be used as guidelines to predict the expected returns to agricultural research. The entire strategy of the agricultural sector of Balochistan needs to be evaluated based on social welfare criteria rather than utopian desires of food self-sufficiency. AZRI needs to be part of this process through seminars and workshops with participation of provincial decision makers and agricultural/livestock scientists.

GERMPLASM RESEARCH

Pre-amble

When deciding on the future strategy for germplasm research at AZRI, the following factors should be taken into account: the areas of the main crops; the human and physical resources available at AZRI; the interests of the staff in the Section; the germplasm research at ARI Sariab; and the chances of new varieties and crops being adopted by farmers. These factors are discussed below. Then follows an outline of the main elements of the future germplasm evaluation strategy of AZRI.

Crop areas. In 1991/92 Balochistan had about 86,000 ha rainfed wheat, 11,000 ha rainfed barley, 20,000 ha of fodder crops most of which are irrigated, and less than 50 ha of lentil (*mansoor*). The areas of irrigated wheat and barley during the same year were 220,000 ha and 14,000 ha, respectively. These irrigated areas should be included in the discussion here since farmers often grow irrigated crop varieties selected for rainfed conditions. About 16,000 ha rainfed and 26,000 ha irrigated millet (*jowar*) are grown as summer crops.

Human and physical resources. By late 1994 the Section is likely to be staffed by one PhD, one MSc and one ASO, since two staff were transferred to the Range Section in 1994 to take charge of range germplasm collection and conservation and research on the ecology of range shrubs (see page 57). There should only be a modest research program on wheat and barley in particular, due to the limited staff in the Section. There is sufficient land available at AZRI and ARI Sariab for detailed research and unlimited farm sites across highland Balochistan for testing promising germplasm[8].

Interests of staff. Ideally, staff in the Germplasm Section should be allowed to continue with evaluation of annual crops which they are trained to do. However, this would contradict the new priorities of the Section. Thus, one staff member should start to allocate an increasing amount of time to developing a small commercial seed unit at AZRI to market improved rainfed varieties to farmers. The staff member with a foreign PhD in lentil breeding will need to switch to cereal breeding since lentils are such a minor crop in Balochistan.

Studies at ARI Sariab. Germplasm research started at AZRI in 1985 because it was included in the Project activities. Before that ARI Sariab was solely responsible for crop

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[8]The Section should continue to use daily labourers to manually sow experimental materials on small plots and a tractor mounted Oyjord for larger areas. This seems appropriate given that there are no facilities, funds or expertise to maintain a self-propelled precision small-plot seeder. This was the main reason why the COP was against spending $20,000 to $30,000 on such a sensitive machine. (At 1994 rates a daily paid labourer costs Rs45 ($1.5) per day.) The second reason for not buying a precision seeder was the reduced priority that should be given to germplasm research at AZRI in the future. Similar arguments apply to the purchase of a small-plot combine. Manual labour is a more sustainable option even when budgets are tight.

improvement in Balochistan and has received since 1980 nurseries from plant breeders at ICARDA. They have continued sending nurseries ever since.

In the short-term at least, it is not recommended to transfer the AZRI germplasm activities to ARI Sariab since this would destroy the morale of the staff in the Section and they would undoubtedly leave AZRI as soon as possible. This would result in the efforts and progress of the last nine years being wasted just at a point when the Section is close to releasing several promising lines of annual crops.

The Future Germplasm Strategy

In view of the above considerations, the future strategy on germplasm evaluation at AZRI should take into consideration the topics discussed in the following paragraphs.

A change in focus: In the short-term AZRI should continue its germplasm research on annual crops with first priority being given to the selection, field verification, certification, seed multiplication and sale of bread wheat and barley seed for rainfed areas. Particular attention should be given to consolidating the good progress already made to identify and test lines of bread wheat resistant to yellow rust. Further selection studies on lentil should be given low priority. Instead, the main effort should be to get the promising large-seeded types identified during the last few years, certified, increased and sold to farmers. Since, according to GOB statistics, there are not more than 100 ha of lentil in Balochistan, a mere five tonnes of the promising seed would replace half the area presently sown with the local landrace! Producing this amount of seed by July 1996 should be well within the capabilities of AZRI. It is claimed that the present area of this crop is very small because there is no demand for the small-seeded lentil that is traditionally grown, since consumers prefer a large-seeded lentil. A survey is needed in collaboration with the Economics Section to see if farmers would grow more lentil if seed of a larger type were available. Lentil provide AZRI with a unique opportunity to show an impact. However, attention to this crop should not be at the expense of the efforts to gain widespread adoption of improved wheats and barleys for rainfed conditions. Routine screening and evaluation of forage legumes should be almost stopped due to staffing constraints. More important is field testing to see how promising vetches can be fitted into local farming systems and whether farmers will use them.

Change in methodology: The present methodology using early sowing after an initial irrigation should be changed to one in which ARI Sariab is used as the site to preserve valuable material on small irrigated plots. The main germplasm testing program should take place on farms under truly rainfed conditions. Sowing of the small amount of seed under irrigation is merely to ensure that enough seed is preserved for the following season, especially when a severe drought occurs such as in 1993/94.

Yellow rust studies. It is highly desirable to replace the yellow-rust susceptible local wheat with resistant material. However, several resistant lines with different genetic backgrounds should be available to farmers at any one time in case of a breakdown in the resistance of one line, and there should always be several promising cultivars in the pipeline. "The development of yellow rust resistant cultivars for Balochistan should not be a big problem since there seems to be currently one prevailing [race] of the pathogen. Material from ICARDA/CIMMYT is thoroughly screened for yellow rust races 6E16 and 82E16. Germplasm screened with these races have effective gene(s) against [them]. The flow of .... facultative and winter ... germplasm from ICARDA/CIMMYT should continue. The screening [for resistance] should be done in close collaboration with ARI Sariab [whereas] the monitoring and surveillance of yellow rust race(s) should be done at the Crop Diseases Research Institute at NARC [Every] effort should be made to continue and strengthen [this] collaboration" (O. Mamluk, personal communication 1994).

Using local knowledge to develop new cultivars and maintain biodiversity. "Breeding philosophies and methodologies developed for favourable and high input agriculture have been ineffective for marginal conditions and low input agriculture. [For this reason the efficiency of a novel approach needs to be tested] based on (a) early selection and testing under real farmer conditions and (b) farmers' participation during selection and testing. The expected output of [such an approach] is to demonstrate that the likelihood of adoption of new cultivars without using additional inputs is enhanced by using this approach. [It is expected] that, even in a relatively small geographical area, farmers will tend to exploit specific adaptation. Thus the approach will have a benefit in terms of biodiversity with the selection and spreading of a number of different cultivars, instead of the few, often closely related, cultivars developed by breeding for wide adaptation" (S. Ceccarelli of ICARDA Germplasm Program kindly provided the foregoing text.) This novel approach deserves serious consideration by the Germplasm Section at AZRI.

Evaluate other crops: millet has received no attention at AZRI largely because it was not included in the Project and also because it lies outside the mandate of ICARDA. However, in view of the area of the crop, it should be studied at AZRI and also be given higher priority than lentil. A visit of the PARC national coordinator for millet is recommended to provide advice on this issue. PARC already has a coordinated research program on millet at ARI Sariab but again, for irrigated conditions. Germplasm research, indeed any research, on other summer crops such as white cumin, is not recommended due to the current resource limitations at AZRI.

Multi-location testing: Until the 1991/92 season, new germplasm was tested at several sites across central and northern Balochistan, as well as at the research stations at AZRI, ARI and Mastung. By 1993/94 the number of sites had fallen to just these three stations. This is most undesirable since the management, moisture and soil conditions at these stations are not similar to those on farmers' fields and the stations are all located in one small area. Thus,

in the future, the number of on-farm testing sites should be restored to the number prior to 1991/92.

Once preliminary screening has identified promising material, federal seed certification regulations apparently state that it must be entered into national yield trials. If this is the true, then a strong case should be made through PARC to change federal procedures using the argument that the material selected in highland Balochistan is targeted for these areas and is thus unlikely to perform well in areas with different climatic and growing conditions. This would pre-empt the argument that the material failed to perform outside the Province and therefore cannot be certified. A second attempt should be made immediately to get the promising AZRI lines approved at the provincial level.

Development of the commercial seed sector: The final essential element of a successful germplasm evaluation strategy at AZRI is to ensure that sufficient promising material reaches farmers so that an impact is achieved at the provincial level. At present there is no private or government cereal seed industry specifically for highland Balochistan and this is unlikely to change in the future. Therefore, AZRI should take the initiative to establish a small commercial seed unit. It has sufficient modest equipment purchased during Phase I of the Project to clean perhaps 100 tonnes of seed each year during an initial phase. This is sufficient to sow 1000 ha. The activity could be seen as a useful income-generating project for AZRI. Once the initial phase has been shown to the successful, a second and more ambitious phase could be started to produce 1000 tonnes each year. This would probably be sufficient to meet the annual demand for new cereal seed since it would be equivalent to about 10% of the annual seed requirement for the total rainfed area of cereal crops in Balochistan. This commercial operation would need to be linked to extensive seed multiplication activities using contracts with private farmers.

Developing a small commercial seed unit at AZRI is probably the only way that the investment in germplasm research will ever have an impact on rainfed cereal production in highland Balochistan. Indeed, it is difficult to justify continuing germplasm research unless it is linked to an on-farm testing program and a commercial operation, however modest. This kind of development would certainly find favour with donors that need to be approached to help AZRI make an impact on rainfed crop yields in highland Balochistan.

EXTENSION AND COMMUNICATIONS ACTIVITIES

Although an essential component of the research program of AZRI, the activities of the Extension and Communication Section are likely to remain modest as long as the Section continues to be severely under-staffed. Indeed, the role and potential contribution of AZRI to solving the agricultural, range and livestock problems of Balochistan would be far better appreciated if this Section were strengthened. It would then produce promotional brochures

and films and organize field days attended by both farmers and officials from the public and private sectors. AZRI must give more attention to public relations.

The Section should consider its main function to be the demonstration of promising technologies and participatory on-farm research rather than research on extension *per se* which it is clearly unable to do due to its lack of expertise in this field. Even if staff were not a constraint, it is not recommended that the Section get involved in such research.

LINKS WITH OTHER ORGANIZATIONS

It is a simple task to proclaim that AZRI should strengthen its collaboration with other GOB departments, scientific councils, research centers and organizations. But it is an exceedingly difficult task to actually persuade these entities to work together. The length of the list of the main GOP councils, centers and institutes[9], GOB departments[10], and foreign-assisted projects and NGOs that AZRI could or should collaborate with, illustrates how AZRI could devote most of its efforts to collaborative activities. AZRI is also linked to ICARDA through ICARDA's Highlands Regional Program that includes Turkey, Iran, Afghanistan and Balochistan. It therefore seems pointless to labour the point about the need for better collaboration. AZRI will have to set its own priorities and collaborate in the way it is most able to do. It cannot be forced to collaborate with other entities, nor they with AZRI. Indeed, when AZRI has many problems of its own, it can hardly be expected to effectively collaborate the other entities.

Links with ICARDA: ICARDA has had a 15 year association with Balochistan, first with ARI Sariab and since 1985 with AZRI. This association with both institutes is likely to continue in the future although at a reduced level than in the recent past. This is mainly due to the budgetary constraints at ICARDA. However, it is envisaged that "the very productive relationship between AZRI and ICARDA [will] be continued for the foreseeable future" (MART, 1993).

NGOs and other Projects. AZRI is likely to strengthen its links with the Balochistan Rural Support Program (BRSP), the main NGO in the Province. It certainly should learn from

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[9]**GOP Councils, Centers and Institutes:** Pakistan Council for Scientific and Industrial Research (PCSIR), Pakistan Council for Research in Water Resources (PCRWR), Soil Survey of Pakistan and the institutes of the NARC (such as the WRRI, Land Resources Research Institute (LRRI), Range Research Institute (RRI) and Sheep and Wool Unit (SWU), not to mention the Crop Diseases Research Institute (CRDI) and the coordinated commodity programs of NARC on wheat, pulses, etc.

[10]**GOB Departments and Institutes:** Departments of Livestock, Forestry and Agriculture (including Extension), and the Agricultural Research Institute (ARI) at Sariab. The Livestock Department also has a Veterinary Research Institute and a feed quality laboratory is being established by the FAO/UNDP Feed Resources Project.

BRSP and the FAO Kanak valley project how to conduct on-farm studies using participatory methods with full community involvement. Projects that AZRI already is, or could be, linked to are indicated below.

Name of project	GOB Client	Donor
Kanak Valley (Farmer Participatory Approach)	Forestry	Italy(FAO)
Integrated Range/Livestock Development Proj.	Forestry	UNDP(FAO)
Feed Resources Project	Livestock	UNDP(FAO)
Watershed Management Project	Forestry	UNDP(FAO)
Livestock Development Project	Livestock	Asian DB[1]
Resource Management Project (proposed)	Forestry/EPA[2]	World Bank

[1]Asian Development Bank. [2]Environmental Protection Agency.

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Chapter 5

THE FINAL WORD

The February 1989 MART Project Evaluation Report (MART, 1989) states: "The objective of a fully functional, well organized and well managed Arid Zone Research Institute, staffed with competent professionals by the end of the contract (in November 1989) will not be reached by PACD. Current staff lacks the capacity and experience to design and manage research independently. Technical assistance should continue for an estimated four to six years". This technical assistance was continued during the grant phase until August 7, 1994. The same evaluation report continued: "Most of the research sections have been trying to conduct to many field trials, evaluate too many variables at too many locations for effective control. Staff competence will improve soon with two returning PhDs but will still lack experience in research design and execution."

"AZRI has made significant progress since the 1989 midterm review" (MART, 1993). But it still has a long way to go. Institution strengthening is a 15-20 year process, even when the environment is conducive to development. There should be a cadre of trained professions by the year 2000, mainly as a result of the long-term training of staff funded by the MART and ARPII projects. But it will still take many years before these newly trained staff have gained the experience and confidence to design and manage research independently. Thus, they will need to receive the support from other scientists in Pakistan, particularly at NARC, ICARDA and other overseas research institutes and universities. More intractable are the problems of research management and funding. However, the latter problem is more apparent than real and should not be used as a pretext to reduce the research program beyond a certain point since funds are known to be available from federal sources and donors. AZRI management needs to aggressively tap these sources.

AZRI has one of the most difficult tasks of all the PARC affiliated institutes. As mentioned earlier, the climate is harsh, the farmers extremely poor, the *sardari* (tribal) system medieval, and the feeling of isolation and neglect always present among the scientists and their families. Thus AZRI needs inspired research leadership if it is to even achieve some of the modest targets by the year 2000 indicated previously (page 55). This will require:

- Taking decisions that are often unpopular.
- Creating a team spirit and motivating the staff.
- Clearly defining a sense of direction as outlined in a five-year plan.
- Holding an annual planning meeting, agreeing to a modest annual work plan, publishing it in good time and keeping to deadlines.
- Avoiding *ad hoc* experiments that deviate from the main thrust of the institute.
- Resisting pressures from elsewhere to undertake research and activities that deviate from the main thrust, unless these are included in the annual work plan.

- Initiating a public relations effort to disseminate the role, purpose and achievements of AZRI.
- Imposing a rigidly adhered to policy of ensuring that projects are reviewed and reported annually, before starting new projects.
- Close coordination and cooperation with provincial government departments, NGOs and other bilaterally funded projects.
- Maintaining close contacts with donors who have shown an interest in supporting projects at AZRI.
- Creating income-generating activities, that could include sale of improved seed and saltbush seedlings, and making the sheep flock at Tomagh self-financing.
- A willingness to be assertive and to forcefully tackle administrative matters with managers, scientists and administrators at AZRI and at PARC.

The greatest asset now accruing to AZRI is its cadre of young and well trained scientific staff, many of whom completed overseas PhD and MSc programs during the last three years. Strong leadership will be the only way to convince them to stay at AZRI for a number of years after completing their higher degrees. Otherwise they will continue to devote all their attention to getting transferred elsewhere. A pernicious brain-drain away from AZRI will destroy it and this has already cost three overseas trained PhDs. With the proper leadership this migration could be slowed to a trickle, despite the shortage of research operating funds. Only staff domiciled in Balochistan should be offered overseas long-term training slots, and great care given to choosing a university offering a wide range of courses.

Good research can be conducted with a surprisingly modest budget if staff are prepared to do the research themselves as they did for their postgraduate degrees. Even though some new equipment has been provided by the Project, staff will have to work with some out-dated but functional equipment and techniques. Such techniques may not carry the prestige in a scientific paper that the high-tech ones do. But they are often less susceptible to power surges and breakdowns and replacement parts tend to be more available and less expensive. Good research is primarily a function of the relevance of the topic, the soundness of the hypotheses being tested, the statistical designs used and the experimental management. Use of state-of-the-act techniques is of secondary importance.

The staff will need to be freed from the red tape that has a strangle-hold on AZRI. They should get a vehicle when they need it, and even be free to drive to their research sites if necessary. AZRI is being left with a large fleet of vehicles (Annex 4), several of which are fairly new. The accounting and purchasing system must be liberalized to allow them to get advances to purchase inputs when they need them. They should be protected from demands on their time that are merely distracting side-shows of the main performance. Ways must be found to reduce the time wasted on unnecessary paper work such as writing justifications to purchase even trivial items. These activities could easily be streamlined using standardized request forms.

The annual research priority setting exercise should be used to determine budgets for each project. Then give staff the responsibility of administering this budget, such as in the case of the Productivity Enhancement Program. If they run short of funds, tell them they have not budgeted correctly and there is no additional money. The operating funds from the ARPII project could be allocated in this way to the areas covered by the project. An annual budget should be made to show the flow of funds for each year of that project. This can be adjusted from time-to-time as budget modifications and disbursements are made. AZRI will have to fight hard to get its full share of the ARPII budget.

An additional way to strengthen management at AZRI is to appoint a representative to the Chairman of PARC with special responsibility for AZRI. The person appointed could complement the Member Natural Resources whose diverse brief includes responsibility for the RRI, WRRI and LRRI at NARC, not to mention Forestry, Environment, Bees and the Karakoram Institute at Juglot. Responsibility for the institutes at NARC immediately creates a potential conflict situation since there is considerable overlap between the activities of the NARC institutes and those of AZRI. The Member can be, and certainly is, in a difficult position when it comes to making decisions affecting all the institutes. For example, how does the Member objectively advise the Chairman PARC about whether a RRI or AZRI scientist should become the national coordinator between PARC and a research institute outside Pakistan. Also, there are always conflicts about who should get overseas training slots. AZRI often looses out.

The Chairman's special representative for AZRI would have the seniority to handle the numerous tasks that the Director of AZRI should handle but cannot due to being in Quetta. Even monthly visits by the Director AZRI to PARC HQ would not be effective since these tasks require almost daily pressure on the administrators and bureaucrats at PARC. Directors of institutes at NARC can do this with relative ease because they are so close by. This gives them an enormous advantage over the Director of AZRI.

The vast investment of the MART project over nine years at AZRI will only be sustained if: AZRI is lead by an inspired research manager and scientist; if solutions are found to the apparently intractable administrative difficulties and inter-factional tensions and intrigue; if there is a marked improvement in the operating budget; and, if incentives are provided to work at AZRI. Otherwise the future of AZRI is indeed bleak. It could easily revert to being one of the most disadvantaged institutes of PARC and slowly cease to be effective. This should not be allowed to happen. It will not provided their is a will to surmount the numerous difficulties.

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ANNEXES

Annex 1. List of Papers and Reports

(Reprints of papers in refereed journals can be obtained from: The Director, AZRI, PO Box 63, Quetta, Pakistan. Copies of MART/AZR Project Research Reports can be obtained from the same address, or from the Distribution Office, CODIS, ICARDA, PO Box 5466, Aleppo, Syria.)

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Annex 2. Summary of the short-term overseas visits of AZRI staff, 1990-94

Name	Description of course/workshop/visit	Length (weeks)	Month	Year
K.N. Babar	DRMP workshop held in Amman, Jordan (funded/arranged by ICARDA DRMP project)	1	October	1991
Usman Mustafa	DRMP workshop held in Amman, Jordan (funded/arranged by ICARDA DRMP project)	1	October	1991
Shahid Rafique	Visiting scientist to Pasture, Forage and Livestock Program of ICARDA	4	February	1992
Sarwat N. Mirza	Visiting scientist to Pasture, Forage and Livestock Program of ICARDA	4	March	1992
M. Anwar Khan	Visiting scientist to Germplasm Program of ICARDA	4	April	1993
Z. Ali Qureshi	Individualized training course on methods of measuring soil water and analysis of AZRI water harvesting data (at ICARDA HQ) (includes attendance at workshop at ICARDA HQ funded/arranged by ICARDA DRMP Project)	6	Mar-May	1993
M. Islam	Individualized training course on methods of measuring soil water (at ICARDA HQ)	2	April	1993
Usman Mustafa	DRMP workshop (funded/arranged by DRMP project	1	May	1993
Muhammad Jalil	Cereal/legume travelling workshop in Turkey	1	June	1993
Shahid Rafique	Visit to ARC Sheep Laboratory in Du Boise (funded/ arranged by BOSTID office), and attendance at Small Ruminant Collaborative Research Support Project planning meeting at San Juan (Puerto Rico) (MART funded)	5	Aug-Sep	1993
Abdul S. Alvi	Attendance at Small Ruminant Collaborative Research Support Project planning meeting at San Juan (Puerto Rico), and visits to see AZRI long-term trainees at Utah, Colorado, Oklahoma and Iowa State Universities	3	September	1993
Z. Ali Qureshi	Visit to Texas A&M and Utah State University (Funded/ arranged by BOSTID office, Washington)	2	January	1994
Inam Ul-Haq	Visit to Texas A&M and UC Davis (Funded/arranged by BOSTID office, Washington)	2	March	1994
M. Anwar Khan	Multiplication/commercialization of improved crop varieties (Montana, Colorado and Mississippi State Universities)	2	April	1994
Sarwat N. Mirza	Shrub research: saltbush, sagebrush, etc (Utah and New Mexico State Universites, Shrub Research Lab, Provo, Texas Agricultural Exp. St. (San Angelo))	3	April	1994
Muhammad Jalil	Statistical methods in agricultural research (Funded from ICARDA training budget)	2	April	1994
Javed Afzal	Workshop on Dryland Agriculture (Texas, USA)	4	June	1994

Annex 3. Laboratory, computer and other equipment purchased during 1990-94 (Includes commodities purchased for the ICARDA office and to be handed over to AZRI at the end of the Project)

ITEM	DESCRIPTION	UNITS
AUDIO-VISUAL EQUIPMENT		
1.	SLIDE PROJECTOR (REFLECTA MODEL AFM)	2
2.	VIDEO CAMERA (PANASONIC NV-M9000 S-VHS, PLUS ACCESSORIES	1
3.	VCR (PANASONIC MULTISYSTEM MODEL NVSD-25)	1
4.	OLYMPUS CAMERA (SUPERZOOM 110, MULTIAF)	1
COMPUTERS, PRINTERS, UPS, STABILIZERS, PHOTOCOPIER, FAX		
5.	AST PREMIUM COMPUTER 386/25, 110 MB HD, MONITOR + KEYBOARD	1
6.	AST PREMIUM COMPUTER 386SX/16, 80 MB HD, MONITOR + KEYBOARD	1
7.	EPSOM LQ-850 PRINTER	1
8.	HP LASERJET III PRINTER	1
9.	TRIPP LITT LINE STABILIZER/CONDITIONER 2000 W	2
10.	TODD SYSTEMS STEP DOWN TRANSFORMER 1000 VA	3
11.	COMPAQ PROLINEA 4/50 COMPUTERS, 240 MB HD, MONITOR + KEYBOARD	4
12.	COMPAQ CONTURA 4/25 LAPTOP COMPUTER, 120 MB HD, MONITOR+KEYBOARD	2
13.	EPSOM LQ1170 PRINTER	3
14.	HP LASERJET VI PRINTER	1
15.	UPS (PCM POWERCOM, 550 VA)	2
16.	UPS (SPS - AMERICAN POWER CONVERSION)	2
17.	UPS (SHAVEH 550 VA)	7
18.	UPS (SHAVEH 1.2 KVA)	2
19.	STABILIZERS STAVOL (AETCO) (500 VA)	9
20.	STABILIZERS STAVOL (AETCO) (1000 VA)	1
21.	PHOTOCOPIER (SHARP SF-8500)	1
22.	PHOTOCOPIER (TOSHIBA 2310)	1
23.	FAX (HARRIS 3M, 2250)	1
24.	FAX (PANAFAX MACHINE UF 128 A)	1
25.	EXTERNAL MODEM (DATA TRANSMISSION) FOR AZRI DIRECTOR'S OFFICE	1
26.	PHONE SET (PANASONIC)	1
27.	PHONE SET (SANYO, CORDLESS)	1
FARM MACHINERY, WORKSHOP EQUIPMENT		
28.	TRACTOR, MASSEY FERGUSON MODEL 375	1
29.	PLOUGH (THREE FURROW, MODEL MT-02H)	1
30.	CULTIVATOR (11 TINES)	1
31.	POST-HOLE DIGGER (MF-815), 9" AND 18" AUGERS	1
32.	ASSORTED WORKSHOP FURNITURE/EQUIPMENT/TOOLS	Various
33.	WELDING PLANT	1
34.	BATTERY CHARGER	2
35.	JIB CRANE (ATTACHABLE TO 3-POINT LINKAGE)	1
36.	ACCESSORIES FOR TRACTOR (FRONT WEIGHTS, CANOPY, PTO PULLEY, STAYS, DRAW BAR)	Various
37.	SOIL AUGERS	5
38.	YAMAHA GENERATOR Y D G 2000 - AZRI	2
39.	WORKSHOP STEEL FURNITURE, STEEL CUPBOARDS	1
40.	DRAWING EQUIPMENT	Various

Annex 3 (cont.). Laboratory, computer and other equipment purchased

ITEM	DESCRIPTION	UNITS
LIBRARY BOOKS AND MICROFILMS		
41.	BOOKS	Various
42.	MICROFILMS OF 19 JOURNALS (UNIVERSITY MICROFILMS)	19
LABORATORY EQUIPMENT		
43.	REPLACEMENT PARTS FOR AUTOMATIC WEATHER STATION ACCESSORIES	Various
44.	DIGITAL CONDUCTIVITY METER	1
45.	MICRO LAB 1000 AUTOMATIC DILUTER/PIPETTE	1
46.	STEREO-MICROSCOPE WITH BINOCULAR TUBE	1
47.	ELECTRONIC ANALYTICAL BALANCE	3
48.	ELECTRONIC TOP-LOADING PLATFORM BALANCE	3
CONSTRUCTION JOBS		
49.	PARTITION WALLS FOR WORKSHOP/SEED ROOM	2
50.	METAL DIGESTIBILITY CRATES	18
51.	BUILDING FOR FEED MILL AND WIRING-UP OF MILL	1
52.	SHED FOR ANIMALS	1
53.	WIRING OF SEED CLEANERS	1

Total expenditure on the above items: $125,790.

Annex 4. List of vehicles assigned to AZRI by July 31, 1994

(All vehicles were in running order and being used except for the pale green Corolla saloon and the Toyota Hilux Double cabin pickup QAF627.)

Description	Plate	Source	Cond.[1]	Age[2]	Year[3]
Pajero (short-wheel base)	QAF1513	MART	New	New	1991
Pajero (long-wheel base) (from PARC)	QAF2586	MART	Good	2	1993
Toyota Landcruiser	QAF2070	MART/AZR	Good	9	1994
Toyota Landcruiser	QAF2071	MART/AZR	Good	9	1994
Toyota Landcruiser	QAF2072	MART/AZR	Good	9	1994
Toyota Landcruiser	QAF2073	MART/AZR	Good	9	1994
Toyota Landcruiser	AD-64-386	MART/AZR	Stolen	-	-
Mitsubishi double-cabin pickup	QAF1512	MART	New	New	1991
Toyota Hilux double cabin pickup	QAD624	MART/AZR	New	New	1985
Toyota Hilux double cabin pickup	QAD625	MART/AZR	New	New	1985[4]
Toyota Hilux double cabin pickup	QAD627	MART/AZR	New	New	1985
Toyota Hilux double cabin pickup	QAD628	MART/AZR	New	New	1985[5]
Toyota Hilux double cabin pickup	QAD629	MART/AZR	Good	9	1994
Toyota Hilux double cabin pickup	QAD630	MART/AZR	Stolen	-	-
Toyota Hilux double cabin pickup	QAD631	MART/AZR	New	New	1994[6]
Toyota Hilux double cabin pickup	QAD632	MART/AZR	New	New	1985
Toyota Hilux double cabin pickup	QAD634	MART/AZR	New	New	1985
Toyota Hilux double cabin pickup	QAD4320	ARPII	New	New	1994
Truck (International)	QAF2074	MART/AZR	Good	9	1994
Truck (Fiat) (from Italian project)	IDB5601	NARC	Good	9	1993
Coaster (Mazda)	QAC9652	MART/AZR	New	New	1985
Toyota Corolla Saloon (White)	QAD635	MART/AZR	New	New	1985[7]
Toyota Corolla Saloon (Pale green)	QAC9580	MART/AZR	New	New	1985

[1]Condition when delivered to AZRI. [2]Age (years) when delivered to AZRI. [3]Year when delivered to AZRI. [4]Transferred to AZRI sub-station D.I. Khan. [5]Transferred to AZRI sub-station Bahawalpur. [6]Transferred to AZRI sub-station Umerkot. [7]Transferred to PARC HQ

Annex 5. AZRI Headquarters Scientific Staff, and ICARDA MART/AZR Project Staff on June 30, 1994

(Staff with names preceded by "*" joined during 1993)
(Staff with names preceded by "+" left during 1993 or 1994)
(Staff with names preceded by "#" are MLLT[1] who returned to AZRI after completing PhD or MSc degree. Not included on list is Babar Raza Qazi who was awarded an MSc from New Mexico State University and was then posted back at Umerkot Sub-station.)

Director	+Bakht Roidar Khan ((PSO[2], PhD), left March 1993 *Abdul Sattar Alvi (CSO[3], PhD), joined March 1993
Agronomy/water-harvesting Section	K.N. Babar (PSO) Muhammad Islam (SO[4]) #,+M. Arshad Ali (SO, PhD), transferred to PARC in April 1994 #Zahid A. Qureshi (SO, MSc) Ahmad Samiullah (SO, MLTT) M. Adel Akbar (AAE[6], ALTT[5])
Germplasm Section	#M. Anwar Khan (SSO[7], MSc) Safraz Ahmed (SO, nominally in Range Section) Asghar Ali (SO, MLTT) S.A. Jaleel (ASO[8])
Range Section	Sarwat N. Mirza (SSO, MLLT, PhD) Ghulam Akbar (SSO, MLTT) Irshad Begum (SSO) Javed Afzal (SO, ALTT)
Livestock Section	Shahid Rafique (SSO, PhD) Inam ul-Haque (SO, ALTT) *Arshad Ali (SO, ALTT), joined June 1993 Atiq-ur-Rehman (SO, LTT-Australian funded)
Economics Section	Usman Mustafa (SSO, PhD) Khalid Mahmood (SO, MLTT) Muhammed Afzal (ASO) Imran Ali (SO, on contract) Nisar Ali Shah (Grade 11)
Extension Section	S. Hassan Raza (PSO) M. Bilal Ahmad Chowdry (SO, ALTT) Abid Hussan (SO)

[1]MART long-term trainee (PhD/MS), [2]Principal scientific officer, [3]Chief scientific officer, [4]Scientific officer, [5]ARPII long-term trainee (PhD/MS), [6]Assistant agricultural engineer, [7]Senior scientific officer, [8]Assistant SO.

ICARDA MART/AZR Project Staff

Euan F. Thomson	Chief of Party/Project Leader/Livestock-Range Advisor
Alister Y. Allan	Agronomy/Water Harvesting/Germplasm Advisor (left 31/3/92)
Abelardo Rodríguez	Agricultural Economics Advisor (left 15/7/92)
Pesi R. Amaria	Office Manager/Financial Administrator (Consultant)
M. Zafar Jalil	Assistant Financial Administrator (left 31/12/93)
Kathy Javed Gill	Secretary (left 30/6/94)
Aslam James	Driver (left 31/3/91)
Nasir Patrick	Driver (left 30/4/91)
Sharafat Barkat	Driver (left 31/7/94)
Eric Masih	Driver (left 31/5/94)
Yousaf John	Driver (left 28/2/94)

Annex 6. Annual expenditure of USAID (a), cumulative expenditure of USAID (b), and ICARDA contribution (c) to the MART/AZR project. (See Grant Modification No 4)

a. Annual expenditure of USAID ([redacted]$)

	1990	1991	1992	1993	1994
Salaries	218,997	243,363	117,219	47,205	13,674
Travel	34,791	20,906	23,766	38,558	7,960
Training	6,428	8,682	2,913	9,847	18,889
Research Operating & Other Direct Costs	136,855	99,635	46,894	75,786	112,691
Indirect Costs[1]	69,424	85,629	0	0	0
Total	466,495	458,215	190,792	171,396	153,214

[1]Only applied during 1990 and 1991.

b. Cumulative expenditure of USIAD by June 30, 1994 ([redacted]$)

	Total cumulative expenditure	Total of grant[1]	Percentage expended
Salaries	640,458	684,271	93.6
Travel	125,981	115,726	108.9
Training	46,759	35,704	131.0
Research Operating & Other Direct Costs	471,861	509,246	92.7
Indirect Costs	155,053	155,053	100.0
Total	1,440,112	1,500,000	96.0

[1]According to Grant Modification No. 4.

c. ICARDA contribution and total share ([redacted]$)

	Cumulative expenditure 1990-93	Estimated expenditure 1994	ICARDA share[1]
Salaries	211,500	26,438	163,574
Travel	39,515	2,334	54,724
Training	42,910	2,534	50,000
Research Operatin Other Direct Costs	23,460	1,385	20,000
Indirect Costs	14,040	829	13,538
Total	331,425	33,520	301,836

[1]According to Grant Modification No. 4.